



MAPPING LEED FOR CITIES AND COMMUNITIES STRATEGIES TO SUSTAINABLE DEVELOPMENT GOAL

A Framework Based Assessment

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Abstract: Rapid urbanisation and increasing urban population density result in cities' expansion, often intensifying economic and social inequalities. This emphasis needs the adoption of long-term sustainability goals. Current literature highlights the urgent need for policy interventions at the implementation level to achieve integration of Sustainable Development Goals (SDGs) and long-term sustainability. To facilitate the assessment of sustainable development, green rating systems have been introduced globally. The study uniquely examines the LEED for cities and communities (LCC) framework from social, environment and economic perspectives. The LCC framework encompasses nine different categories. Each category revolves around specific themes that can be addressed by the application of specific strategies to earn a credit point. Each category is evaluated against its performance score, based on the strategies adopted and its mapping to the Triple Bottom Line (TBL) sustainability framework. The key pillars of TBL structure are Social equity (People), Economic viability (Profit) and Environmental responsibility (Planet). The study aims to understand how each strategy across nine categories contributes to achieving SDGs, aligning with the TBL structure. This study adopts a qualitative research technique using a systematic coding process to identify themes related to LCC strategies. The assessment indicates that LCC is a comprehensive framework that fosters urban development, aligning with global sustainability goals. Sustainable development goals like health and wellbeing, industry innovation and infrastructure, Sustainable cities and communities and climate action show the highest linkages to the LCC framework. A key recommendation of this study is to strengthen efforts toward enhancing awareness and understanding of economic, social, and environmental values among stakeholders, thereby promoting healthier and more environmentally responsible lifestyles. Policymakers and planners, in particular, are encouraged to incorporate the strategies and indicators proposed within the LCC framework into decision-making processes.

Index Terms - Sustainable urban development, Framework analysis, SDGs

I. INTRODUCTION

The concept of sustainability comprehends issues related not only to the environment and ecology but also addresses social and economic concerns (1,2). A lot of work has been seen in the areas of environment and ecology, whereas social sustainability is largely absent from most sustainable and green efforts. Urban form directly impacts social sustainability in addition to the physical shape of the building environment (3,4). With the increase in awareness of climate change and the effects of human activity on the environment, green building has evolved from traditional ideas about the building environment (5,6). Initiatives to create a more resilient, habitable, inclusive, and sustainable environment for future generations.

In order to achieve sustainability goals, the growth of macro scale must be taken into account by integrating sustainability concepts into urban and city planning, going beyond the level of individual buildings (7–9). By providing strategic solutions for integrating local and global sustainability goals into practices, LEED's vision of sustainable cities and communities as an evaluation system seeks to arrange buildings, public spaces, transportation systems, services and amenities more viable, inclusive, participatory and self-sustaining (10).

Efficient and sustainable planning can potentially boost socio-economic growth and promote sustainable development, which is necessary in today's business environment to gain a competitive advantage, given the current global challenge that calls for the development of sustainable economies through decarbonisation (11–13). The advantages of sustainable development, which are associated with existing plans to keep the rise in global temperature well below 2°C, greatly exceed the costs and result in substantial energy savings to the communities (14,15). According to Goh and Rowlinson (2016), sustainable development is linked to long-term improvements in the field of ecological management and preservation, economic growth and social inclusion.

The risk of negative environmental consequences on Earth has increased due to ecological imbalance and ongoing climate change. Issues related to increasing greenhouse gases, pollution, land crises, depletion of natural resources and waste management have posed serious concerns. The construction sector is responsible for 12% water consumption, 40% waste generation, 30% process related energy emissions and 40% energy consumption as per UN (2016). The construction sector contributes 8-9% to India's GDP and is the backbone in shaping cities and their urban development (16–20). Substantial efforts should thus be taken to create cities that are environmentally more sustainable and responsible [22]. Increasing urbanisation, population and climate risk demand the incorporation of sustainable goals by the United Nations (Balaban & de Oliveira, 2017).

This study critically evaluates one of the most well-known sustainable grading systems and connects it to global sustainable development through the lens of socio-economic and environmental viewpoints. Its objective is to evaluate the LEED for Cities and Communities framework's possible application by taking into account pertinent factors for evaluating urban development in accordance with the Sustainable Development Goals (SDGs). The social, economic, and environmental views here are taken into account while analysing how cities are changing. Sustainable community evaluation systems are useful tools for reporting the development of urban areas towards sustainability. The infrastructure framework inspires the consideration of the Triple Bottom Line (TBL) in developments, which promotes the sustainable interconnectedness and growth of towns and cities (21–23). The SDGs largely concentrated on the urban areas, where the implementation of assessment systems is strongly recommended to ensure the future sustainable development of these nations (24,25). In contrast to the traditional green building techniques, this paper presents sustainable cities and communities as a paradigm shift toward a more comprehensive and integrated urban sustainability framework.

1.1 Sustainable Development Goals

To tackle climate change and address the global problem of sustainable development, seventeen sustainable development goals were launched by the United Nations in 2016. The urban models must analyse the development plans to provide thorough solutions for accomplishing the SDGs by incorporating sustainability into the built environment (26–28). All countries globally are trying to integrate the Sustainable Development Goals. In an environment where urban areas are responsible for more than three-fourths of global energy consumption, city planning and urban development can substantially help in achieving SDGs (29,30). Thus, a study that highlights the linkages between sustainable urban development and SDGs could greatly help.

1.2 Cities and Climate Change

Due to development pressure, rapid growth frequently results in loss of priceless ecosystems and land. If the same pattern of resource consumption persists in the present and future urban regions, serious issues are expected. The majority of social injustices, economic activity, socio manifestations, and environmental effects are produced in cities, necessitating careful planning for infrastructure, housing, education, employment prospects and well-being, among other things (31–33).

Urban growth is extremely important for sustainability because of high population density and its profound effects on the economy and society. As per the UN Development Programme (2018), two-thirds of the

world population will reside in urban areas by 2050, underscoring the need to change how urban areas are constructed. According to the study report of the United Nations (UN), predicting future world population of 8.5, 9.7 and 11.2 billion inhabitants in 2030, 2050 and 2100, respectively (18). Currently, over 50% of the world's population resides in urban areas and is expected to rise to 60% by 2030 (17). A more comprehensive approach to sustainability in cities is required, where the built environment, public transportation, and amenities services are always key to improving sustainability performance. The green movement's advocacy could result in a significant reduction in environmental impacts, but the shift in social structure and economic base necessitates a paradigm shift (28,34). The progress of cities can be hampered by lower resource efficiency, higher ecological impacts and wasteful land use due to improper planning and uncontrolled urban development.

Green ratings systems have been implemented for easy assessment of sustainable development in terms of urban development. Evaluation methods for sustainable cities and communities are anticipated to lessen the current challenges faced by green buildings in enhancing social sustainability and offer more tactical ways to carry out and comprehend regional and global sustainability objectives (8,35–37). A growing number of sustainability initiatives call for integrated and cooperative urban planning and administration within the green movement.

The standard of life, social inclusion, residents' economic possibilities and cities' abilities to withstand various environmental, social and health-related hazards are all significantly impacted by the value of infrastructure. The development process, such as better access to education, well-being and lifestyle, could contribute to improving the welfare of the urban population. Unplanned urbanisation, on the other hand, can have the opposite effects by encouraging dense population, spread of illness, poverty and inadequate infrastructure (38,39). To achieve sustainable development, all stakeholders should focus on integrating sustainable design and planning concepts in the city planning process. This calls for a review to examine the current sustainability movements' transition from the building level to a broader context at the sustainable city and community.

1.3 LEED for Cities and Communities (LCC)

LCC is a data-driven certification system designed by the U.S. Green Building Council (USGBC) that evaluates sustainability performance across various categories like waste, transportation, water, energy and quality of life. It provides a framework for tracking improvements in social, economic and environmental metrics to create healthier, resilient and sustainable spaces.¹ LCC is a framework that consists of a few prerequisites for each category and a series of credits based on the indicators that a project needs to attain.

Using a multi-stakeholder approach, LCC aids in promoting equitable, sustainable and resilient communities globally (40–43). Thus, to create a resilient and liveable environment, sustainable cities and communities integrate the idea of sustainability at both the building and urban scale. LCC is globally applicable yet locally acceptable.

II RESEARCH METHODOLOGY

The study adopts a qualitative thematic analysis through systematic interpretation of the qualitative content analysis from secondary sources. The secondary sources include the report provided in the LEED for Cities and Communities handbook and other related articles available as open source. The study aims to understand how each strategy from the LLCC framework can be linked to SDGs. The SDG-LCC mapping was carried out by grouping codes into themes and then classifying them with the Triple Bottom Line (TBL) framework, as shown in Table 1 below, using a framework analysis approach. Similar patterns can be observed using thematic analysis across different textual data. This method is recommended for policy-oriented research as it brings analytical depth and systematic evaluation by assimilating different techniques.

¹ <https://www.usgbc.org/leed/rating-systems/leed-for-cities>

Table 1: Linking of LCC mandatory prerequisites and voluntary credits with SDGs addressed with TBL.

Strategies	TBL	SDG
INTEGRATED PROCESS		
Integrative planning and designing process	Social	11, 13
Green Building Policy and Incentives	Economic	9,16
	Economic	9, 17
NATURAL SYSTEM & ECOLOGY		
Ecosystem Assessment	Environmental	3, 11
Construction Activity Pollution Reduction	Environmental	3, 12, 13
Green Spaces	Social	3, 11, 13
Natural Resources Conservation and Restoration	Environmental	2, 12
	Economic	13, 14, 15
Light Pollution Reduction	Social	9, 13
Resilience Planning	Environmental	3, 8, 9, 13
	Social	16
TRANSPORTATION & LAND USE		
Compact, Mixed Use and Transit-Oriented Development	Economic	7, 8, 9, 10, 11, 13
Walkability and Bikeability	Social	3, 7
Access to Quality Transit	Economic	7, 8, 13
Alternative Fuel Vehicles	Environmental	12
Smart Mobility and Transportation Policy	Economic	3, 7
Historic Sites	Social	11, 15
WATER EFFICIENCY		
Integrated Water Management	Environmental	6, 12
Water Access and Quality	Social	3, 6, 10
Stormwater Management	Environmental	3, 6, 13
Wastewater Management	Environmental	6, 9, 13
Smart Water Systems	Economic	9, 12, 17

Strategies	TBL	SDG
ENERGY & GHG EMISSIONS		
Power Access, Reliability and Resiliency	Social	3, 7, 10
Energy and GHG Emissions Management	Environmental	3, 13
Energy Efficiency	Economic	7, 13
Renewable Energy	Social	7, 9, 12, 13
Low Carbon Economy	Economic	3, 4, 9, 11, 13
Grid Harmonization	Economic	11, 12
MATERIAL & RESOURCES		
Construction and Demolition Waste Management	Environmental	3, 9, 11, 12, 13
Solid Waste Management	Environmental	3, 8, 9, 11, 13, 14, 15
Organic Waste Treatment	Environmental	8, 9, 12, 14
Recycling Infrastructure	Social	3, 8, 9, 11, 13, 15
Responsible Sourcing for Infrastructure	Social	8, 9, 11, 12, 13, 17
Smart Waste Management Systems	Economic	11, 14
QUALITY OF LIFE		
Demographic Assessment	Social	1, 3, 4, 5
Social Infrastructure	Social	1, 6, 7, 8, 11, 12
Economic Growth	Economic	3, 4, 8, 10
Affordable Housing	Social	10, 11
Public Health	Social	3, 13
Emergency Management and Response	Social	11, 13
INNOVATION	Economic	9, 17
REGIONAL PRIORITY	Economic	8, 11
	Social	

III. RESULTS AND DISCUSSION

The analysis reveals that LCC strategies contribute to multiple SDGs, with varying degrees of associations as shown in Figure 1.

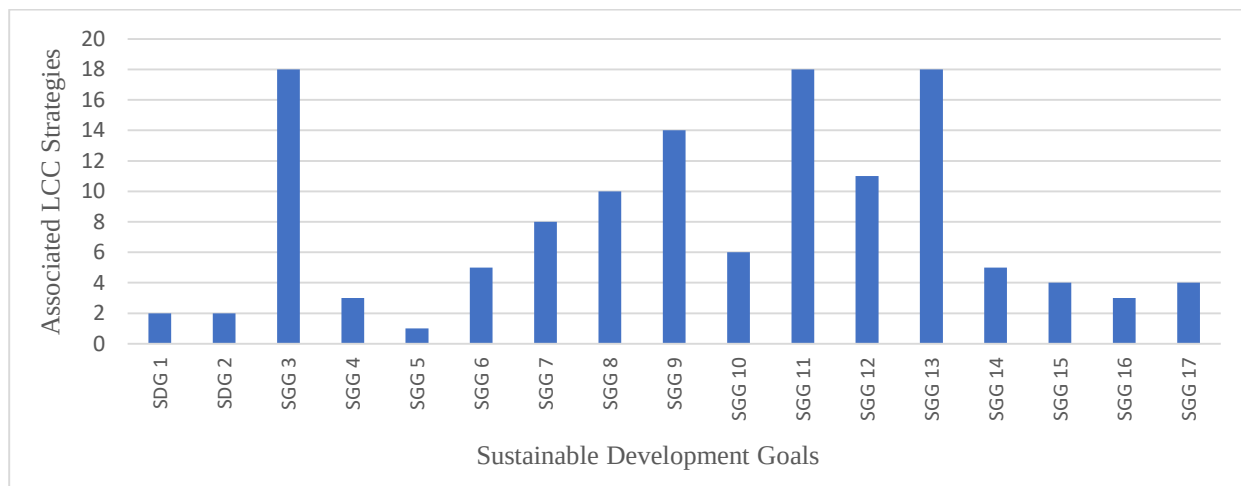


Figure 1: Number of times each SDG is linked to each strategy/indicator to achieve sustainable goals.

Figure 2 reflects that out of 42 strategies, 4 strategies address only one SDG, 17 strategies address two SDGs, 10 strategies where each addresses more than 3 SDGs, and 11 strategies address more than 4 SDGs at a time.



Figure 2: Association between the numbers of strategies from the LCC framework linked against sustainable development goal

The study reveals that the overall direction of sustainable development indicates paths that should be considered to enhance the feasibility of urban development. Adoption of strategies suggested by LCC under different categories can act as guiding principles for sustainable urban development, which addresses geological management and preservation, economic growth and social inclusion. Further classifying it with the Triple Bottom Line (TBL) framework, we can see that 14 targets align with 14 economic, 18 environmental and 16 social frameworks as shown in Figure 3.

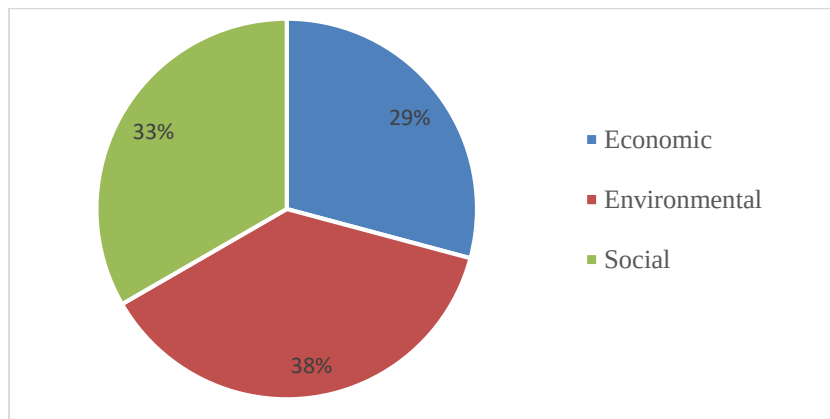


Figure 3: TBL framework association against LCC framework strategies

The study adopts a qualitative thematic analysis through systematic interpretation of the qualitative content analysis from secondary sources. The secondary sources include the report provided in the LEED for Cities and Communities handbook and other related articles available as open source. The study aims to understand how each strategy from the LLCC framework can be linked to SDGs. The SDG-LCC mapping was carried out by grouping codes into themes and then classifying them with the Triple Bottom Line (TBL) framework, as shown in Table 1 below, using a framework analysis approach. .



Figure 4: Association of SDGs in different LCC categories and their association

The analysis reflects that SDG 9 (Industrial innovation and infrastructure) has the highest linkages within the integrated planning processes category. This demonstrates its vital role in fostering integrated planning along with infrastructure development, aligning with regional priorities that promote local innovation and economic growth. Within the category of Natural System and Ecology, SDG 3 (wellbeing) and SDG 13 (climate action) demonstrate strong linkages, as they show high association with strategies like Ecosystem Assessment, Pollution reduction, Green spaces, and resilience planning within the LCC framework.

SDG 7 (Affordable & clean energy) reflects a strong association in the Transport and Land-use category, underlining the substantial energy optimisation potential within the transport system. Using alternative fuel vehicles like electric vehicles (EVs) can help reduce CO2 emissions and address clean energy. Planning concepts like compact planning, mixed-use and Transit Oriented Development enhance accessibility and affordability to people. Improved connectivity and employment opportunities support SDG 3 (health and

wellbeing) and SDG 8 (Decent work & economic growth). It also contributes to SDG 10 (reduced inequalities) as affordable transport also helps reduce inequality, improve accessibility, and foster inclusive urban development, promoting SDG 11 (sustainable cities and communities). Reduced CO₂ emissions to further help reduce climate impacts (SDG 13).

SDG 13 (climate action), followed by SDG 3 (health and wellbeing) and SDG 7 (Affordable and clean energy), establishes strong linkages in the Energy and GHG Emission category as emissions have a direct impact on health and clean energy transitions in sustainable cities and communities (SDG 11). Clean Water and Sanitation (SDG 6) establishes the highest association in the Water Efficiency category of the LCC framework as it addresses critical issues like access to all, water quality and water management. SDG 13 (climate action), followed by SDG 3 (health and wellbeing) and SDG 7 (Affordable and clean energy), establishes strong linkages in the Energy and GHG Emission category as emissions have a direct impact on health and clean energy transitions in sustainable cities and communities (SDG 11). Efficient water consumption and distribution contribute to SDG 12. Furthermore, SDGs 13 and 17 highlight the importance of equitable water access supported by SDG 10 (reduce inequalities) and climate actions in achieving water sustainability, while achieving these objectives often necessitates cross-sectoral collaboration, as highlighted in SDG-17 (partnership for the goal)

Material and Resource identifies material innovation as the core parameter to achieve a sustainable pathway. New industries and infrastructure (SDG 9) are an important deliverable for material production supporting decent work and economic growth (SDG 8) to make cities more sustainable (SDG 11), which helps to combat climate action (SDG 13). It also helps to achieve sustainable life on land and below water due to material extraction (SDG 14, 15) and to consume less of non-renewable material and responsible sourcing through recycling and reuse (SDG 12), for which partnerships across various industries (SDG 17) may be required. The quality of life has a strong correlation with SDG 3 and 11 due to its emphasis on public health systems, social infrastructure, affordable housing and economic development. Quality of life and demographic assessment also touch upon SDG 5 (gender equality), SDG 10 (reduced inequalities), and SDG 4 (quality education) and SDG 2 reduced poverty.

IV RESULTS AND DISCUSSION

The significance of incorporating sustainability principles into urban planning and policymaking is emphasised by the study. Effective implementation requires raising awareness among all stakeholders. LCC offers a thorough framework that complements global sustainability objectives and promotes sustainable urban development. However, stakeholder collaboration and context-specific methods are necessary to achieve the SDGs. The resilience, sustainability, and liveability of cities can be greatly improved by implementing such frameworks throughout the planning phase.

In pursuit of achieving SDGs, government authorities need to commit to the expansion of policies that aim to improve climate action. A combination of context-specific strategies and policies is essential to support SDG attainment and investments that provide positive externalities. Table 2 summarises the strategies and linkages from the LCC evaluation framework for attaining SDGs at the city level. Adoption of suitable strategies for sustainable development is very critical against rapid urban growth. Sustainability goals require serious commitment to long-term sustainability goals, which can be adopted by the LCC framework as a valuable tool for regulating urban development. LCC-based strategies can significantly improve urban resilience and help in the attainment of the United Nations Sustainable Development Goals.

Table 1: Linking of LCC mandatory prerequisites and voluntary credits with SDGs addressed with TBL.

SDG		Strategies to achieve mapped SDG
SDG 1	No poverty	Demographic Assessment, Social Infrastructure
SDG 2	Zero Hunger	Natural Resources Conservation and Restoration
SDG 3	Health & Wellbeing	Ecosystem Assessment, Construction Activity Pollution Reduction, Green Spaces, Resilience Planning, Walkability and Bikeability, Transportation Policy, Water Access and Quality, Stormwater Management, Power Access, Reliability and Resiliency, GHG Emissions, Low Carbon Economy, Solid Waste Management, Demographic Assessment, Economic Growth, Public Health.
SDG 4	Quality Education	Economic Growth
SDG 5	Gender Equality	Demographic Assessment
SDG 6	Clean water & Sanitation	Integrated water management, Water Access & Quality, Storm water management, wastewater management, Social Infrastructure,
SDG 7	Affordable & Clean energy	Walkability and Bikeability, Compact mixed-use and Transit Oriented Development, Access to Quality transit, Power Access, Reliability and Resiliency, Energy Efficiency, Renewable Energy, Social Infrastructure
SDG 8	Decent Work & Economic Growth	Resilience Planning, Compact mixed-use and Transit Oriented Development, waste management and treatment, Recycling infrastructure, Responsible sourcing for infrastructure, Social Infrastructure, Economic growth, Regional Priority
SDG 9	Industry, Innovation & Infrastructure	Green building policy & Incentives, Light pollution reduction, compact mixed-use and Transit-Oriented Development, wastewater management, smart water systems, Renewable energy, low-carbon economy, Construction & Demolition waste management, waste treatment, Responsible sourcing for infrastructure, Innovation
SDG 10	Reduced Inequalities	Water Access and Quality, Power access, reliability and resiliency, Economic growth
SDG 11	Sustainable cities & communities	Integrative planning and designing process, Eco system Assessment, Green spaces, Compact mixed-use and Transit Oriented Development, Historic sites, Low carbon Economy, Grid Harmonisation, waste management and treatment, Recycling infrastructure, Responsible Sourcing for Infrastructure, Social Infrastructure, Affordable housing, Emergency Management & Response, Regional priority
SDG 12	Responsible Consumption & Production	Construction Activity pollution reduction, Natural Resources Conservation & Restoration, Alternative Fuel Vehicles, Integrated water management, Renewable Energy, Grid Harmonisation, Waste generation, Recycling, Responsible sourcing for infrastructure
SDG 13	Climate Action	Integrated planning and designing process, construction activity pollution reduction, Green spaces, Light pollution reduction, Resilience planning, Natural resources conservation & Restoration, Compact mixed-use and transit-oriented development, storm water and wastewater management, Energy & GHG Emissions management, Energy Efficient, low-carbon economy, solid waste, Public health, Emergency Management & Response
SDG 14	Life below water	Natural resources conservation & Restoration, Organic waste treatment, smart waste management systems
SDG 15	Life on Land	Natural resources conservation & Restoration, Historic sites, Recycling Infrastructure
SDG 16	Peace Justice & Strong Institution	Green building policy & Incentives, Resilience Planning
SDG 17	Partnership for the Goals	Green Building Policy & Incentives, Smart water systems, Innovation, Responsible Sourcing for Infrastructure

A key recommendation of this study is to strengthen efforts toward enhancing awareness and understanding of economic, social, and environmental values among stakeholders, thereby promoting healthier and more environmentally responsible lifestyles. Increased seriousness among policymakers can enable efficient evaluation of policy impacts when accompanied regularly by tracking advancements towards the Sustainable Development Goals. The LEED for Cities and Communities (LCC) framework's strategies are encouraged to be integrated into decision-making processes by planners and policymakers. The findings of this study contribute to bridging existing information gaps and enhancing stakeholders' comprehension of sustainable development benefits, while also offering valuable insights for policy formulation.

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Data Access Statement: All relevant data are presented in the paper and its Supporting Information files in Annexures and supplementary files.

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