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Integrated Factors Affecting Sustainability and Value Engineering for Egyptian Road Maintenance Projects

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ABSTRACT

The world's priorities seem to have shifted due to many factors, such as climate change and financial issues. With the growth of cities, road maintenance has become a significant concern. The challenge is to find a way to achieve economic, environmental, and social sustainability while maintaining the road's performance. This research investigates the multifaceted dimensions of sustainability and value engineering in the context of Egyptian road maintenance projects, aiming to identify integrated factors that influence project outcomes. That's where value engineering technology comes in. Before integrating value engineering with sustainability for road maintenance, a survey was conducted to determine the level of awareness and application of value engineering in the road sector in Egypt. A questionnaire was distributed digitally and in hard copies to road professionals. The survey had four parts with a total of 27 questions. It aimed to gather information about the respondent's background, understanding of sustainability, violent extremism, and the factors influencing sustainability. It's fascinating to see the results and learn more about the factors that influence the achievement of sustainable road maintenance. The results demonstrated that the economic aspect of sustainability is the most important, with a margin of 52%, followed by the environmental aspect, with a margin of 31%, and the social aspect, with a margin of 17%. One of the key strengths of the questionnaire survey lies in its ability to capture the subjective experiences and perceptions of those directly involved in road maintenance projects.

Keywords: Sustainability; Value Engineering; Road Maintenance.

1- INTRODUCTION

Large infrastructure projects can be challenging to manage from a project management perspective because they often have complex prerequisites, such as geology, a wide range of technical solutions, and the surrounding society. These projects face various challenges, such as cost-efficiency, quality, and sustainability, which are crucial for sustainable development. These challenges are due to factors such as age, hostile environmental conditions, inadequate design, underfunding, and inappropriate operation and maintenance operations, which can all impact the effectiveness of infrastructure in the long run [1].

Sustainable infrastructure development is increasingly essential, as over 66% of the global population is predicted to live in urban areas by 2050, responsible for up to 100% of all greenhouse gas emissions. Despite these challenges, the ministry believes that preserving and maintaining roads is just as important as building them to ensure the safety of road users and maintain road performance [2].

Roads are crucial for economic growth, development, and significant social benefits. They provide access to social, health, and educational facilities, as well as employment prospects, which is vital in the fight against poverty. Unfortunately, the backlog of unfinished maintenance has severely affected the road system, and without proper upkeep, roads may require replacement or significant repairs in just a few years [3].

To address this issue, road asset management programs or systems can be used to balance long-term requirements and maintain assets through preventive maintenance. This approach aims to improve service level outcomes in exchange for the most cost-effective financial input. The goal is to apply the proper treatment at the right time to achieve the necessary service, demonstrating that roads are a valuable economic resource for society and the economy [4].

Environmental engineering can also reduce project costs, improve quality, and promote sustainability, benefiting the economy and the environment. Using value engineering, service clients can be provided at the lowest overall cost [5].

In the contemporary landscape of road development, the convergence of value engineering and sustainability has emerged as a pivotal paradigm, particularly in the maintenance of roads. The imperative to ensure the longevity and efficiency of road networks, coupled with the growing emphasis on environmentally responsible practices, has prompted a nuanced exploration of the integration between value engineering principles and sustainable road maintenance. This intersection signifies a strategic approach that optimizes the economic aspects of maintenance projects and conscientiously addresses the ecological and societal dimensions, aligning with the broader goals of sustainable development. Value engineering, as a systematic and multidisciplinary methodology, seeks to maximize the functionality and performance of infrastructure while minimizing costs. Traditionally applied during the design and construction phases, its extension to the realm of road maintenance underscores a proactive stance in ensuring that existing infrastructure remains resilient and resource-efficient over time. Concurrently, sustainability in the context of road maintenance encapsulates a holistic commitment to environmental stewardship, economic viability, and social responsibility. The synthesis of value engineering and sustainable road maintenance becomes imperative against the backdrop of escalating challenges such as urbanization, population growth, and climate change impacts. In this context, this exploration seeks to unravel the interconnected factors influencing the amalgamation of value engineering principles with sustainable practices in the maintenance of roads. By delving into this synergy, the aim is not only to enhance the operational efficiency of road networks but also to contribute to the broader discourse on responsible infrastructure management and the pursuit of resilient and environmentally conscious transportation systems. Through a comprehensive analysis, this study endeavors to shed light on the mechanisms, challenges, and opportunities inherent in the incorporation of value engineering principles into the sustainable maintenance of roads, thereby paving the way for a more robust and future-ready infrastructure paradigm.

This research outlines a comprehensive exploration of the interrelated factors influencing sustainability and value engineering in the context of road maintenance projects in Egypt. The primary aim of this research is to employ a questionnaire-based approach to systematically analyze participant's responses and perceptions regarding the integrated factors influencing sustainability and value engineering. By utilizing a quantitative method, the study aims to gather valuable insights from stakeholders, including engineers, policymakers, and project managers, to better understand their perspectives on the critical factors affecting project sustainability and the application of value engineering principles. This research contributes by providing a platform for capturing diverse stakeholder perspectives through the administration of a comprehensive questionnaire. By soliciting input from individuals directly involved in road maintenance projects in Egypt, the study aims to offer a nuanced understanding of the challenges and opportunities related to sustainability and value engineering. The insights garnered from the questionnaire analysis are intended to contribute practical recommendations for policymakers and practitioners involved in road maintenance projects in Egypt. These recommendations aim to bridge the gap between theoretical considerations and on-the-ground realities, fostering more effective and sustainable project planning and implementation

2- LITERATURE REVIEW

2.1 Value Engineering

In 1947, the VE procedure first surfaced. Several alternatives were introduced during the Second World War to increase the performance of systems or processes at the lowest possible cost. These alternatives were systematic, organized, strategic, multidisciplinary teams, and function-oriented tools. The "Father of Value Engineering," Mr Lawrence D. Miles, was engaged by General Electric Company to develop a system that would alter manufacturing processes or design elements, resulting in significant cost savings. Miles created a methodical strategy later known as value analysis/engineering (VA/VE). In 1952, he led the first job session on value analysis. In 1954, the US Merchant Marine adopted VA to reduce costs during design and gave it the moniker VE. A group of professionals established an education organization to advance the VE principles and disseminate their inventive abilities as the value methodology (VM) grew. As a result, the "Group of American Value Engineers" was incorporated in Washington, D.C., in 1959. In 1996, the society's name was "SAVE International." According to [6], numerous nation-states outside the US adopted VE techniques in the 1970s, including South Africa, Saudi Arabia, the

United Kingdom, Japan, India, France, Germany, Canada, Hungary, and others [7]. Value Engineering (VE) is a technique that helps reduce costs while ensuring that quality, dependability, performance, and other crucial elements meet or exceed customer expectations [6]. As per [8], VE involves implementing known methods to identify a system's function at the lowest cost. Defines Value Engineering as the process of achieving the desired function at a reasonable price to increase the project's value [9].

2.2 Sustainability

Sustainability and environmental improvement are critical to creating value during the project. It also helps balance life cycle assessment and quality to meet the end user's expectations. The degree to which sustainability is considered changes from stage to stage based on the team members' knowledge and the project's scale [10].

Sustainability aims to contribute the most outstanding value to present and future generations. Financial sustainability is a continuous flow of public and private projects with successful allocation and management of resources; evaluate financial efficiency using societal criteria rather than enterprise profits [10].

The tripartite bottom line notion may be explored using sustainability as a helpful organizing concept. This principle discusses the three aspects of social, environmental, and economic performance that are closely related to the concept and goal of sustainable development [11]. Sustainability is defined by [12] as "using raw resources in such a balancing condition that they do not reach decay, depletion, or un-renewable point and passing them on to the future generations by preserving them." They also claimed that sustainability aims to balance the natural and artificial environments without lowering the quality of our lives by enhancing everyone's quality of life, safeguarding natural resources, and improving the economy supported by these natural resources. The term "sustainability" also refers to the method through which sustainability is attained (the implementation of sustainable development principles via a construction LCS) [13]. In addition, [12] claimed that the theory of sustainability in building and construction had initially strongly emphasized technical issues like materials, building components, construction technologies, and energy-related design concepts. These issues included limited resources and ways to minimize effects on the environment. The notion of green construction now oversees three essential pillars: environmental preservation, social cohesion, and economic development.

3- RESEARCH METHODOLOGY

The methodology section outlines the systematic approach employed to investigate the integrated factors influencing sustainability and value engineering in the context of Egyptian road maintenance projects. This research utilized a combination of questionnaire-based surveys and rigorous analysis of responses to derive meaningful insights. Having identified the factors that affect sustainability and value engineering of road maintenance, it is necessary to know how each factor could influence the three essential pillars, environmental, social, and economic aspects. The following sections show the steps followed to meet the research objectives.

3.1 Research Design

A mixed-methods research design was adopted to ensure a comprehensive understanding of the complex interplay between sustainability and value engineering in road maintenance. The study incorporated both qualitative and quantitative elements, employing a structured questionnaire as the primary data collection instrument. The comprehensive approach and findings will enhance decision-making and contribute to the development of sustainable and cost-effective road infrastructure in Egypt.

A survey was conducted to determine the level of awareness and application of value engineering in the road sector in Egypt. A questionnaire was distributed digitally and in hard copies to industry professionals who were asked to fill it out in Arabic or English. The survey had four parts with a total of 27 questions. It aimed to gather information about the respondent's background, understanding of sustainability, violent extremism, and the factors influencing sustainability. Out of 132 industry professionals, only 100 filled out the survey.

3.2 Questionnaire Development

The questionnaire was designed to capture key variables related to sustainability and value engineering specific to the Egyptian road maintenance context. The questions were developed based on the extensive literature review, expert consultations, and consideration of road industry best practices. A comprehensive questionnaire is developed, encompassing sections on:

- Current maintenance practices and materials used.
- Value engineering approaches implemented and their effectiveness.
- Sustainability considerations applied and their perceived impact.
- Challenges and barriers to integrated sustainability and their effectiveness.
- Stakeholders perspectives and recommendations.

The questionnaire was pre-tested to ensure clarity, relevance, and reliability with a small group of relevant experts (engineers, contractors, academics). Based on feedback necessary refinements were made before the final version distributed

3.3 Sample Strategy

The target population of this study comprised professionals involved in Egyptian road projects, including engineers, project managers, and sustainability experts. A stratified random sampling technique was employed to ensure representation from various sectors and levels of expertise within the industry.

3.3.1 Population Recognition

Obtaining an accurate population count is crucial when conducting research, especially if it is essential to maintain the community's sustainability and VE policy. The Egyptian sustainability code demands high confidence to assess tangible sustainability with precision. However, estimating the number of specialists working on infrastructure projects is often challenging due to the undefined population.

3.3.2 Correction Margin (Interval of Confidence)

It was challenging to obtain a perfect sample, so an error percentage was estimated. The confidence interval determines the level of uncertainty in the responses. For example, when it is necessary to indicate uncertainty, it is stated that "70% of voters supported this idea, with a margin of error of +/- 5%." The margin of error decreased as more surveys were conducted.

3.3.3 Level of Self-Belief

This value represents the level of confidence in the population's responses. The most common degrees of confidence are 90%, 95%, and 99%. Confidence increases as more surveys are completed.

3.3.4 Average Deviation

The expected prevalence or population proportion reflects the variation in different solutions. This value ensures that the population will be sufficiently satisfied, and it is commonly assumed to be 0.5. According to a study by [14], the survey sample size was determined to be representative. The sample size for an undefined population can be calculated as follows:

n = [Z^2 x P (1 – P)] / E^2 (1),

Assuming an infinite population, where n is the minimum sample size.

The standard deviation for P is assumed to be 0.5

The accuracy or tolerable error margin (E) is 0.05 [5%] at the 95% confidence level.

The confidence level statistic (Z) is 1.654 with 90% confidence, 1.96 at 95% confidence, and 2.58 at 99% confidence.

Assuming that the confidence interval is 0.95 (95% sure), and using the following parameters: Z = 1.96, E = 0.05 [5%], and P = 0.5, we can determine that the sample size for a survey is 96.

However, a sample size of 100 people is considered scientifically sufficient for more accurate survey findings.

3.4 Data Collection Process

Questionnaire were distributed electronically/hard copies distributed to identified participants at relevant events and organizations, accompanied by a clear explanation of the sampling strategy and ethical considerations. The data collection period spanned a suitable specific time frame, allowing participants sufficient time to respond thoughtfully. Informed consent was being obtained from all participants before any data were collected. Data anonymity and confidentiality were be strictly maintained throughout the research process.

3.5 Data Analysis

3.5.1 Background Knowledge and Expertise

(Q1) It has been observed that the respondents possess a diverse range of expertise in various fields. The figure indicates the percentage of respondents from different professions, such as 12.7% site engineers, 3.6% quantity surveyors, 1.8% designers, 23.6% project managers, 1.8% contractors, 10.9% consultants, 18.2% ice engineers, 3.6% of engineers, and 23.6% of respondents with other specializations, including university doctors specializing in the field of roads, the Undersecretary of the Ministry of Roads and Bridges in the North Delta, and pan managers. This information is presented in Figure 1.

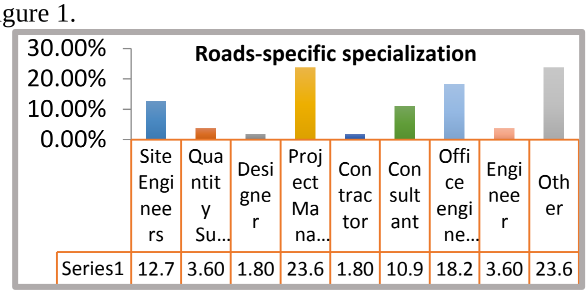

Figure 1: Specialization of violent extremism among those who responded to the questionnaire

(Q2) According to the data, 26% of the respondents have worked in the roads sector for five to ten years. 30% of the respondents have experience ranging from 11 to 15 years, while those with more than 15 years of experience make up 44% of the responses. This information is presented in Figure 2.

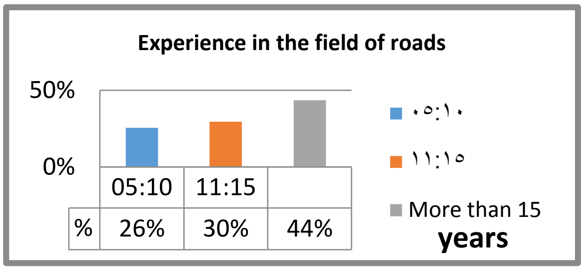

Figure 2: Experience of violent extremism among those who responded to the questionnaire

3.5.2 Value Engineering Information

(Q1) This question is a measure of the respondent understands of the VE process as a whole. According to Figure 3, 5.5% of participants had terrible knowledge, 5.5% had poor knowledge, 19% had fair knowledge, 20% had excellent knowledge, and 50% had good knowledge.

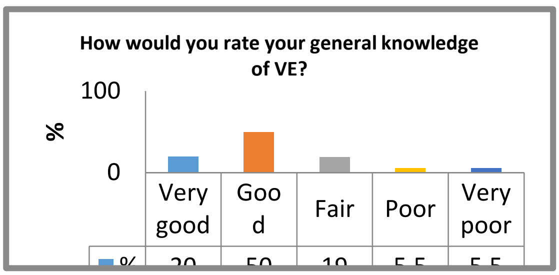

Figure 3: knowledge of violent extremism among those who responded to the questionnaire

(Q2) In the second question of the study, participants were asked to evaluate the certified or equivalent VE specialist in their respective organizations and provide an overall assessment. The results revealed that 69% of respondents lacked sufficient formal VE training, while only 31% had received formal VE training, as shown in Figure 4.

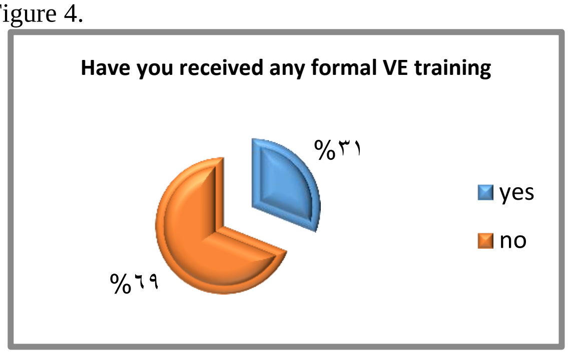

Figure 4: Formal VE training

(Q3) In order to determine how extensively the VE (Value Engineering) process was implemented in the respondent's works, Figure 5 was created. Based on the statistics gathered, it was found that 11% of the respondents never used the VE process, 31% used it to a fair extent, 20% consistently applied it, 33% applied it to an average extent, and 5% applied it poorly. These responses demonstrate a significant number of participants.

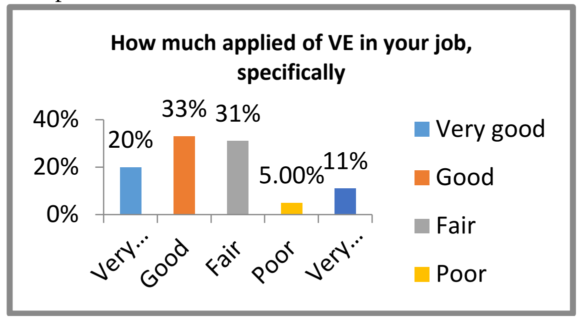

Figure 5: Application of VE

(Q4) The question aimed to know why the VE procedure was being used. According to the responses, only 7% of the respondents believed that it was necessary to obtain funding, 9% of the respondents thought that meeting the schedule would motivate the use of the VE process, and 33% of the respondents believed that it would help reduce or avoid maintenance costs. The majority of respondents, accounting for 51%, said that their primary motivation for using the VE method was to enhance the performance of their project, as shown in Figure 6.

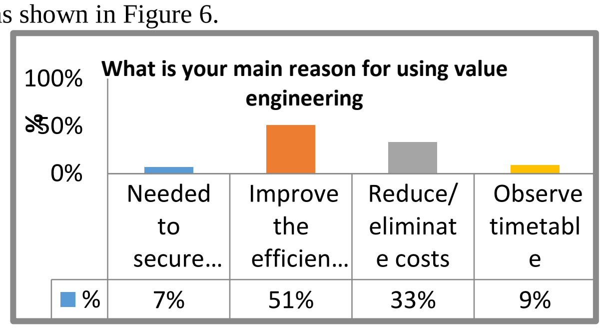

Figure 6: Motivation for Using the VE Process

(Q5) According to a chart in Figure 7, there are multiple perspectives on the benefits of VE in the road sector. Most respondents (66%) agreed that one of the most significant benefits of VE in the road maintenance sector is reducing or eliminating non-essential expenditures. About 27% of respondents stated that it would boost project performance, while only 7% believed that keeping to the schedule is one of the benefits of VE in road maintenance.

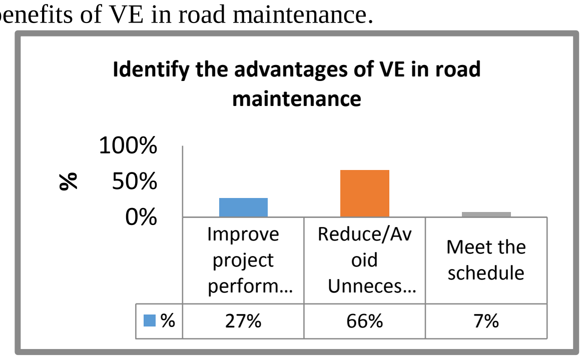

Figure 7: Advantages of VE

(Q6) The graphic Figure 8 represents most people's responses regarding the appropriate size for the VE study team. Only 4% believed a team of 5 to 8 individuals with diverse backgrounds would suit the VE research. On the other hand, 47% of the participants suggested that there should be no restrictions on the number of participants in the study. Additionally, 7% of the respondents thought a team of 1 to 4 people would be sufficient for the VE study. Results showed that 31% of the participants believed that the VE team's ideal size depends on the project's scope. Furthermore, 11% of the respondents were unsure about the appropriate size of the VE team.

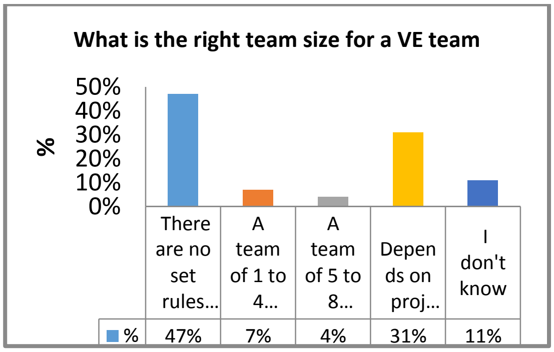

Figure 8: Value engineering team size

(Q7) The analysis gave clear answers to the query. Only 18% of the contributors did not understand the VE research period. Furthermore, 36% of people thought there was no fixed duration to complete the VE task plan. However, 46% of respondents agreed that the VE study's length depends on the project's size, as shown in Figure 9.

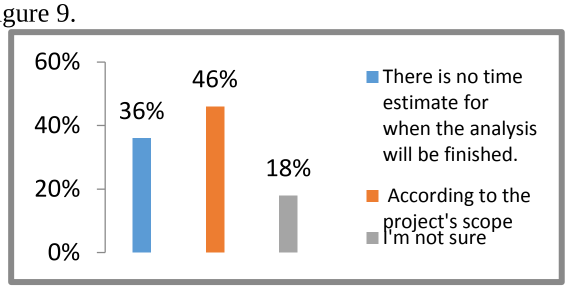

Figure 9: Study period of VE

(Q8) This inquiry aimed to determine if there were any reliable documents regarding the impact of the project's initial cost. Figure 10 shows different perspectives on the issue. The results indicate that 2% of respondents claimed an increase in the initial cost of over 15%, 4% believed in a rise of 10-15%, and 20% assumed an increase of 5-10%. However, the majority of respondents (74%) thought that value engineering (VE) only added 5% to the initial project cost.

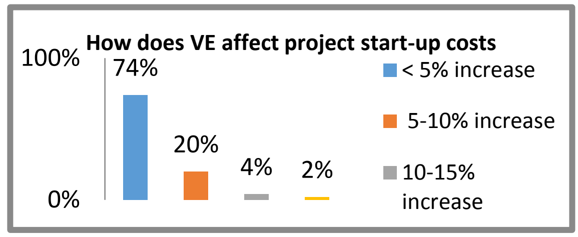

Figure 10: Effect of VE on project's initial cost

3.5.3 Sustainability Information

Efficiency in Sustaining Resources Literature reviews [15,16,17,18] were conducted to collect the information needed to identify the sustainability needs of various infrastructure projects. Considerations for the long-term viability of infrastructure were compiled and organized into the three overarching categories of economic, environmental, and social sustainability. These criteria were chosen carefully so that they would encompass the complete range of activities involved in any infrastructure project, from conception through completion and operation, maintenance, and eventual replacement.

The following data is about long-term planning. There are a total of nine questions, and they are as follows:

(Q1) This survey aimed to assess people's familiarity with sustainability issues. The results showed that most respondents (36.5%) had average sustainability knowledge. In comparison, 16.5% had a shallow level of knowledge, 11% had a low level of knowledge, 27% had a moderate level of expertise, and 9% had a high level of knowledge, as shown in Figure 11.

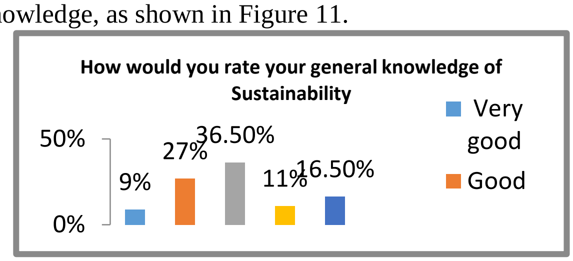

Figure 11: Overall knowledge of sustainability

(Q2) During the inquiry, we aimed to find technologies that can help us increase the number of publications while also preserving resources for future generations. The responses we received from the respondents were as follows: 5% lacked knowledge about the topic, and 4% suggested setting new consumption standards using harvested/quickly renewable materials by brainstorming. 62% of the respondents suggested reusing the previously employed materials, which can lead to fewer new materials and help reduce waste, thereby preserving materials. Another 22% of the respondents indicated that reducing designs and using previous designs can help decrease waste and save money. Finally, 7% of the respondents believed that scientific and technological development would help save costs, as shown in Figure 12.

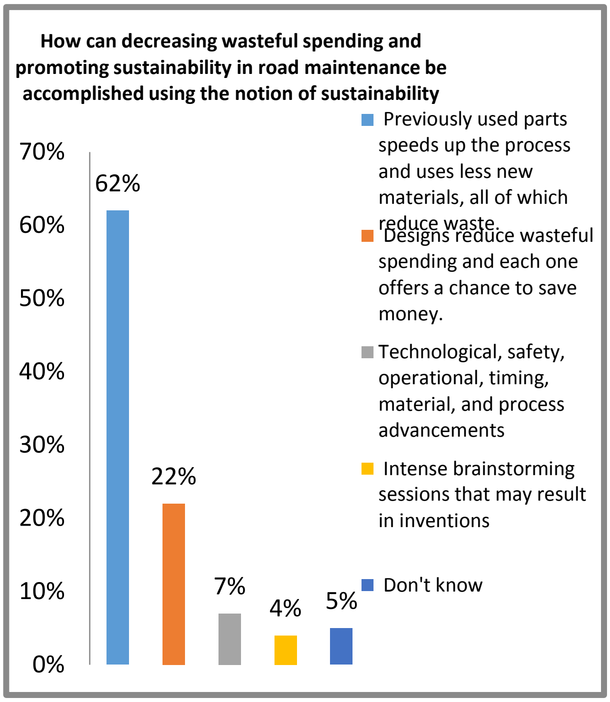

Figure 12: Reducing Waste by Applying Sustainability

(Q3) In response to the question of how to increase customer focus and happiness without expending all resources on road maintenance, the following ideas were suggested:

- 6% of the respondents had no ideas.
- 6% suggested implementing measures to reduce resource use.
- 10% proposed increasing sustainable materials and emphasizing sustainability as an ethical business practice.
- 17% recommended making use of freshly harvested and refurbished sustainable resources.
- 4% believed enforcing and developing new consumption guidelines could save resources.
- Additionally, 57% suggested recycling materials to boost customer focus and happiness while conserving resources. These findings are presented in Figure 13.

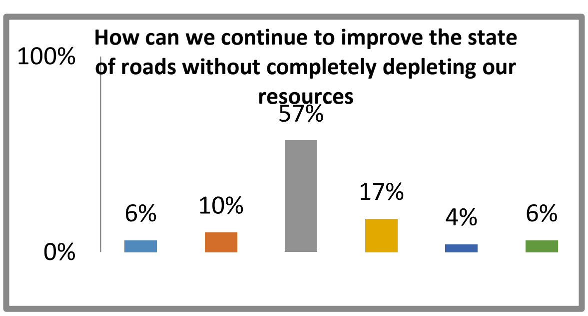

Figure 13: Sustainability improve the state of roads without completely depleting resources

(Q4) The replies to this question are depicted in Figure 14, which shows the extent to which the respondents' works include the notion of sustainability. The breakdown of responses is as follows: 5% of respondents consistently applied sustainability concepts, 20% had an average application, 42% had a good application, 22% had a poor application, and 11% never applied sustainability concepts in their works.

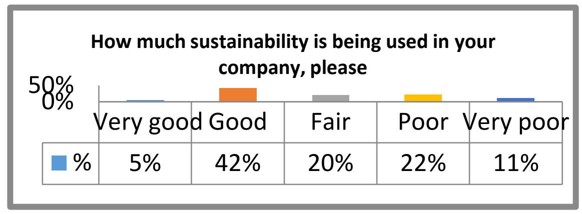

Figure 14: Sustainability level applied in participaints compines

(Q5) The purpose of this question was to gather opinions from respondents about the general trend of countries moving towards sustainable forms of development. According to the survey results, 13% of respondents prefer sustainability to reduce project time, while 5% believe that its importance depends on the urgency of climate change. Additionally, 13% of respondents acknowledge that sustainability can help by reducing inequality and improving the quality of life. Another 3% believe addressing poverty, hunger, and rapid urbanization is necessary. 5% of respondents think that sustainability can enhance societal sustainability, and 15% consider that it can prevent negative impacts on the biophysical environment. Finally, most respondents (46%) believe that the main reason for this rapid shift towards sustainability is the limited availability of resources, as shown in Figure 15.

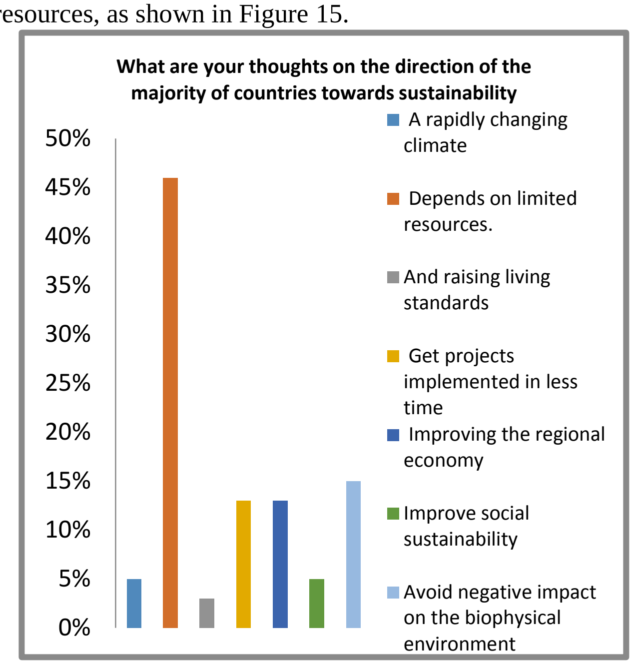

Figure 15: The majority of countries towards sustainability

(Q6) The purpose of assessing the influence of sustainability debates on road engineering in several developing countries was surveyed, and the responses are shown in Figure 16 below. The results were as follows: 2% of the respondents believed that sustainability increases the initial cost; 4% of the respondents had no ideas; 5% of the respondents acknowledged that sustainability reduces the amount of physical effort required; 18% of the respondents believed that sustainability helps to prevent pollution; 18% of the respondents considered that sustainability provides a life cycle cost analysis that meets the needs of the owner; 26% thought that sustainability could increase project value; and the majority of respondents, 27%, believed that sustainability decreases waste.

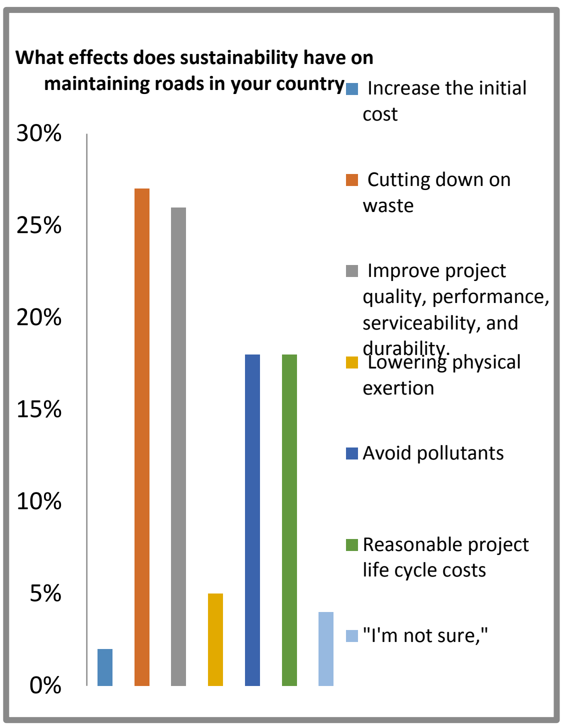

Figure 16: Effects of sustainability on road projects

(Q7) The purpose of this question is to understand the challenges that people face while trying to achieve sustainable roads in their country. The responses were shared with colleagues, and the findings were as follows: 5% of respondents found resource mobilization to be a challenge, 6% found reducing resource use and improving quality to be challenging, 9% of people were unaware of the issue, 13% found environmentally friendly health and safety to be a challenge, 16% found innovation in building materials and methods to be a challenge, and finally, 51% of respondents agreed that raising public awareness about the importance of sustainability is a challenge. The most significant finding is represented in Figure 17.

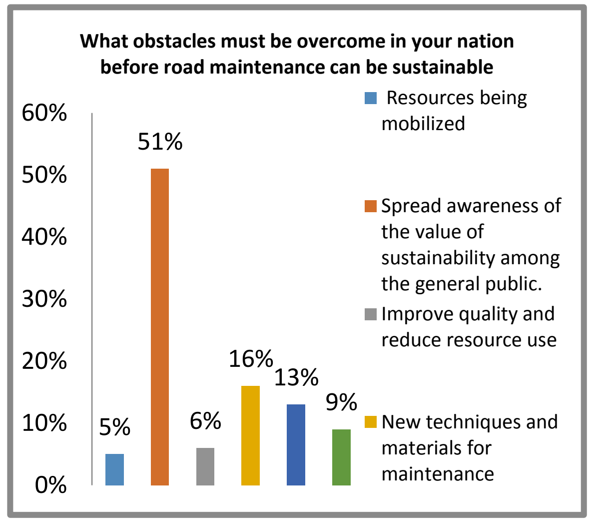

Figure 17: Challenges Facing Sustainability in Road Maintenance

(Q8) This inquiry investigates how sustainability will impact the project's original cost and if there is any evidence to support this. The responses indicate the following: 2% of respondents believed that sustainability would increase the initial cost by more than 5%, 7% of respondents said that sustainability would raise the initial cost by between 10% and 15%, 40% of respondents indicated that sustainability would increase the initial cost by between 5% and 10%, and 51% of respondents believed that sustainability would raise the initial cost by less than 5%. This information is presented in Figure 18.

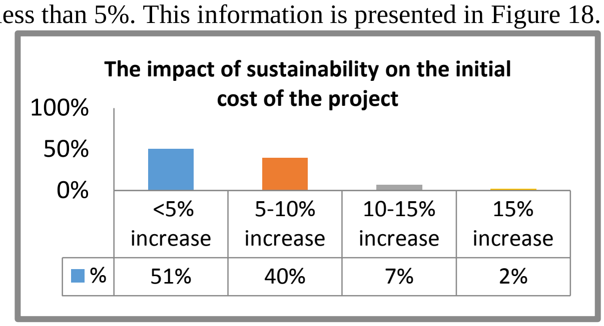

Figure 18: Effect of sustainability on project's initial cost

(Q9) The foundation of sustainability is based on three fundamental aspects—the question aimed to rank the significance of each aspect in descending order. The response to this query demonstrated that the economic aspect of sustainability is the most important, with a margin of 52%, followed by the environmental aspect, with a margin of 31%, and the social aspect, with a margin of 17%. Please refer to Figure 19 for further details.

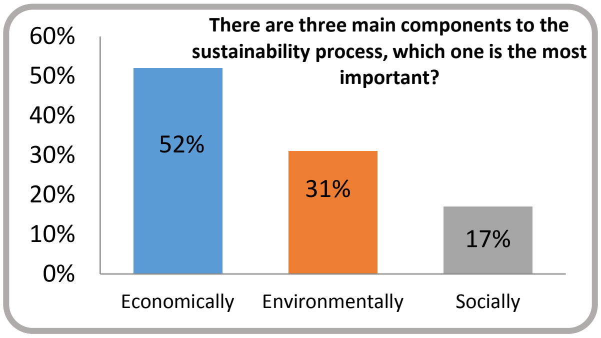

Figure 19: The most Important Aspects of Sustainability

Three crucial factors have been identified to impact sustainability in Egypt significantly, as shown in Table 1. These three aspects have been narrowed down as the most important ones that require further research to achieve full sustainability in Egypt. Hence, the following three questions in the questionnaire are the most crucial ones that would help us identify and understand these significant factors better.

(Q10) This survey indicates that 37% of the participants agreed that EF3 has the most significant impact on the economic aspect of the sustainability process. The other variables follow with varying degrees, as shown in Figure 20.

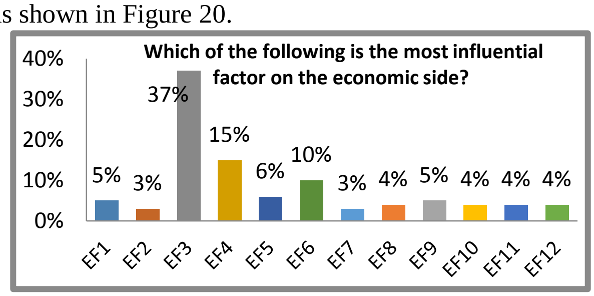

Figure 20: Ranking the factors that have the most effects on the economic side of the sustainability process

(Q11) It was important to find out what factors have the most significant impact on the environmental aspect of sustainability. After conducting a survey and analyzing the responses, we discovered that EnF1 and EnF4 are equally important as they had the highest percentage of 27%, as illustrated in Figure 21.

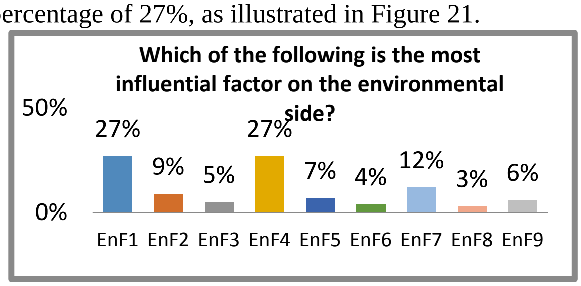

Figure 21: Ranking the factors that have the most effects on the environmental side of the sustainability process

(Q12) According to a recent survey, 47% of respondents believe that the SF5 factor is the most critical factor influencing the social aspect of sustainability that all societies strive to achieve. This factor has been identified as having the most significant impact on society, as illustrated in Figure 22.

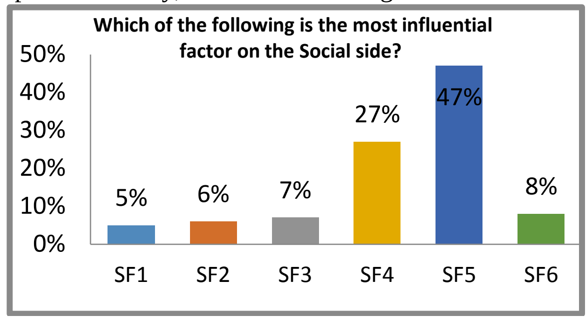

Figure 22: Most affecting factors influence social side of sustainability process

3.5.4 Correlation Information:

This section discusses the hypothesized correlation between virtual environment (VE) and sustainability. The aim was to gather people's opinions on these two concepts to strengthen the claimed correlation.

Regarding question (Q1), the responses to the statement that VE and sustainability are the best combination of eco-building principles that meet the owner's requirements are shown in Figure 23. The results were as follows: 10% of respondents strongly disagreed with the suggestion, while 90% agreed.

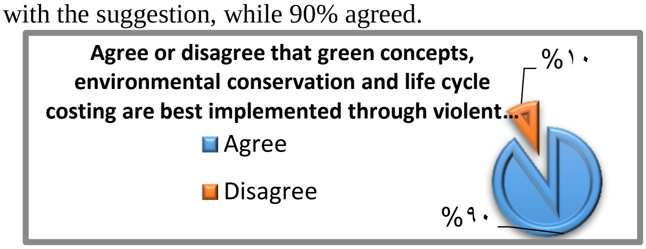

Figure 23: Green facility of value engineering and sustainability

(Q2) Figure 24 aimed to provide various perspectives on how VE can achieve its sustainability goals. The responses received are as follows: 5% agreed that quality and durability should be improved, 6% had no idea, 6% believed that integrating a sustainability proposal during the VE workshop would be helpful, 11% thought that reducing or avoiding costs associated with maintenance and serviceability could help, 18% believed that improving project performance would contribute to sustainability, and the majority, 54%, acknowledged that sustainability goals could be achieved by reducing or avoiding unnecessary costs.

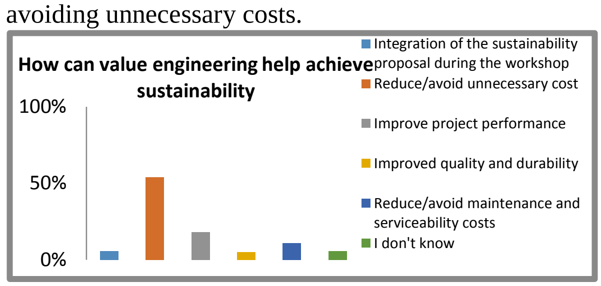

Figure 24: Challenges to implement value engineering in sustainable road projects

Table 1. Key Variables Influencing Each of the Three Sustainability Pillars [14].

Economic factors	Environmental factors	Social factors
{EF1}Determine the project's financing sources and its scheduling plan. **{EF2}**The project manager's competency is the number of years of experience. **{EF3}**Creating a capital budget for planning and reducing overall costs **{EF4}** thoroughly examines the project's scope, design, feasibility studies, drawings, and bid preparation. **{EF5}**The competence of the main contractor, the sum of his years of experience, and administrative and organizational skills. **{EF6}**The ability to troubleshoot errors quickly and make decisions promptly. **{EF7}**The dedication of all project parties to their responsibilities and their understanding of the role and obligation. **{EF8}** Efficiency of on-site supervision and availability of technical skills. **{EF9}**The availability of raw supplies, facilities, and human and financial resources. **{EF10}**Preparing appropriate designs, drawings, comprehensive, and specifications. **{EF11}**Enhancing the processes for awarding contracts and choosing the contractor by giving less weight to price and more weight to the contractor's aptitude, financial standing, and prior performance. **{EF12}**Reflection of the project's positive economic impact on the neighbourhood.	**{EnF1}**The project's effects on public health. **{EnF2}** chemical waste and organic contaminants are treated before being dumped into the sewers. **{EnF3}**Examining how much water the planned project would use and any potential water pollution it might cause. **{EnF4}**Special treatment of radioactive compounds, heavy metals, and poisonous substances released during maintenance and replacement. **{EnF5}**The project's operation had no adverse effects on the ecosystem, vegetation, or animals. **{EnF6}**Use non-toxic alternatives and make efforts to lessen solid infractions. **{EnF7}**Examining possible air pollution from the proposed project and how it would affect the local climate. **{EnF8}**Applying adherence to all environmental standards during project conception, execution, operation, deconstruction, recycling, and disposal. **{EnF9}**Adopting project maintenance techniques and increasing waste reuse and recycling.	**{SF1}**The design must consider the Touareg cases, such as fire, earthquakes, floods, radiation, environmental accidents, and the installation of safety alarms and screens. **{SF2}**The design considers the needs of people with disabilities. **{SF3}** Considering the regulations about the dangers to workers and the public's safety during the project's demolition from explosions, dismantling, poisonous, and radioactive materials. **{SF4}** Implement safety, facilities, and insurance procedures for project employees. **{SF5}** impact on historically significant sites and cultural heritage conservation. **{SF6}**The expected impact on local development.

(Q3) The bar chart presented in Figure 25 shows different viewpoints on the potential link between violent extremism and sustainability when old materials are recycled in developing countries. According to the study, only 4% of respondents disagree with the idea, while 5% somewhat agree with it, 38% agree with it, 22% approve to a certain extent, and 31% strongly approve.

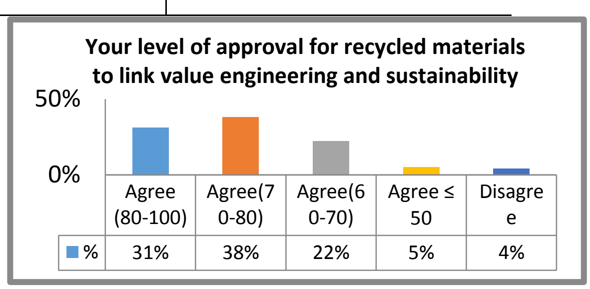

Figure 25: Recycled materials approval level for value engineering and sustainability

(Q4) According to a survey, people have different opinions about how integrating Virtual Environment

(VE) and Sustainability principles may lead to specific outcomes. The results are presented in Figure 26. When asked about the possibility of saving money or time, 4% strongly disagreed, 13% somewhat agreed, 20% approved, 47% fairly settled, and 16% strongly agreed. When asked whether integrating VE and Sustainability can make customers more satisfied, only 10% firmly disagreed, 23% slightly agreed, 30% approved, 23% agreed well, and 14% agreed passionately. Finally, the survey found that 7% of respondents strongly disagreed, 13% slightly agreed, 30% decided, 37% moderately agreed, and 13% strongly agreed on the benefits of value and sustainability engineering in developing nations in decreasing pollution.

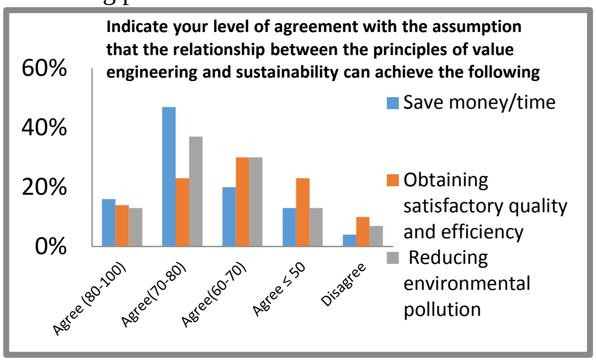

Figure 26: The Correlation between the VE Process and Sustainability Advantages

(Q5) The last question in the survey aimed to gather opinions on the challenges presented by the combination of VE technology and sustainability, as shown in Figure 27. Firstly, 7% of the respondents demonstrated a general lack of understanding of both topics, believing it to be unimportant, while 4% considered it somewhat important, 22% rated it as necessary, 43% as very important, and 24% as extremely important. Secondly, concerning the absence of volunteering workshops, 10% of the participants considered it unimportant, 7% thought it was somewhat important, 27% believed it was important, 36% felt it was indispensable, and 20% deemed it extremely important. Thirdly, concerning the lack of interest in sustainability, 13% of the respondents considered it unimportant, 7% thought it was of little importance, 30% believed it was necessary, 33% deemed it very important, and 17% deemed it necessary. Lastly, when asked about the lack of integrated research and methodology, 10% of the participants considered it unimportant, 10% thought it was somewhat important, 27% believed it was important, 30% felt it was very important, and 23% deemed it extremely important.

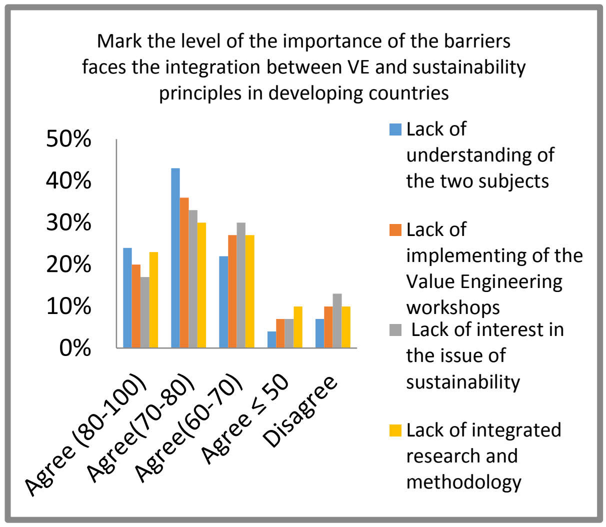

Figure 27: Key Challenges for Integrating VE and Sustainability in Road Projects

4- CONCLUSION

In conclusion, the utilization of a questionnaire survey has proven to be an invaluable methodological tool in our exploration of the integrated factors influencing sustainability and value engineering in Egyptian road maintenance projects. The insights gathered from the diverse perspectives of stakeholders, including engineers, policymakers, and project managers, have provided a rich tapestry of data that enhances our understanding of the intricate dynamics at play in this complex domain. This study was divided into four sections. The first section included gathering information on one's experience level and area of expertise. The collected questionnaires showed that most respondents were project managers and designers with over 15 years of experience. In fact, 44% of those who answered belonged to this category. In the second section, the survey results showed that 50% of the respondents had some knowledge of value engineering, but 69% had not received any training on it, indicating that lack of training was the most significant challenge in applying value engineering. The primary goal of implementing value engineering was to improve project efficiency, while the most significant advantage of value engineering was reducing unnecessary expenses.

Moving on to the third section, it was found that despite a fair understanding of sustainability in developing nations, the primary hurdle to achieving sustainability is the lack of public awareness about its importance. The survey showed that 28% of the respondents believed that policies promoting the reuse of materials were the best way to reduce consumption and conserve resources. This trend is driven by the depletion of resources and the spread of pollution across developing countries. It is also expected to minimize project waste and costs and enhance profitability, customer satisfaction, and focus.

Finally, the survey highlighted the most significant factors impacting the three aspects of sustainability. The EF3 factor had the most important economic impact, the EnF1 and EnF4 factors had the most significant environmental impact, and the SF5 factor had the most significant social impact. Based on the poll findings, there is a significant relationship between violent extremism and sustainability. This connection can potentially add more excellent value to the project over its entire lifespan, which can meet the requirements set by the owner. In conclusion, the study suggests that violent extremism and sustainability are interrelated. However, it is essential to acknowledge the limitations inherent in survey methodologies, such as potential biases in participant responses and the reliance on self-reported data. As we move forward, future research endeavors should consider complementing survey data with in-depth qualitative analyses and on-the-ground assessments to ensure a more holistic understanding of the integrated factors affecting road maintenance projects. The amalgamation of stakeholder perspectives positions this study as a valuable contribution to the broader discourse on responsible infrastructure management, offering a roadmap for more resilient and sustainable road networks in the Egyptian context and beyond.

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