Research Paper

A New Model for Estimating the Value of Human Loss for Cost-Benefit Analysis in Disaster Risk Management in Iran

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ABSTRACT

This research provides a new methodology for evaluating the socioeconomic consequences of earthquakes by reconsidering the debated topic of the value of human loss in the course of disaster loss estimation in Iran. To do this, at first, the relevant methodologies have been investigated, and then the consistency of the results of those methods with the existing norms in Iran has been assessed. Then, a model was proposed to estimate the Value of Human Loss (VHL) to be used in cost-benefit analyses in disaster risk management planning. Finally, the proposed model has been applied to estimate the economic loss arising from the individual's death due to a seismic event in a vulnerable neighborhood in Tehran. The results of this study depicted that the outputs of the proposed model could provide a more tangible understanding of the earthquake losses to decision-makers. Also, it can facilitate the economic analysis required for various stages of disaster management, in particular, choosing more economically-justified risk reduction options. In addition, it can be used for evaluating the importance and urgency of earthquake risk mitigation in different urban and rural places. The proposed methodology can be applied in other countries with certain modifications based on differences in socio-economic characteristics.

Keywords:
Value of Human Loss; Earthquake; Disaster Risk; Iran

1. Introduction

For many centuries, humans have continued to place value on goods and services to facilitate trade and compensation. Traditionally, the valuation of frequently traded items has been more straightforward. As market trade for a specific good declines, its value is subject to more uncertainty. When intangible assets such as trademarks, brand names, and economic goodwill need to be appraised, the situation becomes even harder.

In the discipline of disaster risk management, analysts always in need of assessing the monetary value of damages incurred. In the case of physical damage to buildings, contents and businesses, various methods have already been in place to provide reasonable estimates of the lost assets. However, when it comes to loss of human lives, the valuation techniques rapidly lose credibility. This is mainly due to the ethical considerations that compound the problem of valuation and raise severe criticism against attaching any monetary value to human life. On the other hand, many disaster risk mitigation programs strongly rely on the results of cost-benefit analyses that consider the economic losses saved by implementing various measures that reduce disaster risk. Therefore, any assumption that overlooks the statistical value of human life could compromise the reliability of these cost-benefit assessments. A solution proposed to overcome such challenges is determining the economic value of human life based on the value of lost services and contributions a departed person could have otherwise offered to society.

The present research first examines past studies that proposed methods for determining the value of human life to gain a comprehensive idea about the existing valuation approaches. To achieve this, the techniques used in different disciplines, namely industry, insurance and safety, have been carefully investigated. Secondly, selected methodologies that best fit the requirements and nature of disaster risk management were adapted to the cultural context in Iran. Finally, a model to conform was suggested to assess the economic loss caused by human casualties in disasters occurring in Iran.

2. Background

The value of assets is determined according to its current market value. Such valuation is more common in the case of tangible and quantifiable assets that are frequently and freely traded in marketplaces [1]. As market valuation is not feasible for pricing human life, other non-market techniques have been sought to determine the value of assets that are not tradeable in a market. These methods are also applicable when the required information for valuation is not available [2-3]. As such, most of the studies that estimated the value of human life, e.g. in the insurance industry, have been based on non-market methods [4]. The following section summarizes the seminal methodologies utilized to address the money value of human life.

2.1. Discounted Future Earning (DFE)

The method of Discounted Future Earning (DFE) is widely used in the United States. It has been recently received more attention by other researchers and implemented in various countries (for example in Mauritius by Musango et al. [5]). The method calculates a departed person's potential future earnings. Several parameters directly determine such revenues for a given person. For instance, in studies done by Max et al. [6] and Viscusi and Aldy [7], parameters such as age, gender, nationality, education, and country's Gross Domestic Product (GDP) per capita have been considered. Typically, a discount rate is used to convert the calculated figure to its current value. This method is broadly employed to determine the risk reduction priorities according to the cost-benefit analysis.

2.2. Average Economic Value of Life (EVL)

Razani and Nielsen [8] proposed a method to quantify the value of lives lost for seismic risk assessment. Since this methodology was developed to estimate economic value of lives for earthquake risk planning, it will be explained later in detail. The input parameters to estimate EVL are as below:

$$U = \Delta Le / \Delta S \tag{1}$$

where U is the increase in life expectancy in years per one USD annual expenditure, Le is the average life expectancy of population, and S is per capita expenditure for survival needs (Figure 1).

S can be obtained from Equation (2):

$$S = k \times g \tag{2}$$

where k is the percentage of per capita used for survival needs.

The increase in life expectancy has the following relation with reduction of the risk of death:

$$\Delta Le = \Delta P(Le - Lm) \tag{3}$$

where ΔLe is the change in life expectancy, ΔP is the change in the level of risk, and Lm is the population's average age. By substituting

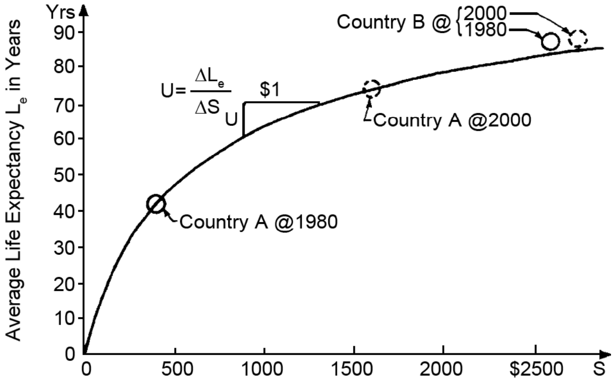

Figure 1. Relationship of average life expectancy to per capita expenditure for survival needs at various stages of development [8].

Equation (3) in Equation (1), the following relation is obtained:

$$U \times \Delta S \;=\; \Delta P(Le - Lm) \quad (4)$$

Razani and Nielson [8] called $\Delta S / \Delta P$ as R. Therefore, Equation (4) can be rewritten as:

$$R = \Delta S / \Delta P = (Le - Lm) / U \quad (5)$$

Accordingly, the average Economic Value of Life (EVL) can be estimated based on Equations (6) and (7):

$$EVL = R / I \quad (6)$$

$$EVL = (Le - Lm) / (U \times i) \quad (7)$$

where i is the actual rate of inflation as the discount rate.

2.3. Willingness to Pay (WTP) Method

This method is considered pioneering in estimating the economic value of human life. Here, the value of human life is determined based on his or her willingness to pay for a sum to reduce the health risks [9]. More recently, other deriving factors such as altruism has been considered in human life valuation, which led to an increase in the results [10]. This method is more applicable to the professions facing serious bodily injuries such as mining or high-risk manufacturing careers. Moreover, employing this method requires a relatively complete set of wages and casualty data to find the relation between wages and risk of life. WTP is generally used in insurance companies with sufficient resources and data to go through the required calculations.

2.4. Stated and Revealed Preference (RP) Method

In this method, even though the information obtained from the buyer's behavior is used as an analysis input, its objective is to value non-market goods such as human life [11-12]. The main concept in this method is to examine the willingness of individuals, based on actual observations, to pay for reducing the health-related risks [13]. Unlike the previous methods, data is not collected directly, rather, it is perceived according to the behavior of people when they purchase goods and services. Based on this method, the value of each person's life increases as she gets older. The value reaches its maximum in the middle of a standard lifetime. The Value of Statistical Life (VSL) then decreases, although this decline will continue with a slower pace than its initial rise [14]. In cases where it is impossible to determine the actual preferences of the individuals or in the event of unavailability of required data, the Stated Preference Method (SP) is prioritized. Here, the level of willingness to pay is related to the level of risk avoided by purchasing goods and services [15]. To do that, a questionnaire filled by individuals in a society is used to collect required information about their hazard-avoiding preferences.

2.5. Risk Mitigation Costs Method

This method uses the actual costs of risk mitigation programs, by which people's lives can be saved accordingly. For this purpose, the total cost of retrofitting, replacement, and reconstruction of buildings are considered equivalent to the value of the lives saved in the event of a possible deadly disaster. A probability tag is also attached to the results to reflect the underpinning uncertainty arising from the likelihood of destructive events. Since this method is dependent on disaster consequences data, an estimate of possible loss data is required to calculate the value of human life [16-17].

2.6. Wage - Risk Method

Here, the death risk associated with different types of jobs is determined by dividing the sum of earnings of injured people by their counts at various intensities. The diagram obtained from the results of such assessment is a concave curve indicating that the higher the risk of a job, the higher wage the person demands. On the other hand, the employer's willingness to pay for work also depends on the perceived risk connected to that task. Given the fact that the willingness of the employer to pay higher wages for riskier works diminishes as the work's risk grows, the resulting curve takes a convex form. In other words, at a certain level of risk-based wage, no more wage increase is justifiable [18]. Such an instance is illustrated in Figure (2). The curve slope at the contact point of employer and worker diagrams could represent a fair value of life.

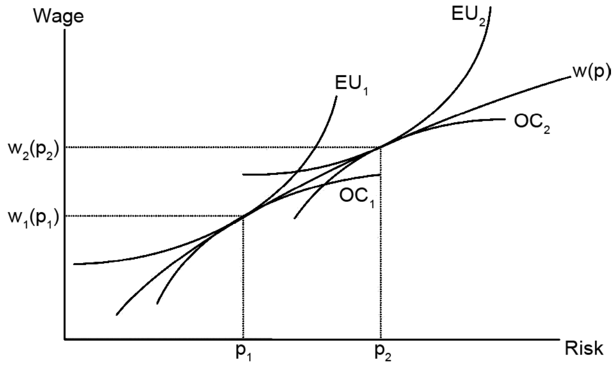

Figure 2. Worker's willingness to take risks and employer's willingness to pay for the same risks [18].

Table 1. Values of loss of individuals in USD (The local currency has been exchanged with the rate of 2016 (1USD = 32,000 IRR)) based on income, education and age.

Age	M.Sc. and Higher	Bachelor	High School	Uneducated
25	1056000	624000	384000	240000
30	924000	546000	336000	210000
35	792000	468000	288000	180000
40	660000	390000	240000	150000
45	528000	312000	192000	120000
50	396000	234000	144000	90000
55	264000	156000	96000	60000
60	132000	78000	48000	30000

2.7. Courts-Based Method

In the jurisdictions system, human lives are valued based on the size of fines that the court rules [19]. In this method, a person's value of life is determined similarly considering all personal backgrounds and attributes, including the level of income, age, sex, the number of people sponsored by the person, etc. A comparable approach in the form of blood money (Diyeh) is followed by the Iranian jurisdiction system, which is a basis in calculating the compensation of lost lives by the Iranian insurers.

3. Monetary Estimation of Human Loss in Iran

The popularity of the methods introduced in the previous section is different around the world due to the level of method sophistication and availability of information required [20]. Among the practices described earlier, four methods seem to be more feasible in Iran either in their original forms or after minor modifications:

- Discounted Future Earning (DFE) Method: Evaluating the potential income loss of a person following his or her death can be used in the economic loss estimation of earthquakes in Iran. To this end, the demographic data collected in 2016 (the selected year for comparing different methods) by the Statistical Center of Iran (SCI) was used, and the income of individuals was calculated accordingly. By assuming 65 as the entirement age, the sum of incomes that each person may gain during his or her expected lifetime can be calculated for different age's bins and education levels. The results are shown in Table (1). These values can be used to evaluate the total economic loss of each community due to the death of its members in the event of earthquakes. According to this method, the worst economic case is the loss of young individuals having higher educations with good level of income, as their total earning may reach USD one million.
- Average Economic Value of Life (EVL): The methodology presented by Razani and Nielsen [8] is applied to estimate EVL in this research. For this purpose, the census data of 2014 and 2016 has been used. In these years, the average inflation rate assumed to be 12.4% according to the data published by the Central Bank of Iran. Additionally, based on the World Health Organization (WHO) statistics, the life expectancy for Iranian people in 2016 was 75.95 years. In that year, the average age of the population was 31.1 years. Using Equations (1) to (7), the EVL was estimated at USD 500,000. It should be noted that the sensitivity of the results of this method to the parameters such as life expectancy and the inflation rate is very high. Therefore, a large uncertainty is attached to the results.
- Risk Mitigation Costs Method: Japan International Cooperation Agency (JICA) in cooperation with Center for Earthquake and Environmental Studies of Tehran Municipality (CEST) in 2004 estimated the investment required to reduce human casualties in earthquakes occurring in Tehran, Iran. The expenses accounted for in their analysis included the cost of retrofitting, repair and reconstruction of buildings, and debris removal. In addition, JICA's experts estimated the number of avoided casualties due to mitigation measures taken [16-17]. A similar approach was adopted in

Table 2. Estimation of damages, costs and investment required for mortality reduction in the study area.

	Case 1 (Without Implementing Mitigation Measures)	Case 2 (30% Decrease in Damage)	Case 3 (90% Decrease in Damage)
Number of Damaged Buildings	3241	2269	324
Number of Casualties	3142	2199	314
Total Loss (USD)	134,700,000	94,300,000	13,460,000
Retrofitting Cost (USD)	----	39,276,000	206,189,000

1. Earthquake damage is estimated using JICA methodology [16].
2. The cost of retrofitting has been obtained based on conventional retrofitting or reconstruction methods.

this research to estimate the number of damaged buildings and required funds to reduce potential casualties in parts of District 17 of Tehran. Table (2) shows the mitigation costs and casualty count estimated based on three different intervention scenarios.

As depicted in Table (2), the total budget needed to renovate and retrofit 30% of the buildings to reduce the earthquake casualties to 2199 was about 39,276,000 USD. This means for saving each individual, around 42,000 USD is needed. Accordingly, in case 3 (for 90% improvement), the necessary expenses for saving each person's life was about 73,000 USD. This is clear that the indicated values cannot be used as the VHL, and this can only demonstrate the total costs that the government should invest in reducing casualties of potential earthquakes in the indicated place. However, such figures may provide some benchmarks for decision-makers to allocate budget for priority projects in risk reduction.

- Wage-Risk Method: Although this method was originally developed to estimate the value of workers' lives in industrial facilities, it can be modified to be used in determining the economic value of lives lost in disasters. In so doing, the diagram of Figure (2) is adopted to illustrate the relation between the number of casualties that can be otherwise avoided by spending money on retrofitting and strengthening buildings. Accordingly, at first, a questionnaire was designed and filled out by random individuals living in District 17 of Tehran to collect required data about their expected payment to save their lives in disasters. On the other hand, the readiness of the local government (as the employer) to invest in risk reduction projects was extracted from the past implemented urban renovation projects in that area. Using the formulation proposed by Bellavance et al. [18], the value of life for people participating in the survey was calculated. Then, the VHL was estimated at about USD one million.

4. Economic Loss Assessment Model for Casualties in Earthquakes

It was shown that using the available methods to assess the economic impacts of casualties in Iran will provide different results. Additionally, uncertainties in some of the introduced methodologies are pretty high and sometimes unacceptable. Therefore, developing a suitable model based on local socio-economic conditions in Iran is essential to address this critical issue [21-22].

Currently, the blood money (Diyeh) is used to determine the compensation sum for death or injuries. This figure is determined annually by the judiciary system. All courts or insurance companies in Iran should comply with the relevant regulations to compensate for the impacts of an accident or unintentional murder. However, this approach has not yet been applied in natural disasters to estimate the value of life. Further, blood money is a predetermined fixed value for all citizens and does not consider the differences among people due to the age, education, effectiveness, etc.

The proposed model should be consistent with rules and regulations in place in Iran and needs to take into account an array of parameters affecting the value of human life. Although the proposed methodology is developed for Iran, it can be used in other countries with some modifications based on the local socio-cultural context.

4.1. Parameters Considered in the Model

In this research, the significant parameters that should be considered in developing a model for estimating VHL have been extracted from existing literature. The selected parameters and their contributions to value of human life are introduced in this section.

- Age: The contribution of people of different ages to the development of society is an important parameter affecting the VHL. Its impacts have been determined by experts' opinions, and the results are shown in Table (3). According to results, an individual is assumed as a pure consumer until the age of 18. From that age onwards, people may play different roles in the economic growth and development of a society. Accordingly, younger generations have normally more time to provide services within their expected life. Thus, their death in the event of disasters has a high economic impact on a society. However, middle-aged people that own great level of expertise in undertaking professional activities and still young enough to serve the community obtain the highest score. The elderly, however experienced, have little time and energy to use it. Therefore, they receive the lower scores.
- Gender: For many centuries, men's contribution to the development of society has been supposed to be more than women's due to socio-cultural beliefs in different countries. However, based on the literature survey, only a slight difference between these two groups was recognized in evaluating the VHL (Table 4).
- Education: The level of education is one of the critical factors in the economic growth. It is assumed that those with higher education levels will have better contribution to the community development. The impacts of education on VHL were quantified based on expert judgment whose results are shown in Table (5).
- Expertise: The expertise of individuals may address their contribution to the progress of community and their share in economic growth. Therefore, this parameter has been chosen to estimate the potential economic growth opportunity loss due to the death of people in earthquakes (Table 6).
- Roles and responsibilities: Each individual plays a specific role in the development of their society. Therefore, the loss of different persons due to earthquakes will have impacts of different severity. For instance, the loss of those involved in leadership, management, and entrepreneurship has more negative impacts on the economic growth of societies rather than ordinary people. Table (7) shows the importance factors associated with each role, according to the experts' judgment.
- Income: The level of income has been considered by many researchers as an index for determining the importance of each individual's life. In this study, that parameter was also considered for assessing the VHL, as shown in Table (8).

Table 3. The impact of the age index on VHL.

Age (Year)	Percentage	Index (I_1)
Less than 18 Years Old	9%	0.09
19-39	27%	0.27
40-65	41%	0.41
66-75	18%	0.18
Older than 76	5%	0.05

Table 4. The contribution of gender in determining VHL.

Gender	Percentage	Index (I_2)
Woman	41%	0.41
Man	59%	0.59

Table 5. The contribution of academic and education levels on VHL.

Education Level	Percentage	Index (I_3)
Master Degree and Higher	52%	0.52
Associate Degree and Bachelor	28%	0.28
High School Diploma and Lower	12%	0.12
Under Diploma	6%	0.06
Illiterate	2%	0.02

Table 6. Determining the share of different expertise on VHL.

Expertise	Percentage	Index (I_4)
Specialist/Professionals	34%	0.34
Teacher/Professor	34%	0.34
Worker/Employee/Military Personnel	16%	0.16
Unemployed	3%	0.03
Other (Self-Employed, etc.)	13%	0.13

Table 7. Contribution of different roles.

Roles	Percentage	Index (I_5)
Entrepreneurship	41%	0.41
Management/Commander	23%	0.23
Guidance and Leadership	16%	0.16
Service Providers	14%	0.14
Other	6%	0.06

Table 8. Contribution of income on VHL.

Income, USD (Monthly)	Percentage	Index (I_5)
More than 1500	41%	0.41
1100-1500	25%	0.25
700-1100	16%	0.16
300-700	11%	0.11
Under 300	7%	0.07

4.2. The Weights of Different Parameters on VHL

The introduced parameters have different contributions to and weights in the assessment of VHL. To evaluate the weights of each parameter, the results of the survey were assessed using AHP (Analytical Hierarchy Process), as presented in Table (9). Amongst the studied parameters, "roles and responsibilities" and "income" have the highest contributions to the VHL, while "gender" have the lowest.

4.3. Conceptual Model to Assess VHL

To propose an applicable model to estimate VHL in Iran, at first, the upper and lower bounds of VHL have been determined and then, based on the design parameters, the appropriate VHL for each individual was determined. In Iran, as indicated before, the judiciary is responsible for determining the blood money (Diyeh) on an annual basis for all citizens based on Islamic rules. This value is a constant for all citizens without considering their age, profession, education or income. Diyeh is used to calculate compensation value for accidents or unintentional murder. In 2021 (the base time of calculation in this study), the blood money for each individual was around USD 25,000. This amount has been considered as the lower bound for VHL in this research.

Table 9. The weight of different parameters on VHL based on the questionnaire survey.

Parameters (i)		Percentages	Weights (Wi)
1	Education	16.55%	0.17
2	Expertise	14.73%	0.15
3	Age	7.10%	0.07
4	Roles and responsibilities	40.47%	0.40
5	Income	18.95%	0.19
6	Gender	2.20%	0.02

On the other hand, in order to formulate an applicable model for estimating VHL, it is necessary to consider a higher bound for VHL as well. For this purpose, the results of Razani and Nielsen [8] method have been considered as the highest possible VHL, which is equal to USD 500,000 per person. The proposed model is used to determine the VHL constrained by these bounds. Therefore, based on the introduced parameters and considering their importance factors (weights), the proposed model for estimating the VHL in Iran can be presented as follows:

$$VHL = BM + BM\left(\sum_{i=1}^{6} W_i . P_j . I_i\right) \qquad (8)$$

In this equation:

- VHL is the estimated Value of Human Loss for each person;
- BM is the blood money, the economic value of each individual's life according to the current law in the country (constant for all citizens, determined annually by the judiciary);
- W_i is the weight of the different parameters that can be selected according to Table (9);
- P_j is the impact factor for each category determined based on questionnaire survey as depicted in Table (10);

Table 10. The value of impact factor (Pj) to determine VHL.

Parameter	Impact Factor (Pj)				
	1	5	10	15	20
Education	Illiterate	Under Diploma	High School Diploma and Lower	Associate Degree and Bachelor	Master Degree and Higher
Age	Older than 76	Less than 18 Years Old	66-75	19-39	40-65
Expertise	Unemployed	Other (Self-Employed, …)	Worker/ Employee/ Military Personnel	Teacher /Professor	Specialist/ Professionals
Roles and Responsibilities	Other	Service Providers	Guidance and Leadership	Management / Commander	Entrepreneurship
Income (USD)	Under 300	300-700	700-1100	1100-1500	More than 1500
Gender			Man and Woman		

- I_i is the percentages' index of different categories for each parameter (Tables 3 to 8).

According to Equation (8), the highest and lowest possible VHLs for a person will be USD 445,000 and USD 29,000, respectively. Such values can be used for evaluating the potential economic consequences of earthquakes in urban settings due to the loss of citizens for making cost-benefit analyses and implementing risk mitigation measures.

5. Implementing the Model in the Pilot Area

Tehran, the capital city of Iran, is located in a seismic prone region along Alpine-Himalayan orogenic belt. The city has been destroyed by many strong earthquakes over the time and it is expected to be affected by other powerful earthquakes in the future [23]. Therefore, estimating the potential socio-economic impacts of earthquakes is a critical issue for risk mitigation and management planning.

According to the existing literature, the city of Tehran is exposed to two main active faults: the North Tehran Fault (NTF) located in the north of the city and the Rey Fault in the south [16-17]. Between these two, the Rey Fault is capable of generating more destructive quakes as it affects the more vulnerable buildings existing in the southern districts of the city. Therefore, an earthquake scenario on the Rey Fault was selected as hazard input to estimate the seismic loss in the pilot area in District 17 of Tehran.

To evaluate the economic consequences of this earthquake, at first, the physical damages to buildings needs to be estimated. This can be done using a set of vulnerability curves proposed by JICA and CEST [16-17]. Using this approach, the number of collapsed or severely damaged buildings can be determined at different zones. Figure (3) depicts the spatial distribution of the collapsed buildings in the study area.

The number of death was estimated by the use of the methodology suggested by Mansouri et al. [24]. This methodology was developed using the procedure originally presented by Coburn et al. [25], which estimates the number of potential casualties based on the damage level of buildings and time of earthquake occurrence. The result of this assessment is depicted in Figure (4).

As illustrated, due to the high population density in this area and the level of seismic vulnerability of buildings, a high number of fatalities is expected at different zones, amounting to 3,142 people (%7.3 of the total population of the study area). This is obtained by assuming that the earthquake takes place at night, where most residents are in their homes.

In order to estimate the economic value of human casualties, the proposed model of this paper was used. The model parameters were collected using the database of Statistical Center of Iran (SCI). Additionally, some necessary data was gathered during field surveys. By applying Equation (8), the economic value of human casualties was estimated at different zones. The results are shown in Figure (5).

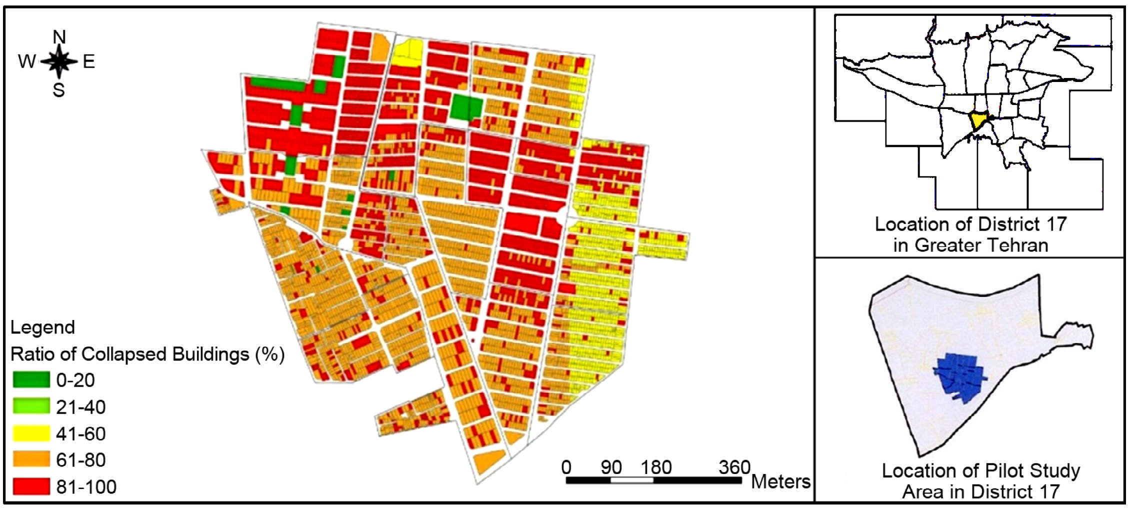

Figure 3. Distribution of the collapsed buildings by potential earthquake in the study area.

To compare the value of lives lost with the economic value of destroyed buildings, the latter was estimated by multiplying the total damaged area by the market price of buildings, considering the impact of depreciation. The result of the calculations is presented in Figure (6).

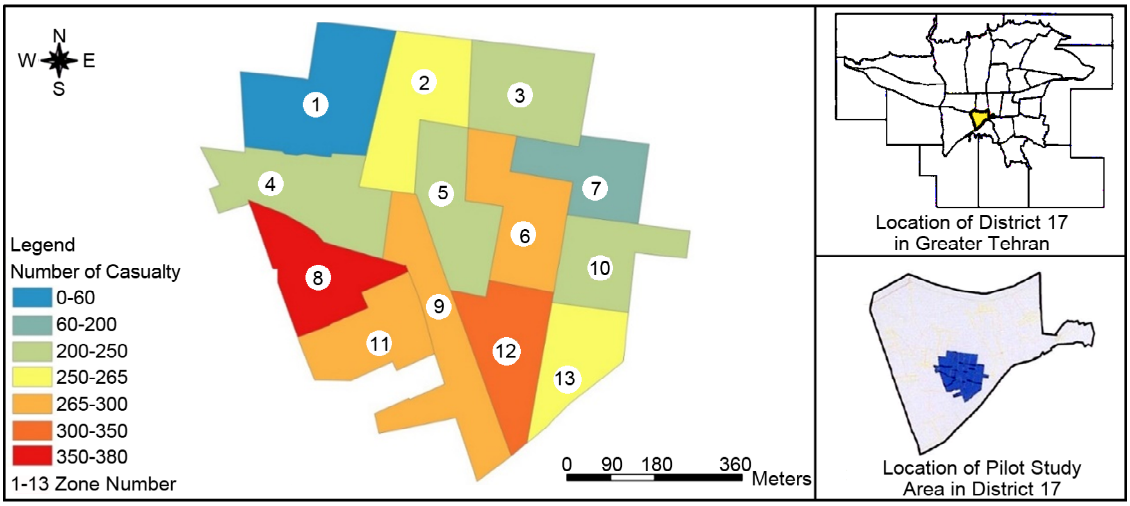

Figure 4. Distribution of casualties due to the potential earthquake at night time in the study area.

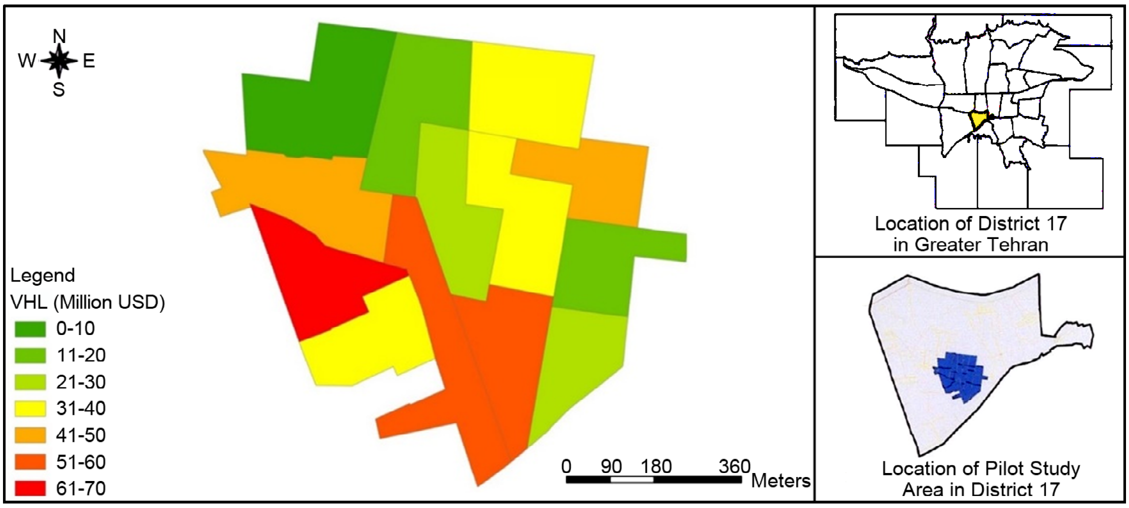

Figure 5. The accumulated economic losses of potential earthquake due human casualties at different zones of the study area.

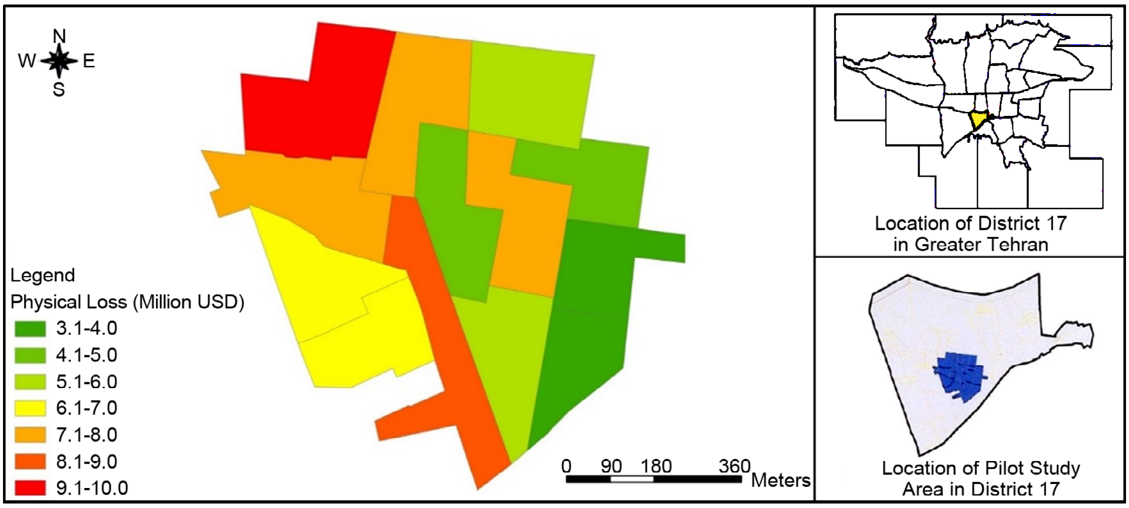

Figure 6. The accumulated economic losses of potential earthquake due human casualties at different zones of the study area.

A comparison between the results demonstrated in Figures (5) and (6) suggests that almost in all parts of the pilot area, the loss of human casualties will be much higher than the costs of physical damages. However, human loss is not normally considered for making decisions in disaster risk mitigation and management, and most of the planning process is done merely based on physical loss values.

6. Conclusion and Recommendation

Indirect and intangible losses caused by earthquakes need to be incorporated into the disaster risk management. One of the most debated topics, here, is the economic value of human lives that are claimed by disasters, which has deliberately or undeliberately been neglected so far. This paper extends the procedure of seismic loss assessment to include the instance where the statistical value of human life is brought into the conventional calculations. The proposed method comprises intangible parameters that could not be easily quantified by the market valuation techniques. Therefore, an expert opinion-based approach compatible with Iranian socioeconomic context and norms was employed to evaluate the economic value of human life. Parameters such as age, income, social contribution, and education that have a key influence on the development and growth of societies were included in the study.

The model was applied to a pilot urban area in Tehran city, Iran and the numerical results were benchmarked against the norms in other studies. The results suggest that the proposed model has more stability and flexibility compared to other methodologies because it considers various socio-economic parameters in determining the economic value of human life in risk assessment. In addition, it is observed that the proposed model presents a reasonable range of VHL based on the under-pinning design parameters such as age, gender, education, etc. Finally, a comparison was made between the dimensions of physical damages to buildings and equivalent economic losses due to the loss of lives. It became clear that the size of human loss is by no means less than the physical losses in the study area.

The proposed model could be used in the course of disaster risk management, and its output results can assist policymakers and disaster management officials in the process of formulating risk reduction strategies. Needless to say, in order to improve the model, it is recommended that it be calibrated with data obtained from health care institutions.

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