Geospatial for Good: Empowering Citizens for Sustainable Urban and Rural Futures

Subrat Kumar Malick [1], Vishwas Chavan [2, 4], Shirish Ravan [2, 3]

[1] Indian Institute of Science Education and Research, Berhampur, Odisha, India – subrat21@iiserbpr.ac.in
[2] EarthSight Foundation, Pune, India – shirishravan@gmail.com, chavan.vishwas@gmail.com
[3] School of Environmental Sciences, Bharati Vidyapeeth, Pune, India
[4] NIST University, Institute Park, Berhampur

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Abstract

Geospatial technologies are rapidly emerging as pivotal tools for advancing sustainable urban and rural development through citizen empowerment in India and worldwide. This study systematically reviews peer-reviewed and grey literature to examine their integration with global frameworks, such as the SDGs, Paris Agreement, and Sendai Framework, while aligning with Indian initiatives like NAPCC, Smart Cities, Digital India, SVAMITVA, AMRUT, and the National Geospatial Policy 2022, with emphasis on the citizen as a crucial feedback factor. Employing thematic mapping and comparative analysis between the Global North and South, we evaluate applications in urban planning, mobility, energy, resilience, and health, highlighting platforms like PPGIS, VGI, Bhuvan, and 'Know Your DIGIPIN' for participatory data collection and decision-making.

Our analysis reveals regional disparities in India, with the southern zone leading in innovation (35% adoption) and the eastern region focussing on disaster management (15%), along with global successes in disaster relief, welfare targeting, and immunisation tracking. Quantitative impacts include India's geospatial market growth to ₹63,000 crores by 2025 and AMRUT 2.0's rapid water and sewerage coverage expansion in many major cities. However, persistent challenges include technical knowledge gaps in academia, insufficient institutional support for geospatial startups, and barriers like low digital literacy and language limitations that restrict broader participation.

We recommend enhanced geospatial education, open data policies, vernacular interfaces, and inclusive citizen science frameworks to bridge these gaps, foster equitable participation, and realise geospatial intelligence's full potential for resilient, data-driven sustainability.

1. Introduction

Geospatial technologies are crucial in supporting sustainable development by enabling the mapping, monitoring, and management of natural resources, urban environments, and social systems. These technologies like remote sensing, GIS, and Earth observation satellites give us detailed location data that help us understand how resources are doing, spot potential problems, and make informed choices for sustainability efforts (Gbadegesin and Orimoogunje, 2019; Cetl et al., 2025; Avtar et al., 2019). They play a vital role in tracking progress toward the United Nations Sustainable Development Goals (SDGs) by supplying the data needed for measuring, monitoring, and reporting on a wide range of indicators, from food security and biodiversity conservation to climate action and urban planning (Cetl et al., 2025; Pandey and Pandey, 2023; Costa et al., 2024; Varriale et al., 2024; Avtar et al., 2019).

In agriculture, geospatial tools support precision farming and biodiversity management, directly contributing to food security and environmental sustainability (Pandey and Pandey, 2023; Varriale et al., 2024). The integration of geospatial data with Internet of Things (IoT) devices supports precision farming, allowing localized monitoring of crop health and environmental conditions to enhance productivity and resource efficiency (NITI Aayog, 2018).

In urban contexts, these technologies help optimize the use of blue-green spaces and support the development of smart, sustainable cities (Costa et al., 2024; Sunita and Kumar, 2021). Geographic Information Systems (GIS) underpin spatial planning, zoning, and infrastructure optimization, helping improve service delivery and sustainability outcomes.

Combining artificial intelligence and machine learning with geospatial data improves our ability to predict outcomes and plan for different scenarios, allowing us to respond to environmental issues more accurately and quickly.

Despite challenges in policy integration and equitable access, geospatial technologies are increasingly recognized as foundational for achieving and monitoring sustainable development at local, national, and global scales (Gbadegesin and Orimoogunje, 2020; Cetl et al., 2025; Avtar et al., 2019).

Geospatial technology is revolutionising the planning, governance, and development of urban and rural spaces. Moving beyond static mapping, these tools now enable dynamic, real-time decision-making across sectors.

India has officially adopted this potential via strategic frameworks, including the National Geospatial Policy (NGP) 2022 and the National Geospatial Mission (NGM) 2025–26. These initiatives aim to democratize access to publicly funded geospatial data and foster innovation across government, industry, and academia (Press Information Bureau, 2025).

By mandating open access and citizen-oriented design, these policies seek to empower communities with spatial intelligence, enabling more informed participation in development processes and fostering inclusive, data-driven governance.

2. Methodologies

This study investigates the integration of geospatial technologies in sustainable urban and rural development, emphasizing citizen empowerment. Through a systematic literature review of peer-reviewed and grey sources, we analysed key domains—geospatial technologies, citizen empowerment, and sustainability—and their alignment with global frameworks like the SDGs, the Paris Agreement, and the Sendai Framework. The review focused on platforms like Public Participation GIS (PPGIS), assessing citizen engagement in resource use and feedback.

Global and national geospatial initiatives, such as India’s Bhuvan, Smart Cities, and AMRUT, were mapped to evaluate their sustainability alignment and citizen participation indices,

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with zonal analysis across Indian regions highlighting key drivers in major cities. Impact was measured through data integration and policy influence, noting barriers like low digital literacy and fragmented governance (Mohan & Singh, 2021; Ghosh et al., 2018). The study aligns with frameworks like PPGIS, citizen science, and India's National Geospatial Policy 2022.

A comparative analysis between the Global North and South revealed differences in geospatial data use for governance and disaster management, focusing on infrastructure optimization and data accessibility. Recommendations include enhancing Indian citizen-geospatial platforms through outreach, training, open data access, local language interfaces, and inclusive citizen science to boost participation and impact.

3. Sustainability Frameworks and Thematic Alignment

3.1. Alignment with Global and National Frameworks

Geospatial technologies play a critical role in advancing international sustainability frameworks. The Sustainable Development Goals (SDGs) provide a unified agenda for addressing global challenges such as poverty, inequality, and climate change, while the Paris Agreement mandates emissions reduction and technological collaboration through periodic Nationally Determined Contributions (Ilyin et al., 2016; UNFCCC, 2015). Complementing these, the Sendai Framework (UNDRR, 2015) emphasizes disaster risk reduction, particularly through geospatial early warning systems and hazard mapping, supported by initiatives like UN-SPIDER.

India's national strategy aligns closely with these global commitments. The National Action Plan on Climate Change (NAPCC) (MoEFCC; GoI, 2018) and associated State Action Plans (SAPCCs) integrate geospatial technologies into sectoral missions on solar energy, urban resilience, and biodiversity. Key initiatives including Digital India, Smart Cities, AMRUT, PM Gati Shakti, and SVAMITVA leverage GIS, remote sensing, and drone data for infrastructure optimization, land record modernization, and participatory planning. Platforms like Bhuvan and standards developed under NSDI promote data interoperability and public access. Institutional actors such as ISRO and NRSC continue to drive training, innovation, and integration, underscoring India's commitment to geospatially enabled governance.

3.2. Thematic Mapping: Geospatial Contributions to Urban Planning, Mobility, Energy, Resilience, and Health

Geospatial data and GIS are essential for assessing environmental conditions, identifying concerns, and tracking changes, forming a foundation for evidence-based sustainable development decisions (Scott and Rajabifard, 2017; Kovacs-Györi et al., 2020). In urban planning (SDG 11), these technologies enable precise land-use mapping, infrastructure design, and Digital Twins using high-resolution surveys and DEMs, aiding population and economic modelling (Batty, 2018). For mobility (SDG 9), GIS supports traffic management, vehicle tracking, and multimodal planning, optimizing infrastructure and reducing congestion (Zhang, 2023). In energy (SDG 7), GIS identifies optimal sites for solar and wind installations, models resources, and forecasts production, enhancing renewable energy access (Avtar, Sahu, et al., 2019). For resilience and climate action (SDG 13, Sendai Framework), Earth Observation and GIS map vulnerabilities, support early warnings, and enable "Build Back Better" reconstruction (Mannakkara and Wilkinson, 2013). In health (SDG 3), GIS aids disease surveillance, analyses triggers, and identifies high-risk areas, improving public health planning (Franch-Pardo et al., 2020). These efforts align with global frameworks (SDGs, Paris Agreement, Sendai Framework) and Indian programs (NAPCC, Smart Cities, AMRUT), with the National Geospatial Policy 2022 reinforcing geospatial tools as key enablers of sustainability metrics (DST, 2022), as illustrated in Figure 1.

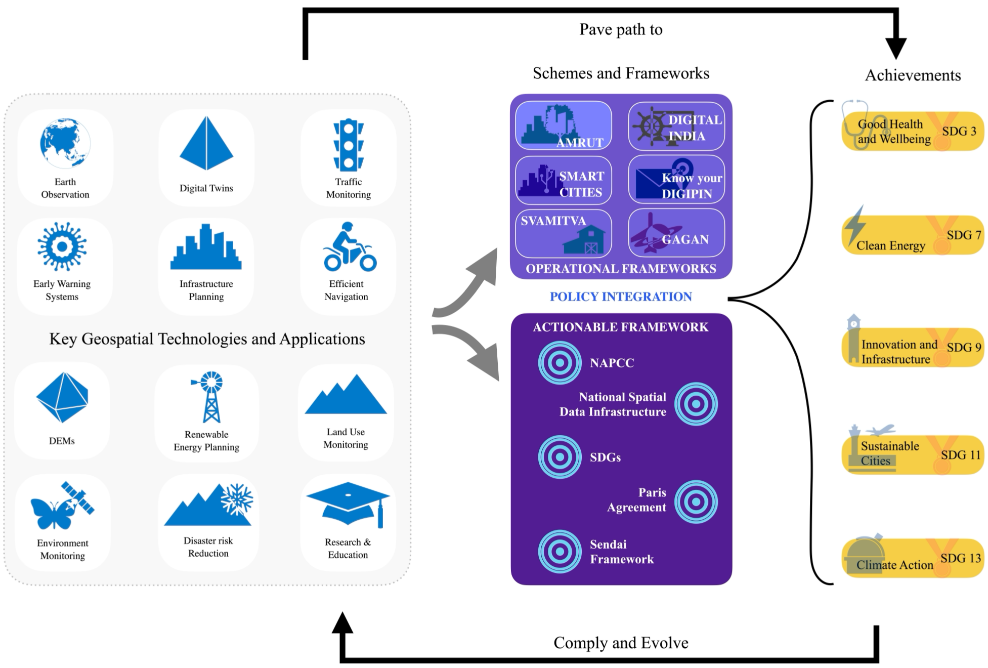

Figure 1. Geospatial Applications Across Thematic Areas for Sustainable Development

4. Conceptual and Scientific Foundations of Geospatial Technologies

Modern geospatial systems rely on Remote Sensing (RS), Geographic Information Systems (GIS), and Global Navigation Satellite Systems (GNSS) to collect, combine, and analyse spatial data for better planning and sustainability. RS has advanced from aerial imagery to high-resolution satellite and UAV coverage; GIS enables multi-layered visualisation; and GNSS (e.g., GPS, NavIC) ensures positional accuracy across applications from urban mapping to disaster response. The rise of the Big Data era has expanded this foundation with AI/ML, IoT, cloud computing, and drones, enhancing geospatial intelligence. AI-based image analysis supports rapid environmental assessments, IoT delivers hyperlocal data, and cloud platforms like GEE democratize processing power for researchers and planners (Zhu et al., 2017; Zhou et al., 2022). UAVs and digital twin models further enable dynamic monitoring for precision agriculture and smart infrastructure (Batty, 2018). Critically, these technologies now empower citizens through Public Participation GIS (PPGIS), Volunteered Geographic Information (VGI), and user-centric platforms. Initiatives like Plantix, StoryMaps, and India's DIGIPIN system exemplify how participatory tools enhance transparency, foster co-creation, and localize decision-making (Brown and Kyttä, 2013; Lee et al., 2022). This transition marks a shift from top-down data consumption to collaborative spatial governance.

5. India's Citizen-Centric Geospatial Programs: Implementation, Impact, and Adoption

India's geospatial transition is anchored in the National Geospatial Policy (NGP) 2022 and the National Geospatial Mission (NGM) 2025–26, which aim to democratize access to spatial data, conduct high-resolution topographic surveys, and establish digital twin models for major cities by 2035 (DST 2022). Supported by a ₹100 crore budget, NGM is closely aligned with PM Gati Shakti, integrating 16 ministries through spatial tools from ISRO and BiSAG-N for coordinated infrastructure planning (MoS&T, 2022).

Characteristic	Southern Region	Western Region	Northern Region	Eastern Region
Regional Archetype	Technology and RD Hub	Infrastructure & Smart Urbanization	Governance & Disaster Resilience	Resource Management & Emerging Frontier
Key Drivers	Private sector enterprise, IT ecosystem synergy, R&D	Large-scale industrial projects, Smart Cities Mission	Government e-governance initiatives, disaster management needs	State government agencies (SRSACs), natural resource management
Primary Domains	Precision Agriculture, Software/Analytics, IT/BPM Services	Smart Cities, Industrial Corridors, Logistics, Utilities	Land Administration (SVAMITVA), Urban Governance, Disaster Risk Reduction	Natural Resource Management (Mining, Forestry), Water Resources, Rural Development
Market Indicators	Leader in geospatial analytics; ₹8,500 cr investment (2020-23)	High investment in smart cities (₹23,000 cr in 3 cities) & DMIC (₹17,500 cr)	Hub for geospatial companies (Delhi NCR) and governance projects (UP, Haryana)	Strategic investment in North-East (e.g., OCTANE CoE: ₹68.76 cr)
Key States	Karnataka, Andhra Pradesh, Tamil Nadu	Maharashtra, Gujarat	Uttar Pradesh, Haryana, Delhi, Uttarakhand, Himachal Pradesh	Odisha, West Bengal, Bihar, Jharkhand, North-Eastern States
Major Hubs	Bengaluru, Hyderabad	Mumbai, Pune, Ahmedabad, Nagpur	Delhi NCR, Lucknow, Kanpur, Dehradun	Kolkata, Bhubaneswar, Guwahati, Itanagar
Representative Projects	Precision Ag initiatives covering 2.3M ha, Operation Dronagiri (AP)	38% of India's Smart Cities, Genesys Digital Twin project	SVAMITVA (Haryana), Kashi Geo-Hub (UP), Himalayan Flood Modelling	Odisha 4K GEO Portal, I-BHUGOAL (Bihar), Mining monitoring (Jharkhand)
Key Challenges	Talent retention, market saturation in specific service areas	High cost of large-scale infrastructure integration	Policy-implementation friction, inter-state coordination	Capacity constraints, last-mile connectivity, dependence on govt. funding
Reference	(DD News, 2025)	(Pednekar, 2025; Software Technology Parks of India, n.d.)	(DST, 2022; Rawat, Pant and Bisht, 2017),	(ORSAC, nd; Singh and Ranjan, 2017; Goparaju, Prasad and Ahmad, 2017)

Table 1. Regional archetypes, strategic drivers, sectoral domains, and key challenges of the India's Geospatial Ecosystem.

Numerous citizen-oriented platforms have emerged from this framework. Bhuvan (by ISRO/NRSC) offers free satellite data, thematic layers, and mobile apps for sectors like agriculture, urban planning, and disaster response (NRSC, 2022; Ghosh et al., 2018). AMRUT 2.0 employs GIS for managing urban water and sanitation systems in 500 cities, increasing tap water and sewerage coverage to 70% and 62%, respectively (MoHUA, 2021). The Smart Cities Mission uses GIS and AI for real-time traffic and city management (NITI Aayog, 2018). Meanwhile, the National Urban Health Mission (NUHM) uses spatial targeting to enhance health services, specifically in low-income urban areas, even though it is not explicitly geospatial (MoHFW, 2021).

The National Spatial Data Infrastructure (NSDI) and National Data Registry (NDR) ensure interoperability using OGC, ISO, and BIS standards (FGDC, 2020), while rural programs like SVAMITVA employ drones for land parcel mapping to strengthen property rights and reduce disputes (MoPR, 2021). 'Know Your DIGIPIN' and 'Know Your PIN Code' platforms enhance address geocoding, logistics, and emergency response through citizen feedback integration (DST, 2022).

These efforts align with SDGs across climate resilience, infrastructure, public health, and disaster management. India's solar capacity increased from 80 GW in 2022 to 92.12 GW in 2024, contributing to the objectives of the Paris Agreement goals (MNRE, 2024). The National Mission on Climate Change and Human Health introduced early warning systems in 50 cities, reducing climate-related morbidity (MoHFW, 2021). Globally, countries like the UAE have adopted geospatial dashboards to track SDG progress (Sustainable Development Report, 2025; UNESCWA, 2024).

Nevertheless, the efficacy of such initiatives relies not solely on legislation but also on public adoption. Although commercial applications such as Google Maps and civic reporting tools are widely utilised (Goodchild, 2007; Zhand and Zhou, 2019), Bhuvan indicates minimal user engagement in official records, with instances of "0" hits and downloads. This highlights a critical gap in usability, outreach, and interface design. Achieving impact requires redesigning public platforms with intuitive interfaces, vernacular accessibility, and citizen co-creation (DST, 2022; Goodchild and Glennon, 2010). This highlights a critical gap in usability, outreach, and interface design. Achieving impact requires redesigning public platforms with intuitive interfaces, vernacular accessibility, and citizen co-creation.

The Indian geospatial market is experiencing significant growth, estimated at ₹38,972 crores in 2021 and employing approximately 470,000 people (Mathur, 2024). Projections indicate a substantial increase to ₹63,000 crores and employment for around 10 lakh people by 2025 (Press Information Bureau, 2022), with the market further anticipated to reach ₹1 lakh crore by 2030 (Mathur, 2024; Ramamoorthy et al., 2025). This growth is largely attributable to government initiatives and policy reforms, such as the National Geospatial Policy 2022, which are expected to drive advancements across urban planning, disaster management, agriculture, environmental conservation, and transportation (DST, 2022).

Specific program outcomes demonstrate tangible progress. Under AMRUT 2.0, 8,998 projects have been approved with a total value of ₹1,89,458.55 crore. Of these, 4,916 projects—valued at ₹85,114.01 crore—have been awarded contracts, while completed projects amount to ₹23,016.30 crore (Ministry of Housing & Urban Affairs, 2024). The initiative has led to measurable improvements in urban services, increasing tap water coverage to 70% and sewerage coverage to 62% across 500 cities (Pti, 2025). Nonetheless, the digital divide and low technical literacy limit marginalized groups' participation. Power imbalances hinder equitable implementation. Enhanced capacity building is crucial for urban sustainability.

5.1. National Case Study – The Zonal Division in India

Regionally, adoption varies: South India (35%) leads due to innovation hubs like Bengaluru and Hyderabad; West India (28%) benefits from smart city investments in Mumbai and Pune.

North India (22%) is driven by governance and public administration in Delhi and Noida; East and Northeast (15%) focus on disaster risk management and rural development. This regional distribution underscores the adaptability of geospatial tools across India's diverse socio-economic and ecological landscapes, yet also reveals the need for more inclusive, accessible, and participatory platforms to unlock their full societal value. Table 01 provides more detailed information.

6. International Initiatives: Global North vs Global South Analysis

Global North Models (EU, US, Canada): Geospatial technology in the Global North enhances advanced infrastructure and governance. The EU integrates Circular Economy principles into spatial planning, using geospatial data for energy and emissions decisions to promote sustainable urban environments (Paoli, Pirlone and Spadaro, 2022). In the US, the use of AI and geospatial mapping during Los Angeles County's wildfire relief efforts increased aid from $2 million to $20 million, which improved impact assessment, fraud prevention, and coordination; however, equitable access in low-connectivity areas remains challenging (Abid et al., 2021). Canada's CGDI leverages open data licenses and Volunteered Geographic Information (VGI) for smart city applications like energy mapping, enhancing decision-making despite adoption barriers (NRC, 2016).

Global South Models (Brazil, Kenya, South Africa, Indonesia): In the Global South, geospatial technologies help close development gaps with citizen participation. Brazil uses spatial analysis to identify Chagas disease welfare clusters, improving disease management, though citizen involvement in data collection is limited (Limongi et al., 2025). Kenya maps zero-dose children to target immunization gaps, enabling region-specific interventions, but socio-economic barriers hinder sustained impact (Gichuki, Ngoye and Mategula, 2025). South Africa's ePPMOSA enhances governance transparency through e-participation and grassroots innovation, facing challenges from skill shortages, political influences, and the digital divide (Molobela, 2025). Indonesia's Participatory GIS (PGIS) empowers Orang Rimba communities to co-develop conservation strategies, though sustained collaboration is difficult (Ramirez-Gomez, Brown and Fat, 2013).

Comparative Analysis: Benchmarking Approaches, Successes, and Challenges Both regions use geospatial technologies for urban planning and disaster management, relying on open data and AI/ML for insights (Goodchild, 2007; Brown and Kyttä, 2013; Zhu et al., 2017). The North optimizes infrastructure with digital twins (Batty, 2018), while the South focuses on participatory methods like PPGIS and Citizen Science to address healthcare and data gaps (Pitidis, Coaffee and Lima-Silva, 2024; Goodchild and Glennon, 2010; Fritz et al., 2019). The EU achieves resource efficiency, the US accelerates aid delivery, and Canada empowers citizens, though integration complexity and adoption persist. In the South, Brazil refines its welfare distribution, Kenya targets health equity, South Africa boosts accountability, and Indonesia fosters conservation while facing hurdles related to participation and implementation. Success depends on context, with the North refining systems and the South building capacity.

7. Operational Mechanisms and Stakeholder Ecosystems Protocols, Data Channels, Platforms

India's geospatial transformation is supported by a layered infrastructure of platforms, protocols, and institutions. The National Geospatial Policy (NGP) 2022 envisions a Geospatial Knowledge Infrastructure (GKI) by 2030, underpinned by open standards and interoperability frameworks to enable seamless data exchange across government, academia, civil society, and private sectors (DST, 2022; Geospatial World, 2023).
Key public platforms such as Bhuvan (ISRO) and the Open Government Data (OGD) Portal offer open access to satellite data, thematic maps, and geospatial applications (NRSC, ISRO, 2023). The National Data Registry (NDR) ensures standardization using OGC, ISO, and BIS protocols, facilitating metadata discovery, inter-agency coordination, and real-time data services (FGDC, 2020). Citizen-oriented platforms like 'Know Your DIGIPIN' enhance geocoded address mapping, feedback integration, and last-mile service delivery in rural areas (DST, 2022).

India's geospatial ecosystem involves multi-stakeholder coordination, moving from a centralized model to one driven by co-creation and distributed governance. Public agencies like ISRO, NRSC, MoHUA, and DST lead policy design and infrastructure rollout (NRSC, ISRO, 2023; MoHUA, 2023), while private companies, enabled by policy liberalization, contribute via data analytics, drone mapping, and PPPs—particularly in programs like PM Gati Shakti (MoPR, 2021).
Academic institutions and NGOs play a vital role in capacity building and community participation. Initiatives like GeoForAll, NESAC training under AMRUT 2.0, EarthSight Foundation and NIUA's PPGIS pilots promote technical literacy and empower citizens to co-produce spatial data (Geo4All; NESAC, 2021; EarthSight ;NIUA, 2022). Despite advances, silos and fragmented communication remain barriers to adoption (Batty, 2018), which points to the importance of interoperable, accessible, and citizen-designed systems.

This collaborative approach is key to realizing a geospatial economy projected to exceed ₹1 lakh crore by 2030—anchored not only in technical infrastructure, but in inclusive innovation, open data access, and participatory governance (Geospatial World / Esri India MD, 2025).

8. Identified Gaps and Systemic Challenges

Despite India's progressive geospatial frameworks—such as the National Geospatial Policy (NGP) 2022 and National Geospatial Mission (NGM) 2025–26—several institutional, educational, and technological bottlenecks hinder citizen-centred impact.

Institutionally, fragmented governance, weak inter-ministerial coordination, and ambiguous data-sharing protocols undermine policy execution. Ministries such as MoHUA, DST, MoSPI, and MeitY often operate in silos, leading to duplication and slow implementation (DST, 2022; Solomon, 2022). Educationally, geospatial training is largely absent from school curricula, and India lacks industry-aligned undergraduate programs compared to nations like the U.S. and China. The mismatch between academic output and workforce demand results in a shortage of job-ready professionals.

Technologically, India trails in high-resolution imaging, real-time analytics, and AI-enabled geospatial intelligence. Rural connectivity gaps further deepen the urban–rural divide, limiting data access and field utility (Geospatial World, 2022; Mohan and Singh, 2021).

A fundamental problem exists in the disparity between policy formulation and practical implementation. Initiatives such as Digital India and the Smart Cities mission frequently stagnate due to bureaucratic lethargy, ambiguous policy agendas, and insufficient funding. State Action Plans on Climate Change (SAPCCs) are inadequately funded by central authorities, necessitating dependence on constrained sectoral budgets.

Additionally, startups in geospatial tech suffer from weak institutional support, especially when compared to India's robust AI or EV ecosystems. Despite 100% FDI allowances and schemes like NIDHI-PRAYAS, seed capital and mentorship pipelines remain underdeveloped. India's space tech startups raised only $81 million in 2024, which is much lower than global counterparts (DST, 2022; Geospatial World, 2023).

The underutilization of geospatial tools in India is driven by a combination of educational, communicative, and societal challenges. A key issue is the technical knowledge deficit, stemming from insufficient integration of geospatial concepts into school and university curricula, as well as outdated training programs that hinder user understanding. This is compounded by outreach gaps, where limited communication efforts have left many citizens unaware of the relevance and potential of public geospatial platforms. Additionally, there is a significant human capital shortage, with a projected workforce demand of 950,000 professionals by 2025, current training capacity and course enrolments remain inadequate.

Finally, citizen participation barriers, including low digital literacy, linguistic diversity, and widespread concerns over cybersecurity, further restrict meaningful public engagement with these technologies.

In summary, while India's geospatial policy environment is ambitious and forward-looking, its effective realization depends on strengthening societal readiness through enhanced education, outreach, digital access, and inclusive institutional support.

9. Recommendations for System and Protocol Enhancements

To strengthen geospatial systems and protocols, a multi-pronged strategy emphasizing capacity building, open data access, and citizen engagement is essential. Integrating geospatial education into school curricula and establishing standardized certifications across institutions, in collaboration with entities like IIRS, can bridge the skill gap (DST, 2022; NRSC, ISRO, 2023). Publicly funded geospatial data should be treated as a public good, with liberalized open data policies that comply with international standards (OGC, ISO) to ensure interoperability (FGDC, 2020). Inclusivity demands local language interfaces and culturally adapted content to overcome barriers faced by rural populations (Digital Empowerment Foundation). Simple, visual GIS toolkits can empower non-experts in tasks like municipal planning, enhancing grassroots engagement (Geospatial World, 2023).

Furthermore, fostering citizen science and co-production frameworks, through platforms like Plantix and initiatives such as PPGIS and community mapping encourages active participation and integration of local knowledge into spatial planning (NIUA, 2020). Continuous monitoring through participatory indicators ensures adaptive planning and sustained involvement (DST, 2022). Collectively, these measures promote a shift from top-down technology deployment to bottom-up social integration, enhancing the effectiveness, sustainability, and community ownership of geospatial systems.

10. Conclusion

This study highlights the transformative potential of geospatial technologies in driving sustainable development across India's urban and rural regions, in alignment with the National Geospatial Policy 2022 and National Geospatial Mission 2025-26 (DST, 2022). The integration of emerging technologies like AI, ML, IoT, and cloud computing has enhanced data-driven decision-making (Geospatial World, 2023), while national initiatives such as Bhuvan, AMRUT 2.0, Smart Cities Mission, NUHM, and NSDI have institutionalized geospatial governance (NRSC, ISRO, 2023; MoHUA, 2021).

Globally, while both the Global North and South advance geospatial innovation, their approaches differ focusing on digital twin systems and open data governance in the former (Anttiroiko, 2023), and community-led, resource-conscious solutions in the latter. In India, persistent challenges including skill shortages, low digital literacy, limited platform adoption, and fragmented coordination undermine the grassroots impact of visionary policies. To address this, future research should prioritize citizen-centric evaluation frameworks and long-term studies on geospatial impact. Implementation must be supported by investment in human capital, culturally tailored outreach, and co-production models that empower citizens as active participants in governance (NRSC, ISRO, 2023; UNESCO, 2025; NIUA, 2020). A collaborative ecosystem involving public, private, and academic stakeholders is vital to realizing an inclusive, resilient, and sustainable geospatial future for India (DST, 2022).

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