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Identification of Site Activities Adversely Affecting the Environment During the Execution Period of Building Construction in Ethiopia: The Case of Southern Nations, Nationalities and Peoples' Regional State

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Abstract - *Construction activities affect the environment throughout the life cycle of development. Even though the construction period is comparatively shorter in relation to the other stages of a building's life, it has diverse significant effects on the environment. This study was carried out to identify the major site activities adversely affecting the environment during the execution period of building construction in Southern Nations, Nationalities and Peoples' Regional State (SNNPRS) of Ethiopia and to propose measures for their mitigation. Eleven site activities adversely affecting the environment were identified from literature. The main approaches used in collecting data for the study were through questionnaire survey, and personal observations of some major construction sites in selected towns. Questionnaires were distributed to a total of 174 purposively selected respondents consisting of 58 contractors, 58 consultants and 58 nearby residents on 58 active building construction projects in selected towns. The respondents were asked to identify the most important item from the listed. The relative importance of the items identified were calculated and ranked by the relative importance index. According to the results of the study, the respondents agreed that concrete vibration; concrete batching, mixing and placement; and excavation are the main site activities having adverse environmental impacts in selected towns. The results of this study will be useful to support the implementation of environmental management systems in construction companies by providing guidance for construction practitioners. The paper recommends that stakeholders in the construction industry should start working with new methods and technologies following sustainable construction techniques to reduce environmental impacts.*

Keywords: *Site activities, construction industry, environment, impacts, building*

1. INTRODUCTION

Construction activities affect the environment throughout the life cycle of development. These impacts occur from initial work on-site through the construction period, operational period and to the final demolition when a building comes to an end of its life. Even though the construction period is comparatively shorter in relation to the other stages of a building's life, it has diverse significant effects on the environment. For that matter, there is progressively growing concern about the impact of construction activities on human and environmental health. Even though, construction project development potentially contributes to the economic and social development, and enhancing both the standard of living and the quality of life, it is also associated with deterioration of the environment [1].

Housing and infrastructural development which are very resource intensive, will so much negatively impact the physical environment. The call for sustainable construction is in the realization of the construction industry's capacity to make a significant contribution to environmental sustainability because of the enormous demands it exerts on global resources [2].

According to Wilmont Dixon [3], construction causes pollution. The construction business in many countries is responsible for nearly a third of all industry-related pollution incidents. There is no construction which does not have an environmental impact. The main aspect of construction is making buildings of varied uses be it for residential, commercial, industrial, recreation, healthcare or any other purposes. The estimate of global pollution that can be attributed to buildings is air pollution 23%, climate change gases 50%, drinking water pollution 40%, landfill waste 50% and ozone depletion 50%.

Because of their size and profound societal importance, construction activities and processes are among the largest consumers of materials and energy and significant polluters on the global scale. For these reasons, more attention should be devoted to understanding, researching, and ultimately reducing their environmental impacts [4].

The aim of this study is to identify site activities adversely affecting the environment during the execution period of building construction in Southern Nations, Nationalities and Peoples' Regional State (SNNPRS) of Ethiopia and to assess the mitigation measures taken by construction practitioners towards those impacts.

2. RESEARCH APPROACH

The types of study design adopted in this research were mainly descriptive survey and exploratory. The study also adopted the concurrent mixed study approach (Quantitative and Qualitative). According to Simon and Samuel [5], Quantitative research investigates facts and tries to establish relationships between these facts. While qualitative research is a subjective assessment of a situation or problem, and takes the form of an opinion, view, perception or attitude towards objects. A combination of quantitative and qualitative approach is advocated because it takes advantage of the strengths in the two approaches while limiting the weaknesses.

2.1 Sample Selection

Simple random sampling procedure was applied to generate the sample for the study. A sample size of 58 active building projects in three selected towns in SNNPRS (i.e. in Hawassa city, 26; in Dilla, 14 and in Wolaita Sodo, 18) was determined from the total population of 102 active building construction projects in those selected towns using the formula proposed by Yamane [6] as follows: $n= N/1+N (e)^2$, Where N = the total population size; e = the standard error of sampling distribution assumed to be 8.5% and n is the sample size. The sample population includes office buildings, hospital buildings, educational buildings, hotels (resorts) and multi-purpose building projects in the selected towns.

The researcher used purposive/judgmental type of sampling to select the respondents basing on their level of education and experience in their interaction with people involved in construction activities. For each project of the sample, three (3) respondents were selected (one (1) from contractor side, one (1) from consultant side and one (1) from nearby residents). In total, the study covered 174 respondents which the researcher considered adequate to provide reliable data pertaining to the research objective.

2.2 Data Collection

The tools used to collect relevant data were questionnaire in the form of both close and open-ended questions, and field observation. The data collection process involved two stages. The first stage consisted of literature search for information on the construction site activities adversely affecting the environment in other countries and unstructured interview of some experts involved in the implementation process. The first phase resulted in the identification of eleven (11) site activities adversely affecting the environment. The second stage involved the development of questionnaire incorporating those data identified in the literature reviewed. Respondents were asked to express their views on the site activities adversely affecting the environment on a five-point Likert scale (from 1(not important) to 5(extremely important)). The questionnaire consisted of two parts. The first part inquired about the context of the respondents business and professional background. The second part comprised issues about the site activities adversely affecting the environment.

Table -1: Summary of questionnaires distributed and percentage of responses received.

Respondents	Questionnaires Distributed	Questionnaires Returned	Response Rate
Contractor side	58	50	86.2%
Consultant side	58	50	86.2%
Nearby residents	58	40	67%
Total	174	140	80.46%

In addition to the questionnaires, site observations were made. The site observation provided useful insights into which site activity has adversely affected the environment and what mitigation measures have been taken to minimize it.

Reliability of data collection instrument is checked by using Cronbach's alpha coefficient which is generally used in acquiring reliability in terms of internal consistency regarding a single test especially in combined measurements. Standard Cronbach Alpha formula is

$$\alpha = \frac{k\,r'}{1+(k-1)\,r'} \quad \text{... (2.1)}$$

Where k is the number of items (variables) and r' is average correlation.

Manerikar and Manerikar [7] described internal consistency of Cronbach Alpha as follows:

Cronbach Alpha, α	Internal Consistency
$0.9 \le \alpha$	Excellent (High Stakes Testing)
$0.7 \le \alpha < 0.9$	Good (Low Stakes Testing)
$0.6 \le \alpha < 0.7$	Acceptable
$0.5 \le \alpha < 0.6$	Poor
$\alpha < 0.5$	Unacceptable

2.3 Data Analysis Technique

The quantitative data were analyzed using the Microsoft excel software. Two forms of statistical analysis were undertaken: Descriptive statistics such as percentages were used to summarize information from respondents. Also inferential statistics such as relative importance index method (RII) was used herein to determine construction practitioners (either contractor side or consultant side) and nearby residents' perceptions of the relative importance of the identified site activities adversely affecting the environment. Qualitative data was analyzed and presented using figures and tables with narrative statements.

The five point scale ranged from 1 (not important) to 5 (extremely important) was transformed to relative importance index (RII) for each factor by using the following formula [8]:

$$RII = \frac{\sum PiUi}{(N)(n)} \quad \ldots (2.2)$$

Where, RII= relative importance index

Pi = respondent's rating given to each factor (ranging from 1 to 5)

Ui= number of respondents placing identical weighting (rating)

N = sample size (the total number of respondents)

n = the highest attainable score (in this case is 5)

The RII value is range from 0 to 1 which the higher the value of RII, the more important was the activity and impacts. The RII is then classified based on the RII classification table [9], as shown in the table below.

Table -2: Classification of RII

Scale	Level of Preference	RII
1	Not preferred at all	0.0 ≤ RII ≤ 0.2
2	Slightly preferred	0.2 < RII ≤ 0.4
3	Moderately preferred	0.4 < RII ≤ 0.6
4	Preferred	0.6 < RII ≤ 0.8
5	Most Preferred	0.8 < RII ≤ 1.0

The Spearman's rank correlation coefficient (ρ) was used to check the degree of agreement between the rankings of any two parties. The correlation coefficient varies between -1 and +1, where +1 implies a perfect positive relationship (agreement), while -1 results from a perfect negative relationship (disagreement).The result is interpreted as: If the rank is close to -1 implies negative correlation, close to 0 implies no linear correlation and close to +1 implies positive of good correlation.

The Spearman's (Rho) rank correlation coefficient for any two groups of ranking is given by the following formula [10]:

$$Rho\ (\rho) = 1 - 6 \times \frac{(\Sigma\ di2)}{N \times (N2 - 1)} \quad \ldots (2.3)$$

Where:

Rho (ρ) – Spearman's rank correlation coefficient

di – The difference between the ranks given by any two respondents for an individual factor.

N – Number of factors (variables)

3. RESULTS AND DISCUSSION

3.1 Profile of Survey Respondents

Initial analysis indicated that there were no significant differences in the responses from contractors' side and consultants' side. Their responses were therefore grouped together under "construction practitioners" in the analysis. The views of residents near construction sites were considered separately from that of the construction practitioners.

Table -3: Profile of survey respondents (construction practitioners)

Profile		Frequency	Percentage
Education	Below diploma	0	0%
	Diploma	14	14%
	B.Sc. degree	62	62%
	M.Sc. degree	24	24%
	PhD	0	0%
Position	Project Manager	28	28%
	Office Engineer	17	17%
	Site Engineer	17	17%
	Resident engineer	17	17%
	Forman	21	21%
Experience	Less than 5 years	41	41%
	5 to 10 years	21	21%
	Above 10 years	38	38%

Table -4: Profile of survey respondents (nearby residents)

Profile		Frequency	Percentage
Education	Below diploma	0	0%
	Diploma	11	27.5%
	B.Sc. degree	19	47.5%%
	M.Sc. degree	10	25%
	PhD	0	0%
Job	public/civil servants	17	42%
	business/self-employed people	15	38%
	unemployed	8	20%
Gender	Male	23	58%
	Female	17	42%

3.2 Site Activities adversely affecting the Environment

In this section, respondents in the two categories were asked to indicate the relative importance of site activities which had adverse environmental effect; and the result was presented in the Table -5 below.

Table -5: The relative importance index (RII) and rank of site activities adversely affecting the environment according to the two groups

Site Activities	Construction Practitioners		Nearby Residents		Average	Overall
	RII	Rank	RII	Rank	RII	Rank
Site clearance	0.53	6	0.50	7	0.52	7
Earthmoving	0.58	4	0.55	6	0.56	6
Demolishing	0.46	8	0.30	9	0.38	9
Excavation	0.59	3	0.65	3	0.62	3
Driving piles	0.39	10	0.20	10	0.30	10
Test drilling	0.42	9	0.35	8	0.39	8
Transportation	0.50	7	0.65	3	0.57	5
Landfill, compaction and leveling	0.54	5	0.65	3	0.60	4
Concrete batching, mixing and placement	0.60	2	0.90	1	0.75	2
Concrete vibration	0.61	1	0.90	1	0.76	1
Renovation /renewing	0.39	11	0.20	10	0.29	11

The perspectives of construction practitioners and nearby residents of the 11 site activities adversely affecting the environment were analyzed based on the relative importance index. The results are shown in Table -5 above. The relative importance index and ranks of site activities by all the respondents are presented in Table -5. Table -5 also illustrates the average relative importance index and ranks of site activities by all respondents.

Based on the overall's view (both construction practitioners and nearby residents), among site activities adversely affecting the environment: concrete vibration was indicated as the first site activity with the average RII of 0.76; concrete batching, mixing and placement was ranked as the second with the average RII of 0.75; excavation; Landfill, compaction and leveling and transportation were ranked third, fourth and fifth with the average RII of 0.62, 0.60 and0.57, respectively. Renovation/renewing was ranked as the last site activity adversely affecting the environment with the average RII of 0.29. The results show that renovation works have no serious environmental effect.

Based on the level of preference in classification of RII (Table -2), concrete vibration, concrete batching, mixing and placement and excavation were the preferred site activities by both groups of respondents which had the most adverse environmental effects. Landfill, compaction and leveling and transportation were moderately preferred site activities. Whereas renovation/renewing, driving piles, demolishing and test drilling were slightly preferred site activities by both groups of respondents.

The activities identified in this study are among those reported by the Ayarkwa [11] as resulting in environmental impacts. The results therefore indicate that if these activities can be controlled or carried out within acceptable levels, the adverse environmental impacts of construction activities can greatly be reduced.

3.2.1 Correlation Tests for Agreements on the Site Activities adversely affecting the Environment on Building Construction Projects

The purpose of this analysis was to check the degree of agreement between the rankings of two groups (construction practitioners and nearby residents) regarding site activities adversely affecting the environment on building construction projects. In this section, the degree of agreement between the rankings of two groups of respondents was checked using Spearman's rank correlation coefficient. The spearman's rank correlation coefficient (ρ) was calculated using equation 2.3 and the result obtained was (ρ=0.868).As indicated in the analysis part, this result is close to +1 and it implies that there is positive of good correlation between two groups. This means that construction practitioners and nearby residents have the same perception about the site activities adversely affecting the environment on building construction projects.

3.2.2 Cronbach's Alpha Coefficient Test Result on the Site Activities adversely affecting the Environment

Cronbach's alpha coefficient is generally used in acquiring reliability in terms of internal consistency. Reliability pertains to the consistency of scores. The less consistency within a given measurement, the less useful the data may be in the analysis. In this study, the researcher needed to understand score reliability because of the possible impact the reliability has on the interpretation of research results. Cronbach's alpha reliability coefficient normally ranges between 0 and 1. The closer Cronbach's alpha coefficient to 1.0, the greater the internal consistency of the items in the scale. In this study, Cronbach's alpha coefficient was calculated by using Standard Cronbach Alpha formula, indicated on (Equation 2.1) and the result obtained was (α = 0.98 or 98%). Therefore, the reliability test on site activities adversely affecting the environment resulted in (α = 0.98 or 98%). According to the classification performed by Manerikar and Manerika [7], this result indicates that 98% of the site activities answered by the respondents have excellent reliability (internal consistency).

3.3 The Mitigation Measures Taken by Construction Practitioners towards Environmental Impacts from Construction Site Activities

Following the scoping exercise and the identification of potential environmental effects, mitigation measures should be proposed to avoid or reduce potential negative impacts to air, water, land, ecology and humans, or to introduce and maximize positive aspects to the development [12].

According to Sadler and Verheem [13], environmental impact assessment (EIA) as a process to assess the environmental consequences of any project, is needed to design proper mitigation plans to minimize the possible adverse impacts.

The targeted survey respondents for this issue were only construction practitioners. Out of those respondents, only 14% were stated that there was environmental impact assessment (EIA) conducted for their project. Also regarding the implementation of the mitigation measures/alternatives stated in EIA report, from those respondents whose projects had EIA, 28.6% stated that the implementation was poor; 42.8% stated that the implementation was satisfactory; and 28.6% stated that the implementation was good. The implementation level of mitigation measures is summarized in figure -1 below.

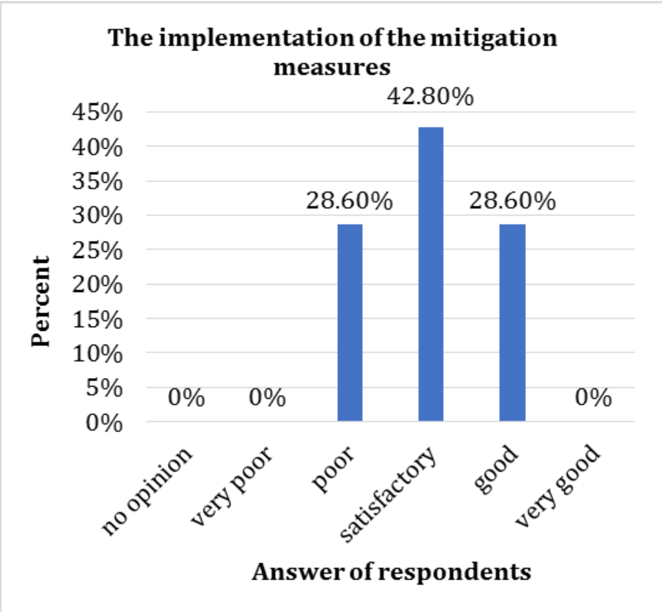

Fig -1: The implementation of the mitigation measures/alternatives stated in EIA report

Finally, the construction practitioners were asked to indicate if there was any mitigation measures taken by them towards negative environmental impacts in general, and accordingly, only 21% of the respondents stated that they had taken the mitigation measures towards negative environmental impacts from their respective project activities. The result shows that most of the construction practitioners (79%) had not taken any mitigation measures towards negative environmental impacts.

4. CONCLUSIONS

As it is recalled, the objective of this study was to identify the site activities adversely affecting the environment during the execution period of building construction. The results obtained from the analysis of the questionnaire survey have been discussed and presented in the previous chapter in detail. Therefore, based on the results, the following major conclusions have been derived and summarized:

Concrete vibration; concrete batching, mixing and placement; and excavation are the construction site activities that were found to have the most severe environmental effects in selected towns of SNNPRS preferred and agreed by all the respondents.

The results showed that only a few (14%) of the target group of respondents had Environmental Impact Assessment (EIA) conducted for their project; and also the implementation of the mitigation measures/alternatives stated in EIA report for those projects which had EIA was very less. In general, again only a few of the construction practitioners had taken the mitigation measures towards negative environmental impacts from their respective project site activities.

Construction organizations are called upon to carry out their activities such that the biodiversity value of the land is conserved, and where possible improved. Limits to hours of working must be enforced to reduce the adverse impact of site activities on local residents and businesses. There should also be specific restrictions on construction vehicles and machinery, and on piling works. Dusty materials have to be sprayed with water during dry weather and the loads of any vehicles carrying potentially dusty materials must be covered during transportation. The cutting and grinding of materials on site should also be controlled.

Finally, there is a pressing need for government to intervene in order that the use of sustainable construction designs and construction strategies that is environmentally friendly becomes the custom in Ethiopia. The paper therefore recommends that government with the support of stakeholders in the construction industry should come up with special legislations, codes or standards relating to sustainable construction practices specific to Ethiopia's construction environment to ensure its proper and effective implementation. Besides, all forms of construction activities should be subjected to an environmental impact assessment to determine the potential impacts and also come up with some mitigation measures before they are executed.

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