

# SI in Building Projects in Khartoum State during Conceptual and Design Stages

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**Abstract:** sustainable performance in the construction industry is a fundamental aspect in attaining the goal of sustainable development. A study was conducted by adopting the sustainability indicators (SIs) relevant of sustainability indicators must be applied during the conceptual stage (CS) and planning and design stage (DS) to achieve the sustainable performance. A questionnaire was designed to collected data to identify the most important SIs must be applied during CS and DS in Khartoum state to achieve the sustainable performance. The weights average was used to determine the most important SIs depend on the different five scales. The results shown that the economic sustainability indicators (CSIs) during CS are: the capital cost, and the social sustainability indicators (SSIs) during CS are: Health and safety of workers and people around project, project as an additional sector for the infrastructure sector and project jobs creation, the environmental sustainability indicators (ESIs) during CS are: the air pollution, water quality, noises pollution in long term and short term and an impact of construction projects on the eco - system . furthermore, the results also shown that (CSIs) are during (DS) are the primary cost for project, life cycle cost of project, restoring damage cost for the eco-system, the fair wages of labours, contracting approach with contractors and (SSI) during (DS) is health and safety and the usefulness of project and (ESIs) are Energy saving, an impact of project on the eco-system, recycling waste, recycling water, water quality and the air pollution.

**Keywords:** Sustainability, Indicators, Conceptual, Design, Performance

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## I. Introduction

The sustainability concept in the form of “maximum sustainable yield” at the starting of the twentieth century, was also introduced to the fishing industry. And for over two hundred years the principle of sustainability extent to made use of at all, was limited to fishing industries. The sustainability concept influence on other sectors of the economy had very little. The principle of business “allowance for depreciation” comes relative to the goal of preservation of living from the yield and not from capital (Gerd , et al., 2016).

The construction industry is a major economic contributor within developed countries and is a rising market for developing nations.

In the construction industry, sustainable performance is through to be a fundamental aspect in attaining the goal of sustainable development.

Focusing on the Khartoum state context, this work is expected to provide an overview on the subject of sustainable construction, explore some of the knowledge gaps related to the subject, and suggested the sustainability indicators that should be addressed by the industry participants in this regard.

The aim of this research is to identify the performance indicators that must be applied in construction projects in Khartoum state to achieving the sustainable performance.

## II. Background Studies

Sustainable development has earned an increasing importance in the construction industry. The application of its principles in this industry is generally described as sustainable construction.

Sustainable development has many definitions, it is the “development that improves the quality of human life while living within the carrying capacity of supporting ecosystems” (WCED, 1987) or “development that meets the needs of current generations without compromising the ability of future generations to meet their needs and aspirations” (Simon & Stephen , 2008).

With the increasing understanding of the importance of the concept, huge number of definitions have emanated. One of the most common definitions of sustainable development is introduced by The World Commission on Environment and Development (Brundtland, 1987) describing it as “Humanity has the ability

to make development sustainable – to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs”. Within the culture of the construction industry, sustainable development has been emerging as a new and important agenda for better practice (Eid, 2004) defining it as the better utilization of resources and the creation of buildings with low environmental and social impact. The construction industry has successfully passed the milestone of recognizing the importance of integrating sustainable development into the core of the industry’s practices (Eid, 2004). Creating sustainable agendas for the construction industry is a vital step towards a paramount change of this industry to achieve a sustainable future.

According to World Commission on Environment and Development (WCED, 1987), sustainability is commonly defined as development that “meets the needs of the present without compromising the ability of future generations to meet their own needs” (Bansal & DesJardine, 2014) a concept that is accepted in many fields of study that include a sustainable approach. Thus, sustainability has been adopted by many companies’ through their task statement and strategy (Sánchez & M.A, 2015), to cope with companies objectives in an epoch that is demanding social and environmental approach. Leading corporate in different sectors are measuring and taking systematic steps to manage their sustainability impact; recognizing the way that a reorientation across sustainable development is essential for ensuring their long-term viability. According to (Mahmoud, 2019), there are five life cycle construction project stages shown in the following figure (1):

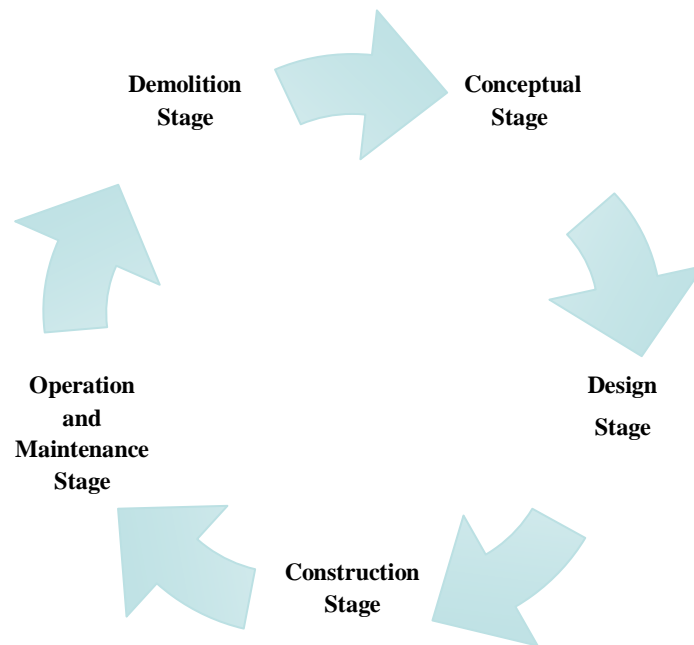


Fig 1: Life cycle construction project stages (Mahmoud, 2019)

Conceptual stage (CS) and Design Stage (DS) involves a wide range of actions with the dimensions of sustainability (Social, Environmental, and Economic). These can result in a wide range of impacts, all of which play a significant role in the long-term security and health of people and communities recovering from disaster (Charles , n.d.). there are many SIs must be applied during the CS and DS to achieve a sustainable performance for the construction projects as shown in figure (2):

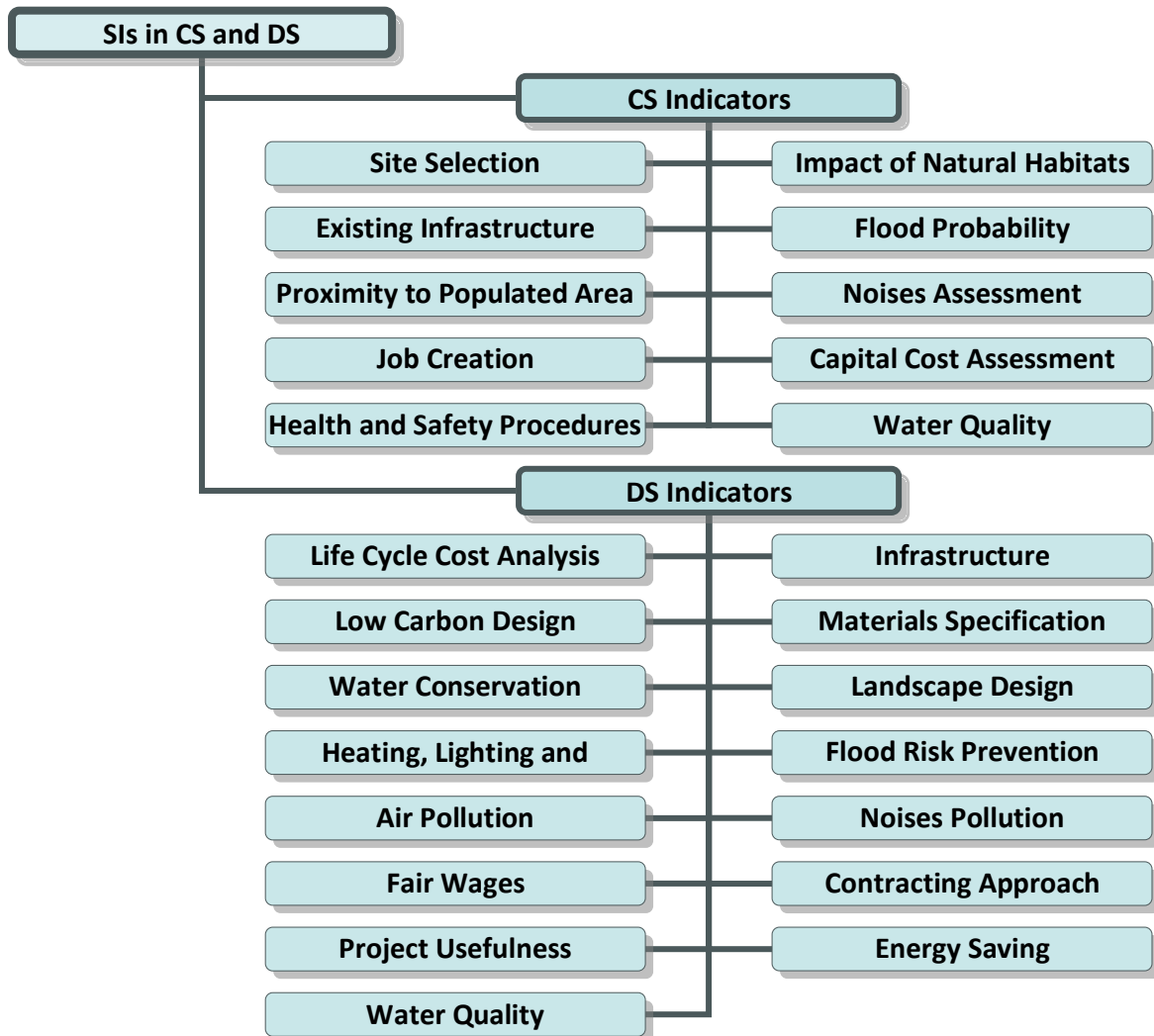


Fig 2: The sustainability indicators must be applied during the conceptual and design stages to achieve the sustainable performance (Hill & Bowen, 1997) , (Rethinking, 2003a) & (Mahmoud, 2019)

### III. Methods and Materials

Based on the approach that used to achieve the goals of the study and the nature of the data the questionnaires was used to collected data from the different construction projects in Khartoum state.

The sections for questionnaire designed as two sections, section one contain general information about participants to match the research sample of the international qualification experience for the specialization sector working with age. A section two of questionnaire designed to identify the performance indicators (Social indicators, Economic Indicators and Environmental Indicators) that must be applied in concrete construction projects in Khartoum State to achieve sustainability issues for the sustainable performance, depending on different five scale (1= Not Important/ 2= Minor / 3 = Medium / 4 = Important / 5= Very Important) for the different construction stages (any stage divided into three pillars of the different sustainability indicators social, economic and environmental).

300 responses were targeted from the engineers work in Construction Company in Khartoum State for the questionnaire.

The survey participants were Contractors, Consultants and other participants have correlate with construction sector, were selected depending on their knowledge in construction projects sustainability issues in from the official reference lists of the Sudanese Contractors Union and the Council of Organizations of Consultants in Sudan. Then the weight average using for data analyzed to reach the goals a research study.

#### IV. Results

The weight average used to describe collected results for any pillar at any construction stage, this part contain five scale from higher scale to lower scale depending on the degree of importance of the indicator to assessment collected results as shown in the following table:

Table 1: the meaning of weights average results

Number	Meaning of Results
5	Very Important
4	Important
3	Medium
2	Minor
1	Not Important

- Conceptual stage results

Table 2: Conceptual stage results

Initiation Stage		Assessment frequency					Weight Average	Description
Indicators		5	4	3	2	1		
Economic	An assessment of capital cost including social and environmental aspects	101	91	18	9	4	4.238	Important
Social	An Impact of projects in occupational health and safety of workers and people around it	96	91	33	2	1	4.251	Important
	An assessment of project as an additional sector for the infrastructure sector	91	81	24	18	9	4.018	Important
	An assessment of project as a center of jobs creation	97	68	31	16	11	4.004	Important
Environmental	an assessment of air pollution of construction projects for an environment around it	101	89	15	8	10	4.179	Important
	an assessment of construction projects on water quality for an environment around it	99	91	15	6	12	4.161	Important
	an assessment of noises pollution in long term and short term and reducing an impact of it	81	99	21	14	8	4.036	Important
	an assessment of probability of flood an put the appropriate plan to minimize an effect of it	19	16	21	89	78	2.143	Minor

	an assessment of construction projects on eco - system	128	83	12	0	0	4.520	Very Important
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Through the results of the questionnaire was distributed, most of the respondent indicated that, all sustainability social indicators (An Impact of projects in occupational health and safety of workers and people around it, an assessment of project as an additional sector for the infrastructure sector and an assessment of project as a center of jobs creation) with weights average more than 3.500 for the conceptual stage was mentioned in the survey process are important to achieving the sustainable performance.

The respondent was indicated also all sustainability environmental indicators was mentioned in the survey process (air pollution of construction projects, an assessment of construction projects on water quality for an environment around it, noises pollution in long term and short term and an assessment of construction projects on eco - system) are important to achieving the sustainable performance with weights average more than 4.00 except the probability of flood indicator with weight 2.143.

Also, the results was obtained shown the economic indicators the capital cost including social and environmental aspects must be apply to achieving the sustainable performance in construction projects in Khartoum state.

- Design stage results

Table 3: Design stage results

Design Stage		Assessment frequency					Weight Average	Description
Indicators		5	4	3	2	1		
Economic	Calculating the primary cost for project including sustainability criteria	91	106	25	1	0	4.287	Important
	An assessment for project life cycle cost including sustainability criteria	92	95	34	2	0	4.242	Important
	Calculating the cost of restoring the damaged of the eco-system resulting from project	151	58	14	0	0	4.614	Very Important
	Calculating the labour employment cost with fair wages	99	61	39	21	3	4.040	Important
	Calculating the costs of paper using in project	11	8	28	85	91	1.937	Minor
	an assessment of the contracting approach with contractors to achieving the economic benefits	71	97	23	19	13	3.870	Important

	an assessment of the contracting approach with suppliers to achieving the economic benefits	21	19	16	96	71	2.206	Minor
Social	an assessment the usefulness of project	109	86	21	4	3	4.318	Important
	Applying the criteria of health and safety for labours	143	67	13	0	0	4.583	Very Important
	Study the project encroachment on the surrounding area (Archaeological area, population expansion,...etc)	11	27	18	91	76	2.130	Minor
Environmental	Design of project taking into account the appropriate methods to saving energy	124	99	0	0	0	4.556	Very Important
	An impact of project on the eco-system	127	81	13	1	1	4.489	Important
	Design with an appropriate plan for the waste recycling	123	95	5	0	0	4.529	Very Important
	Design with an appropriate plan for the water recycling	93	121	5	1	3	4.345	Important
	Project land using with an optimum procedures (an example: fill the voids with trees)	104	81	23	8	7	4.197	Important
	Design for minimizing and reducing the impacts of project on the air pollution	148	61	12	1	1	4.587	Very Important
	Design for minimizing and reducing the impacts of project on the water quality	121	84	17	0	0	4.448	Important

From the obtained results, the respondent indicated that, the important economic indicators must applied to achieving the sustainable performance are the primary cost for project including sustainability criteria, the project life cycle cost including sustainability criteria, the cost of restoring the damaged of the eco-system resulting from project, the labour employment cost with fair wages and an assessment of the contracting approach with contractors taking into account the sustainability criteria in the contacting process with weight average more than 3.800 for these indicators.

The respondent indicated that, most of the social indicators was mentioned (the criteria of health and safety for labours and the usefulness of project) are important to achieving the sustainable performance with weights average more than 4.00 except the an indicator of project encroachment on the surrounding area (Archaeological area, population expansion,...etc) with weight average equal to 2.130, that means the degree in importance for this indicators is minor or there in no need to apply it.

Also, the obtained results indicated that, most of the environmental indicators was mentioned (The appropriate methods to saving energy, an impact of project on the eco-system an appropriate plan for the waste recycling, an appropriate plan for the water recycling, the impacts of project on the water quality and the impacts of project on the air pollution) are important to achieving the sustainable performance in Khartoum state with weights average more than 4.00.

## V. Conclusion

The results obtained from this study displayed the SIs must be applied on concrete projects to achieve the sustainability. It was also confirmed that there is a significant. The results shown that the crucial SIs for the concrete construction projects in Khartoum state to achieve the sustainable performance during the conceptual stages are:

1. The economic sustainability indicators are: The project capital cost including social and environmental aspects
2. The environmental sustainability indicators are: the air pollution, water quality, noises pollution in long term and short term and an impact of construction projects on the eco - system
3. The social sustainability indicators are: Health and safety of workers and people around project, project as an additional sector for the infrastructure sector and project jobs creation.

The results shown that the crucial SIs for the concrete construction projects in Khartoum state to achieve the sustainable performance during the design stages are:

1. The economic sustainability indicators: the primary cost for project including sustainability criteria, the project life cycle cost, the cost of restoring damage for the eco-system, the fair wages of labours and contracting approach with contractors.
2. The environmental sustainability indicators are: Energy saving, an impact of project on the eco-system, recycling waste, recycling water, water quality and the air pollution
3. The social sustainability indicators: health and safety and the usefulness of project.

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