

Lecture Notes in Civil Engineering

Daniele La Rosa
Riccardo Privitera *Editors*

Innovation in Urban and Regional Planning

Proceedings of the 11th INPUT
Conference—Volume 1

 Springer

Lecture Notes in Civil Engineering

Volume 146

Series Editors

Marco di Prisco, Politecnico di Milano, Milano, Italy

Sheng-Hong Chen, School of Water Resources and Hydropower Engineering,
Wuhan University, Wuhan, China

Ioannis Vayas, Institute of Steel Structures, National Technical University of
Athens, Athens, Greece

Sanjay Kumar Shukla, School of Engineering, Edith Cowan University, Joondalup,
WA, Australia

Anuj Sharma, Iowa State University, Ames, IA, USA

Nagesh Kumar, Department of Civil Engineering, Indian Institute of Science
Bangalore, Bengaluru, Karnataka, India

Chien Ming Wang, School of Civil Engineering, The University of Queensland,
Brisbane, QLD, Australia

Lecture Notes in Civil Engineering (LNCE) publishes the latest developments in Civil Engineering—quickly, informally and in top quality. Though original research reported in proceedings and post-proceedings represents the core of LNCE, edited volumes of exceptionally high quality and interest may also be considered for publication. Volumes published in LNCE embrace all aspects and subfields of, as well as new challenges in, Civil Engineering. Topics in the series include:

- Construction and Structural Mechanics
- Building Materials
- Concrete, Steel and Timber Structures
- Geotechnical Engineering
- Earthquake Engineering
- Coastal Engineering
- Ocean and Offshore Engineering; Ships and Floating Structures
- Hydraulics, Hydrology and Water Resources Engineering
- Environmental Engineering and Sustainability
- Structural Health and Monitoring
- Surveying and Geographical Information Systems
- Indoor Environments
- Transportation and Traffic
- Risk Analysis
- Safety and Security

To submit a proposal or request further information, please contact the appropriate Springer Editor:

- Pierpaolo Riva at pierpaolo.riva@springer.com (Europe and Americas);
- Swati Meherishi at swati.meherishi@springer.com (Asia - except China, and Australia, New Zealand);
- Wayne Hu at wayne.hu@springer.com (China).

All books in the series now indexed by Scopus and EI Compindex database!

More information about this series at <http://www.springer.com/series/15087>

Daniele La Rosa · Riccardo Privitera
Editors

Innovation in Urban and Regional Planning

Proceedings of the 11th INPUT Conference—
Volume 1

Editors

Daniele La Rosa
Department of Civil Engineering
and Architecture
University of Catania
Catania, Italy

Riccardo Privitera
Department of Civil Engineering
and Architecture
University of Catania
Catania, Italy

ISSN 2366-2557

Lecture Notes in Civil Engineering

ISBN 978-3-030-68823-3

ISSN 2366-2565 (electronic)

ISBN 978-3-030-68824-0 (eBook)

<https://doi.org/10.1007/978-3-030-68824-0>

© The Editor(s) (if applicable) and The Author(s), under exclusive license to Springer Nature Switzerland AG 2021

This work is subject to copyright. All rights are solely and exclusively licensed by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Organization

Organizing Committee

Laboratorio per la Pianificazione Territoriale e Ambientale, Department of Civil Engineering and Architecture—University of Catania

Daniele La Rosa

Riccardo Privitera

Luca Barbarossa

Viviana Pappalardo

Francesco Martinico

Paolo La Greca

Scientific Committee

Ginevra Balletto, University of Cagliari

Luca Barbarossa, University of Catania

Ivan Blečić, University of Cagliari

Dino Borri, Polytechnic University of Bari

Domenico Camarda, Polytechnic University of Bari

Michele Campagna, University of Cagliari

Valerio Cutini, University of Pisa

Andrea De Montis, University of Sassari

Romano Fistola, University of Sannio

Chiara Garau, University of Cagliari

Carmela Gargiulo, University of Napoli “Federico” II

Davide Geneletti, University of Trento

Roberto Gerundo, University of Salerno

Federica Gobattoni, Tuscia University

Paolo La Greca, University of Catania

Daniele La Rosa, University of Catania
Sabrina Lai, University of Cagliari
Giuseppe Las Casas, University of Basilicata
Antonio Leone, University of Salento
Giampiero Lombardini, University of Genova
Beniamino Murgante, University of Basilicata
Raffaele Pelorosso, Tuscia University
Alessandro Plaisant, University of Sassari
Riccardo Privitera, University of Catania
Bernardino Romano, University of L'Aquila
Francesco Scorza, University of Basilicata
Maurizio Tira, University of Brescia
Angioletta Voghera, Polytechnic University of Turin
Corrado Zoppi, University of Cagliari
Francesco Zullo, University of L'Aquila

Preface

The 11th Edition of the International Conference focuses on how to integrate nature-based solutions in urban and regional planning processes and science. Previously planned for September 2020, due to the COVID-19 pandemic the INPUT 2020 Conference will be hosted in 8–10 September 2021 by the University of Catania (Italy).

The overarching theme of INPUT 2021 edition is “Integrating Nature-Based Solutions in Planning Science and Practice”. There is growing evidence that nature-based solutions (NBS) are strategic instruments to restore or improve the functionality of urban ecosystems towards more livable, healthier and resilient cities. Despite their many advantages, NBS are not widely implemented because the evidence of their effectiveness is not yet sufficiently diffused among policy-makers, city-planners and residents and because NBS are often overlooked due to the complexity of their design and lack of normative instruments supporting planning choices. In order to permanently incorporate NBS into planning instruments, more research and international discussion are required to consolidate the fragmented evidence that NBS can significantly improve the overall degree of environmental sustainability of contemporary cities.

INPUT 2020 gathers international scholars in the fields of planning, civil engineering and architecture, ecology and social science, to build and consolidate the knowledge and evidence on NBS and to help an efficient implementation and replication of solutions.

The INPUT 2020 Conference hosts 14 thematic sessions, namely:

- Enhancing the use of nature-based solutions in urban planning
- Modelling to innovate planning solutions for socio-ecological systems
- Input visions: new technologies, data and hybrid models for spatial planning
- Urban metabolism and simulation for decision-making in spatial planning
- Performance-based planning
- Computational planning
- Geodesign for informed collaborative spatial decision-making

- Planning and design of ecosystems services: assessment frameworks, models, mapping and implications
- Green infrastructure for planning healthy urban environments
- The mitigation of peripheralization risk in urban and regional planning
- Strategies and actions for climate change adaptation and mitigation in mediterranean regions
- Analysis and planning of rural landscapes
- Accessibility in urban planning: moving towards innovative approaches
- Maintenance, upgrading and innovation in cultural heritage

This book presents the first collection of 69 contributions submitted to the INPUT 2020 Conference, following the first call for paper launched in Winter 2020. The accepted articles, after a blind-review process, are here organized in 5 topical parts, which group together the 14 thematic sessions of the conference:

- Nature and Ecosystems for Urban Systems
- Models and Technologies for Spatial Planning
- Climate Change and Spatial Planning
- Peripheries, Rural and Cultural Landscapes
- Accessibility in Urban Planning

INPUT 2020 proceedings explores empirical as well as theoretical frameworks for NBS, their attitude to provide ecosystem services, to deal with climate change effects and to support mitigation and adaptation planning strategies. Integration of NBS in planning science and practice is investigated across different contexts and scales, from urban cores to peripheries as well as from rural to cultural landscapes. Above all, this collection presents the state of the art of modelling approaches and innovations employed in urban and spatial planning, with a trans-disciplinary, boundary-less character to face the complexity of contemporary socio-ecological systems and following a practice-oriented approach aimed to problem solving.

INPUT is a group of Italian academic researchers and academics working in different fields related to the exploitation of innovation for urban and regional planning, with particular reference to geo-informatics and socio-ecological aspects of spatial planning. INPUT Conference is held every two years in Italy, with last editions been hosted in Viterbo (2018), Torino (2016), Cagliari (2014) and Potenza (2012).

INPUT 2020 Conference is organized by [LAPTA](#), a research laboratory of Department of Civil Engineering and Architecture of the University of Catania (Italy), working on sustainable urban and landscape planning.

Catania, Italy
December 2020

Daniele La Rosa
Riccardo Privitera

Contents

Nature and Ecosystems for Urban Systems

Blue-Green Roofs: Hydrological Evaluation of a Case Study in Viterbo, Central Italy 3
Raffaele Pelorosso, Andrea Petroselli, Ciro Apollonio, and Salvatore Grimaldi

Reviewing the Performance of Nature-Based Solutions for Stormwater Management in Urban Areas 15
M. Susana Orta-Ortiz and Davide Geneletti

Ecosystem-Based Adaptation Approach and Adaptation Planning Support Tools: Potential Implementation for the Urban Context 23
Anna Giulia Castaldo, Israa Mahmoud, and Eugenio Morello

Nature-Based Solutions for Healthy Cities: Cross Scale Interaction 33
Roberto De Lotto, Caterina Pietra, and Elisabetta M. Venco

Planning Accessible Urban Green Infrastructure for Healthy and Fair Historical Towns: The Study Case of Viterbo, Central Italy 43
Raffaele Pelorosso, Daniele La Rosa, Stefano Floris, and Nicola Cerino

From Preferences of Social Groups to Planning and Management Solutions of Green Spaces in Bucharest 53
Mariacristina Sipala and Daniele La Rosa

A Methodology to Investigate the Human Health and Environmental Benefits by the Improvement of Urban Mobility and Ecosystem Services: A Case Study in Pisa 63
Greta Frosini, Luisa Santini, and Fabrizio Cinelli

Designing a New Vision of an “Ordered” Nature with an Ecosystemic Approach for a Healthy City 73
Concetta Fallanca and Antonio Taccone

The Challenges of Valuing Urban Nature: Accounting for Urban Ecosystem Services Within the Framework of a Cost-Benefit Analysis of Nature-Based Investments	81
Jing Ma, John Henneberry, and Riccardo Privitera	
Bicycle Accessibility to Cultural Ecosystem Services in a Cross-Boundary Landscape	91
Marcin Spyra and Adam Hamerla	
Policies to Decrease Land Surface Temperature Based on Land Cover Change: An Assessment Related to Sardinia, Italy	101
Sabrina Lai, Federica Leone, and Corrado Zoppi	
Planning of Protected Areas as a Mean of Addressing Concepts of Resilience and Sustainability	111
Federica Isola and Federica Leone	
Investigating the (Un)Integration Between Sectoral Policies with the Habitat Degradation Model	121
Francesco Scorza, Angela Pilogallo, Lucia Saganeiti, and Beniamino Murgante	
Slow Mobility Networks as Tools to Take Care About Cultural Landscape and to Resew Relationships Between Humans and the Ecosystem	131
Giovanni Bruschi and Luisa Santini	
Research on the Global Green Market Based on Big Data	139
Gaochuan Zhang and Bao-Jie He	
A Strategic Performance-Based Planning Methodology to Promote the Regeneration of Fragile Territories	149
Marialuce Stanganelli, Francesca Torrieri, Carlo Gerundo, and Marco Rossitti	
Models and Technologies for Spatial Planning	
Envisaging Urban Changes for the Smart City: The Live City Information Modeling (LCIM)	161
Romano Fistola and Andrea Rastelli	
New Tools to Analyse the Wastescapes of the Cities: The Case Study of the Metropolitan City of Naples	171
Maria Somma	
An Approach for Tackling the Risk of the Residential Building Stocks at the Urban Scale Exploiting Spatial and Typological Archive Data	181
G. Uva, V. Leggieri, and G. Mastrodonato	

From BIM to CIM: A New Instrument for Urban Planners and a New Bottom-Up Planning Process	189
Ida Zingariello	
A Hybrid Approach for the Acquisition and Analysis of Distributed Knowledge on Spatial Planning: The Case Study of the Master Plan for Brindisi (Italy)	195
Stefania Santoro, Dario Esposito, Domenico Camarda, and Dino Borri	
Reflections About Non-knowledge in Planning Processes	205
Maria Rosaria Stufano Melone and Domenico Camarda	
Use of Remotely Piloted Aircraft to Update Spatial Data in Areas of Social Fragility	213
Danilo Marques de Magalhães and Ana Clara Mourão Moura	
Space of Flows and Space of Places: Manuel Castells and the Information Age	221
Alessandro Alfieri	
BIS—Management of Energy Consumption Data for Companies and Public Administration	225
Franco Guzzetti, Karen L. N. Anyabolu, Francesca Biolo, and Lara D'Ambrosio	
Understanding the Importance of Risk Perception in Coastal Socio-Ecological Systems Management: A Case Study in Southern Italy	235
Giulia Motta Zanin, Maria Francesca Bruno, and Alessandra Saponieri	
Urban Occupation Potential by UAV Data: Vale do Sereno—Nova Lima/MG	245
Pedro Benedito Casagrande, Maria Giovana Parisi, Ana Clara Mourão Moura, Lourdes Manresa Camargos, and Danilo Marques de Magalhães	
Co-creation of Ideas in Geodesign Process to Support Opinion and Decision Making: Case Study of a Slum in Minas Gerais, Brazil	255
Ana Clara Mourão Moura and Christian Rezende Freitas	
Applying Geodesign in the City of Bologna (Italy): The Case Study of the Navile Region	265
Alfio Conti, Ana Clara Mourão Moura, Gustavo Adolfo Tinoco Martinez, Simona Tondelli, and Susanna Patata	
Workshop of Geodesign: Geology as the Basis for Planning Alternatives Futures for the Quadrilátero Ferrífero	271
Pedro Benedito Casagrande and Ana Clara Mourão Moura	

Participation, Information, Action: A Collaborative Map to Evaluate Mobility Spots	281
Nadia Giuffrida, Simone Grasso, Enrico Muschella, Delia Valastro, Giuseppe Inturri, Riccardo Dell’Osso, Sebastiano D’Urso, and Matteo Ignaccolo	
Computational Planning Support Systems for Regional Analysis: Real-Estate Values Dynamics and Road-Networks Configuration	291
Diego Altafini, Elisabetta Pozzobon, Simone Rusci, and Valerio Cutini	
Planning Ecological Corridors: A Cost Distance Method Based on Ecosystem Service Evaluation in the Sardinian Cork Oak Forests.	301
Luigi La Riccia, Angioletta Voghera, Emma Salizzoni, Gabriella Negrini, and Sara Maltoni	
Pricing the City: How Spatial Transformations Affect Real Estate Values in Urban Areas.	311
Valerio Cutini, Valerio Di Pinto, and Simone Rusci	
Re-defining Spatial Typologies of Humanitarian Housing Plans Using Machine Learning	319
Camilla Pezzica, Valerio Cutini, Clarice Bleil de Souza, and Chiara Chioni	
Ex Post Evaluation of Cohesion Policies in the Strategic Planning of Italian Metropolitan Cities: Analysis for the Development of New Strategies	329
Ginevra Balletto, Luigi Mundula, Alessandra Milesi, and Mara Ladu	
Assessing Urban Green Spaces Availability: A Comparison Between Planning Standards and a High-Fidelity Accessibility Evaluation	339
Ivan Blečić and Valeria Saiu	
Climate Change and Spatial Planning	
Finding the Resilient City: A Proposal for Implementing “Adaptigation” in Spatial Plan. Case Studies from Sicily.	351
Luca Barbarossa and Viviana Pappalardo	
Local Climate Related Policies in the Mediterranean Region within the Covenant of Mayors Initiative.	361
Valentina Palermo	
A Knowledge Management System as a Tool for Better Climate Change Management	373
Aly A. Ahmed and Ahmed Elshazly	
Assessment of Public Awareness of Climate Change Impacts on Marine Environment in Egypt	381
Ahmed Elshazly and Mohamed A. Hamza	

Nature Based Solutions for Coastal Adaptation to the SLR: A Case Study from the Northwest Mediterranean Coast of Egypt	391
Ahmed Elshazly	
Mitigating the Impacts of Climate Change on Water Scarcity and Drought: Wastewater Treatment as an Exemplary Solution in the Mediterranean	401
Amr I. Madi and Ahmed Elshazly	
Climate Change and Its Impact on Harmful Algae in the Egyptian Mediterranean Waters	411
Amany A. Ismael	
A Methodological Framework for the Comprehensive Assessment of Actions and Territorial Target for the “Sustainable Energy and Climate Action Plan” (SECAP) of Potenza Municipality	419
Luigi Santopietro and Francesco Scorza	
Greenery Systems for the Mitigation of the Urban Heat Island: A Simulation Experience for Southern Italy	427
Gianpiero Evola, Francesco Nocera, Vincenzo Costanzo, Maurizio Detommaso, Serena Bonaccorso, and Luigi Marletta	
The Effect of a Trees’ Shadows on the Indoor Heat Stress Probability and Buildings’ Cooling Loads Reduction in Santiago de Chile	439
Massimo Palme	
Urban Changes to Control and Mitigate the Urban Heat Islands (UHI): Analysis in the Catania’s Territory	449
Federica Leone and Fausto Carmelo Nigrelli	
Peripheries, Rural and Cultural Landscapes	
A Methodology for Analyzing the Role of Environmental Vulnerability in Urban and Metropolitan-Scale Peripheralization Processes	459
Roberto Gerundo, Alessandra Marra, and Ottavia Giacomaniello	
Indicators for Analysing Rural Gentrification for Landscape Assessment	469
Hanna Elisabet Åberg	
Mitigating the Effects of Urban Diffusion—The Case Study of the Urban Agglomeration of Pará de Minas and Itaúna (Brazil)	477
Alfio Conti, Sónia Maria Carvalho Ribeiro, and Gustavo Adolfo Tinoco Martinez	
Between Crisis and In-Settlement-Speeding-Up: The Case of L’Aquila	483
Fabio Andreassi, Cinzia Barbara Bellone, and Fabio Naselli	

The Use of Lamination Basins for Mitigation of the Urban Flooding Risk: The Case Study of Peschici	491
Ciro Apollonio, Andrea Petroselli, Raffaele Pelorosso, Salvatore Grimaldi, Crescenzo Luca Frontuto, Giovanni Russo, Maria Di Modugno, and Marco Muciaccia	
A Configurational Approach for Measuring the Accessibility of Place as an Analysis Tool for Crime Risk Vulnerability	501
Francesca Coppola, Michele Grimaldi, and Isidoro Fasolino	
Qualitative Objectives to Preserve, Protect and Valorise the Lombardy Rural Landscapes in the Regional Landscape Plan	511
Viviana di Martino, Silvia Restelli, and Andrea Arcidiacono	
The Basin Contract as a Project-Oriented Tool for an Integrated and Sustainable Management of Water Resources. A Project for Productive Landscapes in Coros, Sardinia	521
Gian Francesco Faedda and Alessandro Plaisant	
Tourism and Rural Landscape: Sustainable Development and Territorial Enhancement	531
Selena Candia, Francesca Pirlone, and Ilenia Spadaro	
Identification and Assessment of Thematic Paths Through the Cultural Paths Assessment Tool (PAST). The Case Study of Cagliari, Italy	541
Alfonso Annunziata and Chiara Garau	
A Multicultural Tourism for Evaluating the Cultural Heritage: The Case Study of the Region of Sardinia (Italy)	551
Chiara Garau, Giulia Desogus, Federica Banchiero, and Pasquale Mistretta	
Promoting Bottom-Up Initiatives for the Sustainable Conservation of Hidden Cultural Landscapes Using Ubiquitous Digital Technologies	561
Giovanni Bruschi, Daniele Amadio, and Camilla Pezzica	
A Multi Risk Analysis for the Planning, Management and Retrofit of Cultural Heritage in Historic Urban Districts	571
Dario Esposito, Elena Cantatore, and Alberico Sonnessa	
Accessibility in Urban Planning	
Urban Accessibility and Tourist Activity: An Application to the Metropolitan City of Naples	583
Rosa Anna La Rocca	

Multigenerational Urban Planning for Accessible Cities: Lessons from the Case of Milan and Its Senior Population	593
Fulvia Pinto and Mina Akhavan	
Age Inequalities of Accessibility to Essential Urban Services. The Case Study of Primary Health Care in the City of Milan for Older People	605
Gerardo Carpentieri and Carmen Guida	
Spatial Accessibility: Integrating Fuzzy AHP and GIS Techniques to Improve Elderly Walkability	615
Carmela Gargiulo, Federica Gaglione, and Floriana Zucaro	
Crossing Conditions and Kerb Delay Assessment for Better Safety and Accessibility of Road Pedestrian Crossings at Urban Intersections	623
S. Leonardi, Giovanni Tesoriere, N. Distefano, G. Pulvirenti, A. Canale, and Tiziana Campisi	
A Behavioral and Explanatory Statistical Analysis Applied with the Advent of Sharing Mobility in Urban Contexts: Outcomes from an Under Thirty-Age Group Perspective	633
Tiziana Campisi, Giovanni Tesoriere, Matteo Ignaccolo, Giuseppe Inturri, and Vincenza Torrisi	
Socio-Eco-Friendly Performance of E-Scooters in Palermo: Preliminary Statistical Results	643
Tiziana Campisi, S. Basbas, A. Skoufas, Giovanni Tesoriere, and D. Ticali	
Urban and Territorial Accessibility. A New Role for the Marinas	655
Luigi Mundula, Mara Ladu, Ginevra Balletto, and Alessandra Milesi	

Use of Remotely Piloted Aircraft to Update Spatial Data in Areas of Social Fragility



Danilo Marques de Magalhães and Ana Clara Mourão Moura

Abstract A considerable amount of the Brazilian population lives in informal settlements, where there is a massive dynamic of territorial transformation. In this sense, the use of Remotely Piloted Aircraft (RPA) has shown an excellent cost-benefit relation for expeditiously collecting spatial data aiming at the identification of territorial objects, which can be an essential resource to assist planning and public management. This study presents a methodology for updating the spatial database collected by airborne LiDAR (Light Detection and Ranging) using an RPA and high precision GNSS (Global Navigation Satellite System) receivers. The study was carried out in an area of social fragility located in Belo Horizonte, Brazil, which presents geomorphological complexity, high density of territorial occupation, unplanned infrastructure, and complex urban morphology. Such associated characteristics are understood as social risk factors, creating difficulties for technical managers and locals. In that municipality, data are collected with airborne LiDAR every seven years for urban management purposes. However, the dynamics of territorial transformation in these places is very intense, generating demand for updating the database. For this purpose, the Digital Surface Model (DSM) generated by RPA was associated with the DSM generated by LiDAR through raster algebra. The results show the buildings' pavement increases and new buildings' construction, indicating to public managers the territorial changes in the analyzed period.

Keywords Remotely piloted aircraft • Urban management • Illegal settlements • Map algebra

D. M. de Magalhães (✉)

Instituto de Geociências, Universidade Federal de Minas Gerais, Av. Antônio Carlos 6627, Belo Horizonte, Brazil

e-mail: danielommagalhaes@gmail.com

A. C. M. Moura

Escola de Arquitetura, Universidade Federal de Minas Gerais, Rua Paraíba 697, Belo Horizonte, Brazil

e-mail: anaclaramoura@yahoo.com

© The Author(s), under exclusive license to Springer Nature Switzerland AG 2021

213

D. La Rosa and R. Privitera (eds.), *Innovation in Urban and Regional*

Planning, Lecture Notes in Civil Engineering 146,

https://doi.org/10.1007/978-3-030-68824-0_23

1 Introduction

The monitoring of territorial transformations in Brazil is undoubtedly a significant challenge for urban management, mainly due to many existing irregular settlements. Data from the last demographic census show that 6% of the Brazilian population resides in subnormal agglomerations, identified from the precarious condition of infrastructure in existing households. Most of these households (49.8%) are in the Southeast metropolitan regions and frequently in unsuitable areas for urbanization, such as steep slopes, caves, and banks of watercourses (IBGE 2020).

In the municipality of Belo Horizonte, there are 209 illegal settlements and slums, totaling 714 thousand people living in inadequate conditions of urban and sanitary infrastructure (PBH 2020). In this municipality, the management of territorial transformations is carried out with the support of data captured by LiDAR (Light Detection and Ranging) airborne and aerial photographs taken, performed approximately every seven years. However, territorial change dynamics are quite intense, especially in the peripheral regions, where significant increases in buildings can be seen in less than a month. This situation reinforces the demand for updating the cartographic base in a shorter period, which provides resources for monitoring transformations, dialogue with the local population, the management of necessary infrastructure, and the assessment of regulatory possibilities.

In this sense, Remotely Piloted Aircraft (RPA) has been tested as a resource for collecting data on the neighborhood scale to update the municipality's official database. Therefore, this work presents the tests carried out to integrate the database collected with a low-cost RPA with the database generated from LiDAR, aiming to demonstrate the places where there were more significant territorial transformations, as well as presenting challenges and limits of the proposed method.

Studies show that RPA, when combined with high precision GNSS receivers, can generate MDS with accuracy and morphology similar to models generated by laser profiling performed by LiDAR (Marotta et al. 2015; Oliveira et al. 2017).

2 Study Area

The study area is the Conjunto Paulo VI neighborhood, located in the Northeast portion of Belo Horizonte, Brazil (Fig. 1). It is located on the municipality's borders, and it is considered an illegal settlement, as the inhabitants do not have ownership of the land and organized themselves to occupy the area, which included invasions under a power transmission line from the state's distribution company (CEMIG). Thus, the infrastructural deficiencies are evident, such as sanitary sewage, transportation system, paving, water, and installed energy network, among other situations. The area presents geomorphological complexities, including steep slopes and unstable soils where landslides involving victims have occurred. Some studies show that it is also an area of high vulnerability because of the climate

interference of the terrain variation in the quality of the products generated (Magalhães and Moura 2018; Magalhães and Moura, in press). The flight was carried out at the height of 150 m, in April 2019, at 11:40 a.m., when there is less formation of shadows projected by vegetation and buildings to generate better modeling of the surface (Aber et al. 2010). It took approximately 16 min of flight to cover a total area of 65.36 ha, with a total of 261 images at 4.1 cm of GSD each.

In order to ensure the planimetric and altimetric accuracy of the RPA's products, 9 GCPs (Ground Control Points) were collected in a dispersed way in (Santos et al. 2016; Zanetti et al. 2017). The GCPs were collected with the Topcon dual-frequency receiver model Hiper SR, using the static method (Monico 2000). The base receiver performed the observations for 4 h 30 min and the other points, collected by the rover, for 20 min each. The data generated were also corrected based on the Brazilian Network for Continuous Monitoring (RBMC) using the Topcon Tools software.

For generating the DSM from the photographs collected by the UAV, the Agisoft PhotoScan software was used, which allows the 3D reconstruction of objects through an algorithm that operates on multiple images with different perspectives. Medium accuracy and an aggressive filter were adopted as parameters for the point cloud construction, and the DSM was generated in this same software with spatial resolution, also, of 20 cm.

Both surface models were cut in the study area that consists of the Conjunto Paulo VI neighborhood boundary plus a 50 m buffer to avoid edge effects in the data processing.

Simple map algebra was employed to verify the temporal transformations by subtracting DSM RPA (2019) by DSM LiDAR (2015). The results had some noises due to the greater density of the RPA point cloud than LiDAR and, consequently, the product quality difference. In order to reduce this noise and facilitate data analysis, a 5×5 smoothing filter was applied. This entire procedure was performed using ArcGIS software.

From these data, profile graphics were made to compare the occurred transformations and to interpret the results generated, which are presented below.

4 Results and Discussions

Based on the profile graphs generated on the DSM, values groupings were made to understand the changes and separate the existing data noise.

The first group, with values from -30.1 to -1.5 m, shows the places where the vegetation cover was removed and other objects extinct over the analyzed period. Several irrelevant changes related to the study proposes were observed, such as variation of parked vehicles and a significant volume of noise arising from the difference between the analyzed product's quality. Such factors excluded this class from the analysis.

The values identified between -1.4 and 1 m represented those places that remained unchanged in the analyzed period, basically corresponding to the model's road axes and the buildings without noticeable modifications. It was noticed significant noises in results up to 1 m when located at the building's edges due to the difference in data quality. Therefore, these values were not considered as real changes.

The values from 1 to 3 m represented building changes of up to 1 floor, which could be a new building where there were none or the increase of a new floor in an existing one (Fig. 2). The figure shows that it is impossible to perceive the building's increased volume only using aerial photos. Besides, the steep relief, the densification of buildings in narrow alleys, and the vegetation make the analysis process hard. However, the profile graph shows that both data's terrain is quite similar, which generates reliability in the analysis.

The results with values between 3 and 6 m represent the buildings with an increase of up to two new floors. As these are more significant changes concerning the neighbors, these places had a low amount of noise and, therefore, a robust identification.

The values that show changes from 6 to 9 m represent those buildings with an increase of up to three floors. In general, the results were quite similar to those of the previous class: a higher altimetric increase leading to a smaller amount of noise in the data due to a more evident change and less interference from the surrounding objects. In the study area, few changes were identified at this level; for instance, the construction of a public hospital with three floors stands out (Fig. 3). In some places, it was also possible to see the vegetation increases. However, this data is not reliable since LiDAR technology can capture information also under the canopy of trees, and the differences between these data make the analysis unfeasible.

Alterations were also identified in two buildings in the neighborhood that resulted in values between 9 and 12 m, representing an increase of up to four floors. As in the previous two classes, no significant noises were observed in this class due to the significant variation between the dates analyzed.

With values greater than 12 m, the last class consists of noise from the data and changes observed in the vegetation that is not reliable—as already mentioned—and neither object of this analysis. No significant increments of more than four floors were observed in the neighborhood buildings within the analyzed period.

It is essential to highlight that this analysis required a strong human-machine interaction, which means that it takes a significant time to be done, and it is not friendly to the automation process. Other related methodologies and other spatial analysis filters can be tested to make it feasible.

On the other hand, the results are reliable since both MDS have similar accuracy. And the presented analysis can be done quickly and by simple map algebra, which can help public managers understand the main territorial changes and then guide the field works.

In this sense, the altimetric data observed on both analyzed DSM were consistent since the GNSS receivers were used to improve the drone's data. It can be understood as a reference to the accuracy of the results.

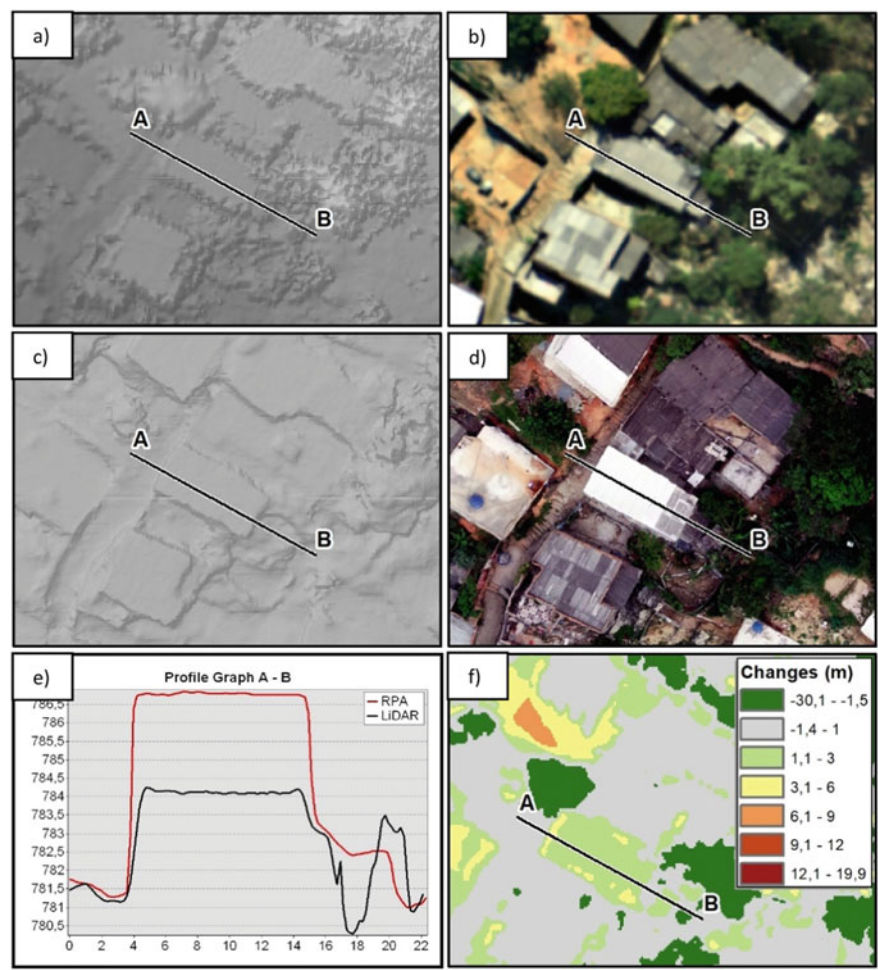


Fig. 2 Changes up to 3 m—Construction of a new floor. **a** DSM LiDAR (2015); **b** Orthomosaic PBH (2015); **c** DSM RPA (2019); **d** Orthomosaic RPA (2019); **e** Profile graph; **f** Result of map algebra (DSM RPA—DSM LiDAR). *Source* the authors

The biggest challenge in this analysis was to filter the noise to understand the information generated. It is caused by the different density of the point clouds used to create the surface models, and the analyst will need to deal with it. In the study presented, it became viable from studying the shapes of the features observed on the orthomosaics and its comparison with the forms observed in the DSMs. Another challenge to face when working with RPA images is the shadows cast by the trees, the buildings, and other objects, making it impossible to generate a precise surface model in these areas. It is a well-known problem concerning drone images, and it is necessary to be aware of the limits of this technology's use.

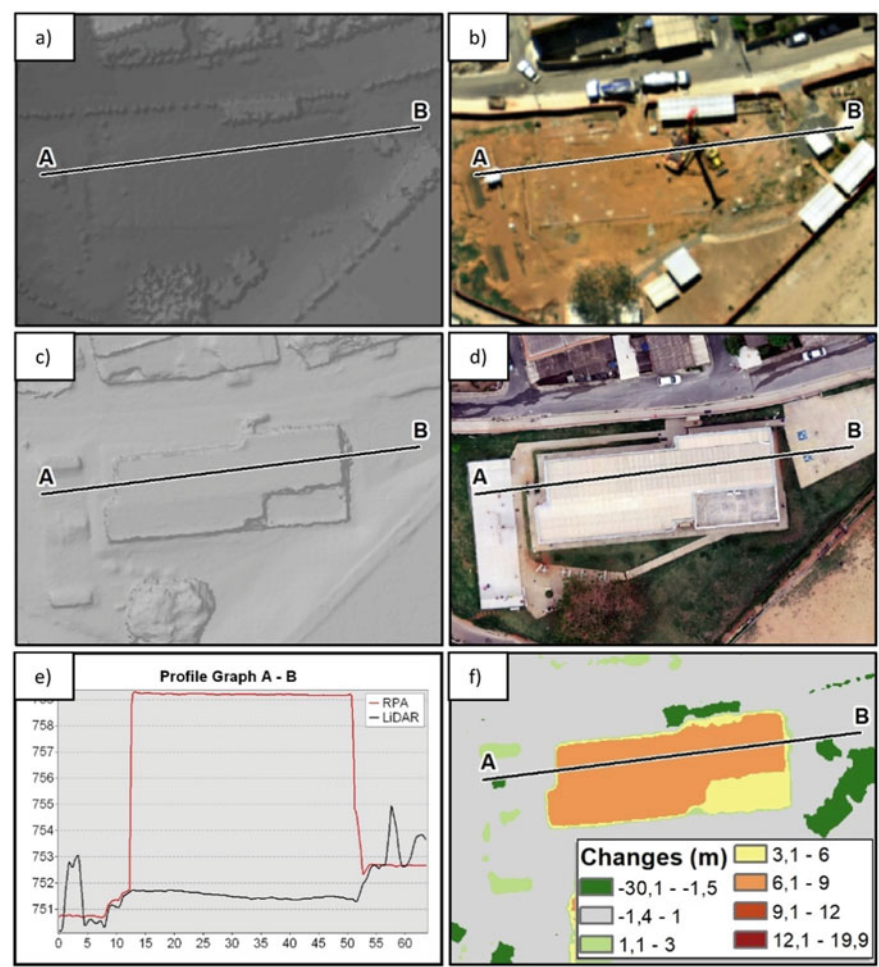


Fig. 3 Changes up to 9 m—Public health center. **a** DSM LiDAR (2015); **b** Orthomosaic PBH (2015); **c** DSM RPA (2019); **d** Orthomosaic RPA (2019); **e** Profile graph; **f** Result of map algebra (DSM RPA—DSM LiDAR). *Source* the authors

5 Conclusions

This work allowed us to conclude that the RPA can be an important instrument to monitor territorial transformations in the presented context, as it is considered feasible to associate the data collected with the LiDAR database. The study reinforces that using GCP to improve the RPA products is possible to achieve an accuracy similar to the LiDAR data. In this sense, there are gains in cost reduction and agility in collecting and updating data, enabling neighborhood scale and on-demand works.

Significant noises were observed among the data that must be treated carefully, avoiding erroneous analyzes.

It is essential to emphasize that this work does not eliminate the necessity for on-site visits to validate the transformations for cadaster purposes. However, it can guide managers to plan these actions in a more agile and assertive way.

Acknowledgements The authors thank CNPq support through the project Process 401066/2016-9, FAPEMIG PPM-00368-18, FAPESC/PRO2019071000025, and CAPES 88887.474274/2020-00 for the support for taking part in the conference.

References

- Aber JS, Marzolf I, Ries JB (2010) Small-Format aerial photography: principles, techniques and geoscience applications. Elsevier, Amsterdam
- Instituto Brasileiro de Geografia e Estatística (IBGE) Homepage, <https://agenciadenoticias.ibge.gov.br/agencia-sala-de-imprensa/2013-agencia-de-noticias/releases/14157-asi-censo-2010-114-milhoes-de-brasileiros-60-vivem-em-aglomerados-subnormais>. Last accessed 2020/03/05
- Magalhães DM, Moura ACM (2018) Avaliação da acurácia do modelo tridimensional de uma edificação gerado por um micro VANT. *Geografia y Sistemas de Información Geográfica (GEOSIG)* 10(1):62–86
- Magalhães DM, Moura ACM (in press). Análise da morfologia de Modelos Digitais de Superfície gerados por VANT. *Revista Brasileira de Cartografia*
- Marotta GS, Cicerelli AMR, Roig HL, Abreu MA (2015) Avaliação posicional de um modelo digital de superfície derivado de câmera de pequeno formato. *Revista Brasileira de Cartografia* 67(7):467–1477
- Monico JFG (2000) Posicionamento pelo NAVSTAR-GPS: Descrição, Fundamentos e Aplicações. Unesp, São Paulo
- Oliveira DR, Cicerelli RE, Almeida T, Marotta GS (2017) Geração de modelo digital de terreno a partir de imagens obtidas por Veículo Aéreo Não Tripulado. *Revista Brasileira de Cartografia* 69(6):1143–1151
- Prefeitura Municipal de Belo Horizonte (PBH) Homepage, <https://prefeitura.pbh.gov.br/urbel/pge-planejamento>. Last accessed 2020/03/05
- Santos AP, Rodrigues DD, Santos NT, Gripp Junior J (2016) Avaliação da acurácia posicional em dados espaciais utilizando estatística espacial: proposta de método e exemplo utilizando a norma brasileira. *Boletim Ciências Geodésicas* 22(4):630–650
- Way Carbon (2016) Análise de vulnerabilidade às mudanças climáticas no município de Belo Horizonte. Prefeitura Municipal de Belo Horizonte, Belo Horizonte
- Zanetti J, Gripp Junior J, Santos AP (2017) Influência do número de pontos de controle em ortofotos geradas a partir de um levantamento por VANT. *Revista Brasileira de Cartografia* 69(2):263–277