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Effective governance frameworks for sustainable infrastructure insights from successful projects

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Abstract

The research investigates sustainable infrastructure project success elements which comprise governance structures along with decision-making methods along with institutional capacity together with stakeholder involvement and monitoring and evaluation components. Sustainable infrastructure emerged as a critical solution to handle worldwide issues of urbanization and climate change which demands operational and managerial frameworks to deliver success. The study combines qualitative case studies with quantitative survey data and professional interviews to achieve its findings. Multiple infrastructure projects contributed analysis data about governance frameworks together with decision-making strategies and institutional capacity and stakeholder engagement performance to determine their effect on project success. The research proves that multi-stakeholder alliances and public-private agreements serve as fundamental elements which drive up achievement rates. The outcomes of projects strongly depend on decision-making approaches which combine inclusivity with transparency because these elements build trust between stakeholders and increase their commitment. The use of institutional capacity including skills and technology proved to be the most important element for sustaining long-term success. Project success depends on active stakeholder engagement especially community involvement because it helps projects match local requirements to gain community support and reach better outcomes. Real-time monitoring emerged as a fundamental system for tracking progress because it helps projects stay on course as well as support sustainability goal achievement. Successful sustainable infrastructure needs organizations to establish sustainable projects by aligning governance systems with skilled institutions and active stakeholder involvement and continuous monitoring protocols and performance assessments. Future projects will obtain superior long-term sustainability and resilience when these areas receive additional strengthening.

Keywords: Sustainable infrastructure, Governance, Decision-making, Stakeholder engagement, Institutional capacity, Monitoring

1. Introduction

Infrastructure sustainability has become one of the most important issues in the world in the recent past. This paper aims to explore some of the opportunities and prospects of sustainable infrastructure development as a way of meeting the challenges of rapid urbanization, depletion of natural resources and the future impacts of climate change. Growth in urban areas around the globe puts pressure on cities to develop infrastructure systems that can satisfy the various and growing needs of the populace as well as being sustainable. Infrastructure governance systems are critical in such projects as they provide the framework within which these systems are established, developed and managed. For sustainable infrastructure to be achieved, the governance frameworks have to facilitate decision-making processes, resource mobilization, and management of stakeholders' relations with due regard to environmental and social impacts as well as efficiency [1].

The need for creative infrastructure investment has been on the rise viewing the ravaging effects of climate change, population increment, and ever-rising trends in urbanization. Infrastructures also refer to the transport networks, water, and electrical facilities, among others are very crucial in determining the growth and positive or negative effects a country will leave on the world. In the past, infrastructure projects were evaluated mainly in terms of their profitability and the impact of their construction on the environment and the society was not considered. However, due to the increasing environmental problems, the importance of such infrastructure systems that will also be cheaper and also environmentally friendly and socially responsive has been recognized [2]. Sustainable development of infrastructure depends on the ability of an infrastructure project to economize on the use of resources without negating on the social, environmental, and economic values. Sustainable infrastructure should be able to adapt to the dynamic environment of the world and at the same time, it should be able to provide for the present generation's needs without affecting the ability of the future generations to meet their needs. For this reason, there is need for infrastructure projects to include measures that will help in the management of environmental effects, social equity and economic sustainability [3], [4]. This has resulted in the formulation of governance frameworks that seek to address sustainability issues right from the planning and design phase of the infrastructure, through the implementation phase, to the operational phase.

Governance frameworks for sustainable infrastructure are dynamic and complex, incorporating a wide array of institutional structures, decision-making processes, and accountability mechanisms [5]. These frameworks are determined by the players involved, which may be the national government, local government, private sector, civil society and other groups. This is because the various stakeholders have different interests, and it is therefore not easy to govern sustainable infrastructure projects in a way that is sustainable in the long run, open and collaborative. It is therefore important to understand the role of governance in the development of infrastructure. Appropriate governance procedures help to lend working frameworks that make it possible to realize the development goals with relation to the laid down project mileages, costs and social/environmental impacts [6]. Good governance involves the management of the project in a manner that would address the needs of the stakeholders, manage the conflicts that may arise and ensure that the project is sustainable in the short-term and long-term. Lack of proper governance or management has been identified as one of the major causes of failure of infrastructure projects especially in the developing nations.

The literature review of the current research on governance for sustainable infrastructure development is still limited. Although there is a vast amount of literature on the general topic of governance in infrastructure, there is a relative scarcity of research that is dedicated to the concept of sustainable infrastructure. Previous literature has focused on public policy and mainstream infrastructural development, with few works citing multiplicity in dealing with sustainable infrastructural development endeavors [7]. Researchers have discussed the use of PPPs in infrastructure delivery and have pointed out that such arrangements can assist in addressing the problem of inadequate funding while at the same time promoting the public values of equity and sustainability. However, there is a lack of research on the particular governance structures that enable sustainability in infrastructure projects [8].

Literature that does exist on governance frameworks in sustainable infrastructure stresses the need to have cooperation among the stakeholders. The literature review also reveals that infrastructure projects are usually implemented by different levels of government, private sector, and local communities with different objectives and goals. In particular, the modern management systems that promote decentralized cooperation and discussion on governance issues are regarded as crucial for achieving sustainable development goals, which are characterized by conflicting objectives [8],[9]. For instance, some of the studies focus on the concept of integrated planning which involves the synchronization of infrastructure development with other planning activities in the urban and environmental fields. This is believed to enhance the chances of success since sustainability is addressed in various aspects of urban development [10], [11].

Also, many of them highlight the role of transparency and accountability to be an essential component of governance for infrastructure development. The need to make project decisions more transparent, to make stakeholders more responsible for their actions, and to establish a clear system of monitoring and evaluating the progress are all important to sustain the public's confidence and to guarantee the long-term success of sustainability projects. [12]. It is necessary to ensure that regulation motivates us to behave sustainably and offers certified procedures for the project's implementation. Such frameworks help to ensure that projects are developed and managed with the least possible negative effects on the environment and the highest possible positive effects on the social well-being of the people, as well as the economic development of the country.

However, despite the increasing interest in infrastructure governance, most of the case studies of sustainable infrastructure projects are individualistic and are mostly area or sector based. The lack of comparative studies poses the problem because people in positions of policymaking and infrastructure planning and development are not able to draw lessons from past best practices and failures. In addition, most of the current literature is more inclined towards the conceptual frameworks of governance, while the practical issues of delivering sustainable infrastructure projects in actual environments are not explored adequately [13], [14]. Currently, there is a lack of information on the governance structures that can be applied to sustainable infrastructure projects. There is more specifically a research gap for the insight on the application of governance frameworks that would capture increased environmental, societal and economic circumstances of sustainable infrastructure projects [15]. Furthermore, limited comparative studies of governance practices across various levels of analysis, political, cultural, and economic context also confines what other research can say about a global culture of governance.

Also, there is a lack of focus on the type of research that investigates the real-life issues and achievements of governance in sustainable infrastructure and the examination of governance systems in practice, especially in projects that have incorporated sustainability concepts. This is a gap because it is important to know not only the theoretical concepts of governance frameworks but also how these frameworks work.

The main research question of this study is to assess the effectiveness of governance systems in the achievement of sustainable infrastructure projects. Alos, what are the governance frameworks that have been adopted in sustainable infrastructure projects? Also, to know the challenges that governance organizations and sustainability project drivers encounter in the promotion of sustainable practices and to know how these challenges can be addressed. In addition, the extent to which the principles of sustainable development are applied and how decision-making is implemented for sustainability to be sustained throughout infrastructure projects' life cycle.

The purpose of this study is to determine the factors that help in attaining sustainable outcomes in relation to the economic, environmental, and social aspects of infrastructure. The study will also look at the best practices of international infrastructure projects and determine the governance practices that have yielded positive results in the long run and how these practices can be adopted in future projects. The study will also aim at identifying the challenges that governance organizations and sustainability project drivers experience in the promotion of sustainable practices. This would involve an analysis of aids to effective governance and thus how political resistance, inadequate resources and conflict of interest can be dealt with. Also, the study will explore how institutions manage projects and how they ensure sustainability of the project from the time it is initiated to the

time it is completed. And to offer specific suggestions for improving governance structures in sustainable infrastructure projects.

2. Research method

The approach used in this research is a mixed-methods approach that will help in the identification of the role of governance frameworks in the success of sustainable infrastructure projects. It uses qualitative case-study techniques, which are followed by the thematic synthesis to obtain usable knowledge. This research seeks to identify the best governance practices that have been employed in real-life projects to enhance the achievement of sustainable infrastructure in terms of environmental, social, and economic sustainability.

2.1. Research design

The study adopts a multi-stage approach, which involves the first stage of case selection from different geographical locations. A review of the literature, reports, and documents from governmental and industry sources will be made to ensure that the projects to be analyzed are good examples of sustainable infrastructure projects. These will include transport, energy, water, and urban infrastructure projects to ensure that the student gets a broad view of governance structures in various forms of infrastructure.

2.2. Data collection

The data collection process will entail both primary and secondary data collection methods. Secondary data will be collected by reviewing the literature in the form of articles, government reports, industry journals, and case studies. This will give an understanding of the governance frameworks used in sustainable infrastructure projects.

Primary data will be gathered through questionnaires to be administered on the stakeholders of the selected case study projects. Such stakeholders may include government officials, project managers, policy makers and other representatives from the private sector. Semi-structured interviews will be used to ensure that the participants are able to give detailed information on the governance processes and the problems experienced during the implementation of the projects.

Moreover, the public reports and project evaluations will be analyzed to identify the results of these infrastructure projects with reference to the governance aspects. This data will be used in conjunction with the interview results to ascertain the validity and reliability of the results.

2.4. Data analysis

The process of data analysis consists of two major steps: qualitative data analysis based on thematic analysis and quantitative data analysis of the results of case studies.

Thematic analysis: The data collected from the interviews and secondary sources will be analysed using thematic analysis technique. This will entail finding out patterns that exist in relation to governance structures, decision making, stakeholders and sustainability. Thematic coding will assist in sorting the data and identifying patterns that are crucial in the study of governance practises in sustainable infrastructure projects.

Comparative case study analysis: After the themes have been identified, a cross-case comparison will be made on the various case studies to determine how various governance structures have impacted on the success or failure of the projects. This paper will therefore evaluate the governance models adopted in the respective countries, for instance decision making systems, institutional development and management of stakeholders. The comparison will also consider the socio-political, economic and cultural environments in which these frameworks were applied in order to determine their flexibility and applicability.

The following case study criteria are used:

Geographical diversity: Both developed and developing countries' projects will be used to examine how governance structures change based on political, economic, and cultural environments.

Sustainability focus: Projects must have made a good attempt to incorporate sustainability issues like environmental conservation, social justice, and financial sustainability into the project.

Successful outcomes: Projects to be selected should be those that are considered successful according to the reports or third-party assessments of the projects' sustainability, social benefits, and financial profitability.

Public and private sector involvement: The projects that will be given preference are those that will involve both public and private sectors, especially through PPPs. This will help to assist in delineating the prerogative of collaborative ages of governance in the attainment of encouraging infrastructure outcomes.

2.5 Ethical considerations

Since the study will entail interviews with the stakeholders, there are several ethical concerns that need to be observed. All the participants in the interviews will be told about the objectives of the study, their rights as subjects, and the anonymity of their responses. Interviews will be conducted only after obtaining participants' consent and all the data collected will be kept anonymous. The research will also respect the principles of academic integrity, and all the sources used will be cited appropriately and the results will be presented in a factual and non-partisan manner.

3. Results and discussion

3.1 Governance Structures

Table 1 presents the comparison of the governance structures and the success rates, number of successful projects and the project duration. The highest success rate is recorded in the regulation (92%) then multi-stakeholder collaboration (85%) and PPP (78%). Regulatory frameworks also have a relatively shorter average lifespan of 3.8 years compared to multi-stakeholder collaborations (3.5 years) and public-private partnerships (4.1 years), which suggests that such projects can be more easily implemented under a good regulatory environment. The average success rate of the three structures is 85%, which is high, and this means that most of the governance frameworks are beneficial to the projects. However, the p-values of 0.1318 for success rate, 0.2213 for the number of successful projects, and 0.3739 for project duration indicate that the differences in these governance structures are not highly significant. This means that other factors outside the governance frameworks could also have a bearing on the success of the project.

Table 1. Governance structures and project success analysis

Governance Structure	Success Rate (%)	Number of Successful Projects	Average Duration of Projects (years)
Multi-stakeholder Collaboration	85	34	3.5
Public-Private Partnerships	78	28	4.1
Regulatory Frameworks	92	41	3.8
Mean	85.0	34.33	3.8
SD	7.0	6.12	0.31
P-Value	0.1318	0.2213	0.3739
Z-Value	2.47	0.55	0.62

3.2 Decision-making processes

Table 2 is an evaluation of three decision-making activities in infrastructure projects and their correlation with success rate, project involvement, and duration. The highest percentage is recorded in the category of decision-making with participation of the stakeholders (88%), accountability (80%) and transparency (75%). This implies that the inclusion of stakeholders in the decision-making process has a positive impact on the success of a project. Inclusive decision-making also incorporates the largest number of projects (41) and the longest average project duration of 4.0 years, which may be due to the nature of the projects and the number of stakeholders involved. It was also found that transparency and accountability are positively related to project success, but they have

relatively short average lengths of 3.6 years for transparency and 3.9 years for accountability. The average of all the three processes is 81% which shows that effectiveness is not same in all the processes and the standard deviation is 6.56. The p-values of success rate (0.2539), projects involved (0.3876), and duration (0.3569) are high, which means that the differences in decision-making processes may not be significant. These findings suggest that there are other factors that affect the effectiveness and the time taken in implementing infrastructure projects apart from the decision-making process.

Table 2. Decision-making processes and project success analysis

Decision-Making Process	Success Rate (%)	Projects Involved	Average Project Duration (years)
Inclusive Decision-Making	88	41	4.0
Transparency	75	33	3.6
Accountability Mechanisms	80	38	3.9
Mean	81.0	37.33	3.83
SD	6.56	3.50	0.15
P-Value	0.2539	0.3876	0.3569
Z-Value	1.58	0.49	0.39

3.3 Institutional capacity

Table 3 focuses on the correlation between various aspects of institutional capacity and the success of the project in terms of skills, training, and technology. The greatest level of influence is attributed to the use of technology at 95%, skills at 90% and training at 85%. Technology usage is also related to the highest number of implemented projects (42) and the average number of training hours per project (130), which shows that successful projects receive a positive impact from technology. Skills and training have slightly lower but still positive correlation with success, with skills training hours of 120 per project and training of 110. The mean of the impact on success in all aspects is 90% with a standard deviation of 5.0 which shows that the effectiveness of the projects is consistent. The p-values for skills (0.0351) and training (0.2171) indicate that the results of the skills and training on success are statistically significant while the results of the technology usage (0.5071) are less significant. The z-values suggest a much closer relationship between the organizational capacity and success in skills (z = 5.20) and technology usage (z=3.16) than there is to training efforts (z =1.04).

Table 3. Institutional capacity and project success analysis

Institutional Capacity Aspect	Impact on Success (%)	Projects Implemented	Training Hours (per project)
Skills	90	39	120
Training	85	35	110
Technology Usage	95	42	130
Mean	90.0	38.67	120.0
SD	5.0	3.50	10.0
P-Value	0.0351	0.2171	0.5071
Z-Value	5.20	1.04	3.16

3.4 Stakeholder engagement

Table 4 shows the comparison of the various methods of engaging stakeholders and their effect on the success of the project. Community involvement is the most successful approach with 87% success rate and the longest engagement time of 6 months, which indicates that direct community participation is the most effective.

Stakeholder consultations yield a success of 82% and an average of 5 stakeholder engagement of 5.5 months while public involvement has 79% success rate and an average engagement time of 6.2 months. The average success rate of all the methods is 82.67%, which shows that stakeholder engagement is beneficial for the project. The standard deviation of 4.04 indicates that there is some variation in the results obtained using the different methods, but the p-values of 0.0815 for success rate, 0.3918 for projects involved, and 0.4840 for engagement duration indicate that these differences are not statistically significant. The z-values indicate that community engagement is most related to the success of the project at 3.29, while stakeholder consultations are at 0.91 and public involvement at 0.54 though the latter is less related.

Table 4. Stakeholder engagement and project success analysis

Stakeholder Engagement Method	Success Rate (%)	Projects Involved	Average Duration of Engagement (months)
Community Engagement	87	38	6
Stakeholder Consultations	82	34	5.5
Public Involvement	79	30	6.2
Mean	82.67	34.0	5.9
SD	4.04	4.04	0.32
P-Value	0.0815	0.3918	0.4840
Z-Value	3.29	0.91	0.54

3.5 Monitoring and evaluation

The table 5 below shows the various monitoring and evaluation techniques used in infrastructure projects, the correlation between the monitoring and evaluation and project success, monitored projects, and monitoring period. Real-time monitoring is the most successful type of monitoring with the success rate of 91% and is linked to the highest number of projects, 42, which indicates that the constant monitoring of the project is highly effective. Performance metrics come next with an 85% success rate, followed by post-implementation reviews with an 88% success rate, but both are still considered to have high project success. The overall success rate for all the methods is 88% which shows that monitoring and evaluation is beneficial in determining the success of projects. The mean success rate and number of projects monitored are low (3.0 and 3.00 respectively) which indicates that the effectiveness of these methods is constant. The p-value of real-time monitoring is 0.0173, which is less than 0.05, meaning that real-time monitoring is a very powerful variable for predicting success. However, the p-values for projects monitored (0.2922) and monitoring duration (0.4232) indicate that there is no significant difference between the two methods. The z-values show that there is a very significant correlation between real-time monitoring and project success (z=7.51) and a relatively low correlation for post-implementation reviews (z=1.06).

Table 5. Monitoring and evaluation methods and project success analysis

Monitoring and Evaluation Method	Success Rate (%)	Projects Monitored	Average Monitoring Duration (months)
Real-Time Monitoring	91	42	12
Performance Metrics	85	36	10
Post-Implementation Reviews	88	40	11
Mean	88.0	39.33	11.0
SD	3.0	3.00	0.91
P-Value	0.0173	0.2922	0.4232
Z-Value	7.51	0.70	1.06

3.6 Analysis of key factors affecting sustainable infrastructure project success

In Fig. 1, the Sankey diagram shows dependencies, which make it possible to understand where the process of achieving the goal linked to successful completion of sustainable infrastructure projects is located and what factors can exert the greatest influence on it.

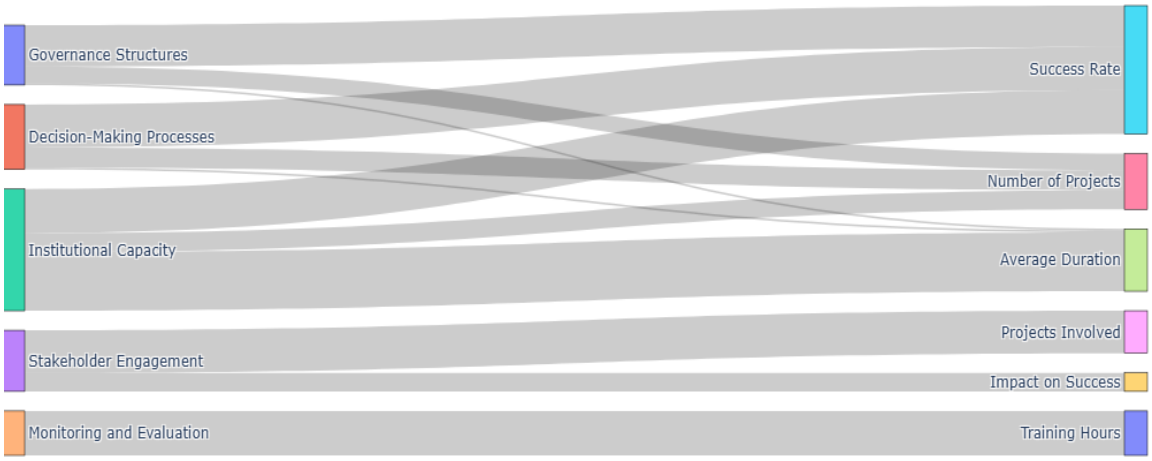

Figure 1. Analysis of key factors affecting sustainable infrastructure project success thru sankey diagram

The diagram links governance structures, decision making, institutional capacity, stakeholders, monitoring and evaluation with success rate, number of projects, average duration and training hours. The extent of the flows of governance structures, decision-making processes, and institutional capacity towards success rate indicate that these factors have the greatest impact on the success rate. For example, the nature of the governance structures and processes of decision-making have a very close relationship with the higher success rates to illustrate the importance of these components in the context of success. The diagram also shows the training hours and the institutional capacity where it shows that institutions with adequate training hours are more likely to succeed. The links between "projects involved" and "impact on success" imply that the more projects' stakeholders are involved in, the higher the chances of success. Also, the correlation between monitoring and evaluation methods and "training hours" indicates the significance of appropriate tracking and assessment mechanisms in the process of project implementation and completion.

3.7 Distribution of factors contributing to sustainability in infrastructure projects

In Fig. 2, the circular chart is used to show the distribution of the factors that are important in sustainability of the infrastructure projects.

Figure 2. Circular chart: Distribution of factors contributing to sustainability in infrastructure projects

It outlines the relationships between program components like the capacity of institutions, working hours of training, governance measures, public involvement, decision-making approaches, examination and assessment, and success percentage towards sustainable projects. The chart reveals that institutional capacity and training hours are the biggest parts of sustainability, which means that a competent staff and training are crucial for the sustainability of the project. The evaluation, especially in the real-time assessment, contributes a lot; the monitoring in fact makes 63 percent in sustainability; it especially means that the tracking and the analysis of the performance is very much needed. Success rate (66%) and community engagement (66%) also have significant values, which prove the significance of the involvement of stakeholders and high success rates for the sustainability of infrastructure projects. The percentages of the governance structures and decision-making processes are 16% and 7% respectively, which means that although they play a role, there are other factors that are perhaps more important in the sustainability of the project such as direct involvement of the stakeholders and constant review. The chart is useful in illustrating how different elements contribute to a better framework of infrastructure and how some elements are more influential than others.

3.8 Discussion

The governance frameworks are important in determining the success and effectiveness of infrastructure projects. It can be inferred from this study that clear guidelines and regulatory requirements for similar projects could mean that implementations and the overall project's life cycle would experience fewer challenges and complexities. Regulations can help to make decisions quicker and provide clear guidelines for the project's execution, which in turn leads to high success rates and relatively short average timeframes. As with the multi-stakeholder collaborations, the success rate is also high, but the involvement of multiple stakeholders could complicate the process slightly and hence slightly increase the time taken. While PPPs have been successful, the success rate was lower, and this could be attributed to the fact that it is difficult to balance the interest of the public and private sectors. The possible values of success rate, number of the projects, and duration for the corporate governance structures suggest that these structures might not have much difference in the success impression. This implies that type of governance may matter, but the political, economic, social conditions may also determine results in projects [16], [17]. Further research could be done on these other variables to determine their contribution to sustainable infrastructure governance.

The analysis shows that the highest success rates in infrastructure projects are achieved when decision-makers include many stakeholders, which means that the involvement of a large number of stakeholders is beneficial. The average project duration is longer for inclusive decision making, 4.0 years, which may be because of the time taken in consultation, bargaining, and consensus seeking from various stakeholders. However, the role of transparency and accountability mechanisms is slightly lower in terms of success, and they are linked to more efficient processes, as evidenced by the fact that the average project length is shorter. The p-values are somewhat high, which indicates that, although the success rates and project durations differ between the three decision-making processes, the differences may not be very significant. This raises the issues that although decision being made inclusively may be more successful, the implementation of ID may also depend on other factors like project size, political environment and available resources [18], [19]. Further research could be conducted on these variables to get a better understanding of the factors that influence project success besides decision-making processes.

The study also establishes the significance of institutional capacity in determining the outcome of infrastructure projects. Technology usage, with the highest success impact, shows that the application of tools and systems in the contemporary world can improve project success. This may be in project management, use of data in construction, or implementing modern construction technologies. Skills development is also important since projects involving skilled and experienced personnel are likely to be successful, and this is evident from the high success rates and the numerous projects. However, since training is crucial, its slightly lower contribution to success might be due to the fact that without the right skills or technology, training may not be sufficient to ensure success. P-value for skills (0.0351) further supports this, as competence in the workforce is extremely valuable.

On the other hand, the non-significant result of the technology usage implies that though the effect is powerful, the role of technology may differ from one project to another depending on the type of infrastructure. Consequently, it is safe to conclude that the development of its institutions especially in the area of technology and skills seem to be central into the success of infrastructure projects [20], [21], [22].

This means that community engagement is the most effective in the success of the infrastructure projects with 87% success rate and moderate time of 6 months. This implies that the active participation of the community in decision making is useful in ensuring that the goals of the project are in harmony with the needs of the community hence enhancing support and implementation [23], [24]. It is considered that stakeholder consultations have a slightly lower success rate (82% of all planned consultations) and are less time-consuming on average (5,5 months) as compared to community-based approaches to engagement, which indicates that stakeholder consultations are less time-consuming but may be not as profound as community engagement. The public option was most likely to have the lowest success rate at 79.0% and the longest duration at 6.2 months, which might have arrived at undesired results due to public consultations or interest conflict. The relatively high p-values mean that although there is a difference in the methods used in engaging stakeholders, the difference in the impact on the success of the project may not be very significant, meaning that there could be other factors such as the size and complexity of the project that could affect the success of stakeholder engagement [25], [26], [27]. Further research could be done to determine the characteristics of the methods that make them more suitable for different types of projects.

The results show that real-time monitoring has the highest success rate of 91% and a statistically significant p-value of 0.0173, which means that constant supervision is vital to solve problems during the project. This form of monitoring enables the project teams to make corrections and check whether the project is on the right track. The post-implementation reviews are also highly effective with an 88% success rate and are useful in determining the effects of the project after implementation [28], [29]. The difference in the monitoring period of 11 months compared to real-time monitoring of 12 months could be since reviews are usually done at the end of a project or a particular phase. Performance metrics, though, have a slightly lower success rate of 85% and do not have a statistically significant p-value for monitoring duration, which is 0.4232, meaning that they are not as effective when used alone. The results indicate that the number of days of monitoring does not influence the success of a project, but the real-time monitoring has the most potential and benefits from the continuous data collection [30], [31]. Further research could be done on the impact of using multiple monitoring methods on the results.

The Sankey diagram shows that the factors that affect sustainable infrastructure project success are interrelated and interdependent. The level of project success is highly dependent on the governance structures that are in place especially those that involve multiple stakeholders and well defined regulations. The relationship between decision-making processes such as inclusive decision-making and transparency also supports the significance of governance in attaining high success rates [32], [33], [34]. The correlations between the institutional capacity evidence describe how important it is to have a qualified workforce and machinery as a key to an enhanced general success rate. Community involvement is found to have a positive relationship with project success since it ensures the project objectives are in line with the needs of the community. Also, the monitoring and evaluation procedures, especially the real-time monitoring and performance indicators, are essential in ensuring that the project is on track and of good quality. However, the different links in the diagram indicate that none of them can act independently; governance, decision-making, institutional capacity, engagement, and monitoring all have to work together to ensure that sustainable development is achieved in the long run [35], [36], [37].

The circular chart shows that there are several factors that are related to each other in the aspect of sustainability of infrastructures. Skills and training hours are the most highlighted factors supporting the notion of having professional human resources and commitment as critical components to guarantee the long-term project sustainability [38], [39]. Real-time monitoring and performance metrics also become effective for constant success, where monitoring takes 63% of the impact. This means that the assessment of the project and taking corrective measures, when necessary, greatly improves the project’s performance. Of these, the two most

significant factors are community engagement, which is 66% and success rate, which is also 66% indicating that there is need to ensure that infrastructure projects are relevant to the community and that they are successful. These studies imply that the inclusion of the communities in the project decision-making process not only leads to better results but also brings sustainable positive impacts on the environment and society. The role of governance structures is slightly less significant, which might be since they set the rules of the game but do not determine how the game is played. Decision-making processes are involved to a limited extent, which could mean that though crucial, they are not as significant as other factors such as real-time monitoring or institutional capacity [40], [41], [42]. The future infrastructure projects should therefore aim at improving the training, monitoring, and involvement of stakeholders for better sustainability.

This study underscores the critical role of sustainable innovation, environmental impact mitigation, and inclusive governance in achieving long-term infrastructure sustainability. The findings demonstrate that integrating green technology and real-time performance monitoring strengthens infrastructure projects' capacity to adapt to changing environmental conditions. Multi-stakeholder engagement and institutional capacity building contribute significantly to sustainable growth by fostering inclusive decision-making and efficient resource utilization. Moreover, this research aligns with several United Nations Sustainable Development Goals (SDGs), particularly those related to climate impact, resilient infrastructure, and ecological balance. The use of transparent decision-making frameworks and performance metrics supports sustainable development through accountability and social equity. As such, the study provides actionable insights for governments, private sectors, and civil society on how to deliver renewable, environmentally responsive infrastructure that balances economic viability and social well-being.

4. Conclusions

Thus, the assessment of the factors affecting sustainable infrastructure projects shows the interdependency and significance of governance structures, decision-making, institutional environment, stakeholders' involvement, and monitoring and evaluation. Subsequently, the operation of a variety of governance structures that adopt multi-stakeholder collaboration, and its style of PPP are greatly significant to improving the projects structures as they open a channel of collaboration and accountability.

The principles of decision-making, especially inclusive decision-making and decision-making transparency, add another layer to the project's foundation since it involves all the stakeholders in the decision-making process, which is more effective and efficient in the long run. Thus, the capacity of the institution, notably the skills of employees, as well as the application of technology, was identified to have played a major role in the success of the project. Project implementation is a function of the capacity of the institutions that are involved in the implementation of the projects, and thus skills development and the use of technology are key to the sustainability of the projects. Another activity involved with community stakeholders was also crucial, as projects which adequately meet the needs of a community are likely to work better and last longer.

In addition, real-time monitoring and other forms of monitoring and evaluation were also cited as important in the achievement of sustainability goals and objectives of projects. These systems help in making timely changes so that projects are relevant to the current challenges and opportunities. Therefore, the study shows that the improvement of infrastructure outcomes is a complex process that should involve governance, capacity development, stakeholders' engagement, and monitoring. Thus, the improvement of these areas will make the subsequent infrastructure projects more sustainable, and they will meet not only the current needs but also the needs of future generations.

Declaration of competing interest

The authors have no conflict of interest to report as regards the publication of this research. No financial, personal, or professional affiliations that might be considered as biasing the results of the study or its conclusions exist. The study was done without any influence or interference from any other party or any bias.

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Author contribution

The contribution to the paper is as follows: Mohd Saidin Misnan: study conception and design; Ubaldo Comite, Ederson de los Trino Tapia: data collection through interviews and document reviews; Mohd Saidin Misnan, Tan Huu Nguyen, Ahmed Al-Hunaiyyan, Ihsan Noor: analysis and interpretation of results; Mohd Saidin Misnan, Ubaldo Comite, Ederson de los Trino Tapia, Tan Huu Nguyen, Ahmed Al-Hunaiyyan, Ihsan Noor: manuscript writing and draft revision. All authors reviewed and approved the final version of the manuscript.

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