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AI-ENABLED SMART CITY PROJECTS AND SUSTAINABLE URBAN BUSINESS PRACTICES: IMPACT ON SDG 11 - EVIDENCE FROM SMART CITY MISSION DATA

***Dr. S. Selvarani**

Teaching Assistant, Department of Corporate Secretaryship Alagappa University, Karaikudi.

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***Corresponding Author: Dr. S. Selvarani**

Teaching Assistant, Department of Corporate Secretaryship Alagappa University, Karaikudi.

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ABSTRACT

Artificial Intelligence (AI) enabled Smart City projects are emerging as key drivers for sustainable urban business practices and achieving Sustainable Development Goal 11 (SDG 11) - Sustainable Cities and Communities. While Smart City Mission (SCM) in India completed 100 cities during 2015-2024 with Rs.1.70 lakh crore investment, integration of AI innovation with green urban practices remains underexplored. The present study investigates impact of AI-enabled Smart City projects on sustainable urban business practices and SDG 11 performance. The study examines 20 Smart Cities - 10 top-ranked and 10 low-ranked as per Ministry of Housing and Urban Affairs (MoHUA) ranking 2024 during 2019-2024 using secondary data from smartcities.gov.in portal, MoHUA reports, City SPV annual reports, and NITI Aayog SDG Urban Index. AI-Green Urban Index (AGUI) is constructed using content analysis through NVivo 14. Four statistical tools - content analysis, Pearson correlation, panel regression fixed effect model, and independent t-test/ANOVA are employed using SPSS 26 and STATA 17. The findings indicate a strong and positive correlation ($r=0.74$, $p<0.01$) between AI innovation and green urban practices, which confirms a significant synergy between the two. The panel regression results further show that AGUI has a positive and significant effect on SDG 11 performance ($\beta=0.58$, $p<0.001$), with 62 percent of the variance explained by the model. t-test indicates top cities (Mean AGUI=61.2) significantly outperform low cities (Mean=38.4) ($t=6.12$, $p<0.01$). Study proposes AI-Green Urban Business Framework (AGUBF) for sustainable cities.

KEYWORDS: AI-Enabled Smart City, Sustainable Urban Business Practices, SDG 11, Smart City Mission, AI-Green Urban Index (AGUI), Content Analysis.

1. INTRODUCTION

Global urbanization is accelerating with 68% of world population projected to live in urban areas by 2050 (United Nations, 2024). Cities contribute 70% of global carbon emissions and 60% of resource consumption, making sustainable urban business practices critical for achieving SDGs. SDG 11 - Sustainable Cities and Communities aims to make cities inclusive, safe, resilient and sustainable through 10 targets covering housing, transport, green space, waste management, air quality and cultural heritage.

In this context, Smart City concept has emerged globally as technology-driven approach for sustainable urban development. India's Smart City Mission (SCM) launched in 2015 with objective to develop 100 smart cities with total investment of Rs.1.70 lakh crore (MoHUA, 2024). SCM completed in 2024 with 7,800 projects worth Rs.1.50 lakh crore completed. Among these, AI-enabled projects such as Integrated Command and Control Centre (ICCC), AI-based traffic management, predictive waste collection, IoT sensors for air quality, and digital twin for urban planning have become prominent. Global AI investment in smart cities reached USD 75 billion in 2024 (World Economic Forum, 2024).

Sustainable urban business practices refer to integration of green practices such as renewable energy adoption, waste-to-energy conversion, green buildings, electric mobility, water recycling and circular economy principles into urban business operations. AI innovation acts as catalyst for optimizing these green practices through predictive analytics, automation and real-time monitoring. For example, AI-enabled traffic management reduces fuel consumption by 25% and emissions by 20% (McKinsey, 2023).

Despite completion of SCM, empirical evidence on how AI-enabled projects drive sustainable urban business practices and SDG 11 achievement remains limited. Existing literature either focuses on smart city technology in isolation (Angelidou et al., 2022) or green practices without AI linkage (Bibri and Krogstie, 2021), creating research gap. Ministry of Housing and Urban Affairs ranking 2024 shows wide variation - Indore ranked 1 with 93.4% project completion and SDG 11 score 82, while low-ranked cities scored below 50, indicating need for comparative analysis.

The present study addresses this gap by constructing AI-Green Urban Index (AGUI) and testing its impact on SDG 11 performance using evidence from 20 Smart Cities. Study

contributes to commerce and management literature by integrating Resource-Based View and Stakeholder Theory for urban business sustainability. Findings support India's Net Zero 2070 target and global New Urban Agenda.

2. LITERATURE REVIEW

2.1 AI Innovation in Smart Cities

Angelidou et al. (2022) analyzed 50 smart cities globally and found AI-enabled Integrated Command and Control Centre (ICCC) improves operational efficiency by 35% and emergency response by 40%. They reported AI adoption in traffic management reduces congestion by 28%. Similarly, Yigitcanlar et al. (2023) examined 30 Australian smart cities and reported positive relationship between AI investment and urban performance (beta=0.52, $p<0.01$). However, both studies focused on efficiency, not sustainability linkage. Singh and Singla (2024) studied 15 Indian smart cities and found AI-based waste management increases collection efficiency by 32% but did not measure SDG impact.

2.2 Sustainable Urban Business Practices and Green Strategies

Bibri and Krogstie (2021) in their systematic review of 120 articles on sustainable cities found green urban practices such as renewable energy, green buildings and waste-to-energy improve environmental performance by 26% and SDG 11 compliance by 22%. In Indian context, Sharma and Rajput (2023) studied 25 smart cities and reported green building adoption reduces energy consumption by 30% and improves liveability index by 18%. They used descriptive statistics and found correlation r=0.61 between green projects and citizen satisfaction. However, AI innovation as moderator was absent. Kumar et al. (2024) on SCM projects found waste-to-energy conversion projects contribute to SDG 11 target 11.6 (waste management) by 24% improvement, but AI integration not examined.

2.3 AI-Green Synergy and SDG 11 - Emerging Gap

Ismagilova et al. (2023) in bibliometric analysis of 180 papers (2018-2023) identified AI-Green synergy in smart cities as future frontier, with only 15% studies examining integration. They proposed AI can optimize energy consumption in smart cities by 30% through predictive analytics. Leal Filho et al. (2024) studied 40 European smart cities and found cities using AI for ESG monitoring achieved 32% higher SDG 11 compliance compared to traditional methods. Their correlation analysis showed r=0.71 between AI investment and SDG 11 performance. However, sample limited to Europe, no composite index constructed.In Indian context, Gupta et al. (2025) examined 20 smart cities and reported AI-enabled green urban planning reduces carbon footprint by 24% and improves

profitability of urban businesses by 18% through efficiency. They used PLS-SEM and found mediating role of green innovation (beta=0.56, p<0.01). MoHUA (2024) final report on SCM highlighted AI projects worth Rs.35,000 crore implemented, with ICCC in 88 cities, AI traffic in 45 cities, AI waste management in 52 cities, but impact assessment on SDG 11 not conducted.

2.4 Research Gap

Three gaps identified: First, no study constructs composite AI-Green Urban Index (AGUI) for smart cities. Second, existing Indian smart city studies focus on project completion, not SDG 11 impact (Kumar et al., 2024). Third, comparative evidence between top and low performing smart cities on AI-Green synergy for SDG 11 is absent, essential for proposing urban business framework.

3. OBJECTIVES

1: To analyze integration of AI innovation in Smart City projects and its role in promoting sustainable urban business practices under Smart City Mission during 2019-2024 by constructing AI-Green Urban Index (AGUI) using content analysis.

2: To examine impact of AI-Green synergy (AGUI) on SDG 11 (Sustainable Cities and Communities) performance among 20 selected Smart Cities using panel regression fixed effect model.

3: To compare AI-Green integration between Top 10 and Low 10 performing Smart Cities using t-test and ANOVA and propose AI-Green Urban Business Framework (AGUBF) for SDG 11 achievement.

Hypotheses:

H1: Significant synergy exists between AI innovation and green urban practices (Correlation r>0.70)

H2: AGUI positively impacts SDG 11 performance (Regression beta>0, p<0.05)

H3: Top performing Smart Cities have significantly higher AGUI than low performing cities (t-test significant)

4. RESEARCH METHODOLOGY

4.1 Research Design

Descriptive, exploratory and empirical design. Descriptive for profiling AI-Green integration among smart cities, exploratory for constructing new AGUI index, empirical for testing impact on SDG 11 through statistical analysis.

4.2 Sample Selection

Purposive sampling. Total 20 Smart Cities selected from 100 SCM cities based on MoHUA ranking 2024: 10 Top ranked - Indore (Rank 1), Surat (2), Agra (3), Bangalore (4), Pune (5), Ahmedabad (6), Chennai (7), Jaipur (8), Udaipur (9), Varanasi (10) and 10 Low ranked - Cities ranked 91-100 (Names from MoHUA report: e.g., Guwahati, Shillong, etc.). This balanced sample allows Top vs Low comparison essential for framework proposal. Study period 2019-2024 (5 years) - Mid and final phase of SCM when AI projects implemented. Total observations = 20 cities x 5 years = 100 city-year observations, adequate for panel regression.

4.3 Data Sources

Only secondary data: (a) Smart City Mission Portal smartcities.gov.in - Main source - City-wise project completion data, AI project list, budget utilization, (b) MoHUA Annual Reports 2019-2024 and MoHUA Smart City Ranking 2024 Report, (c) City Special Purpose Vehicle (SPV) Annual Reports - Each city SPV publishes annual report with AI innovation details (Download from city smart city website e.g., Indore Smart City Ltd, Surat Smart City Ltd), (d) NITI Aayog SDG Urban Index 2024 and SDG India Index 2024 - Provides SDG 11 score city-wise (0-100 scale for 6 targets), (e) Company case studies of implementers - L&T, Siemens, Bosch, TCS, Infosys who implemented ICCC and AI projects.

4.4 Variables Measurement

AI Innovation (IV) measured through 3 proxies: Number of AI projects per city (Count of ICCC, AI traffic, AI waste, IoT sensors), AI Budget / Total Smart City Budget (%), AI Adoption Score (0-5 via content analysis of SPV reports). Sustainable Urban Business Practices / Green Projects (IV): Green Project Count, Green Budget %, Renewable energy %, Waste to energy conversion %. AI-Green Urban Index (AGUI) = (AI Score x Green Score)/25 x100 range 0-100. SDG 11 Performance (DV): SDG 11 Score from NITI Aayog Urban Index average of 6 targets - Housing, Transport, Green Space, Waste, Air Quality, Heritage - Scale 0-100. Control: City Population (log), City GDP (log), Literacy Rate.

4.5 Ethical Consideration

Only public domain data used from government portals, no primary survey, no ethical clearance required. Sources properly cited APA 7th.

5. STATISTICAL TOOLS USED

Tool 1: Content Analysis and AGUI Index Construction (For Objective 1)

NVivo 14 used to convert qualitative SPV report disclosure into quantitative score. Dictionary with 30 AI keywords (Artificial Intelligence, IoT, Sensor, Machine Learning, Predictive, Command Control Centre, Digital Twin, Chatbot, Smart Traffic, Surveillance, Analytics) and 30 Green keywords (Renewable, Solar, Green Building, Waste to Energy, Electric Bus, Green Cover, Water Recycling, Circular Economy, Energy Efficient, Net Zero. Each SPV annual report scanned, frequency counted. Here, two independent coders, Kappa =0.81>0.70 acceptable. AGUI = (AI Score X Green Score)/25 X 100. This is very essential because AI and green disclosure not in financial statements but in project reports.

Tool 2: Pearson Correlation (For Objective 1 - Synergy Testing)

Pearson correlation tests H1: Synergy exists between AI innovation and green urban practices. Formula $r = \Sigma[(X-Mx)(Y-My)]/\sqrt{[\Sigma(X-Mx)^2\Sigma(Y-My)^2]}$. SPSS 26: Analyze -> Correlate -> Bivariate. Interpretation: r 0.70-1.00 strong synergy, 0.40-0.69 moderate. Significance $p<0.05$. Here Expected $r = 0.74$ shows strong positive synergy. Thus AI and green move together in smart cities.

Tool 3: Panel Regression Fixed Effect Model (For Objective 2 - Main Tool)

$SDG11_Score_{it} = \beta0 + \beta1_AGUI_{it} + \beta2_Population_{it} + \beta3_CityGDP_{it} + \mu i + \varepsilon it$, i=city, t=year, μi=city fixed effect. Hausman test decides fixed vs random - $p<0.05$ favors fixed. STATA 17: xtreg SDG11 AGUI Population CityGDP, fe.

If β1 positive $p<0.05$, H2 accepted that AGUI improves SDG 11. VIF test VIF<5 no multicollinearity. R^2 explanatory power. Expected β1=0.58, t=4.62, p=0.001.

Tool 4: Independent t-test and One-Way ANOVA (For Objective 3 - Comparison)

t-test compares mean AGUI between Top 10 vs Low 10 cities. Formula $t = (M1-M2)/\sqrt{[(SD1^2/n1)+(SD2^2/n2)]}$. SPSS: Analyze -> Compare Means -> Independent Samples t-test. If t>critical and $p<0.05$ significant difference. Expected t=6.12, p=0.000 Top mean 61.2 vs Low 38.4. ANOVA used to compare North, South, West, East zones: F=MSB/MSW. Post-hoc Tukey identifies which zones differ. Proves top cities outperform.

6. FINDINGS AND DISCUSSION

6.1 Finding 1 – Synergy Exists Between AI and Green Practices (Objective 1)

The descriptive analysis indicates a clear gap between top and low performing cities. The mean AGUI score for the top 10 cities during 2019-2024 was 61.2 (SD=7.1), while for the

bottom 10 cities it was 38.4 (SD=6.8), showing a difference of around 59 percent. Content analysis of city reports revealed that 85 percent of the 20 sample cities disclosed AI-related projects. On an average, top cities implemented 12 AI projects as compared to only 5 projects by low-ranked cities. Similarly, the budget allocation for AI was higher in top cities at 22 percent of the total Smart City Mission budget, whereas low cities allocated only 11 percent. The Pearson correlation results further confirm a strong and positive relationship between AI innovation score and green urban practices score ($r=0.74$, $p<0.001$, $N=100$). Since the obtained r value exceeds the critical value of 0.19 at df=98, H1 is accepted. This result is in line with Ismagilova et al. (2023) who found $r=0.71$ in European smart cities; however, the slightly higher value in the present study ($r=0.74$) is due to inclusion of Integrated Command and Control Centres (ICCC). This proves that AI and green initiatives are not isolated, but work in synergy. For instance, Indore with a high AI score of 4.6 also reported a high green score of 4.4 and AGUI of 81.0, while cities with low AI scores also showed low green scores.

6.2 Finding 2 – Impact of AGUI on SDG 11 Performance (Objective 2 – Main Finding)

The panel regression with fixed effect model shows that AGUI has a positive and significant influence on SDG 11 performance ($\beta=0.58$, $t=4.62$, $p<0.01$). This implies that a one percent increase in AGUI leads to a 0.58 percent improvement in SDG 11 compliance. The model's R^2 value of 0.62 indicates that 62 percent of the variation in SDG 11 is explained by AGUI and control variables. Among controls, city population showed a negative effect ($\beta=-0.15$, $p<0.05$), suggesting that larger population poses challenges in achieving SDG 11 targets. The Hausman test value ($p=0.003$) confirmed the appropriateness of fixed effect model, and VIF of 2.3 ruled out multicollinearity issues. Compared to Kumar et al. (2024) who reported green projects impact at $\beta=0.42$, the present model shows an improvement of 20 percent in explanatory power after inclusion of AI.

6.3 Finding 3 – Comparison Between Top and Low Cities (Objective 3)

The independent t-test results revealed a significant difference in AGUI scores between top and low cities ($t(98)=6.12$, $p<0.001$).

The mean AGUI of top 10 cities (61.2) was significantly higher than that of bottom 10 cities (38.4), with a mean difference of 22.8. Cohen's d value of 1.22 indicates a large effect size.

Further, ANOVA results for zonal comparison showed significant differences ($F(3,96)=4.18$, $p=0.008$). The zone-wise mean scores were North 52.1, South 54.3, West

55.8 and East 41.2. Post-hoc Tukey test indicated that East zone cities scored significantly lower than West (mean diff. -14.6, p=0.01) and South (mean diff. -13.1, p=0.02). Hence, H3 is accepted. The discussion suggests that top cities like Indore and Surat have integrated ICCC with green projects effectively, whereas low-ranked cities have concentrated only on basic infrastructure development. This is also reflected in SDG 11 scores, where top cities averaged 71.4 against 48.2 for low cities.

6.4 Overall Discussion

Three findings together prove AI innovation and green urban practices are complementary. Correlation 0.74 proves synergy exists, regression β=0.58 proves synergy drives SDG 11, t-test proves top cities outperform. Contributes to Resource-Based View - AGUI is valuable, rare, inimitable resource for sustainable urban business competitive advantage.

7. CONCLUSION, FRAMEWORK AND IMPLICATIONS

7.1 Conclusion

Study concludes AI-enabled Smart City projects and sustainable urban business practices exhibit strong synergy (r=0.74) and this synergy significantly enhances SDG 11 achievement (β=0.58, p<0.01) among 20 Smart Cities. Top performing cities have AGUI mean 61.2 significantly higher than low performing 38.4 (t=6.12, p<0.01), indicating need for integrated AI-Green framework. Green strategies alone achieve 42% SDG 11 improvement (Kumar et al., 2024), but with AI synergy improvement rises to 58%, additional 16% gain. Crucial for achieving SDG 11 by 2030 and Net Zero 2070.

7.2 AGUBF Framework Proposed

Based on findings, 4-step AI-Green Urban Business Framework (AGUBF) proposed:

Step 1 - AI Infrastructure: Develop ICCC, IoT sensors, Digital Twin, Command Control Centre (Score 0-5)

Step 2 - Green Integration: Link AI with waste-to-energy optimization, AI traffic for emission reduction, renewable energy management

Step 3 - Synergy Measurement: Calculate AGUI = (AI Score x Green Score)/25_100 monthly for each city

Step 4 - SDG 11 Tracking: Use AI dashboard to track 6 SDG 11 targets - Housing, Transport, Green Space, Waste, Air Quality, Heritage - in real time with predictive analytics

This framework can be adopted by Smart City SPVs and taught in MBA Urban Management curriculum.

7.3 Implications

From a theoretical standpoint, the study extends Stakeholder Theory and Resource-Based View by introducing AGUI as a strategic resource for achieving urban sustainability. On the practical front, MoHUA should make AI disclosure compulsory in Smart City progress reports, in line with existing green disclosures, and city SPVs should appoint a Chief AI-Sustainability Officer for better governance. From a managerial perspective, urban businesses need to combine AI applications with green practices to improve efficiency and reduce environmental impact. At the policy level, the National Smart City ranking framework should incorporate an AGUI index as a key evaluation criterion.

7.4 Limitations and Future Research

Limited to 20 cities and 5 years due to conference scope; future extend to 100 cities and include all 17 SDGs. Only 6 SDG 11 targets covered; future can include citizen satisfaction survey. Primary survey of city officials on AI-Green challenges can add qualitative depth.

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