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Research Article

Assessing risks of sewage pipeline implementation and their impact on local communities

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Abstract
Sewage pipeline projects in Iraq are typically implemented using the open-cut method along public roads. This approach presents numerous risks that adversely affect the daily lives of residents in the construction areas. This study evaluates the negative impacts of sewage pipeline network construction based on prior research concerning the affected population. Confirmatory factor analysis, including both first- and second-order factors, was conducted on data collected from 100 individuals within the study area. Five research hypotheses were tested and confirmed, revealing that traffic, welfare, environmental, economic, and safety factors significantly disrupt the daily activities of the local populace. The study's findings indicate that welfare-related risks contribute to 92% of the observed adverse effects, economic risks account for 88%, and safety-related risks for 86%. In contrast, environmental risks had a comparatively lower impact, influencing only 45% of the variations in adverse effects. Among welfare services, water, electricity, and internet networks were the most affected due to excavation-related disruptions. The study advocates for adopting trenchless piping technology to minimize disturbances to essential services, roadways, the environment, and the economic activities of residents during sewage pipeline construction.

Keywords
Sewage pipeline projects, Construction risks, Open-cut method, Community impact, Trenchless technology, Infrastructure disruptions.

1.Introduction
The sewage pipeline is an essential infrastructure project, as it directly affects the citizens' lives by collecting and transporting wastewater from residential areas to treatment facilities [1]. In numerous developing nations, swift urbanization and insufficient infrastructure planning have resulted in informal settlements with restricted or non-existent access to adequate sanitation [2]. This frequently leads to the release of untreated sewage into rivers, lakes, and the adjacent environment, which presents significant health hazards to the populace and exacerbating environmental degradation [3]. Although they hold significant value post-completion, numerous disruptions may occur during the phases preceding it [4].

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Sewage pipeline installation is recognized as a significant disruption to residents at the project site during the implementing of certain infrastructure projects [5].

The implementation phase entails adverse risk impacts and detriments to the surrounding environment and residents' livelihoods, manifesting as pollution, traffic issues, economic disruptions, and harm to both natural and constructed environments [6, 7]. Researchers [8] indicated that the communities adjacent to the ongoing project experienced damage, including road deterioration, loss of livelihoods, adverse environmental effects, and disruption of commercial activities in the area. Sewage construction invariably results in traffic disruptions, which cause congestion and delays for travellers and businesses [9]. According to [9], one way to improve construction processes and reduce congestion in urban areas is to use trenchless methods when building sewer networks. The welfare of residents is also adversely affected by the construction activities of sewage, which may disrupt essential services such as water and electricity, as well as the production of noise, dust, and vibrations [10]. As stated by [10], the construction sites and on-site activity greatly impact public welfare and health. The potential for soil and water contamination during pipeline installation and excavation is a significant environmental concern. For instance, [11] stated that pipe bursting generated lower carbon emissions than traditional trenching and minimized soil disturbance. This method significantly reduced the environmental impacts of sewage construction. Maintenance, and operation of sewage systems necessitate substantial investments from governments or municipalities, creating economic challenges [12].

Ultimately, safety hazards pose a risk to the public and construction workers, such as exposure to toxic substances, injuries, and accidents [13]. Researchers [14] contend that there is a substantial effect on human health. The health implications during infrastructure project execution have been assessed using a developed methodology, indicating that the activities adversely affect the project sites' economic, sociological, and environmental systems [15]. It is believed that traditional trenching operations using the open-cut method incur high social costs, including repaving, repairing damage to public services, safety risks, environmental harm, and traffic accidents [16]. Researchers [17] have suggested incorporating the cost of adverse risk impacts into the project budget due to the disruptions these projects cause to residents' economic and social lives during construction. Lack of awareness of the negative effects during the implementation phase of a project of sewage pipelines in an area could pose a threat to the project and cause it to stop or affect the implementation time and increase the project cost. Consequently, the project management team must judiciously mitigate these adverse effects to guarantee that the project progresses in alignment with the established quality, budget, and timeline. Not all methodologies that identify the adverse risk effects of projects are identical. They vary from project to project, resulting in differing resource allocations for each initiative. The most detrimental effect on the lives of the local populace must be ascertained.

In Iraq, a developing country with infrastructural deficiencies, installing sewage networks poses distinct challenges. This study examines Iraq's distinct socio-economic and environmental conditions to identify the primary obstacles to sewage infrastructure projects and to contribute in mitigation strategies. This research utilizes a questionnaire survey to examine the risks linked to the stages of project implementation in a specific case study area. The questionnaire results were analysed to identify the most critical adverse effects of the risks at the project implementation site, allowing the administration to reduce citizen distress and gain their support. This study offers a comprehensive analysis of the challenges faced in installing sewage networks in developing countries, thereby enhancing the existing body of knowledge. The findings of this study are valuable for policymakers, engineers, and urban planners in Iraq and similar contexts, as they provide insights into improved project management, execution, and planning. By implementing these recommendations, stakeholders can mitigate risks, minimize disruptions, and promote public health and environmental sustainability.

The five sections of this paper—introduction, review of prior studies, research methods, study findings, discussion and conclusions—highlight the significance of tackling these challenges to enhance the effective execution of sewage infrastructure projects in developing nations like Iraq.

2.Literature review

The detrimental effects of the current construction project in Northern Cyprus are examined by [5]. The questionnaire method was employed to collect respondents' responses regarding 18 factors across four categories: “Damage to Nature and Built Environment,” “Pollution,” “Traffic,” and “Human Society.” The descriptive analysis and criticality index method were employed to rank the factors according to their reliability and effectiveness. Pollution is the primary concern for residents in the vicinity of the project. The research recommended considering the influence of each country's conditions when formulating the environmental model. The study's findings were confined to their country, and the study variables may serve as benchmarks for similar research in other nations, as stated by the researchers. The study used the average of respondents' answers for each factor to draw conclusions, but no reliability or validity assessments were performed for the research questions.

Matthews et al. [6] examined the social cost implications of pipeline infrastructure construction projects using two methods: open-cut and trenchless.

The social costs were categorized into eight key areas: travel delay, vehicle operating costs, diminished road surface value, lost business income, decreased parking revenue, dust control expenses, noise pollution costs, and safety. They proposed a mathematical model for calculating these costs based on a quantitative approach. Among the identified cost factors, dust and dirt control, diminished road surface quality, and noise pollution were the most expensive. Their findings indicated that the social cost of trenchless construction methods ranged between 1% and 9% of the total project expenditure. A minority opinion led them to recommend the trenchless method over open-cut, particularly in densely populated areas. Ultimately, they argued that social costs should be incorporated into the bid invitation to ensure a comprehensive project budget.

Apeldoorn [8] analyzed the societal cost implications of using open-cut and trenchless methods in Australia. The research encompasses direct and indirect costs and social costs, including traffic delays, business interruptions, accident expenses, pollution, environmental effects, and quality-of-life considerations. The research determined that the trenchless technique outperforms the open-pit drilling method in terms of social costs, with minimal impact on the environment and surrounding community.

Li et al. [14] identified three categories of adverse impacts in their model for evaluating the environmental effects of construction processes in China: health damage, resource depletion, and ecosystem damage. A case study was examined to evaluate the severity of the human health impacts and the model's applicability. Danku et al. [17] performed an exploratory study to investigate the economic repercussions of adverse impacts in the Ghanaian construction sector. An online questionnaire was disseminated among pertinent professionals involved in various construction projects. The findings indicated that social costs were excluded from the bidding phase for all projects due to challenges such as “difficulty in allocating social costs,” “governmental interferences,” “absence of historical data,” “insufficient recognition of social costs,” and “minimal stakeholder agitation.” The study advised that the prospective costs of adverse construction impacts be incorporated to compel stakeholders to employ construction methods that do not disrupt the lives of residents in the project implementation zone.

Gilchrist and Allouche [18] analysed four categories of adverse effects: traffic, economic activities, pollution, and ecological, social, and health impacts. These categories include several adverse effects: detours, noise, prolonged road closures, safety hazards, vibrations, utility disruptions, dust, water and air pollution, surface and subsurface disturbances, and damage to recreational services, along with the disruption and destruction of surface and subsurface recreational amenities. A framework for cost components was developed to incorporate adverse impacts, quantified as measurable costs and included in the project's final cost. Xueqing et al. [19] indicated that the primary impacted indicators in their model are "Natural Environment," "Public Property," "Local Economy," and "Human Society," which can be assessed through 12 sub-factors. They created a bid evaluation model that incorporates the financial costs associated with the adverse effects of project execution, compelling contractors to implement construction techniques that mitigate these costs. A multi-target decision-making process employing a fuzzy evaluation method was utilized. A theoretical case study was employed to evaluate their model for pre-bid assessment for four companies.

Liu et al. [20] employed the identical four categories and twelve subcategories to measure the social cost of construction projects, mirroring the approach of [19]. They employed an alternative approach to assess their proposed pre-bid evaluation model. Intuitionistic fuzzy entropy, relative entropy, intuitionistic fuzzy cross-entropy, intuitionistic fuzzy hybrid averaging operator, and intuitionistic fuzzy weighted averaging operator were utilized in the bid evaluation of infrastructure projects. They contend that incorporating the costs arising from the adverse impacts of infrastructure project implementation requires additional investigation.

Yuan et al. [21] examined residential building constructions and categorized the adverse effects on the community into several primary classifications: effects on the environment, economy, and public assets. Wang et al. [22] employed 26 subcategories across four primary categories: biological/ecological, physical/chemical, economic/operational, and sociological/cultural, to construct their environmental assessment model. The evidential reasoning (ER) approach was employed to aggregate various environmental factors in decision-making scenarios for environmental analysis. Yu and Lo [23] delineated three categories of adverse effects that incur social costs in all construction projects, traffic, environmental, and business impacts, to develop their model, which they subsequently tested using a roadworks project as a case study. The adverse impact is estimated to account for approximately 5.5% of the total expenses associated with road work projects. The developed model excludes global and local economic impacts and certain environmental effects, including solid and water waste.

Ferguson [24] developed a survey to assess the financial repercussions of road construction on businesses and residents within the project vicinity. Their research encompassed the expenses associated with negative effects on traffic and commerce. The study determined that traffic congestion is the primary concern for residents, while the reduction in customer numbers and financial losses for businesses are the most significant components of the examined social costs. The study failed to consider the financial implications of the project's adverse environmental effects.

Celik [25] studied the cost of the effect of the project construction stage on the surrounding area and their people in Turkish projects. Brainstorming sessions were adopted to list the factors causing the negative impact during execution, followed by a questionnaire survey. The study includes four main categories: traffic, economic activities, pollution, and ecological / social / health, containing 17 perceivable nuisance sub-criteria. The research developed a sequential system for calculating the costs of negative impacts from project implementation in residential areas, as well as a method for compensating the affected people. Werey et al. [26] examined the financial repercussions of adverse effects on residents' lives and the environment while implementing sewer rehabilitation projects. A questionnaire was created to gather the population's perspectives within the project area. The expenses associated with adverse effects on traffic, economic activities, and environmental degradation, including surface and groundwater pollution due to sewerage project maintenance, were examined. Factors including noise, dust, service disruption, traffic interference, and financial losses were incorporated. The study does not address health or safety losses.

Çelik et al. [27] formulated a model to integrate the costs associated with the adverse effects of residential construction, termed social costs, into the preliminary cost assessment of the project before contracting in Turkey and Northern Cyprus. A survey was conducted in the vicinity of ongoing residential construction projects to quantify the costs associated with road and traffic modifications, loss of parking, disruption of neighbourhood tranquillity, and impacts on health, well-being, and personal care. They recommended for the applicability of their study to residential areas adjacent to construction sites and proposed researching other types of infrastructure projects. Budayan and Çelik [28] delineated 18 sub-criteria across five categories of adverse effects on the vicinity of residential projects, encompassing environmental degradation, dust, noise, traffic, and societal impact. A structural equation modelling (SEM) analysis demonstrated that all categories negatively affected the residents. The most severely detrimental effects were observed in environmental damage and dust. Extended road closures and detours constituted the most substantial negative effects within the traffic category. The residents highlighted those adverse effects emerged years after the project's completion, which they did not attribute to the implementation phase, particularly concerning disease prevalence and quality of life. Consequently, they urged contractors to consider the immediate negative impacts experienced by the community. This model is particular to the country of study, and the factors examined in the research may serve as a foundation for further investigations in other nations.

Nunes [29] evaluated the open trench and trenchless methods by analysing the financial repercussions of pipeline construction on the surrounding community. The primary categories in the proposed model are traffic, pollution, environmental damage, health, and the economy. Data collection methods employed included literature review, interviews, and surveys. The assessed factors included increased vehicle operating costs, traffic delays, pedestrian delays, loss of parking spaces, reduction in pavement service life, air pollution, noise pollution, dust pollution, and loss of business revenue. The primary sources of cost associated with the project's adverse impacts were "business revenue loss," "reduction in pavement service life," "noise pollution," and "loss of parking space." The researcher determined that incorporating the costs of negative impacts into the project's overall expenditure did not yield a substantial difference; however, if the owner seeks to mitigate these impacts, such costs must be included in the project budget. The proposal suggested conducting further research in this domain, incorporating factors such as soil contamination and access to ambulance and traffic police services.

After reviewing all relevant studies, this study identifies five primary risk categories and seventeen subcategories, based on the analysis of previous research. The intensity of these adverse risks is influenced by the cultural context of the region and the particular circumstances of each nation, as articulated by [5]. Their recommendations informed analogous research in various countries, and the factors they examined served as benchmarks for conducting similar studies. To the researchers' knowledge, this is the inaugural study in the Arab region regarding the detrimental effects of risks associated with the sewer pipeline construction phase on residents.

3.Methods

A review of previous studies was conducted to outline the adverse effects of sewer pipeline implementation risks on individuals' lives. An open-ended questionnaire was distributed to fifteen selected experts, who were asked to describe the nature and significance of the risks that negatively impact residents' daily activities in the project area. Additionally, to ensure comprehensive risk identification, it is crucial to evaluate and refine the quality and content of the survey items, culminating in a pre-test.

The questionnaire is a common method for quickly and economically collecting data, and it is considered acceptable in scientific research once its reliability and validity are tested [30]. Residents of the study area assessed the negative impacts using a Likert scale ranging from 1 to 5, where 1 signifies very low adverse impact, 2 indicates low adverse impact, 3 represents medium adverse impact, 4 denotes high adverse impact, and 5 reflects very high adverse impact. The composite scores were derived by subtracting the scale's range (5 – 1 = 4) and determining the class width, calculated as 4 / 5 = 0.8. The class intervals are established by adding 0.8 to the lower limit of the initial class interval and continuing this process for the subsequent intervals, as illustrated in *Table 1* [31].

Table 1 Likert scale intervals

Interval	Midpoint	Interpretation
1-1.8	1.4	Very low adverse impact
1.81- 2.61	2.21	Low adverse impact
2.62-3.42	3.02	Moderate adverse impact
3.43-4.23	3.83	Heigh adverse impact
4.24-5	4.64	Very high adverse impact

The convenience sampling method was employed following the division of the region into sectors to ensure that the sample accurately represents the population of the area under investigation. One hundred and one forms were distributed in a closed questionnaire designed exclusively with clear expressions to facilitate easy responses from all individuals. The questionnaire consisted of two sections. The initial section aims to ascertain the respondents' demographic attributes, including educational attainment, experience, and profession. Section two includes the study questions to evaluate the detrimental effects of risks associated with the sewage pipeline's execution on the local community.

The Imam Ali Quarter in Karbala, Iraq, where the sewage pipeline project has been completed and implemented, was chosen as a case study. The questionnaire was analyzed descriptively to identify the most significant risk based on the severity of its adverse impacts. SEM combines confirmatory factor analysis (CFA) and a structural model in a single statistical test. It is a robust statistical method designed to test hypotheses about relationships between observed and dependent variables. SEM was used to construct and evaluate complex model and relationship using datasets. The potential of SEM to dealing with many factors of dependent variables and testing direct and indirect relationships between one or more independent variables and one or more dependent variables let it be the superior for this study. Five categories of latent variables and 19 quantifiable risks associated with the sewer project affect the residents in the vicinity, as shown in *Table 2*.

Table 2 The main risk categories and the sub-factors of the adverse impact of the risk

Main risk category	Code	Sub adverse impact
Traffic (T)	T1	Partial or complete interruption of traffic
	T2	Increased in the road distance
	T3	Increase in the time it takes to pass the road.
	T4	**Parking spaces lost**
Welfare (W)	W1	Reducing public spaces used by citizens
	W2	Reducing the parking spaces of citizens in front of their homes
	W3	Negatively affects the psychology of citizens, drivers and people's lives.
	W4	It negatively affects the services already on the same path, such as the electricity network or the Internet, causing it to be interrupted.
Environment (En)	En1	The effect of dust and dirt in the air

Main risk category	Code	Sub adverse impact
	En2	Noise pollution and its negative psychological effects on the local population
	En3	Negatively affects landscapes and vegetation.
	En4	**Vibration negatively affects health**
Economic (Ec)	Ec1	Low productivity of workers due to congestion and delays in working hours
	Ec2	Increase in fuel consumption
	Ec3	Negatively affect the cost of living.
	Ec4	It affects some shops that depend on people's traffic.
	Ec5	Additional costs for repairing existing services that are damaged by work
Safety (S)	S1	Increased incidence of falls in trenches
	S2	Increase in traffic accidents.

3.1Sample Size

The determination of an appropriate sample size was conducted using Equation 1 [32]:

$$S = Z^2 \times P \times (1 - P)/C^2 \quad (1)$$

Let S represent the sample size, Z denotes the standardized variable, P signifies the picking choice percentage expressed as a decimal, and C indicates the confidence interval, also expressed as a decimal. In this study, Z=1.96, C=±10%, and P=0.5. The resultant sample size is 96, deemed sufficient by researchers [33, 34], who assert that the recommended sample size ranges from 40 to 240 when employing SEM.

3.2Research hypothesis

From the review of previous literature especially [6,7,18,19,20,] and the open questionnaire that was distributed to the experts, five hypothesized relationships by SEM model formulated as follows:

H1: Factors related to traffic risk have a significant negative impact on the usual daily tasks of the local population.

H2: Factors related to welfare risk significantly negatively impact the usual daily tasks of the local population.

H3: Factors related to environmental risk have a significant negative impact on the daily tasks of the local population.

H4: Factors related to economic risk have a significant negative impact on the daily tasks of the local population.

H5: Factors related to safety risk significantly negatively impact the usual daily tasks of the local population.

3.3Case study area

The Karbala governorate is located approximately 105 km southwest of Baghdad, Iraq’s capital, as shown in *Figure 1*. The city is located at 44°40' longitude and 33°31' latitude. The governorate encompasses an area of 52,856 square kilometers and has an estimated population of 1,437,502 individuals for 2023. only 37.2% of the populace is accommodated by public and communal sewage systems [35]. The Imam Ali Quarter encompasses an area of 265,700 square meters, housing 6,900 individuals across 1,277 families, with approximately 960 residential units [36]. The study area was selected due to the ideal conditions provided for the project, including financing from the World Bank and specialized companies with a good reputation in design, implementation and consulting, in addition to the supervision of the government employer, the Ministry of Housing and Construction. Such conditions are often unavailable in most Iraqi construction projects, which are typically limited to the employer and contractor. Despite these favourable conditions, a delay exceeding three years (2008-2011) in implementing the sewage project, resulting in significant hardship for the residents.

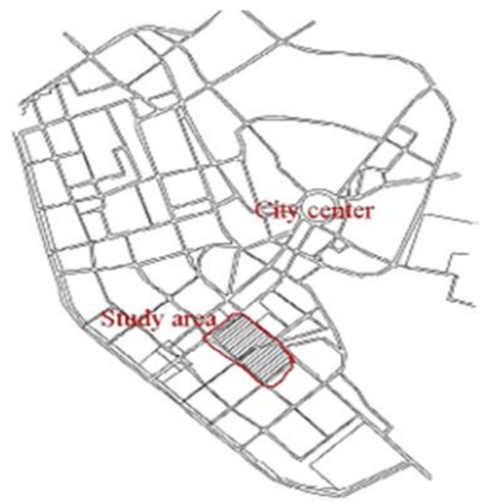

Figure 1 Case study area (Imam Ali Quarter)

3.4Data analysis

The demographic characteristics of participants were examined through descriptive statistical analysis. Only one case out of 101 was manually excluded for having incomplete data and was not included in the statistical analysis. The structure of factors conceived from previous researches has been adopted instead of to perform expletory factor analysis (EFA) firstly before carrying out CFA.CFA was performed at the primary level to designate the five risks (traffic, welfare, environmental, economic, and safety) as a latent variable assessed through a directly measurable item. A substantial correlation was identified among the latent variables, necessitating the execution of a second-order CFA [37]. The goodness of fit (GFI) between the observed data and the proposed model was assessed through second-order CFA to evaluate the detrimental effects of risks associated with sewage pipeline execution. The model fit parameters assessed included the root-mean-square error approximation (RMSEA), the ratio of the Chi-squared value to the degrees of freedom ($\chi 2$/df), the comparative fit index (CFI) ranges from 0 to 1 with values near one usually taken to be indicative of good fit, and the GFI. Previous studies [33,38] suggested that acceptable model fit parameters include $\chi 2/df < 5$, GFI, CFI, incremental fit index (IFI), and Tucker-Lewis Index (TLI) >0.90 or approaching one. RMSEA values below 0.05 signify excellent fit, while values ranging from 0.06 to 0.10 denote adequate fit. Guidelines such as $\chi 2$ statistics, its df, p-value, the RMSEA and its associated confidence interval, and CFI have been chosen over other indices as they have been found to be the most insensitive to sample size, model misspecification and parameter estimates [38]. *Figure 2* used the methodology employed in this research.

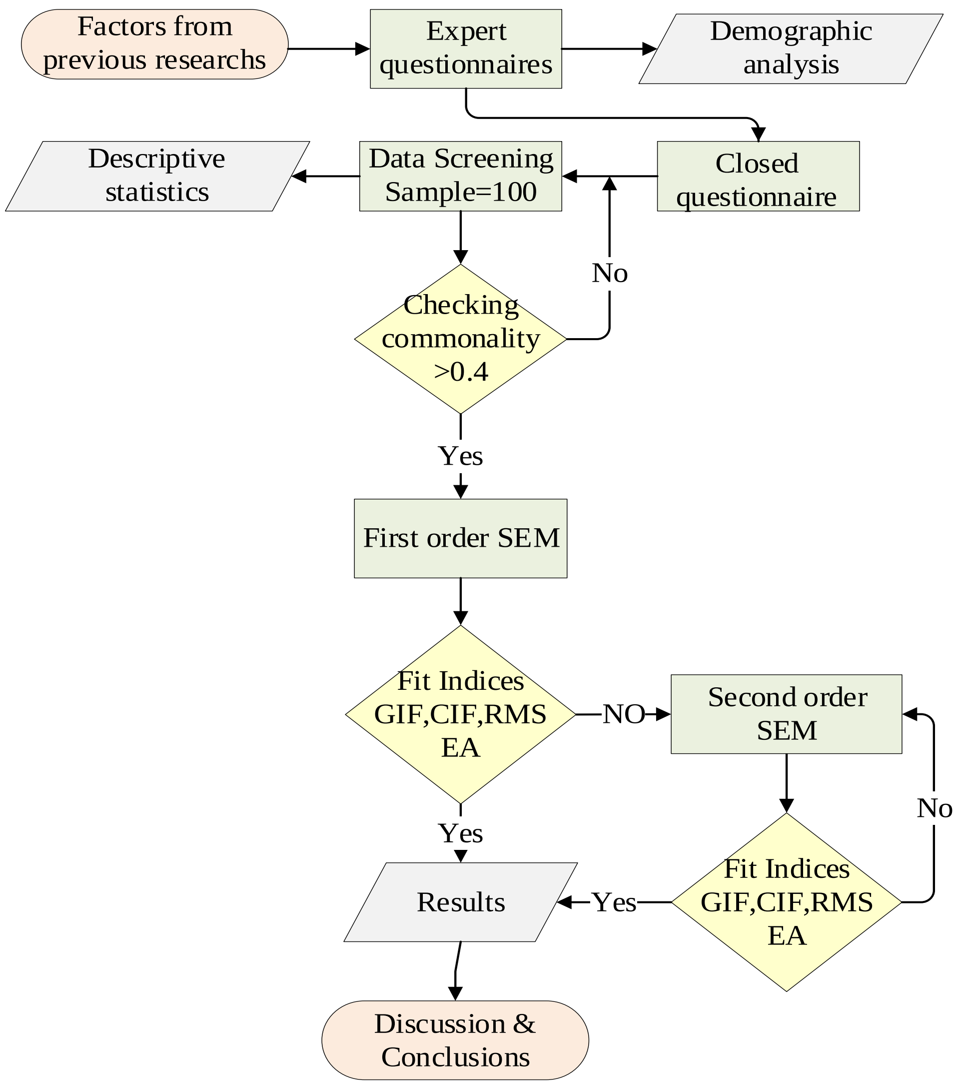

Figure 2 Flowchart of methodology

4.Results

4.1Demographic analysis

Eight percent of the expert sample in the open survey possess a civil engineering certification. Over 15 years of experience in construction project management is held by 40% of the sample size, while 33% possess more than 10 years of experience. Fifty-three percent of the expert cohort possessed a Bachelor's degree in civil engineering, while 27% held a PhD. This signifies that the research sample can provide a scientific assessment and evaluate the efficacy of the questionnaire.

4.2Descriptive sstatistics

The sub-risks parking spaces lost (T4) and the vibration (En4) in the Traffic and Environment categories respectively was eliminated in the initial analysis with factor loading 0.3 and 0.35 where they not pass the threshold which is 0.4. This is due to small effect on the residents based on their opinion in the survey. The Cronbach's Alpha test yielded a value of 0.863, indicating that the questions are adequate and reasonable, surpassing the accepted minimum threshold of 0.6. This test indicates that removing any factor from the factors of the sample Alpha coefficient is superfluous. The sample size and mean deviation of the factors are presented in *Table 3*. All adverse impact factors have an average respondent mean exceeding 3.3, except for (Ec4), indicating a scarcity of shop owners in the research sample due to the limited number of shops in the studied area.

Table 3 Statistics for the variables

Variable	Mean	Std. Deviation	N
T1	3.41	.922	100
T2	3.70	.785	100
T3	3.51	1.030	100
W1	3.42	.966	100
W2	3.31	.992	100
W3	3.64	1.059	100
W4	3.32	1.162	100
En1	3.61	.827	100
En2	3.82	.936	100
En3	3.76	.955	100
Ec1	3.49	1.020	100
Ec2	3.45	1.095	100
Ec3	3.22	1.186	100
Ec4	2.89	1.171	100
Ec5	3.51	.959	100
S1	3.77	1.014	100
S2	3.66	.997	100

N= Sample Size

4.3Factor analysis

Factor analysis employing the varimax rotation technique was utilized to evaluate the commonality of each factor within each latent variable. The results indicated the contribution of each factor to its latent variable. An augmentation in the road distance (T2) variable in accounted for 96.9% of the variance in traffic category risk, representing the highest explained variance. The variable (W1) explained about 95% from the variance in the welfare category. Variables such as; T1, W4, En3, Ec2 and S2 have approximate similar degree (81-86%) in variance explanation in their categories. Minimum variance explained was in the variables; En3, Ec5, Ec4 ranging from 49 to 55% in their categories. All variables exhibit a substantial variance explanation in their latent variable, with none falling below 0.4, as indicated in *Table 4.*

Table 4 Commonalities of the variable

	Traffic	Economic	Welfare	Environment	Safety
T1	**0.809**	0.132	-0.001	0.009	0.008
T2	**0.968**	0.156	0.018	-0.018	-0.041
T3	**0.769**	0.192	0.021	-0.002	-0.009
W1	0.099	0.114	**0.949**	-0.066	0.002
W2	-0.163	-0.181	**0.75**	-0.206	-0.043
W3	0.081	0.075	**0.941**	-0.136	0.016
W4	0.114	-0.051	**0.833**	-0.124	0
En1	-0.061	-0.203	-0.335	**0.717**	0.158
En2	-0.023	0.25	-0.04	**0.852**	0.141
En3	0.051	0.02	-0.213	**0.552**	-0.2
Ec1	0.119	**0.911**	-0.041	0.1	-0.16
Ec2	0.057	**0.822**	0.142	0.059	0.103
Ec3	0.273	**0.719**	-0.028	-0.162	-0.003
Ec4	0.106	**0.494**	-0.01	0.127	-0.144
Ec5	0.273	**0.532**	0.124	0.3	-0.275
S1	0.032	-0.153	0.013	-0.035	**0.692**
S2	-0.106	0.006	-0.052	0.293	**0.855**

CFI, IFI, and RMSEA were used [28] solely to assess the overall fit of their model; therefore, this model is also considered a good fit. GFI value 0.863 is acceptable due to [34, 38] who suggested to be ≥0.8 and from the researcher view because it represents the extent to which can explain from the variance in the proposed model just like the coefficient of determination (R2). *Table 5* indicates that all indices are near the requisite benchmarks, implying that the CFA model is acceptable. Furthermore, the RMSEA varied from 0.06 (lower bound) to 0.09 (upper bound), with a 90% confidence interval indicating a satisfactory fit.

Table 5 Fitness indicators of the model

Parameters	**Model results**	**Supported**
$\chi 2$	290.175	**Yes**
Degree of Freedom (DF)	114	**Yes**
$\chi 2$/DF	2.545	**Yes**
GFI	0.863	**Yes**
IFI	0.899	**Yes**
TLI	0.857	**Approximately**
CFI	0.909	**Yes**
Normed-fit index (NFI)	0.85	**Approximately**
RMSEA	0.078	**Yes**

The factor loading results for the welfare risks latent variable indicate the highest loading (0.92) on the adverse effects of the sewer project execution phase on local citizens, followed by the economic and safety risk latent variables with loadings of 0.88 and 0.86, respectively. The minimal factor loadings for the traffic and environment latent variables are 0.62 and 0.45, respectively, as illustrated in *Figure. 3.*

Table 6 presents the hypothesis test outcomes based on p-values. Factors related to welfare risk significantly negatively impact the usual daily tasks of the local population with p-value (***) which means less than 0. 0005.Factors related to Environment, Economic and Safety have a significant negative impact on local population activities with p-value 0.032,0.002 and 0.002 respectively. Based on the p-value results, it can be said that the six research hypotheses are acceptable.

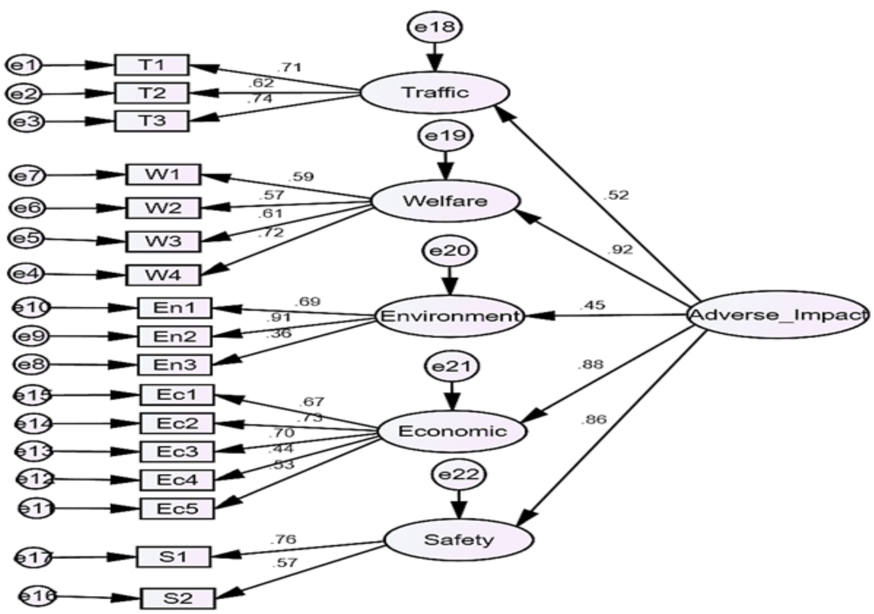

Figure 3 Second order CFA model for adverse Impact of the risks

Table 6 Regression weights in the final model

			Estimate	**S.E.**	**C.R.**	***P***
Traffic	←	Adverse_Impact	1.000	-	-	-
Welfare	←	Adverse_Impact	2.244	.640	3.506	***
Environment	←	Adverse_Impact	.450	.210	2.143	**.032**
Economic	←	Adverse_Impact	1.307	.418	3.126	**.002**
Safety	←	Adverse_Impact	1.414	.461	3.069	**.002**

			Estimate	S.E.	C.R.	*P*
T1	←	Traffic	1.000			
T2	←	Traffic	.746	.155	4.823	***
T3	←	Traffic	1.155	.226	5.105	***
W4	←	Welfare	1.000	-	-	-
W3	←	Welfare	.768	.147	5.237	***
W2	←	Welfare	.678	.137	4.968	***
W1	←	Welfare	.680	.133	5.104	***
En3	←	Environment	1.000	-	-	-
En2	←	Environment	2.476	.811	3.052	**.002**
En1	←	Environment	1.660	.507	3.276	**.001**
Ec5	←	Economic	1.000	-	-	-
Ec4	←	Economic	1.010	.292	3.457	***
Ec3	←	Economic	1.635	.350	4.675	***
Ec2	←	Economic	1.573	.330	4.769	***
Ec1	←	Economic	1.349	.295	4.575	***
S2	←	Safety	1.000	-	-	-
S1	←	Safety	1.367	.307	4.459	***

C.R.=Composite Reliability, S.E.= Standard Error, *P*= Probability Value

5.Discussion

The findings indicate that latent factor welfare risks account for 92% of the variance in the adverse impacts of sewerage network implementation on citizens. The welfare services most adversely impacted (W4) are water, electricity, and internet networks, which are compromised due to excavations. The psychology of citizens, drivers and people's lives (W3) which comes secondly, was negatively affected by the sewer project execution accounts for 61% of the variance in negative effects in welfare category. Economic risk accounts for 88% of the negative effects of risk by leading to heightened fuel consumption (Ec2) followed by (Ec3) which was leading to (increase in cost of living), corroborating [6]'s conclusion that travel delay constitutes 55% of the overall social costs. The risk associated with safety issues accounts for 86% of the negative effects attributed to rising falls in trenches (S1) especially due to the relative increase in rainfall rates during the research years from 2008-2016 [39] which is led to an increase in the impact on the population as a result of changing of excavation waste into mud that impedes traffic and pedestrian movement. According to resident opinions, traffic risks account for 52%especially (T3) factor which was (increase in the time it takes to pass the road) and this result consistent with Study [24, 28], which found that traffic congestion was the main concern of residents in the project implementation area while "loss of parking space" in [29] study ranked fourth. Environmental risks exhibit a minimal impact of 45% in contrary with study [5, 28], which showed that the main concern of the population was pollution. The researcher posits that this is attributable to the citizens' lack of interest in environmental issues, which may be considered a secondary concern relative to their livelihood challenges. Yu and Lo [23] support this conclusion, emphasizing the need for future research to justify the environmental impacts of solid waste, wastewater, air pollution, and noise. Although the environmental risk latent variable has a minimal impact on the overall negative effects of risks, the measured factor (En2) indicates that the noise and pollution generated by the machinery and equipment at the work site account for 91% of the variance in this latent variable. This outcome aligns with the findings of Celik and Budayan [5]. In North Cyprus, the adjacent community regards pollution as the most troubling negative consequence. Vyas and Varia [37] regard noise as a detrimental risk to human life and well-being. These findings corroborate the studies conducted by Gilchrist and Allouche [18] and Xueqing et al. [19], formulating a cost prediction model that incorporates the social cost associated with the adverse effects of risk during the implementation phase. The welfare, environmental, economic, and safety factors, with a 95% confidence interval, significantly detrimentally affect the daily activities of the local populace. As the demographic composition of the study area is similar to most Iraqi residential areas, these results can be generalized to say that these negative risks occur in any area where a sewage project is being implemented, and the implementing authorities must take the necessary actions to elevate the aforementioned negative impacts.

Limitations

This study is limited to a case study area focusing on sewer projects in Karbala, a sacred site in Iraq. The questionnaire was conducted in 2022 and analyzed using SEM techniques. Some respondents may have struggled to fully understand the survey questions due to cultural factors, potentially affecting data quality. Additionally, the quality of results may have been impacted by respondents who rushed through the questionnaire due to time constraints or perceived lack of importance. A complete list of abbreviations is listed in *Appendix I.*

6.Conclusion and future work

The study indicated that there are not always positive effects in the implementation phase of infrastructure projects. It depends on the extent of cooperation and participation between the local community and the authorities in reaching the best solutions to avoid potential negative effects. To mitigate the detrimental effects of risks during the execution phase of the sewage network, focusing on minimizing damage to the area's electricity supply lines and water infrastructure is essential. This recommendation suggests using trenchless piping technology instead of traditional open-cut pipe installation. Additionally, identifying shorter and alternative routes is advisable to safeguard individuals from potential hazards and reduce machinery-generated noise and pollution. The study recommends conducting environmental impact assessments before implementing sewage projects. Healthier and more livable conditions for residents can be achieved by adopting modern construction technologies. Additionally, budget allocations should include compensation for residents affected by project-related disruptions. Beyond sewer projects, similar evaluation procedures can be applied to assess risks to local citizens during the implementation phase of other infrastructure projects. Further research is recommended in different regions and projects, incorporating advanced techniques such as artificial neural networks. Emphasis should be placed on sustainable construction methods to minimize negative impacts and risks during sanitation project implementation. Using face-to-face interviews for questionnaire administration is preferable to ensure clarity and prevent misunderstandings among respondents. Additionally, a study should be conducted to estimate and determine appropriate cost allocations to mitigate negative effects during sewage project implementation.

Acknowledgment

None.

Conflicts of interest

The authors have no conflicts of interest to declare.

Data availability

The data considered in this study were gathered from Imam Ali Quarter, Karbala, Iraq using questionnaire method. The data may be provided by the corresponding author upon reasonable request.

Author’s contribution statement

Gafel Kareem Aswed: Contributed to the study's design, data collection, analysis, and interpretation. **Ali Hasan Hadi:** Contributions include drafting and editing. Mohammed **Neamah Ahmed's** contribution pertains to the discussion of results. **Muhammad Abdulredha's** contributions include manuscript editing and proofreading. All authors reviewed the findings and approved the manuscript.

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Appendix I

S. No.	Abbreviation	Description
1	$(\chi 2/df)$	Ratio of the Chi-Squared Value to the Degrees of Freedom
2	C.R.	Composite Reliability
3	CFA	Confirmatory Factor Analysis
4	CFI	Comparative Fit Index
5	DF	Degree of Freedom
6	EFA	Expletory Factor Analysis
7	GFI	Goodness of Fit
8	IFI	Incremental Fit Index
9	N	Sample Size
10	NFI	Normed-Fit Index
11	P	Probability Value
12	R2	Coefficient of Determination
13	RMSEA	Root-mean-square error approximation
14	S.E.	Standard Error
15	SEM	Structural Equation Modelling
16	TLI	Tucker-Lewis Index