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A Conceptual Framework for Sustainable Road Infrastructure Project Implementation in Developing Countries

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Abstract

Evidently, no generally accepted framework, concept and constructs currently exist although notably a lot of research has been made in the arena of Sustainable Road Infrastructure Project (SRIP) implementation. As a matter of fact, there are differing views by scholars regarding the SRIP implementation theory thereby making it a hazy and vague concept which is still a subject of debate. Till date, there has been a varied understanding of sustainability in terms of infrastructure development. This paper introduces a conceptual framework integrating the existing frameworks while considering the gaps in the literature and suggesting other criteria to succinctly help in addressing those gaps.

The methodological approach adopted for the study was a content analysis of published peer-reviewed journal articles discussing Sustainable Infrastructure Development. The conceptual framework herein introduced, defines the criteria and indicators to be considered in the implementation of SRIPs in developing countries. It subsequently shows the various constructs that influence successful implementation of SRIP in developing countries. The framework developed in this paper can be generally applied in the implementation of SRIPs in developing countries.

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1. Introduction

According to the World Bank [28], although developed nations comprise 17% of the entire world's populace, they are responsible for the release of 66% of the world's GHG (Green House Gas) pollutants into the atmosphere. However, it is developing nations that will be significantly affected by the consequent effects of extreme weather conditions. These signals question developing countries' obligation to Sustainable Development (SD). As a result, in questioning the readiness of the various industries, it has been established world-wide that, the transportation industry contributes to about 25% of CO₂ (Carbon dioxide) contaminants, while as a subset of this industry, road transport contributes 80% of such contaminants [29].

In light of the identified concerns and the new agenda for SD, the infrastructure development sector and every aspect of society has been burdened with a critical role to play to attain a sustainable society [14]. Thus, it becomes evident that, within the area of infrastructure development projects, irrespective of their size, design, build, operation,

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maintenance, and deconstruction, consideration would have to be given to sustainability throughout their entire life-cycles. It is expected that policies such as sustainable procurement, sustainable monitoring, and sustainability reporting using appropriate requirements, become gradually become pertinent specifications required by clients and key stakeholders for the specific sectors to win work or remain competitive [23]. Reliable and sound road transport system is the core of sustainable economic growth, which contributes to poverty alleviation, distributed prosperity and improved quality of life in developing nations [22]. A significant part of the Sustainable Development Goals (SDGs) focuses directly and indirectly on Sustainable Infrastructure Development (SID). One of the objectives of the SDGs is that, all nations should provide access to sound, affordable, accessible and sustainable transportation systems, such as infrastructure for all, enhancing road safety, particularly by expanding public transport, with special consideration to the needs of those in insecure situations such as women, children, individuals with disabilities and older people by the year 2030. Thus, the road infrastructure industry cannot be left out of the sustainability agenda since it forms a significant part of infrastructure development. Stakeholders in the road infrastructure sector are under immense pressure to look for economically feasible, socially viable and ecologically responsible project outcomes or procedures that will bring about Sustainable Road Infrastructure Development (SRID). This will demand not only the incorporation of sustainability guidelines throughout projects' life cycles, but also, the assessment of outcomes and the consideration of responsibility during project delivery. Even though in an ideal sense, the principles of sustainability should fuel road infrastructure development, many stakeholders are involved in the process and this seems to complicate the matter. With any given road infrastructure development project, stakeholders have their own concerns, main priorities, and interests, leading to differing targets in the project delivery. The professionals similarly face the challenge of accepting and deciphering strategic sustainability goals into real action at project-specific levels [26]. This is further hindered by the varied vested interests of project stakeholders and the multi-dimensional viewpoints of sustainability, coupled with the absence of a carefully planned decision-making method and compiling information at various categorized levels in road infrastructure project development.

Decision-making for SRID, therefore, requires the use of new techniques that are able to incorporate and synthesize all the perspectives and differing points of opinion, in an all-inclusive way [9, 19]. This procedure necessitates the application of a well-practicalized structure and an evaluation strategy, that is able to guide stakeholders through the decision-making methods for SRID. Regrettably, at this instance, such a structure for planning the information needed in decision-making is not yet available, or at least has not been decided upon by the different professions and areas of actions in the road infrastructure sector in developing countries. The lack of an agreed structure that will assist stakeholders to achieve greater sustainability in RID is a major concern [2].

Literature in the field indicates the existence of initiatives endeavoring to develop infrastructure sustainability assessment indicators and tools [5, 26, 27, 20, 8, 4, 12, 21], but they do not center on a specific type of infrastructure such as roads. Although there are existing Sustainable Roads Assessment Tools such as one developed by Australia's Victorian State Road Agency (VicRoads) in 2007, GREENROADS, Envision, among others, the adoption of these tools is rather limited and unclear.

Whilst focusing on assessing the end results, the assessment tools did not probe into identifying and addressing precise issues that influence the gap between sustainability efforts and their real deliverables during project delivery – which are the crux of every sustainability initiative. This is also coupled with the fact that these tools are many, with varied criteria and indicators.

2. Sustainable Road Infrastructure Development (SRID) Concept

Though studies have been undertaken in the discipline of SRID implementation, no generally accepted SRID concept and constructs currently exist. As a matter of fact, scholars have diverse thoughts about the SRID theory making the concept a continuing subject of debate as well as, still a hazy and ambiguous concept [3, 11]. So far, different persons have a diverse understanding of sustainability in terms of infrastructure development [3, 24].

Sustainable Infrastructure Development is also a cross-cutting matter and connotes diverse things to different individuals. The analysis of associated research shows several meanings are available [15, 30, 10, 17] and there is a

discrepancy with respect to scope and perspective. In simple terms though, Sustainable Infrastructure Development is best defined as the subdivision of sustainable development and its application to infrastructure development. According to CRISP [7], infrastructure development involves all planning, designing, developing, producing, modifying or maintaining of the built environment and comprises producers and dealers of materials, clienteles, contractors, consultants and users of the final product. Therefore, Sustainable Infrastructure Development can be defined as a subsection of sustainable development, which encompasses issues such as procurement, project planning and organization, material selection, reusing, and waste reduction.

In several literatures, a common description of Sustainable Infrastructure Development, is defining it as ‘the construction and responsible management of a healthy built environment grounded on judicious use of resources and environmental values [15] and a myriad of additional descriptions focused on the ecological part of sustainability. Ceres [6] defines Sustainable Infrastructure Development as the design, construction, and usage of the end product in a way that balances the social, economic and environmental practices needed to sustain human justice, diversity, and the functionality of natural systems. The American Society of Civil Engineers (ASCE) also describes Sustainable infrastructure as a structure that offers ecological, economic and social welfare, presently and for the future. According to the United States Environmental Protection Agency (USEPA), Sustainable Infrastructure consists of a collection of products, tools, and practices that use natural processes to improve general ecological quality and offer functional services. Sustainable infrastructure considers strategies, approaches, and investments that reliably offer active schemes over a long-term with sufficient usage, repairs and replacement (USEPA). A few of the current descriptions are all-inclusive and cover the entirety of the idea. Therefore, the SID concept covers a wider scope and considers different dimensions. In this study, Sustainable Road Infrastructure Development could, therefore, be defined as follows: Designing, building, operating, maintaining and deconstructing road infrastructure members in a way that balances the societal, economic and environmental concerns necessary to sustain human justice, diversity, and the functionality of natural environment.

Various authors have divergent views on the concept of SID and its basic elements or variables. Lim [18] agreed that although sustainability is applicable in the infrastructure sector, there is a lack of agreement on the implementation process and lack of understanding of the criteria and indicators as well. Conversely, it should be noted that a number of studies have been undertaken in the field of SID. The literature review conducted revealed that there has been extensive research [1, 22, 16, 18, 5, 26, 27, 8, 12] on sustainability features (constructs) which have been utilized to measure SID implementation. However, there appears to be disagreement among the various identified features by individual researchers and institutions.

3. Research Methodology

The research was conducted with reference to existing theoretical literature as well as published and unpublished literature, with a deep exploration of their context in order to meet the research objectives. The study is mainly a literature review and seeks to develop a conceptual framework for successful implementation of SRIP in developing countries. This is presented through the discussion of the concept of sustainable road infrastructure development.

4. Criteria and Indicators of Sustainable Road Infrastructure Project Implementation in Developing Countries

In a quest to determine the sustainability criteria and indicators for road infrastructure project implementation in developing countries, a review of existing sustainability rating tools and schemes that are applicable to infrastructure development was conducted. The literature review carried out did not seek to develop or argue the validity of specific sustainability criteria and indicators. Rather, it sought to identify and compile the relevant criteria and indicators in order to create a general list of infrastructure sustainability features for road infrastructure project implementation. The review focused on sustainability models, frameworks and guidelines for general infrastructure projects developed by individual researchers, institutions and professional bodies. The criteria and indicators for frameworks and models such as CEEQUAL, FIDIC’s Project Sustainability Management (PSM) Guidelines, BE ST-In-Highways,

EnvisionTM, Green Guide for Roads, GreenLITES, GreenPave, Greenroads, I – LAST, and INVEST were thoroughly reviewed. CEEQUAL was the most comprehensive framework which considered eleven (11) criteria namely, Project Management; Land Use; Landscape; Ecology & Biodiversity; The Historic Environment; Energy and Carbon; Material Use; Waste Management; Transport; Effects on Neighbours; Relations with the Local Community and other Stakeholders.

Besides the various sustainability models, frameworks and guidelines for infrastructure projects developed by institutions and professional bodies, there is a fair number of research works that attempted to develop sustainability frameworks and sustainable criteria and indicators for infrastructure projects. A comprehensive literature review was done on six main studies, as evidenced in Montgomery, Schirmer and Hirsch [22], Lim [18], Transport for New South Wales [25], Assah Amiril et al [1], Ugwu & Haupt [26], and Huang & Yeh [13]. Lim [18] and Ugwu & Haupt [26] are the most comprehensive studies which considered most of the criteria and indicators in the other studies and frameworks.

Lim [18] in his study identified twenty-three (23) critical sustainability factors specific for Australian road infrastructure projects. These are air quality, water quality, noise and vibration, erosion and sediment control, flora and fauna, environmental and social impact assessment, life cycle cost, project risk, cultural heritage, inter-modality of transport, functional performance of physical asset, community involvement and public governance, liaison with client, liaison and collaboration with internal stakeholders, type of contract and project governance, compliance with contract and project specifications, hazardous goods, road user safety, road worker safety, quality control, supply chain management, waste management and recycling. These 23 critical sustainability factors are clustered into ten (10) categories; environmental, economic, social, engineering, community engagement, relationship management, project management, institutional sustainability, health and safety, resource utilization and management.

A study by Montgomery et al. [22] in their research sought to develop a sustainability rating system for road infrastructure in developing nations. The study provided a broad set of environmentally sustainable road features. The authors grouped the sustainability features into 5 groupings; quality of life, Project leadership, Natural world, Natural resource management and resilience, and greenhouse gas emissions. Existing literature also reveals that different frameworks have adopted similar criteria for sustainability under different titles. Hence, for a successful implementation of SRIP, it is imperative that stakeholders integrate and build consensus on the appropriate features and understand its implementation.

In a research that identified Key Performance Indicators (KPI) for infrastructure in the South African construction industry, Ugwu and Haupt [26] developed a comprehensive list of key sustainability items and their indicators. These constructs incorporate internationally accepted sustainability metrics such as the economy, environment, and society. Furthermore, as suggested by the industry, they incorporated other performance-based indicators such as health and safety, resource utilization and aspects related to project management.

From the conceptualized sustainability models and frameworks discussed above, CEEQUAL as well as a matrix of criteria and indicators established by Ugwu & Haupt [26], and Lim [18] are the most comprehensive conceptual frameworks of sustainability criteria for infrastructure development. The selection of the variables for this study is anchored around these three (3) frameworks. Almost all the frameworks and models studied have some common constructs conceptualized on a frequent basis. Using the reviewed conceptual frameworks as examples, it became clear that the cost of the models were based on the three dimensions of sustainable development (Economy, Society, and Environment). The various sustainability criteria and indicators (constructs) are contained within the following main domains: Social and Cultural Sustainability; Economic Sustainability; Environmental Sustainability; Institutional Sustainability; Health & Safety; Project Management; Resource Utilization and Management; and Engineering Performance. However, the current study brings into focus public participation; climate change response; and stakeholder management. These three additional constructs were not found in the identified models and frameworks. The gaps identified in the literature review were these three additions and were found to be peculiar to developing countries. Thus, the SRIP implementation conceptual framework in this study consists of eleven (11) features.

Table 1: Sustainable Infrastructure Development framework comparison

No.	Framework	Features
1.	Proposed Framework for this study	Social and Cultural Sustainability; Economic Sustainability; Environmental Sustainability; Institutional Sustainability; Health & Safety; Project Management; Resource utilization and Management; Engineering Performance; Climate Change Response; Public participation; and Stakeholder management.
2.	CEEQUAL – Civil Engineering and Environmental Quality Assessment and Award Scheme	Project Management; Land Use; Landscape; Ecology & Biodiversity; The Historic Environment; Energy and Carbon; Material Use; Waste Management; Transport; Effects on Neighbours; Relations with the Local Community and other Stakeholders.
3.	FIDIC's Project Sustainability Management (PSM) Guidelines	Equity; Health; Human rights; Education; Housing; Security; Population; Culture; Integrity; Atmosphere; Land; Oceans, Seas & Coast; Fresh Water; Biodiversity; Economic Structure; Consumption & Product Patterns; Institutional Framework.
4.	BE ² ST-In-Highways	Social Carbon saving; Life Cycle Cost; Traffic Noise; Hazardous waste; Water Consumption; waste reduction (including in-situ materials); waste reduction (including ex-situ materials); Energy Use; Greenhouse gas emissions.
5.	Envision TM	Climate; Natural World; Resource Allocation; Leadership; Quality of Life.
6.	Green Guide for Roads	Mobility for All; Transportation Planning; Environmental Impact; Energy and Atmosphere; Materials and Resources; Community Impact; Innovation and Design.
7.	GreenLITES	Innovation/Unlisted; Materials and Resources; Energy and Atmosphere; Water Quality; Sustainable Sites.
8.	GreenPave	Pavement Technologies; Energy and Atmosphere; Materials and Resources; Innovation and Design.
9.	Greenroads	Pavement Technologies; Materials and Resources; Energy and Atmosphere; Construction Activities; Access and Equity; Environment and Water,
10.	I – LAST	Materials; Lighting; Transportation; Water Quality; Environmental; Design; Planning.
11.	INVEST	Operations and Maintenance; Project Development; Systems Planning.
12.	Montgomery, Schirmer and Hirsch (2014)	Quality of life category; Project leadership; Natural world; Natural resource management; Resilience and greenhouse gas emissions.
13.	Lim (2009)	Environmental; Economic; Social, Engineering; Community engagement; Relationship management; Project management; Institutional sustainability; Health and safety; Resource utilization and management.
14.	Transport for New South Wales (2012)	Environmental category (GHG emissions, water, pollution control, noise management, resource management, waste management, material consumption and biodiversity); Social category; (stakeholders' relationship, communities/public acceptance and heritage conservation); Economic category (corporate sustainability).
15.	Assah Amiril et al (2014)	Environment; Economic; Social; Engineering/resource utilization; Project administration.
16.	Ugwu & Haupt (2007)	Economy; Environment; Society; Resource Utilization; Health and Safety; Project Management/Administration.
17.	Huang & Yeh (2008)	Ecology; Landscaping; Material; Waste Reduction; Water Conservation; Energy Conservation.

Table 2: Conceptual Framework Features

No.	Features (Criteria)
1.	Socio-cultural sustainability (SCS)
2.	Economic Sustainability (ES)
3.	Environmental Sustainability (EnS)
4.	Institutional Sustainability (IS)
5.	Health and Safety HS)
6.	Project Management (PM)
7.	Resource Utilization and management (RUM)
8.	Engineering Performance (EP)
9.	Climate Change Response (CCR)
10.	Public Participation (PP)
11.	Stakeholder Management (SM)

3.1. Structural Component of the Framework

The integrated SRIP implementation conceptual framework for developing countries, is derived from Social & Cultural Sustainability (SCS); Environmental Sustainability (EnS); Economic Sustainability (ES); Institutional Sustainability (IS); Health and Safety (HS); Project Management (PM); Resource Utilisation and Management (RUM); Engineering Performance (EP); Climate Change Response (CCR); Public Participation (PP); and Stakeholder Management (SM). The SRIP implementation conceptual framework is not based on prior study or examination and is composed of SCS, EnS, ES, IS, HS, PM, RUM, EP, CCR, PP, and SM. It is a multi-dimensional structure.

The theoretical underpinning relating to this is derived from the works of Lim, [18]; CEEQUAL, [5]; and Ugwu and Haupt [26] as discussed earlier on. The conceptualized framework is the notion that implementation of SRIPs is related to the evaluation of a number of variables, such as SCS, EnS, ES, IS, HS, PM, RUM, EP, CCR, PP, and SM. It is untenable to discuss the principal variables without reference to variables of climate change response, public participation and stakeholder management and the inclusion of the other variables. The evaluation will depend on the implementation and assessment of several indicator variables under each of the variables.

Fig. 1: Integrated SRIP Implementation Conceptualized Framework

5. Conclusion

This paper proposes a conceptual framework for the implementation of sustainable road infrastructure projects in developing countries. After a thorough analysis of earlier studies, it has been established that various sustainability pundits in the infrastructure sector have differing interpretations of SRID, though some similarities can be established. It was also discovered in the literature that there are frameworks and models for assessing and rating sustainability of infrastructure projects. These frameworks and models provide insights into the application of sustainability to infrastructure projects and improve the researchers' understanding of SRID and its constructs. Nonetheless, it was obvious that there are disparities in the various sustainability frameworks and models. Moreover, the frameworks also failed to capture a number of factors affecting their implementation in developing countries.

In search of the sustainability criteria and indicators for road infrastructure project implementation in developing countries, there was the need to conduct a review of existing sustainability rating tools and schemes that are applicable to infrastructure development. The study established eight (8) sustainability criteria and indicators (constructs) from literature namely: Social and Cultural Sustainability; Economic Sustainability; Environmental Sustainability; Institutional Sustainability; Health & Safety; Project Management; Resource Utilization and Management; and Engineering Performance. However, the current study brings into focus Public Participation; Climate Change Response; and Stakeholder Management as gaps identified from the literature. These three additional constructs were not found in the identified models and frameworks. The gaps identified were found to be peculiar to developing countries. Thus, the SRIP implementation conceptual framework in this study consists of eleven (11) features.

In conclusion, the approach to sustainable road infrastructure project implementation in developing countries is still in its early stage and not fully understood in a consistent way. The findings of this study suggest that practitioners, government agencies, and academic researchers have made efforts to develop some frameworks. The proposed conceptual framework developed in this study is much more comprehensive, robust and holistically integrated for the implementation of SRIP. However, there is a need for further study to validate the developed framework.

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