Sustainable Road Construction: A Review of Community-Driven Approaches and their Environmental Impact

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Abstract

Sustainable road construction plays an indispensable role in mitigating environmental degradation that could be generated due to infrastructure projects nonetheless a thorough evaluation of these eulogized practices' effectiveness is non-negotiable. This study investigates the environmental impacts of sustainable road construction practices, with a focus on community-driven approaches in Nepal that involve participatory planning and local stakeholder engagements. The research has systematically reviewed peer-reviewed literature accessible in databases such as Science Direct, Scopus, and Google Scholar, focusing on studies that address the environmental effects and community involvement in sustainable road construction. The findings reveal that community-driven approaches, if duly adopted, significantly reduce environmental impacts, particularly through the incorporation of recycled materials with participatory decision-making processes. Adoption of PRISMA study methodology regarding incorporation of recycled materials into operations and including them in decision-making process values much in this course. Factors such as stakeholder engagement, local regulations, and sustainability principles are detected to have strongly influenced expected outcomes. This paper, hence, emphasizes the possibility for alleviating/limiting the environmental damage due to road construction through enhanced community engagements. As the effectiveness of these approaches varies depending on location and socio-economic contexts, the follow-up of this research needs a focus on gaining a deeper understanding of these approaches and comparing their effectiveness across different geographic and socioeconomic settings.

Keywords: Sustainable Road Construction, Environmental Impact, Community Engagement, Participatory Planning & Eco-friendly Practices

Introduction

The global demand for sustainable infrastructure is primarily driven by the urgent need for a balance between development and environmental conservation. Conventional road construction has shed serious environmental consequences, including habitat loss and alarmingly accruing pollution and carbon emissions. Sustained road construction directly impacts ecosystems, drainage patterns, and soil stability, with erosion and sedimentation having a direct impact on waterways and wildlife (Marzouk et al., 2071; Teo et al., 2019). Sustainable road construction, however, is impelled by another urgent necessity: a locally relevant roadway infrastructure is fundamental to any prospect of economic development. Roads are vital for propelling the efficiency of transport, which is the lifeblood of overall economic growth.

The review has consolidated the results of 22 articles in order to impart an understanding regarding community engagement's influences on the sustainable and ecologically sound outcomes in roads projects. This article has five purposes; the first is to identify common elements in the community engagement approaches used in successful roads-to-friendliness transformations. Second is to assess how well participatory methods work to reduce negative environmental effects such pollution, habitat damage, and carbon emissions. Third, to analyze how community-driven methods might help road infrastructure projects foster long-term sustainability and environmental care. The fourth objective is to examine the impediments and enablers to community participation in road construction, including technological integration, legal frameworks, and socioeconomic variables. The final, to pass on valid recommendations for upcoming road construction projects with an emphasis on increasing community involvement, reducing harm to the environment, and guaranteeing the use of sustainable materials and methods.

Construction operations are frequently identified as one of the main contributors to environmental degradation. BRI's environmental implications necessitate a multi-scale strategy that examines how sociopolitical, economic, and environmental factors interplay while addressing the cumulative environmental repercussions both regionally and globally (Teo et al., 2019). Despite the effects on the environment, it might not take into consideration all ecological factors or local environmental expertise. Despite these concerns, the construction of roads is believed to contribute in improving transportation efficiency, enhancing economic growth, increasing access to education and healthcare, reducing poverty, and fostering environmental and social sustainability in various regions.

In the search for eco-friendly construction materials, road strength, durability, water resistance, and environmental sustainability are all greatly increased when 15% recycled polymers and 75% recycled coarse aggregates are used in the creation of eco-friendly asphalt (Al-Hasan et al., 2020). The results might not be widely applicable because they are specific to certain contexts. A particular area of environmental impact that several studies identified as heavily affected by road development is GHGs. The major finding of the studies among literature reviewed for the purpose of this study is that road construction has a hugely harmful effect on every impact category evaluated. The studies reviewed here feature the use of BIM as a way of help to mitigate those impacts.

Road construction projects, whether present or future, must increasingly shift their concentration to the reduction of greenhouse gas emissions. Achieving this goal will require using sustainable materials; making good, practical use of life cycle assessment tools; and attending to three essential aspects of road construction projects: collaboration among stakeholders, adherence to rules and regulations, and a sufficient investment of resources. The last aspect, particularly, connects strongly to an almost holy grail of road construction: innovation. Innovations in planning, design, and construction can drastically change a road's

impact on a community, not just during the construction phase but for the entire life of the road. In the Gemidiriya community-driven development project in Sri Lanka, three critical success factors (CSFs) have been identified.

The construction of roads in developing nations requires something more than and different from the standard project management typically applied to such infrastructure work. A recent study defined four "highly relevant" project characteristics that appear to influence the outcomes of sustainable road infrastructure projects (SRIPI) in a number of developing countries: effective resource usage and management, outreach, project management, and stakeholder management (Ametepey et al., 2022). Sustainability can be enhanced in job sites like road construction in order to improve workers' well-being. Among the many aspects of well-being, health seems paramount (Riley-Powell et al., 2018). The push for "green" road construction is closely tied to this, as the overall aim of such an initiative tends to be not just reducing direct road-building impacts (like those on local flora and fauna).

Moreover, ethical problems are very important. Research as per Moore et al. (2021) identifies five key ethical challenges: (1) adopting a comprehensive eco-centric approach that avoids limiting objectives and the misuse of mitigation measures; (2) balancing ecological effects with socioeconomic values; (3) defining what constitutes tolerable negative impacts; (4) avoiding value-laden language that might lead to "road ecology" becoming a "road to nowhere"; and (5) ensuring that "road ecology" serves as a guide to sound ethical practice. such issues are prone to make prospective road construction an almost insurmountable problem for the road ecologist.

Ecosystems are seriously jeopardized by rampant road constructions. The construction industry, for its part, makes a substantial amounting to the problem. Life-cycle assessments (LCAs) opt for the road infrastructure to fall under the environmental category of "high impact." The same studies say that this kind of construction accounts for 37% of carbon

dioxide emissions and 34% of global energy consumption (Picardo et. al, 2023). Given how environmentally un-friendly everything associated with road construction seems, the civil engineering industry could first and foremost use the newly minted "green" label to emphasize the sustainable practices it most dearly wishes to consider.

The study goes further and tries to build resilience against climate change. Rayan et al. (2022) present a participatory framework for planning Khyber Pakhtunkhwa's Urban Green Infrastructure. They propose that a sustainable framework for the UGI indicators can be established if different stakeholders are involved in a participatory planning process. The community should have the air quality management role, and that can only happen with a robust participatory and community-driven process. In a community-driven process, air quality management can be more achievable (Badach et al., 2021). Strengthening community ties and direct involvement in environmental quality were also anticipated as outcomes of these green spaces (Kou et al., 2019). The study emphasizes alignment with local planning goals and fairness while developing an Index of Distributive Environmental Justice for urban green space design (Kronenberg et al., 2020; Xu et al., 2024). The index recognizes three kinds of injustices: those related to environmental threats, those related to disadvantaged communities, and those related to the benefits of green space.

The research has found "gaps" related to access to public transportation that, combined with the hazards associated with being an active commuter, make individuals in underprivileged communities more susceptible to problems related to traffic pollution. These findings highlight the necessity for targeted "intervention schemes". Data, knowledge, and planning give citizens and governments a way to see what is happening. They also provide a means for parties to engage in conversations that will lead to solving the problems (Kronenberg et al., 2020; Dong et al., 2013). Where community engagement approaches used in successful roads-to-friendliness transformations (Yalegama et al., 2016).

The field of sustainable road construction can greatly benefit from a systematic review. Such a review is essential because the existing research often presents inconsistent and sometimes contradictory findings. Although many good practices are documented in the literature, the overall efficacy of community-based techniques remains poorly understood. In this study, it is aimed to closely examine some techniques. So, it is provided that a broad overview of their reported effectiveness and explore potentially novel applications that could enhance future road construction projects.

In addition, using specially tailored frameworks like PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guarantees that there is a robust mechanism for selecting and judging pertinent studies. This way of working likely helps preserve the repeatability and transparency of the review process and, consequently, the validity and reliability of the review's conclusions (Moher et al., 2009). Traditional methods often ignore local knowledge and community involvement, leading to less adaptable solutions to specific ecological and social situations. While the subject of sustainability in road construction has been researched, less focus has been placed on community-driven solutions and their potential to solve issues of social equality and environmental ramifications. This is the research deficit in the present. The review endeavored to tackle the subsequent research question: What are the environmental impacts of community-driven approaches in sustainable road construction?

Sustainable road construction requires an integrated approach that combines advanced materials, community involvement, and stakeholder collaboration to address the environmental and socioeconomic impacts of infrastructure projects. By prioritizing lifecycle planning, ethical considerations, and climate resilience, these strategies can reduce ecological risks and promote long-term sustainability.

Materials and Methods

Assessing Community-Driven Approaches for reducing environmental impact during road construction is the goal of this systematic review, which adheres to PRISMA principles. In order to address specific research problems, the review methodology was created to methodically find, assess, and summarize pertinent materials.

An investigation that attempts to address research issues by evaluating the findings of previous studies and prior executed researches is known as a systematic review of the literature. First proposed by Dr. David Transfield, PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) is another device used in the SLR. It features a four-stage flowchart like in Figure 1 below, as Moher et al. (2009) discuss. The following databases were searched for literature: Science Direct, Scopus, and Google Scholar. Combinations of the following keywords were included in the search terms: "sustainable road construction", "environmental impact" and "community-driven approaches". English-language studies released in 2015-2024 were given consideration for inclusion.

This inquiry has been conducted using a methodical approach, as shown in Figure 1: Technical Roadmap for Research and Data Collection and Selection for the Systematic Literature Review. The PRISMA tool searches papers and literature for review studies using a variety of methods. Utilizing the PRISMA protocol has several advantages, chief among them being the reduction of search time for relevant articles. Researchers must meticulously complete, record, and submit the phases. The following sections contain a classification of each of these stages. The flow diagram details the way PRISMA was designed for this particular studies.

The keywords used in the Science Direct, Scopus, and Google Scholar databases during the systematic literature review procedure are displayed in Table 1.

Table.1

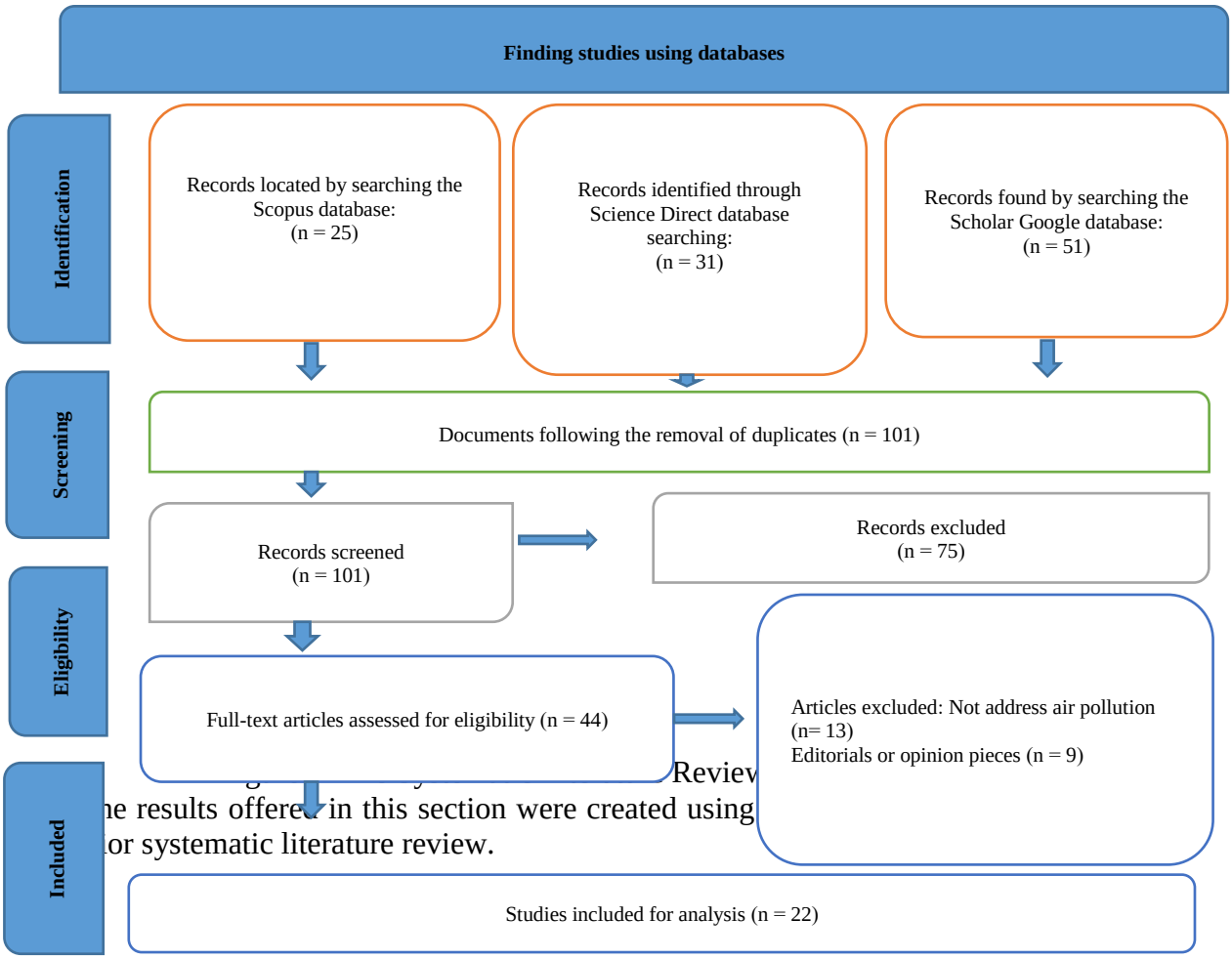
Keywords applied during the systematic literature review process

Databases	***Keywords***
Science Direct	Sustainable Road Construction AND Community-Driven Approaches AND Environmental Impact
Scopus	Sustainable Road Construction AND Community-Driven Approaches AND Environmental Impact
Scholar Google	Sustainable Road Construction AND Community-Driven Approaches AND Environmental Impact

Source :Author's compilation

SLR investigations look for pertinent main articles, gather the required data, evaluate, and synthesize findings in order to gain a deeper and more thorough understanding of the topic at hand (Van Dinter et al., 2021). Transparency, clarity, accessibility, and thorough coverage of a specific topic are the goals of a logical review in the areas of management education (Thorpe et al., 2005).

PRISMA flow diagram



Review
he results offered in this section were created using
or systematic literature review.

2.1 Formulation of Research

PICO (P - Population, Patient, or Problem; I - Intervention, Indicator, or Interest; C - Comparison intervention or group or Context & O - Outcomes), as part of the Research Questions Development Tool (RQDT), was used for constructing the research question in his section. Which is shown in Table 2.

Table 2. PICO table

Population, Patient or Problem	**Intervention or Indicator or Interest**	**Comparison or Context**	**Outcomes**
– Communities involved in road construction projects – Regions affected by road construction and its environmental impact	– Community-driven approaches to road construction – Implementation of sustainable practices and technologies in road projects	– Traditional road construction methods – Community-driven approaches versus top-down government-led initiatives	– Environmental impact (e.g., biodiversity loss, pollution, ecosystem disruption) – Social outcomes (e.g., community engagement, satisfaction, economic benefits) – Long-term sustainability and resilience of road infrastructure

Source: Author's compilation

The key words are shown as follows in Table 3.

Table 3. Term phrases and extended terms (Source: www.thesaurus.com)

Keyword	**Used Keywords**
Characteristics	Aspect, quality, element, component, feature, or attribute
Sustainable Road Construction, Their Environmental Impact	Sustainable Road Construction, Environmental Impact, Community Engagement, Participatory Planning Eco-friendly Practices

Source: Author's compilation

2.2 Examine the Process of Selection

It explains the process of screening and choosing the studies. Furtherance, it describes the screening process, including its stages (title screening, abstract screening, and full-text review), as well as the people who carried it out (one or more reviewers). The number of studies that were found, screened, included, and excluded can be shown by referring to or including a PRISMA flow diagram. Three steps made up the process of choosing studies:

1. Titles and abstracts are used for the first screening.

2. Screening of the remaining articles in full text.

3. Final acceptance was predicated on applicability to the study questions.

22 of the 107 papers that were found in the search passed the requirements for inclusion after a full-text assessment. Figure one shows the PRISMA flow diagram that depicts the selection procedure.

As a result shown in table 2, this study takes into account "Communities involved in road construction projects & Regions affected by road construction and its environmental impact" (problem), "Community-driven approaches to road construction & Implementation of sustainable practices and technologies in road projects" (indicator), "Traditional road construction methods & Community-driven approaches versus top-down government-led initiatives" (comparison), and "Environmental impact (e.g., biodiversity loss, pollution, ecosystem disruption), Social outcomes (e.g., community engagement, satisfaction, economic benefits) & Long-term sustainability and resilience of road infrastructure" (outcomes) and the review's research query is: What are the environmental impacts of community-driven approaches in sustainable road construction?

Table 3. Search string used for data searching

Database	**Search String**
Scopus, Science Direct and Scholar Google databases	KEYS (Sustainable Road Construction AND Community-Driven Approaches AND Environmental Impact)

Source: Author’s compilation

2.3 Identification and Screening Process

The researchers decided to use the Science, Direct Scopus and Scholar Google databases as the primary resource for searches of literature. Furthermore, the authors selected research

papers that were entirely written in English to understand and analyze the study. A critical and reasonable description of the findings from the literature on a given subject becomes crucial conclusion what constitutes a systematic review (Linares-Espinós et al., 2018). Using a standardized form, data were retrieved, capturing information about the study type, geographic focus, mitigation techniques for air pollution, community involvement, and important outcomes.

The essential concepts in this inquiry were "Sustainable Road Construction", "Community-Driven Approaches" and "Environmental Impact" (Table 4). Using synonyms to create a varied selection of keywords is essential to uncovering as much information as possible about a subject. The researcher began the literature search using the Science Direct and Scholar Google databases after determining which terms had been diversified using the synonym. Systematic review search strategies need to be created with the goal of finding every study that has been done on a particular topic (Nightingale, 2009). Since it is believed that if the search results are irrelevant to the topic, the study will not be appropriate for a systematic literature review. Consequently, the investigator chooses to focus the search while adhering to the study question.

2.4 Criteria for Inclusion and Exclusion

Articles included those related to the environmental impact of road construction, as well as community-based or citizen science initiatives focused on road impact monitoring.

The articles were excluded if those did not particularly address air pollution in relation to road construction or were editorials or opinion pieces devoid of factual information.

The given search string yielded 22 articles in total for this study. The database display shows a number of criteria that are used to filter the articles (Table 4). Based on search results from the database Scopus, Science Direct and Scholar Google the researcher has set a 10 years' time limit, spanning from 2015 to 2024. The researcher started the eligibility review of

every article because it was crucial to gather information that is actually relevant to the subject under investigation. Using each of these parameters, 22 articles were found. In this study, the exclusion criteria listed in Table 4 were used. After this, the eligibility process was done three times to ensure accuracy and only 22 relevant publications were successfully collected for the study.

Table 4.

Source: Author's Compilation

Criteria	**Inclusion**	**Exclusion**
Access	Open Access	Closed Access
Document Type	Articles	Book chapter, Review, Not undergone peer review, Conference paper, Book, Editorial, Letter, Short survey & Irrelevant studies
Source Type	Journal	Book, Conference proceeding and book series
Language	English	Non-English
Period	2015-2024	2014 and below
Publication stage	Final	
Subject Area	Road Construction, Sustainable Development, Environmental Science, Community Engagement, Ecological Impact Assessment & Policy and Planning	Other Subjects

Source: Author's compilation

2.5 Data Analysis, Quality Assessment & Data Synthesis

This research paper uses an analytical approach to address the pre-formulated research questions. This methodology is implemented subsequently to the ultimate curation of constituents pertinent to the features of sustainable road constructions. Using narrative synthesis, data were combined with an emphasis on finding recurring themes and patterns in community-based air pollution mitigation approaches. The studies were divided into groups according to the kind of intervention, the study site, and the results of reducing air pollution.

In this way, the researcher has applied the PRISMA method to guarantee that after the identification, screening, and eligibility processes, the final data is clear and impartial. PRISMA focuses on how writers may guarantee that systematic reviews and meta-analyses are fully and transparently reported (Moher et al., 2009).

2.6 Limitations of the Review

The PRISMA approach is utilized to collect data on the attributes of road construction and environmental impact. This analysis, however, is limited to the Scopus, Science Direct and Scholar Google databases. Actually, the only condition for the researchers is that the selected work must adhere to a clearly specified methodology. Due to the consideration of studies only in English, this review may be exclusionary towards publications in other lingua franca. Furthermore, the generalizability of the results may be restricted by the paucity of research on community-based initiatives in developing nations.

The researcher used PRISMA guidelines to ensure that the SLR study on smart city characteristics was conducted fairly and methodically and to confirm the standard of the research papers included in this study. In up to three investigations, the researcher has additionally used the QA questions that were previously specified. The PRISMA process flow diagram offers academics a structure for carrying out a systematic review. It shows how many records were found, added to, and removed from the systematic review. Researchers can utilize PRISMA as a helpful tool to make sure that their systematic review is carried out in an open and repeatable way (Amin et al., 2022).

Thus, without the need for software, researchers can assess the calibre and degree of significance of the papers included in this SLR according to the established criteria. So, there are seven easy steps that can be used to summarize the structure of this SLR formation: 1. Formulate research inquiries 2. Choosing relevant terms (the identification process) 3. Choose pertinent databases to act as platforms for the extraction of data from. (The process of

identifying) 4. Indicate search parameters, including time limits, languages to be used, and any relevant features. (The screening procedure) 5. Create a review plan. 6. Examine research results from a few chosen documents. (Procedure for eligibility) 7. Display the results with descriptions and tables.

1. Results And Discussions

The studies were categorized into the following dimensions following a systematic review: 1. Analysis of the Publication Trend by Year 2. Index of Articles for Each Journal 3. The researchers' publication 4. Features of Reviews in Articles 5. Objectives, Variables, Results and Relevance in Practice mentioned. SLR article has found the result and discussion to be very effective as per Shunmugasundara & Maurya (2023); so in this article, the studies obtained from 22 articles and have been analysed accordingly.

3.1 Analysis of Descriptive Data

3.1.1 Examination of the Yearly Publication Trend

The quantity of papers released between 2015 and 2024 is seen in Figure 2. In the years 2020, there were four times as many articles published. In the years 2019 & 2021, there were three–three times articles published. The number of years published at the rate of two is five, which includes 2016, 2018, 2022, 2023 and 2024. One article was published in 2015 and 2017. So, 2015 and 2017 had the fewest publications overall, with only one. Based on the provided data, there was a four-fold increase in publications after 2020 compared to 2015 and 2017.

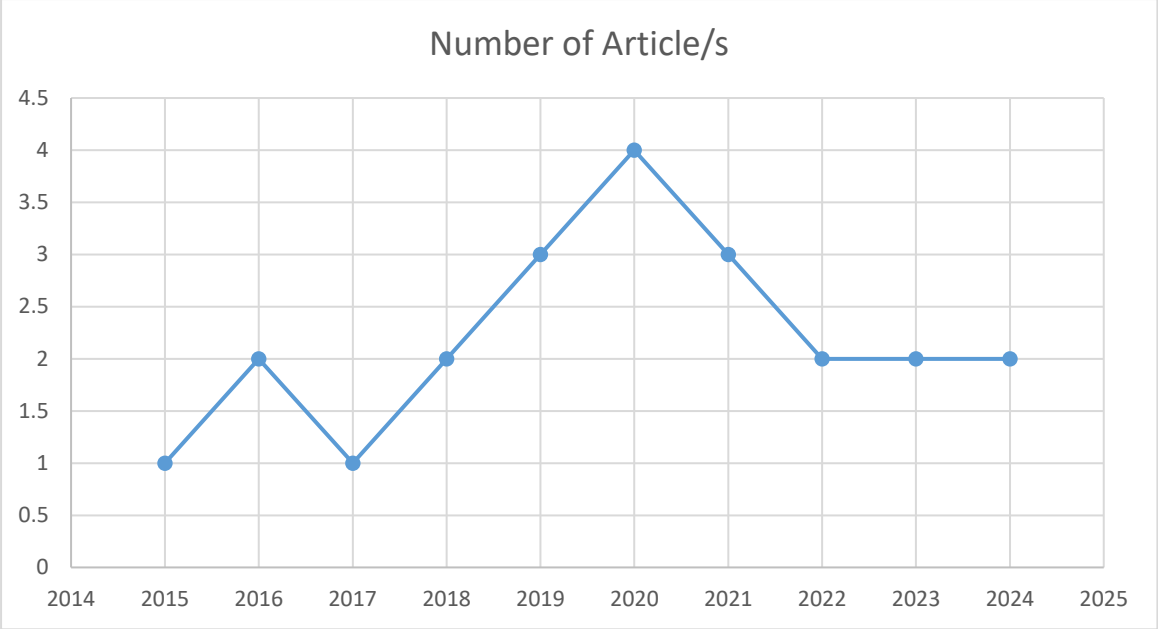


Figure 2. Annual Trend of Article Publication

3.2.2 List of Articles for Each Journal

The quantity of papers gathered from various journals is shown in Table 5. A total of seventeen journals released twenty-two publications concerning the topic. With a total of 5 papers, Table 5 displays the best articles published in Sustainability. Likewise, the journal that publishes the second most papers is Science of the Total Environment, in which three have been published. The remaining 14 journals have published one each.

Table 5. List of Journals

No.	**Journal Names**	**No. of article/s**
01.	Buildings	1
02.	Ecological Indicators	1
03.	Environments	1
04.	Frontiers in Ecology and Evolution	1
05.	International Journal of Disaster Risk Reduction	1
06.	International Journal of Environmental	1
07.	International Journal of Environmental Research and Public Health	1
08.	International Journal of Project Management	1
09.	International Journal of Sustainable Building Technology and Urban Development	1
10.	Journal of Human, Earth, and Future	1
11.	Landscape and Urban Planning	1
12.	Natural Hazards and Earth System Sciences	1

13.	Science of the Total Environment	3
14.	Sustainability	5
15.	Sustainable and Resilient Infrastructure	1
16.	Transportation Research Procedia	1
TOTAL		**22**

Source: Author's compilation

3.2 Main Analysis

3.2.1 Features of Reviews in Articles

The descriptive characteristics of the research publications that were reviewed are shown in Table 6. The 22 articles are assessed in this research. It includes the name and year of the author(s), the name of the journal in which the article was published and the country of publication. Similarly, it names the kind of research method used in those articles and their area of studies as well.

Table 6. Key characteristics of the publications in this review

No.	Author/s & Year	Journal Name	Publisher's Country	Method Used	Area of Studies
1.	Al-Hasan et al., 2020	Journal of Human, Earth, and Future	Oman (Sultanate of Oman)	Various testing methods including sieve analysis, impact tests, Los Angeles tests, penetration tests, and Marshall stability tests	Civil and environmental engineering, specifically the use of eco-friendly materials (recycled polymers and aggregates) in road construction for sustainable development
2.	Ametepey et al., 2020	Sustainable and Resilient Infrastructure	United Kingdom (Informa UK Limited)	Sequential mixed-method approach (comprising Delphi study and questionnaire survey)	Sustainable road infrastructure project implementation in developing countries, focusing on constructs influencing sustainability outcomes

3.	Arshad et al., 2021	Sustainability	Switzerland (MDPI, Basel)	Analytical Hierarchy Process (AHP) for the development of the Life Cycle Sustainability Assessment (LCSA) integration model	Road infrastructure projects, focusing on life cycle sustainability assessment (LCSA), environmental impacts, social impacts, economic impacts, and decision-making frameworks
4.	Badach et al., 2021	Science of the Total Environment	Netherlands (published by Elsevier B.V.)	Mobile measurement campaign and gradient boost model	Environmental science, public health, transportation equity, and urban air pollution
5.	Dong et al., 2024	Ecological Indicators	Netherlands (Elsevier)	Geographic Cellular Automata (GCA) Model, Minimum Spanning Tree (MST) Model, Circuit Theory Model & Carbon Storage Calculation using the InVEST Model	Ecological connectivity in the Qilian Mountains, Construction of ecological corridors, Carbon storage and ecological restoration & Impacts of human activities on ecosystems
6.	Espinoza et al., 2019	Sustainability	Switzerland	Life Cycle Assessment (LCA)	Environmental impact assessment, specifically focusing on carbon footprint estimation in road construction
7.	Joo et al., 2022	International Journal of Disaster Risk Reduction	United Kingdom (Elsevier Ltd.)	Deep Reinforcement Learning (RL)	Disaster Management and Risk Reduction,

					Human Mobility and Traffic Management, Data-Driven Modeling and Simulation, Infrastructure Recovery & Spatial Information Science
8.	Kato-Huerta & Geneletti, 2023	Landscape and Urban Planning	Netherlands	Distributive Environmental Justice Index (DEJI), integrating qualitative content analysis of planning documents and GIS mapping	Environmental Justice (EJ), Urban Planning, Ecosystem Services, Geographic Information Systems (GIS)
9.	Kou et al., 2019	International Journal of Environmental Research and Public Health	Switzerland (MDPI)	Community-engaged research methods and community-based participatory research (CBPR)	Community gardens, Healthy urban environments, Public health, Community engagement and building & Urban planning and sustainability
10.	Kronenberg et al., 2020	Science of the Total Environment	Netherlands (Elsevier B.V.)	Using a gradient boost model, exposure surfaces are produced based on mobile data, land use, built environment, weather, and the Ontario Marginalization Index, which measures social disadvantage in neighborhoods	– Environmental justice, urban air quality, socioeconomic status, and sustainable transportation – Exposure to ultrafine particles (UFPs), socioeconomic characteristics, and availability

					of sustainable mobility in metropolitan environments, with a focus on Toronto, Canada
11.	Marzouk et al., 2017	Sustainability	Switzerland (MDPI)	An Environmental Building Information Modeling (EBIM) methodology for assessing environmental impacts in road construction projects	Environmental Impact Assessment, Construction Engineering, Sustainable Development & Building Information Modeling (BIM)
12.	McAdoo et al., 2018	Natural Hazards and Earth System Sciences (Nat. Hazards Earth Syst. Sci.)	Germany (Copernicus Publications)	GIS analysis is used to examine the spatial distribution of landslides in relation to roadways, looking at landslide inventory from both before and after the earthquake	Focuses on environmental risk assessment, specifically analyzing the relationship between road development and landslides in Nepal, particularly in the context of socio-economic factors and climate impacts
13.	Moore et al., 2021	Frontiers in Ecology and Evolution	Switzerland (Frontiers Media S.A.)	Utilizes a perspective methodology to discuss ethical issues in road ecology, drawing on existing applied ethics	Road ecology, ecological restoration, transportation, conservation, and sustainable development are all related to applied ethics
14.	Park & Ahn, 2015	International Journal of Sustainable Building Technology	United Kingdom	Analytic Hierarchy Process (AHP) for developing	Sustainability in road construction, focusing on ecological,

		and Urban Development		the green road rating system	social, and economic performance. It integrates construction management, environmental assessments, and green practices in infrastructure development
15.	Picardo et al., 2023	Buildings	Switzerland (MDPI, Basel)	The main technique for assessing the environmental performance of road networks is life cycle assessment, or LCA	Sustainable road networks, environmental impact assessments, and the application of LCA in civil engineering and infrastructure development
16.	Puodziukas et al., 2016	Transportation Research Procedia	Netherlands (Elsevier B.V.)	Feasibility studies and environmental impact assessments to analyze sustainable development measures for road networks	Sustainable development in transportation infrastructure, specifically road networks, analyzing environmental impacts, climate change, human health, and biodiversity
17.	Rayan et al., 2022	Sustainability	Switzerland (MDPI)	Field data analysis using the Relative Importance Index (RII) and Inter-Quartile Range (IQR)	The socio-ecological effects of urban greening initiatives in Pakistan, sustainable urban planning, urban green infrastructure (UGI), and climate change adaptation

18.	Riley-Powell et al., 2018	International Journal of Environmental Research and Public Health	Switzerland (MDPI)	A mixed-methods strategy is used to collect and analyze data using both quantitative and qualitative methods.	Public Health, Environmental Health, Sociology, Community Well-Being & Sustainable Development
19.	Ruiz & Guevara, 2020	Sustainability	Switzerland	Analytic Hierarchical Process (AHP) and System Dynamics (SD) are integrated in a hybrid technique	Road infrastructure, Sustainable decision-making in road maintenance policies, Environmental impact assessment (specifically CO2 emissions) & Economic and socio-economic factors in road development
20.	Teo et al., 2019	Environments	Switzerland (MDPI)	An analysis of the environmental effects of infrastructure development under the Belt and Road Initiative (BRI) using an interdisciplinary framework and an Earth systems approach	Environmental Science, Geography, Development Policy, Infrastructure Development, Environmental Impact Assessment & Socio-economic Studies
21.	Xu et al., 2024	Science of the Total Environment	Netherlands (Elsevier)	Gradient boost model to generate exposure surfaces for ultrafine particle	Environmental Science, Public Health, Transportation Equity,

				(UFP) concentrations	Urban Planning & Air Quality and Pollution
22.	Yalegama et al., 2016	International Journal of Project Management	United Kingdom (Elsevier Ltd.)	Factor analysis to identify critical success factors (CSFs) based on community perspectives. It also involved surveys and interviews for data collection	initiatives for community-driven development (CDD), with a focus on the Gemidiriya project in Sri Lanka, and a special examination of crucial success elements in the framework of international development

Source: Author's Compilation

Table 7. Objectives, Variables, Results and Relevance in Practice mentioned

3.2.3 Objectives, Variables, Results and Relevance in Practice of Sustainable Road Construction, Community-Driven Approaches and Their Environmental Impact

Several researches' points of view on the influence of road construction, community-driven approaches and their environmental impact were discovered. The goals, factors used, conclusions, and recommendations pertaining to it are displayed in Table 7.

Year & Author/s	**Title**	**Objectives**	**Variables**	**Results**	**Relevance in Practice**
2024, Dong et al.	Enhancing ecological connectivity in the Qilian Mountains: Integrating GCA and optimized MST models for ecological corridor construction	– To optimize ecological corridor construction using the MST model – To validate ecological corridors with remote sensing and carbon stock data	***Dependent Variables***: Ecological corridor connectivity, carbon stock, ecological recovery ***Independent Variables***: Road network data, ecological	Ecological corridors improve connectivity, there is potential for a 1.4748 million ton increase in carbon stocks, and growth is anticipated in	By offering a framework for the development of ecological corridors, the study promotes biodiversity preservation and helps China achieve its carbon

		– To identify key areas for ecological protection	source sites, anthropogenic activities	the areas of forests and grasslands	neutrality objectives by enhancing ecosystem management
2024, Xu et al.	Exploring the triple burden of social disadvantage, mobility poverty, and exposure to traffic-related air pollution	To investigate the connections, with an emphasis on environmental justice and equality, between transportation accessibility, socioeconomic status, and exposure to ultrafine particles in Toronto	***Dependent Variables***: Ultrafine particle exposure, sustainable transportation accessibility ***Independent Variables***: Socioeconomic status, residential instability, ethnic concentration, mobility patterns	Urban environmental and health disparities are exacerbated in disadvantaged communities by restricted transit alternatives and increased exposure to ultrafine particles	Specific municipal policies have the potential to enhance mobility equality and mitigate the effects of air pollution, thereby promoting healthier surroundings for Toronto's vulnerable populations
2023, Kato-Huerta & Geneletti	A distributive environmental justice index to support green space planning in cities	To Develop a Composite Index, To Identify Intra-Urban Distributive Injustices, To Test the DEJI in a Case Study & To Support Planning and Policy Goals	***Dependent Variable*:** Distributive Environmental Justice Index (DEJI) ***Independent Variables*:** Environmental Risks & Social Disadvantages	The study found the need for customized environmental justice indicators in urban design by identifying notable distributive inequities in access to green spaces	The DEJI provides guidance to urban planners regarding the identification of underprivileged areas, fair green space interventions, and the alignment of environmental justice objectives with regional policies
2023, Picardo et al.	Life cycle assessment of sustainable road networks:	To evaluate road LCA approaches, appraise ongoing research	***Independent Variables***: LCA methodologies, tools, and databases	The complexity of data makes LCA application difficult,	Enhancing LCA methods can help regulatory compliance for

	Current state and future directions	endeavors, and pinpoint technical resources for useful road LCA implementations	***Dependent Variables***: Environmental impact assessments, sustainability outcomes, and resource efficiency in road construction	necessitating specific databases and specialist procedures for efficient environmental assessments in road projects	environmental impact reduction in infrastructure projects, encourage circular economy practices, and improve sustainable road design
2022, Rayan et al.	Frameworks for urban green infrastructure (UGI) indicators: Expert and community outlook toward green climate-resilient cities in Pakistan	To engage with local people and experts to establish a sustainable framework for urban resilience against climate threats using UGI indicators	***Independent Variables***: UGI indicators, stakeholder engagement ***Dependent Variables***: Urban climate resilience, ecological and socio-economic benefits	Sustainable UGI indicators greatly improve urban resilience; stakeholders in Khyber Pakhtunkhwa place the greatest importance on the ecological and economic components	In order to promote resilient urban settings in Pakistan, good UGI policies can enhance community involvement, land-use planning, and climate adaptation techniques
2022, Joo et al.	Road-reconstruction after multi-locational flooding in multi-agent deep RL with the consideration of human mobility: Case study: Western Japan flooding in 2018	To maximize the effectiveness of disaster management by taking human movement into account and employing multi-agent deep reinforcement learning for road rehabilitation following flooding	***Dependent Variables***: Human mobility recovery rate, travel time, road usability ***Independent Variables***: Damage extent, road capacity, restoration efforts, agent actions	The model successfully gave road recovery first priority, recovering over 75% of human movement through agent collaboration and optimal decision-making	By improving disaster response plans, the method helps governments better allocate resources and expedite affected communities' rehabilitation

2021, Arshad et al.	Evaluation of road infrastructure projects: A life cycle sustainability -based decision-making approach. Sustainabilit y	To provide a life cycle sustainability evaluation tool that integrates social, environmental , and economic aspects when assessing road infrastructure projects	***Independent Variables***: Project alternatives, sustainability criteria ***Dependent Variables***: Sustainability scores, decision outcomes	Stakeholder viewpoints, sustainability, and the integration of qualitative and quantitative assessments are all highlighted by a complete framework that improves project evaluation	Assists decision-makers in choosing environmenta lly friendly road projects by enhancing the decision-making process with organized frameworks catering to various stakeholders' interests
2021, Badach et al.	Exploring the institutional and bottom-up actions for urban air quality improvement : Case studies in Antwerp and Gdańsk	To investigate institutional and bottom-up approaches to managing urban air quality in Antwerp and Gdańsk, with an emphasis on stakeholder ideas and behaviors	***Dependent Variable***: Air quality improvement ***Independent Variables***: Urban planning policies, stakeholder engagement, environmental perceptions, and local governance practices	Different stakeholders have different opinions about the quality of the air; in both cities, public awareness and management efficacy are greatly influenced by local activities and policies	Better air quality initiatives can promote sustainable urban development, improved health outcomes, and increased public participation by addressing local perspectives
2021, Moore et al.	On the road without a map: Why we need an “ethic of road ecology.”	To create a moral framework for road ecology that takes into account the effects that transportation infrastructure has on the environment, society, and culture	***Independent Variables***: Road planning methods, ecological assessments ***Dependent Variables***: Environmenta l impacts, community well-being,	An ethic of road ecology can enhance decision-making by including moral factors to successfully strike a balance between socioeconomi c and	promotes the use of holistic techniques by transportation planners, guaranteeing stakeholder participation and environmenta lly friendly methods for managing and

			ecological integrity	ecological objectives	developing roads
2020, Al-Hasan et al.	Eco-friendly asphalt approach for the development of sustainable roads	– To investigate how recycled aggregates and polymers affect the characteristics of asphalt. – To evaluate mechanical performance and suggest ways to lessen the impact on the environment	***Independent Variables***: Percentage of recycled polymers and aggregates. ***Dependent Variables***: Physical and mechanical properties of asphalt	For sustainable roads, a batch consisting of 75% recycled aggregates and 15% polymer performed best in terms of stability, penetration, and total material efficiency	By addressing environmental issues, cutting costs, and improving sustainability, the use of recycled materials in road construction promotes the development of environmentally friendly infrastructure
2020, Ametepey et al.	Determinants of sustainable road infrastructure project implementation outcomes in developing countries. Sustainable and Resilient Infrastructure	Determine the factors impacting the implementation outcomes of sustainable road infrastructure projects and estimate the importance of each	***Dependent Variable***: SRIPI (Sustainable Road Infrastructure Project Implementation) outcomes ***Dependent Variables***: Social, cultural, economic, environmental, institutional sustainability, health and safety, project management, resource utilization, engineering performance, public participation, stakeholder management	Stakeholder management, public participation, project management, and resource use are the four factors that most strongly predict SRIPI outcomes	When constructing sustainable road projects, stakeholders are guided by insights, which improve the infrastructure development procedures in developing nations

2020, Kronenberg et al.	Environmental justice in the context of urban green space availability, accessibility, and attractiveness in postsocialist cities	To investigate the connection between socioeconomic class, exposure to ultrafine particles, and environmentally friendly transportation in Toronto areas	***Dependent Variable***: Ultrafine particle (UFP) exposure. ***Independent Variables***: Socioeconomic status (SES), sustainable transportation accessibility, ethnic concentration, and mobility patterns	Environmental injustices and health disparities are made worse in disadvantaged neighborhoods by restricted access to sustainable mobility and increased exposure to UFPs	In order to enhance public health and environmental justice, targeted actions are required in high-risk neighborhoods to increase transportation equality and reduce UFP exposure
2020, Ruiz & Guevara	Sustainable decision-making in road development: Analysis of road preservation policies	To employ a hybrid technique that integrates system dynamics and the analytic hierarchy process in order to assess and evaluate sustainable road maintenance policies through Colombia	***Dependent Variables***: Road conditions, costs, CO2 emissions. ***Independent Variables***: Maintenance policies, budget allocation, intervention types	Road conditions and emissions are impacted by economic variables that strongly influence maintenance decisions and favor short-term remedial tactics over long-term predictive maintenance	In order to improve road infrastructure management, the system balances technical, financial, and environmental factors to help policymakers create sustainable maintenance plans
2019, Teo et al.	Environmental impacts of infrastructure development under the Belt and Road Initiative	– To define BRI and its infrastructure. – To assess environmental impacts across Earth systems – To develop a typology of BRI infrastructure	***Dependent Variables***: Environmental impacts (e.g., air pollution, habitat loss) ***Independent Variables***: Type of infrastructure, socio-economic	Infrastructure for the Belt and Road Initiative (BRI) has a substantial impact on ecosystems, causing cumulative environmental changes at many scales	Comprehending the environmental implications of Belt and Road Initiatives (BRI) facilitates the creation of sustainable infrastructure and policies

		– To analyze socio-economic drivers of impacts	factors, policy frameworks	and requiring interdisciplinary studies for efficient planning and policy-making	that tackle environmental issues while bolstering regional socio-economic progress
2019, Kou et al.	Community-engaged research for the promotion of healthy urban environments: A case study of community garden initiative in Shanghai, China	To investigate community involvement in garden construction as a means of fostering wholesome urban settings in quickly urbanizing regions	***Independent Variables***: Community involvement, external interventions ***Dependent Variables***: Neighbourhood environmental health, community cohesion, participants' attitudes	Effective self-governance in garden programs and greater acceptability of public participation were two benefits of community engagement that improved environmental health and cohesiveness	The study recommends integrating professional support at the outset to empower communities and promote sustainable urban settings through active engagement and collaboration
2019, Espinoza et al.	Carbon footprint estimation in road construction: La Abundancia-Florencia case study	to calculate the La Abundancia–Florencia highway's carbon footprint and to increase public understanding of the environmental effects of road construction	***Independent Variables***: Material types, construction processes, energy sources. ***Dependent Variables***: Carbon footprint (CO2e emissions)	The highway's construction has an environmental impact of 65.8 kg CO2e/km, of which 38%–39% are attributable to the manufacturing of HMA	Emphasizes the necessity of using sustainable building methods to reduce the negative effects on the environment. This will help shape industry standards and legislation for upcoming projects
2018, McAdoo et al.	Roads and landslides in Nepal: How development affects environmental risk	To assess how informal road construction in Nepal contributes to landslide occurrences,	***Independent Variable***: Informal road construction ***Dependent Variable***:	Compared to earthquake-triggered landslides, monsoon-triggered landslides are	Environmental dangers must be taken into account while building new roads. In

		particularly after the 2015 Gorkha earthquake	Landslide occurrences	twice as likely to occur along unpaved roads, underscoring the importance of roadways in landslide risk	Nepal, better engineering techniques can reduce the risk of landslides and encourage the establishment of sustainable communities
2018, Riley-Powell et al.	The impact of road construction on subjective well-being in communities in Madre de Dios, Peru	To investigate how the development of new roads affects the subjective well-being (SWB) of the people living near the Interoceanic Highway in Madre de Dios, Peru	***Dependent Variable***: Subjective well-being (SWB) scores. ***Independent Variables***: Income, social support, food security, health, community dynamics, and environmental changes	The effects of road development on SWB were mixed, according to communities, who noted both advantages like more possibilities and disadvantages like environmental deterioration and health risks	Enhancing access to resources and community support can improve subjective well-being in the face of infrastructure changes, addressing issues connected to health and the economy
2017, Marzouk et al.	Assessing environmental impact indicators in road construction projects in developing countries	To use a BIM-based methodology to estimate environmental impact indicators in road construction projects	***Independent Variables***: Project phases, environmental impact indicators, input parameters. ***Dependent Variables***: Emissions, life cycle costs, energy consumption	The suggested methodology efficiently evaluates the effects on the environment, highlighting the importance of sustainability and identifying noteworthy emissions throughout the different stages of development	The approach supports sustainable practices in road construction, helps project teams assess environmental implications early, and enhances decision-making

2016, Puodziukas et al.	Measures for sustainable development of road network	To analyze the development of a sustainable road network, pinpoint important objectives, and suggest actions in line with national and EU sustainability standards	***Independent Variables***: Road development measures, resource usage, emissions ***Dependent Variables***: Environmental impact, human health outcomes, biodiversity preservation	By drastically lowering resource consumption and emissions, sustainable road practices can improve public health and the environment while also generating economic benefits	Road networks can benefit financially from the adoption of sustainable practices, which also enhance public health, the environment, and long-term infrastructure resilience
2016, Yalegama et al.	Critical success factors for community-driven development projects: A Sri Lankan community perspective	To determine the key success factors (CSFs) that community-driven development (CDD) projects in Sri Lanka need to know in order to succeed	***Dependent Variable***: Project success ***Independent Variables***: Enabling community environment, measurable project management outcomes, community project management engagement	From the perspective of the beneficiaries, three CSFs—an enabling community context, measurable outcomes, and engagement—have a major impact on project success	To boost CDD initiative efficacy and project success, project managers should place a strong emphasis on measurable outcomes and community engagement
2015, Park & Ahn	Development of a green road rating system for South Korea	To develop a green road grading system for South Korea that encourages environmentally friendly methods of building roads and raises industry standards.	***Independent Variables***: Categories, indicators, and credits of the green rating system ***Dependent Variable***: Sustainability performance of road construction projects	A thorough framework for a green road grading system was developed, encouraging eco-friendly behaviors and enhancing social, political, and financial results	Greener infrastructure development can be achieved by the system's guidance of road construction methods, improvement of sustainability education,

	and promotion of stakeholder participation

Source: Author's Compilation

Based on the findings of the reviewed literature, a set of following ideas are inferred. Recycled aggregates and polymers are combined in sustainable road and such operations are to increase effectiveness and protect the environment (Puodziukas et al., 2016). Project success is assessed into important characteristics like resource efficiency, public participation, and stakeholder management. The CO2 emissions from road construction must be considered; and local activities influence the quality of the air (Ruiz & Guevara, 2023). Green infrastructure ensures a balance between social and ecological demands, emphasizing the value of integrated frameworks for better socioeconomic and environmental results.

An investigation by Al-Hasan et al. (2023) deduced that a section consisting of 75% recycled aggregates and 15% polymer performed best in terms of stability, penetration, and total material efficiency for the sustainable roads construction. furtherance, stakeholder management, public participation, project management, and resource use are the four factors that most strongly predict SRIPI outcomes (Ametepey et al., 2022). The finding of Badach et al. (2021) shows that different stakeholders have different opinions about the quality of the air; in both cities, public awareness and management efficacy are greatly influenced by local activities and policies.

According to a study by Espinoza et al. (2019), the highway's construction has an environmental impact of 65.8 kg CO2e/km, of which 38%–39% are attributable to the manufacturing of HMA. In that case, the model successfully ranked road recovery as the first priority, recovering over 75% of human movement through agent collaboration and optimal

decision-making (Joo et al., 2022). In Nepal, unpaved roads intensify the possibility of landslides, which generates a severe effect on safety and development during the monsoon season (McAdoo et al., 2022). A study by Kato-Huerta et al. (2023) stresses on the need for customized environmental justice indicators in urban design by identifying notably distributive inequities in access to green spaces. The life cycle approach integrates social, economic, and environmental issues to increase the sustainability of road projects (Arshad et al., 2021).

The finding of another valued literature by Moore et al. (2021) shows that an ethic of road ecology can enhance decision-making conscientious by including moral factors to successfully adhere a balance between socioeconomic and ecological objectives. According to the study by Rayan et al. (2022), sustainable UGI indicators greatly improve urban resilience; stakeholders in Khyber Pakhtunkhwa place the greatest importance on the ecological and economic components (Park & Ahn, 2015) as a thorough framework for a green road grading system was developed, encouraging eco-friendly behaviors and enhancing social, political, and financial results.

2. Conclusion

The criteria for searching the publications from the last ten years (2015–2024) for intended systematic review were advanced on limiting the key terms as sustainable road construction, community-driven approaches and their environmental impact. The analysis also reveals that more than four authors have significantly contributed the most among published articles. The study also exemplifies the features of papers that have undergone a systematic review. It has presented the trend of publication by Year, number of listed articles for each journal, the researchers' publication, features of reviews in articles, objectives, variables, results and relevance in practice. Only articles were taken into consideration for the study; no books, periodicals, or conference papers were included for this purpose.

From the study, it is analyzed that the commonly used environmentally friendly techniques in community-driven methods for building sustainable roads include the following three ideas. Regional economies are strengthened while environmental effect is decreased through the use of local resources, material recycling, and community involvement in design. Water quality, biodiversity, and ecosystems are all protected via resilient drainage systems, green design, and erosion management. To improve sustainability and reduce interruption, low-impact construction, renewable energy, and educational initiatives should be included.

In order to improve community-driven approaches, researchers want to better understand trends in sustainable road construction and its environmental impact. To this goal, a thorough literature review is conducted. Future researches should focus on creating integrated frameworks that take into account the various environmental, social, and economic effects of sustainable road infrastructure in a variety of contexts. These frameworks should also incorporate the perspectives of localized stakeholders, ecological factors, and long-term maintenance strategies. The findings highlight the need for customized strategies to address a range of environmental and social challenges while highlighting the critical roles that sustainable practices, stakeholder engagement, environmental justice, and interdisciplinary approaches play in improving road infrastructure, public health, and ecological outcomes, respectively.

The following conclusion have been drawn from the five objectives mentioned in the introduction. First of all, community involvement in road projects amounts volume to sustainable development. In order to guarantee sustainable results, successful transformations require strong community participation and stakeholder collaboration. Second, the effect of participatory methods comes into the second. These techniques lessen environmental effects by coordinating project objectives with ecological and community norms. Thirdly,

encouraging long-term sustainability as community-driven strategies incorporate indigenous knowledge, encouraging sustainable road infrastructure and environmental management. The fourth is the barriers to participation whereas inadequate legal frameworks and socioeconomic inequality present difficulties, but engagement can be improved by policies that are helpful.

Lastly, paying attention to utilizing sustainable materials, enhancing community involvement, and removing legal and socioeconomic obstacles can be considered as arch suggestions and advices for future research initiatives. Finally, this study offers future researchers a number of recommendations. First, the study has only based on open-access data; however, more studies may choose to rely at closed-access publications. Second, future researchers can add more subjects to the study, where this review has only covered a small number of focused issues, including community-driven approaches, sustainable road construction, and their environmental impact. Fourth, last but not the least, the study only looks back ten years' worth of review publications. Therefore, the study's duration may be expanded.

3. Recommendations

Based on the findings of this materials and resources reviewed systematically for this study, recommendations have been made as follows. This will be useful for policymakers, environmentalists, development experts, project managers, stakeholders, and communities to ensure that road construction has no disastrous environmental impacts in the future.

1. ***Boost Community Engagement***: To encourage sustainable and socially responsible results, community can apply inclusive planning procedures and make sure that stakeholders are actively involved in road construction projects.

2. ***Adopt Participatory Methods***: To reduce environmental consequences and increase project acceptance by using participatory methods that match community demands with road project aims.

3. ***Integrate Local Knowledge***: To improve long-term sustainability and environmental care in road construction, encourage the inclusion of community inputs in project design.

4. ***Address Participation Barriers***: To address issues that prevent the community from effectively participating in road construction, enabling legislative frameworks and socioeconomic policies should be developed.

5. ***Emphasis on Sustainable Practices***: To reduce environmental impact and improve road project sustainability, community-driven approaches and the use of eco-friendly materials and technologies must be attributed as the first priority.

Acknowledgment

Sincere gratitude for all who supported and paid due assistance me during this project. Their consistent advice, regular feedbacks and close guidance can never be seconded to any one in any other grounds. Additionally, I would like to express my gratitude to Dr. Rishi Bastakoti, Dr. Atindra Dahal, Dr. Tulasi Acharya, Dr. Kamal Phuyal, Er. Hari Ghimire, Dr. Hari Joshi, and Dr. Chetnath Kandel for their friendly guidance and constructive inputs. Their expertise and insightful critique have substantially advanced and standardized this assignment. I earnestly acknowledge that this research was entirely self-funded. Additionally, Finally, I would want to thank all of the anonymous reviewers whose scholarly observations and suggestions have improvised my work to this level.

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