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Sustainability Indicators in Building Projects in Khartoum State during Construction and Operation Stages

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Abstract— *The construction industry is a major economic contributor within developed countries and is a rising markets for developing nations. Focusing on the Khartoum state this work present the most important sustainability indicators (SIs) must applied during construction stage (COS) and operation stage (OPS) for achieve sustainable performance of the construction projects. A study was conducted by adopting the SIs relevant of SIs must be applied during the COS and OPS to achieve the sustainable performance. A questionnaire was designed to collected data. Then the weights average was used to determine the most important SIs depend on the different five scales. The results shown that the important economic indicators (ECIs) during COS are: Fair wages, client changes, productivity and profitability, and the social indicators (SOIs) during COS are: direct employment opportunities, client satisfaction, health and safety and the ratio of local employment, the result also shown that the environmental indicators (ENIs) during COS are: recycling materials, water quality, use of renewable energy system and reducing dust and noises pollution. Furthermore, the results also shown that the ECIs during OPS are: impact of project on the local economy and infrastructure, and the SOIs during OPS are: the role of project in developing services and client satisfaction, and the ENIs during OPS are: reducing chemical emissions, water pollution and waste generated, indoor quality and use of renewable energy system. The results of this research can be helpful to sustainable building planners, designers, and developers in Khartoum state to achieve the sustainability requirements.*

Keywords— ***Sustainability, Indicators, Construction, Operation, Performance***

I. INTRODUCTION

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

In spite of a slow-down in the rate of the productivity, the construction industry remains the largest industrial sector in the community, ahead of the food and chemical industries and it is decisive in producing investment goods (Apine & Valdés, 2016).

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

The construction sector in Khartoum state has witnessed an increase in the volume of financial investments in parallel with the emergence of various construction companies.

The importance of performance based benchmarking has become a necessity in a modern construction company and presents a constant challenge for the construction industry.

Focusing on the Khartoum state context, this work is expected to provide an overview on the subject of sustainable construction performance, present the most important sustainability indicators must applied in construction and operation stages (the social, the economic and the environmental indicators) of sustainable construction. The aim of this research is to identify the

sustainability indicators that must be applied in construction projects in Khartoum state to achieving the sustainable performance.

II. BACKGROUND STUDIES

Sustainability is considered one of the most significant challenges encountered by the society today. The concept of sustainability is widely applied by many companies through their assignment statement and strategy. It is one of the most widespread research fields for scholars (Dobrovolskiien˙e & unien˙e, 2015).

The sustainable development concept is not only the result of scientific research; instead, it is an ethically grounded concept. The ethical criterion upon which this concept is based, one of the most common being the principle of justice, are not subject to critical examination in most works on sustainability, nor are reasons given for it. The German Advisory Council annual Report in 1994 did attempt to ethically ground concept (Gerd , Wiek, Pim, & Heinrichs, 2016). In an ethics of responsibility, which it defines as "the unity of wisdom and duty" (Janko , Damjan , & Peter , 2004). The Council distinguishes ethical elements of sustainable development:

- Humanity responsibility for its natural environment.
- Humanity responsibility for its social world.
- Humanity responsibility for itself.

Within the culture of the construction industry, sustainable development has been emerging as a new and important agenda for better practice, (Gerd , Wiek, Pim, & Heinrichs, 2016) 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 (Gerd , Wiek, Pim, & Heinrichs, 2016). Creating sustainable agendas for the construction industry is a vital step towards a paramount change of this industry to achieve a sustainable future.

With this context sustainable development has become a fundamental objective of development planning that requires dealing with economic, social and environmental policies in a mutually reinforcing way. As the concept of sustainable development is becoming increasingly important, interest in monitoring development strategies in terms of sustainability has increased, resulting in a need to formulate special monitoring tools (Eid, 2004).

In spite of among the different definitions of sustainability, there is a wide acceptance that sustainable development integrates, at least, three dimensions: social, economic and environmental. Further many researches are suggested the sustainability indicates related to the construction industry as shown in Fig (1):

Fig 1 Sustainability Indicators (Mahmoud, 2019)

According to (Mahmoud, 2019), there are five life cycle construction project stages to apply a SIs during them shown in the following Fig (2):

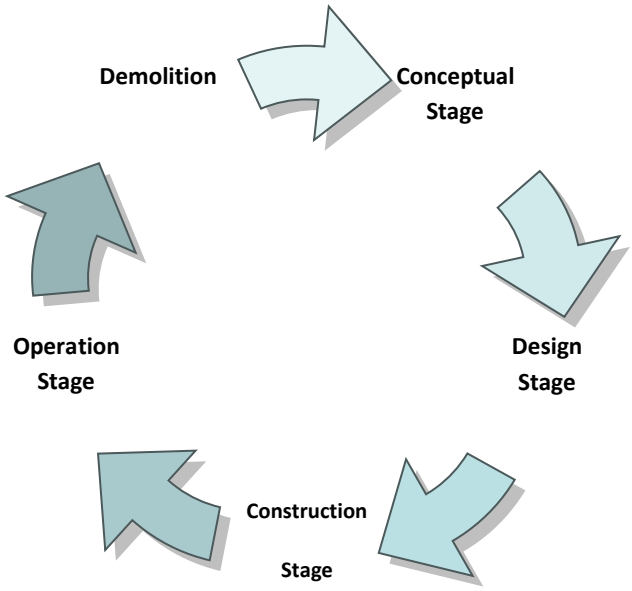

Fig 2 Construction Projects Stages (Mahmoud, 2019)

The construction management for any project depends on pre-defined the objectives of which required the techniques and tools to achieve the project objectives and to assess and improve its performances. In addition to, the processes of construction management are classified into initiation, planning, execution, control and closing processes (Elkhalifa, 2011).

The construction stage is the physical processes for all aspect of building and completes the scope and building of the project. Construction work are typically carried out by the contactors, builders, suppliers and may appoint subcontractor (Wiki, 2021).

According to (Mahmoud, 2019) the following figures describe the sustainability indicators must working together during the construction stage to achieving the sustainable performance.

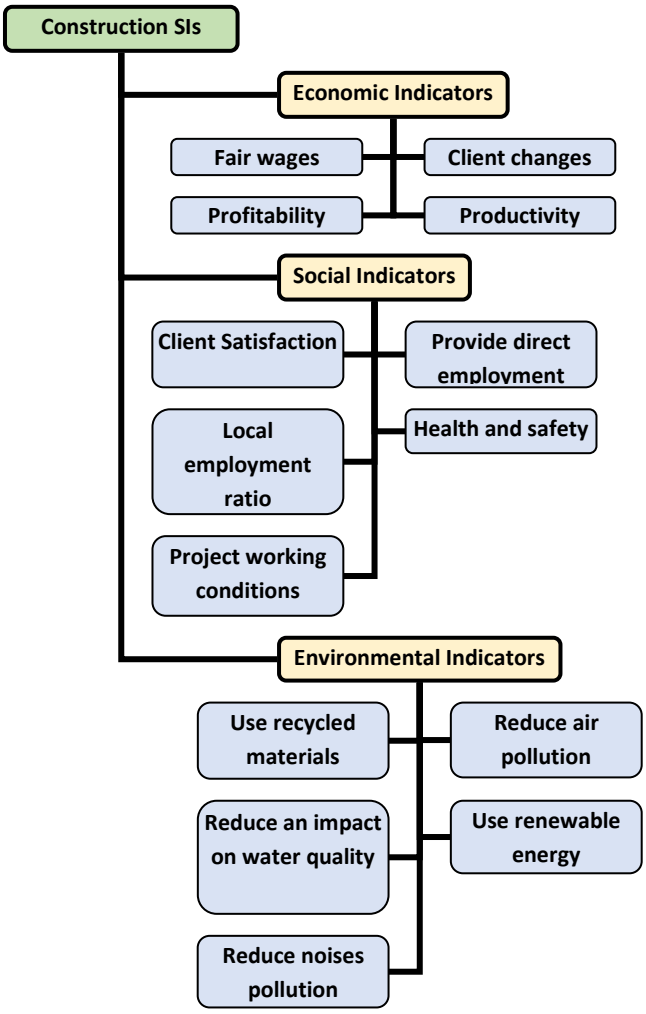

Fig 3 Construction stage SIs (Rethinking, 2003a; Hill & Bowen, 1997; Mahmoud, 2019)

The operation stage is the longest stage of construction building because some buildings have a life span of more than fifty years. Water, energy, power lighting systems, electricity and telecommunications networks are required for users during an operation stage. Furthermore, other sources of energy are required also such as: crude oil, gas, and renewables and waste. Buildings also require crucial services such as pipelines for the provision of water and sewage waste disposal etc.

According to department of Environmental Affairs and Tourism (DEAT) (Tourism, 2009), the three stages of buildings construction, operations and deconstruction use about 15 % of the world's water resources; and approximately 40 % of the world's energy; and produce about 23-40 % of the world's greenhouse gas emissions (GHG). Furthermore, (OECD, 2003) inform that the energy consumption during operation stage around the world approximately 25-40 % of total final.

According to (Mahmoud, 2019) the following figures describe the sustainability issues must working together during the operation stage to achieving the sustainable construction project.

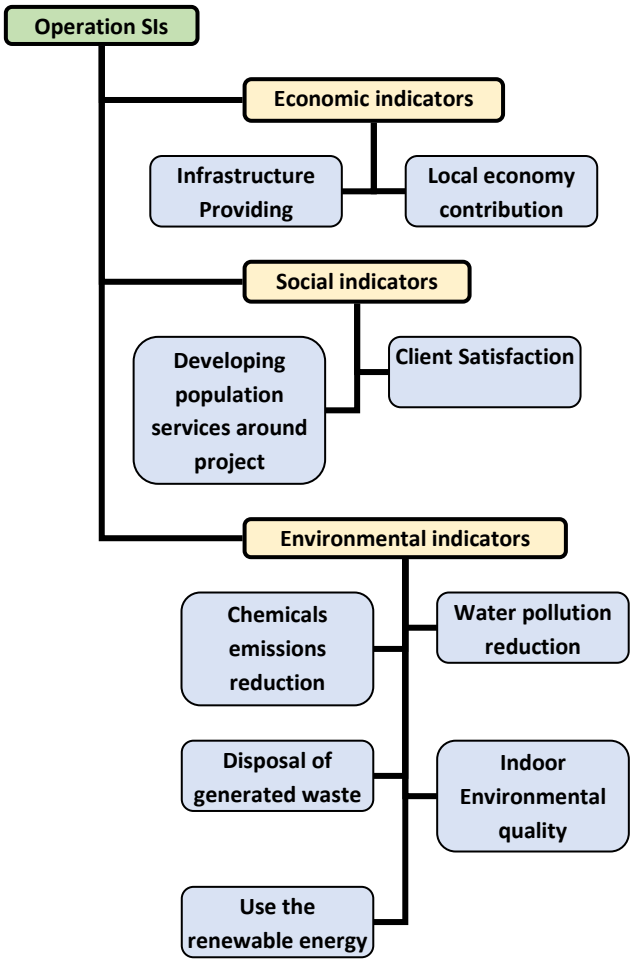

Fig 4 Operation Stage SIs (Rethinking, 2003a; Hill & Bowen, 1997; Mahmoud, 2019)

III. METHODOLOGY

Based on the approach that used to achieve an objective of the paper a questionnaire was used to collected data from the different building projects in Khartoum state. The sections for designed questionnaire are two sections, section one consist general information about participants to match the research sample of the international

qualification experience for the specialization sector working. A section two of a questionnaire designed to identify the performance indicators must be applied in concrete building projects in Khartoum State to during construction and operation stages to achieve sustainability the sustainable performance, depending on five scales for the different two construction stages.

300 responses were targeted from the engineers work in Construction Company in Khartoum State for the questionnaire and 243 of the respondents successfully participated in the questionnaire survey. The survey in building projects sustainability issues. Then the weight average using for data analyzed to reach the goals a research study.

IV. RESULTS

The information about the participants those filled the questionnaire shown as the following:

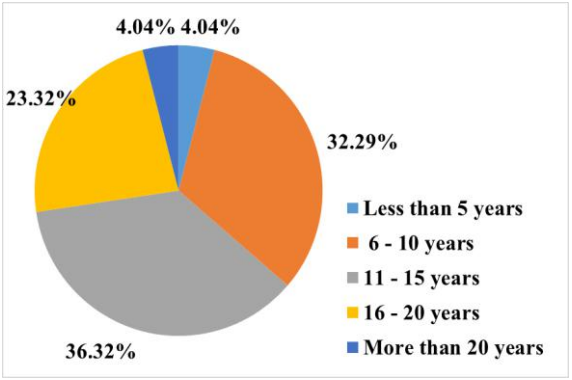

Fig 5 participants Experiences

It is very clear from the results of the questionnaire obtained that most of the participating group have experience more than 10 years with percentage 69.06%, which supports the validity of the results obtained due to their long experience.

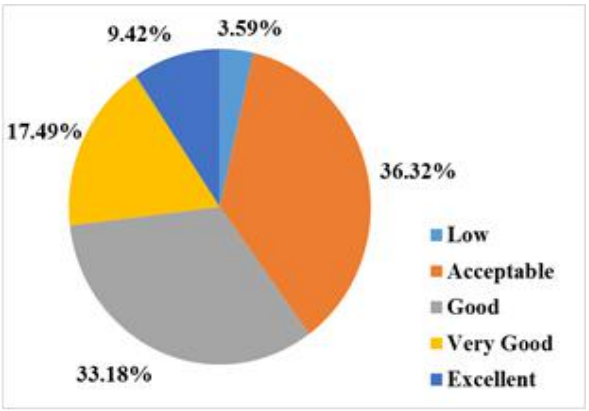

Fig 6 The participants Knowledge of Sustainability Issues

It is very clear from the obtained results most of the participating group have enough knowledge of sustainability issues in construction projects. Where, 96.36% of the respondent have acceptable knowledge in sustainability issues in construction projects, which supports the validity of the results obtained due to their sustainability knowledge.

The weight average used to describe a section two of the 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

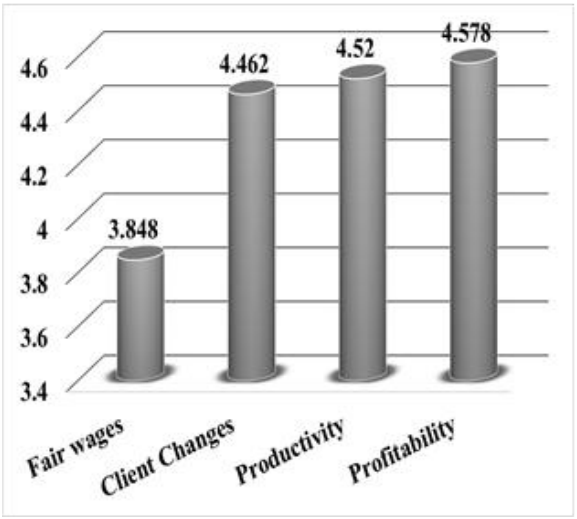

Fig 7 Construction Stage Economic Indicators

From the obtained results, the respondent indicated that, all economic indicators for a construction stage (Dealing optimally with different labour costs with fair wages, Client Changes, Productivity and Profitability) are important to achieving the sustainable performance during the construction stage with the average weights more than 3.500.

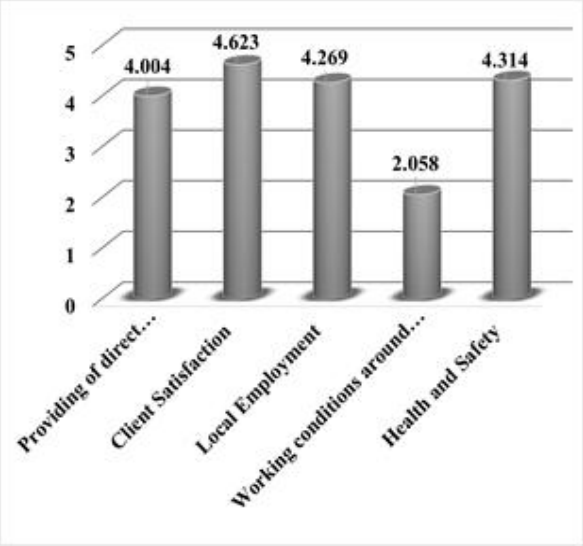

Fig 8 Construction Stage Social Indicators

The results also indicated that, all social indicators for a construction stage (the role and impacts of project as providing of direct employment opportunities, client satisfaction, applying an appropriate plan to ensure health and safety for labours and Ratio of Local Employment) are important to achieving the sustainable performance during the construction stage expect an indicator of the working conditions around the projects with weight average 2.058.

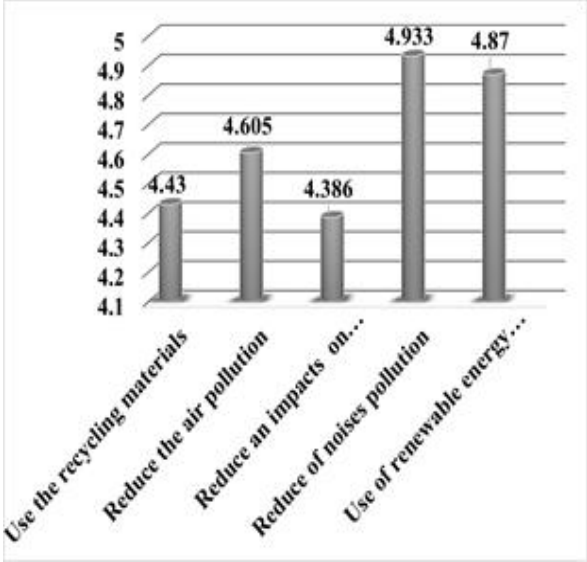

Fig 9 Construction Stage Environmental Indicators

The respondent indicated that, all environmental indicators for a construction stage (use the recycling materials in the projects, measuring to reducing the impacts of construction dust, reduce and minimize the impacts of project on water quality for the environment around project, reducing and minimize the impacts of noises pollution and use of renewable energy system) are also important to achieving the sustainable performance during the construction stage with weights average more than 4.00.

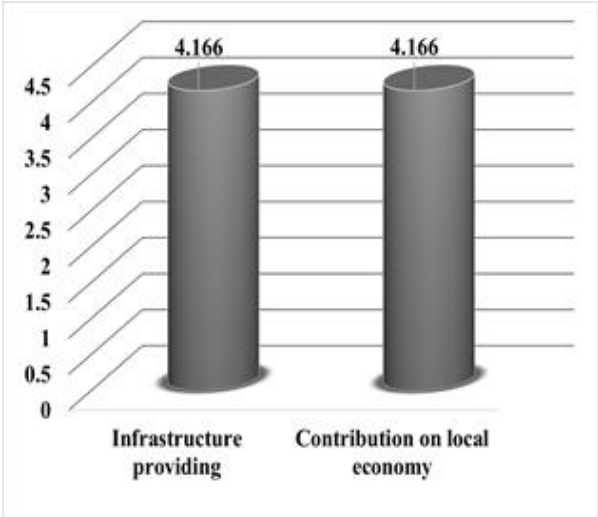

Fig 10 Operation Stage Economic Indicators

From the results was obtained shown the economic indicators studying an impact of project on the local economy and infrastructure is important to apply for achieving the sustainable performance in construction projects in Khartoum state during an operation stage with weights average more than 4.00.

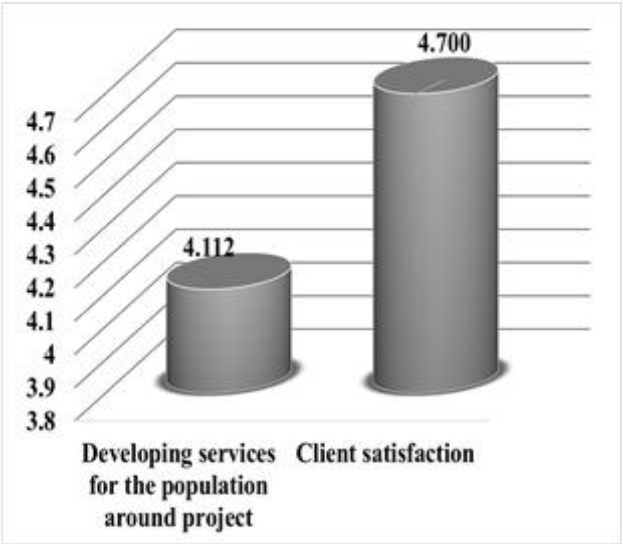

Fig 11 Operation Stage Social Indicators

Also, the results indicated that, all social indicators for an operation stage (An assessment an impact of project in developing the project services for the population around project and Client satisfaction) are important to achieving the sustainable performance during operation stage.

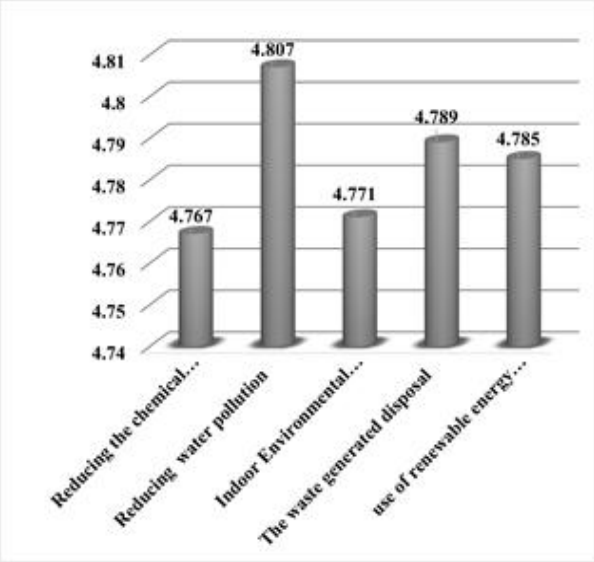

Fig 12 Operation Stage Environmental Indicators

The respondent indicated that, all environmental indicators for an operation stage (an appropriate project management to reducing the chemical emissions effects from the project, Indoor environmental quality, an appropriate project management to reducing and minimizing an impact of project in water pollution, Making an appropriate project management for the waste generated from the project and use of renewable energy system) are also important to achieving the sustainable performance during the operation and maintenance stage with weights average more than 4.00.

V. CONCLUSION

The final frame work shown that the most important SIs must be applied on concrete projects during construction stages in Khartoum to achieve the sustainable performance are:

1. The economic sustainability indicators are: Fair wages for labours, client Changes, productivity and profitability.
2. The environmental sustainability indicators are: use of recycling materials, reducing the impacts of construction dust, reduce and minimize the impacts of project on water quality for the environment around project, reducing and minimize the impacts of noises pollution and use of renewable energy system.
3. The social sustainability indicators are: the role and impacts of project as providing of direct employment opportunities, client satisfaction, applying an appropriate plan for health and safety procedures and ratio of local employment.

Also, the results shown that the crucial SIs for the concrete construction projects in Khartoum state to achieve the sustainable performance during the operation are:

1. The economic sustainability indicators: an impact of project on the local economy and infrastructure is important.
2. The environmental sustainability indicators are: reducing the chemical emissions, indoor environmental quality, reducing and minimizing an impact of project in water pollution, making an appropriate project management for the waste generated and use of renewable energy system.
3. The social sustainability indicators: the role of project in developing the services for the population around project and client satisfaction.

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