Smart Buildings and Cities with Remote Sensing and GIS

Edited by Shiv Mohan,
Navneet Munoth, and Neha Sharma

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Smart Buildings and Cities with Remote Sensing and GIS

The built environment is undergoing a profound transformation driven by the integration of cutting-edge geospatial technologies. *Smart Buildings and Cities with Remote Sensing and GIS* serves as a comprehensive guide to navigating this transformation and bridges the gap between traditional architectural and planning practices and the innovative possibilities of remote sensing (RS) and geographic information systems (GIS).

The book demonstrates how architects, planners, and decisionmakers can use GIS and RS to design smarter, context-aware, and eco-friendly urban spaces. It explores innovative approaches for architecture, focusing on geospatial site analysis, net-zero energy building designs, heritage preservation, innovative virtual campus planning methodologies and even futuristic concepts like habitat design on the lunar surface.

Key features:

- Brings together contemporary geospatial technologies and their applications to address the challenges and opportunities in designing smart buildings and cities.
- Provides actionable solutions for professionals, researchers, and policymakers.
- Includes global contributions that provide diverse perspectives on smart city and building applications.
- Highlights how geospatial data-driven insights can revolutionize decision-making processes in urban planning and building design.

The work is designed for postgraduate students and researchers in the departments of architecture, planning, and geomatics, geoinformatics and software engineering.

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Preface

The built environment, encompassing everything from individual buildings to entire cities, has long been shaped by the hands of architects and planners. Yet, as the world faces growing challenges in sustainability, efficiency, and resilience, the need for innovative approaches in the field has become more pressing than ever. This book, *Smart Buildings and Cities with Remote Sensing and GIS*, stands at the forefront of this evolution, proposing a novel way to bridge the gap between traditional architectural and planning practices and the cutting-edge world of geospatial technologies. These technologies hold immense potential to revolutionize the way we design, plan, and manage our built environment, paving the path toward smarter buildings and digital cities.

The seeds of this book were sown through a simple observation: the immense potential of remote sensing (RS) and geographic information systems (GIS) remained largely untapped in the domain of architecture and planning. For decades, the fields of architecture and planning have relied on traditional methods for site analysis, resource assessment, and infrastructure development. While valuable, these approaches can be time-consuming, resource-intensive, and sometimes limited in scope. RS and GIS, however, offer an exciting new paradigm. These powerful technologies hold the key to unlocking a wealth of information about the Earth's surface, encompassing everything from terrain analysis to environmental monitoring. We envisioned a future where architects and planners could leverage this data to create smarter, more sustainable, and contextually responsive designs, ultimately contributing to the development of digital cities that are not only functional but also thrive in harmony with their surroundings.

Remote sensing, the science of acquiring information about an object or area without physical contact, empowers us to gather detailed data on the Earth's surface from satellites and aircrafts. This data encompasses diverse aspects like land use, topography, vegetation cover, and even climate patterns, providing architects and planners with a birds'-eye view of the landscape, literally. GIS, a framework for capturing, analyzing, and managing spatial data, acts as the engine that allows us to make sense of the vast datasets acquired through RS. By integrating RS data with other relevant information, such as demographic statistics and infrastructure maps, GIS creates a powerful tool for spatial analysis, visualization, and decision-making. This book is intended to serve as a comprehensive guide for anyone interested in exploring the intersection of RS, GIS, architecture, and planning. Whether you are an architect seeking to integrate innovative tools into your design process, a planner looking to optimize urban development strategies, or simply someone with a keen interest in the future of our built environment, this book has something for you.

WHAT SETS THIS BOOK APART?

- **First of its kind:** There have been numerous books focusing on urban planning. This book fills a critical gap in the existing literature by integrating the advanced technologies of RS and GIS specifically with architecture as well as planning. This unique combination offers fresh perspectives and practical applications for professionals in both fields.
- **Broadens the scope:** The book delves beyond mere technology, highlighting how its integration can broaden the scope of both fields. Architects and planners will gain valuable insights into how RS and GIS can enhance their design, planning, and decision-making processes through the practical case studies included in the book.
- **Global perspectives:** This perspective caters to a wider audience and provides valuable insights from professionals working in different nations.
- **Educational resource:** As a reference material, this book is designed to equip students in architecture, planning, and geomatics/geoinformatics programs with the knowledge and skills necessary to embrace and utilize these emerging technologies in their professional careers.

The heart of this book lies in showcasing the practical applications of RS and GIS in architecture and planning, beyond theoretical expertise. We will explore how these technologies can be used in various aspects of the design process, from selecting the most suitable site for a building to analyzing solar radiation patterns and optimizing energy efficiency. We will also delve into the exciting realm of "smart cities," exploring how RS and GIS can contribute to the development of urban environments that are not only sustainable but also equipped to address the challenges of the 21st century. This book is not just a technical guide; it is a call to action. It encourages architects, planners, and other professionals to embrace the transformative potential of RS and GIS. As we delve deeper into this new era of technological advancements, it becomes crucial to equip ourselves with the skills and knowledge necessary to navigate this changing landscape. We believe that *Smart Building and Cities with Remote Sensing and GIS* will serve as a valuable resource for government officials, experienced professionals, academicians, researchers, and aspiring students. It is our hope to spark a dialog and inspire innovation in the field of architecture, planning, and smart city development by bridging the gap between traditional practices and the exciting possibilities offered by emerging technologies.

As authors, we are not just passionate about the subject matter but also deeply committed to fostering knowledge exchange and collaboration in this rapidly evolving field. This book is not intended to be the final word on this topic but rather a springboard for further exploration and innovation. We encourage readers to engage with the ideas presented here, experiment with the technologies discussed, and contribute to the ongoing conversation about shaping a brighter future for our built environment. It is a culmination of our collective efforts, and we are immensely grateful to everyone who has contributed to its creation. Finally, we thank you, the

reader, for embarking on this journey with us. We hope that this book inspires you to explore the possibilities of integrating RS and GIS with architecture and planning, ultimately contributing to the creation of a smarter, more sustainable, and equitable future for all.

Let us embark on this journey together, shaping a future where the built environment thrives in harmony with technology, fostering a sustainable and resilient tomorrow.

With warm regards,
Book Editors

Acknowledgements

The journey of this book began with a spark of inspiration, and along the way, it has been nurtured by the support and guidance of countless individuals. We owe a profound debt of gratitude to them all. First and foremost, we express our deepest gratitude to the *Almighty* for guiding us throughout this journey and bestowing upon us the knowledge and perseverance to see it through.

We are incredibly grateful to *CRC Press, Taylor and Francis Group,* for accepting our book proposal and for their support throughout the publishing process. Their faith in our work has been instrumental in bringing it to the world. We would also like to express our sincere appreciation to the *editorial team* for their invaluable guidance and expertise, as well as to the anonymous reviewers who provided insightful feedback that helped us strengthen the manuscript. Their expertise and commitment have ensured the content, quality, and structure of the book.

We are fortunate to have been surrounded by supportive colleagues throughout this journey. We express our heartfelt thanks to *Mr. Anandababu Devendiran* (senior engineer, LTIMindtree) and *Mr. Shivansh Sharma* (B. Plan, MANIT), for their support and assistance with the editorial work. Their attention to detail and dedication were invaluable in ensuring the book's clarity and quality.

We are deeply indebted to the *chapter contributors* who generously shared their knowledge and expertise, enriching the content and scope of this book. Their contributions have been instrumental in making this a comprehensive and valuable resource. We acknowledge and appreciate the countless *sources of inspiration* that sparked our initial interest in this undertaking and motivated us to delve deeper. Their work and insights have shaped our understanding and fueled our passion for this subject.

Finally, we extend our heartfelt gratitude to our *families and friends*, who have provided love, support, and encouragement throughout this endeavor. Their belief in us and their constant motivation were the driving forces behind this accomplishment.

We also acknowledge and appreciate the *unknown reviewers* who directly or indirectly provided valuable feedback during the publishing process. Your thoughtful observations have helped us strengthen the book's content and presentation.

Thanks to everyone mentioned above and to anyone else who may have contributed in a way, big or small, to the creation of this book. We are truly fortunate to have received so much support and encouragement. This book wouldn't be here without each and every one of you.

Thank you.
Book Editors

About the Editors

Shiv Mohan is a leading researcher and educator with specialization in microwave remote sensing of the Earth and lunar surface. During his service at ISRO, he initiated a research programme related to microwave remote-sensing applications. He was Principal Investigator of various SAR application projects awarded to him through international global announcement of opportunity projects from European Space Agency, Japanese Exploration Agency, Italian Space Agency, and NASA/DLR. These experiments resulted in the development of in-house applications programmes for ISRO such as the Joint Experiment Programme and Disaster SAR and Satellite SAR programmes. He was the main architect of India's first RISAT utilization programme where he worked as Project Director until 2011. He was also the lead contributor of Chandrayaan-1 Mini SAR water ice detection model and in the definition of Chandrayaan-2 dual frequency SAR payload. After retiring from ISRO, he worked with the planetary exploration programme at Physical Research Laboratory, where he evolved the application of dual-frequency microwave data for lunar water ice model, regolith depth modeling, and crater morphology. He has served as a member of 70 technical committees of ISRO including RISAT-1, Chandrayaan-2, and future Venus's mission. He has 320 research papers in journals, conferences, and ISRO reports and has conducted about 190 tutorials on microwave remote sensing. He also served as a visiting scientist at DLR, Germany, during 1980 and 1981, and a chief scientist, HARSAC, Haryana government, from 1998 to 2001. He is recipient of the Indian National Remote Sensing Award 1995, outstanding reviewer award from Elsevier, Netherland (2015), and IEEE GRSS outstanding service award (2022). Dr Shiv Mohan is presently visiting faculty at CEPT University, Gujarat University, and IEEE GRSS Liaison for the Asia Pacific region.

Navneet Munoth is an architect and urban planner currently engaged at the Maulana Azad National Institute of Technology, Bhopal, an institute of national importance established by the government of India. Dr Munoth pursued his bachelor's in architecture from the National Institute of Technology Hamirpur and subsequent post-graduation as well as doctorate from the Indian Institute of Technology Roorkee, one of the premier institutions of India.

Dr Munoth has been serving in his current position as an associate professor in the Department of Architecture and Planning, MANIT Bhopal, for the past 14 years. He is also the Honorary Director of the Council of

Architecture's Training and Research Centre (COA-TRC) established in December 2018 at MANIT Bhopal.

Dr Munoth has also presented his research in the form of research papers and book chapters at several acclaimed International conferences organized in India or abroad like Singapore (National University of Singapore), Malaysia (University of Malaya), and Italy (University of Naples). Recently, his research papers have been accepted in international conferences at the University of East London (United Kingdom), Pusan National University (South Korea), and University of Aveiro, Portugal.

Dr Munoth has been awarded the prestigious 13th CIDC Vishwakarma Award for the year 2022 in the 26th CIDC Annual Day Ceremony conducted by the Construction Industry Development Council, set up by the erstwhile Planning Commission (now Niti Aayog) at the India Habitat Centre, New Delhi. He is the first architect and planner from the architecture and planning fraternity to receive this award for his academic as well as professional achievements and pursuits. In 2023, Dr Munoth revived K. F. Antia Memorial Prize by the Institution of Engineers (India) at Jabalpur (MP), India, for the best research paper titled 'Carbon Sequestration Potential of Urban Trees: A Case of Kolar Area in Bhopal City, India' (published in the Series 'A' Journal of IEI, Vol. 103, Issue 2) and has been selected for the subject prize. This is the fourth national-level award that he has received till now.

Neha Sharma is a GeoAI professional with an interdisciplinary foundation in architecture, geomatics, and data science. Currently a Product Engineer II – Geospatial Data Science at ESRI's GeoAI R&D Center she specializes in developing innovative geospatial solutions for global challenges. Previously, she worked with Larsen & Toubro (L&T) as a software engineer on the GeoAI team, contributing to transformative projects at one of India's leading construction firms.

An academic gold medalist, she has won prestigious awards such as the Gujarat Institute of Civil Engineers and Architects (GICEA) Gold Medal and hackathon accolades for her AI-driven geospatial solutions at L&T. Her expertise encompasses remote sensing, GIS, geospatial data science/GeoAI, and computer vision. She holds an MS in Data Science from Liverpool John Moores University, Great Britain, an M.Tech in Geomatics from Centre for Environmental Planning and Technology (CEPT) University, and a Bachelor's in architecture from Maulana Azad National Institute of Technology (MANIT), Bhopal, a Government of India-designated Institute of National Significance.

Passionate about education and mentoring, Neha has trained over two hundred students and professionals through workshops and programs bridging architecture and geospatial technologies. She has actively participated in organizing national-level training programmes, faculty development initiatives, and workshops organized by prestigious bodies like the Council of Architecture – Training and Research Center (CoA-TRC), IEEE GRSS, and MANIT, Bhopal. Neha is a member of the Indian Society of Geomatics (ISG), the Institution of Engineers (India) and Society

of Women Engineers – USA. She has authored multiple research papers and book chapters in national and international journals, conferences, and symposiums .

Neha's vision is to shape the future of GeoAI by advancing research in human-centered AI. She seeks to deepen her expertise by collaborating with global researchers, mentoring emerging talent, and advancing interdisciplinary innovation that transforms data into actionable insights for a better world.

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Part I

Introduction