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Perceived Environmental Impacts of Construction Activities on Urban Residents' Quality of Life in Hanoi

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ABSTRACT: Road construction activities may generate fugitive dust, engine exhaust emissions, noise, and vibration in nearby residential areas. This study analyzes the associations among residents' perceived environmental impacts, their assessment of construction control, the self-reported number of days on which health or daily activities were affected, and satisfaction with the living environment in areas with road construction projects in Hanoi. Data were collected through a household survey (N = 500) using Likert scales and self-report items. The analytical methods include descriptive statistics, Pearson correlation, ordinary least squares (OLS) regression with HC3 robust standard errors, and ordered logit regression for the five-level satisfaction variable. The results show that the perceived impact index is positively associated with the number of days on which health or daily activities were affected ($\beta = 1.425$; $p < 0.001$) and negatively associated with the level of environmental satisfaction ($\beta = -0.324$; $p < 0.001$). A more positive assessment of construction control is positively associated with satisfaction ($\beta = 0.419$; $p < 0.001$). The results reflect associations among experiences self-reported by residents, rather than evidence from direct measurement of pollution levels or of medical causality. The findings provide a survey-based foundation for proposing improvements in construction management, communication, and community feedback mechanisms.

1. INTRODUCTION

Investment in the construction and upgrading of road infrastructure is an important prerequisite for enhancing connectivity, reducing transport costs, and supporting urban development. However, construction activities may generate fugitive dust, engine exhaust emissions, noise, and vibration. The magnitude of impacts on residential areas depends on the type of equipment, the intensity and duration of construction, meteorological conditions, shielding measures, machinery maintenance, and the distance from the emission source to the receptor.

In project management, environmental assessment is usually tied to procedures and technical standards; meanwhile, the experiences of residents—including perceived impact levels, self-reported health, and satisfaction with the living environment—also need to be considered concurrently. An analytical framework that combines environmental monitoring indicators with sociological survey data helps formulate testable hypotheses, identify population groups likely to have higher exposure, and support the design of effective monitoring policies.

This paper addresses three questions:

- Is the perceived level of environmental impact associated with the number of days on which health or daily activities were affected?
- Are perceived impacts and the assessment of construction control associated with environmental satisfaction?
- Is the distance from home to the construction site associated with the self-reported number of days on which health or daily activities were affected?

The study uses sociological survey data from residential areas adjacent to road construction projects in Hanoi, focusing on environmental perceptions, health and daily-life experiences, and assessments of construction management.

The main contributions of the study are as follows:

- Structuring an analytical framework that links construction-related factors with perceived impacts, self-reported health, and satisfaction.
- Estimating regression models based on survey data, using HC3 robust standard errors and an ordered logit model to test the sensitivity of the results for the satisfaction variable.
- Deriving empirical findings and proposing feasible management and policy measures to mitigate the environmental impacts of construction equipment in Hanoi.

2. THEORETICAL BACKGROUND AND RESEARCH HYPOTHESES

2.1 The DPSIR analytical framework

The DPSIR (Drivers–Pressures–State–Impact–Response) framework is used as a guiding structure: the drivers are the demands of infrastructure development and urbanization; the pressures are the operation of machinery and vehicles and construction operations; the state is reflected in residents' perceptions of dust, exhaust/odor, noise, and vibration; the impacts are self-reported health and daily-life experiences and satisfaction; and the responses are management, monitoring, and communication measures with residents. An approach that jointly assesses environmental pressures and community responses is consistent with studies on air pollution, noise, and construction noise management (Nikolopoulou et al., 2011; Liu et al., 2017; Hong et al., 2020; Zou et al., 2020; Mir et al., 2022). The present study quantifies only the aspects recorded through the questionnaire and does not directly measure environmental parameters.

2.2 Literature review

2.2.1 Literature search and synthesis method

The review is organized as a structured review, focusing on three strands of evidence: (i) measurement of dust and ambient air quality around construction sites (Hong et al., 2020; Jaafar et al., 2024); (ii) noise, vibration, and community annoyance responses (Liu et al., 2017; Zou et al., 2020; Pinsonnault-Skvarenina et al., 2021); and (iii) the effectiveness of management, mitigation, and resident communication measures (Mir et al., 2022; Pinsonnault-Skvarenina et al., 2022). The priority databases include Scopus, Web of Science, ScienceDirect, PubMed, and Google Scholar, with a priority time window of 2014–2025.

2.2.2 Strands of evidence and key findings

The research strand that combines environmental measurements with resident surveys has been pursued in numerous international studies. Nikolopoulou et al. (2011) combined measurements of particulate matter, noise, and microclimate with 260 interviews in areas with road construction sites and in traffic areas; the results showed that perceived air quality was closely associated with particle concentrations and visible signs of dust. Liu et al. (2017) combined a community survey with noise measurements at 40 construction sites and established relationships with annoyance levels. Zou et al. (2020) combined noise and vibration measurements with a resident survey, showing that impact levels varied according to location within the structure and the characteristics of sound/vibration transmission. Pinsonnault-Skvarenina et al. (2021, 2022) analyzed survey participants around a highway project and showed that annoyance and satisfaction were explained not only by measured noise but also by personal and psychological factors and the quality of construction management.

In the strand on emission source control and monitoring, Hong et al. (2020) and Jaafar et al. (2024) highlighted the spatial variability of pollutants, the occurrence of localized pollution hotspots around construction sites, and the need for simultaneous monitoring of environmental indicators.

Table 1. Summary of representative studies and methodological implications for the present study

Study	Data/method	Contribution to the present study
Nikolopoulou et al. (2011)	260 interviews; measurements of particles, noise, and microclimate at construction/traffic sites	Suggests jointly analyzing environmental perceptions and self-reported experiences
Liu et al. (2017)	Community survey and noise measurements at 40 construction sites; dose–response model	Consider time, location, and context when analyzing annoyance
Zou et al. (2020)	Noise/vibration measurements combined with a resident survey	Consider differences in location, floor level, and sound/vibration transmission when designing the sampling
Pinsonnault-Skvarenina et al. (2021)	Survey of 1,409 people around a highway project; multivariate model	Personal, psychological, and contextual factors may matter beyond measured noise levels
Pinsonnault-Skvarenina et al. (2022)	Survey of awareness, use of, and satisfaction with mitigation measures	Measure management/mitigation quality separately rather than combining it with environmental impacts
Mir et al. (2022)	Systematic review of construction noise management	Organize management along assessment–prediction–control–monitoring; attend to measurement consistency
Jaafar et al. (2024)	Low-cost $PM_{2.5}$ sensors; time-series and spatial analysis	Control for spatial/temporal variability and exercise caution when interpreting perceptions as a substitute for monitoring data

2.2.3 Research gap and contribution

Based on the reviewed studies on dust perception, responses to noise and vibration, and mitigation measures at construction sites (Nikolopoulou et al., 2011; Liu et al., 2017; Hong et al., 2020; Zou et al., 2020; Pinsonnault-Skvarenina et al., 2021, 2022; Mir et al., 2022; Jaafar et al., 2024), the identified research gap is the lack of quantitative survey evidence on the simultaneous associations among perceived environmental impacts, self-reported health and daily-life experiences, assessments of construction control, and the satisfaction of residents living around road construction projects in Hanoi. The study contributes by developing and testing an analytical framework based on household survey data, while clarifying the limitations of self-reported evidence.

2.3 Conceptual model and research hypotheses

The proposed model focuses on the context of exposure to construction activities; perceived environmental impacts; self-reported effects on health and daily activities; the perceived quality of construction management; and satisfaction with the residential environment (**Figure 1**).

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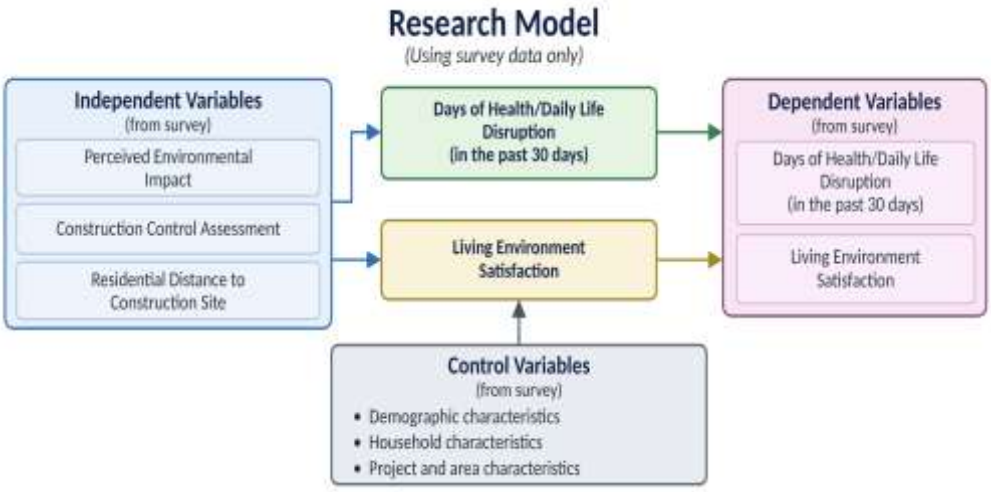

Figure 1. Research model (using survey data only)

- H1: The higher the perceived level of environmental impact, the greater the self-reported number of days on which health or daily activities are affected.
- H2: The higher the perceived level of environmental impact, the lower the satisfaction with the living environment.
- H3a: A positive assessment of construction control is associated with a lower level of perceived environmental impact. H3b: A positive assessment of construction control is associated with higher environmental satisfaction.
- H4: The greater the self-reported number of days on which health or daily activities are affected, the lower the level of satisfaction with the living environment.
- Health consequences for satisfaction (H5): The greater the self-reported number of days with disrupted daily activities or impaired physical condition, the less satisfied residents are with their living environment.

3. MATERIALS AND METHODS

3.1 Data source and survey scope

The research data were collected through a survey of households living near road construction projects in Hanoi. A total of 523 questionnaires were administered, of which 500 were returned. The sample comprises three groups of projects: the Ring Road 4 Project (183 observations; 36.6%), urban road projects (171; 34.2%), and national highway upgrading/widening projects passing through urban areas (146; 29.2%). By distance from home to the construction site, the distribution is as follows: 164 households (32.8%) at less than 100 m, 199 households (39.8%) at 100–300 m, and 137 households (27.4%) at 301–500 m. By gender, the respondents comprised 274 women (54.8%) and 226 men (45.2%). The environmental variables in this study are perceptions self-reported by the respondents, not physical monitoring indicators.

3.2 Measurement of variables

To test the research hypotheses and ensure consistency in the quantitative models, the variables are classified into three main functional groups: dependent variables (reflecting outcome dimensions), main explanatory variables (reflecting impacts and construction control), and control variables intended to isolate confounding factors specific to the survey respondents. Details on the definition, measurement scale, and data collection method of each variable are summarized in **Table 2**.

Table 2. Definitions and measurement scales of the variables in the analytical model

Variable group	Analytical variable	Measurement / Description
Health/daily-life outcome	Number of affected days	Number of days in the past 30 days on which health or daily activities were affected by construction (count variable)
Satisfaction outcome	Environmental satisfaction	1–5 Likert scale; higher scores indicate a higher level of satisfaction
Main explanatory variable	Perceived impact index	Mean score of five items (B1–B5), 1–5 Likert scale; higher scores reflect a greater level of perceived impact
Main explanatory variable	Construction control index	Mean score of three items assessing the contractor's control, 1–5 scale; higher scores reflect better control
Control variables	Age, gender, distance, project type	Age (continuous); Gender (binary, 1 = Female); Distance and Project type are categorical variables

All research variables were derived from survey responses, including the environmental perception scale, the assessment of construction control, the self-reported number of days on which health or daily activities were affected, and the level of satisfaction. Because they all rely on self-reported data, the results may be subject to common method bias and recall bias; the study does not infer objective pollutant concentrations from these results.

3.3 Model estimation method

The analytical procedure comprises descriptive statistics, Pearson correlation, and two OLS models:

- **Model M1:** The dependent variable is *Number of affected days*.
- **Model M2:** The dependent variable is *Level of environmental satisfaction*.

HC3 robust standard errors are applied to the OLS models to improve the reliability of inference given the possible presence of heteroskedasticity. The 100–300 m distance group and the national highway upgrading/widening project group are selected as the reference categories.

In addition, because the *Environmental satisfaction* variable is ordinal in nature (Likert 1–5), an ordered logit model is additionally estimated as a sensitivity check with respect to measurement. The conventional significance level is $a = 0.05$ ($p < 0.05$).

3.4 Ethical considerations

The study was conducted in accordance with the Declaration of Helsinki. The survey protocol was approved by the Scientific Council of the Faculty of Transport Economics, University of Transport and Communications (approval No. 15.09.2026/KTVT.UTC). Informed consent was obtained from all respondents before the interview. Participation was voluntary; respondents could skip any question or stop at any time. The information was used solely for research purposes, aggregated by group, and no individual identities were disclosed (see the consent section of the questionnaire in Appendix A).

4. RESULTS AND DISCUSSION

4.1 Descriptive statistics

Descriptive statistics are used to summarize the distributional characteristics of the study variables, including the level of environmental impact perceived by residents, the assessment of construction control, the number of days on which health or daily activities were affected in the past 30 days, and the level of satisfaction with the living environment. The mean, standard deviation, minimum, and maximum help identify the general tendency of evaluations as well as the degree of dispersion in respondents' experiences. The statistical results are presented in **Table 3**.

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Table 3. Descriptive statistics of the survey variables

Variable	N	Mean	Standard deviation	Min	Max
Perceived impact index (1–5)	500	2.43	0.66	1.00	4.80
Construction control index (1–5)	500	2.95	0.53	1.67	4.33
Number of affected days/30 days	500	3.67	2.14	0.00	11.00
Environmental satisfaction (1–5)	500	3.43	0.84	1.00	5.00

The results in **Table 3** show that the perceived environmental impact index has a mean value of 2.43 points, below the neutral midpoint of the five-point scale. This indicates that negative evaluations of the environment are not high across the entire survey sample, although differences in experiences among households still exist. The standard deviation of 0.66 reflects a certain degree of dispersion in respondents' evaluations.

The construction control index has a mean of 2.95 points, approximately at the neutral midpoint of the scale. This result suggests that residents do not evaluate the effectiveness of measures to control construction-related impacts in a truly positive manner. This aspect warrants further consideration in the analysis of factors related to satisfaction with the living environment.

The number of days on which health or daily activities were affected averages 3.67 days in the past 30 days, with a standard deviation of 2.14 days. The minimum of 0 and maximum of 11 indicate that residents' experiences are heterogeneous: some respondents reported no affected days, while others reported a higher number of affected days. This is self-reported information from survey participants, not the result of a medical diagnosis or evidence establishing the cause of health effects.

Meanwhile, satisfaction with the living environment has a mean of 3.43 points, above the neutral midpoint. The results indicate that the overall evaluation of the living environment still leans slightly toward the positive side, even though perceived environmental impacts and assessments of construction control are not truly favorable. This discrepancy calls for the simultaneous consideration of the variables in regression models to identify the factors significantly associated with the number of affected days and residents' satisfaction.

4.2 Correlations among variables

After describing the characteristics of the study variables, Pearson correlation analysis was performed to examine the direction and strength of the linear associations among the survey variables. The analysis focuses on the associations among perceived environmental impacts, the assessment of construction control, the number of days on which health or daily activities were affected, and satisfaction with the living environment. The correlation results provide an initial basis for guiding the regression analysis but are insufficient to determine the independent effect of each variable when other factors need to be controlled for.

Table 4. Pearson correlation matrix of the survey variables

Variable	Perceived impact	Construction control	Affected days	Satisfaction
Perceived impact	1.000	−0.029	0.476	−0.250
Construction control	−0.029	1.000	−0.059	0.280
Affected days	0.476	−0.059	1.000	−0.225
Satisfaction	−0.250	0.280	−0.225	1.000

Table 4 shows that the most notable association is the positive correlation between the perceived environmental impact index and the number of days on which health or daily activities were affected, with a coefficient of $r = 0.476$. This indicates that people who rate environmental impacts as more severe tend to report more affected days. This level of correlation suggests a

moderate association, which needs to be further tested using regression models that control for individual characteristics and project context.

The perceived impact index is negatively correlated with environmental satisfaction ($r = -0.250$). The results show that a higher level of perceived negative impact is typically accompanied by a lower level of satisfaction. This finding is consistent with the argument that adverse environmental experiences may be associated with less positive evaluations of the quality of the living environment.

Regarding construction control, the correlation coefficient with satisfaction is $r = 0.280$, indicating that more positive assessments of construction control tend to be accompanied by higher satisfaction. By contrast, the correlation between construction control and the number of affected days is only $r = -0.059$, reflecting a very weak linear association in the survey data.

In addition, the number of affected days is negatively correlated with environmental satisfaction ($r = -0.225$), indicating that residents who report more affected days tend to be less satisfied. Overall, the correlation matrix provides initial evidence supporting the inclusion of perceived impacts and the assessment of construction control in the regression models.

However, these coefficients reflect only bivariate correlations. Because the table does not report accompanying p-values or confidence intervals, no conclusion can be drawn regarding the statistical significance of each correlation coefficient from these values alone. Determining the associations after controlling for other factors must rely on the regression results.

4.3 OLS regression results: number of affected days (M1)

To assess the association between perceived environmental impacts and residents' health or daily-life experiences, the first OLS regression model (M1) uses the number of affected days in the past 30 days as the dependent variable. The main explanatory variables are the perceived impact index and the construction control index. Age, gender, distance from home to the construction site, and project type are included in the model to control for observed differences among groups of respondents.

Robust standard errors based on the HC3 method (heteroskedasticity-consistent standard errors, type HC3) are used to support statistical inference in the case of non-constant error variance. Residents living 100–300 m from the construction site and the road upgrading/widening project group are used as the reference categories according to the model design. The estimation results are presented in **Table 5**.

Table 5. Estimation results of model M1 (dependent variable: number of affected days)

Variable	β	HC3 SE	p-value	95% CI
Perceived impact index	1.425	0.151	<0.001	[1.129; 1.722]
Construction control index	−0.147	0.157	0.350	[−0.455; 0.161]
Age	−0.006	0.007	0.369	[−0.021; 0.008]
Female (1 = Female)	−0.407	0.170	0.017	[−0.739; −0.074]
Distance <100 m	0.604	0.207	0.004	[0.197; 1.010]
Distance 301–500 m	0.291	0.228	0.201	[−0.155; 0.737]
Ring Road 4	0.018	0.212	0.933	[−0.397; 0.433]
Urban road	−0.103	0.213	0.628	[−0.521; 0.314]

Note: $R^2 = 0.253$; *adjusted* $R^2 = 0.240$; $N = 500$.

The perceived impact index is positively and highly significantly associated with the number of affected days ($\beta = 1.425$; $p < 0.001$): a 1-point increase in perceived impact is associated with an increase of 1.43 days per month on which health or daily

activities are affected. Residents living within a radius of less than 100 m are affected approximately 0.60 days more than the 100–300 m group ($p = 0.004$).

4.4 OLS regression results: environmental satisfaction (M2)

Model M2 is used to analyze the associations between perceived impact factors, the quality of construction control, and residents' level of environmental satisfaction. The input data were collected through a resident survey and processed using ordinary least squares (OLS) regression. HC3 standard errors are used to enhance the reliability of statistical inference in the case of non-constant error variance. The model simultaneously controls for individual characteristics, distance to the affected area, and project type, thereby assessing the partial associations between the explanatory variables and environmental satisfaction.

Table 6. Estimation results of model M2 (dependent variable: environmental satisfaction)

Variable	β	HC3 SE	p-value	95% CI
Perceived impact index	−0.324	0.061	<0.001	[−0.444; −0.204]
Construction control index	0.419	0.073	<0.001	[0.277; 0.562]
Age	0.005	0.003	0.128	[−0.001; 0.011]
Female (1 = Female)	−0.081	0.071	0.254	[−0.220; 0.058]
Distance <100 m	−0.058	0.089	0.516	[−0.233; 0.117]
Distance 301–500 m	−0.097	0.091	0.288	[−0.275; 0.082]
Ring Road 4	−0.043	0.090	0.629	[−0.219; 0.133]
Urban road	−0.059	0.092	0.520	[−0.239; 0.121]

Note: $R^2 = 0.146$; adjusted $R^2 = 0.133$; $N = 500$.

The results in **Table 6** show that both main explanatory variables are associated with environmental satisfaction at the 1% significance level, but in opposite directions.

First, the perceived impact index has a negative and statistically significant regression coefficient ($\beta = -0.324$; HC3 SE = 0.061; $p < 0.001$; 95% CI: [−0.444; −0.204]). This result indicates that when the perceived impact index increases by one unit, the level of environmental satisfaction tends to decrease by 0.324 units, holding the other control variables constant. The 95% confidence interval lies entirely below zero, reinforcing the evidence of an inverse association between perceived environmental impacts and residents' satisfaction. In practical terms, the result suggests that people who perceive a greater level of environmental impact tend to report lower satisfaction. However, because the data were collected through a survey, the result reflects a statistical association and is insufficient to establish a causal relationship.

Second, the construction control index has a positive and highly significant coefficient ($\beta = 0.419$; HC3 SE = 0.073; $p < 0.001$; 95% CI: [0.277; 0.562]). This indicates that when residents' assessment of the quality of construction control increases by one unit, the level of environmental satisfaction tends to increase by 0.419 units, holding other factors constant. The positive coefficient, together with a confidence interval that does not contain zero, indicates that this association is statistically consistent. Comparing the absolute values of the two coefficients, the coefficient of construction control is larger than that of perceived impact (0.419 vs. 0.324). However, it can be concluded that the construction control variable has a larger estimated association only if the two indices are measured on the same scale and have compatible standardization; if the scales differ, standardized coefficients should be used for direct comparison.

Regarding the control variables, age has a positive coefficient but does not reach statistical significance at the 5% level ($p = 0.128$). The female gender variable has a negative coefficient ($\beta = -0.081$; $p = 0.254$), but there is insufficient statistical evidence to conclude that the satisfaction of women differs from that of men. Similarly, the distance groups of less than 100 m and 301–

500 m both have negative coefficients relative to the reference distance group, but they are not statistically significant ($p = 0.516$ and $p = 0.288$). The Ring Road 4 and urban road variables also do not reach statistical significance, with $p = 0.629$ and $p = 0.520$. Therefore, in the current model, there is insufficient evidence that environmental satisfaction differs systematically across these control characteristics after accounting for the remaining variables.

In terms of goodness of fit, the model has $R^2 = 0.146$ and an adjusted R^2 of 0.133, with N = 500. Thus, the model explains approximately 14.6% of the variation in environmental satisfaction in the survey sample; after adjusting for the number of explanatory variables, this proportion is approximately 13.3%. This is a relatively limited explanatory power, suggesting that environmental satisfaction may also be related to factors not included in the model, such as residents' expectations, the level of trust in the project owner, the quality of information, and the effectiveness of receiving and handling complaints. These factors should be considered for inclusion only when there is an appropriate theoretical basis and suitable survey data.

Overall, the M2 results highlight two notable associations: higher perceived environmental impacts are associated with lower satisfaction, whereas more positive assessments of construction control are associated with higher satisfaction. The practical implication is that attention should be paid simultaneously to limiting the impacts perceived by residents and to improving the quality of construction control, information provision, and community feedback. This is an implication derived from the survey results, not direct evidence of pollution levels or actual environmental conditions at the site.

4.5 Sensitivity analysis using the ordered logit model

To test the robustness of the M2 results, the study uses an ordered logit model with the dependent variable being the level of environmental satisfaction measured on an ordinal scale. Unlike OLS, the ordered logit model is appropriate when the dependent variable reflects ordered levels of satisfaction for which the distances between levels are not necessarily equal. Comparing the results of the two methods helps assess whether the direction and statistical significance of the main associations depend substantially on the choice of estimation model.

Table 7. Ordered logit model results (dependent variable: environmental satisfaction)

Variable	Logit coefficient	SE	*p*-value	95% CI
Perceived impact index	−0.728	0.131	<0.001	[−0.985; −0.471]
Construction control index	1.010	0.168	<0.001	[0.681; 1.338]
Age	0.012	0.007	0.096	[−0.002; 0.027]
Female (1 = Female)	−0.185	0.170	0.279	[−0.519; 0.150]

The ordered logit results show that the two main explanatory variables retain the same direction of effect as in the OLS model in **Table 6**.

Specifically, the perceived impact index has a negative and statistically significant coefficient ($\beta = -0.728$; SE = 0.131; $p < 0.001$; 95% CI: [−0.985; −0.471]). The results indicate that a higher perceived impact index is associated with a tendency to fall into lower levels of environmental satisfaction, holding the other explanatory variables constant. The 95% confidence interval does not contain zero, thereby reinforcing the statistical evidence of this inverse association.

Conversely, the construction control index has a positive and statistically significant coefficient ($\beta = 1.010$; SE = 0.168; $p < 0.001$; 95% CI: [0.681; 1.338]). The positive coefficient indicates that more positive assessments of construction control are associated with a tendency to reach higher levels of environmental satisfaction. This result is consistent with the OLS model, in which the construction control variable also has a positive and highly significant coefficient.

It should be noted that the coefficients of the ordered logit model cannot be directly compared in magnitude with the OLS coefficients. In the ordered logit model, a coefficient represents the change in the logarithm of the cumulative odds when the explanatory variable increases by one unit, according to the coding convention of the satisfaction levels. Therefore, a coefficient of 1.010 does not mean that satisfaction increases by 1.010 units. For interpretation in terms of odds ratios, one may compute

$e^{1.010} = 2.75$; however, the coding of the dependent variable and the proportional odds assumption should be verified before reporting this result. Similarly, $e^{-0.728} = 0.48$ for the perceived impact index, indicating that the cumulative odds of being in higher satisfaction levels decrease as this index increases, provided that the levels are coded from low to high and the model is interpreted under the corresponding cumulative odds convention.

Regarding the control variables presented, age has a positive coefficient but does not reach statistical significance at the 5% level ($p = 0.096$). The female variable has a negative coefficient but is not statistically significant ($p = 0.279$). These results are consistent with the OLS results, in which age and gender were also not statistically significant at the 5% level. However, because **Table 7** does not yet fully report the distance and project-type variables, it should not be concluded that all control variables are consistent across the two models.

Overall, the ordered logit results provide additional evidence supporting the robustness of the direction and statistical significance of the two main associations in M2. The negative coefficient of perceived impact and the positive coefficient of construction control are maintained when moving from OLS to a model suited to an ordinal dependent variable. Nevertheless, this consistency supports the robustness of the results only within the specifications tested; it does not by itself establish causality or rule out all bias due to omitted variables.

4.6 Interpretation of empirical results and comparison with the literature

The survey results show that perceived environmental impacts are positively associated with the self-reported number of days on which health or daily activities were affected and negatively associated with environmental satisfaction. A positive assessment of construction control is positively associated with satisfaction. Because the data were collected through a cross-sectional, self-reported survey, the results should be interpreted as statistical associations rather than causal relationships.

- The level of perceived environmental impact is a factor clearly associated with health/daily-life experiences and satisfaction. This approach adds a sociological perspective to studies on construction impacts but does not replace objective environmental monitoring.
- Increased perceived impacts are associated with more days of affected health or daily activities and with lower satisfaction; this finding shares similarities with studies on community responses to construction noise and on predictors of noise annoyance (Liu et al., 2017; Pinsonnault-Skvarenina et al., 2021).
- In particular, the survey results show that more positive assessments of construction control are positively associated with residents' satisfaction ($\beta = 0.419$). This finding is consistent with research examining the perception of, and satisfaction with, noise mitigation measures at construction sites (Mir et al., 2022; Pinsonnault-Skvarenina et al., 2022). However, the current data do not allow the conclusion that any individual measure—shielding, water spraying, or noise control—directly increased satisfaction.
- The study does not have direct measurement data to determine a physical pollution threshold by distance. Nevertheless, the survey analysis can help identify the resident groups that should be prioritized for consultation and complaint handling.

4.7 Management and policy implications for Hanoi

Based on the empirical findings, the study proposes three key groups of policies for transport construction management in Hanoi:

- **Establishing a priority exposure-control buffer within a 100 m radius:** The most stringent monitoring regulations should be applied to residential areas located less than 100 m from the construction site boundary, including the installation of noise barriers, fully enclosed dust screens, and continuously operating automatic mist-spraying dust suppression systems.
- **Strengthening complaint handling and information disclosure:** Establishing channels for receiving, classifying, and responding to residents' complaints; and providing construction schedules and information on mitigation measures in an accessible manner.
- **Enhancing the control of equipment and construction processes:** Strictly inspecting the exhaust emissions and noise levels of construction machinery (bulldozers, excavators, pile drivers, and road rollers); restricting high-noise construction work at night; and requiring the removal of mud and soil from vehicle wheels before leaving the

construction site. At the same time, establishing channels for receiving and promptly responding to residents' complaints.

5. CONCLUSIONS

The study analyzed survey data from residents living near road construction projects in Hanoi, focusing on perceived environmental impacts, the self-reported number of days on which health or daily activities were affected, assessments of construction control, and satisfaction. The regression results show that perceived impacts are positively associated with the number of affected days ($\beta = 1.425$) and negatively associated with environmental satisfaction ($\beta = -0.324$). The assessment of construction control is positively associated with satisfaction ($\beta = 0.419$). Because no direct field measurements were used, the study draws no conclusions about $PM_{2.5}$ or PM_{10} concentrations or actual noise levels. The findings provide a survey-based foundation for proposing improvements in construction management, communication, and community feedback mechanisms.

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AUTHOR CONTRIBUTIONS

Hong Thai Nguyen: Conceptualization; Methodology; Supervision; Writing – review & editing.

Lam Khanh Nguyen: Data curation; Formal analysis; Investigation; Writing – original draft.

All authors have read and agreed to the submitted version of the manuscript.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ETHICS STATEMENT

The study involving human participants was conducted in accordance with the Declaration of Helsinki and was approved by the Scientific Council of the Faculty of Transport Economics, University of Transport and Communications (approval No. 15.09.2026/KTVT.UTC). Informed consent was obtained from all participants involved in the study.

DATA AVAILABILITY STATEMENT

The survey data supporting the findings of this study are available from the corresponding author upon reasonable request.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES

During the preparation of this manuscript, the authors used Claude (Anthropic; model Claude Opus 5.5) to translate the original Vietnamese manuscript into English and to format it according to the journal's guidelines. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

APPENDIX A. HOUSEHOLD SURVEY QUESTIONNAIRE

HOUSEHOLD SURVEY QUESTIONNAIRE

PERCEPTIONS OF THE ENVIRONMENTAL IMPACTS OF CONSTRUCTION ACTIVITIES AND QUALITY OF LIFE IN HANOI

Questionnaire ID: _____ Survey date: ____/____/_____ Enumerator: _____

Area/construction site: _____ Household ID: _____

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INTRODUCTION AND CONSENT TO PARTICIPATE

This questionnaire aims to understand the perceptions and experiences of residents living near construction sites regarding dust, noise, construction activities, and quality of life. The information is used solely for research purposes, is aggregated by group, and no individual identities will be disclosed. Participation is voluntary; respondents may skip any question or stop at any time.

Do you agree to participate in the survey? □ Yes □ No (if no, end the survey)

SECTION A. GENERAL INFORMATION

A1. Respondent's age: _____ years

A2. Gender: □ Male □ Female □ Other □ Prefer not to say

A3. Highest educational attainment: □ Primary school or below □ Lower secondary school □ Upper secondary school □ Vocational secondary/College □ University □ Postgraduate

A4. Main occupation: □ Civil servant/employee □ Business □ Self-employed/freelance worker □ Retired □ Homemaker □ Student □ Other: _____

A5. Number of years living at the current address: _____ years

A6. Distance from home to the nearest construction site boundary: □ Less than 100 m □ 100–300 m □ 301–500 m □ More than 500 m □ Not sure

A7. Time when someone is usually at home: □ Daytime □ Evening/night □ All day □ Not fixed

A8. The construction site near your home is of the following type: □ Road/bridge □ Metro/railway □ Housing/civil building □ Other infrastructure □ Not sure

SECTION B. ASSESSMENT OF THE SURROUNDING ENVIRONMENT

For items B1–B8, please tick one level that matches your experience over the past 30 days: 1 = Strongly disagree; 2 = Disagree; 3 = Hard to say/Neutral; 4 = Agree; 5 = Strongly agree.

The questionnaire uses items B1–B8 to capture perceptions of different environmental aspects. Before computing composite scores, reliability and factor structure should be examined; it should not be assumed by default that all items measure a single construct.

Code	Statement	1	2	3	4	5
B1	Dust from construction activities frequently appears at my residence.	□	□	□	□	□
B2	I often see dust settled on doors, floors, vehicles, or household items around my home.	□	□	□	□	□
B3	Exhaust fumes/odors from construction machinery or vehicles cause discomfort.	□	□	□	□	□
B4	Noise from construction machinery affects my family's daily activities.	□	□	□	□	□
B5	Vibration from construction activities can be felt at my residence.	□	□	□	□	□
B6	Construction activities reduce the quality of the living environment around my home.	□	□	□	□	□
B7	I am concerned that exposure to dust/exhaust/noise may affect health.	□	□	□	□	□
B8	I observe that the construction site has effective dust and noise control measures.	□	□	□	□	□

The items in the table are a proposed instrument for field data collection, not survey results. Cognitive testing of the questions, review of potentially leading wording, and recording of non-response rates should be carried out before the official questionnaire is used.

B9. In your opinion, the most bothersome factor is: □ Dust □ Exhaust/odor □ Noise □ Vibration □ Trucks/traffic congestion □ Other: _____

B10. Time when the effects are most noticeable: □ Morning □ Noon □ Afternoon □ Evening/night □ Not fixed

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SECTION C. HEALTH AND DAILY ACTIVITIES

C1. In the past 30 days, on how many days did you feel that your health or daily activities were affected in a way that you consider related to the environment around the construction site? _____ days (0–30).

C2. Symptoms you experienced in the past 30 days (multiple answers allowed): □ Cough/throat irritation □ Eye/nose discomfort □ Difficulty sleeping □ Headache/fatigue □ Stress/difficulty concentrating □ None □ Other: _____

C3. Overall level of impact on household daily activities: □ 1 Very low □ 2 Low □ 3 Moderate □ 4 High □ 5 Very high

C4. Please note: this is a self-report of experience; the questionnaire is not used to diagnose disease and does not establish medical causation.

SECTION D. SATISFACTION AND ASSESSMENT OF MANAGEMENT

D1–D5: 1 = Very dissatisfied/strongly disagree; 2 = Dissatisfied/disagree; 3 = Neutral; 4 = Satisfied/agree; 5 = Very satisfied/strongly agree.

Items D1–D5 capture satisfaction and assessments of management measures.

Code	Statement	1	2	3	4	5
D1	I am satisfied with the current environmental quality around my residence.	□	□	□	□	□
D2	The shielding and dust-reduction measures at the construction site are appropriate.	□	□	□	□	□
D3	Construction hours are managed to limit impacts on residents.	□	□	□	□	□
D4	Information on construction activities and environmental measures is adequately provided.	□	□	□	□	□
D5	I believe that the contractor and the regulatory authorities respond seriously when complaints are made.	□	□	□	□	□

D6. Have you ever complained about dust/noise from the construction site? □ No □ Yes; outcome: □ Resolved □ Partially resolved □ Not resolved □ Unknown

SECTION E. PRIORITY SOLUTIONS

E1. Please select up to 3 solutions that should be prioritized: □ Water spraying/misting to reduce dust □ Covering construction sites and material transport vehicles □ Cleaning vehicle wheels and road surfaces □ Maintaining/replacing old machinery □ Restricting noisy construction hours □ Installing monitoring sensors and publicly disclosing data □ Increasing inspections and penalties □ Receiving residents' complaints □ Other: _____

E2. Other comments/suggestions: _____

Thank you for your cooperation!

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