An evaluation of environmental impacts of construction projects

Evaluación de los impactos medioambientales de los proyectos de construcción

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Abstract

Construction sector is considered as one of the main sources of environmental pollution in the world. It has massive direct and indirect effects on the environment. Gaza Strip is witnessing widespread construction projects which increase the pressure on the ecosystem and generate various pollutants. Gaza Strip is suffering from weak and deteriorating ecosystems due to limited natural resources, deteriorating economic and political situation, escalating population growth, and lack of awareness of environmental issues. The aim of this paper is to assess the environmental impacts due to construction projects activities in Gaza Strip and propose some suggestions in curbing down these adverse impacts. A total of 50 questionnaires were distributed to professionals working in the construction industry. The environmental impacts are categorized into three safeguard subjects: ecosystems, natural resources and public impacts. The results of this study revealed that dust generation, noise pollution, operations with vegetation removal, and air pollution are the most significant environmental impacts of construction projects. The results also revealed that labors and those who are working in construction sector are the most slices of people exposing every day to health problems such as respiratory problems, liver, cancer, hearing impairment, hypertension, annoyance, sleep disturbance, and other cardiovascular adverse effects. In addition, the public impact was found as the most important category that affects the environment in Gaza Strip. It is recommended to enhance the knowledge and awareness of construction participants with regard to environmental impacts of construction and enact strict laws to attempt curbing down the adverse impacts of construction such as enforcing institutions to conduct environmental impact assessment (EIA) in the early stage of the projects. The results of this study can help decision makers to identify major construction impacts on environment and make environmentally friendly construction plans in the early stages of construction.

Keywords: Environment, construction, ecosystem, pollution

Resumen

El sector de la construcción es considerado mundialmente como una de las principales fuentes de contaminación medioambiental, pues produce enormes efectos negativos en el medioambiente ya sea directa o indirectamente. La Franja de Gaza está experimentando un aumento de los proyectos de construcción, incrementando la presión sobre el ecosistema al introducir y generar diversos contaminantes. Los ecosistemas de la Franja de Gaza se están debilitando y deteriorando debido a sus limitados recursos naturales, a su deteriorada situación política y económica, al crecimiento de la población y a la escasa conciencia sobre el cuidado del medioambiente. El objetivo de este trabajo es mejorar la conciencia pública sobre los impactos ambientales negativos causados por las actividades derivadas de los proyectos de construcción en la Franja de Gaza y proponer algunas sugerencias con la finalidad de reducirlos. Para ello se distribuyó un total de 50 encuestas entre profesionales que trabajan en la industria de la construcción. Los impactos ambientales se clasificaron en tres categorías: ecosistemas, recursos naturales e impacto en la comunidad. Los resultados del estudio revelaron que la generación de polvo, contaminación acústica, operaciones con remoción de la vegetación y la contaminación atmosférica son los impactos ambientales más significativos de los proyectos de construcción. Los resultados, además, revelaron que tanto los trabajadores como quienes laboran en el sector de la construcción son quienes más se exponen diariamente a problemas de salud como afecciones respiratorias y al hígado, cáncer, deterioro de la audición, hipertensión, molestias, trastornos del sueño y problemas cardiovasculares. Además, se encontró que el impacto social o impacto en la comunidad era la categoría más importante que afectaba al entorno en la Franja de Gaza. Se recomienda mejorar los conocimientos y la conciencia de los trabajadores de la construcción respecto de los impactos ambientales provocados por la construcción y promulgar leyes estrictas que conduzcan hacia la reducción de estos impactos negativos como obligar a las instituciones a realizar Evaluaciones de Impacto Ambiental (EIA) en las primeras etapas de la construcción. Los resultados de este estudio pueden ayudar a quienes toman las decisiones a identificar los principales impactos negativos de la construcción sobre el medioambiente y a formular planes de construcción amigables con el medio durante las primeras etapas de la construcción.

Palabras claves: Medioambiente, construcción, ecosistema, contaminación

1. Introduction

Environmental protection is an important issue in developed and developing countries (Tse, 2001). Construction is not an environmentally friendly process by nature (Li et al., 2010). Levin (1997) indicated that building construction and operations have a massive direct and indirect effect on the environment. Ijiga et al. (2013) stated that identifying the impacts of construction project on the environment is a task that needs to be accomplished to realize an effective environmental.

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Shen et al. (2005) claimed that construction is a main source of environmental pollution, compared with other industries. Li et al. (2010) agreed with Shen (2005) and maintained that any typical construction process involves using various construction equipment's and natural resources and generates many pollutants. Several writers (Morledge and Jackson, 2001; Ball, 2002; Chen et al., 2004; Lam et al., 2011; Zolfagharian, 2012) summarized these pollutants as noise, air pollution, solid and liquid waste, water pollution, harmful gases, and dust. Furthermore construction projects have become one of the driving forces for the national economy, whose energy consumption, environmental emissions, and social impacts are significant (Chang et al., 2011).

It has been reported that very few contractors and private developers spend efforts in considering the environment and developing the concept of recycling building materials (Lam, 1997), because most of them ranked completion time as their top priority and pay little attention to the environment (Poon et al., 2001). Zolfagharian (2012) concluded that the level of knowledge and awareness of project participants, especially project managers, with regards to environmental impacts of construction processes needs to be enhanced. Gangolells et al. (2011) agreed with Zolfagharian (2012) at this point and claimed that enhancing the identification of the major environmental impacts of construction processes will help to improve the effectiveness of environmental management systems. Unfortunately developing countries are suffering from the limited scientific data about the impacts of building materials and technologies on the environment and it is difficult to make informed choices aiming at reducing such impacts (Pittet and Kotak, 2009). This study aims to assess the environmental impacts due to construction projects activities in Gaza Strip and to propose some ideas in curbing down these adverse impacts.

2. Gaza Strip situation

The Gaza Strip is a very narrow and highly populated area along the coast of the Mediterranean Sea (360 km²) (Al-Agha 1995). Gaza Strip is suffering from a weak and deteriorating ecosystem because of the very limited natural resources, deteriorating economic situation, and escalating population growth. The United Nation Environment Programme (2009) reported that the war increased the pressure on environmental facilities and institutions in the Gaza Strip. There are significant volume of demolition debris that was generated and the serious damage done to the sewage system. Other adverse environmental impacts include the widespread destruction of agricultural areas, damage to smaller industrial enterprises and an increase in pollution discharged into the Mediterranean and into the groundwater (Enshassi et al., 2010).

Gaza strip is witness now a widespread of construction projects which cause a lot of problems and generate several pollutants. A research undertaken by Al-Agha (1997) discussed some of these impacts which hardly effect the environment, he clarified that this impact include noise pollution, air pollution, groundwater pollution,

soil salinization, and possible radioactive hazards. Enshassi (2000) stated that there is a massive need to take into account this pollutant and develop a green ethic which may upgrade the donors and developers intellectual to plan a project in an environmentally friendly way. Enshassi and Kochendoerfer (2013) recognised the necessity of monitoring the environmental situation in Gaza strip and making environmental assessment.

3. Impact of construction on the environment

Any development project plan to improve the quality of life has some built-in positive and negative impacts. The development project should be planned in such a manner that it has maximum positive impacts and minimum negative impacts on the environment (Kaur and Arora, 2012). Prediction of the environmental impacts of construction in the early stages of projects, may lead to improvements in the environmental performance of construction projects and sites (Gangoellis et al., 2011). It is expected that construction damages the fragile environment because of adverse impacts of construction. This impacts include resource depletion, biological diversity losses due to raw material extraction, landfill problems due to waste generation, lower worker productivity, adverse human health due to poor indoor air quality, global warming, acid rain, and smog due to emissions generated by building product manufacture and transport that consumes energy (Lippiatt, 1999). Environmental impacts are categorized into three safeguard subjects: ecosystems impacts, natural resources impacts and public impacts (Li et al., 2010; Chang et al., 2011; and Zolfagharian et al., 2012).

3.1 Ecosystem impact

In light of a large number of ongoing construction projects, the ecosystems impact of construction has become an important issue (Zolfagharian, 2012). These adverse environmental impacts like waste, noise, dust, solid wastes, toxic generation, air pollution, water pollution, bad odour, climate change, land use, operation with vegetation and hazardous emissions. Air emissions are generated from vehicular exhaust, and dust during construction (Kaur and Arors, 2012). This emissions include CO_2 , NO_2 , and SO_2 (Kaur and Arors, 2012; Li et al., 2010; Pittet and Kotak, 2012). Noise emissions are generated as a result of various construction equipment's, air compressors and vehicles. The construction equipment's and other sources will generate noise within the range of 70 to 120 DB within the vicinity of construction site (Kaur and Arors, 2012). Wastes are generated from construction activities, labors camps, sewage treatment plant, and other sources. The solid waste generated during operational phase is categorized as biodegradable, recyclable, inert/ recyclable and hazardous. Out of the total waste generated 50% of it would be biodegradable, 20% of the waste would be recyclable, 30% would be inert and it is assumed that a small quantity (0.3%) of it would be hazardous waste (Kaur and Arora, 2012).

Waste water is generated from construction activities, sewage, commercial activities, and other sources (Kaur and Arora, 2012).

3.2 Natural resources

Various natural resources are used during any typical construction process, this resources include energy, land, materials, and water (Shen et al., 2005). In addition, construction equipment operations consume a lot of natural resources, such as electricity and/or diesel fuel. Construction sector is responsible for consuming a high volume of natural resources and generation a high amount of pollution as a result of energy consumption during extraction and transportation of raw materials (Li et al., 2010; and Morel et al., 2001). Construction sector generate worldwide substantial environmental impacts. It contributes to about half of the total energy consumption of high-income countries and is responsible of a major share of greenhouse gas emissions also in developing nations (Stern et al., 2006; Asif et al., 2007; Cole, 1999; and Emmanuel, 2004). Some of the available statistics indicate that the construction and operation of the built environment accounts for: 12-16 % of fresh water consumption; 25% of wood harvested; 30-40 % of energy consumption; 40% of virgin materials extracted and 20-30% of greenhouse emissions (Macozoma, 2012).

3.3 Public impact

Most construction projects are located in a densely populated area. Thus, people who live at or close to construction sites are prone to harmful effects on their health because of dust, vibration and noise due to certain construction activities such as excavation and pile driving (Li et al., 2010). During the construction phase of a project, construction dust and noise are regarded to be two major factors that affect human health (Tam et al., 2004). Li et al. (2010) and Zolfaghrian et al. (2012) conducted a research about environmental impacts of construction in United States of America; they categorized the environmental impact into three safeguard categories: ecosystems, natural resources, and public impacts.

Li et al. (2010) stated that health damage accounts for 27% of the total impact, which is less than the ecosystem damage (65%), but far beyond the resource depletion (8%), which justifies the necessity of performing health damage assessment. Zolfaghrian et al. (2012) confirmed that transportation resources, noise pollution, and dust generation with construction machinery are the most risky environmental impacts on construction sites. Among the three environmental impacts, 'ecosystem impacts' has the greatest impact on the environment (67.5%) of total impacts. 'Natural resources impact' accounts for 21% of the total impacts, while 'public impact' consists of only 11.5% of the total impacts. Table 1 shows the list of selected impacts of construction projects on environment adopted from previous studies.

Tabla 1. Impactos medioambientales de los proyectos de construcción

Table 1. Environmental impacts of construction projects

Autor/Author Environmental impacts/ Impactos medioambientales		Muhwezi et al. (2012)	Zolfagharian et al. (2012)	Li et al. (2010)	Tam et al. (2006)	Enshassi (2000)	Pittet and Kotak (2012)	Chang et al. (2011)	Horvath (2004)	Kaur and Arora (2012)	Chen et al. (2000)	Eras et al. (2012)	Gangoilels et al. (2011)	Gangoilels et al. (2009)	Ijjah et al. (2013)	Tam et al. (2004)	Shen et al. (2005)	Svensson et al. (2006)
No.	Efecto en el ecosistema/Effect on Ecosystems																	
1	Contaminación por ruido o acústica/Noise pollution	✓	✓		✓	✓	✓			✓	✓		✓	✓	✓	✓	✓	✓
2	Generación de polvo con la maquinaria de construcción/Dust Generation with construction machinery	✓	✓											✓				
3	Contaminación del suelo/Land pollution		✓							✓		✓	✓	✓			✓	
4	Sustancias suspendidas en el agua tales como plomo y arsénico (Toxicidades transmitidas por el agua)/Waterborne suspended substances such as lead and arsenic (Waterborne toxicities)		✓	✓														
5	Contaminación del aire o atmosférica/Air pollution		✓		✓				✓	✓				✓	✓	✓	✓	
6	Uso del suelo/Land use	✓			✓		✓								✓			✓
7	Operaciones con remoción de la vegetación/Operations with vegetation removal		✓										✓	✓	✓			
8	Emisión de COV y CFC/Emission of VOC and CFC	✓	✓				✓						✓	✓				✓
9	Generación de residuos inertes/Generation of inert waste	✓	✓	✓	✓			✓		✓	✓		✓	✓	✓	✓	✓	
10	Operaciones con alto potencial de erosión del suelo/Operations with high potential soil erosion	✓	✓			✓							✓	✓	✓			
11	Contaminación del agua/Water pollution		✓		✓				✓	✓				✓	✓	✓	✓	
12	Generación de polvo por las actividades de construcción/Dust Generation from construction activities	✓	✓	✓	✓					✓	✓	✓	✓	✓	✓			
13	Agua inerte y contaminación de aguas interiores/Inert water & Inland water pollution		✓															✓
14	Contaminación química/Chemical pollution	✓	✓			✓		✓										
15	Landscape alteration/Alteración del paisaje		✓										✓	✓				
16	Toxic generation/Generación de tóxicos		✓				✓					✓		✓			✓	✓
17	Greenhouse gas emissions/Emisión de gases de efecto invernadero	✓	✓									✓	✓	✓	✓			
18	Climate change/Cambio climático					✓	✓								✓			✓
19	waste water discharge/Vertido de aguas residuales	✓		✓	✓			✓		✓	✓		✓	✓				
20	Ozone exhausting/Gases que agotan el ozono			✓			✓											✓
Author		Muhwezi et al. (2012)	Zolfagharian et al. (2012)	Li et al. (2010)	Tam et al. (2006)	Enshassi (2000)	Pittet and Kotak (2012)	Chang et al. (2011)	Horvath (2004)	Kaur and Arora (2012)	Chen et al. (2000)	Eras et al. (2012)	Gangoilels et al. (2011)	Gangoilels et al. (2009)	Ijjah et al. (2013)	Tam et al. (2004)	Shen et al. (2005)	Svensson et al. (2006)
21	Calentamiento global/Global warming			✓											✓			
22	Emisiones de CO ₂ , SO ₂ , CO y Nox/CO ₂ , SO ₂ , Co and Nox emissions			✓	✓		✓	✓	✓	✓	✓	✓						
23	Partículas en suspensión/Airborne suspended particles		✓	✓														
24	Acidificación y calor residual/Acidification and waste heat			✓			✓											✓
25	Eutrofización/Eutrophication			✓								✓						✓
26	Esmog fotoquímico/Photochemical smog			✓														
27	Consumo innecesario en edificaciones/Unnecessary building consumption				✓													
28	Los impactos ambientales de las edificaciones durante toda su vida útil están reconocidos como un problema grave para la industria de la construcción/Environmental impacts of buildings over their entire life cycle process have been recognized as a serious problem for the construction industry				✓

29	Malos olores/ <i>Bad odor</i>		√				√						√			√
30	Emisión de gases causada por el movimiento de los vehículos y de la maquinaria de construcción/ <i>Gas emissions due to construction machinery and vehicle movements</i>											√				
31	Vertido de aguas provenientes de la ejecución de las fundaciones y muros de contención/ <i>Dumping of water resulting from the execution of foundations and retaining walls</i>											√				
32	Vibraciones provocadas por las actividades de la obra/ <i>Vibrations due to site activities</i>											√	√			
33	Rotura de tuberías subterráneas (cables eléctricos, líneas telefónicas, tuberías de agua)/ <i>Breakage of underground pipes (electric power cables, telephone lines, water pipes)</i>	√	√									√				
Efecto sobre los recursos naturales/Effect on Natural Resources:																
34	Recursos para el transporte/ <i>Transportation resources</i>		√									√	√			
35	Use of water resources/ <i>Uso de recursos de agua</i>	√		√	√		√	√				√	√			
36	Extracción de materias primas/ <i>Extraction Of Raw Materials</i>		√										√			
37	Consumo de energía/ <i>Energy consumption</i>	√	√	√	√	√	√	√	√					√	√	√
38	Consumo de materias primas/ <i>Raw materials consumption</i>	√	√	√		√						√				√
39	Agotamiento de los recursos/ <i>Resource depletion</i>			√	√									√	√	√
40	Incremento del tráfico rutero externo por el transporte hacia la obra en construcción/ <i>Increase in external road traffic due to construction site transport</i>		√									√	√			
41	Agotamiento de combustibles fósiles/ <i>Depletion of fossil fuels</i>				√		√	√			√		√	√		√
42	Aguas subterráneas/ <i>Ground water</i>								√			√				
43	Deterioro de los recursos/ <i>Resource deterioration</i>		√			√										
44	Importante consumo de recursos renovables y no renovables/ <i>Substantial consumption of both renewable and non renewable resources</i>	√					√						√	√		√
45	Consumo de electricidad/ <i>Electricity consumption</i>		√				√	√				√	√	√		
Efecto en la comunidad/Effect on Public																
46	Condición higiénica de la obra/ <i>Site hygiene condition</i>		√									√	√			√
47	Public health effects/ <i>Efectos en la salud pública</i>		√	√					√							√
48	Victimas/ <i>Causalities</i>						√	√				√	√			√
49	Trastornos sociales/ <i>Social disruption</i>	√	√			√										
50	Seguridad pública/ <i>Public Safety</i>		√										√			√

4. Methodology

In order to unveil and determine the weightings of the environmental impacts of construction, a structured survey questionnaire was adopted. A non-probability convenience sampling method was used which involves choosing a sample that is accessible and willing to take part in the survey (Ijigah et al., 2013). The questionnaire was designed based on previous studies (Zolfagharian et al., 2012; Ijigah et al., 2013; Muhwezi et al., 2012; Li et al., 2010; Tam et al., 2006; Pittet and Kotak, 2012; Chang et al., 2011; Horvath, 2004; Kaur and Arora, 2012; Chen et al., 2000; Eras et al., 2012; Gangoellis et al., 2011; Gangoellis et al., 2009; Tam et al., 2004; Shen et al., 2005; Svensson et al., 2006).

A total of 50 environmental impacts of construction were identified and used as the basis of the questionnaire. These 50 factors were further grouped under three major categories: ecosystem, natural resources, and public impacts.

Content validity test was conducted by sending the questionnaire to three experts in construction to evaluate the questionnaire validity, clarity, comprehensive, readability and reliability, or to add more information or to delete unacceptable wording if needed. The experts notes were taken into consideration by merging two impacts into one impact (dust from construction activities and dust generation with construction machinery were merged to be dust generation). Also flooding and effects of construction on the wild life were removed; because it's not applied in Gaza Strip. The target population of the study comprised of governmental institutions, private institutions, and international institutions. A total of 50 questionnaires were distributed to them, and 40 were retrieved which were used for the analysis, giving a response rate of 80%.

The respondents were invited to rate their opinion according to five-point Likert scale (1 = very low effect, 2 = low effect, 3 = neutral effect, 4 = strong effect, and 5 = very strong effect). Likert scale was chosen in order to expand the way the respondents would reply. The Relative Importance Index (RII) was calculated (Enshassi, 2009). The RII for each factor and category was computed by SPSS Software version 20. The importance index formula can be described as follows:

$$(RII) = \sum w / (A * N) \quad (1)$$

Where w is the weighting given to each factor by the respondent, ranging from 1 to 5; '1' is the least strong effect and '5' is the extremely strong effect, A is the highest weight; in this study it is 5; and N is the total number of samples. The relative importance index value ranges from 0 to 1. The group index is the average of relative importance index of the identified factors.

5. Results and discussion

Sample Profile

As shown in Table 2 the response rates of governmental institutions, private institutions, and international institutions were 90%, 82.3%, and 61.5% respectively.

Tabla 2. Tasa de respuesta del cuestionario
Table 2. Response rate of questionnaire survey

Categoría de la institución Institution /Category	Distribuidos /Distributed	Recibidos/ Received	Tasa de respuesta/Response rate (%)
Gubernamental/Governmental	20	18	90
Privada/Private	17	14	82.3
Internacional/International	13	8	61.5
Total	50	40	80

Table 3 illustrates the institution profile. The percentages of works types were 55%, 25%, and 20% for buildings, roads, and water respectively. It could be noted that the majority of works types were buildings (55%). Table 3 also shows that 25 % of the respondents have an experience less than 5 years, 40% have an experience from 5 years to 15 years, 22.5% have an experience from 16 years to 25 years, and only 12.5 % have experience over than 25 years.. 42.5% of the institutions haven't any permanent engineers' team for environmental impact assessment (EIA). The results also show that 25 % of the institutions had executed less than 10 projects in the last 5 years, 25% had executed from 11 to 20 projects in the last 5 years, 20% had executed from 21 to 30 projects in the last 5 years, and 30% had executed more than 30 projects in the last 5 years.

Tabla 3. Perfil de la institución**Table 3.** Institution profile

Item	Categoría/Category	Frecuencia/ Frequency	Porcentaje/Percentage
Tipo de obra/Types of works	Edificación/Buildings	22	55%
	Caminos/Roads	10	25%
	Agua y alcantarillado/Water and sewer	8	20%
	Otra/Another	0	0%
Experiencia de la institución/Experience of the institution	Menos de 5 años/Less than 5 years	10	25%
	Entre 5 años – 15 años/From 5 years – 15 years	16	40%
	Entre 16 años – 25 años/From 16 years – 25 years	9	22.50%
	Over 25 years	5	12.50%
Número de ingenieros permanentes en el equipo de EIA/ Number of permanent engineers in EIA team:	Menos de 5/Less than 5	15	37.50%
	Más de 5/More than 5	8	20%
	Ninguno/No one	17	42.50%
Número de proyectos ejecutados en los últimos 5 años/ Number of executed projects in the last 5 years	Menos de 10 proyectos/Less than 10 projects	10	25%
	Entre 11 – 20 proyectos/From 11 – 20 project	10	25%
	Entre 21 – 30 proyectos/From 21 – 30 projects	8	20%
	Más de 30 años/More than 30 years	12	30%

As shown in Table 4 the majority of respondents (62.5 %) work as site/office engineer. About the educational qualification of the respondents, the results show that 60%, 24.5%, and 12.5% of the respondents have B.Sc, Master, and PhD respectively. The results also indicated that 25 % of the respondents have experience less than 5 years, 40% have experience from 5 to 10 years, 22.5% have experience from 11 to 15 years, and only 12.5% have experience more than years.

Tabla 4. Perfil del encuestado**Table 4.** Respondents profile

Item	Categoría/Category	Frecuencia/ Frequency	Porcentaje/Percentage
Cargo del encuestado/ <i>Position of the respondent</i>	Director	4	10%
	Administrador de Proyectos/ <i>Project manger</i>	10	25%
	Ingeniero oficina/obra/ <i>Site/Office Engineer</i>	25	62.50%
	Ingeniero en equipo de evaluación/ <i>Engineer in evaluation team</i>	1	2.50%
Nivel de educación/ <i>Educational qualifications</i>	BSc	24	60%
	Master	11	27.50%
	PhD	5	12.50%
Años de experiencia/ <i>Experience years</i>	Menos de 5 años/ <i>Less than 5 years</i>	10	25%
	Entre 5 años – 10 años/ <i>From 5 years – 10 years</i>	16	40%
	Entre 11 años – 15 años/ <i>From 11 years – 15 years</i>	9	22.50%
	Más de 15 años/ <i>More than 15 years</i>	5	12.50%

As shown in Table 5 more than half (52.5%) doesn't take into account the adverse impacts of construction on the environment. The majority of institutions (72.5%) did not have an environmental impact assessment system. This means that the awareness of institution regarding the environmental impacts of construction needs to be enhanced. However 42.5% percent of them attempted to find a practical solution to mitigate the environmental impacts of construction. The results revealed that the majority of labors (62.5%) did not wear the protective respirator masks; this means that they are exposing every day to construction pollutants, and breathe a lot of dust, gases emissions and chemical pollutants. These pollutants may be a strong reason to deteriorate their health, and lead them to suffer from many diseases especially respiratory diseases. Also, results showed that only 10 % percent of labors and residents have been complained because of the impacts of construction on the environment.

Tabla 5. Nivel de conciencia de la institución sobre los impactos medioambientales provocados por la construcción**Table 5.** The institution level of awareness of the environmental impacts of construction issue

Pregunta/Question	Respuesta/Response	Frecuencia/Frequency	Porcentaje/Percentage
¿Su institución considera los impactos negativos que provoca la construcción sobre el medioambiente?/Does your institution take into account the adverse impacts of construction on the environment?	Si/Yes	15	37.5 %
	No	21	52.5 %
	No está seguro/Not Sure	4	10 %
¿Su institución cuenta con un sistema de evaluación medioambiental?/Does your institution have an environmental impact assessment system?	Si/Yes	8	20 %
	No	29	72.5 %
	No está seguro/Not Sure	3	7.5 %
¿Su institución trata de proponer o poner en práctica soluciones para mitigar los impactos medioambientales provocados por la construcción?/Does your institution attempt to find a proposal or a practice solution to mitigate the environmental impacts of construction?	Si/Yes	20	42.5 %
	No	17	50 %
	No está seguro/Not Sure	3	7.5 %
¿Los trabajadores o vecinos que viven cerca de la obra han sufrido algún tipo de daño por los impactos medioambientales provocados por la construcción?/Have any labors or residents who are living beside the project ever harmed because of the impacts of construction on the environment?	Si/Yes	16	40 %
	No	21	52.5 %
	No está seguro/Not Sure	3	7.5 %
¿Los trabajadores usan máscaras protectoras nasales?/Do labors wear a protective respirator masks?	Si/Yes	11	27.5 %
	No	25	62.5 %
	No está seguro/Not Sure	4	10 %
¿Algún trabajador o vecino ha reclamado por los impactos medioambientales provocados por la construcción (ruido, residuos sólidos, polvo)?/Have any labors or residents ever complained because of the impacts of construction on the environment (noise-solid waste-dust)?	Si/Yes	4	10 %
	No	29	72.5 %
	No está seguro/Not Sure	7	17.5 %

Information about the environmental situation of Gaza Strip

The results in Table 6 revealed that the majority of respondents (60%) have suffered personally from the adverse impacts of construction on the environment. This means that the situation in Gaza Strip is very serious and need to be controlled. The majority of respondents (72.5%) also mentioned that the war contributed the environmental pollution.

Tabla 6. Información sobre la situación medioambiental de la Franja de Gaza
Table 6. Information about the environmental situation of Gaza strip

Pregunta/Question	Respuesta/Response	Frecuencia/Frequency	Porcentaje/Percentage
Personalmente, ¿ha sufrido alguna vez algún tipo de impacto medioambiental provocado por la construcción (ruido, residuos sólidos, polvo)?/Have you ever suffered personally from the adverse impacts of construction on the environment (noise-dust-pollution)?	Si/Yes	24	60 %
	No	12	30 %
	No está seguro/Not Sure	4	10 %
¿Vive cerca de alguna casa demolida que haya sido dañada por la guerra en Gaza?/Are you living closed to any demolished houses which have been damaged through the war on Gaza?	Yes	11	27.5 %
	No	27	67.5 %
	No está seguro/Not Sure	2	5 %
¿Ha contribuido la guerra a la contaminación ambiental (agua, aire, suelo)?/Did the war contribute the environmental pollution (water-air-soil)?	Yes	29	72.5 %
	No	9	22.5 %
	No está seguro/Not Sure	2	5 %
¿Ha sufrido de algún tipo de problema de salud debido a su exposición a contaminantes medioambientales generados por la construcción?/Have you ever suffered from any health problem because of your exposure to pollutants which generated from construction on the environment?	Yes	11	27.5 %
	No	29	72.5 %
	No está seguro/Not Sure	0	0 %

Tabla 7. Impactos medioambientales de la construcción
Table 7. Environmental impacts of construction

Nº	Impacto en el medioambiente/ <i>Environmental impact</i>	Grado de efecto/ <i>Degree of effect</i>					Total Respuesta/ <i>Total respond.</i>	Desv. Estándar / <i>St.Dev.</i>	Ponderación/ <i>Weight</i>	IIR/ <i>RII</i>	Rango en el grupo/ <i>Rank in the group</i>	Rango gral/ <i>Over all Rank</i>
		5	4	3	2	1						
Efecto en los ecosistemas/ <i>Effect on Ecosystems:</i>												
1	Generación de polvo/ <i>Dust Generation</i>	15	23	2	0	0	40	10.46422	173	0.865	1	1
2	Contaminación por ruido o acústica/ <i>Noise pollution</i>	13	19	6	2	0	40	7.905694	163	0.815	2	2
3	Operaciones con remoción de vegetación/ <i>Operations with vegetation removal</i>	13	13	14	0	0	40	7.314369	159	0.795	3	3
4	Contaminación del aire o atmosférica/ <i>Air pollution</i>	7	24	9	0	0	40	9.823441	158	0.79	4	4
5	Contaminación del suelo / <i>Land pollution</i>	2	24	13	1	0	40	10.36822	147	0.735	5	9
6	Emisiones de gases por la maquinaria de construcción y vehículos en movimiento/ <i>Gas emissions due to construction machinery and vehicle movements</i>	11	11	11	7	0	40	4.795832	146	0.73	6	10
7	Rotura de tuberías subterráneas (cables eléctricos, líneas telefónicas, tuberías de agua)/ <i>Breakage of underground pipes (electric power cables, telephone lines, water pipes)</i>	10	11	13	6	0	40	5.147815	145	0.725	7	11
8	Contaminación del agua/ <i>Water pollution</i>	6	19	8	7	0	40	6.892024	144	0.72	8	12
9	Alteración del paisaje/ <i>Landscape alteration</i>	8	11	16	5	0	40	6.041523	142	0.71	9	15
10	Partículas en suspensión trasportadas por el aire / <i>Airborne suspended particles</i>	6	13	16	5	0	40	6.442049	140	0.7	10	17
11	Generación de residuos inertes/ <i>Generation of inert waste</i>	5	11	21	3	0	40	8.306624	138	0.69	11	20
12	Sustancias suspendidas en el agua como plomo y arsénico (toxicidades trasportadas por el agua)/ <i>Waterborne suspended substances such as lead and arsenic (Waterborne toxicities)</i>	6	10	19	5	0	40	7.106335	137	0.685	12	21
13	Vibraciones causadas por las actividades de la obra/ <i>Vibrations due to site activities</i>	3	15	16	6	0	40	7.17635	135	0.675	13	25
14	Malos olores/ <i>Bad odor</i>	5	13	14	8	0	40	5.787918	135	0.675	14	26
15	Emisiones de CO ₂ , SO ₂ , CO and NO _x /CO ₂ , SO ₂ , Co and Nox emissions	5	11	18	6	0	40	6.819091	135	0.675	15	27
16	Emisión de gases de efecto invernadero/ <i>Greenhouse gas emissions</i>	6	11	15	8	0	40	5.612486	135	0.675	16	28
17	Cambio climático/ <i>Climate change</i>	8	8	13	11	0	40	4.949747	133	0.665	17	31
18	Uso del suelo/ <i>Land use</i>	8	8	13	11	0	40	4.949747	133	0.665	18	32
19	Generación de tóxicos/ <i>Toxic generation</i>	10	5	14	9	2	40	4.636809	132	0.66	19	33
20	Contaminación química/ <i>Chemical pollution</i>	8	5	18	8	1	40	6.284903	131	0.655	20	34
21	Acidificación y calor residual/ <i>Acidification and waste heat</i>	6	8	16	10	0	40	5.830952	130	0.65	21	35
22	Calentamiento global/ <i>Global warming</i>	8	5	16	11	0	40	6.041523	130	0.65	22	36
23	Vertido de aguas provenientes de la ejecución de las fundaciones y muros de contención/ <i>Dumping of water resulting from the execution of foundations and retaining walls.</i>	3	11	18	8	0	40	7.035624	129	0.645	23	37

N°	Impacto en el medioambiente/Environmental impact	Grado de efecto/Degree of effect					Total Respuestas/Total respond.	Desv. Estándar /St.Dev.	Ponderación/Weight	IIR/RII	Rango en el grupo/Rank in the group	Rango gral/Overall Rank
		5	4	3	2	1						
24	Descarga de aguas residuales/Waste water discharge	2	16	9	13	0	40	6.892024	127	0.635	24	38
25	Emisión de VOC y CFC/Emission of VOC and CFC	2	16	9	13	0	40	6.892024	127	0.635	25	39
26	Gases que agotan el ozono/Ozone exhausting	5	6	19	10	0	40	7.106335	126	0.63	26	41
27	Consumo innecesario de la edificación/Unnecessary building consumption	5	5	19	11	0	40	7.28011	124	0.62	27	42
28	Esmog fotoquímico/Photochemical smog	5	3	21	10	1	40	8	121	0.605	28	43
29	Eutrofización/Eutrophication	3	10	14	11	2	40	5.244044	121	0.605	29	44
30	Aguas inertes y contaminación de aguas interiores/Inert water & Inland water pollution	2	6	22	10	0	40	8.717798	120	0.6	30	45
31	Operaciones con riesgo potencial de erosión del suelo/Operations with high potential soil erosion	1	10	16	13	0	40	7.17635	119	0.595	31	46
Efecto sobre los recursos naturales/Effect on Natural Resources												
32	Consumo de materias primas/Raw materials consumption	10	16	14	0	0	40	7.615773	156	0.78	1	7
33	Incremento del tráfico rutero externo por el transporte hacia la obra en construcción/Increase in external road traffic due to construction site transport	8	17	13	2	0	40	7.17635	151	0.755	2	8
34	Consumo de energía/Energy consumption	3	19	16	2	0	40	8.803408	143	0.715	3	13
35	Deterioro de los recursos/Resource deterioration	5	17	13	5	0	40	6.855655	142	0.71	4	16
36	Importante consumo de recursos renovables y no renovables/Substantial consumption of both renewable and nonrenewable resources	5	14	16	5	0	40	6.745369	139	0.695	5	19
37	Uso de los recursos de agua/Use of water resources	2	19	13	6	0	40	7.905694	137	0.685	6	22
38	Contaminación de aguas subterráneas/Ground water pollution	14	3	11	10	2	40	5.244044	137	0.685	7	23
39	Consumo de electricidad/Electricity consumption	3	11	24	2	0	40	9.874209	135	0.675	8	29
40	Recursos para el transporte/Transportation resources	3	13	19	5	0	40	7.81025	134	0.67	9	30
41	Extracción de materias primas/Extraction of raw materials	2	15	11	12	0	40	6.595453	127	0.635	10	40
42	Agotamiento de los combustibles fósiles/Depletion of fossil fuels	0	10	17	13	0	40	7.713624	117	0.585	11	47
Efecto en la comunidad/Effect on Public:												
43	Trastornos sociales/Social disruption	8	22	10	0	0	40	9.055385	158	0.79	1	5
44	Condición higiénica de la obra/Site hygiene condition	14	11	13	2	0	40	6.519202	157	0.785	2	6
45	Efectos sobre la salud pública/Public health effects	8	10	19	3	0	40	7.314369	143	0.715	3	14
46	Víctimas/Casualties	6	17	10	5	2	40	5.787918	140	0.7	4	18
47	Seguridad pública/Public Safety	0	24	11	3	2	40	9.874209	137	0.685	5	24

Environmental impact on construction

Effects on ecosystem

As shown in Table 7 the respondents ranked "dust generation" is in the first position with RII= 0.865. This means that dust is the most important impact that affects the environment in Gaza strip. There are three types of dusts, these are:

Dust because of vehicles: vehicles entrance and exist to the site is very important task, which generate a large amount of pollutants. Transport materials to site of work cause a large amount of dust. Also vehicles wheels contain large amount of suspended materials such as dust, sand, clay, and cement. These dusts are suspended with air, soil and water. Furthermore vehicles transport this dusts out the site, this means that not only the labors will harm, but also the public.

Dust because of construction activities: The majority of construction activities causes an adverse effect on the environment, and generates a large amount of dust. These activities such as excavation, backfill, earthworks, bleaching, painting, tiling, mix of concrete, and finishing works.

Dust because of construction materials: These materials include cement, aggregate, sand, clay, lime, wood and calcium carbonate. Manufacture these materials caused a capture exposure to its emissions. This means that workers, managers in factories, and neighbors of these factories are the most injured people. Also labors who are working in the site and using these materials in their work are suffering from high exposure to the dust of these materials.

There is a lot of people exposing and breathing dust every day regardless they are labors, residents, or those who are using roads near to construction sites. Respondents in Gaza believed that this pollutant is very dangerous, serious, and have an adverse effect on public health and environment. The risk of exposure to dust regardless to its cause (from vehicles, construction activities, construction materials manufacture or delivery) is because dust create health problems, particularly for those with respiratory problems, cause environmental degradation, including air, soil and water pollution, obscures vision, damage or dirty property and belongings, and create unsafe working conditions.

Baby et al. (2008) as cited by Singh (2011) demonstrates that cement dust contains heavy metals like nickel, cobalt, lead, and chromium, pollutants hazardous to the biotic environment, with adverse impact for vegetation, human and animal health and ecosystems. Several studies have demonstrated linkages between cement dust exposure, chronic impairment of lung function and respiratory symptoms in human population. Cement dust irritates the skin, the mucous membrane of the eyes and the respiratory system. Its deposition in the respiratory tract causes a basic reaction leading to increased pH values that irritates the exposed mucous membranes (Zeke et al., 2010). Occupational cement dust exposure has been associated with an increased risk of liver abnormalities, pulmonary disorders, and carcinogenesis. Decreased antioxidant capacity and increased plasma lipid peroxidation have been posed as possible causal mechanisms of disease (Aydin et al., 2010).

Ijigah et al. (2013) conducted his research in Nigeria, and found that "dust generation" is in 11th position with $RII=0.752$, and "destruction of vegetation" is ranked in the 1st position with $RII=0.841$. Li X et.al (2010) conducted his research in USA, and found that "dust generation" is in the second position, and "Steel Use" is in the first position. This result indicated that peoples in USA believed that dust is a very important impact that affects the environment. Zolfagharian et al. (2012) conducted his research in Malaysia, and found that "dust generation" is in the 3rd position, and "transportation resources" is ranked in the 1st position. The respondents stated that construction "noise" is in the second position with $RII=0.815$. The results can be due to the absence of strict laws to mitigate noise in Gaza strip. In addition Gaza is threat of conflict from decades, this means that people in this area are suffering from several causes of noise. The major causes of noise are grouped into three categories:

- Noise from vehicles movement (e.g., material transportation)
- Noise from construction activities (e.g., excavation, backfill)
- Noise from construction tools (e.g., concrete mixer, grinders)

Labors in the site are using tools such as: concrete mixer, concrete breakers, compactors, sanders, grinders and disc cutters, hammer drills, and chainsaws are the most people who are suffering from exposure to construction noise. Also residents who are living beside the sites of construction works and those who are using the roads near to sites are suffering from the noise of construction. That means that a lot of people are suffering every day from construction noise, in light of the widespread of construction process in Gaza strip.

The respondents also believed that noise can cause hearing loss, which can be temporary or permanent, stress, annoyance, accidents if it makes it difficult for workers to communicate effectively or stops them hearing warning signals. The respondents indicated that construction noise can cause social disruption to them at their homes, works, and when they are trying to sleep. Construction noise has the potential to disturb people 24 hours a day, 7 days a week. Noise health effects are the health consequences of elevated sound levels. Elevated workplace or other noise can cause hearing impairment, hypertension, ischemic heart disease, annoyance, and sleep disturbance. Changes in the immune system and birth defects have been attributed to noise exposure (Passchier-Vermeer and Passchier, 2000). Noise exposure also has been known to induce tinnitus, hypertension, vasoconstriction, and other cardiovascular adverse effects (WRUC, 2007). Ijigah et al. (2013) conduct his research in Nigeria, and found that "Noise Pollution" was ranked in 6th position with $RII=0.794$. Zolfagharian et al. (2012) conducted his research in Malaysia, and found that "Noise Pollution" in the 2nd position.

Effects on material resources

As shown in Table 7 the respondents ranked "raw material consumption" is in the first position in materials resource category with $RII=0.78$. This means that raw material consumption is one of the most important impacts that affect the environment in Gaza strip. This finding can be interpreted that construction process needs a lot of raw materials such as sand, gravel, clay, calcium carbonate, water, aggregate, wood, iron, bitumen, aluminum and fuel for vehicles. In light of the widespread of construction growing in Gaza strip, this raw material is endangered by depletion. This means that raw materials use need to be controlled. Zolfagharian et al. (2012) conducted a research about the impacts of construction projects on environment in Malaysia, and found that "raw material consumption" is in the 7th position. This result indicated that construction participants in Malaysia controlled the use of raw materials in construction.

The respondents ranked that "Increase in external road traffic due to construction site transport" is in the second position in material resource category with $RII=0.755$. The results can be due the high movement of construction vehicles which carrying construction materials, and transportation of construction tools and labors every day. This movements may affect the residents of this roads, and cause detriment to those people who are using this roads, by disrupt their interest, noise emissions, dust emissions, vehicles exhausts, traffic disruption and vibration.

Effects on public

As illustrated in Table 7 the respondents ranked social disruption is in the first position in public effects category with $RII=0.79$. This result can be interpreted as construction works cause closure of roads and disrupt people's interests. Construction transportation causes traffic disruption, because of the closure of roads. In addition, respondents stated that construction noise and vibration which produced by construction activities and construction vehicles movement can cause social disruption to them at their homes, works, and when they are trying to sleep. Ijigah et al. (2013) conducts his research in Nigeria, and found that "Social Disruption" is in 14th position with $RII=0.711$. Zolfagharian et al. (2012) found that "Social Disruption" is ranked in the 22nd position.

Site hygiene conditions was ranked in the second position in public effects category with $RII= 0.785$. This finding can be traced to four points: first construction activities produce a large amount of wastes which cause a filth site condition. Second labors are exposing every day to these wastes, which contain a large amount of hazard emissions and cause a lot of diseases. This means that the construction sites suffered from uncontrolled unhealthy conditions. Third workers tools are always dirty. Fourth workers breathe every day a large amount of dust, chemical pollutions, gas emissions, and vehicles exhausts. Furthermore they use pollutant water.

This means that the construction sites suffering from dangerous and serious hygiene conditions which need to be controlled. Zolfagharian et al. (2012) found that "Site Hygiene Conditions" is in the 5th position.

Tabla 8. IIR y clasificación de las categorías de impacto medioambiental

Table 8. RII and ranks of environmental impacts categories

Categoría/Category	IIR/RII	Rango/Rank
Efecto en la comunidad/Effect on public	0.735	1
Effect on natural resources/Efecto en los recursos naturales	0.69	2
Efecto en los ecosistemas/Effect on Ecosystems	0.68306	3

Table 8 illustrates results regards to environmental impacts categories. As shown in table 8, the effect on public was ranked in the first position with average RII=0.735. Majority of construction impacts regardless to its category cause detriments to human health. Construction impacts cause a lot of diseases to human such as cancer, liver, respiratory and vascular disease. The respondents believed that a good health, comfort, and safety, are the minimum rights for human. However all this categories are important and approximately closed to each other in their importance and adverse effects on the environment? Gaza Strip is an area of conflict for decades. Gaza strip witnessed three wars at the last few years (war at 2008, war at 2012, and war at 2014). Also, peoples in Gaza Strip are suffering from lack knowledge and awareness regarding to environmental impacts of construction issue. This special situation damages all livelihoods, and contributes deteriorating the ecosystem, material resources, and public health.

Li et al. (2010) and Zolfagharian et al. (2012) conducted a research about environmental impact assessment, and categorized the environmental impact into three safeguard subjects: ecosystems, natural resources, and public impacts. Li et al. (2010) conducted his research in United States of America; his results demonstrated that public impacts form 27% of the total impacts. Ecosystem damage form 65% of the total impacts. Resource depletion form 8% of the total impacts. This means that developed countries like USA take the necessary measures to protect public health, and enacted strict laws to curb these effects down. Zolfagharian et al. (2012) conducted an interview with an expert panel group in Malaysia, to determine the frequency and severity of the environmental impacts in the Malaysian construction industry. Their results demonstrated that among the three environmental categories, an ecosystem impact is ranked in the first position (67.5%) of the total impacts. Natural Resources Impact forms 21% of the total impacts. Public Impact consists of only 11.5%. This means that Malaysiya has a high awareness regard to impacts of construction on public health. It takes the necessary measures to protect human health, and enacted strict laws to curb these effects down.

Tabla 9. Soluciones propuestas para enfrentar los impactos adversos de la construcción sobre el medioambiente**Table 9.** Proposed solutions to face the adverse impacts of construction on the environment

Pregunta/Question	Grado de aprobación/Degree of Approval					Total Resp/Tot. Resp.	Ponderación /W	IIR/R.I.I	Rango /Rank
	5	4	3	2	1				
<p><i>Toma las medidas necesarias para proteger a los trabajadores y residentes que viven cerca del sitio en construcción como:</i></p> <ul style="list-style-type: none"> <i>Promulga leyes estrictas que obligan a las instituciones a realizar EIA en las primeras etapas del proyecto.</i> <i>Promueve la conciencia en los participantes de la construcción respecto de los impactos de la construcción en el medioambiente.</i> <p><i>Take the necessary measures to protect labors and residents who are living near to construction sites such as</i></p> <ul style="list-style-type: none"> <i>Enact strict laws to enforce institutions to make environmental impact assessment (EIA) in the early stage of projects.</i> <i>Enhance the awareness of construction participants with regard to impacts of construction in the environment.</i> 	27	12	1	0	0	40	186	0.93	1
<p><i>Busca métodos alternativos de construcción para mitigar los impactos negativos de la construcción en el medioambiente/Search about alternative methods for construction to mitigate the adverse impacts of construction on the environment.</i></p>	12	21	7	0	0	40	165	0.825	2
<p><i>Busca materias primas alternativas en lugar de construir en hormigón/Search about alternative raw materials instead of concrete construction.</i></p>	11	16	5	5	3	40	147	0.735	3
<p><i>Acepta estos impactos como un hecho/Accept these impacts as a fait accompli.</i></p>	1	10	5	16	8	40	100	0.5	4
<p><i>Ignora los efectos/Ignore these affects.</i></p>	1	3	0	19	17	40	72	0.36	5

Table 9 illustrates the results regarding suggestions to face the adverse impacts of construction projects on the environment. As shown in Table 9, 'take the necessary measures to protect labors and residents who are living near to construction sites' was ranked in the first position with RII=0.93. This measures such as enact strict laws to enforce institutions to make environmental impact assessment (EIA) in the early stage of projects, and enhance the awareness of construction participants with regard to impacts of construction in the environment. Results also showed that 'search about alternative methods for construction to mitigate the adverse impacts of construction on the environment' was ranked in the second position with RII=0.825.

Therefore, there is an urgent need of enact laws and take a serious measure to protect the environment, and attempt to mitigate the adverse impacts of construction on labors and residents who are living near to construction sites.

6. Conclusion

The objective of this study was to identify and investigate the most common environmental impacts of construction projects in Gaza Strip. The results showed that construction sector has massive direct and indirect impacts on environment. The cumulative environmental impacts of construction processes have been increasing in Gaza strip due to a large number of ongoing construction projects. The results showed that construction process has a massive effect on ecosystem, resources, and public health. The results also revealed that labors and those who are working in construction sector are the most slices of people exposing every day to health problems such as respiratory problems, liver, cancer, hearing impairment, hypertension, annoyance, sleep disturbance, and other cardiovascular adverse effects. Moreover construction impacts cause environmental degradation, including air, soil and water pollution, obscures vision, damage or dirty property and belonging and create unsafe working conditions. Therefore, there is an urgent need to control these adverse impacts of construction, to protect human, environment, and resources. Forty seven environmental impacts of construction projects were identified, and grouped under three categories: ecosystems, natural resources, and public impacts. The results revealed that "dust generation" was ranked in the 1st position with regard to its adverse effects on the environment. This factor belongs to ecosystem group. The results indicated that "noise pollution" was ranked the 2nd position. Additionally, the results also indicated that "operation with vegetation removal" was ranked in the 3rd position. The results also showed that "air pollution" was ranked in the 4th position.

'Consumption of both renewable and nonrenewable resources' appeared to be one of the important impacts that affect the environment. It can be interpret that construction process consume a lot of raw materials such as sand, gravel, clay, calcium carbonate, water, aggregate, wood, iron, bitumen, aluminum and fuel for vehicles. In light of the widespread of construction growing in Gaza strip, there is a serious concern of depletion of these raw materials. That means that the situation in Gaza strip is very serious, and resource use need to be controlled. Construction also contribute 'Air pollution' because of the construction vehicles gas emissions, dust generation, hazard emissions which generated from solid and liquid wastes, (CO₂, CO, and NO_x) emissions, and (VOC and CFC) emissions. The results of this study stressed the massive need to protect the environment. The results showed that "take the necessary measures to protect labors and residents who are living near to construction sites" was ranked in the first position with regard to proposed solutions to mitigate the environmental impacts of construction.

This measure include enacting strict laws to enforce institutions to make environmental impact assessment (EIA) in the early stage of projects, and enhancing the awareness of construction participants with regard to impacts of construction in the environment. The results also revealed that "search about alternative methods for construction to mitigate the adverse impacts of construction on the environment" was ranked in the second position with regard to proposed solutions to mitigate the environmental impacts of construction.

Because dust appears as the greatest critical impact that affects the environment, managers should issue their instructions for the contractors to use appropriate method to control dust by using one of the following techniques or a combination of them, such as using wet systems that use water sprays to prevent dust or capture airborne dust, enclosures to contain dust, and ventilation systems/exhaust systems to remove dust. To reduce the amount of sediments transported onto paved roads by motor vehicles leaving a construction site, wheels of vehicles should be washed if they are carrying mud or debris. The government should enhance legislations to attempt curbing the adverse impacts of construction such as enforce institutions to make environmental impact assessment (EIA) in the early stage of the projects. The knowledge and awareness of construction participants with regard to environmental impacts of construction need to be enhanced. The results of this study can be useful for project participants to enhance their awareness regard to environmental impacts of construction. The results also can help decision makers identify major construction impacts on environment and make environmentally friendly construction plans in the early stages of construction. Moreover the results will be useful to architects, designers and builders in order to carefully design buildings and other infrastructure that are environmentally friendly and sustainable.

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