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Investigation of the Impacts of the Construction Industry on the Environment: The Case of Western Oromia National Regional State

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Abstract: Throughout the process of its development, construction operations have effects on the environment. These affects happen from the beginning of work on site through the development period, the operational period, and the ultimate devastation when a building comes to the conclusion of its existence. Indeed, in spite of the fact that the development retro is comparatively shorter in comparison to the other stages of building's life, it has assorted critical influences on the environment. This essay explores the main impacts of construction activities on the environment in waster Oromia, a national regional state. From the literature, forty-four negative impacts of construction activities on the environment have been identified. A cross-sectional survey was conducted after these impacts were further divided into ten main groups. Respondents' opinions were obtained through interviews and questionnaires. Questionnaires were distributed to one hundred professional respondents, who included 52 structural engineers, 29 quantity surveyors, and 14 architects. The respondents were asked to identify the greatest environmental impacts. The environmental impacts identified were evaluated and ranked by the relative impact index method. According to the results of the study, the respondents agreed that resource consumption groups are the highest ranked among the top ten groups impact of construction activities on the environment in the western Oromia national regional state. The paper makes recommendations for stakeholders in the construction sector to adapt regulations or standards to the construction environment in western Oromia national regional state and ensure their correct and efficient implementation.

Keywords: Construction Activities, Construction Industry, Environmental, Impacts, Western Oromia

1. Introduction

Environmental deterioration has captured the sector's attention and has been one of the most frequently mentioned topics locally, nationally, and globally. Langston and Ding posited that the world is in a crucial environmental disaster [1]. The environment is impacted by construction projects at every stage of the development process. These impacts happen from the beginning of work on site through the development period, the operational period, and the ultimate devastation when a building comes to the conclusion of its life. There are also big problems in the transportation, handling, and storage of materials during the construction phase [2]. Transportation is one of the required parts while working in construction. Notwithstanding, the effects of transportation can ultimately prompt issues in the environment. The issues brought about by transportation are depicted as immediate effects, circuitous effects, and combined impacts [3]. The construction industry has a huge impact on the environment and available resources. Furthermore, it harms the environment by polluting the air, land, and water. As a result, the necessity of mitigating such effects is critical [4].

Construction dust can also spread swiftly through the air due to its tiny particle size, which is dangerous. Deforestation and fossil fuel combustion both contribute to air pollution and global warming. These processes contribute to the depletion of natural resources and the emission of greenhouse gases into the atmosphere. Air pollution is one of the most serious environmental threats to human health [5].

Construction sites are significant causes of soil pollution in urban areas due to their almost ubiquitous nature [6]. In general, any chemical handled at construction sites may pollute the soil. [7].

According to a recent study, the construction sector is responsible for air pollution, drinking water pollution, climate change, and landfill waste [4]. When contaminants from building sites penetrate into the groundwater, the supply of human drinking water becomes polluted, making it far more difficult to clean than surface water [8]. The construction sector is one of the most polluting industries, generating between 30% and 40% of the worldwide environmental burden in terms of raw materials, direct and indirect energy consumption, waste, and carbon dioxide emissions [9]. Direct and indirect waste are two categories of construction waste. Construction activities produce a vast amount of waste, accounting for nearly 40% of all waste produced globally [10]. Most researchers have been working on finding or identifying the impact of construction activities on the environment. Nevertheless, the study of the construction sector's effects on the environment still requires more precise attention as the world [11]. As production initiatives keep growing, they're going to additionally create extra pollutants, which harm all communities [12]. In general, the building sector is one of the world's most resource-intensive and ecologically harmful industries [13]. Nowadays, there are impacts of construction activities on the environment due to the expansion of urbanization.

The objective of the study was to identify and rank the critical factors of construction activities on the environment in the case of western Oromia National Regional State from the perspectives of the three significant gatherings in construction, namely architecture, civil engineering, and quantity survey, to distinguish the significant effects of construction activities on the environment. The results of this research will help the overall society. Because construction companies continue to grow and become a much greater need in our society, they will continue to cause greater damage to the environment. Exposure to environmental harm may lead to health and quality-of-life problems.

2. Materials and Methodology

2.1. Description of the Study Area

The study was conducted in the western Oromia National Regional State, which is located in western Ethiopia in the central town of western Oromia (Nakamte town), 328km by road west of Addis Abbaba. Its geographical coordinates are between 10°00′00″N latitude and 35°00′00″E longitude.

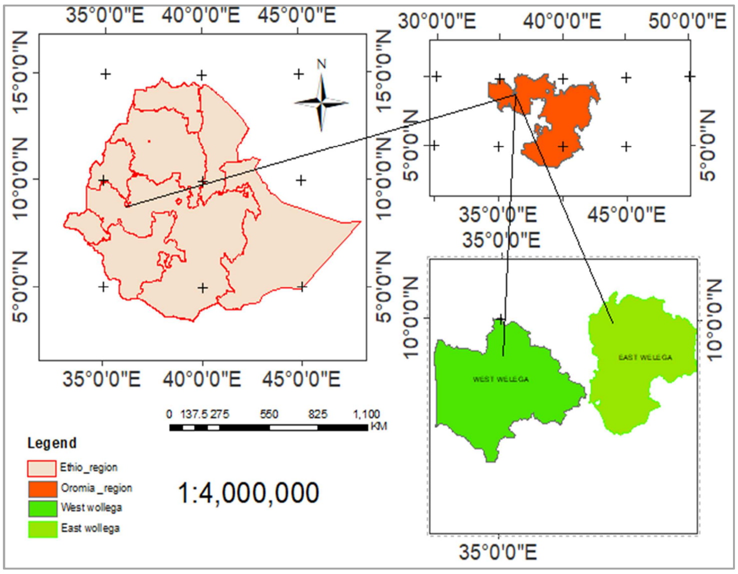

Figure 1. *Study area.*

2.2. Methods of Data Collection and Analysis Technique

The research methods used for this study were quantitative and qualitative. For this study, there will be two steps in the data collection procedure. The first step involves interviewing some of the professionals involved in the implementation process and searching the literature for information on how construction projects affect the environment in other nations. In order to gather data for the qualitative study, semi-structured interviews were performed with architects, structural engineers, and quantity surveyors in the second stage. Interviewing the experts will be crucial to verifying a preliminary set of construction activity impacts on the environment derived from the literature and identifying additional environmental impacts due to construction activities in the western Oromia regional state based on their experience. Additionally, semi-structured interviews and case studies were used in depth to investigate the particular circumstances of the research problem. The study sample is created using stratified sampling techniques, and the proposed sample size is n=N/1+N (e) 2, where n is the sample size, is the population’s total size, and e is the standard error of the sampling distribution. The entire population of 100 practitioners served as the study’s sample, and since we used a standard error of sampling distribution of =0.013, the results were n=100.034. The questionnaires evaluation was carried out using the chosen sample in order to collect the necessary data. A total of 100 questionnaires were distributed to the respondents: 53 structural engineers, 17 architects, and 30 quantity surveyors. The ranking of the attributes in terms of their criticality as perceived by the respondents was done using the Relative Impact Index method. The relative importance index values range from 0 to 1, and the group index is the average of the relative importance index of the identified factors. The values of the Relative Impact Index method range from 0 to 1 (0 not inclusive); the higher the Relative Impact Index method, the greater the impact of construction activities on the environment. The Relative Impact Index method value is ranked, and the results are shown using tables and text. Kendall's coefficient of concordance was used to determine whether there was a significant degree of agreement among the three groups of respondents.

3. Results

Findings related to respondents: out of 95 percent, architectural engineers are 14 percent; quantity surveyors are 29 percent; and structural engineers are 52 percent. From the respondents, 54 worked with contractors, 15 with consultants, and 26 worked with clients. Also, the educational qualifications of the respondents showed that most of them held a BSc. while some of them held an MSc, and of the total number of respondents, none of them held a Ph.D.

Table 1. *Result of Questionnaire Response Rate.*

Respondents	Distributed	Returned	Un returned In percent (%)	Valid	In percent (%)
Structural engineering	53	52	1.89%	52	98.11%
Quantity survey	30	29	3.45%	29	96.67%
Architectural engineer	17	14	17.65%	14	82.35%

The survey data, consisting of the forty-four causes of environmental deterioration, was identified and grouped into ten. These groups are: dust emission impacts due to construction activities; effective of biodiversity during construction work; water pollution from the construction industry; waste generation from construction materials; resource consumption for construction activities; noise and vibration pollution from construction machinery on site; accidents and incidents in the construction industry; transportation during construction work; green gas emissions after completion of building construction material; and impacts on public health due to the effects of construction activities on human health. The results are presented in Table 2, according to the three parties.

Table 2. *Overall of Relative Impact Index (RII) From respondents.*

Environmental Impacts		Architects		Structural Engineers		Quantity Surveyors		Overall	
		RII	Rank	RII	Rank	RII	Rank	RII	Rank
	Dust Emission								
1	From, soil, sand, and gravel dust.	0.743	6	0.69	6	0.779	4	0.738	8
2	From, wood dust.	0.657	15	0.61	19	0.655	16	0.641	28
3	From, silica dust.	0.657	15	0.57	26	0.586	23	0.605	33
4	From, non-silica mineral dust.	0.614	18	0.58	24	0.634	17	0.61	32
5	From, demolition dust.	0.914	1	0.66	13	0.779	4	0.784	2
6	From, drilling and blasting.	0.657	15	0.57	26	0.621	19	0.617	30
	Effect On Biodiversity								
7	Vegetation removal.	0.829	2	0.69	6	0.772	5	0.764	6
8	Loss of edaphic soil.	0.757	5	0.67	11	0.738	8	0.72	10
9	Potential soil erosion.	0.643	16	0.66	12	0.807	3	0.704	14
10	Interception of water bodies.	0.657	15	0.63	17	0.738	8	0.674	20
11	Interference with the ecosystems.	0.786	4	0.64	15	0.745	7	0.724	9
	Water Emission								
12	Water from cleaning tools.	0.8	3	0.64	16	0.621	20	0.685	17
13	From diesel and oil.	0.543	21	0.61	20	0.621	20	0.591	34
14	From other toxic chemicals.	0.514	22	0.6	22	0.628	18	0.579	35
15	Water emission, from dredging materials.	0.8	3	0.65	14	0.807	3	0.752	7
	Waste Generation								
16	Insulation and asbestos material wastes.	0.743	6	0.64	16	0.669	15	0.682	18
17	Concrete, bricks, tiles, and ceramics wastes.	0.714	8	0.7	5	0.731	9	0.716	11
18	Glass and plastic wastes.	0.8	3	0.69	6	0.628	18	0.707	13
19	Metallic wastes.	0.657	15	0.68	8	0.634	17	0.657	25
20	From cement bag.	0.7	9	0.72	4	0.69	12	0.702	16
21	Trees, earth, and rock from clearing sites.	0.829	2	0.72	3	0.779	4	0.776	3
22	Salvaged building components wastes.	0.586	19	0.67	10	0.71	10	0.655	26
23	Gypsum wastes.	0.657	14	0.62	18	0.703	11	0.661	23

Environmental Impacts		Architects		Structural Engineers		Quantity Surveyors		Overall	
		RII	Rank	RII	Rank	RII	Rank	RII	Rank
24	From wood wastes.	0.643	16	0.67	9	0.703	11	0.673	21
	Resource Consumption								
25	Water consumption.	0.729	7	0.75	2	0.828	2	0.768	5
26	Tree trunk.	0.729	7	0.72	4	0.869	1	0.771	4
27	Raw materials consumption.	0.79	4	0.77	1	0.828	2	0.794	1
	Noise And Vibration Pollution.								
28	From quarry site.	0.71	8	0.66	13	0.738	8	0.703	15
29	From machinery.	0.71	8	0.69	7	0.745	7	0.715	12
30	From vehicles.	0.67	12	0.64	15	0.703	11	0.672	23
31	From heavy equipment.	0.69	11	0.67	10	0.683	13	0.679	19
	Accident And Incident								
32	Fire outbreaks.	0.4	23	0.49	29	0.497	24	0.463	40
33	Breakage of service pipes.	0.51	22	0.52	28	0.497	24	0.51	38
34	Breakage of receptacles.	0.51	22	0.52	28	0.476	25	0.503	39
	Impact Due To Transportation								
35	Direct impacts	0.69	11	0.64	15	0.71	10	0.679	19
36	Indirect impacts	0.67	12	0.59	23	0.676	14	0.645	27
37	Cumulative impacts	0.67	12	0.63	17	0.676	14	0.658	24
	Greenhouse Gas Emissions								
38	GGE. From aluminum materials.	0.56	20	0.55	27	0.607	22	0.571	36
39	GGE. From concrete materials.	0.67	12	0.6	21	0.607	22	0.626	29
40	GGE. From steel materials.	0.66	15	0.58	25	0.607	22	0.614	31
	On Public Health								
41	Public safety.	0.66	15	0.61	20	0.71	10	0.658	24
42	Social disruption.	0.63	17	0.6	21	0.614	21	0.614	31
43	Public health effects.	0.67	12	0.6	21	0.703	11	0.658	24
44	Site hygiene condition.	0.19	24	0.66	12	0.759	6	0.538	37

4. Discussion

4.1. Group of Environmental Impacts Due to Resource Consumption

Raw material consumption has the highest impact on the environment due to construction activities. The results show that in the western Oromia national regional states, the groups of resources consumed are ranked in group one. Relatively, the World Watch Institute shows that building construction consumes 40 percent of raw stone, gravel, and sand and 25 percent of virgin wood per year. It also consumes 40 percent of energy and 16 percent of water in a year [14].

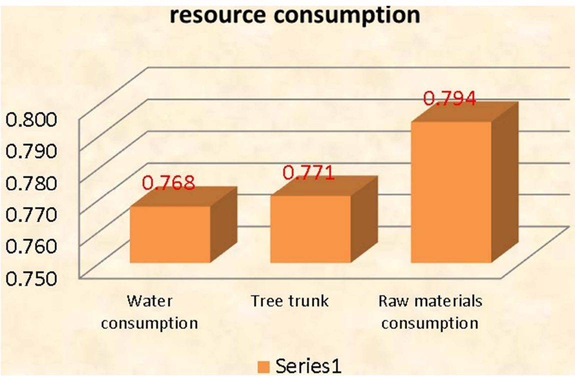

Figure 2. *Resource consumption group.*

4.2. The Group of Dust Emissions Impacts the Environment

According to respondents' rankings of the various negative impacts of construction activities in the western Oromia national regional state, dust emission is the second stage. This dust comes from during construction work, from soil, wood, silica mineral, non-silica mineral dust, and demolition dust. In the top ten environmental impacts groups, the group of dusts are assigned group two.

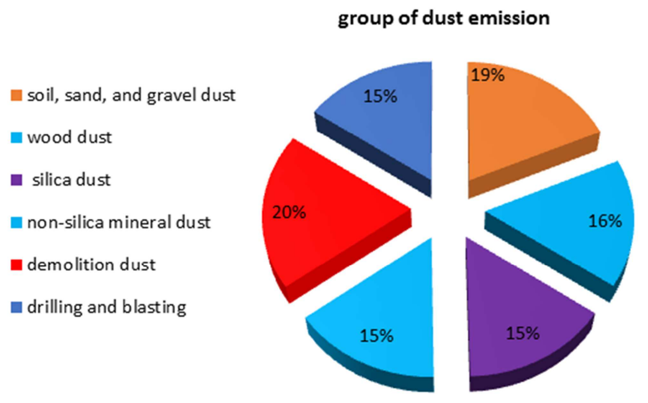

Figure 3. *Dust emission group.*

4.3. The Group, Impacts of Waste Generation on the Environment

From the top ten environmental impact groups in western Oromia regional state, the group of waste generation is the third critical environmental impact. According to the results, relatively, the research in Gahanna shows that waste generation is the fifth-ranking environmental impact from construction work [15].

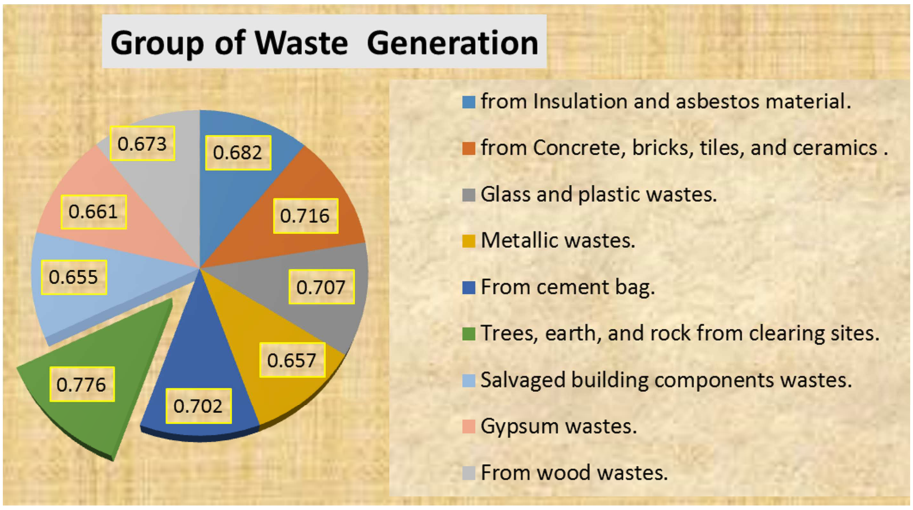

Figure 4. *Waste generation group.*

4.4. Impact of Biodiversity Groups

The effects of biodiversity due to the construction activity groups are ranked as the six greatest environmental impacts, according to the groups of respondents. In the category of biodiversity, vegetation removal has a high environmental impact during construction work. From the top ten groups of environmental impacts, the biodiversity impact groups are ranked in group four.

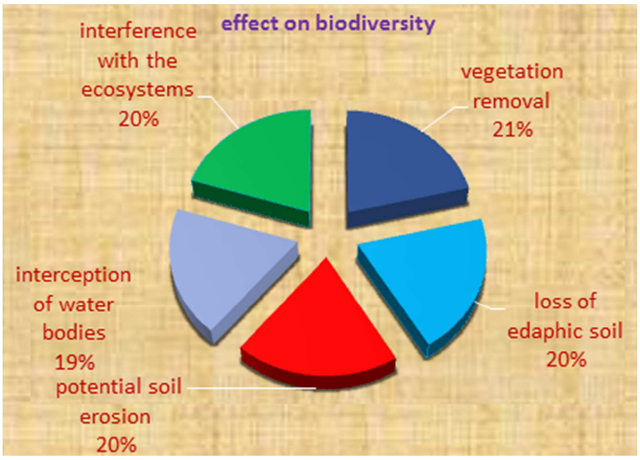

Figure 5. *Effect on the biodiversity group.*

4.5. Environmental Impact of a Group of Water Pollution

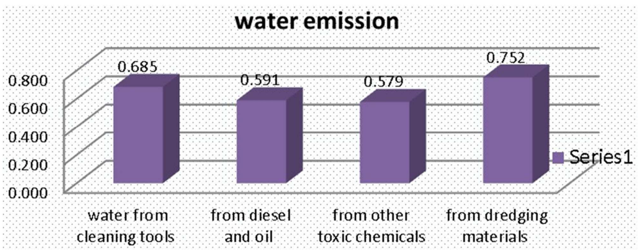

Figure 6. *Shows the water emission group.*

The water pollution groups were ranked fifth according to the three groups of respondents. As indicated by the respondents results, water pollution from construction activities impacts are the top ten environmental impact groups; water pollution is ranked to group five.

4.6. Group Noise and Vibration Pollution Impact on the Environment

The Impact of construction activities on the environment is noise and vibration pollution from construction machinery sites. From the top ten environmental impact groups, noise and vibration ranked in group six, according to research in western Oromia.

In China the Environmental Noise and Vibration Control Annual Report 2018 showed noise reports accounted for 35.3% of the total and ranked second, behind air pollution. According to the report of noise problems, building construction disturbed the public with a proportion of 43.0% [16] and another researcher showed in Congo that in the construction industry's pollution due to noise and vibration is in the 4th rank. [1].

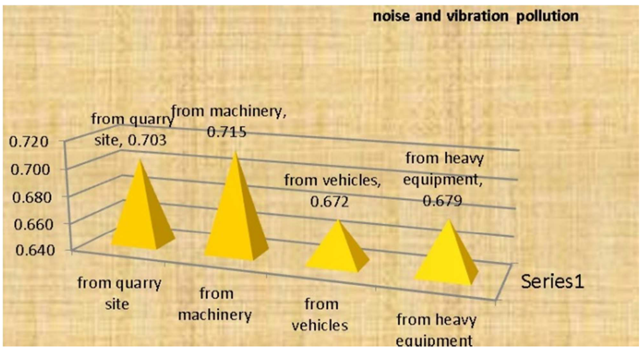

Figure 7. *Noise and vibration pollution.*

4.7. Group of Environment Impact Due to Transportation

The most significant environmental effects are related to construction work transportation. With an average relative importance index of direct impact of 0.679, indirect impact of

0.645, and cumulative impact of 0.658, and the overall ranks are 19, 27, and 24, respectively. From the top ten environmental impact groups, transportation ranked group seven.

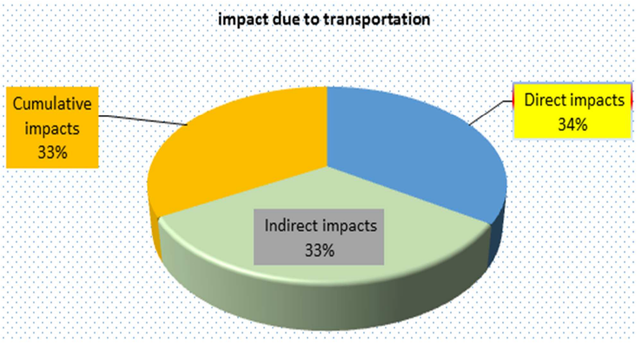

Figure 8. *Impact due to transportation.*

4.8. Construction Work Group Impacts on Public Health

When the three parties combined ranked the environmental impact of construction activities on public health, the construction work's effect on public health was ranked 24th, and from the group of environmental impacts, it was ranked 8th.

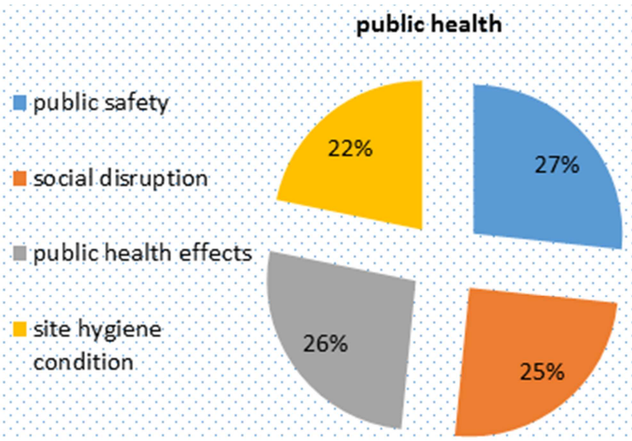

Figure 9. *Impact of construction work on public health.*

4.9. Group of Greenhouse Gas Emissions or Particulate Pollution

Greenhouse Gas Emission, or particulate pollution, was ranked the 29th most environmental impactful of construction activities. In the top ten environmental impact groups, greenhouse gas emissions are assigned to group nine.

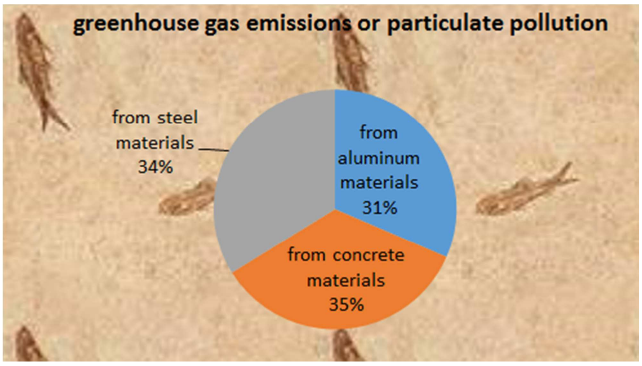

Figure 10. *Greenhouse Gas Emissions.*

4.10. Group of Accidents and Incidents Impacts on the Environment

According to the information the three parties, construction-related accidents and incidents ranked 38th in terms of environmental harm. Under this group of accidents an incidents, fire outbreaks average 0.463, breakage of service pipes 0.510, and breakage of receptacles 0.503. And the ranks were shown as 40, 38, and 39, respectively. From the top ten environmental impact groups, accidents and incidents are assigned to group ten.

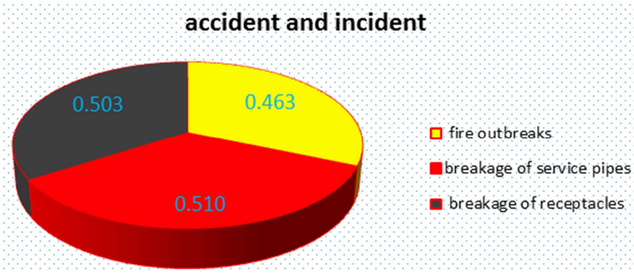

Figure 11. *Accidents and incidents.*

4.11. The Degree of Agreement for All Groups

Kendall's coefficient of concordance is used to measure the raters' agreement and decide whether there is a notable level of agreement amongst the three raters (quantity surveyors, structural engineers, and architects). Ho: There is no significant difference between the responses of the quantity surveyors, architects and structural engineers.

H1: The responses from structural engineers, quantity surveyors, and architects range significantly from one another. The table summarizes the results.

Table 3. *The result of group respondents relationship according to Kendall's Coefficient of Concordance.*

Environmental effects category	W	Chi-square	P-value	Judgment	degree of freedom
Dust emission	0.674	8.087	0.018	Reject Ho	2
effect on biodiversity	0.480	4.800	0.091	Retain Ho	2
water emission	0.077	0.615	0.735	Retain Ho	2
waste generation	0.029	0.514	0.773	Retain Ho	2
resource consumption	0.818	4.909	0.086	Retain Ho	2
noise and vibration pollution	0.054	0.429	0.087	Retain Ho	2
accident and incident	1.000	6.000	0.050	Reject Ho	2
impact due to transportation	0.778	4.667	0.097	Retain Ho	2
greenhouse gas emissions	0.778	4.667	0.097	Retain Ho	2

Environmental effects category	W	Chi-square	P-value	Judgment	degree of freedom
impacts on public health	0.417	3.333	0.187	Retain Ho	2

*At the ά=0.05 level, the agreement is significant.

According to Kendall's coefficient of concordance result related to samples of groups (architectural engineers, structural engineers, and quantity surveyors), the null hypothesis distribution is the same. So the decision excludes a group of dust emissions, accidents, and incidents. The p-value is greater than ά or the significance of it, thus, the inference is that there are no significant differences between the groups. As a result, the null hypothesis can be said to be sufficiently supported by the evidence. Consequently, there is a substantial level of consensus among the architects, structural engineers, and quantity surveyors regarding the impacts of construction activities on the environment in western Oromia.

The kruskal-wallis (kw) test was used to confirm the results of the kendall's coefficient of concordance test. the kruskal-wallis (kw) test is a statistical procedure for comparing the rank means of two or more samples. This test is designed to determine whether the respondents'' points of view differ significantly from one another about the severity of each effect that construction operations have on the environment. Ho: the responses from structural engineers, quantity surveyors, and architects do not significantly differ from one another. H1: The responses from structural engineers, quantity surveyors, and architects range significantly from one another. The outcomes the studies are shown in table 4.

Table 4. *The results of environmental impact groups according to the Kruskal-Wallis test.*

Group of environmental impacts	Kruskal-Wallis H	Sig.	Degree of freedom	Decision
Dust emission	3.364	0.186	2	Retain Ho
effect on biodiversity	3.393	0.183	2	Retain Ho
water emission	0.208	0.901	2	Retain Ho
waste generation	2.051	0.359	2	Retain Ho
resource consumption	5.263	0.072	2	Retain Ho
noise and vibration pollution	0.483	0.785	2	Retain Ho
accident and incident	7.385	0.025	2	Reject Ho
impact due to transportation	5.695	0.058	2	Retain Ho
greenhouse gas emissions	5.793	0.055	2	Retain Ho
impacts on public health	3.024	0.22	2	Retain Ho

*At the ά=0.05 level, the agreement is significant.

For all the environmental impact groups, as Table 4 displays, the P-values (Sig) for further groups are greater than a = 0.05 (a is the level of significance), excluding the groups of accidents and incidents of environmental impact groups. Hence, the null hypothesis, Ho, is not rejected, so there is sufficient evidence to support the null hypothesis. Thus, it can be concluded that there are no discernible disparities between the responses from the three practitioner categories about the environmental effects of construction activities. The preceding finding is supported by this outcome (Kendall's coefficient of concordance test). Therefore; it can be reliably revealed that all three respondent groups agree with each other regarding their perception of the impacts of construction activities in the western Oromia.

5. Conclusion

Construction activities impact on the environment in western Oromia was the focus of this study. The researchers wanted to hear from architects, quantity surveyors, and structural engineers about the environmental impacts of construction activities in western Oromia, a national regional state. Throughout the development life cycle, construction activities have an influence on the environment. From the literature, Forty-four construction activities with tangible impacts on the environment were identified. A cross-sectional survey was conducted after these impacts were further divided in to ten main groups.

Based on their overall relative impact index, the top ten environmental impact factors that all respondents agreed on are: (1) raw material consumption; (2) demolition dust; (3) waste generation from trees, stumps, earth, and rock from clearing sites; (4) tree trunks; (5) water consumption; (6) effects on biodiversity from vegetation removal; (7) water emission from dredging materials; (8) dust emission from soil, sand, and gravel dust; (9) effects on biodiversity, ecosystem interference; and (10) effects on biodiversity, loss of edaphic soil.

The findings also show that the natural resource consumption of environmental impact and consequence was the influential, as per every response.

The most major impact of construction activities on environmental deterioration was a second-rank group of dust emissions, according to all respondents. And the waste generation groups of environmental deterioration have a third rank. The environmental impacts of accidents and incidents are relatively low. The environment is weakening and degrading as a result of limited natural resources, a declining economy, growing population growth, and a lack of environmental consciousness. As a result, the government must act quickly to ensure that environmentally friendly development designs and practices become the standard in the western Oromia national regional state.

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Conflicts of Interest

The authors declare no conflicts of interest.

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