Assessing the social cost of housing projects on the built environment:
Analysis and monetization of the adverse impacts incurred on the neighbouring communities

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Abstract:

Construction projects generate serious environmental nuisances for the adjacent residents. All those harmful consequences and damages that third parties or the community sustain due to the implementation of construction processes are called social costs. Although, the presence of social costs is mentioned in the literature widely, in project initial cost estimation practices, the social costs are not estimated and included. Whereas since these costs are not compensated, problems can be emerged by the community. It is a truism that the majority of the models proposed to quantify the social costs have been concentrated on the construction, repair and maintenance of infrastructure projects namely; utilities, roads and highways. On the other hand, up to the present, no attempt has been made to quantify residential building associated social costs. Thus, this research aims to expand and/or contribute the existing body of knowledge via estimating how much social cost society surrounding building construction sites are subjected to. For this purpose, a social cost estimation model is developed to assist industry professionals on how; (1) to estimate building construction borne social costs, (2) to incorporate the social costs into project initial cost, (3) to compensate it for the third parties. The social cost estimation model is developed to provide guidance for phase by phase monetization of the building construction associated social costs. In this paper, the model proposed for social cost estimation is tested and validated through case studies conducted in north Cyprus and Turkey.

Keywords: social cost, social cost definition, social cost quantification, construction adverse impacts, housing projects, built environment, neighbouring community

1. Introduction

Countries perform extensive construction activities to sustain economic growth (Osei 2013). However, the construction projects can lead to adverse impacts on the ecological, sociological and economical systems of their neighbouring community (Abidin 2010, Balaban 2012). Especially, the residents and businesses in proximity to construction projects performed in urban areas can be affected intensively because of the high density of population (Çelik et al. 2017, Ferguson 2012, Gangolells et al. 2009). These inevitable causative adverse impacts on the daily routines of the society is called "social costs" (Apeldoorn 2013, Boyce and Bried 1998, Environmental Operations Unit 2012). Although the reality and presence of the social costs are widely mentioned and encompassed in theory, they are generally ignored and not estimated during project bid evaluation practices (Gilchrist and Allouche 2005), since in the traditional practices, the construction projects are evaluated as successful based on three criteria, namely cost, time and quality (Bowen et al. 2012). Whereas, ignorance of the social costs can lead to the emergence of the public objection, which in return leads to delay and cost overruns due to the protests and lawsuits (Yu and Lo 2005, Zhou et al. 2017). In addition, the exclusion of the social costs on the project cost estimation can lead to miscalculation of total costs of the construction projects to society, therefore the importance of utilization of new environment friendly construction methods and technologies cannot be understood completely (Matthews et al. 2015).

Emergence of the social costs as an inevitable and inherent case for construction projects inspired many researchers to come up with numerous approaches to identify the potential adverse impacts exposed to communities surrounding construction sites and to evaluate the cost of those impacts (Allouche et al. 2000, Gilchrist and Allouche 2005, Read and Vickridge 2004, Yu and Lo 2005, Yuan et al. 2013). However, the quantification of social cost in construction projects is a difficult and complex process (Apeldoorn 2013, Gilchrist and Allouche 2005, Yu and Lo 2005), therefore it is impossible to develop a general formula for all types of construction projects. Consequently, in the existing body of knowledge, scholars worked on predicting the equivalence of the adverse impacts exposed to third parties neighbouring a construction site where infrastructure construction, repair or maintenance works are carried out. Up to the present performed approaches promote contractors to compensate the social costs through incorporating them into bid evaluation. In this way, contractors are motivated to perform more rational planning of the construction methods. This can be attributed, at least partially, to the fact that infrastructure projects form a large part of public works financed by taxpayers' money for the social benefit of the public. This can be interpreted as: public who are the beneficiaries of infrastructure projects and who indirectly fund the projects are inevitably incurred by the social costs borne by the execution of the projects. Thus, infrastructure projects need to be justified in terms of the sustainable construction methods to the public (Yeow and Feltham, 2008). For compensation purposes, it is reasonable to consider the social cost as a component of initial project cost and evaluate it in the bidding.

On the other hand, no attempt has been made to estimate building construction oriented social costs. In majority of the building construction projects, the beneficiaries are private investors instead of public whereas the social costs are inevitably incurred on the public. Although surrounding community is potentially not the financer of the project and is not the beneficiary of the output, owners of the project and contractors must somehow and someway justify their construction methods and make any necessary compensations to the community. Proposal of social cost estimation model can if not directly, at least indirectly enforces contractors to justify their construction methods just as the contractors of public projects to eliminate the social costs and if not eliminated, to compensate them to public in an applicable way. Lack of such a model puts developing countries such as North Cyprus and Turkey in a more desperate situation as their building code of practices and construction regulations do not enforce the contractors for considering sustainable construction methods/applications to mitigate incurrence of social costs on the public.

In the literature, some of the researches related to social cost have monetized the adverse impacts of infrastructure projects incurred on the third parties (Ferguson, 2012). However, the measurement and quantification of social costs is a complicated process due to the lack of a paradigm for practice used for the classification and assessment of the social costs in a feasible way (Rahman et al. 2005). In the grand scheme of things, existing approaches have not managed to go beyond conjecture in providing a phase by phase road map to be followed by the professionals, so that they can monitor/measure the actual effects of construction activities on the third parties. It is noteworthy to highlight the importance of measuring alterations in one's routine as once these alterations are somehow measured. Then, they can easily be enumerated and monetized, hence attributed to the project under development in the format of "social cost". This supposition overlaps with the philosophy that lays behind the definition of the social cost. As the definition of the social cost implies; these are the construction-oriented nuisances that are paid by the third parties. It is a must to incorporate them to construction estimation. This can provide to opportunity to justify how accurate our scholarly hypothesis match with their real-life practice. In this way, conducting indirect superficial assumptions on behalf of them can be by-passed. Therefore, the model proposed in this paper arrays steps on how to include third parties and estimate the social costs incurred to them.

In this study, a social cost estimation model that standardizes the quantification of the social costs of the residential building is proposed in accordance with the definition of the social costs. Therefore, a direct and elaborative method, which literally measures the perceived nuisance based on the alterations in the daily routine of the third parties, is proposed. Relevant variables of the model are obtained according to responses of 320 participants who reside in proximity to building construction sites located in most populous and urban cities of Cyprus: Kyrenia, Famagusta, Nicosia; and Turkey: Istanbul, since people living in different geographical locations can have different perceptions on the causative adverse impacts of the construction projects on the third parties due to the culture and manner differences (Oltedal et al. 2004). Finally, having estimated the building construction associated social costs, a way should be developed to apply these costs in practice. Therefore, within the practical context, a new model is proposed to compensate the adverse impacts of the construction projects on the neighbourhood.

2. Quantification of Social Cost

In the quantification of social costs, the cost of construction emerged due to the adverse impacts is evaluated. There are different approaches proposed in the literature, however these approaches are composed of similar procedures for the evaluation of the social costs. These approaches are generally developed by considering the adverse impacts of the infrastructure projects. Gilchrist and Allouche (2005) proposed a model to quantify social costs of the infrastructure projects taking place in urban environments by considering 22 sources of social costs. Yu and Lo (2005) focused on the road construction causative adverse impacts and developed a model. Similarly, Jiang et al. (2010) quantified excess user costs at work zones by including the delay costs; such as deceleration, reduced speed, acceleration and vehicle queue delay cost; and additional vehicle operating costs due to reduction of available lanes. On the other hand, Florez et al. (2012) focused on the pavement rehabilitation of highways and evaluated the adverse impacts of pavement rehabilitation activities on neighbouring community via identifying road user and agency costs. Liu et al. (2013) developed a decision model by using intuitionistic fuzzy group for bid evaluation of urban infrastructure projects by considering social costs. They evaluated the effects of six aspects of social cost by considering experts' group character and fuzziness. Another attempt for quantifying the infrastructure projects is performed by Matthews et al. (2015) and they presented mathematical methods for calculating the eight social cost categories of pipeline infrastructure projects. A different effort for quantification of social cost was performed by Zhou et al. (2017). They used emergy analysis method for quantifying the social cost of large-scale construction projects. They applied their method for calculating the social cost of each stage of a project and concluded that the social costs should also be included into the estimation of the total of the construction projects.

Establishing a standardization for evaluating the infrastructure associated social costs and proposing a method to compensate them is a major common state of the previously proposed approaches but it is still necessary to propose a pragmatic way to monetize the building construction associated social costs. Therefore, there is a need for an elaborative study that gathers drivers of the building construction associated social costs in a certain way thereby that provides an imminent social cost figure for a specific construction project.

3. Research Methodology

The model proposed in this study is composed of two parts. The underlying philosophy of the first part of the model is to quantify residential building causative social costs in urban areas by measuring the change in standard of the third parties' possessed assets in terms of the reactions given by them to bring the standard of their assets back to its original state. Therefore, a social cost estimation model is developed.

In the second part of the model social cost compensation method is proposed. Necessity for this is attributable to the fact that, in the developed countries, the building construction regulations or the permission conditions are so strict that many precautions are taken to reduce the disturbances of the inhabitants neighbouring the construction site under the sustainable construction phenomenon. On the other hand, in most of the developing countries those regulations are loose that third parties' exposure of social costs are to be compensated somehow.

As one of the duties of the municipalities/local authorities is providing a more liveable environment for the society to live in comfort, peaceful, easy and calm in their neighbourhoods, by referring to the introduction section of this paper, municipalities will be compensating building construction associated social costs to the community through the social cost bond of the project owner and contractor.

4. Development of the Social Cost Estimation Model

In this study, a social cost estimation model for measuring and enumerating the social cost of the residential building is developed based on the recommendations made by Çelik et al. (2017). They proposed a five-phase framework for quantification of the construction social costs. These phases are modified and applied for residential buildings in this study. Finally, the developed model is tested and validated on real case studies, which is the phase 6 in the research process. The framework used in this study is shown in Figure 1. The types of research methods and techniques used in each stage of this study are also shown in this figure.

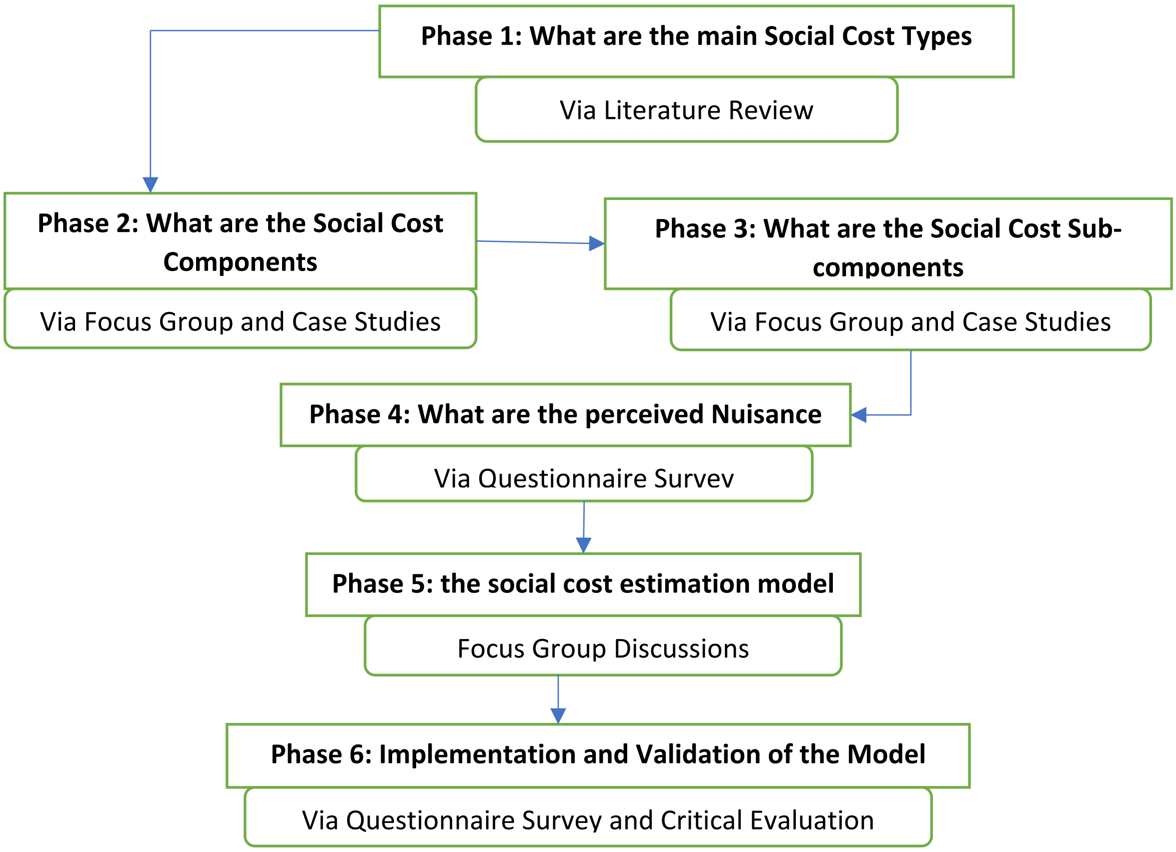

Figure 1: Research Process Design

The nature of this study enforces the application of the triangulation method to achieve the reliability and validity of the research. The three methods used in this study are literature review, focus group discussion, case studies and questionnaire surveys.

- **Focus Group Study**: Initially the main goal of the focus group is identified as; identification of the components that are being exposed to construction adverse impacts with the main lines. Subsequently, target audience considering profession (environmental impact assessor, municipality environmental problems and complaints department representatives, engineers and town planners) and residents of developing areas of major cities are selected upon their availability. Initially, the participants are briefed about the social cost phenomenon and answers of the participants are recorded on the video and essential information are analysed by organizing the discussions into categories.
- **Case Studies:** Observations from case studies and the participatory experiences in case studies are the techniques used for collecting data. Initially, current trend and practices in targeted construction industries are examined. Afterwards, descriptive and reflective notes about researcher's visual observation, auditory perception and what has experienced is taken for the analysis purposes.

Specification of the social cost sub-components and identification of perceived nuisance criteria are achieved through and exemplifying cases where the investigated elements broadly showed existence of the social cost theory. As a matter of fact, behaviour, perception, attitudes and knowledge of authors, their families and the community they live in are reflected for the analysis purposes. The List of case studies used in the research are given in table 1 below.

Table 1: Case Study projects used in the research for the social cost estimation model development

	Proj.	Proj. Type	Commencement	# of participants	Budget ($)	Size	Number of Floor
Kyrenia	P1	Residential	September 2011	20	9 M	12,000 m²	15
	P2	Commercial/ Residential	December 2011	23	10,4 M	8,550 m²	5
	P3	Residential	April 2011	19	1,52 M	1,950 m²	4
	P4	Residential	January 2012	20	4,3 M	5,200m²	8
Nicosia	P5	Residential	January 2012	24	3,7 M	4,800m²	5
	P6	Sports Complex	December 2011	26	4,1 M	5,000 m²	2
	P7	Residential	March 2012	21	2,2 M	2,850 m²	6
	P8	Commercial/ Residential	March 2012	30	8 M	9,500 m²	8
Famagusta	P9	Residential	February 2012	31	790K	940 m²	3
	P10	Residential	February 2012	26	1,8 M	2,300 m²	4
	P11	Residential	December 2011	26	5,1M	6,050 m²	6
Istanbul	P12	Residential	May 2015	54	18,4 M	35,000 m²	12

4.1. Phase 1: Identification of the Social Cost Impact Types

A literature survey is performed for identifying the types of social cost impact. Different social cost impact types are proposed in the literature. For instance, Gilchrist and Allouche (2005) identified the four main categories of social costs according to their impacts, including traffic, economic activities, pollution impacts and ecological/social/health impacts. Similarly, according to Yuan et al. (2013), 11 social costs on residential building can be categorized into four main categories, namely the impact on the community, economy, environment and public property. Matthews et al. (2015) categorized social cost in eight important groups for pipeline infrastructure projects. By considering these studies and other studies (Apeldoorn 2013, Florez et al. 2012, Lee et al. 2005, Najafi and Gokhale 2005, Yu and Lo 2005), residential building-borne adverse impacts are identified. The clusters of these adverse impacts are determined as; damage to natural and built environment, pollution and traffic problems.

Social costs of construction projects do not show immense variations. According to Unites States Environmental Protection Agency's report (2011), the type of construction project in progress is not identified as an important parameter in creation of local population. Therefore, the social cost parameters identified for infrastructure construction associated activities in the existing body of knowledge and among them the ones that are compatible within the limitations of this research are benefitted in this phase.

4.2. Phase 2: Identification of Social Cost Components

In the existing practices, scholars firstly segregate the construction causative adverse impacts types, and the social cost indicators of each adverse impact type are determined and the social costs are evaluated with respect the determined indicators. However, due to an inherent correlation among the determined social cost indicators, so among the determined social cost indicators, proposed approaches can be considered as obscure and complex in precisely estimating construction social costs.

This study asserts that difficulty in evaluating the project social costs can be minimized through segregating the impact types of the social costs with respect to community's possessed components. The life quality can be measured by evaluating a variety of determinants including physical being, psychological being, and physical belonging (Raphael et al. 1996). Especially, physical belonging is related to the connections with the physical environments of home, workplace, neighbourhood, school and community. Thereby, it is interpretable that when these physical belongings are exposed to causative adverse impacts, the people are ready to make additional payments for resolving or mitigating the perceived impairment to preserve their quality of life.

By considering the findings obtained from literature survey and brainstorming sessions, observations, and self-experience, the third parties are identified as the possessed assets, namely households, house and neighbourhood, are identified as social cost components. Based on these possessed assets, a social cost equation is proposed in this study, this formula shown below covers the local residents for the components of Phase 2. In equation 1, SC_{LR} is social cost for local residents, SC_{N} is social cost for neighbourhood, SC_{HH} is social cost for households and SC_{H} is Social cost for house/car(s)

$$SC_{LR}=SC_{N}+SC_{HH}+SC_{H} \qquad \text{(Equation 1)}$$

4.3. Phase 3: Identification of Social Cost Sub-components

In this phase, the subcomponents of each social cost components are identified by segregating the social cost components and an equation is proposed to calculate each social cost components.

During the implementation of this process, different resources, namely literature, brainstorming sessions with experts, case study observations and self-experience are used to crystallize the components of social costs into subcomponents.

4.3.1. Subcomponents of Neighbourhood

The four subcomponents are proposed for neighbourhood, and these subcomponents are identified as cost of traffic problems (C_{TP}), cost of car parking space problems (C_{CP}), cost of deficiency in using recreational facilities of the neighbourhood (C_{RF}), cost of alterations in the ambient standard of neighbourhood (C_{AS}). Equation 2 is proposed for calculating the social cost of neighbourhood by including these subcomponents.

$$SC_N=C_{TP}+C_{CP}+C_{RF}+C_{AS} \qquad \text{(Equation 2)}$$

4.3.2. Subcomponents of Households

In this study, the three subcomponents of households are proposed, and these subcomponents are cost of having problems in meeting daily necessities (C_{DN}), cost of maintaining standard health /personal care (C_{HP}) and cost of limitations in the use of outdoors (C_{LO}). Based on these subcomponents, Equation 3 is proposed to calculate the social cost related to household.

$$SC_{HH}=C_{DN}+C_{HP}+C_{LO} \qquad \text{(Equation 3)}$$

4.3.3. Subcomponents of House and Car

The subcomponents of house and car are determined as cost of additional dirtiness of the outdoor areas of the house (C_{OC}), cost of additional dirtiness of the indoor areas of the house (C_{IC}), and cost of additional dirtiness of the cars (C_{CW}).

The cost of maintaining the standards of the house and cars can be calculated by these components, therefore the equation is proposed to calculate the social cost of maintain the standard of house and car.

$$SC_H=C_{OC}+C_{IC}+C_{CW} \qquad \text{(Equation 4)}$$

4.4. Phase 4: Identification of Perceived Nuisance Criteria

In this study, omnipresent nuisance parameters are considered to propose a social cost estimation equation for measuring the additional costs on the local residents. However, the values of these parameters cannot be calculated without conducting a field survey at the geographical location of the project, so that the parameters which start out a reaction in people neighbouring a construction project can be identified because of the presence of omnipresent nuisances. These parameters should be identified carefully, since different cultures and social manners between the communities lead to different type of social costs.

In other words, the communities intrinsically show different reactions to resolve/mitigate the negative changes on in their life due to the adverse impacts of construction activities. Because of this, the construction causative nuisances on third parties should be identified for each community and there cannot be a standard generalization. This case can be further analysed by taking an analogy from an estimation perspective between social and traditional costs.

In this study, a field survey is performed in North Cyprus and Turkey to identify the perceived nuisances on residents neighbouring a construction site. Four cities, namely Nicosia, Famagusta, Kyrenia in North Cyprus, and Istanbul in Turkey are selected for this field survey. A total of 266 questionnaire surveys are collected at the end of this field survey. Participants for these surveys were selected according to having resided within 150m of a distance to a building construction site , since additional construction dust formation is shown to significantly disturb the residents within 150 m of a construction site (Watkins 1981).

In the conducted questionnaire 52.26% of the respondents were men, and 47.74% of the respondents were women, therefore both genders are included in this study and the findings of this study are based on the both genders' views. Also, according to the age groups and their distributions shown in Table 2, the views of different age groups are used in this study to capture the all ideas from the community.

Table 2: Demographic structure of the respondents

		Percentage
Gender of the respondents	Male	52.26 %
	Female	47.74 %
Age groups of the respondents	18-24	22.56 %
	25-33	24.06 %
	34-44	21.43 %
	45-54	15.04 %
	55-65	12.41 %
	66 and over	4.51 %
Education level of the respondents	Literate	0.38 %
	Primary school	16.17 %
	Secondary school	7.89 %
	High school	34.59 %
	Vocational high school	0.38 %
	Undergraduate	25.94 %
	Master degree	3.01 %
	Doctorate degree	11.65 %

Lastly, education levels of the respondents are examined. Although the majority of the respondents are graduated from high school (34.59%), the other respondents have different education levels.

Therefore, the views of the respondents from different equation levels are also included into this study. Consequently, these figures indicate that this study reveals the different views from different demographical backgrounds.

According to the conducted field survey, 17 different nuisance criteria are identified. Subsequently, pre-identified social cost components are used to categorize these designated nuisance criteria and each criterion is associated with the abovementioned social cost sub-components. Table 3 shows the lists of criteria for the perceived nuisances identified.

Table 3: The lists of criteria for the perceived nuisances identified.

Social Cost Sub-components	**Perceived Nuisance Criteria**
C_{TP}	- Lessened road safety standards of the neighborhood ($C_{TP(1)}$) - Road dirtiness of the neighborhood ($C_{TP(2)}$) - Alterations in standard flow of traffic in the neighborhood ($C_{TP(3)}$)
C_{CP}	- Car parking space problems in the area ($C_{CP(1)}$)
C_{RF}	- Lessened serviceability standards of the playfields / parks / hiking trails ($C_{RF(1)}$)
C_{AS}	- Additional dirtiness of the ambient / neighborhood ($C_{AS(1)}$) - Lack of serviceability of the habitat/parks ($C_{AS(2)}$) - Alterations in standard peace and quietude of the neighborhood ($C_{AS(3)}$)
C_{DN}	- Meeting daily necessities ($C_{DN(1)}$)
C_{HP}	- Alterations in standard health/well-being/personal care ($C_{HP(1)}$)
C_{LO}	- Limitations in the use of outdoors ($C_{LO(1)}$)
C_{OC}	- Additional dirtiness of the walls of the house ($C_{OC(1)}$) - Additional dirtiness of the house's yard ($C_{OC(2)}$)
C_{IC}	- Additional dirtiness of the house ($C_{IC(1)}$) - Additional dirtiness of the curtains ($C_{IC(2)}$) - Additional dirtiness of the windows ($C_{IC(3)}$)
C_{CW}	- Additional dirtiness of the car(s) ($C_{Cw(1)}$)

The cost estimation of a construction project requires the identification of all parameters affecting the project as well as the above stated parameters representing social cost sub-components. However, at each stage, different surveys are required to estimate the costs of the manpower, equipment, machinery, material and expenses such as head-office overheads locally. Likewise, the local surveys should be performed to identify the local nuisance criteria to quantify the social costs monetarily.

4.5. Phase 5: Consolidation of the Findings for the Social Cost Estimation Model

At this phase, the findings for the social cost estimation model is consolidated. For that purpose, defining nuisance criteria acquired at phase 4 is an important link to monetize probable alterations in the daily routine. The nature of this study makes conducting a questionnaire as the most convenient tool to perform the monetization, in addition Çelik et al. (2017) recommend to conduct questionnaire survey at this phase. For instance, in phase 4 additional dirtiness of the car(s) is recognized as a common nuisance criterion. The quantification of this nuisance criterion requires the additional number of the car wash during construction to clean up their car, however this information can only be obtained by questioning the surrounding community by conducting a questionnaire.

In order to obtain quantify each nuisance criteria, a unique empirical equation should be developed for each nuisance criteria. Although Çelik et al. (2017) mentioned about the importance of the development of the empirical equations, they do not show how these nuisance criteria can be quantified. Accumulating the quantified entire nuisance criteria perceived by the residents via implementing the developed equations will output the social costs associated with the building construction project. The equation 5, developed by integrating the equations 2, 3, and 4, is proposed for this purpose. Therefore, equation 5 shown below is the final equation used to estimate the social cost.

$$SC_{LR}=[C_{TP} + C_{CP} + C_{RF} + C_{AS}]+[C_{DN} + C_{HP} + C_{LO}]+[C_{OC} + C_{IC} + C_{CW}] \quad \text{(Equation 5)}$$

4.6. Phase 6: Implementation of the Proposed Social Cost Estimation Model

To test the practicability of the proposed social cost estimation model, set of field surveys as necessitated, are performed in Turkey and North Cyprus. In this section, how the typical social costs emerged due to the construction of the residential housing projects are quantified is explained sequentially.

4.6.1. Measuring the effects of nuisances perceived by the local residents

Another questionnaire survey is conducted in the nearby of Project 12 in Istanbul to measure the consequences of perceived nuisances on residents neighbouring a construction site. 54 surveys are conducted within the 150m vicinity of the project. Daily routine alterations of these 54 residents are enumerated through the questionnaire survey and equivalence of their alterations in monetary units for social cost estimation is carried out.

Participants of the questionnaire are initially asked if there were any alterations in their daily routine because of being exposed to the nuisances. This paves the way to obtain more accurate results during estimation of the building construction related social costs. For instance, if 50% of the residents stated that they were adversely affected by perceivable nuisance criteria. Then, estimated cost for these criteria, which is to be incurred on the residents, is halved.

Afterwards, alterations in the daily routine of the residents concerning each social cost sub-component are obtained via the questionnaire with respect to three categories namely; additional cleaning (man hour/month), additional distance travelled (kilometres/month) and additional miscellaneous actions performed in a month. Numbers representing the alterations in the daily routine of the residents, which shed light on to estimation of the generated social costs, are given by Table 4.

Table 4: The weighted daily alterations of perceivable nuisance criteria and their social cost estimates

Associated social cost Sub-components	**Rate of participants who have altered their daily routine (%)**	**Type of daily alteration**			**Generated social cost (£/day/house)**
		Additional cleaning (man-hour/month)	Additional distance travelled (kms/month)	Additional miscellaneous (actions/month)	
$C_{TP(1)}$	61.6		36		0.13
$C_{TP(2)}$	65.6		46		0.16
$C_{TP(3)}$	66.8		66		0.23
$C_{CP(1)}$	42.9		45		0.11
$C_{RF(1)}$	61.9		64		0.20
$C_{AS(1)}$	71.0		56		0.18
$C_{AS(2)}$	66.8		62		0.21
$C_{AS(3)}$	71.1		81		0.29
$C_{DN(1)}$	58.7		42		0.14
$C_{HP(1)}$	45.0			2.1 (residents visit to a doctor/specialist)	0.90
$C_{LO(1)}$	85.0			93 hours(air-conditioning usage)	0.85
$C_{OC(1)}$	69.2	3.8			0.36
$C_{OC(2)}$	60.9	1.9			0.17
$C_{IC(1)}$	79.3	5.8			0.62
$C_{IC(2)}$	69.2	7.0			0.68
$C_{IC(3)}$	73.4	4.8			0.48
$C_{CW(1)}$	72.6			1.66 (car wash)	0.54

On the other hand, for two types of daily alteration categories; additional distance travelled and additional cleaning, the two examples are worked out below to illustrate in more detail, where the numbers stated in Table 4 falling into these categories come from.

Category; alterations in daily routine in terms of additional cleaning

Example 1 - Additional dirtiness of the house's yard ($C_{OC(2)}$);

It should be known that to calculate additional cleaning in terms of man-hour/month for the relevant social cost sub-components, respondents are asked to state the time required to fulfil each activity (each social cost sub-component).

For example, they indicated that activity to clean the yard of the house takes about 22 minutes. This shed light on calculating the approximate additional cleaning performed with respect to $C_{OC(2)}$ during the construction in terms of man-hours/month as follows;

- Participants stated that before the construction they used to maintain the standard cleanliness of their house's yard by getting it cleaned approximately 17.33 times (mean value) in a month. However, during the construction, this number has increased to about 22.24 times showing that residing near a construction site led them to perform 4.91 times additional cleaning in their house's yard.
- Responses of the participants indicate that it takes averagely 22 minutes to clean the yard of their house hence, it works out by 4.91×22 that each month there is an additional 108.02 minutes of cleaning in house's yard.

Numbers given in Table 4 and representing the rest of the social cost sub-components falling into this category are worked out in the same manner.

Category; alterations in daily routine in terms of additional distance travelled.

Example 2 – The method used in the transportation departments are modified for calculation of costs emerged due to additional distance travelled. Additional distance travelled as a result of alterations in standard flow of traffic in the neighborhood ($C_{TP(3)}$);

It should be known that when calculating additional distance travelled for the relevant social cost sub-components, respondents are asked to state frequency of each activity (each social cost sub-component) fulfilled in a day.

For instance, participants state that they have averagely attempted 7 times to detour/deviate their routine way to avoid traffic congestion problems. This shed light on calculating the approximate additional distance travelled with respect to $C_{TP(3)}$ during the construction in terms of kilometres/month as follows;

- Participants stated that during the construction in their neighbourhood, each time they detoured/deviated due to traffic congestions they had to travel additional 300 meters (mean value).

- Having indicated that they have detoured/deviated approximately 7 times in a day, it works out by 7×300 that each day they have additionally travelled 2,100 meters in a day.

The statement mentioned in the previous example is valid for this example.

4.6.2. Estimation of the Social Costs

The generated social costs are estimated through the 6 different experiential equations, which are given below. In estimation of the social cost, local unit rates obtained from North Cyprus State and Planning Organization (2014) are used during the implementation of developed equations. In a point of fact, the developed experiential equations act in a way as the sub equations of equation 2 (SC_N), 3 (SC_{HH}), and 4 (SC_H) hence, they are used to calculate equation 5 (SC_{LR}).

4.6.3. Experiential equation 1

This equation is developed to assist the estimation of cost of additional dirtiness of house/car and it is as follows;

$$C_{msc} = W_c \times T_c \times N_{ac} \times \frac{1}{60} \times \frac{1}{30} \times A\% \qquad \text{(Equation 6)}$$

where, $C_{msc(n)}$ means daily cost of cleaning up the additional dirt, (n) is used to give a number for the output of each different criterion; W_c is hourly wage of cleaner in pounds and is obtained from North Cyprus State Planning Organization; T_c is time required for cleaning in minutes and the value of this parameter is obtained from the questionnaire survey; N_{ac} is number of additional cleaning performed in a month and this is also obtained from the questionnaire survey; A% is percentage of the residents who have altered their daily routine (applied to all the perceivable nuisance criteria in accordance with the numbers given in Table 4). $\frac{1}{60}$ is also added to the equation to convert the time required for performing each criterion from minutes to hours. Finally, $\frac{1}{30}$ is added to the equation, since the number of additional cleaning performed is responded on monthly basis, therefore this number is should be converted to the daily basis.

To give an example of how this equation is used, $C_{OC(1)}$ is calculated via implementing experiential equation 6. The values of the parameters are determined as W_c=£4.15/hour, T_c=66.4 minutes and N_{ac}=3.36 for $C_{OC(1)}$ and $C_{OC(1)}$ is calculated as £0.36/day.

Estimation of the generated social costs concerning $C_{OC(2)}$, $C_{IC(1)}$, $C_{IC(2)}$, $C_{IC(3)}$ are carried out in the same manner.

4.6.4. Experiential Equation 2

This equation is also developed to assist the estimation of C_{cw} and it is as follows;

$$C_{cw} = P_{cw} \times N_{acw} \times N_{oc} \times \frac{1}{30} \times A\% \qquad \text{(Equation 7)}$$

Where P_{cw} means the price of a car wash in pounds and it is determined as £10 and N_{oc} is number of cars held per each house, these values of the parameters are obtained from North Cyprus State Planning Organization; N_{acw} is number of additional car washes in a month and this value is obtained from the questionnaire as 1.66.

This equation is applied for estimation of C_{CW} in North Cyprus and Turkey. According to statistical results of the Turkish State and Planning Organization (2017), there is an average of 1.34 car per each house in the surveyed regions. As a result, average daily money spent by the residents of each house is calculated as £0.54/day.

4.6.5. Experiential Equation 3

This equation is developed to assist the estimation of cost of additional distance travel and it is as follows;

$$C_{ADT(n)} = D_{at} \times C_{ap} \times P_{of} \times N_{at} \times \frac{1}{1000} \times A\% \quad \text{(Equation 8)}$$

Where $C_{ADT(n)}$ means daily cost of additional distance travelled,(n) is used to give a number for the output of each different criterion; D_{at} is additional distance travelled in a day (in meters); N_{at} is number of times the activity repeated in a day. The values of D_{at} and N_{at} are obtained from the questionnaire. C_{ap} is average petroleum consumption of the car per km, this value is obtained from observations depending on the size of the cars used in the country and experience; P_{of} is Average price of fuel (£/liters), is obtained July2018; $\frac{1}{1000}$ is used as a conversion factor (kilometres/meters).

To give an example of how this equation is used, $C_{TP(1)}$ is calculated. The values of parameters of Equation 8 for $C_{TP(1)}$ are D_{at}=240 meters, C_{ap}=0.125 liters/km, P_{of}=£1.15/liter, N_{at}=6/day, and $C_{TP(1)}$ is calculated as £0.13/day.

Estimation of the generated social costs concerning $C_{TP(2)}$, $C_{TP(3)}$, $C_{DN(1)}$, $C_{AS(1)}$, $C_{AS(2)}$, $C_{AS(3)}$, $C_{RF(1)}$,$C_{CP(1)}$ are carried out in the same manner.

4.6.6. Experiential Equation 4

This equation is developed to assist the estimation of cost of alterations in standard health/well-being/ personal care (C_{HP}) and it is as follows;

$$C_{HP} = P_{vds} \times N_{ov} \times \frac{1}{30} \times A\% \quad \text{(Equation 9)}$$

Where P_{vds} is average price of visiting a doctor/specialist and the value for this parameter in the region is £30; N_{ov} is additional number of visits to a doctor/specialist and this value is obtained from the questionnaire as 2.0.

This equation is applied for estimation of C_{HP} and it is calculated as £0.90/day.

4.6.7. Experiential equation 5

In this study; it is assumed that C_{LO} can be calculated based on daily cost of extra air- conditioning usage, since the residents have to spend more time inside and use air conditioner to maintain the room temperature, especially in hot region countries, such as Turkey and Cyprus, this additional usage of air-conditioning is leading additional cost on the residents. The following equation is developed to assist the estimation of C_{LO}.

$$C_{LO} = C_{ae} \times P_e \times U_{aa} \times A\% \qquad \text{(Equation 10)}$$

C_{ae} is average electricity consumption of air conditioners per hour, and there is no secondary data about the value of this parameter, therefore the value of this parameter is obtained through observations as 1.5 kilowatts/hour; P_e is electricity cost per kw, the value for this parameter is obtained from North Cyprus Electricity Administration as £0.22/kilowatts; U_{aa} is additional air-conditioning usage hours/day, and the value for this parameter is obtained from the questionnaire as 3.02 hours/day.

It is remarkable that 17.91% of the respondents do not have air conditioners fitted at their houses, but if they had, they would have utilized it. Consequently, for evaluation of the "A%" value, the respondents, of this case are also incorporated in the analyses. Consequently, C_{LO} is calculated as C_{LO}=£0.85/day.

4.6.8. Estimation of the Social Cost/day Incurred to the Local Residents (SC_{LR})

Based on the findings of the questionnaire survey, alterations in the residents' daily routine are enumerated and development/implementation of the above-mentioned experiential equations contributed greatly for the estimation of the social costs of the residential building for North Cyprus and Turkey.

Within this context, for this specific case, by implementing the equation 5, social cost/day/house incurred on residents living near a construction site are calculated as £6.25. In which social cost sub-components do variables used during the calculation belong to is illustrated in table 4 under generated social costs section.

Finally, an average of 27 houses located within 150 m distance of each construction site is determined in this study. Considering this information, for this specific case, total social costs generated from a construction to a neighbourhood is calculated as £168.75.

5. Discussions

In this paper, a new social cost estimation model is proposed to demonstrate that people who reside within a certain distance of building construction sites also face the consequences of activities performed on site. Even though it is the members of the society who are unavoidably incurred with the social costs, up to the present, no attempt has been made to propose a model that incorporates the society during estimation process of the social costs. Within this respect, the model is proposed in this study which arrays the steps to be followed by professionals revealing how to incorporate the society, and estimate the costs incurred to them.

In the first phase of the model, construction activities associated adverse impacts that are already existent in literature are filtered with respect to the limitation of this study: quantification of building construction related social costs incurred to people living in residential areas of the cities. It is a common notion that social costs are expressed for every functioning day of a construction site due to difficulties and complexities in defining them activity wise. On the other hand, based on engineering experience, observations, and studies performed in literature (US EPA, 2011, Yuan et. al, 2013) it is believed that resultant nuisances due to execution of construction activities do not show immense variations with respect to the building construction project in preference (i.e. RC framed building, Steel framed building). However, countries' building code of practices and construction regulations play a critical role if these laws are not rigid to enforce the contractors for considering sustainable construction methods/application hence; construction project and method in preference become immense variance factor on the intensity of generated social costs. Therefore, in developing countries like North Cyprus and Turkey, it is a must to estimate construction activities associated social costs and compensate them to the suffered parties.

On the other hand, both in developed and developing countries, it is presumed that construction, repair, and maintenance of building constructions are involved intensely with the society. Within this context, in phase 2 of the proposed model a generic equation (see equation 1), which is globally applicable in determining building construction sites associated social costs is proposed. The nuisance criterions proposed for the calculation of the social costs associated with building construction projects in residential areas are clustered under three different sets namely, (i) neighbourhood, (ii) households and (iii) house.

However, the proposed nuisance criterions and proposed empirical equations to enumerate them cannot be globally applicable due to set of variables: (1) differences in countries' building code of practices and construction regulations; (2) perception of people for the construction activities related nuisances and the reaction given against very much varies based on culture, the way of living, and fastidiousness of the community; (3) from region to region types of construction projects vary with the economic social and political conditions of the countries; (4) availability of construction technology, materials, and other resources. Therefore, the nuisance criterions determined in this research are proposed to be applicable specifically for targeted construction industry.

In this research, after implementing the proposed model for social cost of dwellers near building construction sites was calculated to as £168.75 per day. This amount is remarkable and should be considered in the budgets of construction projects.

Lastly, the proposed social cost compensation method for the residential buildings is based on considering the contractor of the project as responsible body to defray the generated social costs on the community that are affected by the construction. The client will submit a social cost bond to the municipality, who is going to provide the building permission of the project. Amount of the bond will be decided by the municipality. However, this social cost bond will be provided by the contractor and submitted to the client as a contract document. It is deemed that this method will enforce the contractor to reconsider the construction methods and management of the project to minimize, if not totally avoid, the generation of the social costs. Any incurred social costs will be compensated by the municipality through the submitted social cost bond. It is believed that this method of compensation is applicable especially in the developing countries.

After the estimation of the building construction associated social costs, a way to compensate them needed to be proposed. In this paper, the proposed model firstly enforces the contractor to generate less construction caused nuisances to the local community via reconsidering their construction methods and management. Secondly, the incurred social costs to the surrounding community of construction sites are offered to be compensated by the contractor through the municipality. The instrument proposed for this action is a type of surety bond, named as "social cost bond". So, the contractor will be enforced to provide another type of bond to the client just as performance bond or payment bond. The client will provide this social cost bond to the municipality while getting the residential building permission. The amount of the social cost bond will be estimated by the municipality depending on either their experiences or implementing the model proposed in this paper. In this way, it is deemed that the contractor will be under the pressure to minimize the social costs to secure the social cost bond. However, if any social cost is incurred on the third parties, the municipality will be entitled to compensate them to community through the social cost bond provided by the contractor.

6. Conclusions

In the literature, there is a limited number of studies about the social costs in the construction industry. Some researchers proposed different methods to quantify and compensate the social costs in some infrastructure projects, and these projects are placed outside the residential areas (Boyce and Bried 1998, Environmental Operations Unit 2012, Gilchrist and Allouche 2005). Therefore, the effects of the construction on the residents are generally ignored or considered limitedly. This study proposed a methodology for quantifying the social costs of a building construction site in residential areas and proposed a method of compensating it to community.

This study lights the way for industry professionals by proposing a comprehensive social cost estimation system composed of a framework that assists them on how to obtain the building construction related social costs and compensate them. With the help of conducting literature survey, brainstorming sessions, observations, and self-experience, three categories of social cost components, namely house, households and neighbourhood, are identified. Also in the same way, 17 different perceivable nuisance criteria are identified.

Within this context, to estimate the social costs arising because of executing building construction projects, a questionnaire study is performed in North Cyprus and Turkey by 320 locals. Alterations in the daily routine of the participants are enumerated to form a basis for estimating the social costs by using local unit rates. For this study, total social cost is obtained as £6.25/day/house and on average £168.75/day/building construction site.

In this research, the aim is describing and monetizing the social costs of the residential building. However, this is not an easy process, since it is a time consuming and long-lasting study which in turn lead to some limitations. Three potential limitations of the current research study, stated below, deserve attention and future research could extend the findings from this research by addressing its current limitations.

I. In this study, the residential building social costs are quantified in terms of per day. However, this quantification in terms of per activity can be more convenient, since the social costs can be assigned to the activity costs separately in the planning software and the timely cash flow of the construction can be obtained more precisely and practically.
II. The proposed equation is alleged to be commonly applicable by means of collecting the values of designated parameters locally. By taking notice of locally driven cultural and social manner variations of people, enhanced accuracy is obtainable for the proposed quantification procedure.
III. The questionnaires are conducted in this study by visiting only houses. Therefore, the findings of this study are based on the perception of the house residents. This study can be developed by including the commercial premises as well.
IV. The findings of this study are specific to building construction sites in only a residential area, therefore the other studies should be performed by following the procedures suggested in this study for different construction types, such as infrastructure projects in residential areas.

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