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Project Definition Rating Index (PDRI) Analysis of Road Infrastructure in India

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Abstract

India has set a path towards colossal infrastructure development in recent years which increases the functionality of the country. Though there are many challenges on this path, infrastructure projects are affected by cost and time overruns. This situation arises due to a lack of funding and poor project management. Project Definition Rating Index (PDRI) of infrastructure is used in preplanning of road project points out areas of development in a structured process. PDRI along with Sustainable Development Goals (SDGs) helps to identify & mitigate the issues simultaneously. Present study aims to develop stimulating the growth of road projects by using Sustainable Development Goals and finding alternative materials to reduce CO2 emissions. Total 9 projects were analyzed considering all categories of roads in the Indian context is done and sustainable goals are incorporated to mitigate risk. Embodied Energy of materials is considered to select sustainable material. Thus, it can be concluded that PDRI and SDGs can work simultaneously to achieve better pre-planning and sustainability.

Keywords: Project Definition Rating Index (PDRI), Sustainable Development Goals (SDGs), Road Infrastructure, Embodied Energy, Global Warming Potential.

Introduction

India has about 6.2 million km of road network, which is the second-largest in the world. This comprises Expressways, National Highways, and State Highways. Significant efforts have been underway since the 1990s to modernize the country's road infrastructure. According to the Ministry of Road Transport and Highways, as of March 2020, India had 138,531 kilometres of national highways and expressways and 176,818 kilometres of state highways. Under the government initiative, Bharatmala's major projects are being implemented.

Indian Infrastructure is rapidly growing in the past two decades. The total length has increasedfrom 3.99 lakh km in 1951 to 62.16 lakh km in 2018. Despite the rapid expansion of the road network, the total length of roads is only 62.5% which is much lower than that of the UK and France which are at 100 [3]. Apart from this, the national highway network constitutes only 2% of the total length of the road network but it carries 40% of traffic creating congestion and delays [6]. In the commissioned 15 years of achieving the Sustainable

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Development Goals, the very first tier of the SDG financial estimate of India shows a shortfall of INR 533 lakh crore (USD 8.5 trillion) [1]. As stated by the Ministry of Urban Development, there are three factors impacting revenue negatively – inadequacy in project completion as per schedule, lack of finance, and incompetent project execution. Poor scope definition is a major cause of the failure of projects. Effective early planning improves project performance, both in terms of schedule and cost [11].

The Project Definition Rating Index (PDRI) for infrastructure projects is a powerful easy-to- use tool that provides a method to measure the completeness of project scope definition. The PDRI allows to quantify, rate, and assess the level of scope development on projects before detailed design and construction. It identifies and precisely describes each critical element in a scope definition package. It also enables the project team to quickly identify project risk factors related to desired outcomes in terms of cost, schedule, and operational performance [7]. Using the PDRI method, project teams can also capture mitigation actions. It is designed to evaluate the completeness of scope definition at any point before detailed design and construction [4, 10].

Although investment in infrastructure is done to increase employment and economic productivity, it directly or indirectly influences the attainment of Sustainable Development Goals (SDGs), including 72% of targets. Therefore, it is essential to meet a balance between growth and nature and to face the challenge of sustainability which integrates the economic, societal, and environmental aspects. It is crucial for achieving the 2030 Agenda of sustainable development and the Paris Climate Change agreement [13]. In a 2016 report, the Secretary- General's High-level Advisory Group defined sustainable transport as “the provision of services and infrastructure for the mobility of people and goods that promotes economic and social development for the benefit of current and future generations- in a manner that is safe, affordable, accessible, efficient, and resilient while minimizing carbon and other emission and environment impacts” [14]. Wen-Mei Fei, et.al, [7] concluded that construction industries are significant in achieving all 17 SDGs but prevalent in achieving 10 Goals – 3(Good Health and Well-Being), 5(Gender Equality), 6(Clean Water and Sanitation), 7(Affordable and Clean Energy), 8(Decent Work and Economic Growth), 9(Industry, Innovation, and Infrastructure), 11(Sustainable Cities and Communities), 12(Responsible Consumption and Production),

13(Climate Change), 15(Life on land). The Technical Working Group on Transport (TWG) presented a paper to analyze the relevance to transport of each 17 proposed SDGs. They concluded that eight of the seventeen goals illustrated have the cross-cutting role of transport in sustainable development. The Goals which were included are Goal 2 (Zero Hunger), 3 (Good Health and Well-Being), 6(Clean Water and Sanitation), 7(Affordable and Clean Energy), 9(Industry, Innovation, and Infrastructure), 11(Sustainable Cities and Communities), 12(Responsible Consumption and Production), 13(Climate Change) Climate Action (Goal 13)is the most prominent facet to slow down climate change [2]. From this, the mapping matrix is developed between 13 PDRI categories used for road infrastructure and SDGs identified as applicable for road sector in any country [8].

Rendering to Asian Development Bank (ADB), transportation is the fastest-growing major contributor to global climate change, which contributes about 23% of energy-related carbon dioxide (CO_2) emissions.

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Many experts predict a rapid increase in CO_2 emissions from transportation in Asian countries by 2030 if changes are not made to investment strategies and policies [12]. Greenhouse Gases (GHG) emitted from the material of roads contribute majorly to global warming and climate change. To reduce the effects caused due to materials carbon foot printing is necessary. Studies suggest that embodied energy of building material consumes a greater proportion of energy compared to the energy consumed during its life [4]. Replacing the high embodied energy material with a low embodied energy alternative is a simple way of reducing the effects. International Finance Corporation has developed a database of embodied energy and global warming potential in the Indian context [5].

Objectives of the study:

1. Determine the PDRI score of nine ongoing road projects of Indian Infrastructure and forecast aboutthe success possibility of each.

2. Recommend measures enabling the achievement of targeted SDG's; vis-à-vis improve upon PDRI score; facilitating project successes further.

3. Compare embodied energies of conventionally used road materials such as asphalt mortar, cementwith lime mortar, fly ash.

Research Methodology and Sample Calculations

Nine road projects are considered in this research representing each of the road categories- National Highway, State Highway, District Roads, Rural Roads, and Urban Roads. Data/information is inferred from Detailed Project Report (DPR), Feasibility Report (FR), Inception Report (IR) as well as from discussion with client and consultancy firms. Based on this, the research methodology is developed.

Common SDGs that were correlating to PDRI categories of the Goal 3 (Good Health and Well Being), 7 (Affordable and Clean Energy), 8 (Decent Work & Economic Growth), 9 (Industry, Innovation and Infrastructure), 11 (Sustainable Cities and Communities), 12 (Responsible Consumption and Production), 13 (Climate Action), 15 (Life on Land) and 17 (Partnershipfor Goals) [8].

PDRI analysis from the road project reports has been done by rearranging contents from the project documents according to need of the PDRI elements and from this, PDRI score is calculated by considering the parameters which impact the PDRI [4]. The elements which have high score then segregated. By recommending measures with reference to the subgoals of targeted SDGs, score curtailment is done, since lesser the PDRI score better is the project. Sample calculations based on this methodology is illustrated in table no. I. Further, for the SDG goal no. 12 i.e., responsible consumption and use, the embodied energy of conventional road materials along with alternative materials is calculated, on the basis of which further recommendations are suggested.

Sample Road Project-1: Proposed Improvement & Maintenance of Road from MDR-13 Nirgudsar to Cholichamala Road CH Km 0/000 to CH Km 2/640 in Taluka: Ambegaon, District: Pune.

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Table I: PDRI scores before and after applying SDG's for Road Project-1

Section	Section-I: PDRI score on the basis ofproject decision					Section-II: PDRI score on the basis of design				Section-III: PDRI score on the basis of execution approach				Total PDRI Score	Remark
Categories	A	B	C	D	E	F	G	H	I	J	L	L	M		
Score before applying SDG's	40	33	42	47	23	53	25	30	36	0	30	40	39	438	Since, PDRI score is very high, very less possibility for project to be successful
	Total PDRI score for section-I= 185					Total PDRI score for section-II =144				Total PDRI score for section-III =109					
Score after implementation of SDG's	10	12	16	47	12	20	11	16	13	0	8	10	21	196	Acceptable PDRI score for project success.
	Total PDRI score for section-I= 97					Total PDRI score for section-II = 60				Total PDRI score for section-III= 39					

Total PDRI Score before applying SDG's is 438 which is more than cut-off 200 which makes it likely to be failed project. The section 1, Basis of Project Decision has the highest score which is 185.

From section-I, if we consider Category B (Owners/ Operators Philosophies) has a total score of 33(outof 67).

If Sustainability Development Goal (SDG- 3,7, 8, 9, 11, 12, 13, 15, 17) are incorporated with Category B; it proposes to, Promote a good work–life balance through job shares and flexible working arrangements contributing to good health and well-being. Support economic development and human well-being by developing quality, reliable,sustainable and resilient infrastructure.Fulfill functional requirements of the road project.

Develop strategic operation plans to prevent capacity related problem. Evaluate consideration of potential expansion and use.

In category B, following elements are considered for calculating the score.B1. Design philosophy

B2. Operating philosophy B3. Maintenance philosophy

B4. Future expansion and alteration consideration

For project 1, PDRI definition level before SDGs for element B1, B2, B3 & B4 is 2, 3, 2 & 4. And, their respective PDRI scores are 7, 9, 4 & 13 (total 33). By implementing SDG goal no. 3 (ensure healthy livesand promote well-being for all at all ages) which is applicable for B2 and B4. Following points can be considered

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for improving definition level of B2 and B4.

SDG goal no. 3, has following subgoals:

1. Injuries and deaths due to traffic accidents can be reduced.

2. Accesses to maximum pollution can be provided so as to easily avail medical facilities in thezones connected to roads.

3. Measures for reducing air pollution on the roads.

4. Providing free public service to rural roads.

5. Measures for reducing noise pollution on rural roads.

If above subgoals are incorporated on element B2 and B4, definition level can be improved from 3,

4 to 2, 2. And their respective score will become 5, 5.

Similarly, by incorporating other SDG goals which are applicable for category B, PDRI score canbe reduced to 12(out of 67).

Similarly, PDRI score for remaining categories is improved by applying SDG's which are directly and indirectly related to road infrastructure.

In similar manner the PDRI score for the other 8 road projects are calculated (refer table no. II & III).

Table II. PDRI Section and total score of 9 road projects before application of SDG's.

Road number	1	2	3	4	5	6	7	8	9
Section	PDRI Score								
Section-I: Basis of Project Decision	185	50	74	144	169	80	80	164	133
Section-II: Basis of Design	144	88	82	101	142	90	96	142	126
Section-III: Execution Approach	109	66	72	77	95	55	52	95	142
Total Score	438	204	228	322	406	225	228	401	401

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Table III. PDRI Section and total score of 9 road projects after application of SDG's.

Road Number	1	2	3	4	5	6	7	8	9
Section	PDRI Score								
Section-I: Basis of Project Decision	97	39	66	93	42	80	80	42	87
Section-II: Basis of Design	60	88	57	68	69	55	61	69	43
Section-III: Execution Approach	39	66	72	21	71	55	52	71	67
Total Score	196	193	195	182	182	190	193	182	197

Out of nine projects considered in this research paper, five projects scored higher than the cut-off 200 illustrating costs, schedule and budget overruns & four projects have scored near to the cut-off which demonstrates an increased success rate on the project.

Sample calculations of embodied energy of conventional road materials along with alternative materials for road project-1:

a) Asphalt Mortar:

Dimensions of road= 2640m X 3m X 0.15mVolume of Asphalt layer= 1188 m3
Density = Mass/Volume

Density of Asphalt mix= 2300 kg/m32300= Mass/1188
Mass= 2300 X 1188

Mass= 2732400 Kg Asphalt required for your volume

Note: As per MORTH specifications BC-II Mix need 5% (60g) of Asphalt (VG-30) for Marshallspecimen of 1200g
1200g mix need 60g Asphalt

So, 2732400X1000 g need how much Asphalt? Asphalt mass= (2732400X1000X60)/1200 Asphalt Mass= 136620Kg
Embodied Energy per kg of Asphalt= 11 MJGWP (kg CO2 eq.) = 0.24
Embodied Energy for required mass= 136620 X 11= 1502820 MJ

GWP (kg CO2 eq.) for required mass= 136620 X 0.24= 32788.8 kg CO2 eq.

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b) Lime mortar:

If Asphalt mortar is replaced by the lime mortar for the same project. Embodied energy calculations will be as follows

Dimensions of road= 2640m X 3m X 0.15mVolume of lime mortar layer= 1188 m3

= 1188000 kg

Embodied Energy per kg of Lime mortar= 1.6 MJGWP (kg CO2 eq.) = 0.43

Embodied Energy for required mass= 1188000 X 1.6 = 1900800 MJ

GWP (kg CO2 eq.) for required mass= 1188000 X 0.43= 510840 kg CO2 eq.

= 510.84 tons of CO2

= 510.840 equivalent Carbon Creditsearned by replacing asphalt mortar is replaced by the lime mortar.

Similarly, embodied energy along with GWP for various conventional road materials along with alternative their alternative materials is calculated for nine road projects and shown in figure no. I

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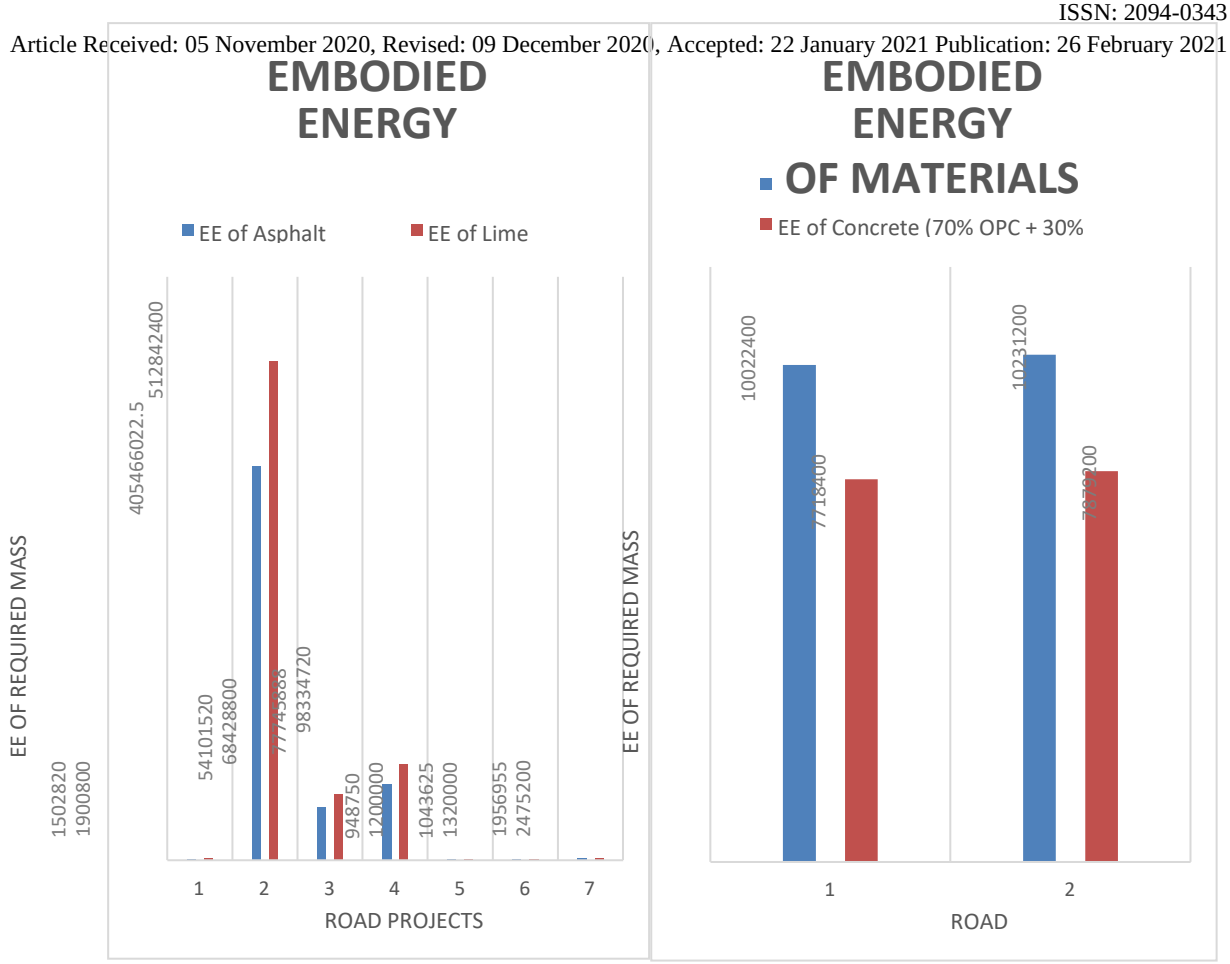

Figure I: Embodied energies for conventional materials and sustainable materials for 9 road projects.

Result and Discussions:

- From the results obtained, it is inferred here that out of the 9 ongoing road infrastructure projects in India; 4 projects have a good possibility of success; since their PDRI values are 204, 225, 228 for further 2 projects, respectively.
- After the successful incorporation of SDGs (SDG- 3,7, 8, 9, 11, 12, 13, 15, 17) in PDRI of Road Infrastructure it was observed that the scores decreased significantly. This indicates that the effectiveness of the projects is increased due to incorporation of the SDG's.
- Bitumen and concrete roads have high embodied energy and global warming potential than lime and concrete with fly ash (30% pozzolana) respectively. Thus, these materials can replace with the original materials making construction work moresustainable, thus the embodied energy calculations enable decision making to select materials for pavements, which emit low carbon dioxide or its equivalent, CHGemission's.

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Conclusion:

- The PDRI tool can improve the predictability of project success by providing a detailed process based on approach which is used for the evaluation of the project scope.

- If PDRI is further used in conjunction with the incorporation of the relevant sustainable development goals, it may enhance the performance of project execution, contribute towards sustainability and reduce carbon emissions.

- An innovative holistic method so as to potentially improve sustainability on existing road projects for decision-makers; as suggested in this research, is a proactive step towards sustainable road infrastructure development projects in India.

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