Executive Summary:

Title of the Project: “**Satellite Insights into Green Spaces: Towards Sustainable Cities**”

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Introduction:

This study conducts a multidimensional analysis of urban sustainability, using satellite imagery to assess the balance between built-up areas and green spaces. By evaluating vegetation distribution and its elasticity, we contribute to Goal 15 (Life on Land) while intersecting with Goals 11 (Sustainable Cities and Communities), 13 (Climate Action), and 3 (Good Health and Well-being). Our research highlights the role of urban green spaces in enhancing climate resilience, mitigating urban heat island effects, and promoting the well-being of city dwellers. Collaboration and data sharing, essential for achieving these goals, align with Goal 17 (Partnerships for the Goals).

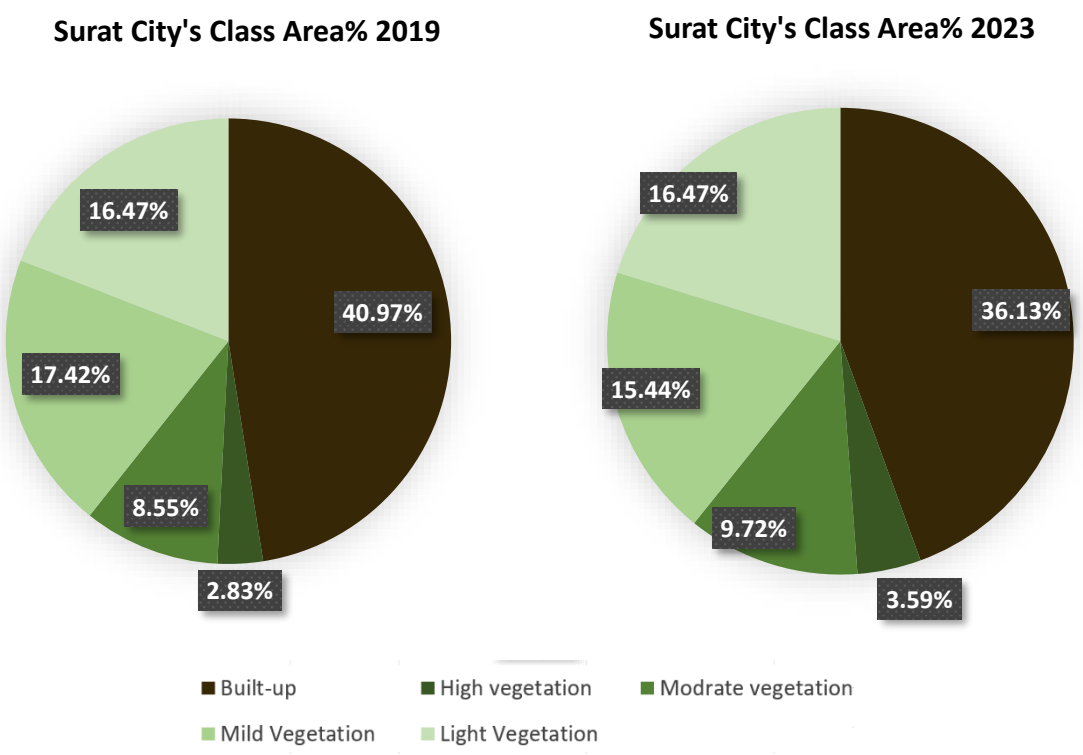
Study Area and Importance of Remote Sensing in Surat:

Our study focuses on Surat City in Gujarat, India, a rapidly urbanizing commercial hub known as "The Silk City," "The Diamond City," and "The Green City." Spanning 461.6 square kilometers and divided into 8 zones and 134 wards, Surat has experienced significant population growth due to its strong economy and job opportunities. Remote sensing plays a crucial role in sustainable urban development by providing precise data on land use, vegetation, and urban expansion. In cities like Surat, it helps balance growth with ecological preservation, enabling informed decisions for achieving sustainability goals.

Key Findings:

Land Cover Changes in Surat: 2019 vs. 2023

- **Built-up Areas**: Decreased from 40.97% in 2019 to 36.13% in 2023, reflecting a reduction in urban space.
- **High Vegetation**: Increased from 2.83% to 3.59%, showing growth in dense green cover.
- **Moderate Vegetation**: Rose from 8.55% to 9.72%, indicating a slight expansion in moderately vegetated areas.
- **Mild Vegetation**: Decreased from 17.42% to 15.44%, suggesting a reduction in lighter green cover.
- **Light Vegetation**: Remained constant at 16.47%, indicating stable low-density green areas.



Conclusion: Surat experienced a significant 1.17% increase Moderate vegetation and significant decline of 1.98% in Mild vegetation cover from 2019 to 2023

Built-Up to Green Cover Ratio in Surat (2019-2023)

- 2019: Built-up area was 16.15 times the green cover.
- 2020: Increased to 19.99 times, showing accelerated urban expansion.
- 2021: Peaked at 21.14 times, indicating the highest growth relative to green cover.
- 2022: Slightly decreased to 19.23 times, but still high.
- 2023: Remained at 20.64 times, reflecting continued significant urban growth.

Conclusion: Mumbai and Ahmedabad show an increase in green spaces, with Mumbai's being more significant. Bangalore has seen a slight rise in built-up areas. Surat and Vadodara have increased urbanization, but Surat shows potential green cover efforts. Chandigarh maintains high vegetation cover. Overall, trends vary, with some cities focusing on greenery and others on urban growth.

Analyzing Vegetation Elasticity in Tier 1 & 2 Cities: Effects of Built-Up Areas (2019-2023)

Vegetation Type	Impact of 1% Increase in Built-Up Area					
	Mumbai	Bengaluru	Ahmedabad	Surat	Vadodara	chandigarh
High Vegetation	-0.22	-0.09	-0.42	-0.06	-0.37	0
Modrate Vegetation	-0.21	-0.34	-0.37	-0.31	-0.16	-0.09
Mild Vegetation	-0.68	-0.67	-0.2	-0.52	-0.68	-0.11
Light Vegetation	0.58	0.32	-0.82	-0.06	-0.12	0.3
High+Modrate Vegetation	-0.62	-0.39	-0.25	-0.26	-0.54	-0.22
High+Mild Vegetation	-0.21	-0.12	-0.35	-0.15	-0.26	-0.11
High+Light Vegetation	0.5	0.16	-0.57	-0.05	-0.16	-0.1
Modrate+Mild Vegetation	0.18	-0.1	-0.67	-0.16	-0.18	-0.13
Modrate+Light Vegetation	0.49	0.17	-0.73	-0.04	0.03	-0.26
Mild+Light Vegetation	-0.66	-0.54	-0.25	-0.47	-0.46	-0.24
High+Modrate+Mild Vegetation	-0.37	-0.37	-0.33	-0.3	-0.4	0.3
High+Modrate+Light Vegetation	0.05	-0.04	-0.54	-0.14	-0.22	0.37
High+Mild+Light Vegetation	-0.11	-0.15	-0.48	-0.21	-0.39	0.33
Modrate+Mild+Light Vegetation	-0.1	-0.23	-0.46	-0.3	-0.32	0.4
High+Modrate+Mild+Light Vegetation	-0.13	-0.19	-0.45	-0.24	-0.33	-0.19

In Surat, even a small 1% increase in built-up areas slightly reduces green cover across all vegetation types, with **mild vegetation seeing the most significant loss at 0.52%**. However, **light vegetation shows remarkable resilience, decreasing by just 0.06%**. This suggests that while urban expansion is encroaching on the city's greenery, certain types of vegetation are holding their ground better than others.

In Vadodara, **moderate and high vegetation are moderately impacted**, with decreases of 0.16% and 0.37%, respectively, highlighting a more delicate balance between development and green spaces. Chandigarh, however, tells a different story—**light vegetation actually thrives with a 0.3% increase**, reflecting effective urban greening strategies.

Moving to Tier 1 cities, **Mumbai faces notable challenges with high vegetation decreasing by 0.22%**, yet it also sees an unexpected **0.58% increase in light vegetation**, suggesting targeted efforts to maintain green areas amidst rapid urbanization. Bengaluru sees a similar trend, with **moderate vegetation taking a hit but light vegetation growing by 0.32%**. In contrast, **Ahmedabad shows significant vulnerability**, particularly in light vegetation, which drops by **0.82%**, indicating that its green areas are under intense pressure from urban development.

Conclusion: Urban expansion in these Indian cities is exerting varying levels of pressure on green spaces. **Surat and Ahmedabad are particularly vulnerable**, with significant losses in mild and light vegetation. However, **light vegetation in Mumbai, Bengaluru, and Chandigarh shows some resilience or even growth**, suggesting that targeted urban greening initiatives can mitigate the negative impacts of development. The data underscores the importance of strategic planning to protect and enhance green areas as cities continue to grow.

Importance of the Study with Respect to the Sustainable Development Goals (SDGs)

1. **Goal 15: Life on Land**
    - **Protection of Ecosystems:** The study emphasizes the need to preserve green cover in urban areas, which directly contributes to the conservation of terrestrial ecosystems. Protecting and restoring mild vegetation and green spaces help maintain biodiversity, prevent land degradation, and support ecosystems that are crucial for life on land.
    - **Resilience of Vegetation:** By examining the elasticity of vegetation in response to urban expansion, the study informs strategies to strengthen the resilience of natural ecosystems in urban settings.
2. **Goal 11: Sustainable Cities and Communities**
    - **Urban Sustainability:** The findings highlight the role of urban green spaces in promoting sustainable cities. Green spaces enhance the quality of life by reducing air pollution, mitigating the urban heat island effect, and providing recreational spaces for residents.
    - **Inclusive Urban Planning:** The study supports the development of policies that integrate green infrastructure into urban planning, ensuring that cities grow sustainably without compromising the well-being of their inhabitants.
3. **Goal 13: Climate Action**
    - **Climate Mitigation:** Urban vegetation plays a significant role in carbon sequestration and temperature regulation, helping cities adapt to and mitigate the impacts of climate change. The study's focus on preserving green cover contributes to climate resilience strategies.
    - **Disaster Risk Reduction:** By strengthening roadside vegetation and other green spaces, the study suggests ways to reduce the vulnerability of urban areas to extreme weather events, such as cyclones, which are expected to increase in frequency due to climate change.
4. **Goal 3: Good Health and Well-being**
    - **Public Health Benefits:** The study underscores the importance of green spaces in promoting physical and mental health. Urban green areas provide clean air, reduce stress, and encourage physical activity, contributing to the overall well-being of city residents.
    - **Reduction of Health Inequalities:** By advocating for the expansion of green spaces, particularly in densely populated and underprivileged areas, the study supports efforts to reduce health disparities among urban populations.
5. **Goal 17: Partnerships for the Goals**
    - **Collaborative Urban Planning:** The study calls for collaboration between government bodies, environmental organizations, and the public in implementing urban sustainability initiatives. Data sharing and partnerships are essential to effectively monitor and protect green spaces, ensuring that sustainability efforts are comprehensive and inclusive.

Policy Recommendations Based on the Study

1. **Urban Greening Policies:**
    - **Green Infrastructure Integration:** Develop policies that mandate the incorporation of green roofs, vertical gardens, and urban parks in new construction projects. Incentivize developers to prioritize green spaces in urban design.
    - **Green Space Accessibility:** Ensure equitable access to green spaces across all city areas, particularly in low-income neighborhoods, through strategic urban planning.
2. **Ecosystem Protection Policies:**
    - **Conservation of Mild Vegetation Zones:** Establish regulations that protect vulnerable mild vegetation zones, including roadside trees, from further degradation due to urbanization. Create buffer zones and enforce construction practices that are vegetation-friendly.
    - **Tree Protection Ordinances:** Implement and enforce ordinances that restrict the use of impermeable materials around tree roots and mandate the use of permeable surfaces to support tree health.
3. **Climate Resilience Policies:**
    - **Urban Climate Adaptation Plans:** Develop and implement urban climate adaptation strategies that incorporate the preservation and expansion of green spaces as a key element in mitigating the effects of climate change.
    - **Disaster Preparedness:** Integrate green cover protection into disaster preparedness plans, ensuring that urban vegetation is resilient to extreme weather events.
4. **Public Health Policies:**
    - **Health and Green Spaces Link:** Recognize green spaces as essential components of public health infrastructure. Promote policies that connect the development of urban green areas with public health initiatives, particularly in densely populated cities.
    - **Community Health Programs:** Encourage the integration of community health programs with urban greening efforts, fostering active participation in the creation and maintenance of green spaces.
5. **Remote Sensing and Data-Driven Policies:**
    - **Data-Driven Urban Planning:** Utilize remote sensing data to inform urban planning decisions, ensuring that policies are based on accurate and up-to-date information about land use changes and vegetation health.
    - **Monitoring and Evaluation:** Establish monitoring frameworks using remote sensing to regularly assess the effectiveness of green cover policies and make necessary adjustments based on real-time data.

By aligning with the SDGs, these policies will not only protect and enhance Surat's green cover but also contribute to global sustainability efforts, creating a healthier, more resilient urban environment for current and future generations.

Conclusion

To sustain Surat's green cover amidst rapid urbanization, it is imperative to adopt a multifaceted approach that includes strengthening roadside vegetation, expanding urban greening initiatives, and protecting vulnerable mild vegetation zones. Remote sensing plays a critical role in this effort, offering cost-effective and precise monitoring capabilities that support effective urban planning and environmental conservation. By prioritizing the preservation and enhancement of green spaces, Surat can achieve a balance between growth and sustainability, ensuring the well-being of its residents and contributing to broader environmental goals.

The decline in mild vegetation, especially roadside trees, underscores the need for strategic interventions to prevent further degradation and promote the resilience of urban ecosystems.