CAPITAL UNIVERSITY OF SCIENCE AND TECHNOLOGY, ISLAMABAD

# Developing a Framework of Sustainability Indicators for Small-Scale Construction Projects by Private Contractors in Islamabad and Rawalpindi

by

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A thesis submitted in partial fulfillment for the degree of Master of Science

in the

Faculty of Engineering
Department of Civil Engineering

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*I dedicate my work to my father, to my mother for believing in my abilities, to my sisters for their undeterred emotional support and to my teachers who made me what I am today.*

## CERTIFICATE OF APPROVAL

## Developing a Framework of Sustainability Indicators for Small-Scale Construction Projects by Private Contractors in Islamabad and Rawalpindi

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1. **T. Ahmad**, N. Shaheen, M. Ali. (2023) "A review of sustainability indicators for small-scale construction projects by private contractors," 2nd International Conference on Advances in Civil and Environmental Engineering, UET, Taxila, Pakistan, Feb 22-23. Paper 601.

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# *Abstract*

There is a frequent perception that the construction sector is lacking behind in terms of sustainable construction, operational process improvement, and staying abreast of current business trends. Private contractors are playing as a major role in the Pakistani construction industry, where they are viewed as the key to economic growth and job creation. According to recent surveys, a number of these private contractors face issues that force them out of business. This study tries to resolve the issues faced by private contractors and analyzing methods for mitigating several significant issues, such as cost overruns, waste generation, and project delays, commonly faced by private contractors in small-scale construction projects.

This study illustrates the sustainability indicators framework for small-scale construction projects by private contractors in industrialised countries. This study's primary objective is to determine the most pertinent measures of sustainability for small-scale construction projects (SSCPs). Initially, a literature study is undertaken to determine the research gap and to identify sustainability indicators in building projects. In construction projects, several indicators of sustainability have been established. The sustainability indicators is divided into three categories: environmental sustainability, economic sustainability, and social sustainability. On the basis of these sustainability indicators, a questionnaire survey is designed, and samples were employed as the study instrument to collect respondents' important rankings. For the development of a framework, a questionnaire is used to identify suitable sustainability indicators. Statistical Package for the Social Sciences (SPSS) and Excel were used for the analysis. Respondents to the questionnaire survey were professional construction contractors working for small private contracting organisations. Frequency analysis, reliability analysis, normality analysis, factor analysis, and correlation analysis were done on each of the indicators that were shortlisted. For the final questionnaire development, from experts applied the Delphi method. On the basis of study results, revealed the most important indicators and their significance in small-scale construction projects.

74 percent response rate, Of the 76 copies of the questionnaire that were distributed, 56 were filled out and returned. It was determined that fifty-six surveys were adequately filled out. Frequency, percentages, and reliability of 0.98, which is greater than the minimum needed value of 75 percent, were utilised to analyse the data acquired for the study, along with the mean score. The reliability analysis impact data statistic was 0.981, indicating values larger than 0.7. This finding confirmed the validity of the effect statistics. On the basis of the frequency data, RII values were calculated for each of the 49 sustainability indicators and their three primary elements in the criteria layer. Values of the relative relevance index for the 10 most essential sustainability indicators Resource planning/allocation of resources (ECO7) 0.82, Cost management plan (ECO6) 0.81, Site Planning/Site Investigation/Tracking of construction (ECO12) 0.79, Water consumption (ENV11) 0.78, Project monitoring and evaluation (SOC18) 0.77, Organizational culture (ECO8) 0.77, Sustainable use of natural resources (ENV2) 0.77, Project manager awareness/knowledge (SOC9) 0.775, Environmental responsibility/justice ENV3 0.76, and Public acceptance of the project The study identified suitable sustainability indicators and established a framework for their use in small-scale construction projects. The report advises that the government play a crucial role by establishing this framework of sustainability metrics so that they can compete with their rivals. Private contractors are urged to take into account the major factors mentioned in the study so as to make decisions that will positively impact the long-term goals of small-scale construction projects by private contractor firms.

**Keywords**: SSCPs, Waste Generation, Sustainability Indicators, Planning, Framework, Private Contractors, Construction Projects

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# Abbreviations

| | |
|---|---|
| **ENV** | Environmental |
| **ECO** | Economical |
| **LCA** | Life Cycle Assessment |
| **PLS-SEM** | Partial Least Square Structural Equation Modeling |
| **RII** | Relative Importance Index |
| **SSCPs** | Small-scale construction projects |
| **SPSS** | Statistical Package for the Social Sciences |
| **SOC** | Social |
| **UN** | United Nation |
| **WWTP** | Waste water treatment plants |
| **WW** | Waste water |
| **WG** | Waste Generation |

# Chapter 1

# Introduction

## 1.1 Background

Sustainability is becoming increasingly essential in the design of public and private sectors, as well as in the civil engineering sector. Construction project stakeholders in both the public and private sectors are increasingly concerned about the environmental, social, and economic effects [1]. The sectors adoption of a sustainable construction concept is delayed [2]. However, traditional tendering criteria are frequently employed as the routine commissioning method for small-scale construction projects (SSCPs), and sustainability elements are eliminated from the projects [3]. This is a challenge for improving project sustainability in Pakistan. The framework also has the potential to be adapted and applied [4]. Therefore,the identification of sustainability indicators'set is necessary that ulimately affects the construction prosedure for SSCPs which are often driven by private contractors. Private contractors must overcome major challenges in order to improve the contractors sustainability performance for these SSCPs.

The heterogeneous character of sustainability and the lack of defined guidelines and criteria for project sustainability integration are the key challenges in the industry [5]. Furthermore, in the construction sector, the fragmentation of the project process, in which project decisions and activities are poorly integrated, and difficult for meeting sustainability performance targets. This fragmentation of the project process, along with a lack of project sustainability indicators guidelines, results in the inclusion of sustainability objectives being late and poor decision making during the project process [3]. As a result, enhancing the project sustainability performance of SSCPs is a complicated problem. Appropriate Sustainability indicators can play an essential role in advancing the practice of sustainable construction. Despite the numerous studies on sustainability indicators, there is still a gap in identifying appropriate sustainability indictors that can be used during construction of SSCPs by private contractors.

The linkages between construction activities and the subsequent environmental impact on the construction methods employed by private contractor firms. Historically, there has been a proportionally rapid growth in the amount of construction waste that coincides with the proportionally quick increase in the number of construction projects [6]. It will do so in a round about way, but it will indirectly contribute to the growth in the output of waste from building [7]. Therefore, the reduction of waste should be a primary focus of attention during the implementation of environmentally responsible construction waste management on construction sites. According to Zuo and Rameezdeen [8,] the generation of waste as a result of construction activities is widely acknowledged as a significant contributor to environmental contamination. Although past studies revealed that unsustainable construction could be credited to a variety of factors such as a lack of environmental issues, lack of social obligation and restricted financial support, academics have not sufficiently addressed the sustainability indicators for controlling waste generation, cost overrun and project delay problems for SSCPs. As a consequence, the goal of this research is to clarify the metrics for attaining sustainable construction. The research introduces appropriate sustain- ability indicators for small-scale construction projects by private contractors. The findings might help to reduce unsustainable methods in small-scale construction projects. Thus, we hope this tiny work will also contribute to a better utilization of sustainability indicators for project delay, cost overrun and waste generation in small-scale construction projects.

## 1.2 Research Motivation And Problem Statement

The incorporation of sustainability into construction projects is a truth. Around the world, several rules, prohibitions, and regulations specify the need for sustainability [9]. One of the most prominent sustainability principles is the requirement to build the set of indicators to permit the sustainable objectives to be implimented in construction, for regulation and monitoring the progress of short listed indicators in te long run. As a result, researching sustainability indicators for small-scale building projects is critical. This requirement inspires the research in this study, which emphasized on the variables that strive the sustainable building indicators. These undertakings have far greater, far-reaching positive and negative effects. Because of this, private contractors must understand sustainability [10]. As a result, decision-makers will be able to monitor performance using various sustainability evaluation frameworks both during the projects feasibility phase and subsequently, when it is really being implemented. The sustainability indicators approach to sustainability evaluation is preferred for a comprehensive evaluation of sustainability. With more than 2,000 performance measures already identified by the previous literature, the real challenge lays in the development of the right set of indicators [11]. To evaluate a projects performance in terms of social, environmental, and financial factors, the sustainability indictors might be employed. Thus, the problem statement is as follows:

*Small-scale construction projects are as important as mega projects. These also play a significant role as the backbone of the construction industry of any country. The majority of SSCPs are being done by private contractors in developing countries. These contractors are not very well aware of the importance of sustainability aspects like sustainable use of natural resources, cost management plans, resource planning, advance planning for variations(design, rates etc), labor practices, etc. Therefore, the major problems in SSCPs are waste generation(WG), cost overruns(CO), project delays(PD), etc. The social impacts of PD, CO, and WG are inconvenience for the public, financial difficulties for owners, and health issues, respectively. The environmental impacts of these problems are increase in waste* *generation, negative impacts on energy efficiency plans, and adverse impacts on the environment (air pollution, etc.), respectively. The economical impacts of these issues are project failure, deficit in the projects, and waste management expenses, respectively. Due to the importance of private contractors, they should be strong in sustainable construction. So, there is a need to explore the sustainability indicators for resolving such issues for SSCPs by private contractors.*

### 1.2.1 Research Questions

- What are the considerable sustainability indicators in SSCPs?
- Which among the important ones are the most appropriate sustainability indicators for SSCPs in developing countries?
- How can the majority of private contractors ensure sustainability in SSCPs?

## 1.3 Overall Aim of the Research Program, Objectives and Specific Aim of this MS Thesis

The specific aim of this research program is to ensure sustainability for all scale construction projects through appropriate sustainability indicators framework.

*The specific aim of this MS thesis is to explore the sustainability indicators framework for resolving certain major issues of small-scale construction projects by private contractors so as to have their construction projects sustainable in the long run.*

The specific objectives of this MS thesis are given below:

- To Develop a framework of sustainability indicators for private contractors.
- To Shortlist important sustainability indicators.
- A set of guidelines for practical implementation.

## 1.4 Scope of Work and Study Limitations

A suitable framework of sustainability indicators has been developed for contractors working on both residential and commercial building projects. It covers mainly planning for construction site activities, cost management, waste management, energy efficiency plans and pollution issues.

The research work has some limitations such as; only small private contractors will be the subject of this study, This study is limited for small-scale residential and commercial buildings only and contractors handling transportation and water resources projects are not included in this scope of study.

### 1.4.1 Rationale Behind Variable Selection

Sustainability indicators are becoming important in construction projects. It is argued that sustainability indicators play a significant role in sustainable construction. An indicator is a representation of linkages whereby multiple effects can be monitored by a fundamental indicator. Many researchers studied sustainability indicators for resolving issues of SSCPs in developed countries. So, there are certain problems of SSCPs in developing countries that need to be resolved as well by sustainability indicators. The potential of such indicators to promote sustainability in SSCPs to make their construction sustainable.

## 1.5 Novelty of Work, Research Significance and Practical Implementation

No study on private contractors for sustainability has been undertaken. Therefore, the current study aims to investigate the appropriate sustainability indicators and framework adopted in small-scale construction projects. Several studies have done for construction projects having sustainability aspects by the using of critical success factors and relative indicators in construction projects. But, the idea of achiving the sustainability in small-scale construction projects is a challenging due to unavailability of framework of sustainability indicators. Therefore,it is necessary to develop a framework that ultimately influence the sustainability performnace of construction project by implementing them. This study suggests the implimenetation of relevant indicators for attaining this path. These appropriate indicators will aid in the creation of a high-efficiency and en- vironmentally friendly environment for use in the engineering and construction industries. This research will assist to reduce waste generation, project delays, and cost overruns by decreasing hidden difficulties in construction, as well as the negative consequences of unsustainable development on the environment.

Several studies have been undertaken to address and regulate the building industry's challenges in emerging nations. However, lack of progress monitoring such challenges was seen for a variety of reasons, including the perception that organisation and planning was the most essential component contributing to company performance, when all aspects were considered. However, there is still an issue with private contractors, which is preventing them from succeeding since they are not sufficiently informed on sustainability metrics. This study aims to educate people about sustainability indicators in small-scale construction projects by which they can get high success in competition with other private contractors. Time and cost on SSCPs can save in major, if our private contractors do best, it can lead towards sustainability success. Moreover, this study may help the researchers to provide a way of thinking and guidelines and to use sustainability indicators by an effective way.

The study findings can be utilised by private contractors for various SSCPs as guidelines or tactics. One of the most difficult problems for developing nations in the twenty-first century is to strive towards sustainable building. Sustainability indicators are metrics that describe the status of the social, environmental, and economic systems and have a greater relevance than the value of the parameter. It can lead to sustainability by all these parameters. Private contractors can work on these appropriate indicators to get high value. All of these characteristics can contribute to sustainability. To obtain a high value, private contractors can work on these applicable indications. This study is significant because it addresses a research gap that has been discovered. Furthermore, our research supports private contractors in determining the most relevant sustainability indicators for their building projects in order to measure sustainability performance during the construction phase.

## 1.6 Brief Research Methodology

The methodology of the research work is divided into steps. Firstly, a critical literature review is conducted to identify the research gap. Secondly, Considerable sustainability indicators have been identified from literature. A questionnaire survey is conducted for appropriate sustainability indicators framework on the basis of cosiderable sustainability indicators. For this analysis, SPSS and AMOS are applied. Based on the results, conclusions and recommendations are made.

## 1.7 Thesis Outline

This research study consists of five chapters. These includes:

Chapter 1: This chapter simply provided the overview and backdrop of the research, research goal and problem statement, objective and scope of work, study limitations, and brief methodology, as well as the thesis outline.

Chapter 2: This chapter discusses a detailed literature regarding the overview, issues of sustainability and small private contractors in developed and developing countries, and the idea of sustainability indicators in construction projects, as well as the research gap.

Chapter 3: This chapter explains the research approach in depth. techniques and procedures for analysis have been highlighted for selection and implementation.

Chapter 4: This chapter cocnsists of the results attained by the analysis and thier relative discus- sion on theattained results.

Chapter 5: This chapter governs the practical guidelines of the research

Chapter 6: This chapter discusses the research's result and future recommendations.

References

Annexure

# Chapter 2

# Literature Review

## 2.1 Background

When it comes to managing construction waste, quality, the environment, and safety, private contractors have a variety of issues. Building costs continue to rise, and more stringent regulations are being implemented. Many studies have been carried out in order to get a better understanding of the difficulties that are faced by contractors in the fields of managerial abilities, planning, and safety issues. These difficulties have an effect on the success or failure of private contractors. As a consequence of this, the incorporation of sustainable construction concepts and practises is required in order to make it sustainable. Research into the construction industry's efforts to reduce its environmental impact has resulted in the development of a number of potential subjects and directions for further investigation. Sustainable building often emphasises the mitigation of environmental impact and may include components such as waste prevention, reuse, and management, with direct benefits to society and less emphasis on profitability. It is necessary to offer a framework of sustainability indicators for analysing the sustainability of small-scale building projects. Sustainable small-scale construction projects must be evaluated using a variety of indicators, such energy usage, waste management, cost control plan, planning, water usage, and so on.

## 2.2 Private Contractors

Large and small private contractors differ in numerous ways, including staff size, financial competence, and access to equipment and technology. This may cause the sustainability metrics of small-scale construction projects to differ between small and big private contractors [12]. Achieving success in construction is a vital problem for pre contractors in order to thrive in a competitive business climate. The construction industry is significant in size and importance in the economy, yet in recent years there has been an increase in the amount of construction private contractor failures. Meanwhile, private contractors aid in the development of the construction sector by their competitiveness, efficiency, and flexibility [13]. A variety of studies have been undertaken in underdeveloped countries to tackle and regulate the industry's difficulties. Private contractors confront the same issues as SSCPs do.

Some construction faults might result in significant issues for the entire project during construction. Morris et al. [14] conducted this study, which reviewed the data of over 4000 construction projects and discovered that projects were seldom completed on time or within the specified budget, and that project delay and cost overruns were typical in small-scale construction projects globally. The project cost increased, and there was a delay in the approval of important adjustments to the work scope [15].This was notably true in Turkey, where building investments account for more than half of all investments and where delays reached enormous proportions in the 1970s and 1980s. This was especially true in Turkey because construction investments account for over half of all investments. That is, construction owners and a significant number of private contractors in Turkey who do construction work for government entities were polled to identify and rate the causes of such delays in order of significance [16]. The findings revealed that the most common causes of failure and delay include a lack of some supplies, financial challenges for public agencies and contractors operational faults and delays in project design, frequent maintenance orders, and a lack of sustainable building techniques.

Rapid expansion in building activity increase construction sustainability challenges worldwide. Construction waste has a detrimental influence on the environment, expenses, time, productivity, and the social well-being of the country. Tafesse and Girma [17] conducted this study, which examined the important social and environmental implications of building waste. The findings revealed that waste materials is a problem for about 95.71 percent of active building projects. Only 57.14 percent of construction enterprises, however, have recorded and evaluated the level of material waste. 610 percent of acquired materials are reported as waste, resulting in project cost overruns. Furthermore, because 75.71 percent of private contractors do not have a professional engaged to tackle waste concerns [18], authorities must prioritise improving the entire business climate for all private contractors [19]. The main reason why projects fail among private contractors (or simply private enterprises and builders) is a lack of experience [20]. According to the study, the five major impacts of construction waste are project cost overrun, pollution of the environment, loss of profit and no sustainability practises on site, too much usage of raw materials, and public health and safety risks, with recyclable materials left on the sites to minimise construction waste and its impacts. Construction waste is a major impact which affects the sustainable construction .

### 2.2.1 Problems Faced by Private Contractors in Developed Countries

Private contractors encounter difficulties and challenges all around the world. Small contractors are defined differently in each nation [21]. Small private contractors, according to Kamal and Flanagan [22], are defined as businesses with less than 200 full-time employees. According to Edmonds and Johannessen [23], SMBCs are businesses that, by definition, compete in a relatively confined market. Sibanda [24] defined small private contractors as those who, in general, lack of resources and, as a result, seek support in managing their firm. The Department of Water Resources, Works, and Housing in Ghana divides civil and construction providers into four financial categories: 1, 2, 3, and 4. Contractors in economic classes 2, 3, and 4 are referred to as small private contractors since they have comparable features in terms of managerial style [25]. Each of the following contractor classes is eligible to work on government-funded projects worth up to 500,000.00 dollars, 200,000.00 dollars, and 75,000.00 dollars, respectively.

Furthermore, the findings of the comparison between small and large contractors indicated that eight characteristics were significantly different as judged by industry practitioners. These elements include the contracting process,[26] cost management, commitment to altering behaviour, and teaching customers on the benefits of sustainable building, Laborers with expertise executing sustainable building construction projects, a heavy fee and tax on unsustainable construction processes, and public demand for sustainable building development and industrial culture. It looked into the crucial success criteria for small contractors working on sustainable building projects. This study is also useful for industry practitioners, particularly small contractors who anticipate carrying out sustainable building construction projects in the near future: delay in payment date, lack of employee coaching, lack of waste management strategy, schedule overruns duration imposed by clients, rework due to construction errors, excessive subcontracting, delay in getting approvals from government entities, ineffectual planning. Small private contractors are also causing duration delays in the building industry in developing countries [28]. The penalty of hefty charge and tax on unsustainable building techniques can create tremendous financial in-fluence on small contractors, resulting in a far higher loss of profit for them as compared to larger firms.

The study then used questionnaires to collect critical success factor assessments from 30 small contractors in developed nations. Initially, this study identified 30 characteristics crucial to small contractors while carrying out sustainable construction projects [28]. Data research revealed the top ten significant success criteria, which included Laboures with competence working on green construction projects for buildings It offers small contractors with a list of essential success characteristics that could be utilized to develop strategies to assist them enhance the execution of sustainable building construction projects. The construction workforce's management abilities must be improved. Workers should be trained in the necessary skills and procedures for scheduling, cost and time control, create a powerful modelling system, and risk analysis. Using reducing waste management techniques such as construction industry.

### 2.2.2 Problems Faced by Private Contractors in Developing Countries

A conceptual mix of these elements and the contractor's class can fairly establish the insignificance or size of a construction firm. In the purpose of this study, a minor contractor is one who falls within the fourth quarter of the categories. There is no universal definition of what it means to be a small contractor [29]. The degree of construction industry in each country varies too much. The Bolton Committee [30] aimed to address issues with private contractors operating on minor construction projects in underdeveloped nations. And developed several definitions for small contractors from various industries. They classified construction enterprises with 25 employees as private contractors (firms). Given the all around of subcontractor in the construction industry, this may be feasible, however a contractor may have 25 or fewer workers and be involved in very complicated and expensive projects subcontracted to other businesses [31]. Given his turnover, machinery, and plant holdings, he is not a tiny contractor. Contractors in many developing nations [32] are classified into distinct groups depending on variables like as turnover, expertise with certain sorts of projects, equipment and plant holdings, and management and technical capabilities. On this premise, a contractor, especially one from the lower classes, could only begin on certain sorts of projects (size, contract sum, nature).

Most private contractors in Vietnam lack an adequate technique for measuring performance and identifying flaws and dangers. The AnGiang Construction Company (ACC) was utilised as an example to validate the technique. Many construction companies have fallen on hard times for the previous ten years. Luu and Kim [33] assessed the performance of private contractors in developing countries.

Only the sustainability viewpoint scored poorly on the performance scale, while the customer, learning and growth, and internal process views scored moderately. Developing private firms struggle to get money for sustainable building due to poor planning and a lack of awareness of sustainability [18]. For the previous ten years, a number of construction enterprises have failed. In emerging nations, the building environment grows riskier [34]. Many small construction contractors in Vietnam lack an efficient approach for assessing their strengths and shortcomings and measuring their performance. As a result, it is extremely difficult for them to enhance their position in a competitive business.

One of the greatest obstacle to the success of small contractors in developing nations is a lack of management team. Governments and respected donor organisations have made little progress in mitigating the problem. Dealing with small contractors in general need a significant level of risk and transaction expenses [35]. Given the crucial role that small private contractors may play in the implementation of modest projects at the local government level, a deeper knowledge of how this sector might be successful is necessary, as it is critical to the economy's stability. In the view of [36] the high failure among all contractors provides the basis for studies into what is required to assist small private contractors to survive and improve their performance. A comparison with other survey studies pointed out that several developing countries have faced analogous delay factors. Delay of progress payment is the most frequent cause of delays, affecting 80 percent of the selected African and Asian developing countries. Followed by problems related to subcontractors with an occurrence of 60 percent [28]. They also lack information about small business ownermanagers and their businesses to better evaluate their According to [36], the high failure rate of all contractors serves as the basis for research on what is needed to help small private contractors survive and improve their performance. A comparison with comparable survey research revealed that numerous emerging nations have experienced similar delays. The most common reason of delays is a delay in progress payment, which affects 80 percent of the chosen African and Asian poor nations. Then there are difficulties with subcontractors, which occur in 60 percent of cases [28]. They also face uncertainty about small firm owners and managers and their firms, which would allow them to better analyse their loan requests. Furthermore, various variables make obtaining appropriate collateral to compensate for the risk challenging. There is a substantial body of research on the issues encountered by small and medium-sized private building contractors.

It is incredibly difficult for a selection process to identify individuals with the necessary desire, enthusiasm, and skill to work as contractors. Small emerging private contractors in South Africa face the following challenges in contractor development programmes, according to CIDB, DPW, and CETA [37]: Typically, open advertisements are placed in the media inviting people to come out and participate; this attracts the unskilled people to the programmes and easily needs to drive them away; the required academic qualification is generally matric or less; no previous technical and supervisory skills or experience in construction relevant areas are needed; According to the statistical study, the top five ranking factors are Activity Start Delays, Rework, Waste Employee Creativity, Long Authorizations, and Waiting because others' work has not been finished [38]. The consequences of skills shortages in private contractor firms are depicted in Figure 2.1. According to the statistical study, the top five factors to examine include delayed activity. The absence of construction projects was shown to have the largest impact (43.9).

Small and medium-sized contractors in developing nations are largely underdeveloped, owing to limited access to and high cost of capital, as well as inadequate government assistance programmes by which they cannot compete with other countries firms. There is also a shortage of skills. The most important determining elements in the growth of small private contractors in developing countries are availability to money, a scarcity of skills, and enough government backing due to these resources and facilities they ara lacking in sustainability. Small business survival, development, and expansion are critical for economic growth and employment creation in emerging nations. Regulatory process is undoubtedly a key vehicle for dispersing societal resources and opportunities in a country. Such as, In Malaysia, the government has aggressively utilised procurement to empower, skill, and divert resources for the benefit of the people.

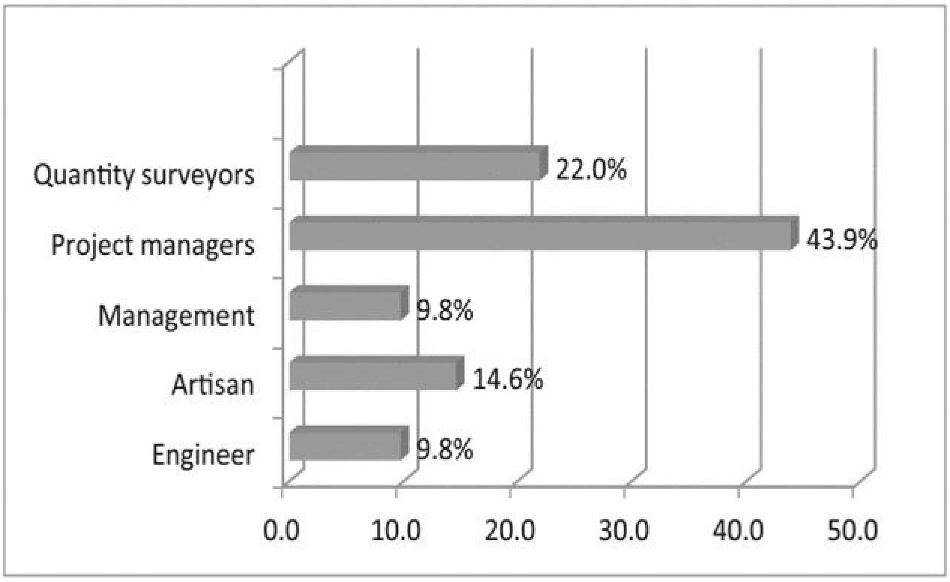


Figure 2.1: Consequences of Shortages of Professional Skills in Sustainability

## 2.3 Small-Scale Construction Projects

In civil engineering, construction projects are the coordinated effort to create a buildings and infrastructure. Construction projects include several modest tasks. Larger scale construction projects need human involvement; in most cases, these construction activities are overseen by a project manager and monitored by a construction manager [40]. With growing project scale comes greater complication, necessitating a larger staff. Major construction projects are overseen by a design engineer and a construction engineer. Because a mega construction project, traditionally defined as a contract worth more than one billion dollars, necessitates a large-scale financial investment, there is a significant chance of set budget and restriction throughout both the project execution and planning stages. The majority of public works contracts undertaken in developing countries have a total cost of less than US dollar 15 000 [41]. Small-scale construction projects mean projects of a total value less than 50,000 dollars (11,327,500.00 Pakistani Rupees) [42]. Larger projects call for a larger on-site presence, with management teams that include a site superintendent, assistant site superintendent, project manager, assistant project managers, project coordinator, and health and safety The bulk of public works contracts performed in underdeveloped nations are for less than dollars15,000 [41]. Small-scale building projects are those with a total cost of less than dollars 50,000 (11,327,500.00 Pakistani rupees) [42]. Greater projects need a bigger on-site presence, with managements consisting of a site director, a deputy site superintendent, a project manager, junior project managers, a project coordinator, and representatives from health and safety. Regardless of magnitude, we always ensure that our leadership is directly involved in each project to a certain level.

According to USAID, SSCPs are constructions with a total surface area of less than 10,000 square feet and a total cost of less than 200,000 dollars. Projects of this magnitude and expense are unlikely to have a substantial negative impact on the environment. This general rule does not apply when there are complicated elements present, such as the site being located in an environmental sustainable location or the work including the rehabilitation of a structure holding poisonous chemicals [43]. Because of the job's unchanging environmental and financial effect, all construction projects need preparation [44]. They include improved water supply and sanitation, access routes and pavements, modest community structures, and solid-waste construction. In order to address the information gap in SSCPs, this research was reported the creation and testing of 67 indicators for use on small-scale construction projects. These statistics are based on information gathered from over 800 small-scale building projects. In underdeveloped nations. The indicators application was also discussed. Projects were typically considered small when no big investment is required. SSCPs are those in which the contract amount is less than 5 million Malaysian ringgit [44]. Construction on a size many times bigger than this rule of thumb may still be considered small-scale, but severe detrimental effects become more likely, necessitating more careful assessment and mitigation.

Small initiatives have more obstacles than large ones since they are limited in cost, length and resources availability, while also facing harsh competitiveness and low productivity. Small-scale construction projects have a project value of less than 10 million Sri Lankan rupees, a construction length of 12 months, no expansion work on the project, and the people employed are more professionals than experts. According to the findings, project size vary differed throughout the construction industry, but overall, a program's level of difficulty Shen, Tam [41] and Lekan, Chukwuemeka [44]. Small-scale construction projects are best distinguished from large-scale building construction projects. The nine most often used project complexity indicators (i.e., characteristics, specifications). The investigation also revealed that the criteria for these features varied. For example, while determining whether a project should be deemed modest, the most commonly used project feature was implemented cost. The replies to a suitable total installed cost criteria ranged from 200,000 dollars to 250 million dollars.

Standard on-site building techniques has long been criticised in small-scale construction projects for their durability, reduced performance, low degree of safety, and significant quantity of waste. The creation and testing of appropriate indicators to be used in small-scale building projects [45]. They contain not just general performance standards, but also indicators for success frameworks. Small projects account for 40 to 50 percent of today's industry capital budgets, making good small project execution all the more critical. It is obvious that offering general guidelines for small project execution and validating their worth would help to the construction industry's overall efficiency [46]. The major reasons for this are a shorter project life cycle and fewer managerial assistance owing to limited visibility [47]. Sustainability indicators also contribute to additional advantages at the site, such as quicker construction time, improved environmental monitoring, and enhancing the quality and viability of small-scale building projects.

### 2.3.1 Nature of Small-scale Construction Projects in Developed Countries

Construction methods and procedures vary depending on the scale of construction used to execute the job. Construction projects in developed nations can also have a significant impact on their quality. It was discovered that project size differentiators varied throughout the industry, but projects demonstrated that project of complexity [48]. The nine most often stated indicators of project complexity best separates SSCP efforts from large-scale building projects (i.e., characteristics). This research helped construction contractors hold the common set of rules in an SSCPs application instance [49]. Indicators of sustainability also contribute to added Site benefits include shorter construction periods, superior environmental control, and testing appropriate and relevant indicators for small-scale building projects in industrialized countries [50]. Indicators for both sustainability and framework were included. As a result of modifications in our SSCPs in developed countries, these difficulties were detected, and warnings were provided that ensure sustainability would be challenging [51]. Conventional on-site construction methods have long been criticize in SSCPs for their lack of durability, efficiency, safety, and wastage.

Naturally, using sustainable construction methods will have a lower environmental effect. If you are the customer for a proposed construction, your specifications will have a significant influence on the project specifications and short or medium building operating expenses. Many construction enterprises in wealthy nations, such as the United Kingdom, do not comment on sustainability concerns, implying that both office-based and on-site personnel take a rudimentary approach to understanding sustainability [52]. Furthermore, as shown in Figure 2.2, the concept of project success is evolving into "sustainable project success," with more integrated sustainability concerns [53]. Enshassi, AlNajjar [54] was shown to be among the top ten of 42 criteria examined.

### 2.3.2 Nature Of Small-Scale Construction Projects In Developing Countries

Several studies looked at the impact of various elements impacting cost performance on project success. The research was carried out utilising a quantitative approach of a survey form to assess the viewpoint of practitioners involved in the construction industry regarding several elements that cause cost overruns in SSCPs. Enshassi et al. [56] discovered that the top ten of 42 examined cost overrun

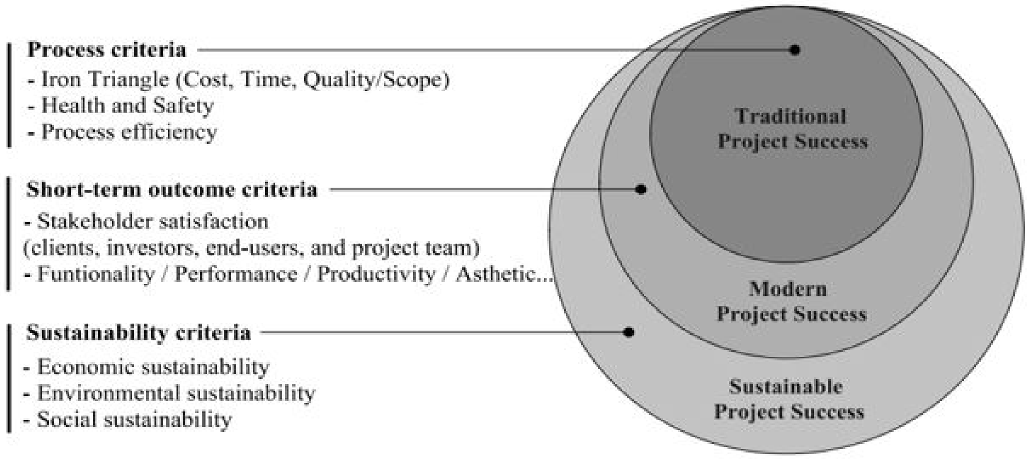


FIGURE 2.2: Project Success Motivation Based on Different Schools of Thought [53]

reasons. Client, supplier, and consultant representatives working in small-scale construction projects in Malaysia were the targeted participants [57]. In all, 54 completed surveys were gathered from the 100 sets issued. The surveys were evaluated using an advanced multivariate statistical method called Partial Least Squares Structural Equation Modeling (PLS-SEM). It simulated the link between numerous elements and their influence on budget shortfall. The findings of the research model study revealed that the factors significantly had a significant overall influence on cost overrun [58]. This was examined using criterion related validity tests, and the R2 value for the model is 0.71, indicating that the analysed components resulted in 71 percent variance extraction [47]. The study identifies numerous elements that contribute to cost overruns in building projects. To solve such problems, suitable cost management measures should be implemented.

Understanding the causes of cost overruns in Malaysian small-scale projects. Contractors site management-related criteria are shown to be the most important among all factors. This revealed that contractors must enhance their organization in relation to the highlighted criteria in order to achieve better cost performance in small projects. Furthermore, these findings will help those involved in managing the cost performance of small-scale building projects [47]. Khknen and Artto [59] examined 8,000 projects and discovered which only 16, The percentage of projects that were able to meet the three well-known performance criteria, namely executing projects on schedule, within budget, and to the required quality standard. While a study of 258 projects in 20 countries concluded that 90 percent of projects experienced cost overruns and that cost performance has not improved with time, it is on the same scale as it was ten, thirty, or seventy years ago. In Nigeria, [61] reported a minimum average cost escalation of 14 percent for construction projects, whereas [62] recorded a minimum cost overrun of 12 percent for building projects in Portugal. This cost overrun in construction projects is attributable to a number of essential aspects that must be uncovered and comprehended. In his investigation of 42 causes of cost overruns, Ameh, Soyingbe [63] discovered that the lack of experience of contractors, the cost of materials, the fluctuation in the prices of materials, frequent design changes, and economic stability were the most significant contributors in developing countries.

The lack and/or inadequacy of government laws, regulations, and requirements on contractor requirements (financial, technical, expertise, etc.) has opened the way for and fostered the development of small contracting businesses, the majority of which are untrained and unsuited for the work. Poor site governance and monitoring, poor project management guidance, money troubles of the owner, financial difficulties of the contractor, and design changes were identified as the most severe and common causes of cost overruns in the Vietnamese construction industry by Le-Hoai and Lee [64]. O'Reilly III and Chatman [65] investigated private residential developments in Kuwait and came to the conclusion that contractor-related difficulties, Cost overruns were mostly caused by material-related issues and financial restrictions. Aside from them, an insufficient quality system has a substantial influence on profit [66]. Cost overruns are a key worry for academics and practitioners in Malaysia as well [67], [68]. As a result, the focus of this study was on examining the key reasons of cost overruns in minor construction projects in Malaysia. The ongoing surge in private home building activities has drawn the attention of an increasing number of small contractors, both skilled and unqualified.

The mix of rising demand for private building construction, owner building experience, and a huge pool of untrained contractors has resulted in several court cases in recent years dealing with conflicts between owners, material suppliers, and contractors [69]. Despite the enormity of the problem, no systematic investigation of elements linked with private residential building concerns in the State of Kuwait has been done [70]. This study study was performed to fill this knowledge gap. Poor cash inflows, breach of contract terms from either the client or the contractor and private contractors, poor management of building workers, poor or perhaps even a lack of making plans to ensure all aspects of construction are firmly attached to, i.e., ensuring timely the project's completion. as per the spread plan on the specific tasks such as milestones, making sure service efficiency within budget.

Several of the corrective measures from many publications for small-scale building projects. 11 effective solutions that may be classified into four categories: (1) staff sustainability training; (2) better worksite process management; (3) increased cost control; and (4) improved equipment management. The findings may be useful not only to Vietnamese contractors, but also for construction firms in other underdeveloped countries in identifying their strategies, quantifying strategic performance, and improving their comparative edge. Lack of good management during the early phases of a business is a primary cause of firm failure for private contractors [72]. Clients frequently operate their own enterprises in order to cut expenditure. Sustainable building practises and cost management are two variables that might lead to corporate success in the construction sector. Several studies have previously been completed, thus the purpose of this research is to identify and address indicators for frameworks and control of private contracting difficulties for SSCPs in backward countries.

## 2.4 Construction Projects Sustainability

The study looked at how sustainably is assessed in building construction projects in developed and developing countries. According to the literature, investigations on sustainability in building construction projects are still dispersed among various study fields and subjects of study. One significant research demonstrated how building projects are carried out to improve sustainability [73]. Sustainable architecture typically emphasises reducing environmental impact and may include components such as trash reduction, recycling, and maintenance, with a way by adding on serving the public rather than profit [41]. Designing an efficient on-site waste disposal system and continuously updating building processes and procedures to improve performance in attaining a sustainable environment [44]. To attain a harmonic conclusion, A economic feasibility should be undertaken prior to the start of the project, since this activity has a direct influence on overall success of the project [41]. Sustainability is a method journey with no single set path that may be accomplished through a variety of efforts [74]. Construction sustainability would be achieved by reacting to social, environmental, and economic performance in project implementation, with all sustainability elements being equally important [75]. The word may be applied to building projects as well as ecologically conscious design [76]. Sustainability is reached through balancing the economic, environmental, and social impacts. Before the building project implementation phase, the feasibility study must be evaluated.

Construction waste and pollution Construction waste management is critical for improving green building standards and reducing environmental burden throughout the structure's life cycle. Wang and Li [77] discovered in their research that crucial parameters such as minimising the floor and internal wall thickness can help to reduce construction waste. Breen and Schultz [78] investigated models and several types of air exchange rate systems for improving air pollution assessment. Schroer and Hlker [79] recommended many light pollution reduction techniques, such as smart lighting systems and the installation of shades Table 2.1 shows the many categories of sustainability indicators that have been created. Spitschan et al. [80] investigated the daylighting influence on outdoor illumination. The ability to exist in a steady condition, serving the demands of the current generation without utilising the assets of the future generation to overcome future challenges, is referred to as sustainability [81].

The sustainability of natural assets and the ecosystem is referred to as environmental sustainability [87]. Social sustainability is accountable for the community

TABLE 2.1: Sustainability Indicators in Different Categories of Construction Projects

| Theme | Sustainability category | Indicators | Author (year) |
|---|---|---|---|
| Sustainability infrastructure rating system | Management, society, environment and economy | 29 | Diaz-Sarachaga, Jato-Espino [82] |
| Hydropower sustainability | Environmental, social, economical, and Technical, | 28 | Tahseen and Karney [83] |
| Environmental sustainability | Less use of land, sustainable use of nature, and non renewable energy resources. | 13 | Baos-Gonzlez, Martnez-Fernndez [84] |
| Renewable and sustainable energy | eco-efficiency; socioeconomic, and socio-environment. Lifecycle; environmental indicators, economic indicators, and social indicators | 44 | Chong, Teo [85] |
| Life cycle sustainability assessment | Social, Environmental, Economical; | 19 | Steen and Palander [86] |

well-being of residents and employees [88]. Finally, economic sustainability includes the project's initial direct and indirect expenditures, as well as running costs during the project's lifetime [89]. Economic sustainability in construction, which deals with the cost of building throughout the construction period as well as after the project's life cycle, should be kept to a minimum.

### 2.4.1 Environmental Sustainability

The construction and awareness of sustainability is dependent on an understanding of the consequences of individual acts, a desire for knowledge, and total engagement and dedication to the idea. Environmental sustainability refers to the long-term viability of a natural environment that contributes to long-term development by using resources for supply and emissions [87]. It has identified the environmental side of sustainability as a devalue of organization s economic, a decrease in material resources can reduce stress on natural systems, and prolong environmental sustainability economy's services [90]. Water use, carbon dioxide emissions, the utilization of recyclable sources, low safety materials, renewable energy utilisation, and environmental sustainability criteria are all recognised as standards for basic envrionmental safety and sustainability.

### 2.4.2 Social Sustainability

There is a scarcity of theories and empirical studies on social sustainability in terms for construction as well as generally. According to the literature study reveals, the social was only recently introduced into arguments over environmental sustainability. The comfort of every individual directly or indirectly touched by development initiatives is connected with social sustainability [88]. As a result, the social component is linked to human feelings like safety, comfort, security, and skills, as well as human contributions like perception, desire, and healthy environment [87]. The goal of social sustainability is to preserve people's cultural and basic needs while maintaining stability in human morals, relationships, and organisations [87]. Environmental sustainability or maintenance and secure the nature, according to Said et al. [88], is necessary to social sustainability overall, despite being crucial to the system that sustains life [87]. A common interest in the construction project in all countries, requirements for worker protection during working, leadership and organisational learning, and training of resident employees and workers throughout construction, operation, repair, and destruction are all examples of the social aspect of sustainability [89]. Members of the community who are focused on the changes, difficulties, and accomplishments made possible by policy initiatives. However, their technique could not address the limitations of measuring various social activities, which are regarded as a goal result in the research.

### 2.4.3 Economic Sustainability

Economic sustainability entails using full-cost accounting rules and real-cost pricing to determine prices and collect for products and services and achieve more effective resource utilisation. Economic sustainability refers to the decrease of direct and indirect expenses, operational costs, and building time [89]. Economic well-being is related with financial gains from building projects that benefit the public, the contractor, the client, and the government [91]. As a result, financial or economic sustainability may be defined as building costs, running expenses, operation and maintenance costs, and market potential. Sustainable building considers ecological and human costs in addition to economic considerations.

### 2.4.4 Indicators Of Sustainability In Construction Projects

Indicators are statistics or other metrics that allow information about a complicated topic, such as environmental effect, to be simplified into a form that is relatively straight forward to use and comprehend. A priority matrix is provided based on the significance and importance of the indicators, as well as the labour necessary to apply them [92]. As stated in the introduction, there is a high need for indicators related to SSCPs (building and civil engineering) have usually implemented more indicators into their system of performance management [93]. Figure 2.3 depicts published articles on sustainability indicators from 2015 to 2022. There is currently no standard or standardized model of identification that follows a technical-scientific process, while some ideas exist [94]. We think that a plan is sustainable whenever it increases in all three aspects of sustainable development, namely environmental respect, social integration, and social economy, while keeping cost, time, safety, and efficiency within acceptable limits. Indicators of sus-

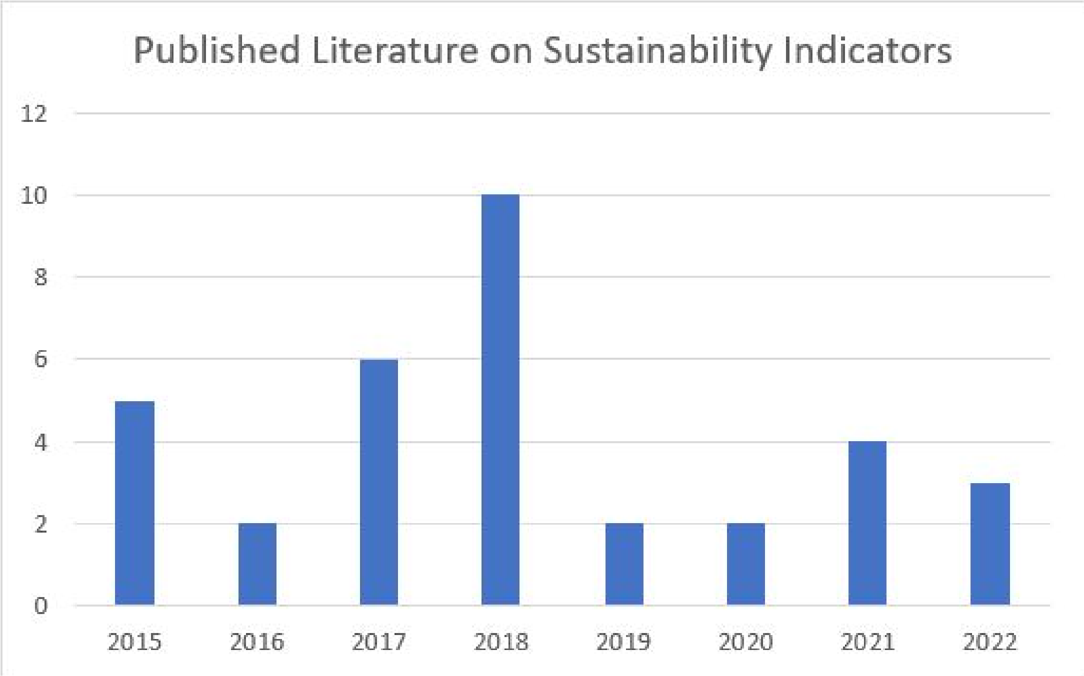


FIGURE 2.3: Yearly Published Nos of Articles

tainability give managers with decision-making information that can easily track the progress and quality of construction. Indicators of management instrument performance are comprised of one or more indicator groups that permit continuous evaluation of the position and evolution of a company's particular activity [95]. Indicators of sustainability are not merely conventional performance measurements; they are also essential to municipal development. Over the past few decades, Construction firms have become increasingly active in issuing sustainability reports [96], [97], and [98] Corporations gain from these releases by enhancing their public role and stakeholder connections with others firms and industries [96]. Recent publication showed evaluations of the quantity of sustainability indicators in construction projects. Figure 2.4 depicts the number of sustainability indicators found in each article. Thus, sustainability is seen as a crucial aspect in the performance of businesses [96, 99]. To define the scope of sustainability, the United Nations created Agenda 2030, which includes 17 sustainable development objectives and 169 integrated goals UN [100]. Building resilient infrastructures, supporting inclusive and sustainable industrialization, stimulating innovation, and making cities and human settlements inclusive, safe, resilient, and sustainable are some objectives associated with the construction industry.

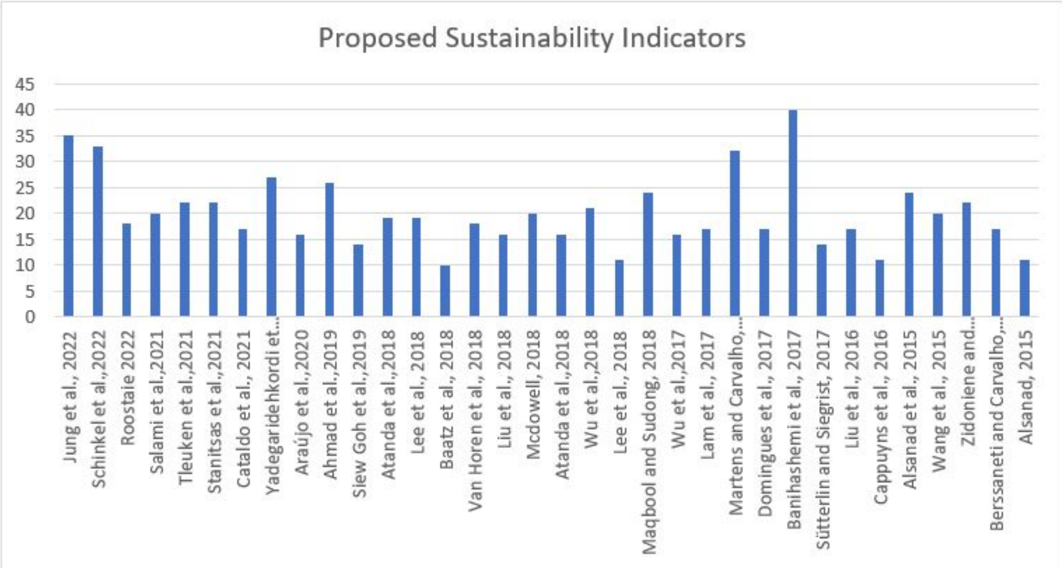


Figure 2.4: Proposed Sustainability Indicators in Construction Projects

To select these indicators, the authors conducted a literature research and compiled all construction industry-related indicators. At all phases of a project, sustainability is vital. The success of construction projects is determined by specific indicators [101]. The variables evaluated give a framework criterion for the performance of sustainable construction projects. It is probable that some of these indicators are similar to those of other projects, but that is beyond the scope of this work; additional research will provide light in this regard. Yadegaridehkordi, Hourmand [102] assessed sustainability indicators for green building manufacturing using fuzzy multi-criteria decision making. The use of the principal building materials in the construction industry has negative environmental effects [103]. Sustainability indicators for evaluating green building manufacturing in Malaysia using Green Building Index (GBI), the most widely used sustainability grading tool in Malaysia. A panel of experts and the Laboratory for Fuzzy Decision-Making Trial and Evaluation collect data. According to the results, Energy Efficiency and Indoor Environmental Quality are the most essential criteria for evaluating construction projects, while Water Efficiency and Innovation are the least important.

Success is the ultimate objective of all projects. Criteria or indicators for evaluation are the set of principles or norms by which judgements can be formed.

Typically, a successful project will meet its initial goals or objectives [104]. It is the accomplishment of an externally observed set of objectives. A set of ultimate standards or evaluation criteria (indicators) must be developed in order to measure the achievement of sustainable development objectives in affordable housing. Indicators of sustainability play crucial roles in projects by allowing policymakers and practitioners to quantify the level of project success [105]. Moreover, they aid building professionals and policymakers in resource allocation planning [106]. In addition, evaluation criteria are essential for comparing the performance levels of related initiatives [107]. Therefore, numerous evaluation criteria have been offered in the literature. While general evaluation methods may apply to all construction projects, the most typical causes are (1) the owner's financial difficulties, (2) change guidelines, and (3) a lack of communication/poor connection [108]. Sustainability in construction can be achieved by identifying sustainability indicators that define the success of a building project. These indicators can also aid in the construction's performance.

The principles of sustainability indicators have substantial significance in construction projects. The field of project management is increasingly incorporating sustainability concerns into its techniques. Cossio and Norrman [109] hold indicators for the social sustainability of limited wastewater treatment facilities (WWTPs) in low and lower-middle income nations. Several research proposed sets of sustainability indicators for examining the planning and/or operation of WWTPs. The creation of a contextualised collection of relevant and effective sustainability indicators to support the planning and/or operation of small-scale WWTPs in poor and lower-middle income nations is critical. This research created a contextualised set of sustainability metrics for small-scale wastewater treatment plants in Bolivia, a lower-middle income nation. A literature analysis was paired with empirical investigations employing focus groups with executives and operators, as well as workshops with specialists, to identify indicators. Nineteen authors from the literature were chosen to represent the key sustainability issues [110]. This whole set of recommended indicators framework may be found in study work for small-scale building projects. Understanding the appropriate indicators is necessary to handle sustainability challenges in building projects.

## 2.5 Summary

The major problems faced by private contractors are waste management, inadequate planning and lack of sustainability practices. The challenges faced in small-scale construction projects are poor site management, lack of sustainability in construction and cost management issues for such projects, which cause project delays and waste generation. Sustainability in construction can be achieved by responding to social, environmental, and economic performance in construction, such as reducing harm to the environment and enhancing performance to achieve sustainability. In construction projects, sustainability indicators and their frame- work are becoming more important. It is claimed that sustainability indicators such as sustainable use of natural resources etc have a significant impact on sustainable construction in small-scale construction projects.

# Chapter 3

# Research Methodology

## 3.1 Background

This chapter explains the procedure of research work and describes the methods and techniques selected for the completion of the research objectives. The foundation of the suggested methodology identified sustainability indicators and created a framework by taking sustainability into consideration. In this study, the first step was to identify the crucial sustainability indicators in construction projects using a literature review, Science Direct, Web of Science (WOS), Google Scholar, and Springer Link. Scholars believe that these comprise the vast majority of scientific literature. The appropriate sustainability indicators have been obtained through an online survey. A survey was conducted among private contractors working with SSCPs and registered with the Pakistan Engineering Council. This study has been outlined to highlight the sustainability indicators impacting small-scale construction projects in order to meet the objectives of the guidelines related to sustainability at construction sites. The statistical package for social sciences (SPSS) was used to conduct the analysis. Figure 3.1 defines a comprehensive summary of the flow of research methodology in graphical format.

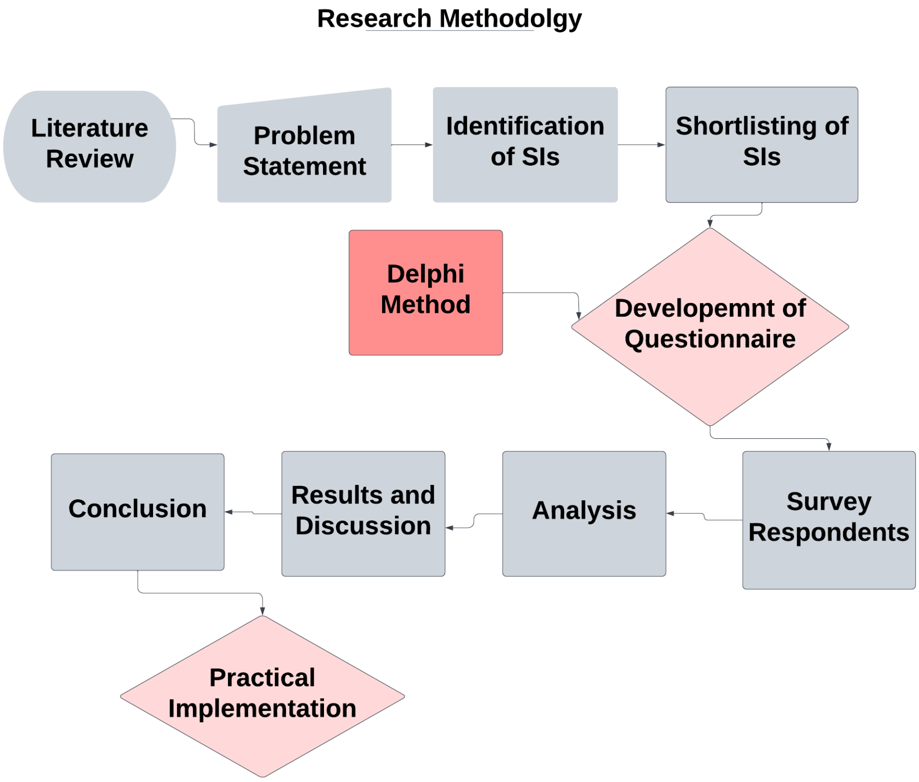


FIGURE 3.1: Schematic Presentation of the Method Used in this Research

## 3.2 Shortlisting of Sustainability Indicators

The valuable indicators that can be assessed and monitored in construction projects are shortlisted from the literature. Literature has been used to shortlist the most important indicators that may be used to evaluate sustainability in construction projects. Many sustainability indicators have been published on different aspects of sustainability in various research areas, but we shortlisted only specific to construction and building projects.

### 3.2.1 Identification of Sustainability Indicators for Construction Projects

The discovery and gathering of sustainability indicators not only offers valuable information for management choices, but also gives an opportunity for construction enterprises that conventional development techniques have failed to deliver [111].

The stage of a research study in which acceptable and essential sustainability indicators are obtained in accordance with the study's aims and objectives is known as indicator collection and identification. A study of the literature [112] and research on Web Of science and Google Scholar, among other sources, were used to identify the most significant indicators for building projects. For building projects, 157 significant indicators were found. Scholars consider the great majority of academic literature to fall within this category.

### 3.2.2 Governing Sustainability Indicators for SSCPs

This relates to the frequency of published research's sustainability indicators. Some metrics are based on energy usage and the life cycle of construction projects, for example. The regulatory sustainability indicators are based on variables that have been carefully chosen to ensure the success of the construction sector and small-scale building projects. Contractor success is sometimes characterised in terms of progress towards strategic goals [113], although it is most typically defined as the recurring, periodic attainment of some degree of operational goal (e.g., zero defects, 10/10 customer happiness, etc.). According to the literature review, several writers have established numerous dimensions and sub-dimensions to quantify sustainability performance. A compiled list of the most often quoted dimensions and subdimensions in works of literature A number of additional sustainability indicators have recently been discovered and examined. After using frequency table based on previously published data, the governing indicators were around 69.

## 3.3 Questionnaire Development and Finalization

In order to properly weight sustainability indicators prior to the development of the Sustainability indicators framework, a questionnaire survey was designed and constructed. Firstly, the delphi technique was used to identify the essential indicators of sustainability and construct a questionnaire. The Delphi method is a formal technique or procedure for communication that was initially developed as a detailed prediction methodology based on a panel of professionals, researchers, and experts. the Delphi method is used in a variety of contexts, including scientific research and business decision-making. In most cases, the feedback was gathered through the use of the delphi technique and dialogues in focus groups [114]. However, the delphi method which makes the procedure more thorough, straightforward, and effective than other procedures [115]. In the current study, three rounds of delphi techniques were adopted by which we finalized indicators for the survey. Seven experts participated in the first round, which reduced the number of sustainability indicators to 85. Six experts made revisions to the questionnaire in the second round and lowered the number of indicators to 60. Six experts were chosen in the last round to finalize the 49 sustainability indicators for the questionnaire survey. This field study included a number of industry experts who were asked to participate in order to provide insightful feedback on the development of the questionnaire.

A list of sustainability indicators is narrowed down after in-depth discussion with experts and comments from industry experts. These sustainability indicators were used to develop the questionnaire included in Annexure A. It is intended to build a questionnaire survey in order to correctly weight sustainability indicators and rank them in terms of importance based on experts opinions. This tool is particularly effective for measuring subject behavior, preferences, intentions, and opinions. The questionnaire then contained two important parts. The first part consisted of survey objectives, permission form, profile information, such as their occupation, contact information, years of experience, and organization type. In the second section, participants ranked the significance of sustainability indicators based on their level of expertise. The construction sector and private contractors were chosen as the source of the targeted respondents. The questionnaire samples were sent to private contractors working on small-scale construction projects.

The number of targeted respondents were counted by the Kothari formula. Used kothari formula for number of responses based on given population of area. Kothari (2004) argued that the result from the sample can be used to make generalizations about the entire population as long as it is truly represented. According to given population Kothari showed minimum responses should be 45 as shown in the given formula (i), for this study 56 responses were received.

The formula for sample size: n= N/1+N (e)2..(i)

n = Sample size to be studied N= Population size , e = margin of error

by this formula, the sample size for this study : 100/1+100(0.1)2 = 45

The required sample size 45.

Various rating measures have been created to directly gauge (i.e. the person knows their attitude is being studied). The most used instrument is the Likert scale (1932). Using the Likert scale, the replies were evaluated. The matching conditions listed in table 3.1 of the scale [116] were applied. Typically, the Likert scale includes five alternative responses to a statement or question, allowing respondents to express the degree to which they agree or feel strongly about the statement or subject.

TABLE 3.1: Feedbacks Scale, [117]

| Sr.No | Description | Score Range |
|---|---|---|
| 1 | Not important | 1 |
| 2 | Less important | 2 |
| 3 | Neutral | 3 |
| 4 | Important | 4 |
| 5 | Very important | 5 |

## 3.4 Conduct of Survey

The weight of the considerable indicators has been evaluated through an online portal, A questionnaire was created and sent to private contractors. Registered contractors provided all of the responses in Rawalpindi and Islamabad as figure

3.2 indicates. The range of responses from Rawalpindi and Islamabad contractors were 56. Only replies from registered contractors were considered. The views

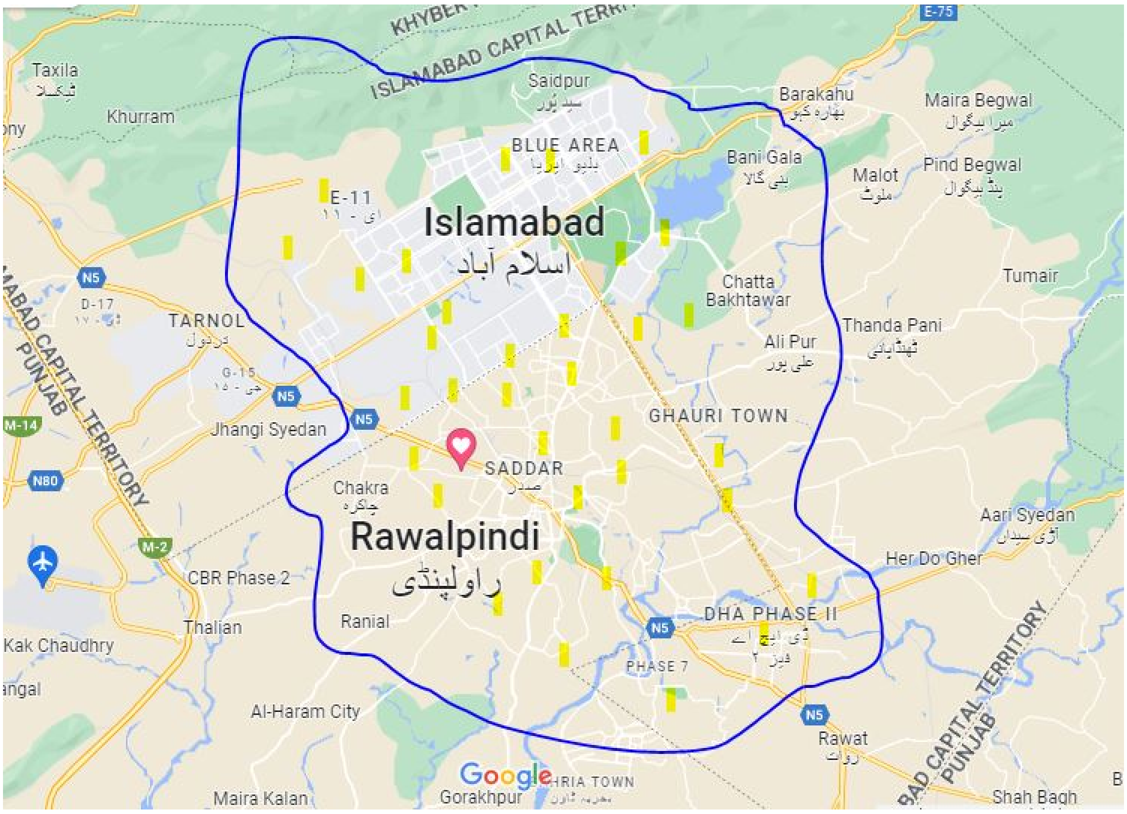


FIGURE 3.2: Location of the Study

of construction experts were collected using a 5-point ordinal Likert scale ranging from not important to very important. Point 1 (i.e., not significant) indicates that the supplied SIs is the least significant; hence, it may make a minimal impact or none when comparing the two approaches' sustainability [118]. Conversely, point 5 (i.e., very important) is deemed highly essential, and the SIs has drastically different values/amounts in each building technique. At the conclusion of the questionnaire, respondents were requested to submit any other Sustainability indicators that were not already on the list.

In this study, prospective volunteers were contacted by direct and indirect means. Under the indirect contact technique, construction industry-related organisations were sought to ask for participation in the survey by distributing the questionnaire to its participants, i.e., private contractor businesses. In the event of direct interaction, a list of construction practitioners and connected specialists who have participated in construction processes was compiled for the survey. Upon completion of the contact list, the questionnaire was sent to the earlier mentioned possible responders either online, i.e., by emailing the interactive version, or offline, i.e., by distributing paper copies. After all the surveys were sent, two follow-up reminders were issued.

## 3.5 Analysis Procedure

After obtaining all of the filled forms, the subsequent crucial step was to examine the gathered data. Initially, a reliability study was conducted to examine the questionnaire's dependability. Different things (in this case, SIs) are employed to measure the same idea. To do this, Cronbach's alpha, commonly known as the reliability coefficient, was used to determine how closely the questionnaire's generated sustainability indicators (SIs) relate to each another. Cronbach's alpha values vary from 0 to 1, with higher values indicating more internal consistency reliability of the SIs. According to Nunnally (1978), coefficients of dependability over 0.70 are acceptable [119]. SPSS v.21 is the version of Statistical Package for the Social Sciences that is utilised for the purpose of determining Cronbach's alphas..

Using a ranking technique, the acquired data was used to rate the created SIs. As indicated before, a 5-point ordinal Likert scale was utilised to evaluate the significance (applicability) of SIs in this research. Scoring is based on the rank order of indicators on ordinal scales, and the precise difference between two points is not known. For instance, point 4 is more significant than point 3, but it is impossible to quantify by how much. According to [120], when utilising descriptive statistics (e.g., Likert scales), non-parametric approaches rather than parametric statistics should be used to rank the items (here SIs) (means, standard deviations, etc.). Since the scoring system was ordinal in nature, the Relative importance index (RII) technique was utilised to rank the SIs according to their application (importance) [121]. The SIs are computed in an Excel spreadsheet. First, the frequency analysis was performed to get the percentage ratings for the various selection indicators. This was accomplished using SPSS. The percentage ratings (provided by SPSS as valid percentages) were then used to compute the RII using an Excel sheet. The value shown is the SPSS-calculated valid percentage.

All of the sustainability indicators were ranked according to the values of their relative importance index (RII) both under the overall sustainability indicators (i.e., all 49 SIs) and within each associated sustainability dimension category, such as the environmental category, the economic category, and the social category. These rankings were determined on a given scale. The next step was to assign a significance index (SI) relevance level to each of the Sustainability indicators, using the RII important scale as a guide. The key sustainability indicators are those SIs that were given a very high, very important, or high priority degree of assignment. In other words, they may be deemed relevant SIs that, from the perspectives of the people who took part in the study, are capable of making a significant difference in the degree to which building is more or less sustainable compared to traditional construction.

### 3.5.1 Reliability Test

The reliability test is one of the most fundamental methods for determining the dependability of the results for a given study. The reliability test checks the stability and correctness of the statistics which you perform for your results. Cronbach's alpha is an essential method or term for assessing the internal accuracy and reliability of any data collection [122]. Cronbach's alpha is solely used for analysing reliability and some standard range according to mentioned in literature from low to good. Its value greater than 0.7 is deemed appropriate and acceptable for research, indicating that the collected data can be evaluated appropriately for future study [123]. Statistical studies typically employ Cronbach's alpha data sets [124], as illustrated in table 3.2 there range from unacceptable to excellent [125].

Table 3.2: Ranging Scale of Cronbachs Alpha, [125]

| Internal consistency | Cronbachs Alpha |
|---|---|
| Excellent | Alpha is greater than or equal to 0.9 |
| Good | 0.9 greater than Alpha and Alpha greater than or equal to 0.8 |
| Acceptable | 0.8 greater than Alpha and Alpha greater than or equal to 0.7 |
| Questionable | 0.7 greater than Alpha and Alpha greater than or equal to 0.6 |
| Poor | 0.6 greater than Alpha and Alpha greater than or equal to 0.5 |
| Unacceptable | 0.5 greater than Alpha |

### 3.5.2 Normality Test

Shapiro-W-test Wilk's (1965) is a well-established and reliable technique for determining normality. The Shapiro-Wilk test, often known as the normality test, is used to determine whether or not the data obtained is normal. If data are normally distributed (parametric data), then the significant level should really be larger than 0.05, but a value less than 0.05 indicates that the data range is not normal (nonparametric data) [126].

#### 3.5.2.1 Parametric and Non-parametric Evaluation

In statistical analysis, the choice between parametric and nonparametric tests is made when the results do not confirm the test hypothesis. The parametric test is valid for a stable, regularly distribution pattern with precisely defined spreads for each group, as well as for linear data. However non-parametric tests are performed when data is examined on ordinal and ordered scales, doesn't really follow a specific distribution, and exhibits non - linear behavior [127]. Non-parametric tests reveal that the data are not distributed normally, whereas parametric tests demonstrate that the data are distributed normally. Kim and Park [128] demonstrated that a non-parametric test is utilised when data do not have a normal distribution. The normality hypothesis is rejected if p-value is less than or equal to 0.05. The normality assessment hypothesis is as follows: H0: The data follows a normal distribution if p-value greater than alpha level. H1: The data does not follow a normal distribution if p-value less than alpha level.

### 3.5.3 Demographic Analysis

In this analysis, the characteristics of survey respondents are evaluated. Basically, their education, relative job experience and related construction industry sectors have been assessed. All the responses were counted from industry experts.

### 3.5.4 Relative Importance Index

This study's methodology consisted of identifying and evaluating the intensity level of results associated with accidents and hazards, harmful behaviours, unsafe settings, management systems and social groups, and natural factors. The value of each component was calculated by averaging the data set values supplied by respondents. Therefore, the intensity level selected by respondents was used to compute the relative significance index for each piece. The 1-to-5 ranking scale was converted into a relative relevance index for each component [129] in order to quantify the ranks of all the elements. RII is determined by the equation (1), [130]:

RII = W/A N (1) W = Weightage given to each factor by respondents ranges from 1 to 5 using Likert scale A = Highest value for factors (which is 5 on the Likert scale) N = Total number of respondents.

### 3.5.5 Co-relation Analysis

In this analysis, the relationship among different variables is assessed. Their relationship can be positive, negative or mutual.

### 3.5.6 Frequency Analysis

Frequency analysis is a descriptive statistical approach which presents the number of occurrences of each response as chosen by respondent and analyses the results in a way that would draw the final conclusion. Frequency analysis is an approach which gives the idea to know the perception of the respondents. In more detail the trend followed in the survey can be observed by this technique. The cumulative percentage versus various variables assists in revealing the percentage value for data plus percentage for all values that precede it. In this study the frequency analysis was performed against selected sustainability indicators and the number of occurrences of each response were measured as chosen by the respondent. Indicators selection has been made on the base of mean score value, SPSS has been used for the calculation of the mean. After calculating mean factors are arranged in descending order of mean and factors from top, middle and bottom are being selected for further analysis.

## 3.6 Framework Development Using SPSS AMOS

Providing a structure for the integration of building projects by identifying different qualities based on their relative significance. The suggested framework is a beneficial tool for construction professionals to utilise their resources effectively in order to complete a project that is more integrated. Despite the traits described in this research, such as coordination, cooperation, leadership, information sharing, and trust, the report lacks a comprehensive grasp of integration attributes such as change management and uncertainty integration. Consequently, a framework for sustainability indicators is required to adequately capture the elements that impact the construction industry. Construction is more difficult than other industries due to its dynamic, fragmented, and complicated structure, since it demands the participation of several parties and the effective management of processes. This necessitates the creation of well-defined plans and procedures to compete with uncertainties and hazards. Variations in cost and scheduling may result in unintended repercussions that reduce client satisfaction. When the success of a project is of the highest significance, it is essential to identify underlying criteria that must be addressed. Several research studies demonstrate that work performed safely and on schedule are the most essential determinants of project success [131]. Projects are deemed successful for businesses if customer satisfaction and cost targets are met in the majority of cases. Several studies have already shown the significance of customer satisfaction and on-time completion of the project to the success of a project.

## 3.7 Summary

This thesis's idea is based on a comprehensive literature research that explains construction project issues in the Pakistani construction sector, particularly SSCPs. This research has been designed to highlight the sustainability factors influencing small-scale building projects in order to achieve the sustainability criteria for construction sites. The survey approach has been employed to gather the information via questionnaires from the site man- ager, construction specialists, and construction personnel at the site. This study was done using descriptive research to evaluate the sustainability implementation. The Delphi technique was used to identify the essential parameters of sustainability and construct a questionnaire. The statistical approach has been applied to analyse the information received. After the data analysis, findings and conclusions were generated.

# Chapter 4

# Results and Discussion

## 4.1 Background

This chapter provides a summary of the responses given by contractors based in Pakistan's capital city to the questionnaire that was distributed previous. The use of SPSS in the analysis allowed for the development of conclusions about the results. Graphs and tables are included in this report. This study's objective was to compile a selection of the sustainability indicators that are especially suitable for managing small-scale construction projects in Pakistan. The evaluation of the respondents on the questionnaire that was collected by private Companies in Islamabad and Rawalpindi formed the basis for these findings, which may be found below. Both the framework for sustainability indicators and a set of recommendations for contractors have been designed and explained.

## 4.2 Reliability Analysis

this section explain detail analysis that has been done by SPSS. The results are shortlisted and categorised according to the objectives of the study. Analysis results of questionnaire survey is explored in below subsection. The idea of reliability is used to evaluate the quality of research. It illustrates how well a procedure or test measures something. Reliability refers to a measure's consistency [122].

Cronbach's alpha was used to the questionnaire to guarantee its reliability. Cronbachs alpha is the most popular indicators of internal consistency. As stated in table 4.1, the value 0.98 was satisfactory. It is used most often when a survey or questionnaire has many Likert items that create a scale and the reliability of the scale must be determined.

The reliability test is one of the fundamental tests conducted to verify the reliability of the data. Reliability test is also known as Cronbachs alpha test. Summarize reliability data from SPSS is shown in table 4.1. Cronbachs alpha test is a valuable analysis used to assess the reliability or internal consistency of any given data sets.

TABLE 4.1: Reliability Statistics

| Name | Number | Percent | Cronbach's Alpha | Number of Items |
|---|---|---|---|---|
| Valid | 56 | 100.0 | 0.980 | 49 |
| Excluded | 0 | 0 | | |
| Total | 56 | 100.0 | | |
| a. Listwise deletion based on all variables in the procedure. | | | | |

Statistics is used to evaluate the inter-item consistency reliability test. A greater score indicates a stronger association between test items, whereas a lower number indicates a weaker relationship. Reliability is adequate if the alpha is between .70 and .99. If the alpha value is larger than 0.70, it indicates that the data is suitable for further study [125]. In this study, Cronbachs alpha .980 is collected which corroborate the consistency of data produced. According to this assertion, findings from a reliability study are accurate, and additional analysis may be conducted.

Coding is the process of identifying and specifying the relationship between ideas. Coding is a method for classifying or categorising material in order to provide a framework for organising themes. This research comprises 3 parameters of sustainability Economical, Social, and Environmental. For the ease of indicators evaluation coding for economical sustainability indicators ECO= (ECO1, ECO2, ECO3, ECO4, ECO5..) are referred to each indicators and all the sustainability contain 49 in- dicators. The coding for Environmental indicators ECO=(ENV1, ENV2, ENV3, ENV4), and for social indicators SOC=(SOC1, SOC2, SOC3, SOC4). Indicators coding are essentially the short form of the questionnaire data with grouping numbers respectively.

## 4.3 Normality Analysis

The normality test, which is also known as the Shapiro-Wilk test, was carried out in SPSS to examine the distribution pattern of the obtained data in order to determine whether or not the data were normally distributed [126, 127]. This test is also known as the Shapiro-Wilk test. Kim and Park [128] provided evidence that non-parametric tests are appropriate to perform when the normal distribution of the data cannot be assumed. If the p-value is less than or equal to 0.05, the normality hypothesis cannot be accepted as true. As can be seen in table 4.2 down below, the value of 0.000 was determined to be the significant value for the size of influence.

Because the results of the normality test (the Shapiro Wilk test) suggest that all significant values are lower than the alpha threshold of 0.05, we can conclude that the null hypothesis is not correct. This lends credence to the idea that the data do not follow a normal distribution, which is required under the normality hypothesis. Data refers to non-parametric data.

Table 4.2: Results of Normality Test (Shapiro Wilk Test)

| Sr.No | Description | Factors Code | Statistics | Sig. |
|---|---|---|---|---|
| 1 | Economic and Political stability | ECO1 | .831 | .000 |
| 2 | Innovative Construction Methods/New product development | ECO2 | .877 | .000 |
| 3 | Target marketing and benefits | ECO3 | .861 | .000 |
| 4 | Best practice strategy/Implementing an effective change management strategy | ECO4 | .834 | .000 |
| 5 | Scope control through managing changes | ECO5 | .820 | .000 |
| 6 | Cost management plan | ECO6 | .738 | .000 |
| 7 | Resource planning/resource allocation | ECO7 | .784 | .000 |
| 8 | Organizational culture | ECO8 | .863 | .000 |
| 9 | Building Inner Engineering/Management(facilities) | ECO9 | .870 | .000 |
| 10 | Renewable Energy and Onsite Energy Capture/Recovery | ECO10 | .849 | .000 |
| 11 | Verification and Maintenance | ECO11 | .853 | .000 |
| 12 | Site Planning/Site Investigation/Tracking | ECO12 | .810 | .000 |
| 13 | Process quality | ECO13 | .869 | .000 |
| 14 | Life cycle costs | ECO14 | .861 | .000 |
| 15 | Facility set-up costs(labor etc) | ECO15 | .862 | .000 |
| 16 | Market supply demand | ECO16 | .872 | .000 |
| 17 | Financial/Economic performance | ECO17 | .818 | .000 |
| 18 | Efficient data processing | ECO18 | .855 | .000 |

The results of the Kolmogorov-Smirnova normality test indicate that all of the significant values are lower than the alpha threshold of 0.05, which suggests that the null hypothesis should be rejected. The results are presented in the table that can be found below. This is consistent with the normality hypothesis, which states that this indicates that the data does not adhere to the normal distribution. Further analysis will be carried out using a non-parametric test because the data does not conform to any certain metrics.

TABLE 4.3: Kolmogorov-Smirnova

| Sr.No | Description | Factors Code | Statistics | df | Sig |
|---|---|---|---|---|---|
| 1 | Economic and Political stability | ECO1 | .227 | 56 | .000 |
| 2 | Innovative Construction Methods/New product development | ECO2 | .254 | 56 | .000 |
| 3 | Target marketing and benefits | ECO3 | .257 | 56 | .000 |
| 4 | Best practice strategy | ECO4 | .237 | 56 | .000 |
| 5 | Scope control through managing changes | ECO5 | .296 | 56 | .000 |
| 6 | Cost management plan | ECO6 | .286 | 56 | .000 |
| 7 | Resource planning or resource allocation | ECO7 | .274 | 56 | .000 |
| 8 | Organizational culture | ECO8 | .271 | 56 | .000 |
| 9 | Building Inner Engineering/-Management (facilities) | ECO9 | .259 | 56 | .000 |
| 10 | Renewable Energy and Onsite Energy Capture | ECO10 | .272 | 56 | .000 |
| 11 | Verification and Maintenance | ECO11 | .302 | 56 | .000 |
| 12 | Site Planning/Site Investigation/Tracking of construction | ECO12 | .240 | 56 | .000 |
| 13 | Process quality | ECO13 | .205 | 56 | .000 |
| 14 | Life cycle costs | ECO14 | .244 | 56 | .000 |
| 15 | Facility set-up costs(labor etc) | ECO15 | .224 | 56 | .000 |
| 16 | Market supply demand | ECO16 | .257 | 56 | .000 |
| 17 | Financial/Economic performance | ECO17 | .252 | 56 | .000 |
| 18 | Efficient data processing | ECO18 | .259 | 56 | .000 |

### 4.3.1 Kruskal Wallis Test Result

After the normality test, it was essential to check the degree of perception of the respondents. As shown by the normality hypothesis, data is non-parametric. As a result, the Kruskal-Wallis test was used to examine the level of perception among the respondents. According to Kruskal and Wallis [134], this test determined if respondents' views of each indicated component were the same or distinct. If the p-value is less than 0.05, the hypothesis is rejected. The following Table 4.4 illustrates the opinions of the respondents.. The results of the Kruskal-Wallis test

TABLE 4.4: Kruskal Wallis Test Results

| Sr.No | Factors Code | Description | Magnitude of Impact | Decision |
|---|---|---|---|---|
| 1 | ECO1 | Economic and Political stability | .306 | Retain the null hypothesis |
| 2 | ECO2 | Innovative Construction Methods/New product development | .240 | Retain the null hypothesis |
| 3 | ECO3 | Target marketing and benefits | .900 | Retain the null hypothesis |
| 4 | ECO4 | Best practice strategy/Implementing an effective change management strategy | .331 | Retain the null hypothesis |
| 5 | ECO5 | Scope control through managing changes | .637 | Retain the null hypothesis |
| 6 | ECO6 | Cost management plan | .142 | Retain the null hypothesis |
| 7 | ECO7 | Resource planning/resource allocation | .333 | Retain the null hypothesis |
| 8 | ECO8 | Organizational culture | .421 | Retain the null hypothesis |
| 9 | ECO9 | Building Inner Engineering/Management (facilities etc) | .078 | Retain the null hypothesis |
| 10 | ECO10 | Renewable Energy and Onsite Energy Capture/Recovery | .153 | Retain the null hypothesis |
| 11 | ECO11 | Verification and Maintenance | .115 | Retain the null hypothesis |

support the null hypothesis for the respondents (H0: p alpha level, medians are equal). It indicates that respondents have the same perception of the amount of effect for the majority of sustainability indicators. The Kruskal-Wallis test is a generic non-parametric test that may be used to compare more than two independent samples. It may be used to determine if samples are drawn from the same distribution. If the significance value is larger than 0.05, all respondents have the same opinion.

## 4.4 Demographic Analysis

A total of 76 questionnaires were distributed, of which 56 were filled out and returned, making the total number of questionnaires 76. This equates to a response rate of 74%, which is considered to be fairly high for the purpose of establishing study results. In the event when the size of the population is unknown, any sample size that is greater than fifty percent may be regarded appropriate and sufficient [132]. According to Ashley and Boyd's [133] research, a response rate of fifty percent is deemed adequate, sixty percent is seen as remarkable, and a response rate of seventy percent or higher is regarded as great. This remark gives the perception that the response rate of 74 percent was significantly higher than average. Figure 4.1 demonstrates that those with expertise in construction contributed the greatest information.

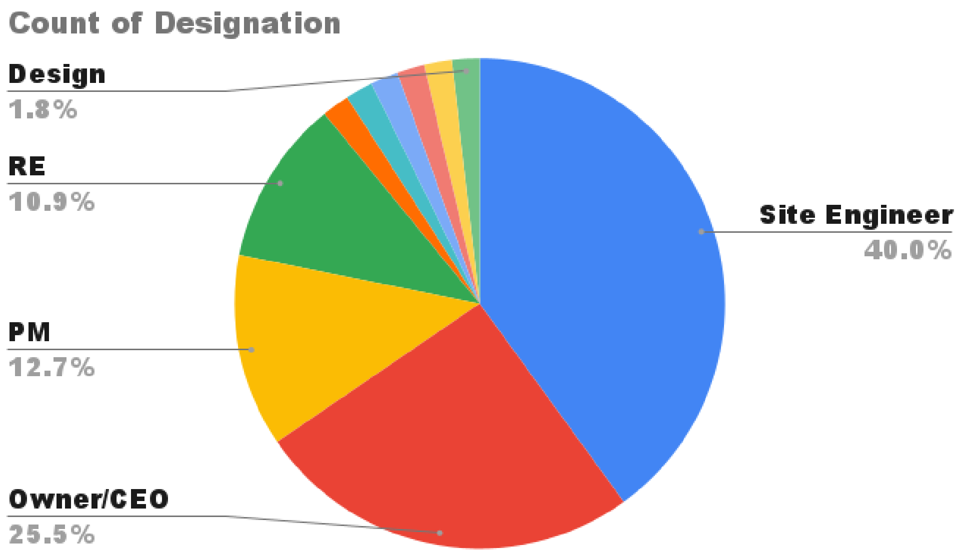


FIGURE 4.1: Profession of the Respondents

The demographic question received a significant number of responses, and those responses suggested that the vast majority of respondents work in the field of professional civil engineering. The response rate was 40 percent of site engineers, 10.9 percent of residential engineers, 12.7 percent of Project managers, and 25.5 percent of Owner/CEO.

The demographic response data presents respondents different educational qualification. Figure 4.2 shows that 44.6 percent of the respondents had done.

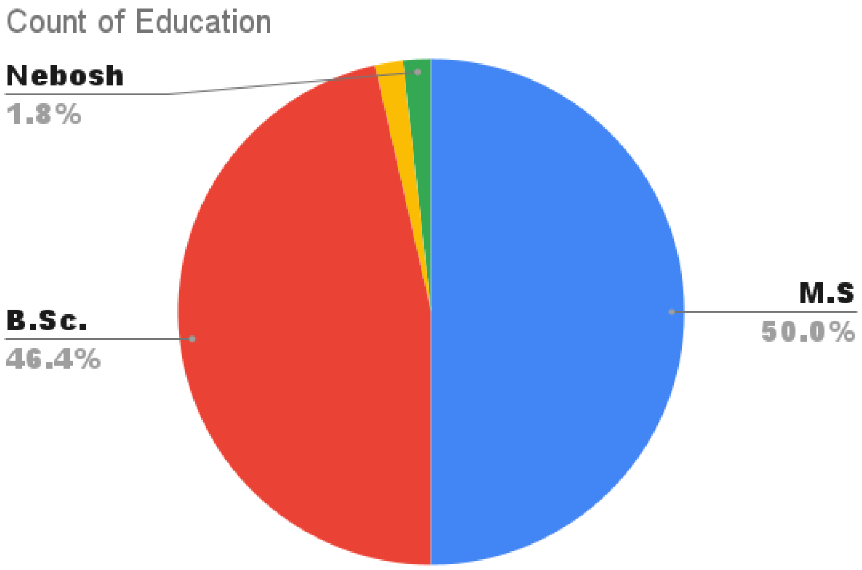


Figure 4.2: Education of Respondents

A master's degree, 48.2 percent had a bachelor's degree, 5.4 percent had an associate degree, and just 1.8 percent had some other educational background.

The amount of time spent is a critical factor in determining the capabilities of the experts. A significant number of respondents have previous experience working on building construction projects. Figure 4.3 illustrates that 46.5 percent of respondents have fewer than 5 years of experience.35.7 percent have experience ranging from 05 to 10 years, 10.7 percent have experience ranging from 10 to 15 years, 3.6 percent have experience ranging from 15 to 20 years, and 3.6 percent have experience ranging from more than 20 years.

The number of years an private contractor has been in business is critical to their success in construction industry. As can be seen in Figure 4.4 below, of the

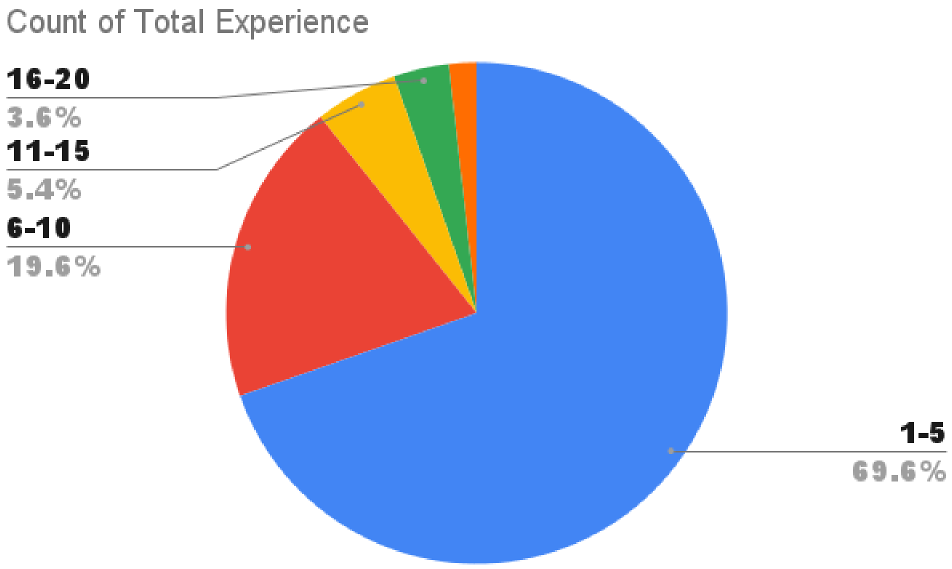


FIGURE 4.3: Working Experience of Respondents

respondents who are contractors, 32.1 percent have been in business for less than 5 years, 28.6 percent have been in business for between 5 and 10 years, 12.5 percent have been in business for between 10 and 20 years, and 26.8 percent have more than 20 years of experience working on construction projects.

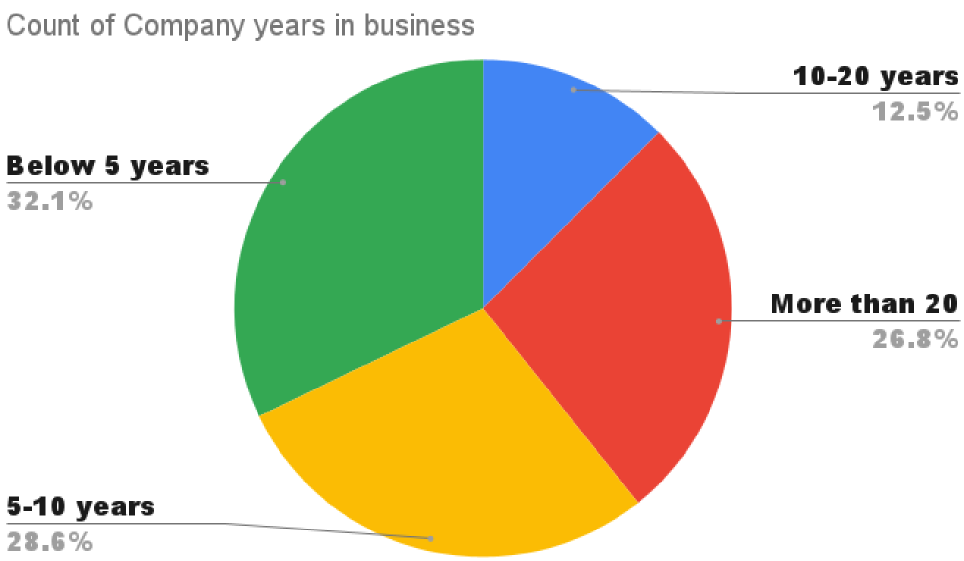


FIGURE 4.4: Company years in business

## 4.5 Relative Importance Index

In a questionnaire survey, the five-point Likert scale was employed to obtain data. As indicated before, it is comprised of three pillars of sustainability indicators, each of which has been subdivided into a number of indicators. Initially, the relative significance, The relative importance index (RII) values of each sustainability indicator were evaluated individually, and then the RII values of all the sustainability indicators were calculated by averaging the RII values of all the sustainability indicators for each indicator in order to determine the impact level and ranks. As are shown in table 4.5:

Table 4.5: Ranking of RII for Economical Indicators

| Sr.No | SIs | RII | Overall Rank | Rank (Individual Parameter) |
|---|---|---|---|---|
| 1 | ECO1 | 0.757143 | 17 | 7 |
| 2 | ECO2 | 0.728571 | 33 | 14 |
| 3 | ECO3 | 0.75 | 22 | 10 |
| 4 | ECO4 | 0.775 | 7 | 5 |
| 5 | ECO5 | 0.757143 | 17 | 7 |
| 6 | ECO6 | 0.810714 | 2 | 2 |
| 7 | ECO7 | 0.817857 | 1 | 1 |
| 8 | ECO8 | 0.778571 | 5 | 4 |
| 9 | ECO9 | 0.746429 | 23 | 11 |
| 10 | ECO10 | 0.675 | 49 | 18 |
| 11 | ECO11 | 0.689286 | 48 | 17 |
| 12 | ECO12 | 0.796429 | 3 | 3 |
| 13 | ECO13 | 0.725 | 34 | 15 |
| 14 | ECO14 | 0.739286 | 27 | 12 |
| 15 | ECO15 | 0.753571 | 21 | 9 |
| 16 | ECO16 | 0.703571 | 46 | 16 |
| 17 | ECO17 | 0.764286 | 13 | 6 |
| 18 | ECO18 | 0.732143 | 30 | 13 |

The initial objective was to assess the influence of sustainability indicators on small-scale construction projects. Table 4.4 reveals that the top five indicators with high RII values, ECO 7 (0.817), ECO 6 on construction site (0.810), ECO 12

(0.796), ECO 8 (0.778), and ECO 4 (0.775), had a significant impact on Economical sustainability, whereas indicators with low impact, such as ECO 10 (0.675), were deemed negligible in the evaluation of the impact on sustainability in the construction industry. High relative relevance index values for sustainability indicators indicate that these indicators have a greater influence on small building sites. It must be concentrated. By elaborating on the Using the respondent-provided data set values, the value of each indicator was determined. Consequently, the intensity level chosen by respondents was utilised to calculate the relative importance index for each element. Table 4.6 presents the relative importance index values and rankings of the environmental sustainability-related parameters.

Table 4.6: Ranking of RII for Environmental Sustainability Indicators

| Sr.No | SIs | RII | Overall Rank | Rank (Individual Parameter) |
|---|---|---|---|---|
| 1 | ENV1 | 0.725 | 34 | 10 |
| 2 | ENV2 | 0.775 | 7 | 2 |
| 3 | ENV3 | 0.767857 | 10 | 3 |
| 4 | ENV4 | 0.732143 | 30 | 9 |
| 5 | ENV5 | 0.717857 | 41 | 12 |
| 6 | ENV6 | 0.703571 | 46 | 13 |
| 7 | ENV7 | 0.721429 | 38 | 11 |
| 8 | ENV8 | 0.757143 | 17 | 6 |
| 9 | ENV9 | 0.746429 | 23 | 7 |
| 10 | ENV10 | 0.742857 | 26 | 8 |
| 11 | ENV11 | 0.785714 | 4 | 1 |
| 12 | ENV12 | 0.764286 | 13 | 4 |
| 13 | ENV13 | 0.764286 | 13 | 4 |

Small-scale construction projects are influenced by the level of sustainability indicators. The findings of table 4.9 indicate that the top five indicators with high RII values ENV 11 on construction site (0.785), Env 2 (0.775), ENV 3 (0.767), ENV 12 and 13 (0.764), and ENV 8 (0.757) had a high impact on Economical sustainability, whereas indicators with low impact, such as ENV 6 (0.703), were deemed negligible in the evaluation of the impact on sustainability in the construction industry. High relative importance index values for sustainability indicators indicate that these indicators have a greater impact on small building sites. It must be concentrated.

Sustainability indicators have an influence on small-scale building construction projects. According to the findings of table 4.7, the top five indicators with high RII values, SOC 18 on construction site (0.778), SOC 9 (0.775), SOC 5 (0.767), SOC 8 (0.760), and SOC 13 (0.746), had a high impact on Economical sustainability, whereas the indicators with low impact, such as SOC 10 (0.707), were deemed negligible in the assessment of the impact on sustainability in the construction industry. In small-scale construction sites, sustainability indicators with a high relative relevance index value have a greater impact. It requires concentration.Sustainability indicators with a high relative relevance index value have a higher effect level on small-scale building sites. It must be concentrated.Factors with high relative importance index values are most notably among all the factors because of their high impact level at the construction projects. They need to be focused.

## 4.6 Correlation Analysis

The fundamental purpose of this study is to establish relationships between the variables. Within SPSS, the crosstabs method of descriptive statistics analysis was used. Chi-square was chosen on the statistics tab, and the display of corrected standard residuals was enabled. The SPSS version 21 software package was used to perform factor analysis and descriptive statistics on the collected data. Factor analysis is a statistical approach used to pinpoint a relatively small number of factors that explain observed relationships between variables. The 2-sided Asymptotic Significance, which is derived from the Pearson Chi-Square, was used

Table 4.7: Ranking of RII for Social Indicators

| Sr.No | SIs | RII | Overall Rank | Rank (Individual Parameter) |
|---|---|---|---|---|
| 1 | SOC1 | 0.721429 | 38 | 13 |
| 2 | SOC2 | 0.767857 | 10 | 3 |
| 3 | SOC3 | 0.735714 | 28 | 8 |
| 4 | SOC4 | 0.732143 | 30 | 10 |
| 5 | SOC5 | 0.767857 | 10 | 3 |
| 6 | SOC6 | 0.725 | 34 | 11 |
| 7 | SOC7 | 0.757143 | 17 | 6 |
| 8 | SOC8 | 0.760714 | 16 | 5 |
| 9 | SOC9 | 0.775 | 7 | 2 |
| 10 | SOC10 | 0.707143 | 45 | 18 |
| 11 | SOC11 | 0.735714 | 28 | 8 |
| 12 | SOC12 | 0.717857 | 41 | 15 |
| 13 | SOC13 | 0.746429 | 23 | 7 |
| 14 | SOC14 | 0.725 | 34 | 11 |
| 15 | SOC15 | 0.714286 | 43 | 16 |
| 16 | SOC16 | 0.714286 | 43 | 16 |
| 17 | SOC17 | 0.721429 | 38 | 13 |
| 18 | SOC18 | 0.778571 | 5 | 1 |

to assess the existence of a relationship between the two variables in question. For values of Asymptotic Significance (more often known as p-values) less than 0.05, a strong connection was assumed, and a tendency was assumed for values between 0.05 and 0.06. In this research, only tables showing correlations or trends based on the aforementioned criteria are provided. Adjusted residuals are used to determine the statistical significance of a deviation from the mean. When the value of the discrepancy is more than -1.96, it is regarded as significant. The degree of freedom for all correlations was 0.2639, which was fewer than all of the values created from the correlation table (obtained through two-tailed analysis). Overall values are determined using correlation, and the degree of freedom for all correlations was less than all of those values (obtained from two tailed). It is common practise to consider a relationship to be strong whenever the value of the correlation coefficient (r) between two variables is more than 0.70. The linear link between two quantitative variables can be measured using the correlation coefficient, abbreviated as "r".

### 4.6.1 Descriptive Analysis Mean and Standard Deviation

Indicators of sustainability are subjected to a mean and standard deviation calculation before being subjected to the descriptive test. Here you will find a summary of the findings from the descriptive research conducted on the sample. The means and standard deviation (SD) for each of the key competencies for construction, as perceived by the survey respondents, are presented in descending order. The reliability (Cronbachs alpha) of the 49 items was 0.98. Table depicts the characteristics of the individuals involved in the Economical indicators, presents the Environmental sustainability indicators, and descriptively analyses the details of its presentation which is analyzed by SPSS tool. Table also depicts the characteristics of the individuals involved in the Environmental sustainability indicators. Individual determinant of sustainability parameters In order to facilitate straight forward and uncomplicated comparison of the results and discoveries, the data that is currently accessible has been formatted and presented in tables in a manner that is consistent with the methodology utilised in relevant international scientific research. In order to calculate the mean and standard deviation of the environmental sustainability index using a straightforward descriptive test analysis, SPSS was utilised. ECO 6 had a mean value that was higher than average (4.00), and it had a standard deviation of 1.30, whereas ECO 7 had a mean value that was lower than average (3.98), and it had a standard deviation that was greater than average (1.19). The score for ECO 9 was the worst of all possible scores. The mean value is 3.58, and the standard deviation is 1.20, which is a figure that is higher than the mean value of all environmental indicators. This rating is expected to change over time because sustainable construction methods are beginning to be seen as a way to decrease economic, social, and environmental loss. The mean and standard deviation for the various environmental sustainability measures are presented in Table 4.8.

Table 4.8: Economical Sustainability Indicators Mean and Standard Deviation

| Economical SIs | Mean | Std Deviation |
|---|---|---|
| ECO6 | 4.000 | 1.3073 |
| ECO7 | 3.982142857142957 | 1.198348430565669 |
| ECO12 | 3.982142857142956 | 1.151932312225107 |
| ECO17 | 3.821428571428671 | 1.280726255005337 |
| ECO4 | 3.821428571428671 | 1.252011368771353 |
| ECO1 | 3.785714285714386 | 1.275136865585135 |
| ECO15 | 3.767857142857242 | 1.128008243499498 |
| ECO8 | 3.7500 | 1.06600 |
| ECO5 | 3.7500 | 1.20981 |
| ECO3 | 3.714285714285814 | 1.171080087538340 |
| ECO14 | 3.696428571428671 | 1.189646897301875 |
| ECO18 | 3.660714285714386 | 1.148545098877738 |
| ECO13 | 3.62500 | 1.272971 |
| ECO2 | 3.62500 | 1.137182 |
| ECO9 | 3.589285714285813 | 1.202675588606010 |
| ECO16 | 3.517857142857244 | 1.250324633170097 |
| ECO11 | 3.446428571428671 | 1.204833339770948 |
| ECO10 | 3.321428571428672 | 1.428376610092740 |

The Environmental sustainability indicators Mean and Standard deviation were calculated by SPSS with simple descriptive test analysis. ENV 11 showed a high Mean value by results which were (3.92) and a standard deviation (1.14), and second rank ENV 2, which revealed (3.875) standard deviation (1.25), which is greater than ENV 11. The lowest rank number resulted in ENV 6. The value of the Mean is (3.51) and the standard deviation (1.32) which is greater than among all environmental indicators. Table 4.9 indicates Environmental sustainability indicators Mean and Standard deviation.

TABLE 4.9: Top Sustainability Indicators of Environmental

| Environmental Sis | Mean | Stand Deviation |
|---|---|---|
| ENV11 | 3.928571428571528 | 1.141882701461202 |
| ENV2 | 3.87500 | 1.251363 |
| ENV3 | 3.839285714285814 | 1.091733995478448 |
| ENV13 | 3.821428571428672 | 1.192509086790604 |
| ENV12 | 3.821428571428671 | 1.177163661397395 |
| ENV8 | 3.785714285714386 | 1.246293205167629 |
| ENV9 | 3.732142857142957 | 1.257574453658215 |
| ENV10 | 3.714285714285814 | 1.330950251297485 |
| ENV4 | 3.660714285714386 | 1.297224810043528 |
| ENV1 | 3.62500 | 1.229375 |
| ENV7 | 3.607142857142958 | 1.139035819192191 |
| ENV5 | 3.589285714285814 | 1.187461550983935 |
| ENV6 | 3.517857142857242 | 1.321033637016914 |

The Social sustainability indicators Mean and Standard deviation were calculated by SPSS with simple descriptive test analysis. SOC 18 showed a high Mean value by results which were (3.89) and a standard deviation value (1.288), and second rank SOC 9, which revealed (3.875) value and standard deviation value of the sustainability indicators is (1.206), which is greater than SOC 18. The lowest rank number resulted SOC 10. The value of the Mean is (3.53) and the standard deviation (1.29) which is greater than among all environmental indicators. Table 4.10 shows social sustainability indicators Mean and Standard deviation of the selected study in tabular form.

TABLE 4.10: Social Sustainability Indicators Mean and Standard Deviation

| Social | Mean | Std. Deviation |
|---|---|---|
| SOC18 | 3.892857142857243 | 1.288813004682688 |
| SOC9 | 3.87500 | 1.206987 |
| SOC2 | 3.839285714285815 | 1.172050041039858 |
| SOC5 | 3.839285714285814 | 1.156433163800612 |
| SOC8 | 3.803571428571529 | 1.326919095391483 |
| SOC7 | 3.785714285714386 | 1.073893269020235 |
| SOC13 | 3.732142857142958 | 1.257574453658215 |
| SOC11 | 3.678571428571529 | 1.222622261700415 |
| SOC3 | 3.678571428571527 | 1.266450197953460 |
| SOC4 | 3.660714285714386 | 1.179780961400612 |
| SOC14 | 3.62500 | 1.244077 |
| SOC6 | 3.62500 | 1.137182 |
| SOC17 | 3.607142857142957 | 1.216232206127195 |
| SOC1 | 3.607142857142956 | 1.185956789471583 |
| SOC12 | 3.589285714285813 | 1.424165282980539 |
| SOC16 | 3.571428571428672 | 1.109580475300937 |
| SOC15 | 3.571428571428671 | 1.188691302646423 |
| SOC10 | 3.535714285714384 | 1.292837411057102 |

## 4.7 Frequency Analysis

The number of responses on each scale which was selected for questionnaire survey. Range of scale was 1 to 5, 1 has been shown for lower value and 5 has been selected for greater value and importance of sustainability indicators. The top 10 sustainability indicators which is ranked according to mean values is mentioned in figure 4.5 below.

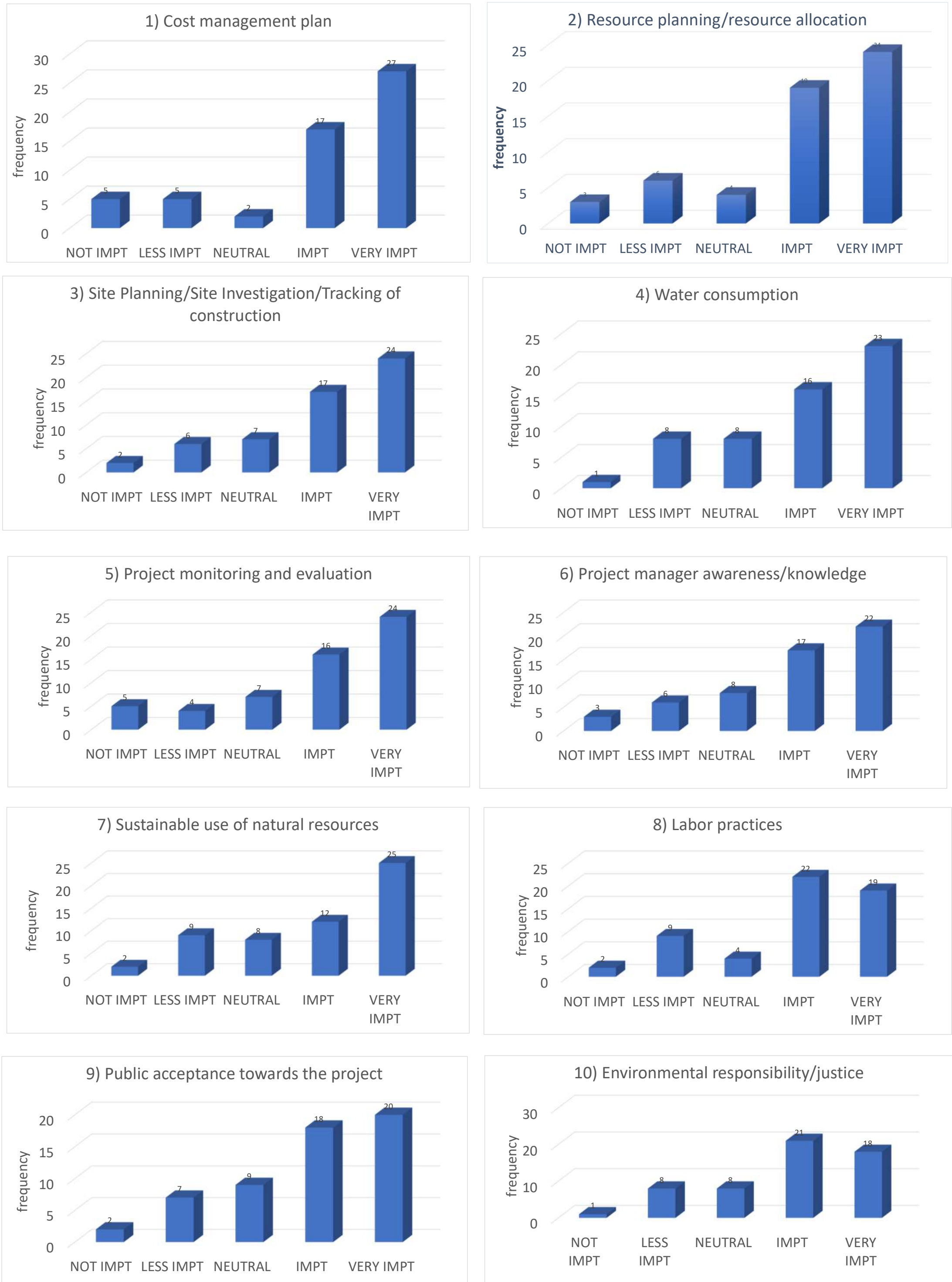


FIGURE 4.5: Frequency of the Sustainability Indicators According to Survey

## 4.8 Summary

Sustainability indicators are analyzed by using the SPSS software tool. Multiples test is conducted to evaluate the most important indicators according to a questionnaire survey. The response rate is resulted from 74 percent, according to previous statements, and the 74 percent response rate is very good. Reliability and factor analysis test is examined. The relative importance factor of sustainability indicators is ranked by SPSS and as well as by EXCEL in comparison of both results were relatively same. Framework is developed for implementation for private contractors in developing countries by SPSS AMOS. The model framework is analyzed first by factor analysis, and the components are then explored by AMOS. The components division-based indicators framework was developed for each aspect of sustainability.

# Chapter 5

# Guidelines for Practical Implementation

## 5.1 Background

This study gives Sustainability indicators to aid in the implementation of sustainable building practises that are incorporated into the design and construction process. The SSCPs (Constructing and Sustaining for Sustainable Construction) are investigating this. Research on sustainable building is given, followed by an introduction to the study and its preliminary results about current practise and the perception of sustainability in the construction sector, based on a questionnaire. This section also examines and emphasises the necessity for an organised framework to analyse and integrate sustainability problems throughout the whole design and construction phase of a project. In the last section of the study, the inclusion of these difficulties is discussed. It is argued that the key to successful use within the industry is awareness of sustainability indicators among design and construction staff and operatives, knowledge of the importance of various activities and sub-activities within the tool, and motivation to bring about improvements within the current system. Construction and design procedures on a daily basis.

The research at the conclusion also identifies the areas that need more study and improvement.

## 5.2 Developing A Framework Of Sustainability Indicators In The Form Of Model

Based on the concept of the three pillars, a sustainability indicator is a measurable component of environmental, economic, or social systems that is useful for monitoring changes in system features that are relevant to the continuation of human and environmental well-being. An integrated systems approach to addressing sustainability issues requires the use of sustainability indicators and accompanying measures. When correctly chosen and implemented, indicators may help managers and policymakers communicate ideas, monitor progress, and provide recommendations based on sustainability to ensure success. The framework for sustainability indicators, within which indicators will be utilised, is a crucial component in selecting indicators. Numerous organisations throughout the world have proposed and implemented numerous sustainability frameworks. The concept of three pillars and the driver/pressure/state/impact/response (DPSIR) model are two examples [135]. System dynamic models may provide additional information on the structure and behaviour of complex dynamic systems, enabling a more informed choice of indicators [136]. Purpose, worldview, and values strongly impact the selection of an acceptable sustainability framework and related indicators. This technique is compatible with all of these methods.

Examine the extent of change relative to a historical baseline or a future objective. As mentioned before, the rate or magnitude of improvement is a relative indicator that reflects whether the system is moving towards or away from sustainability. In some cases, a single sign containing information applicable to two overlapping domains may be chosen. For instance, occupational safety practises are indicative of both environmental hazards and the possibility of human health injury. Changes in industrial employment as a result of green buildings advancements are symptomatic of both natural resource protection and economic growth. The annual amount of charitable donations is a sign of both economic expansion and improvements in quality of life. The per capita floor area of residential structures is an important statistic since it correlates with both energy consumption and poverty alleviation, thereby representing the tension between economic progress, quality of life, and depletion of natural resources. Once indicators and relevant metrics are selected, criteria and methods (e.g., Life Cycle Assessment) must be developed and executed to gather data for each measure in order to evaluate the systems under consideration. [137] provided more information on topics pertinent to sustainability-based decision making and essential tools for measuring the sustainability-related pillars of the system.

Arrangement of Sustainability Indicators as previously described, a sustainability indicator is a quantifiable element of environmental, economic, or social systems that may be used to monitor changes in system characteristics relevant to the continuation of human and environmental well-being. Classifying sustainability indicators according to well defined categories and subcategories is important for facilitating the selection of indicators for certain applications. This categorization system is known as a taxonomy. The majority of the taxonomies that have been produced in the topic of sustainability have been surveyed for the objectives of this research. Listed below are numerous taxonomies that will be useful to EPA for programme design and performance monitoring. Three Sustainability Pillars, The indicators picked from each area and their relative relevance in a decision-making process are crucial factors that should be articulated openly since they represent the decision-makers' priorities and values. A system study to establish which indicators capture characteristics that substantially contribute to movement towards or away from sustainability might give more insight into indicator selection.

### 5.2.1 Environmental Sustainability Indicators Components

Components of sustainability indicators are primarily separated into three groups, as depicted in Figure 5.1, which can be found below. AMOS was selected to carry out the in-depth confirmatory factor analysis. The first category has a total of six different indicators, the second category has a total of five different indicators, and the third category has a total of two different sustainability indicators.

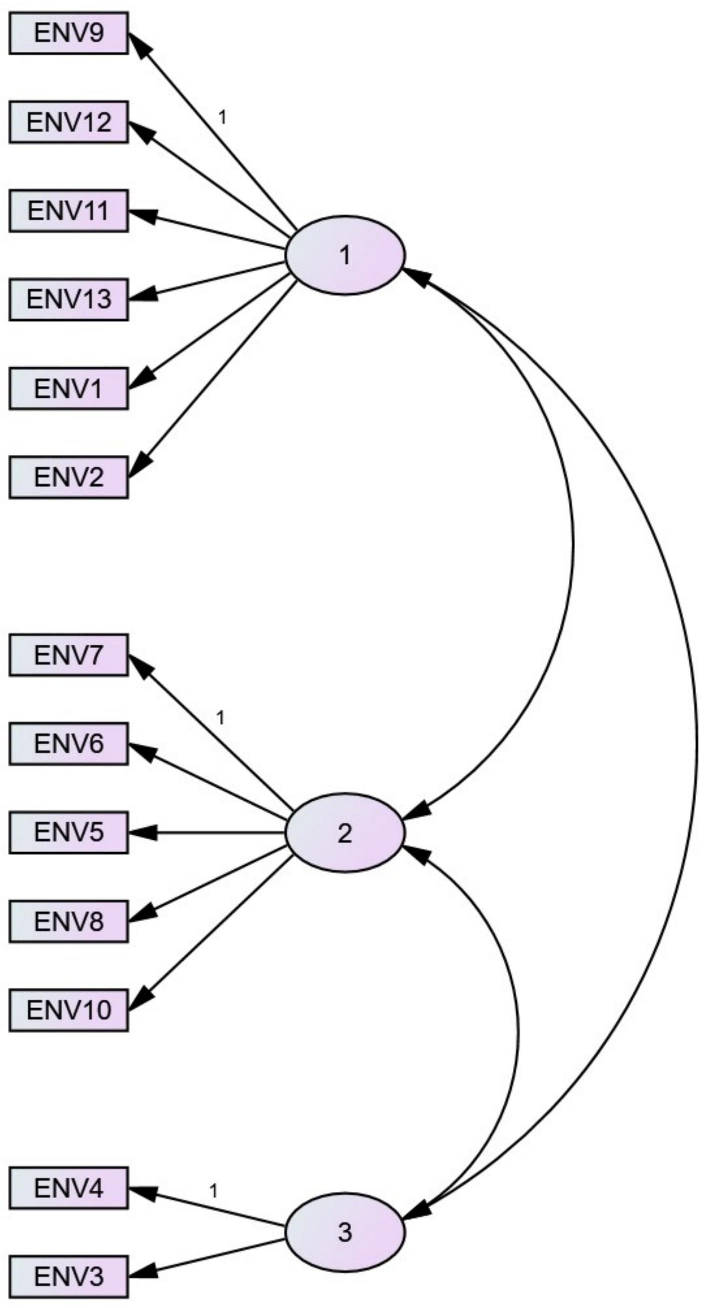


FIGURE 5.1: Components of Environmental Sustainability Indicators by AMOS

### 5.2.2 Social Sustainability Indicators Components

Figure 5.2 defines as shown below, components of sustainability indicators which mainly subdivided into three categories. The first category consist of six indicators, Second category consist of seven indicators and the third category included five sustainability indicators.

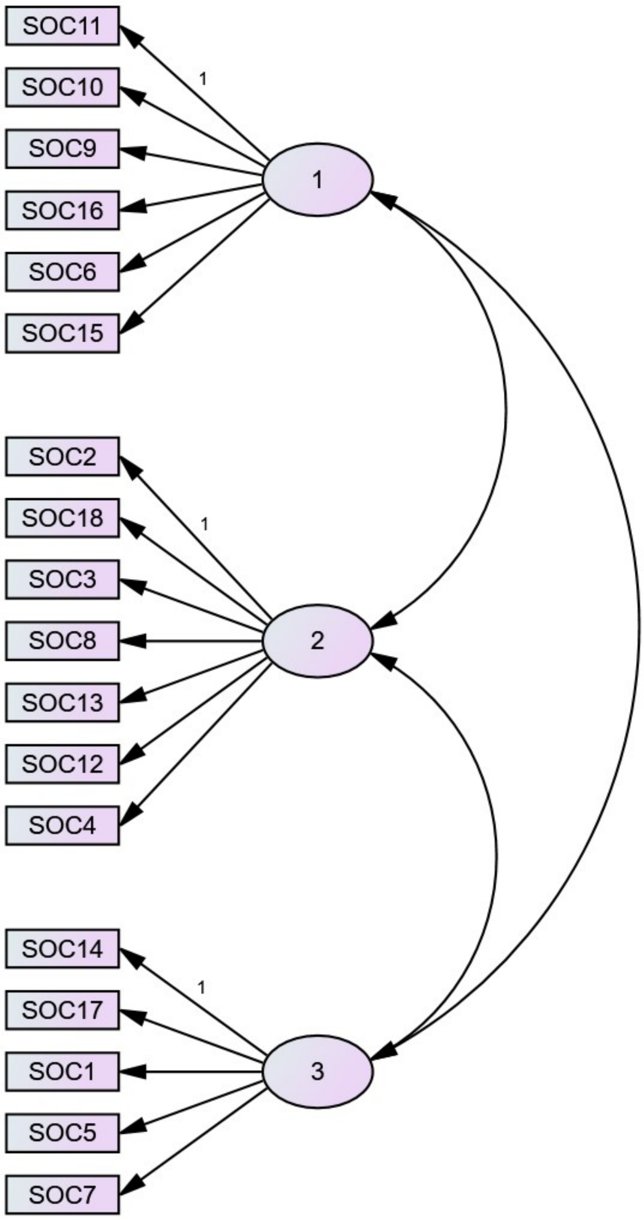


FIGURE 5.2: Components of Sociall Sustainability Indicators by AMOS

### 5.2.3 Economical Sustainability Indicators Components

As Figure 5.3 is depicts below, components of sustainability indicators which mainly subdivided into three categories. The first category consists of six indicators, Second category consist of six indicators and the third category included six sustainability indicators.

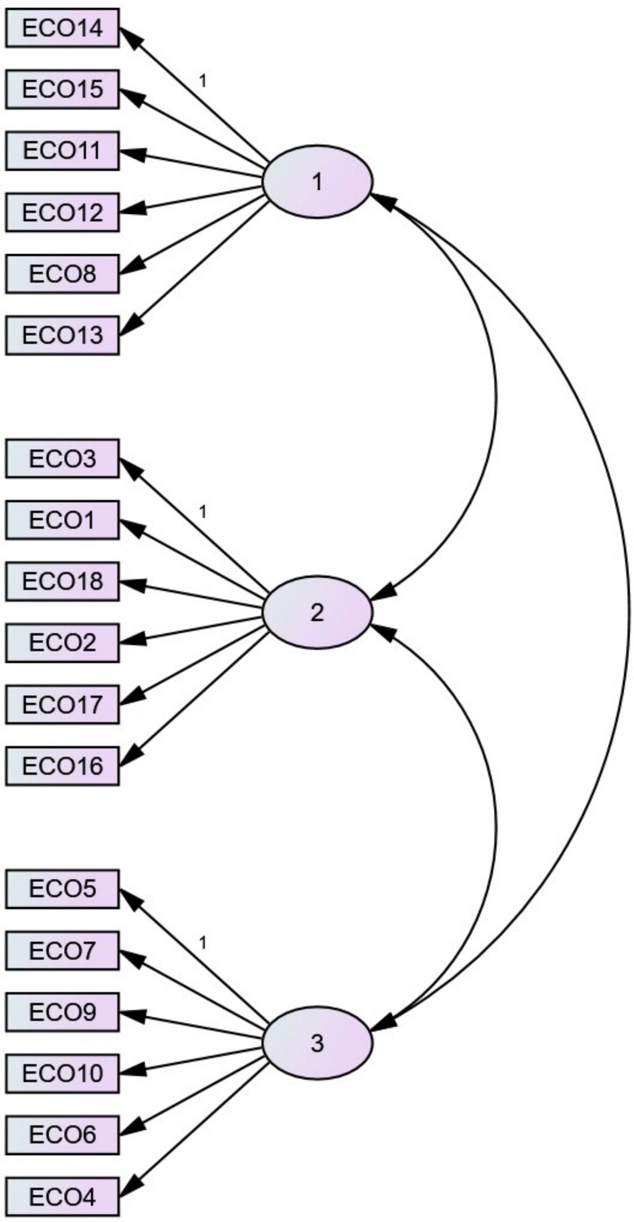


FIGURE 5.3: Components of Economical Sustainability Indicators by AMOS

### 5.2.4 Combine Framework of Sustainability Indicators

Sustainability indicators framework on basis of all three sustainability aspects. These aspects is further divided into components on the basis of SPSS Factorial analysis that has been generated 5 factors which was further subdivided into categorized factors, As shown in Figure 5.4. These factors is also inter dependents which can shows the positive or negative impacts on overall sustainability in construction. Five factors have named project monitoring and its impacts relationship, organizational culture and lifecycle assessment, resource planning, sustainable use of natural resources and financial stability. To better understand and promote sustainable SSCPs, the existing sustainability frameworks reviewed and developed a sustainability indicators framework for sustainable SSCPs. After verifying the content and construct validity of the sustainability indicators framework, the final refined version can be seen in Fig. 5.4. The proposed sustainability indicators framework considers the influence of SSCPs on communities as well as the components and subcomponents needed to improve the sustainability.

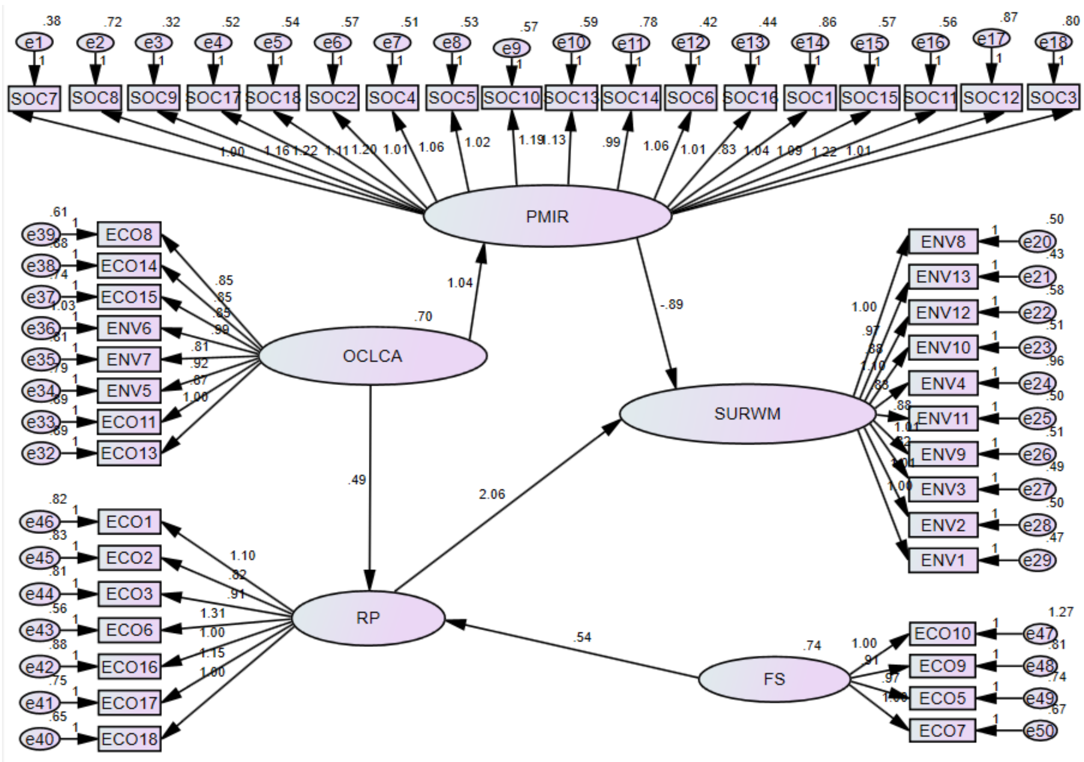


FIGURE 5.4: All Sustainability Base Framework Factors and Relationships

## 5.3 Application of the Research Work in Practical Life

Organizational culture has been identified which plays a role in the success of private contractor firms. Culture is a pattern of basic assumptions which could be invented, discovered, or developed by a given group as it learns to cope with inherent challenge of internal and external adaptations. Consequently, organisational culture benefits the leader of a company by fostering the value system It has established for both current and new members. Within the construction industry, culture is seen as pertaining to the industry's features, methods to construction, the competency of employees and individuals who operate in the industry, as well as the strategies, aims, and values of the organisations within which they work. The significance of site study and planning cannot be overstated. It assists in determining numerous facets of a construction project, including reducing costs and enhancing safety for workers is one of the basic requirements. For their next project, every developer should consider doing a site study to ensure their quality work and improve sustainable construction. In small-scale building construction projects, Private contractors must use innovative techniques and methods. Innovative building methods are goods or processes that diverge from conventional construction methods. These techniques improve the sustainability and efficacy of a company's building process.

The construction industry and construction operations are regarded as one of the most important contributors to economic growth, development, and economic activity. The construction and engineering services business contributes significantly to the nation's economic growth and development. It may be seen as a tool for creating employment possibilities for millions of unskilled, semiskilled, and skilled workers. It also plays a crucial role in both official and informal revenue generation. It augments the foreign currency gains from building supplies and engineering services trade. The supply is the flow of resources utilised to meet demand, including materials, labour, information, talents, etc. It may also refer to skills or resource combinations. In general, commodity suppliers are more focused on pricing, while strategic suppliers are more focused on quality and delivery. The contractor must also consider the supply-demand ratio and market requirements.

Indicators of environmental sustainability consist of main sustainable materials and their management, environmental act management, and environmental safety in the surrounding area. These are further broken into categories. Utilization of recycled materials Currently, the main source of garbage is the destruction of structures. The buildings and construction industry is responsible for 36 percent of the world's ultimate energy consumption and 39 percent of energy- and process-related emissions. It is hardly surprising that the focus has shifted to tackling this issue. The difficulty is that the normal manner of doing things, often known as a linear economy, has been to take, produce, and then discard. It is referred to as linear since the material flow is unidirectional. Many see recycling as the answer to this problem; nevertheless, recycling is faulty, with inefficiencies resulting in 5-30 percent of usable outputs relative to the amount of waste input. In essence, we cannot recycle our way out of the trash issue since demand for resources exceeds availability, even for supposedly limitless resources like sand. When waste is diverted from landfills and reused, it may have massive benefits and greatly contribute to the achievement of carbon reduction goals. Recycling is far less efficient than utilising less materials in the first place.

Globally, the importance of lowering energy use in buildings has risen. This is because the use of fossil fuels for a building's entire operations is comparable to that of other industries. Consequently, the adoption of energy efficiency strategies during the design and operation of buildings will play a vital role in the future production of sustainable structures. This form of recycled materials must be used by construction companies in order to reap financial benefits. Effective preparation is necessary, Any construction management team participating in the design and construction of a building must adopt numerous safety measures and evaluate the whole cost of the project to prevent work-related accidents and financial difficulties. Management of disaster risk; the need to mitigate catastrophe susceptibility in new and existing structures is becoming more critical. How buildings are planned and constructed, as well as their location, are crucial to their capacity to resist varying environmental conditions. sorts of natural or anthropogenic dangers However, this requires a multisectoral and multidisciplinary commitment from all construction industry players.

## 5.4 Summary

The construction industry has massive impacts on society, environmentally, economically, and socially. Sustainability has been an significant issue being considered in the construction industry. However, previous sustainability studies in construction are largely related to the environmental social, and economic aspects. Studies have concluded the most appropriate sustainability indicators that can be applicable for SSCPs by private contractors. These sustainability indicators are shortlisted after the details analysis. The number of these sustainability indicators is around 49 which is subdivided into main categories. The main category of sustainability indicators of economics is Planning and operation, contractor firm capacity, and market economic aspects. The environmental category of sustainability indicators is a sustainable material and their management, Environmental acts or mitigation, and surrounding safety of the environment. The social sustainability indicators main category is society management, ensuring employee rights, and reliability in projects. These sustainability indicators is applicable for practical implementation to resolve issues in SSCPs.

# Chapter 6

# Conclusions and Recommendations

## 6.1 Conclusion

This research prioritised small-scale construction project sustainability indicators using a qualitative assessment framework. The selected acceptable sustainability indicators were highly valued. Identifying critical sustainability indicators, creating a likert scale to rate them, collecting expert opinions, determining importance weights, performing statistical analysis by SPSS, and assessing the Relative Importance Index (RII) for prioritisation were the steps in the proposed framework. The framework is better than the subjective investigation. This paper proposes a basic framework of sustainable construction metrics to assess sustainability. The highly priority sustainability indicators framework will be added to a quantitative sustainability assessment framework that quantifies these indicators, now under development. This framework can help achieve sustainability. Contractors may simply apply most of these indicators, planning to make construction more sustainable. The detailed conclusion are drawn below:

- On the basis of reliability analysis, which revealed high-reliability value and good response rate of questionnaire survey. This means that the data was accurate and respondents filled in questionnaire data correctly, which were used for further analysis.

- The results of normality tests indicated a value less than 0.05 by which we concluded that data were not normally distributed (relation between variables, changes, and differences) which also clarified data towards non-parametric in such cases.

- But the p-value (greater than 0.05) of the Kruskal Wallis test finally implies the decision to retain the null hypothesis (no relation between groups, no changes, and no differences).

- There is a moderate correlation between all indicators and between the three parameters of sustainability. This indicated that all sustainability indicators greatly influence small-scale construction projects by adopting them during construction.

- According to demographic analysis most of the respondents belonged to contractor firms and had good education degrees with experiences in different construction firms. Therefore, expected to have varied experiences by playing different roles in different projects with different capacities, implies that these respondents were capable of providing the importance of sustainability indicators requested in the questionnaire.

- Exploratory Factor analysis was performed to identify the relationship between all the indicators. which reduced data to a smaller set of main indicators and explored the underlying theoretical structure of the phenomena.

- Sustainability indicators of economical categories are planning and operation, Contractor firm capacity, and Market economic aspect. The environmental sustainability indicators category included indigenous/Sustainable material and its management, Environmental acts mitigation, and the safety of the project surrounding environment. Social sustainability indicators of the framework are Project Society management skills, Employee protection and their Rights, and Reliability in the project.

- Indicators of sustainability are subjected to a mean and standard deviation. The most important sub-categories of sustainability indicators were ECO 6 had a high mean value (4.00) and a standard deviation (1.30), while ECO 7 had a lower mean value (3.98) and a higher standard deviation (1.19). ECO 9 was the lowest ranked number, The mean value is (3.58), and the standard deviation is (1.20), which is higher than the mean value of all economical indicators. The Environmental sustainability indicator's Mean and Standard deviation were calculated by SPSS with simple descriptive test analysis. ENV 11 showed a high Mean value by results which were (3.92) and a standard deviation (1.14), and second rank ENV 2, which revealed (3.875) standard deviation (1.25), which is greater than ENV 11. The lowest rank number resulted in ENV 6. The value of the Mean is (3.51) and the standard deviation (1.32) which is greater than among all environmental indicators. The Social sustainability indicator's Mean and Standard deviation were calculated by SPSS with simple descriptive test analysis. SOC 18 showed a high Mean value by results which were (3.89) and a standard deviation (1.288), and second rank SOC 9, which revealed (3.875) standard deviation (1.206), which is greater than SOC 18. The lowest rank number resulted SOC 10. The value of the Mean is (3.53) and the standard deviation (1.29) which is greater than among all social indicators.

- Private contractors are unaware of the main sustainability indicators which are suitable for their firms to adopt and achieve success in comparison to other mega construction firms. Shortlisted appropriate sustainability indicators in a framework can resolve certain problems of private contractors. Sustainability indicators framework on basis of all three sustainability aspects i.e economic, environmental and social. These aspects is further divided into components. Five main indicators have been named project monitoring and its impacts and relationship, organizational culture and lifecycle assessment, resource planning, sustainable use of natural resources, and financial stability. It should need by the top management community to ensure for proper implementation to sustain small-scale construction projects. Based upon this analysis, proper remedial measures would be possible for incorporation at the planning and strategy level to improve and manage these sustainability issues by adopting sustainability indicators.

## 6.2 Future Recommendations

The following recommendations should be taken into count for future work to explore the sustainability indicators framework in further detail:

- Research should be undertaken to evaluate the cost, benefits and effectiveness of SSCPs sustainability indicators framework.
- For small-scale infrastructure and Water resources projects, develop a framework of sustainability indicators.
- Future studies may be performed to further establish, Sustainability indicators framework to be constructed for mega projects in other countries to achieve sustainability.

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## 6.3 Annexure -A



# Developing a Framework of Sustainability indicators for Small-Scale Construction Projects by Private Contractors in Islamabad and Rawalpindi

Respected Sir/Madam,

I am Taimoor ahmad, a postgraduate student at Capital University of Science and Technology (**CUST**), Islamabad. I am conducting a research on **Sustainability indicators for Small-Scale Construction Projects (SSCPs) by Private Contractors in Pakistan**.

This research focuses on sustainability indicators, i.e., social, environmental and economic indicators which will be used in developing a sustainability framework for SSCPs. In this regard, a questionnaire survey has been developed. Your valuable input is required for this purpose to prioritize these sustainability indicators.

The questionnaire is divided into four sections. Section I is regarding the personal/Business information, Section II is based on Economical indicators, Section III is regarding Environmental indicators, Section IV is on Social indicators.

We will be grateful for your help and cooperation and sincerely thank you in advance.

Kind Regard,

Taimoor Ahmad

Post Graduate Student – Construction Engineering & Management

Capital University of Science and Technology (**CUST**), Islamabad.

Should you need any further information, please do not hesitate to contact me.

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**Note:** The following questionnaire has been developed to identify the appropriate sustainability indicators for small-scale construction projects (SSCPs). The information which you will provide by filling this questionnaire will be kept strictly confidential and will be used for research purposes only. This information will help in developing the framework of sustainability indicators for SSCPs.

* Indicates required question

**Developing a Framework of Sustainability indicators for Small-Scale Construction Projects by Private Contractors in Islamabad and Rawalpindi**

Note: The following questionnaire was developed to identify the appropriate sustainability indicators for small-scale construction projects. The information which you will provide by filling this questionnaire will be kept strictly confidential and will be used for research purposes only. This information will help me to develop the framework for sustainability indicators in Islamabad and Rawalpindi.

**SECTION- I**

| | |
|---|---|
| **A** | **Personal Information** |
| | Name |
| | Organization name |
| | Organization type |
| | Contact details |
| 1 | Designation |
| ☐ | Owner/CEO |
| ☐ | Project manager |
| ☐ | Residential engineer |
| ☐ | Site engineer |
| ☐ | Others ________________ |
| 2 | Education |
| ☐ | Ph.D |
| ☐ | M.S |
| ☐ | B.Sc. Engineering |
| ☐ | Associate Diploma |
| ☐ | Others ________________ |
| 3 | Total Experience: |
| ☐ | 1-5 |
| ☐ | 6-10 |
| ☐ | 11-15 |
| ☐ | 16-20 |
| ☐ | More than 20 years |
| **B** | **Business Information** |
| 1 | Company years in business: |
| ☐ | Less than 5 years |
| ☐ | 5-10 years |
| ☐ | 11-20 years |
| ☐ | More than 20 years |
| 2 | PEC category (in case of contractors) |
| ☐ | CA |
| ☐ | CB |
| ☐ | C1 |
| ☐ | C2 |
| ☐ | C3 |
| ☐ | C4 |
| ☐ | C5 |
| ☐ | C6 |
| 3 | In which sectors does your organization work/provides services? (multiple checks are allowed) |
| ☐ | Residential Building Construction (______% of total volume) |
| ☐ | Commercial Building Construction (______% of total volume) |
| ☐ | Industrial Construction (______% of total volume) |
| ☐ | Infrastructure Construction (______% of total volume) |
| ☐ | Others ________________ (______% of total volume) |

## SECTION - II

According to your knowledge prioritize the ECONOMICAL indicators in terms of their importance for small private contractors in SSCPs
**(Not Important=1, Less Important=2, Neutral=3, Important=4 & Very Important=5)**

| | ECONOMICAL SUSTAINABILITY INDICATORS | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| 1 | Economic and Political stability | ☐ | ☐ | ☐ | ☐ | ☐ |
| 2 | Innovative Construction Methods/New product development | ☐ | ☐ | ☐ | ☐ | ☐ |
| 3 | Target marketing and benefits | ☐ | ☐ | ☐ | ☐ | ☐ |
| 4 | Best practice strategy/Implementing an effective change management strategy | ☐ | ☐ | ☐ | ☐ | ☐ |
| 5 | Scope control through managing changes | ☐ | ☐ | ☐ | ☐ | ☐ |
| 6 | Cost management plan | ☐ | ☐ | ☐ | ☐ | ☐ |
| 7 | Resource planning/resource allocation | ☐ | ☐ | ☐ | ☐ | ☐ |
| 8 | Organizational culture | ☐ | ☐ | ☐ | ☐ | ☐ |
| 9 | Building Inner Engineering/Management(facilities etc) | ☐ | ☐ | ☐ | ☐ | ☐ |
| 10 | Renewable Energy & Onsite Energy Capture/Recovery | ☐ | ☐ | ☐ | ☐ | ☐ |
| 11 | Verification & Maintenance | ☐ | ☐ | ☐ | ☐ | ☐ |
| 12 | Site Planning/Site Investigation/Tracking of construction | ☐ | ☐ | ☐ | ☐ | ☐ |
| 13 | Process quality | ☐ | ☐ | ☐ | ☐ | ☐ |
| 14 | Life cycle costs | ☐ | ☐ | ☐ | ☐ | ☐ |
| 15 | Facility set-up costs(labor etc) | ☐ | ☐ | ☐ | ☐ | ☐ |
| 16 | Market supply demand | ☐ | ☐ | ☐ | ☐ | ☐ |
| 17 | Financial/Economic performance | ☐ | ☐ | ☐ | ☐ | ☐ |
| 18 | Efficient data processing for decision-making practices | ☐ | ☐ | ☐ | ☐ | ☐ |
| | Others (please mentioned) | ☐ | ☐ | ☐ | ☐ | ☐ |
| | | ☐ | ☐ | ☐ | ☐ | ☐ |
| | | ☐ | ☐ | ☐ | ☐ | ☐ |
| | | ☐ | ☐ | ☐ | ☐ | ☐ |

## SECTION - III

According to your knowledge prioritize the ENVIRONMENTAL indicators in terms of their importance for small private contractors in SSCPs
**(Not Important=1, Less Important=2, Neutral=3, Important=4 & Very Important=5)**

| | ENVIRONMENTAL SUSTAINABILITY INDICATORS | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| 1 | Energy efficiency/eco efficiency | ☐ | ☐ | ☐ | ☐ | ☐ |
| 2 | Sustainable use of natural resources | ☐ | ☐ | ☐ | ☐ | ☐ |
| 3 | Environmental responsibility/justice | ☐ | ☐ | ☐ | ☐ | ☐ |
| 4 | Climate change adaptation/disaster risk management | ☐ | ☐ | ☐ | ☐ | ☐ |
| 5 | Project biodiversity/control Air pollution | ☐ | ☐ | ☐ | ☐ | ☐ |
| 6 | Identify and address choke points | ☐ | ☐ | ☐ | ☐ | ☐ |
| 7 | Life cycle of products and services to reduce environmental impacts | ☐ | ☐ | ☐ | ☐ | ☐ |
| 8 | Control on noise pollution due to construction activity during day/night | ☐ | ☐ | ☐ | ☐ | ☐ |
| 9 | Waste/ Waste materials/its management | ☐ | ☐ | ☐ | ☐ | ☐ |
| 10 | Maintenance of existing greenery during construction | ☐ | ☐ | ☐ | ☐ | ☐ |
| 11 | Water consumption | ☐ | ☐ | ☐ | ☐ | ☐ |
| 12 | Use of Regional Materials | ☐ | ☐ | ☐ | ☐ | ☐ |
| 13 | Availability of recycled material inputs by location | ☐ | ☐ | ☐ | ☐ | ☐ |
| | Others (please mentioned) | ☐ | ☐ | ☐ | ☐ | ☐ |
| | | ☐ | ☐ | ☐ | ☐ | ☐ |
| | | ☐ | ☐ | ☐ | ☐ | ☐ |
| | | ☐ | ☐ | ☐ | ☐ | ☐ |

| SECTION - IV | | | | | | |
|---|---|---|---|---|---|---|
| According to your knowledge prioritize the SOCIAL indicators in terms of their importance for small private contractors in SSCPs **(Not Important=1, Less Important=2, Neutral=3, Important=4 & Very Important=5)** | | | | | | |
| **SOCIAL SUSTAINABILITY INDICATORS** | | **1** | **2** | **3** | **4** | **5** |
| 1 | Social responsibility/Cultural value | ☐ | ☐ | ☐ | ☐ | ☐ |
| 2 | Labor practices | ☐ | ☐ | ☐ | ☐ | ☐ |
| 3 | Sustainable employment/Employee satisfaction | ☐ | ☐ | ☐ | ☐ | ☐ |
| 4 | Community relationships and involvement/Contractor supplier relationship/management | ☐ | ☐ | ☐ | ☐ | ☐ |
| 5 | Public acceptance towards the project | ☐ | ☐ | ☐ | ☐ | ☐ |
| 6 | Stakeholder engagement/management | ☐ | ☐ | ☐ | ☐ | ☐ |
| 7 | Encourage competition among contractors | ☐ | ☐ | ☐ | ☐ | ☐ |
| 8 | The role of trust | ☐ | ☐ | ☐ | ☐ | ☐ |
| 9 | Project manager's awareness/knowledge | ☐ | ☐ | ☐ | ☐ | ☐ |
| 10 | Experiences in projects (access to relevant experience) | ☐ | ☐ | ☐ | ☐ | ☐ |
| 11 | Managing knowledge and awareness to promote sustainable project delivery | ☐ | ☐ | ☐ | ☐ | ☐ |
| 12 | Ensuring the SHE (safety, health and environment) at the site | ☐ | ☐ | ☐ | ☐ | ☐ |
| 13 | Availability of services(accessible) | ☐ | ☐ | ☐ | ☐ | ☐ |
| 14 | Employee commitment/commitment in the workplace | ☐ | ☐ | ☐ | ☐ | ☐ |
| 15 | Indoor environmental quality | ☐ | ☐ | ☐ | ☐ | ☐ |
| 16 | Building Services (lifts,safety,security etc) | ☐ | ☐ | ☐ | ☐ | ☐ |
| 17 | Design Features(maintenance,layout etc) | ☐ | ☐ | ☐ | ☐ | ☐ |
| 18 | Project monitoring and evaluation | ☐ | ☐ | ☐ | ☐ | ☐ |
| | Others (please mentioned) | ☐ | ☐ | ☐ | ☐ | ☐ |
| | | ☐ | ☐ | ☐ | ☐ | ☐ |
| | | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Thanks for your valuable time** | | | | | | |

**Descriptive Statistics**

| | N | Mean | | Std. Deviation | Variance | Skewness | | Kurtosis | |
|---|---|---|---|---|---|---|---|---|---|
| | Statistic | Statistic | Std. Error | Statistic | Statistic | Statistic | Std. Error | Statistic | Std. Error |
| ECO6 | 56 | 4.000 | .1747 | 1.3073 | 1.709 | -1.266 | .319 | .397 | .628 |
| ECO7 | 56 | 3.98 | .160136079 | 1.19834 | 1.436 | -1.148 | .319 | .363 | .628 |
| ECO12 | 56 | 3.98 | .15393353 | 1.151932 | 1.327 | -1.000 | .319 | .089 | .628 |
| ENV11 | 56 | 3.928 | .152590494 | 1.14182 | 1.304 | -.768 | .319 | -.541 | .628 |
| SOC18 | 56 | 3.893 | .17222488 | 1.288688 | 1.661 | -1.062 | .319 | .078 | .628 |
| SOC9 | 56 | 3.875 | .161290 | 1.206987 | 1.457 | -.910 | .319 | -.122 | .628 |
| ENV2 | 56 | 3.87500 | .167220 | 1.25136 | 1.566 | -.737 | .319 | -.751 | .628 |
| SOC2 | 56 | 3.83928 | .156621497 | 1.1720500 | 1.374 | -.871 | .319 | -.275 | .628 |
| SOC5 | 56 | 3.839285 | .15453819 | 1.156433 | 1.337 | -.772 | .319 | -.326 | .628 |
| ENV3 | 56 | 3.83928 | .14588178 | 1.0917339 | 1.192 | -.712 | .319 | -.413 | .628 |
| ENV13 | 56 | 3.8214 | .15935941 | 1.190604 | 1.422 | -.909 | .319 | -.097 | .628 |
| ENV12 | 56 | 3.821428 | .15730509 | 1.17716 | 1.386 | -.888 | .319 | -.040 | .628 |
| ECO17 | 56 | 3.82142 | .17114474 | 1.28072 | 1.640 | -.892 | .319 | -.339 | .628 |
| ECO4 | 56 | 3.82142 | .167307040 | 1.2520113 | 1.568 | -.745 | .319 | -.562 | .628 |
| SOC8 | 56 | 3.80357 | .177317206 | 1.326919 | 1.761 | -.981 | .319 | -.155 | .628 |
| ENV8 | 56 | 3.785786 | .166542145 | 1.24629 | 1.553 | -.570 | .319 | -.934 | .628 |
| ECO1 | 56 | 3.78576 | .17039386 | 1.2755 | 1.626 | -.727 | .319 | -.696 | .628 |
| SOC7 | 56 | 3.78576 | .143505057 | 1.073835 | 1.153 | -.832 | .319 | .146 | .628 |
| ECO15 | 56 | 3.76785 | .150736651 | 1.128008 | 1.272 | -.546 | .319 | -.771 | .628 |
| ECO8 | 56 | 3.7500 | .14245 | 1.06600 | 1.136 | -.782 | .319 | .097 | .628 |
| ECO5 | 56 | 3.7500 | .16167 | 1.20981 | 1.464 | -1.030 | .319 | .283 | .628 |
| SOC13 | 56 | 3.73958 | .16805403 | 1.25715 | 1.581 | -.778 | .319 | -.435 | .628 |
| ENV9 | 56 | 3.73957 | .16805003 | 1.257575 | 1.581 | -.664 | .319 | -.720 | .628 |
| ENV10 | 56 | 3.7142 | .17780856 | 1.3309 | 1.771 | -.745 | .319 | -.641 | .628 |
| ECO3 | 56 | 3.71428 | .156497290 | 1.17108008 | 1.371 | -.752 | .319 | -.265 | .628 |
| ECO14 | 56 | 3.696428 | .158973 | 1.189 | 1.415 | -.588 | .319 | -.744 | .628 |
| SOC11 | 56 | 3.678571 | .163379 | 1.2226 | 1.495 | -.525 | .319 | -.929 | .628 |
| SOC3 | 56 | 3.678571 | .1692365 | 1.2664 | 1.604 | -.641 | .319 | -.823 | .628 |
| ENV4 | 56 | 3.6607 | .1733489 | 1.29722 | 1.683 | -.472 | .319 | -1.050 | .628 |
| ECO18 | 56 | 3.660 | .1534807 | 1.148545 | 1.319 | -.485 | .319 | -.942 | .628 |
| SOC4 | 56 | 3.6606 | .1576548 | 1.17978 | 1.392 | -.883 | .319 | -.062 | .628 |
| SOC14 | 56 | 3.62500 | .166247 | 1.244077 | 1.548 | -.532 | .319 | -.846 | .628 |
| ENV1 | 56 | 3.62500 | .164282 | 1.229375 | 1.511 | -.391 | .319 | -1.271 | .628 |
| SOC6 | 56 | 3.625 | .151962 | 1.137182 | 1.293 | -.667 | .319 | -.263 | .628 |
| ECO13 | 56 | 3.625 | .170108 | 1.272971 | 1.620 | -.565 | .319 | -.761 | .628 |
| ECO2 | 56 | 3.62500 | .151962 | 1.137182 | 1.293 | -.667 | .319 | -.263 | .628 |
| ENV7 | 56 | 3.607 | .15221006 | 1.13903 | 1.297 | -.542 | .319 | -.643 | .628 |
| SOC17 | 56 | 3.60714 | .1625258 | 1.21623 | 1.479 | -.573 | .319 | -.730 | .628 |
| SOC1 | 56 | 3.6071 | .158480 | 1.18595 | 1.406 | -.536 | .319 | -.603 | .628 |
| ENV5 | 56 | 3.5892 | .158681 | 1.187461 | 1.410 | -.423 | .319 | -.915 | .628 |
| SOC12 | 56 | 3.5892 | .1903120 | 1.4241 | 2.028 | -.638 | .319 | -.972 | .628 |
| ECO9 | 56 | 3.5892 | .160714 | 1.20267 | 1.446 | -.576 | .319 | -.693 | .628 |
| SOC16 | 56 | 3.571428 | .1482739 | 1.109580 | 1.231 | -.725 | .319 | -.182 | .628 |
| SOC15 | 56 | 3.571428 | .1588455 | 1.1886 | 1.413 | -.445 | .319 | -.932 | .628 |
| SOC10 | 56 | 3.5357 | .1727626 | 1.2928 | 1.671 | -.422 | .319 | -.988 | .628 |
| ECO16 | 56 | 3.51785 | .1670816 | 1.25032 | 1.563 | -.621 | .319 | -.616 | .628 |
| ENV6 | 56 | 3.5178572 | .17054500 | 1.321034 | 1.745 | -.506 | .319 | -.955 | .628 |
| ECO11 | 56 | 3.44642 | .16100262 | 1.204833 | 1.452 | -.678 | .319 | -.538 | .628 |
| ECO10 | 56 | 3.32142 | .190874853 | 1.42837 | 2.040 | -.440 | .319 | -1.225 | .628 |

| ID | Mean | Std. Deviation |
|---|---|---|
| ECO6 | 4.000 | 1.3073 |
| ECO7 | 3.982142857 | 1.198348469 |
| ECO12 | 3.982142856 | 1.15193207 |
| ENV11 | 3.9285718 | 1.1418827002 |
| SOC18 | 3.8928573 | 1.2888130088 |
| SOC9 | 3.87500 | 1.206987 |
| ENV2 | 3.87500 | 1.251363 |
| SOC2 | 3.8392855815 | 1.172050058 |
| SOC5 | 3.8392855814 | 1.156433112 |
| ENV3 | 3.83925814 | 1.091733948 |
| ENV13 | 3.82142858672 | 1.192509086790604 |
| ENV12 | 3.82142858671 | 1.177163661397395 |
| ECO17 | 3.82142858671 | 1.280726255005337 |
| ECO4 | 3.82142858671 | 1.252011368771353 |
| SOC8 | 3.80357141529 | 1.326919095391483 |
| ENV8 | 3.7857144386 | 1.246293205167629 |
| ECO1 | 3.78571424386 | 1.275136865585135 |
| SOC7 | 3.7857144386 | 1.073893269020235 |
| ECO15 | 3.76785717242 | 1.128008243499498 |
| ECO8 | 3.7500 | 1.06600 |
| ECO5 | 3.7500 | 1.20981 |
| SOC13 | 3.73214285958 | 1.257574453658215 |
| ENV9 | 3.7321428957 | 1.257574453658215 |
| ENV10 | 3.71428571814 | 1.330950251297485 |
| ECO3 | 3.7142857814 | 1.171080087538340 |
| ECO14 | 3.6964285671 | 1.189646897301875 |
| SOC11 | 3.67857142529 | 1.222622261700415 |
| SOC3 | 3.67857142527 | 1.266450197953460 |
| ENV4 | 3.66071428386 | 1.297224810043528 |
| ECO18 | 3.66071428386 | 1.148545098877738 |
| SOC4 | 3.66071428386 | 1.179780961400612 |
| SOC14 | 3.62500 | 1.244077 |
| ENV1 | 3.62500 | 1.229375 |
| SOC6 | 3.62500 | 1.137182 |
| ECO13 | 3.62500 | 1.272971 |
| ECO2 | 3.62500 | 1.137182 |
| ENV7 | 3.607142857958 | 1.139035819192191 |
| SOC17 | 3.607142857957 | 1.216232206127195 |
| SOC1 | 3.607142857956 | 1.185956789471583 |
| ENV5 | 3.589285714814 | 1.187461550983935 |
| SOC12 | 3.5892857142813 | 1.424165282980539 |
| ECO9 | 3.58928571813 | 1.202675588606010 |
| SOC16 | 3.5714285772 | 1.10958040937 |
| SOC15 | 3.5714285771 | 1.18869136423 |
| SOC10 | 3.5357142884 | 1.2928377102 |
| ECO16 | 3.5178571444 | 1.2503240097 |
| ENV6 | 3.5178571442 | 1.32103366914 |
| ECO11 | 3.4464285771 | 1.2048330948 |
| ECO10 | 3.32142857172 | 1.42837662740 |

**Rotated Component Matrix[a]**

| | Component | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| SOC18 | .847 | | | | |
| SOC9 | .791 | | | | |
| SOC8 | .755 | | | | |
| SOC7 | .755 | | | | |
| SOC17 | .736 | | | | |
| SOC13 | .731 | | | | |
| SOC5 | .731 | | | | |
| SOC10 | .725 | | | | |
| SOC4 | .718 | | | | |
| SOC2 | .704 | | | | |
| SOC6 | .696 | | | | |
| SOC16 | .675 | | | | |
| SOC1 | .637 | | | | |
| SOC15 | .634 | | | | |
| SOC11 | .622 | | | | |
| SOC12 | .611 | | | | .557 |
| SOC3 | .593 | | | | |
| SOC14 | .592 | | | | |
| ENV1 | | .786 | | | |
| ENV9 | | .760 | | | |
| ENV11 | | .752 | | | |
| ENV2 | | .737 | | | |
| ENV3 | | .735 | | | |
| ENV13 | | .698 | | | |
| ENV12 | | .691 | | | |
| ENV10 | | .654 | | | |
| ENV4 | | .614 | | | |
| ENV8 | | .582 | .576 | | |
| ECO14 | | | .817 | | |
| ECO15 | | | .708 | | |
| ECO8 | | | .644 | | |
| ENV7 | | | .616 | | |
| ENV6 | | | .606 | | |
| ECO11 | | | .592 | | |
| ENV5 | | .548 | .567 | | |
| ECO13 | | | .552 | | |
| ECO12 | | | | | |
| ECO3 | | | | .746 | |
| ECO18 | | | | .644 | |
| ECO1 | | | | .618 | |
| ECO17 | | | | .597 | |
| ECO2 | | | | .583 | |
| ECO16 | | | | .561 | |
| ECO6 | | | | .506 | |
| ECO4 | | | | | |
| ECO7 | | | | | .698 |
| ECO10 | | | | | .670 |
| ECO5 | | | | | .620 |
| ECO9 | | | .536 | | .600 |

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.[a]