LNCS 14824

Osvaldo Gervasi · Beniamino Murgante ·
Chiara Garau · David Taniar ·
Ana Maria A. C. Rocha ·
Maria Noelia Faginas Lago (Eds.)

Computational Science and Its Applications – ICCSA 2024 Workshops

Hanoi, Vietnam, July 1–4, 2024
Proceedings, Part X

10 Part X

Springer

Lecture Notes in Computer Science 14824

The series Lecture Notes in Computer Science (LNCS), including its subseries Lecture Notes in Artificial Intelligence (LNAI) and Lecture Notes in Bioinformatics (LNBI), has established itself as a medium for the publication of new developments in computer science and information technology research, teaching, and education.

LNCS enjoys close cooperation with the computer science R & D community, the series counts many renowned academics among its volume editors and paper authors, and collaborates with prestigious societies. Its mission is to serve this international community by providing an invaluable service, mainly focused on the publication of conference and workshop proceedings and postproceedings. LNCS commenced publication in 1973.

Osvaldo Gervasi · Beniamino Murgante ·
Chiara Garau · David Taniar ·
Ana Maria A. C. Rocha ·
Maria Noelia Faginas Lago
Editors

Computational Science and Its Applications – ICCSA 2024 Workshops

Hanoi, Vietnam, July 1–4, 2024
Proceedings, Part X

Springer

Editors
Osvaldo Gervasi
Department of Mathematics and Computer Science
University of Perugia
Perugia, Italy

Chiara Garau
Department of Civil and Environmental Engineering and Architecture
University of Cagliari
Cagliari, Italy

Ana Maria A. C. Rocha
Algoritmi Research Centre
University of Minho
Braga, Portugal

Beniamino Murgante
School of Engineering
University of Basilicata
Potenza, Italy

David Taniar
Faculty of Information Technology
Monash University Clayton Campus
Clayton, VIC, Australia

Maria Noelia Faginas Lago
Department of Chemistry, Biology and Biotechnology
University of Perugia
Perugia, Italy

ISSN 0302-9743 ISSN 1611-3349 (electronic)
Lecture Notes in Computer Science
ISBN 978-3-031-65331-5 ISBN 978-3-031-65332-2 (eBook)
https://doi.org/10.1007/978-3-031-65332-2

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

Preface

These 11 volumes (LNCS volumes 14815–14825) consist of the peer-reviewed papers from the 55 Workshops of the 2024 International Conference on Computational Science and Its Applications (ICCSA 2024) which took place during July 1–4, 2024 in Hanoi (Vietnam). The peer-reviewed papers of the main conference tracks are published in a separate set consisting of two volumes (LNCS 14813–14814).

The conference was held in a hybrid form, with some participants present in person, hosted in Hanoi, Vietnam, by the Thuy Loi University. We enabled virtual participation for those who were unable to attend the event, due to logistical, political and economic problems, by adopting a technological infrastructure based on open source software (jitsi + riot), and a commercial Cloud infrastructure.

ICCSA 2024 was another successful event in the International Conference on Computational Science and Its Applications (ICCSA) conference series, previously held in Athens, Greece (2023), Malaga, Spain (2022), Cagliari, Italy (hybrid with few participants in presence in 2021 and completely online in 2020), whilst earlier editions took place in Saint Petersburg, Russia (2019), Melbourne, Australia (2018), Trieste, Italy (2017), Beijing. China (2016), Banff, Canada (2015), Guimaraes, Portugal (2014), Ho Chi Minh City, Vietnam (2013), Salvador, Brazil (2012), Santander, Spain (2011), Fukuoka, Japan (2010), Suwon, South Korea (2009), Perugia, Italy (2008), Kuala Lumpur, Malaysia (2007), Glasgow, UK (2006), Singapore (2005), Assisi, Italy (2004), Montreal, Canada (2003), and (as ICCS) Amsterdam, The Netherlands (2002) and San Francisco, USA (2001).

Computational Science is the main pillar of most of the present research, industrial and commercial applications, and plays a unique role in exploiting ICT innovative technologies, and the ICCSA conference series have been providing a venue to researchers and industry practitioners to discuss new ideas, to share complex problems and their solutions, and to shape new trends in Computational Science. As the conference mirrors society from a scientific point of view, this year's undoubtedly dominant theme was the machine learning and artificial intelligence and their applications in the most diverse economic and industrial fields.

The ICCSA 2024 conference is structured in 6 general tracks covering the fields of computational science and its applications: Computational Methods, Algorithms and Scientific Applications – High Performance Computing and Networks – Geometric Modeling, Graphics and Visualization – Advanced and Emerging Applications – Information Systems and Technologies – Urban and Regional Planning. In addition, the conference consisted of 55 workshops, focusing on very topical issues of importance to science, technology and society: from new mathematical approaches for solving complex computational systems, to information and knowledge in the Internet of Things, new statistical and optimization methods, several Artificial Intelligence approaches, sustainability issues, smart cities and related technologies.

In the Workshops proceedings we accepted 281 full papers, 17 short papers and 2 PhD Showcase papers. In the Main Conference Proceedings we accepted 53 full papers, 6 short papers and 3 PhD Showcase papers from 207 submissions to the General Tracks of the conference (acceptance rate 30%). We would like to express our appreciation to the workshops chairs and co-chairs for their hard work and dedication.

The success of the ICCSA conference series in general, and of ICCSA 2024 in particular, vitally depends on the support of many people: authors, presenters, participants, keynote speakers, workshop chairs, session chairs, organizing committee members, student volunteers, Program Committee members, Advisory Committee members, International Liaison chairs, reviewers and others in various roles. We take this opportunity to wholehartedly thank them all.

We also wish to thank our publisher, Springer, for their acceptance to publish the proceedings, for sponsoring part of the best papers awards and for their kind assistance and cooperation during the editing process.

We cordially invite you to visit the ICCSA website https://iccsa.org where you can find all the relevant information about this interesting and exciting event.

July 2024

Osvaldo Gervasi
Beniamino Murgante
Chiara Garau

Welcome Message from Organizers

After the very hard times of COVID, ICCSA continues its successful scientific endeavors in 2024, hosted in Hanoi, Vietnam. This time, ICCSA moved from the Mediterranean Region to Southeast Asia and was held in the metropolitan city of Hanoi, the capital of Vietnam. Hanoi is a vibrant urban environment known for the hospitality of its citizens, its rich history, vibrant culture, and dynamic urban life. Located in the northern part of the country, Hanoi is a bustling metropolis that combines the old with the new, offering a unique blend of ancient traditions and modern development.

ICCSA 2024 took place in a secure environment, allowing for safe and vibrant in-person participation. Combined with the active engagement of the ICCSA 2024 scientific community, this set the stage for highly motivating discussions and interactions regarding the latest developments in computer science and its applications in the real world for improving communities' quality of life.

Thuyloi University, also known as the Water Resources University, is a prominent institution in Hanoi, Vietnam, with a strong reputation in engineering and technical education, particularly in water resources and environmental engineering. In recent years, the University has expanded its academic offerings to include computer science, reflecting the growing importance of technology and digital skills in all sectors. This year, Thuyloi University had the honor of hosting ICCSA 2024. The Local Organizing Committee felt the burden and responsibility of such a demanding task and put all necessary energy into meeting participants' expectations and establishing a friendly, creative, and inspiring scientific and social/cultural environment that allowed for new ideas and perspectives to flourish.

Since all ICCSA participants, whether informatics-oriented or application-driven, realize the tremendous advancements in computer science over the last few decades and the huge potential these advancements offer in coping with the enormous challenges of humanity in a globalized, 'wired,' and highly competitive world, the expectations for ICCSA 2024 were high. The goal was to successfully match computer science progress with communities' aspirations, achieving progress that serves real, place- and people-based needs and paves the way towards a visionary, smart, sustainable, resilient, and inclusive future for both current and future generations.

On behalf of the Local Organizing Committee, I would like to sincerely thank all of you who contributed to ICCSA 2024.

Nguyen Canh Thai

Organization

ICCSA 2024 was organized by Thuyloi University (Vietnam), the University of Perugia (Italy), the University of Basilicata (Italy), Monash University (Australia), Kyushu Sangyo University (Japan), the University of Minho (Portugal), and the University of Cagliari (Italy).

Honorary General Chairs

Norio Shiratori	Chuo University, Japan
Kenneth C. J. Tan	Sardina Systems, UK

General Chairs

Nguyen Canh Thai	Thuyloi University, Vietnam
Osvaldo Gervasi	University of Perugia, Italy
David Taniar	Monash University, Australia

Program Committee Chairs

Beniamino Murgante	University of Basilicata, Italy
Chiara Garau	University of Cagliari, Italy
Ana Maria A. C. Rocha	University of Minho, Portugal
Bernady O. Apduhan	Kyushu Sangyo University, Japan

International Advisory Committee

Jemal Abawajy	Deakin University, Australia
Dharma P. Agarwal	University of Cincinnati, USA
Rajkumar Buyya	Melbourne University, Australia
Claudia Bauzer Medeiros	University of Campinas, Brazil
Manfred M. Fisher	Vienna University of Economics and Business, Austria
Pierre Frankhauser	University of Franche-Comté/CNRS, France
Marina L. Gavrilova	University of Calgary, Canada

Sumi Helal	University of Florida, USA & University of Lancaster, UK
Bin Jiang	University of Gävle, Sweden
Yee Leung	Chinese University of Hong Kong, China

International Liaison Chairs

Ivan Blečić	University of Cagliari, Italy
Giuseppe Borruso	University of Trieste, Italy
Elise De Donker	Western Michigan University, USA
Maria Noelia Faginas Lago	University of Perugia, Italy
Maria Irene Falcão	University of Minho, Portugal
Robert C. H. Hsu	Chung Hua University, Taiwan
Yeliz Karaca	University of Massachusetts Medical School, Worcester, USA
Tae-Hoon Kim	Zhejiang University of Science and Technology, China
Vladimir Korkhov	Saint Petersburg University, Russia
Takashi Naka	Kyushu Sangyo University, Japan
Rafael D. C. Santos	National Institute for Space Research, Brazil
Maribel Yasmina Santos	University of Minho, Portugal
Anastasia Stratigea	National Technical University of Athens, Greece

Workshop and Session Organizing Chairs

Beniamino Murgante	University of Basilicata, Italy
Chiara Garau	University of Cagliari, Italy

Award Chair

Wenny Rahayu	La Trobe University, Australia

Publicity Committee Chairs

Elmer Dadios	De La Salle University, Philippines
Nataliia Kulabukhova	Saint Petersburg University, Russia
Daisuke Takahashi	Tsukuba University, Japan

Shangwang Wang	Beijing University of Posts and Telecommunications, China

Local Organizing Committee Chairs

Doan Quang Tu	Academy of Military Science and Technology, Hanoi, Vietnam
Ho Sy Tam	Thuyloi University, Vietnam
Le Quang Tuan	Thuyloi University, Vietnam
Nguyen Huu Quynh	Thuyloi University, Vietnam
Ta Quang Chieu	Thuyloi University, Vietnam

Technology Chair

Damiano Perri	University of Perugia, Italy

Program Committee

Vera Afreixo	University of Aveiro, Portugal
Vladimir Alarcon	Northern Gulf Institute, USA
Filipe Alvelos	University of Minho, Portugal
Debora Anelli	Polytechnic University of Bari, Italy
Hartmut Asche	Hasso-Plattner-Institut für Digital Engineering, Germany
Ginevra Balletto	University of Cagliari, Italy
Socrates Basbas	Aristotle University of Thessaloniki, Greece
David Berti	ART SpA, Italy
Michela Bertolotto	University College Dublin, Ireland
Debnath Bhattacharyya	Koneru Lakshmaiah University, India
Sandro Bimonte	CEMAGREF, TSCF, France
Ana Cristina Braga	University of Minho, Portugal
Tiziana Campisi	Kore University of Enna, Italy
Yves Caniou	Lyon University, France
José A. Cardoso e Cunha	Universidade Nova de Lisboa, Portugal
Rui Cardoso	University of Beira Interior, Portugal
Leocadio G. Casado	University of Almeria, Spain
Mete Celik	Erciyes University, Turkey
Maria Cerreta	University of Naples Federico II, Italy
Mauro Coni	University of Cagliari, Italy

Workshops

Advances in Artificial Intelligence Learning Technologies: Blended Learning, STEM, Computational Thinking and Coding (AAILT 2024)

Workshop Organizers

Alfredo Milani	University of Perugia, Italy
Valentina Franzoni	University of Perugia, Italy
Sergio Tasso	University of Perugia, Italy

Workshop Program Committee Members

Li Yuanxi	Hong Kong Baptist University, Hong Kong, China
Valentino Santucci	University for Foreigners, Perugia, Italy
Krassimir Markov	Institute of Information Theories and Applications, Sofia, Bulgaria
Clement Leung	Chinese University of Hong Kong, China
Rajdeep Niyogi	Indian Institute of Technology, Rooorkee, India

Advanced and Innovative Web Apps 2024 (AIWA 2024)

Workshop Organizers

Osvaldo Gervasi	University of Perugia, Italy
Damiano Perri	University of Perugia, Italy

Workshop Program Committee Members

Tamie Salter	Citizen Alert Inc., Canada
Paolo Nesi	University of Florence, Italy
Tae Hoon Kim	Zhejiang University of Science and Technology, China
Debnath Bhattacharyya	Koneru Lakshmaiah Education Foundation, India
David Berti	ART SpA, Italy

Advanced Processes of Mathematics and Computing Models in Complex Computational Systems (ACMC 2024)

Workshop Organizers

Yeliz Karaca	University of Massachusetts Chan Medical School and Massachusetts Institute of Technology, USA
Dumitru Baleanu	Cankaya University, Turkey
Osvaldo Gervasi	University of Perugia, Italy
Yudong Zhang	University of Leicester, UK
Majaz Moonis	University of Massachusetts Medical School, USA

Workshop Program Committee Members

Tamie Salter	Citizen Alert Inc., Canada
TaiHoon Kim	Konkuk University, South Korea
Debnath Bhattacharyya	Koneru Lakshmaiah Education Foundation, India
Massimiliano Nicolini	OliTec Foundation, Italy
Martin Bohner	Missouri University of Science and Technology, Missouri, USA
René Lozi	Université Côte d'Azur, France
Ravi P. Agarwal	Texas A&M University-Kingsville, USA
Aziz Dursun	Virginia Tech, USA
Muhammad Attique Khan	HITEC University, Pakistan and Lebanese American University, Lebanon
Rasulova Mukhayo	National University Uzbekistan, Uzbekistan

Advances in Information Systems and Technologies for Emergency Management, Risk Assessment and Mitigation Based on the Resilience Concepts (ASTER 2024)

Workshop Organizers

Maurizio Pollino	Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Italy
Marco Vona	University of Basilicata, Italy

Alessandro Giocoli	Italian National Agency for New Technologies, Energyand Sustainable Economic Development, Italy
Chiara Ormando	Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Italy
Angelo Anelli	Italian National Research Council, Italy

Workshop Program Committee Members

Gregorio D'Agostino	Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Italy
Christian Bignami	INGV, Italy
Paolo Clemente	Anti-Seismic Systems International Society, ASSISI, USA
Sonia Giovinazzi	Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Italy

Advances in Web-Based Learning 2024 (AWBL 2024)

Workshop Organizers

Mustafa Inceoglu	Ege University, Turkey
Birol Ciloglugil	Ege University, Turkey

Workshop Program Committee Members

Birim Balci	Celal Bayar University, Turkey
Burak Galip Aslan	Izmir Yuksek Teknoloji University, Turkey
Mahmut Unan	University of Alabama, USA
Nisha S. Raj	Global Indian International School, Japan
Oylum Alatlı	Ege University, Turkey

Blockchain and Distributed Ledgers: Technologies and Applications (BDLTA 2024)

Workshop Organizers

Vladimir Korkhov	Saint Petersburg State University, Russia
Elena Stankova	Saint Petersburg State University, Russia
Nataliia Kulabukhova	Saint Petersburg State University, Russia

Workshop Program Committee Members

Vasily Solodkov	Higher School of Economics Banking Institute
Alexander Bogdanov	St. Petersburg State University, Russia
Alexander Degtyarev	St. Petersburg State University, Russia
Dmitry Vasiunin	Deutsche Telekom Cloud Services E.P.E., Greece
Serob Balyan	National Academy of Sciences of Armenia, Armenia
Suren Abrahamyan	Osensus Arm LLC, Armenia
Ashot Gevorkyan	National Academy of Sciences of Armenia, Armenia
Martin Vala	Univerzita Pavla Jozefa Šafárika Košiciach, Košice, Slovakia
Nodir Zaynalov	Tashkent University of Information Technologies, Uzbekistan
Michail Panteleyev	St. Petersburg Electrotecnical University, Russia
Nikolay Peryazev	Irkutsk State University, Irkutsk, Russia

Computational and Applied Mathematics (CAM 2024)

Workshop Organizers

Maria Irene Falcao	University of Minho, Portugal
Fernando Miranda	University of Minho, Portugal

Workshop Program Committee Members

Ricardo Severino	University of Minho, Portugal
Helmuth Malonek	University of Aveiro, Portugal
Isabel Cacao	University of Aveiro, Portugal
Graça Tomaz	Polytechnic of Guarda, Portugal

Rosário Fernandes	University of Minho, Portugal
Lidia Aceto	University of Piedmont Oriental, Italy
Patrícia Beites	University of Beira Interior, Portugal
Regina de Almeida	University of Trás-os-Montes e Alto Douro, Portugal
Luís Ferrás	University of Porto, Portugal
Helmuth Malonek	University of Aveiro, Portugal
João Morais	Autonomous Technological Institute of Mexico, Mexico
Yilmaz Simsek	Akdeniz University, Turkey

Computational and Applied Statistics (CAS 2024)

Workshop Organizer

Ana Cristina Braga	University of Minho, Portugal

Workshop Program Committee Member

Adelaide Freitas	University of Aveiro, Portugal
Ângela Silva	University of Minho, Portugal
Arminda Manuela Gonçalves	University of Minho, Portugal
Arunasalam Rahunanthan	Central State University, USA
Elisete Correia	University of Trás-os-Montes e Alto Douro, Portugal
Frank Westad	Norwegian University of Science and Technology, Norway
Humberto Rocha	University of Coimbra, Portugal
Ivan Rodriguez Conde	University of Arkansas, USA
Lino Costa	University of Minho, Portugal
Marco Reis	University of Coimbra, Portugal
Maria Filipa Mourão	Polytechnic Institute of Viana do Castelo, Portugal
Martín Pérez Pérez	University of Vigo, Spain
Michal Abrahamowicz	McGill University, Canada
Vanda Lourenço	New University of Lisbon, Portugal
Vera Afreixo	University of Aveiro, Portugal

Cyber Intelligence and Applications (CIA 2024)

Workshop Organizer

Gianni D'Angelo	University of Salerno, Italy

Workshop Program Committee Members

Massimo Ficco	University of Salerno, Italy
Marcello Trovati	Edge Hill University, UK
Michal Choras	Bydgoszcz University of Science and Technology, Poland

Computational Methods, Statistics and Industrial Mathematics (CMSIM 2024)

Workshop Organizers

Maria Filomena Teodoro	University of Lisbon and Portuguese Naval Academy, Portugal
Marina A. P. Andrade	University Institute of Lisbon, Portugal
Maria de Fátima Alves de Pina	University Institute of Lisbon, Portugal

Workshop Program Committee Members

Ricardo Moura	University of Lisboa and FCT, Portugal
Aldina Correia	Escola Superior de Tecnologia e Gestão, Portugal
Eliana Costa	Escola Superior de Tecnologia e Gestão, Portugal
Ana Borges	Escola Superior de Tecnologia e Gestão, Portugal
Cristina Lopes	ISCAP, Portugal
Fernando Carapau	University of Evora, Portugal
Fernanda Costa	University of Minho, Portugal
Maria Luísa Morgado	University of Trás os Montes e Alto Douro and University of Lisboa, Portugal
Ana Isabel Pereira	Instituto Politécnico de Bragança, Portugal
Bruna Ramos	University of Minho, Portugal
Rosário Ramos	Universidade Aberta, Portugal
Elisabete Carolino	Escola Superior da Saúde de Lisboa, Portugal
Sofia Rézio	Instituto Politécnico de Lisboa, Portugal
Matteo Sacchet	University of Turin, Italy

Marina Marchisio Conte	University of Turin, Italy
António Seijas-Macias	University of Coruña, Spain
Luís F. A. Teodoro	University of Glasgow, UK and University of Oslo, Norway
Christos Kitsos	University of West Attica, Greece

Computational Optimization and Applications (COA 2024)

Workshop Organizers

Ana Maria A. C. Rocha	University of Minho, Portugal
Humberto Rocha	University of Coimbra, Portugal

Workshop Program Committee Members

Eligius M. T. Hendrix	University of Málaga, Spain
Joana Matos Dias	University of Coimbra, Portugal
Ana Isabel Pereira	Polytechnic Institute of Bragança, Portugal
Filipe Alvelos	Univeristy of Minho, Portugal
Emerson José de Paiva	Federal University of Itajubá, Brazil

Computational Astrochemistry (CompAstro 2024)

Workshop Organizers

Marzio Rosi	University of Perugia, Italy
Nadia Balucani	University of Perugia, Italy
Daniela Ascenzi	University of Trento, Italy
Stefano Falcinelli	University of Perugia, Italy

Workshop Program Committee Members

Albert Rimola	Universitat Autònoma de Barcelona, Spain
Dimitrios Skouteris	Master-Tec, Perugia, Italy
Piero Ugliengo	University of Turin, Italy
Andrea Lombardi	University of Perugia, Italy
Piergiorgio Casavecchia	University of Perugia, Italy
Fernando Pirani	University of Perugia, Italy
Costanza Borghesi	University of Perugia, Italy

Gabriella Digenova	University of Perugia, Italy
Lisa Giani	Grenoble Alpes University, France
Marco Parriani	University of Perugia, Italy
Cecilia Coletti	University of Chieti, Italy
Massimiliano Aschi	University of L'Aquila, Italy
Emilia Dearagao	University of Perugia, Italy
Giacomo Pannacci	University of Perugia, Italy
Gianmarco Vanuzzo	University of Perugia, Italy

Computational Methods for Porous Geomaterials (CompPor 2024)

Workshop Organizers

Vadim Lisitsa	Russian Academy of Science, Russia
Evgeniy Romenski	Russian Academy of Science, Russia

Workshop Program Committee Members

Kirill Gadylshin	Russian Academy of Science, Russia
Tayana Khachkova	Russian Academy of Science, Russia
Dmitri Prokhorov	Russian Academy of Science, Russia
Mikahil Novikov	Russian Academy of Science, Russia

Workshop on Computational Science and HPC (CSHPC 2024)

Workshop Organizers

Elise De Doncker	Western Michigan University, USA
Fukuko Yuasa	High Energy Accelerator Research Organization, Japan
Hideo Matsufuru	High Energy Accelerator Research Organization, Japan

Workshop Program Committee Members

Tadashi Ishikawa	High Energy Accelerator Research Organization, Japan
Hiroshi Daisaka	Hitotsubashi University, Japan
Naohito Nakasato	University Aizu, Japan

Takahiro Ueda	Juntendo University, Japan
Khiem Hong Phan	Duy Tan University, Vietnam
Naohito Nakasato	University Aizu, Japan
Tasnim Gharaibeh	Kalamazoo College, USA
Robert Makin	Western Michigan University, USA

Cities, Technologies and Planning (CTP 2024)

Workshop Organizers

Beniamino Murgante	University of Basilicata, Italy
Giuseppe Borruso	University of Trieste, Italy
Malgorzata Hanzl	Lodz University of Technology, Poland
Anastasia Stratigea	National Technical University of Athens, Greece
Ljiljana Zivkovic	Republic Geodetic Authority, Serbia
Ginevra Balletto	University of Cagliari, Italy

Workshop Program Committee Members

Silvia Battino	University of Sassari, Italy
Mara Ladu	University of Cagliari, Italy
Maria del Mar Munoz Leonisio	University of Cadiz, Spain
Ahinoa Amaro Garcia	Univeristy of Las Palmas of Gran Canaria, Spain
Maria Attard	University of Malta, Malta
Enrico Dagostini	University of Malta, Malta
Francesca Krasna	University of Trieste, Italy
Brisol García García	Polytechnic University of Quintana Roo, Mexico
Tu Anh Trinh	College of Technology and Design for UEH University, Vietnam
Giovanni Mauro	University of Campania Luigi Vanvitelli, Italy
Maria Ronza	University of Naples, Federico II, Italy
Massimiliano Bencardino	University of Salerno, Italy

Sustainable Digital Circular Economy (DiCE 2024)

Workshop Organizers

Ginevra Balletto	University of Cagliari, Italy
Stefano Epifani	Digital Sustainability Foundation, Italy

Stefano Carboni	University of Sassari, Italy
Francesca Sinatra	University of Cagliari, Italy
Salvatore Dore	University of Sassari, Italy
Andrea Gallo	University of Trieste, Italy

Workshop Program Committee Members

Giuseppe Borruso	University of Trieste, Italy
Silvia Battino	University of Sassari, Italy
Beniamino Murgante	University of Basilicata, Italy
Mara Ladu	University of Cagliari, Italy
Luigi Mundula	University of Perugia, Italy
Maria Attard	University of Malta, Malta
Enrico Dagostini	University of Malta, Malta
Emilio Ghiani	University of Cagliari, Italy
Marco Naseddu	University of Cagliari, Italy
Balázs Kulcsaár	University of Debrecen, Hungary
Tu Anh Trinh	College of Technology and Design for UEH University, Vietnam
Giovanni Mauro	University of Campania Luigi Vanvitelli, Italy
Maria Ronza	University of Naples, Federico II, Italy
Massimiliano Bencardino	University of Salerno, Italy

Evaluating Inner Areas Potentials (EIAP 2024)

Workshop Organizers

Diana Rolando	Polytechnic of Turin, Italy
Alice Barreca	Polytechnic of Turin, Italy
Manuela Rebaudengo	Polytechnic of Turin, Italy
Giorgia Malavasi	Polytechnic of Turin, Italy

Workshop Program Committee Members

John Accordino	Virginia Commonwealth University, USA
Sara Favargiotti	University of Trento, Italy
Maddalena Ferretti	Polytechnic University of Marche, Italy
Daniel Laven	Mid Sweden University, Sweden
Barbara Lino	University of Palermo, Italy
Umberto Mecca	Polytechnic University of Turin, Italy

Lorenzo Savio	Polytechnic University of Turin, Italy
Asja Aulisio	Polytechnic University of Turin, Italy

Econometrics and Multidimensional Evaluation of Urban Environment (EMEUE 2024)

Workshop Organizers

Carmelo Maria Torre	Polytechnic of Bari, Italy
Francesco Tajani	Sapienza University of Rome, Italy
Pierluigi Morano	Polytechnic of Bari, Italy
Simona Panaro	University of Sussex, UK
Maria Cerreta	University of Naples Federico II, Italy
Debora Anelli	Polytechnic of Bari, Italy

Workshop Program Committee Members

Pierfrancesco de Paola	University of Naples Federico II, Italy
Daniela Tavano	University of Calabria, Italy
Giuseppe Cerullo	Sapienza University of Rome, Italy
Francesco Paolo del Giudice	Sapienza University of Rome, Italy
Marco Locurcio	Polytechnic University of Bari, Italy
Maria Rosa Trovato	University of Catania, Italy
Felicia di Liddo	Polytechnic University of Bari, Italy
Maria Paz Saez Perez	University of Granada, Spain
Yasmine Selim	Ain Shams University, Cairo
Hasan Mara	Indian Institute of Technology Roorkee, India
Philipp Wiesner	Technical University of Berlin, Germany
Maria Gamboa Perez	Complutense University of Madrid, Spain
Manuel Yanez	Universidad Autónoma de Madrid, Spain
Lucia Ika Fitriastuti	Solusi Bisnis Indonesia, Indonesia
Frank Devai	London South Bank University, UK
Frank Westad	Norwegian University of Science and Technology, Norway
Eugenio Muccio	University of Naples Federico II, Italy
Chiara Mazzarella	TU Delft, The Netherlands
Daniele Cannatella	TU Delft, The Netherlands
Sabrina Sacco	University of Naples Federico II, Italy
Piero Zizzania	University of Naples Federico II, Italy
Stefano Cuntò	University of Naples Federico II, Italy

Sveva Ventre	University of Naples Federico II, Italy
Caterina Loffredo	University of Naples Federico II, Italy
Giuseppe Ciciriello	University of Naples Federico II, Italy
Maria Somma	University of Naples Federico II, Italy
Ludovica La Rocca	University of Naples Federico II, Italy
Gaia Daldanise	National Research Council, Italy
Giuliano Poli	University of Naples Federico II, Italy

Environmental, Social, Governance of Energy Planning (ESGEP 2024)

Workshop Organizers

Ginevra Balletto	University of Cagliari, Italy
Emilio Ghiani	University of Cagliari, Italy
Roberto De Lotto	University of Pavia, Italy
Alessandra Marra	University of Salerno, Italy
Riccardo Trevisan	University of Cagliari, Italy
Balázs Kulcsár	University of Debrecen, Hungary

Workshop Program Committee Members

Jacopo Torriti	University of Reading, UK
Roberto Gerundo	University of Salerno, Italy
Luigi Mundula	University of Perugia, Italy
Mara Ladu	University of Cagliari, Italy
Giuseppe Borruso	University of Trieste, Italy
Tu Anh Trinh	College of Technology and Design for UEH University, Vietnam
Giovanni Mauro	University of Campania Luigi Vanvitelli, Italy
Maria Ronza	University of Naples, Federico II, Italy
Massimiliano Bencardino	University of Salerno, Italy

Ecosystem Services in Spatial Planning for Resilient Urban and Rural Areas (ESSP 2024)

Workshop Organizers

Sabrina Lai	University of Cagliari, Italy
Corrado Zoppi	University of Cagliari, Italy
Francesco Scorza	University of Basilicata, Italy

Beniamino Murgante	University of Basilicata, Italy
Floriana Zucaro	University of Naples Federico II, Italy
Carmela Gargiulo	University of Naples Federico II, Italy

Workshop Program Committee Members

Carmen Guida	University of Naples Federico II, Italy
Irina Di Ruocco	Insubria University, Italy
Silvia Rossetti	University of Parma, Italy
Barbara Caselli	University of Parma, Italy
Gloria Pellicelli	University of Parma, Italy
Federica Leone	University of Cagliari, Italy
Federica Isola	University of Cagliari, Italy
Francesca Leccis	University of Cagliari, Italy
Francesca Perrone	Sapienza University of Rome, Italy
Angela Pilogallo	Italian National Research Council, Italy
Alfonso Annunziata	University of Basilicata, Italy
Alessandro Marucci	University of L'Aquila, Italy
Francesco Zullo	University of L'Aquila, Italy
Gizem Dinç	Süleyman Demirel University, Turkey
Atila Gul	Süleyman Demirel University, Turkey
Sarah Scheiber	University of Malta, Malta
Matteo Caglioni	Université Côte d'Azur, France

Ethical AI Applications for a Human-Centered Cyber Society (EthicAI 2024)

Workshop Organizers

Valentina Franzoni	University of Perugia, Italy
Alfredo Milani	University of Perugia, Italy
Jordi Vallverdu	University Autonoma Barcelona, Spain

Workshop Program Committee Members

Sergio Tasso	University of Perugia, Italy
Yuanxi Li	Hong Kong Baptist University, Hong Kong, China
Daniele Mezzetti	Santa Maria della Misericordia Hospital of Perugia, Italy
Abeer Dyoub	L'Aquila University, Italy

14th International Workshop on Future Computing System Technologies and Applications (FiSTA 2024)

Workshop Organizers

Bernady Apduhan	Kyushu Sangyo University, Japan
Rafael Santos	National Institute for Space Research, Brazil

Workshop Program Committee Members

Agustinus Borgy Waluyo	Monash University, Australia
Andre Ricardo Abed Grégio	Federal University of Parana, Brazil
Earl Ryan Aleluya	MSU-Iligan Institute of Technology, Philippines
Kai Cheng	Kyushu Sangyo University, Japan
Alvaro Fazenda	Federal University of São Paulo, Brazil
Yusuke Gotoh	Okayama University, Japan
Eric Pardede	La Trobe University, Australia
Yasuaki Sumida	Kyushu Sangyo University, Japan
Kazuaki Tanaka	Kyushu Institute of Technology, Japan
Toshihiro Uchibayashi	Kyushu University, Japan
Toshihiro Yamauchi	Okayama University, Japan
Fenghui Yao	Tennessee State University, USA

Geographical Analysis, Urban Modeling, Spatial Statistics (Geog-An-Mod 2024)

Workshop Organizers

Beniamino Murgante	University of Basilicata, Italy
Giuseppe Borruso	University of Trieste, Italy
Harmut Asche	Hasso-Plattner-Institut für Digital Engineering, Germany
Andreas Fricke	Hasso-Plattner-Institut für Digital Engineering, Germany
Rodrigo Tapia McClung	Centro de Investigación en Ciencias de Información Geoespacial, Mexico

Workshop Program Committee Members

Ginevra Balletto	University of Cagliari, Italy
Silvia Battino	University of Sassari, Italy
Mara Ladu	University of Cagliari, Italy
Marco Mazzarino	IUAV Univeristy Venice, Italy
Maria del Mar Munoz Leonisio	Univeristy of Cadiz, Spain
Ahinoa Amaro Garcia	University of Las Palmas of Gran Canaria, Spain
Veronica Camerada	University of Sassari, Italy
Maria Attard	University of Malta, Malta
Enrico Dagostini	University of Malta, Malta
Francesca Krasna	University of Trieste, Italy
Malgorzata Hanzl	Lodz University of Technology, Poland
Anastasia Stratigea	National Technical University of Athens, Greece
Tu Anh Trinh	College of Technology and Design for UEH University, Vietnam
Giovanni Mauro	University of Campania Luigi Vanvitelli, Italy
Maria Ronza	University of Naples, Federico II, Italy
Massimiliano Bencardino	University of Salerno, Italy

Geomatics for Resource Monitoring and Management (GRMM 2024)

Workshop Organizers

Alessandra Capolupo	Polytechnic of Bari, Italy
Eufemia Tarantino	Polytechnic of Bari, Italy
Alberico Sonnessa	Polytechnic of Bari, Italy

Workshop Program Committee Members

Umberto Fratino	Polytechnic of Bari, Italy
Valeria Monno	Polytechnic of Bari, Italy
Antonino Maltese	University of Palermo, Italy
Athos Agapiou	Cyprus University of Technology, Cyprus
Michele Mangiameli	University of Catania, Italy
Angela Gorgoglione	University of la República de Uruguay, Uruguay
Roberta Ravanelli	Sapienza University of Rome, Italy
Alessandra Mascitelli	D'Annunzio University of Chieti–Pescara, Italy
Ester Scotto di Perta	University of Naples, Federico II, Italy

Giacomo Caporusso	National Research Council, Italy
Andrea Montanino	University of Naples, Federico II, Italy
Antonino Iannuzzo	University of Sannio, Benevento, Italy
Silvano Dal Sasso	University of Basilicata, Potenza, Italy
Laura Mirra	National Research Council, Water Research Institute, Italy
Alessandro Pagano	National Research Council, Water Research Institute, Italy
Francesco Chiaravalloti	National Research Council, Water Research Institute, Italy
Francesco Di Capua	University of Basilicata, Italy
Stefania Santoro	National Research Council, Water Research Institute, Italy
Cinzia Albertini	National Research Council, IREA, Italy
Alessandra Saponieri	University of Salento, Italy

International Workshop on Information and Knowledge in the Internet of Things (IKIT 2024)

Workshop Organizers

Teresa Guarda	Peninsula State University of Santa Elena, Ecuador
José María Díaz Nafría	Madrid Open University, Spain
Filipe Portela	University of Minho, Portugal

Workshop Program Committee Members

Arnulfo Alanis	Instituto Tecnologico de Tijuana, Mexico
Bruno Sousa	University of Coimbra, Portugal
Carlos Balsa	Instituto Politécnico de Bragança, Portugal
Filipe Mota Pinto	Instituto Politécnico de Leiria, Portugal
Gustavo Gatica	Universidad Andrés Bello, Chile
Isabel Lopes	Instituto Politécnico de Bragança, Portugal
José María Díaz Nafría	Universidad a Distancia, Spain
Maria Fernanda Augusto	BiTrum Research Group, Spain
Maria Isabel Ribeiro	Instituto Politécnico Bragança, Portugal
Modestos Stavrakis	University of the Aegean, Greece
Simone Belli	Universidad Complutense de MadridSpain
Walter Lopes Neto	Instituto Federal de Educação, Brazil

Regenerating Brownfields Enhancing Urban Resilience Appeal (INFERENCE 2024)

Workshop Organizers

Francesca Moraci	Mediterranea University of Reggio Calabria, Italy
Maurizio Oddo	University of Enna Kore, Italy
Antonella Versaci	University of Enna Kore, Italy
Celestina Fazia	University of Enna Kore, Italy
Tiziana Campisi	University of Enna Kore, Italy
Kh Md Nahiduzzaman	University of British Columbia, Canada

Workshop Program Committee Members

Alessandro Baracco	University of Enna Kore, Italy
Kaoutare Amini Alaoui	Mohammed VI Polytechnic University, UM6P, Morocco
Maurizio Errigo	Sapienza University of Rome, Italy
Marsia Marino	Sapienza University of Rome, Italy
Nessrine Moumen	Mohammed VI Polytechnic University, UM6P, Morocco
Francesca Perrone	Sapienza University of Rome, Italy
Pasquale Pizzimenti	Mediterranea University of Reggio Calabria, Italy
Barbara Scala	University of Brescia, Italy
Clarastella Vicari Aversa	Mediterranea University of Reggio Calabria, Italy

International Workshop on Territorial Planning to Integrate Risk and Urban Ontologies (IWPRO 2024)

Workshop Organizers

Elisabetta Maria Venco	University of Pavia, Italy
Beniamino Murgante	University of Basilicata, Italy
Roberto De Lotto	University of Pavia, Italy
Caterina Pietra	University of Pavia, Italy

Workshop Program Committee Members

Stefano Borgo	National Research Council, Italy
Valentina Costa	University of Genoa, Italy
Pajouh Danesh	Middle East Technical University, Turkey

Ilaria Delponte	University of Genoa, Italy
Lorena Fiorini	University of L'Aquila, Italy
Veronica Gazzola	Polytechnic of Milan, Italy
Ghazaleh Goodarzi	Islamic Azad University, Iran
Michele Grimaldi	University of Salerno, Italy
Alessandra Marra	University of Salerno, Italy
Naghmeh Mohammadpourlima	Akademi University, Finland
Francesca Pirlone	University of Genoa, Italy
Silvia Rossetti	University of Parma, Italy
Lucia Saganeiti	University of L'Aquila, Italy
Bahareh Shahsavari	University of Minnesota, USA
Ilenia Spadaro	University of Genoa, Italy
Maria Rosaria Stufano Melone	Polytechnic of Bari, Italy

MaaS Solutions for Airports, Cities and Regional Connectivity (MaaS 2024)

Workshop Organizers

Gianfranco Fancello	University of Cagliari, Italy
Francesco Piras	University of Cagliari, Italy
Tanja Congiu	University of Sassari, Italy
Mara Ladu	University of Cagliari, Italy
Martina Sinatra	University of Cagliari, Italy
Ginevra Balletto	University of Cagliari, Italy

Workshop Program Committee Members

Italo Meloni	University of Cagliari, Italy
Tu Anh Trinh	College of Technology and Design for UEH University, Vietnam
Giuseppe Borruso	University of Trieste, Italy
Luigi Mundula	University of Perugia, Italy
Francesca Sinatra	University of Trieste, Italy
Salvatore Dore	University of Trieste, Italy
Andrea Gallo	University of Trieste, Italy
Marcello Tadini	University of Eastern Piedmont, Italy
Marco Mazzarino	IUAV Univeristy Venice, Italy
Maria del Mar Munoz Leonisio	University of Cadiz, Spain
Veronica Camerada	Univeristy of Sassari, Italy

Brunella Brundu	Univerisity of Sassari, Italy
Maria Attard	University of Malta, Malta
Enrico Dagostini	University of Malta, Malta
Giovanni Mauro	University of Campania Luigi Vanvitelli, Italy
Maria Ronza	University of Naples, Federico II, Italy
Massimiliano Bencardino	University of Salerno, Italy

Development of Urban Mobility Management and Risk Assessment (MAINTAIN 2024)

Workshop Organizers

Tiziana Campisi	University of Enna Kore, Italy
Massimo Di Gangi	University of Messina, Italy
Antonio Comi	University of Rome Tor Vergata, Italy
Grigorios Fountas	Aristotle University of Thessaloniki, Greece
Jesús González-Feliu	Excelia Business School, La Rochelle, France

Workshop Program Committee Members

Paola Panuccio	Mediterranea University of Reggio Calabria, Italy
Domenica Savia Pellicano	Mediterranean University of Reggio Calabria, Italy
Alexandros Nikitas	University of Huddersfield, UK
Antonio Polimeni	University of Messina, Italy
Orlando Belcore	University of Messina, Italy
Marinella Giunta	Mediterranea University of Reggio Calabria, Italy
Borja Alonso	University of Cantabria, Spain
Luigi Dall'Olio	University of Cantabria, Santander, Spain
Kh Md Nahiduzzaman	UBC, Canada

Multidimensional Evolutionary Evaluations for Transformative Approaches (MEETA 2024)

Workshop Organizers

Maria Cerreta	University of Naples Federico II, Italy
Giuliano Poli	University of Naples Federico II, Italy
Daniele Cannatella	TU Delft, The Netherlands

Ludovica Larocca	University of Naples Federico II, Italy
Maria Somma	University of Naples Federico II, Italy
Gaia Daldanise	National Research Council, Italy

Workshop Program Committee Members

Maria Lucia Raiola	University of Naples Federico II, Italy
Eugenio Muccio	University of Naples Federico II, Italy
Chiara Mazzarella	TU Delft, The Netherlands
Sabrina Sacco	University of Naples Federico II, Italy
Piero Zizzania	University of Naples Federico II, Italy
Stefano Cuntò	University of Naples Federico II, Italy
Sveva Ventre	University of Naples Federico II, Italy
Caterina Loffredo	University of Naples Federico II, Italy
Giuseppe Ciciriello	University of Naples Federico II, Italy
Laura Di Tommaso	University of Naples Federico II, Italy
Benedetta Grieco	University of Naples Federico II, Italy
Simona Panaro	University of Sussex, UK

Building Multi-dimensional Models for Assessing Complex Environmental Systems (MES 2024)

Workshop Organizers

Vanessa Assumma	University of Bologna, Italy
Caterina Caprioli	Politechnic of Turin, Italy
Giulia Datola	Politechnic of Turin, Italy
Federico Dell'Anna	Politechnic of Turin, Italy
Marta Dell'Ovo	Politechnic of Milan, Italy
Marco Rossitti	Politechnic of Milan, Italy

Workshop Program Committee Members

Maksims Feofilovs	Riga Technical University, Latvia
Ossama Abdelwahab	University of Bari, Italy
Mariarosaria Angrisano	Pegaso Telematic University, Italy
Francesca Torrieri	Polytechnic of Milan, Italy
Maurizio Pioletti	University of Padua, Italy
Daniela Tavano	University of Calabria, Italy
Simone Persico	Polytechnic of Turin, Italy

Chiara D'Alpaos	University of Padua, Italy
Ezgi Şahin	Mersin University, Turkey
Giorgia Sugoni	LINKS Foundation, Italy
Rubina Canesi	University of Padua, Italy
Giulia Marzani	University of Bologna, Italy
Danny Casprini	Polytechnic of Milan, Italy
Simona Barbaro	University of Palermo, Italy
Giulio Cavana	Polytechnic of Turin, Italy
Diana Rolando	Polytechnic of Turin, Italy
Giuliano Poli	University of Naples Federico II, Italy
Francesco Sica	University of Rome La Sapienza, Italy
Sabrina Lai	University of Cagliari, Italy

Models and Indicators for Assessing and Measuring the Urban Settlement Development in the View of Zero Net Land Take by 2050 (MOVEto0 2024)

Workshop Organizers

Lucia Saganeiti	University of L'Aquila, Italy
Lorena Fiorini	University of L'Aquila, Italy
Angela Pilogallo	University of L'Aquila, Italy
Francesco Zullo	University of L'Aquila, Italy
Alessandro Marucci	University of L'Aquila, Italy

Workshop Program Committee Members

Ginevra Balletto	University of Cagliari, Italy
Giuseppe Borruso	University of Trieste, Italy
Chiara Garau	University of Cagliari, Italy
Beniamino Murgante	University of Basilicata, Italy
Ljiljana Zivkovic	MBA, Republic Geodetic Authority, Serbia
Ilaria Del Ponte	University of Genoa, Italy
Carmen Guida	University of Naples Federico II, Italy
Chiara Di Dato	University of L'Aquila, Italy

4th Workshop on Privacy in the Cloud/Edge/IoT World (PCEIoT 2024)

Workshop Organizers

Michele Mastroianni	University of Salerno, Italy
Mauro Iacono	University of Campania Luigi Vanvitelli, Italy
Lelio Campanile	University of Campania Luigi Vanvitelli, Italy

Workshop Program Committee Members

Maria Ganzha	Warsaw University of Technology, Poland
Armando Tacchella	University of Genoa, Italy
Alessio Merlo	School for Advanced Defense Studies, Italy
Antonio Iannuzzi	Roma Tre University, Italy
Arcangelo Castiglione	University of Salerno, Italy
Daniel Grzonka	Cracow University of Technology, Poland
Davide Cerotti	University of Piedmont Oriental, Italy

Scientific Computing Infrastructure (SCI 2024)

Workshop Organizers

Vladimir Korkhov	St. Petersburg University, Russia
Elena Stankova	St. Petersburg State University, Russia

Workshop Program Committee Members

Adam Belloum	University of Amsterdam, the Netherlands
Dmitry Vasiunin	Deutsche Telekom Cloud Services E.P.E., Greece
Serob Balyan	National Academy of Sciences of Armenia, Armenia
Suren Abrahamyan	Osensus Arm LLC, Armenia
Ashot Gevorkyan	National Academy of Sciences of Armenia, Armenia
Michal Hnatic	Univerzita Pavla Jozefa Šafárika v Košiciach, Slovakia
Martin Vala	Univerzita Pavla Jozefa Šafárika v Košiciach, Slovakia
Nodir Zaynalov	Tashkent University of Information Technologies, Uzbekistan
Michail Panteleyev	St. Petersburg Electrotecnical University, Russia

Nikolay Peryazev	Irkutsk State University, Irkutsk, Russia
Alexander Degtyarev	St. Petersburg State University, Russia
Alexander Bogdanov	St. Petersburg State University, Russia
Nataliia Kulabukhova	SberAutoTech, Russia

Downscale Agenda 2030 (SDGscale 2024)

Workshop Organizers

Anna Richiedei	University of Brescia, Italy
Michele Pezzagno	University of Brescia, Italy
Ginevra Balletto	University of Cagliari, Italy
Francesca Sinatra	University of Trieste, Italy
Federico Martellozzo	University of Florence, Italy
Tú Anh Trinh	University of Economics Ho Chi Minh City, Vietnam

Workshop Program Committee Members

Giuseppe Borruso	University of Trieste, Italy
Elisabetta Maria Venco	University of Pavia, Italy
Riccardo Privitera	University of Catania, Italy
Elisa Conticelli	University of Bologna, Italy
Giovanni Marinelli	Polytechnic University of Marche, Italy
Francesca Sinatra	University of Trieste, Italy
Salvatore Dore	University of Trieste, Italy
Maria Attard	University of Malta, Malta
Giovanni Mauro	University of Campania Luigi Vanvitelli, Italy
Maria Ronza	University of Naples, Federico II, Italy
Massimiliano Bencardino	University of Salerno, Italy

Socio-Economic and Environmental Models for Land Use Management (SEMLUM 2024)

Workshop Organizers

Debora Anelli	Polytechnic of Bari, Italy
Pierluigi Morano	Polytechnic of Bari, Italy
Benedetto Manganelli	University of Basilicata, Italy
Francesco Paolo Del Giudice	Sapienza University of Rome, Italy

Workshop Program Committee Members

Laura Gabrielli	University of Ferrara, Italy
Sergio Copiello	University of Venice, Italy
Antonio Nesticò	University of Salerno, Italy
Pierfrancesco De Paola	University of Napoli, Italy
Elena Fregonara	Polytechnic of Turin, Italy
Paola Amoruso	LUM, Italy

Ports of the Future - Smartness and Sustainability (SmartPorts 2024)

Workshop Organizers

Giuseppe Borruso	University of Trieste, Italy
Gianfranco Fancello	University of Cagliari, Italy
Patrizia Serra	University of Cagliari, Italy
Silvia Battino	University of Sassari, Italy
Marco Petrelli	Roma Tre University, Italy

Workshop Program Committee Members

Ginevra Balletto	University of Cagliari, Italy
Beniamino Murgante	University of Basilicata, Italy
Marco Mazzarino	IUAV University Venice, Italy
Maria del Mar Munoz Leonisio	University of Cadiz, Spain
Ahinoa Amaro Garcia	University of Las Palmas of Gran Canaria, Spain
Veronica Camerada	University of Sassari, Italy
Brunella Brundu	University of Sassari, Italy
Maria Attard	University of Malta, Malta
Enrico Dagostini	University of Malta, Malta
Tu Anh Trinh	College of Technology and Design for UEH University, Vietnam
Giovanni Mauro	University of Campania Luigi Vanvitelli, Italy
Maria Ronza	University of Naples, Federico II, Italy
Massimiliano Bencardino	University of Salerno, Italy

Smart Transport and Logistics - Smart Supply Chains (SmarTransLog 2024)

Workshop Organizers

Giuseppe Borruso	University of Trieste, Italy
Marcello Tadini	University of Eastern Piedmont, Italy
Maria del Mar Munoz Leonisio	University of Cádiz, Spain
Maria Attard	University of Malta, Malta
Veronica Camerada	University of Sassari, Italy
Brunella Brundu	University of Sassari, Italy

Workshop Program Committee Members

Ginevra Balletto	University of Cagliari, Italy
Silvia Battino	University of Sassari, Italy
Gianfranco Fancello	University of Cagliari, Italy
Mara Ladu	University of Cagliari, Italy
Martina Sinatra	University of Cagliari, Italy
Francesca Sinatra	University of Trieste, Italy
Salvatore Dore	University of Trieste, Italy
Andrea Gallo	University of Trieste, Italy
Marco Mazzarino	IUAV University Venice, Italy
Enrico Dagostini	University of Malta, Malta
Marco Naseddu	University of Cagliari, Italy
José Ángel Hernández Luis	University of Las Palmas de Gran Canaria, Spain
Maurizio Cociancich	Adriafer, Italy
Giovanni Longo	University of Trieste, Italy
Luca Toneatti	University of Trieste, Italy
Giovanni Mauro	University of Campania Luigi Vanvitelli, Italy
Maria Ronza	University of Naples, Federico II, Italy
Massimiliano Bencardino	University of Salerno, Italy

Smart Tourism (SmartTourism 2024)

Workshop Organizers

Silvia Battino	University of Sassari, Italy
Francesca Krasna	University of Trieste, Italy
Maria del Mar Munoz Leonisio	University of Cadiz, Spain

Ginevra Balletto	University of Cagliari, Italy
Brisol García García	Polytechnic University of Quintana Roo, Mexico
Ainhoa Amaro Garcia	University of Las Palmas of Gran Canarias, Spain

Workshop Program Committee Members

Giuseppe Borruso	University of Trieste, Italy
Beniamino Murgante	University of Basilicata, Italy
Gianfranco Fancello	University of Cagliari, Italy
Mara Ladu	University of Cagliari, Italy
Martina Sinatra	University of Cagliari, Italy
Salvatore Dore	University of Trieste, Italy
Veronica Camerada	University of Sassari, Italy
Brunella Brundu	University of Sassari, Italy
Maria Attard	University of Malta, Malta
Tu Anh Trinh	College of Technology and Design for UEH University, Vietnam
Giovanni Mauro	University of Campania Luigi Vanvitelli, Italy
Maria Ronza	University of Naples, Federico II, Italy
Massimiliano Bencardino	University of Salerno, Italy

Sustainable Evolution of Long-Distance Freight Passenger Transport (SOLIDEST 2024)

Workshop Organizers

Tiziana Campisi	University of Enna Kore, Italy
Socrates Basbas	Aristotle University of Thessaloniki, Greece
Massimo Di Gangi	University of Messina, Italy
Antonio Comi	University of Rome Tor Vergata, Italy
Francesco Russo	Mediterranea University of Reggio Calabria, Italy
Giovanni Tesoriere	University of Enna Kore, Italy

Workshop Program Committee Members

Antonio Polimeni	University of Messina, Italy
Orlando Belcore	University of Messina, Italy
Filippo G. Praticò	Mediterranea University of Reggio Calabria, Italy
Borja Alonso	University of Cantabria, Spain
Luigi Dall'Olio	University of Cantabria, Spain
Antonio Russo	University of Enna Kore, Italy

Sustainability Performance Assessment: Models, Approaches, and Applications Toward Interdisciplinary and Integrated Solutions (SPA 2024)

Workshop Organizers

Francesco Scorza	University of Basilicata, Italy
Sabrina Lai	University of Cagliari, Italy
Jolanta Dvarioniene	Kaunas University of Technology, Lithuania

Workshop Program Committee Members

Carmela Gargiulo	University of Naples Federico II, Italy
Floriana Zucaro	University of Naples Federico II, Italy
Corrado Zoppi	University of Cagliari, Italy
Federica Leone	University of Cagliari, Italy
Federica Isola	University of Cagliari, Italy
Francesca Leccis	University of Cagliari, Italy
Francesca Perrone	Sapienza University of Rome, Italy
Angela Pilogallo	Italian National Research Council, Italy
Alfonso Annunziata	University of Basilicata, Italy
Luigi Santopietro	Italian National Research Council, Italy
Beniamino Murgante	University of Basilicata, Italy
Alessandro Marucci	University of L'Aquila, Italy
Francesco Zullo	University of L'Aquila, Italy
Monica Salvia	Italian National Research Council, Italy
Fulvia Pietrapertosa	Italian National Research Council, Italy
Valentin Grecu	Lucian Blaga University, Romania
Georgia Pozoukidou	Aristotle University of Thessaloniki, Greece
Giampiero Lombardini	University of Genoa, Italy

Specifics of Smart Cities Development in Europe (SPEED 2024)

Workshop Organizers

Chiara Garau	University of Cagliari, Italy
Katarína Vitálišová	Matej Bel University, Slovakia
Paolo Nesi	University of Florence, Italy
Anna Vaňová	Matej Bel University, Slovakia
Kamila Borsekova	Matej Bel University, Slovakia
Paola Zamperlin	University of Florence, Italy

Workshop Program Committee Members

Tiziana Campisi	University of Enna Kore, Italy
Giovanna Concu	University of Cagliari, Italy
Claudia Loggia	University of KwaZulu-Natal, South Africa
Alessandro Plaisant	University of Sassari, Italy
Francesca Maltinti	University of Cagliari, Italy
Silvia Rossetti	University of Parma, Italy
Gerardo Carpentieri	University of Naples Federico II, Italy
Carmen Guida	University of Naples Federico II, Italy
Anastasia Stratigea	National Technical University of Athens, Greece
Yiota Theodora	National Technical University of Athens, Greece
Marco Fanfani	University of Florence, Italy
Emanuele Bellini	University of Rome 3, Italy

Smart, Safe and Health Cities (SSHC 2024)

Workshop Organizers

Chiara Garau	University of Cagliari, Italy
Gerardo Carpentieri	University of Naples Federico II, Italy
Carmen Guida	University of Naples Federico II, Italy
Floriana Zucaro	University of Naples Federico II, Italy
Tanja Congiu	University of Sassari, Italy
Martina Carra	University of Brescia, Italy
Benedetto Barabino	University of Brescia, Italy

Workshop Program Committee Members

Rosaria Battarra	Italian National Research Council, Italy
Barbara Caselli	University of Parma, Italy
Francesca Maltinti	University of Cagliari, Italy
Romano Fistola	University of Naples Federico II, Italy
Sabrina Lai	University of Cagliari, Italy
Claudia Loggia	University of KwaZulu-Natal, South Africa
Alessandro Plaisant	University of Sassari, Italy
Silvia Rossetti	University of Parma, Italy
Michela Tiboni	University of Brescia, Italy
John Zacharias	Peking University, China
Thomas Buhler	University of Franche-Comté, France

Aynaz Lotfata	University of California, USA
Lucia Saganeiti	University of L'Aquila, Italy
Francesco Zullo	University of L'Aquila, Italy
Paola Zamperlin	University of Florence, Italy
Katarína Vitálišová	Matej Bel University, Faculty of Economics, Slovakia
Tiziana Campisi	University of Enna Kore, Italy
Caterina Pietra	University of Pavia, Italy
Elisabetta Maria Venco	University of Pavia, Italy
Vincenza Torrisi	University of Catania, Italy

Smart and Sustainable Island Communities (SSIC 2024)

Workshop Organizers

Chiara Garau	University of Cagliari, Italy
Anastasia Stratigea	National Technical University of Athens, Greece
Yiota Theodora	National Technical University of Athens, Greece
Giovanna Concu	University of Cagliari, Italy

Workshop Program Committee Members

Milena Metalkova-Markova	University of Portsmouth, UK
Tarek Teba	University of Portsmouth, UK
Despina Dimelli	Technical University of Crete, Greece
Gerardo Carpentieri	University of Naples Federico II, Italy
Carmen Guida	University of Naples Federico II, Italy
Floriana Zucaro	University of Naples Federico II, Italy
Anestis Gourgiotis	University of Thessaly, Greece
George Tsilimigkas	University of the Aegean, Greece
Maria Panagiotopoulou	National Technical University of Athens, Greece
George Somarakis	National Technical University of Athens, Greece
Harry Kyriakidis	National Technical University of Athens, Greece
Apostolos Lagarias	Univ. of Thessaly, Greece
Paola Zamperlin	University of Florence, Italy
Giuseppina Vacca	University of Cagliari, Italy
Roberto Minunno	Curtin University, Perth, Australia
Claudia Loggia	University of KwaZulu-Natal, South Africa
Francesca Maltinti	University of Cagliari, Italy
Elisabetta Maria Venco	University of Pavia, Italy

From Street Experiments to Planned Solutions (STEPS 2024)

Workshop Organizers

Silvia Rossetti	University of Parma, Italy
Angela Ricciardello	University of Enna Kore, Italy
Francesco Pinna	University of Cagliari, Italy
Chiara Garau	University of Cagliari, Italy
Tiziana Campisi	University of Enna Kore, Italy
Vincenza Torrisi	University of Catania, Italy

Workshop Program Committee Members

Martina Carra	University of Brescia, Italy
Barbara Caselli	University of Parma, Italy
Tanja Congiu	University of Sassari, Italy
Gabriele D'Orso	University of Palermo, Italy
Matteo Ignaccolo	University of Catania, Italy
Md Kh Nahiduzzaman	University of British Columbia, Canada
Muhammad Ahmad Al-Rashid	University of Malaya, Malesia
Alessandro Plaisant	University of Sassari, Italy
Marianna Ruggieri	University of Enna Kore, Italy
Michele Zazzi	University of Parma, Italy

Sustainable Development of Ports (SUSTAINABLEPORTS 2024)

Workshop Organizers

Giuseppe Musolino	Mediterranea University of Reggio Calabria, Italy
Tiziana Campisi	University of Enna Kore, Italy
Efstathios Bouhouras	Aristotle University of Thessaloniki, Greece
Elena Cocuzza	University of Catania, Italy
Gianfranco Fancello	University of Cagliari, Italy
Massimo Di Gangi	University of Messina, Italy

Workshop Program Committee Members

Georgios Vaggelas	National and Kapodistrian University of Athens, Greece
Antonio Polimeni	University of Messina, Italy

Orlando Belcore	University of Messina, Italy
Lucia Dalla Spina	Mediterranea University of Reggio Calabria, Italy
Elen Twerdy	University of Lubljana, Slovenia
Claudia Caballini	Polytechnic University of Turin, Italy

Theoretical and Computational Chemistry and Its Applications (TCCMA 2024)

Workshop Organizers

Noelia Faginas-Lago	University of Perugia, Italy
Andrea Lombardi	University of Perugia, Italy
Marcos Mandado	University of Vigo, Spain

Workshop Program Committee Members

Ángel Martín Pendás	University of Oviedo, Spain
Ernesto Garcia Para	University of Basque Country, Spain
Giovanni Bistoni	University of Perugia, Italy
Juan Jose Nogueira Perez	University Autonoma of Madrid, Spain
Jose Hermida	Universidade di Vigo, Spain
Luca Mancini	University of Perugia, Italy

Transport Infrastructures for Smart Cities (TISC 2024)

Workshop Organizers

Francesca Maltinti	University of Cagliari, Italy
Mauro Coni	University of Cagliari, Italy
Francesco Pinna	University of Cagliari, Italy
Chiara Garau	University of Cagliari, Italy
Nicoletta Rassu	University of Cagliari, Italy
James Rombi	University of Cagliari, Italy

Workshop Program Committee Members

Benedetto Barabino	University of Brescia, Italy
Martina Carra	University of Brescia, Italy

Mauro D'Apuzzo	University of Cassino, Italy
Roberto Minunno	Curtin University, Australia
Claudia Loggia	University of KwaZulu-Natal, South Africa
Amir Kavussi	Tarbiat Modares University, Iran
Tiziana Campisi	University of Enna Kore, Italy
Alessandro Plaisant	University of Sassari, Italy
Elena Cocuzza	University of Catania, Italy
Vincenza Torrisi	University of Catania, Italy

From Structural to Transformative-Change of City Environment: Challenges and Solutions and Perspectives (TRACE 2024)

Workshop Organizers

Maria Rosaria Guarini	Sapienza University of Rome, Italy
Francesco Sica	Sapienza University of Rome, Italy
Carmelo Maria Torre	Polytechnic University of Bari, Italy
Francesco Tajani	Polytechnic University of Bari, Italy

Workshop Program Committee Members

Angela Pilogallo	Italian National Research Council, Italy
Maria Cerreta	University of Naples Federico II, Italy
Giuseppe Cerullo	Sapienza University of Rome, Italy

Transport and Digital Multiscale Sustainable Network for Circular Economy (TransNet 2024)

Workshop Organizers

Andrea Gallo	University of Trieste, Italy
Mara Ladu	University of Cagliari, Italy
Enrico Dagostini	University of Malta, Malta
Salvatore Dore	University of Trieste, Italy
Martina Sinatra	University of Cagliari, Italy
Francesca Sinatra	University of Trieste, Italy

Workshop Program Committee Members

Martina Carra	University of Brescia, Italy
Ginevra Baletto	University of Cagliari, Italy
Giuseppe Borruso	University of Trieste, Italy
Beniamino Murgante	University of Basilicata, Italy
Maria del Mar Munoz Leonisio	Univeristy of Cadiz, Spain
Ahinoa Amaro Garcia	Univeristy of Las Palmas of Gran Canaria, Spain
Malgorzata Hanzl	Lodz University of Technology, Poland
Balázs Kulcsár	University of Debrecen, Hungary

Temporary Real Estate Management: Approaches and Methods for Time-Integrated Impact Assessments and Evaluations (TREAT 2024)

Workshop Organizers

Chiara Mazzarella	TU Delft, The Netherlands
Hilde Remoy	TU Delft, The Netherlands
Maria Cerreta	University of Naples Federico II, Italy

Workshop Program Committee Members

Maria Lucia Raiola	University of Naples Federico II, Italy
Eugenio Muccio	University of Naples Federico II, Italy
Daniele Cannatella	TU Delft, The Netherlands
Sabrina Sacco	University of Naples Federico II, Italy
Piero Zizzania	University of Naples Federico II, Italy
Stefano Cuntò	University of Naples Federico II, Italy
Sveva Ventre	University of Naples Federico II, Italy
Caterina Loffredo	University of Naples Federico II, Italy
Giuseppe Ciciriello	University of Naples Federico II, Italy
Maria Somma	University of Naples Federico II, Italy
Ludovica La Rocca	University of Naples Federico II, Italy
Laura Di Tommaso	University of Naples Federico II, Italy
Benedetta Grieco	University of Naples Federico II, Italy
Gaia Daldanise	National Research Council, Italy
Simona Panaro	University of Sussex, UK
Giuliano Poli	University of Naples Federico II, Italy

Urban Regeneration: Innovative Tools and Evaluation Model (URITEM 2024)

Workshop Organizers

Fabrizio Battisti	University of Florence, Italy
Giovanna Acampa	University of Florence and University of Enna Kore, Italy
Orazio Campo	La Sapienza University of Rome, Italy

Workshop Program Committee Members

Alice Barreca	Polytechnic of Turin, Italy
Marco Rossitti	Polytechnic of Milan, Italy
Celestina Fazia	University of Enna Kore, Italy

Urban Space Accessibility and Mobilities (USAM 2024)

Workshop Organizers

Chiara Garau	University of Cagliari, Italy
Alessandro Plaisant	University of Sassari, Italy
Barbara Caselli	University of Parma, Italy
Gabriele D'Orso	University of Palermo, Italy
Mauro D'Apuzzo	University of Cassino, Italy
Matteo Ignaccolo	University of Catania, Italy

Workshop Program Committee Members

Ivan Blečić	University of Cagliari, Italy
Mauro Coni	University of Cagliari, Italy
Martina Carra	University of Brescia, Italy
Tiziana Campisi	University of Enna Kore, Italy
Tanja Congiu	University of Sassari, Italy
Francesca Maltinti	University of Cagliari, Italy
Silvia Rossetti	University of Parma, Italy
Angela Pilogallo	Italian National Research Council, Italy
Lorena Fiorini	University of L'Aquila, Italy
Francesco Pinna	University of Cagliari, Italy

Aime Tsinda	University of Rwanda, Rwanda
Nicoletta Rassu	University of Cagliari, Italy
Youssef El Ganadi	International University of Rabat, Morocco
Marco Migliore	University of Palermo, Italy
Elena Cocuzza	University of Catania, Italy
Alessio Salvatore	Italian National Research Council, Italy
Giuseppe Stecca	Italian National Research Council, Italy
Gerardo Carpentieri	University of Naples Federico II, Italy
Carmen Guida	University of Naples Federico II, Italy
Floriana Zucaro	University of Naples Federico II, Italy

Virtual Reality and Augmented Reality and Applications (VRA 2024)

Workshop Organizers

Osvaldo Gervasi	University of Perugia, Italy
Damiano Perri	University of Florence, Italy
Sergio Tasso	University of Perugia, Italy

Workshop Program Committee Members

Massimiliano Nicolini	OliTec Foundation, Italy
JungYoon Kim	Gachon University, South Korea
Paolo Nesi	University of Florence, Italy
David Berti	ART SpA, Italy
Tamie Salter	Citizen Alert Inc., Canada
Marcelo Guimarães	Federal University of São Paulo, Brazil

Workshop on Advanced and Computational Methods for Earth Science Applications (WACM4ES 2024)

Workshop Organizers

Luca Piroddi	University of Malta, Malta
Patrizia Capizzi	University of Palermo, Italy
Marilena Cozzolino	Università Del Molise, Italy
Sebastiano D'Amico	University of Malta, Malta
Chiara Garau	University of Cagliari, Italy
Giuseppina Vacca	University of Cagliari, Italy

Workshop Program Committee Members

Andrea Angelini	ISPC, CNR, Italy
Raffaele Martorana	University of Palermo, Italy
Paolo Mauriello	University of Molise, Italy
Raffaele Persico	University of Calabria, Italy
Eufemia Tarantino	Polytechnic of Bari, Italy
Roberto Ricciu	University of Cagliari, Italy
Stefano Sfarra	University of L'Aquila, Italy
Peter Iregbeyen	University of Malta, Malta
Elisa Pilia	University of Cagliari, Italy
Emanuele Colica	Ministry for Transport, Infrastructure and Public Works, Malta
Luciano Galone	University of Malta, Malta
Sergio Vincenzo Calcina	University of Cagliari, Italy
Maria Brovelli	Polytechnic of Milan, Italy
Francesca Trevisiol	University of Bologna, Italy

Additional Reviewers

Burak Aslan	Izmir Institute of Technology, Turkey
Birim Balcı	Manisa Celal Bayar University, Turkey
Atrin Barzegar	Università degli Studi della Campania L. Vanvitelli, Italy
Manuel Carlos Figueiredo	University of Minho, Portugal
Chiara Chioni	University of Trento, Italy
Annalisa Contato	University of Palermo, Italy
Aurora Costales	Universidad de Oviedo, Spain
Hamid Daneshpajouh	Middle East Technical University, Turkey
Vito Dario Camiola	Università di Catania, Italy
Roberta De Fazio	Università degli Studi della Campania Luigi Vanvitelli, Italy
Michele Di Giovanni	Università degli Studi della Campania, Italy
David Ferro Costas	University of Santiago de Compostela, Spain
Michal Hnatič	P.J. Šafarik University in Košice, Slovak Republic
Francesco Loddo	Henge S.r.l., Italy
Caterina Loffredo	University of Naples Federico II, Italy
Vanda Lourenco	Universidade Nova de Lisboa, Portugal
Ángel Martín Pendás	Universidad de Oviedo, Spain
Maria Mourao	Polytechnic Institute of Viana do Castelo, Portugal

Martin Perez Perez	University of Vigo, Spain
Marco Pezzella	University of Perugia, Italy
Maria Polidoro	ESTG IPP, Portugal
Josef Rebenda	Brno University of Technology, Czech Republic
Donatella Rita Fiorino	University of Cagliari, Italy
Evgeniy Romenskiy	Sobolev Institute of Mathematics, Russia
Ezgi Sahin Toptal	Mersin University, Turkey
Domenica Savia Pellicanò	Mediterranean University of Reggio Calabria, Italy
Carina Silva	ESTeSL-IPL, Portugal
Paula Simões	CMA FCT UNL CINAMIL, Portugal
Francesca Sinatra	University of Trieste, Italy
Ana Sofia Rézio	Iscal, Portugal
Alexandra Stankulova	Politecnico di Torino, Italy
Maria Stella De Biase	Università della Campania Luigi Vanvitelli, Italy
Guan Yue Hong	Western Michigan University, USA

Sponsoring Organizations

ICCSA 2024 would not have been possible without the tremendous support of many organizations and institutions, for which all organizers and participants of ICCSA 2024 express their sincere gratitude:

Springer Nature Switzerland AG, Switzerland
(https://www.springer.com)

Computers Open Access Journal
(https://www.mdpi.com/journal/computers)

Thuyloi University, Hanoi, Vietnam
(https://en.tlu.edu.vn/)

University of Perugia, Italy
(https://www.unipg.it)

University of Basilicata, Italy
(http://www.unibas.it)

Monash University, Australia
(https://www.monash.edu/)

Kyushu Sangyo University, Japan
(https://www.kyusan-u.ac.jp/)

Universidade do Minho
Escola de Engenharia

University of Minho, Portugal
(https://www.uminho.pt/)

University of Cagliari, Italy
(https://en.unica.it/en)

Venue

ICCSA 2024 took place on the main campus of Thuyloi University in Hanoi, Vietnam.

Renewalling Public Real Estate Asset in Sustainable Perspective: Guidelines from International Best Practices

Maria Rosaria Guarini[1](✉), Emma Sabatelli[1], Francesco Sica[1], Francesco Tajani[1], Debora Anelli[2], and Rossana Ranieri[1]

[1] Department of Architecture and Design, "Sapienza" University of Rome, 00196 Rome, Italy
mariarosaria.guarini@uniroma1.it

[2] Department of Civil, Environmental, Land, Building Engineering and Chemistry, Polytechnic University of Bari, 70125 Bari, Italy

Abstract. Contemporary models of urban transformation emphasize regeneration as a strategic response to mitigate and reverse the negative impacts of urbanization. The acknowledgment of evaluation methodologies and frameworks for sustainable development in a global setting highlights the necessity to analyze the urban sustainability until the building-scale of analysis. Although sustain-ability is more measurable at broader dimensions, it is challenging to apply the same evaluation methodology to more constrained geographical areas with more detail. This complex framework makes measurement particularly difficult for those interested in studying urban sustainability from different perspectives. This paper aims to identify key indicators used to assess the sustainability at various urban scales, focusing on key categories such as economic-financial, environmental and socio-cultural analyses. Using a dual approach, a bottom-up perspective - which derives indicators from a real tangible case (the redevelopment of a public housing neighborhood in Le Lignon)- is integrated by a top-down one, which identifies commonly used indicators in key sustainability categories through a review of the literature. A comparative analysis of the results obtained from both approaches allows a set of key sustainability indicators to be formulated.

Keywords: sustainable development · system indicators · urban regeneration · assessment methodology

---

Author Contributions: The paper is the result of the joint work of the authors; in particular Conceptualization, M.R.G., F.S., F.T.; methodology, M.R.G., F.S., F.T.; validation, M.R.G. and F.T.; formal analysis, F.S., R.R. and D.A.; investigation, F.S., R.R. and D.A.; resources, F.S., R.R: and D.A.; data curation, F.S., R.R. and D.A.; writing—original draft preparation, M.R.G. and E.S.; writing—review and editing, M.R.G. and F.S.; visualization, M.R.G. and F.T.; supervision, M.R.G. and F.T.; project administration, M.R.G. All authors have read and agreed to the published version of the manuscript.

O. Gervasi et al. (Eds.): ICCSA 2024 Workshops, LNCS 14824, pp. 193–205, 2024.
https://doi.org/10.1007/978-3-031-65332-2_13

1 Introduction

Conurbations play a central role in sustainable development, with their increasing urbanization leading to environmental, social and economic consequences. In particular, cities significantly affect the global environment through CO2 emissions, resource consumption, and other issues including pollution, waste production, and urban heat islands [1]. Rapid sprawl also intensifies economic and social inequalities, leading to limited access to resources for low-income residents and increased social exclusion. Cities may be catalysts for constructive development, despite the difficulties presented by the fast urbanization of the world [2].

In order to mitigate and reverse the detrimental effects of urbanization on the ecosystem, regeneration is emphasized in modern models of urban transformation. As a result, it plays a crucial part in modelling sustainable development strategies [3].

These issues are widely included in international policies and agendas [4–7], highlighting the critical importance of the sustainability analysis within regeneration strategies.

The complex nature of urban sustainability requires an assessment holistic approach, by taking into account the interconnectedness of the economic, social and environmental dimensions of urban development [8]. In this context, indicator-based assessment systems are widely used by scientific communities, governments and policy makers [9]. Indeed, indicators are increasingly recognized as indispensable tools for measuring the effectiveness of sustainable development policies, initiatives and actions due to their ability to articulate and simplify complex aspects of sustainability [10–12].

The wide variety of available indicators, quantitative or qualitative, addressing a range of issues at different spatial scales, presents a challenge in identifying those best suited to capture the complexity of the specific context, scale of analysis and objectives of urban sustainability assessment [13, 14].

Therefore, defining each urban regeneration intervention involves a complex decision-making process that must take into account a wide range of factors at various scales with interrelationships between the components, stakeholders, and procedures to be taken into consideration in a diachronic dimension of time that is iterative and interactive [15]. In order to achieve this, the identification of potential solutions depends on the application of evaluation frameworks that integrate participatory techniques, multi-criteria decision-making analyses, and strategic planning tools. The objectives, which serve as the foundation for evaluating alternative intervention scenarios, must also be defined and communicated to stakeholders in relation to indicators that have been carefully chosen to take into account the effects that, e.g., adopting Nature-Based Solutions (NBS) can have on the ecosystem [16]. Composite Indicators (CI) are often required to measure the level of urban environmental and economic sustain-ability in order to express both qualitatively and quantitatively the socio-economic and environmental impact (trade-off) that the single initiative generates in the settlement context taken into consideration in the transition between the ex-ante and ex-post phases of the urban transformation process [17].

One of the challenges associated with the appropriate selection of indicators to be used to evaluate urban development and regeneration policies is the interconnectedness of issues related to sustainability [18]. In fact, many sustainability issues related to environmental, social, and economic aspects are interrelated and affect each other, which makes it difficult to isolate and measure individual indicators by complicating the selection of appropriate indicators and the context in which they are applied [19].

A key issue that can influence the selection of indicators for sustainability assessments of urban regeneration interventions is related to the scale of analysis [20]. There are tools and indicator frameworks at different geographic scales, operating at the building, neighborhood, city, region, up to the national and supranational scale, each providing results specific to the scale considered [21, 22]. The effectiveness of indicators is closely related to the context in which they are used. For example, at the level of individual buildings, the assessment focuses mainly on aspects related to individual structures [23]. Extending the analysis to the neighborhood level, a number of interrelated issues emerge regarding the organization of different elements, such as neighborhoods, commercial areas and green spaces [24, 25]. At the city or metropolitan level, indicators tend to address general issues that affect the entire urban area, taking into account, for example, city infrastructure, regional economic trends, and environmental issues that are broader than individual neighborhoods [12]. National or international urban sustainability indicators, on the other hand, take a broader perspective, addressing general issues and trends that extend beyond individual cities [2].

The data availability is another important challenge in defining urban sustainability indicators. In fact, assessment is highly dependent on the quantity and quality of available data, with availability varying at different spatial scales. For example, data tend to be more complete at larger spatial scales, while it is more difficult to collect data at smaller scales [26]. This problem can hinder the comprehensive assessment of sustainability at different spatial scales. The data availability may also vary between different urban areas, with some having well-documented information and others lacking detailed datasets. Such spatial disparities can lead to biased assessments, favoring areas with more available data and excluding many countries from assessment and comparison [6].

In addition, there may be biases due to temporal limitations: some datasets may have limitations in terms of temporal coverage, i.e. they only include data for a specific period or a few years, hindering the ability to analyze long-term trends and understand the sustainable performance of urban areas over longer periods [27].

While there is a greater degree of measurability of sustainability at larger scales, the resulting measures may provide too general insights that fail to capture the complexities of more localized scales [26]. Replicating the same approach used in large-scale sustainability assessments becomes complicated when applied to geographically limited scales, which are characterized by unique issues and needs that require addressing [27]. The great number of existing indicators, frequently applied across various scales, coupled with the challenges related to their adaptability according to the specific purpose of the assessment, make a complex framework that causes difficulty for those subjects interested in studying urban sustainability [18].

Consequently, the guiding research questions are:

Q1: What are the main indicators used for assessing the sustainability level at different urban scales?

Q2: Was the sustainability assessment carried out through the adoption of upscaling methods?

To address the research questions, this paper aims to provide a comprehensive overview of key sustainability indicators applied at different urban scales, with reference to the main categories of economic-financial, environmental and socio-cultural analysis. To this end, a dual approach is adopted, integrating *bottom-up* and *top-down* strategies.

The rehabilitation of a social housing community in Le Lignon (Vernier, Switzerland) serves as the basis for putting the bottom-up method into practice. An expert group consisting of planners, estimators, architects, and modern architecture historians chose this community as a model for best practices in residential development neighbourhoods constructed between the 1970s and the 1990s. This approach makes it possible to derive indicators from a real case that reveal the sustainability of the intervention by assessing the variations between the *ex-ante* and *ex-post* intervention status.

Conversely, the *top-down* strategy begins with a literature review to identify commonly used indicators in the main categories of sustainability. The most widely used important performance indicators for sustainable accounting are chosen by examining the current contributions to the literature on sustainability in relation to metrics related to sustainability aspects that may be applied to the design visions.

The simultaneous use of both methodologies – top-down and bottom-up – is meant to capture the characteristics of the given situation and permit a comparison study with frequently used indicators in existing literature.

Following it provided showing to the work-flow based on the aforementioned methodologies used along the route of case-specific formulation of sustainable indicators.

2 Materials and Method

2.1 Two-Way Researching Method: Bottom-Up & Top-Down

A methodology including the systematic and parallel application of two way researching method: bottom-up & top-down is presented in order to pursue the work's purpose. Generally these approaches differ in their analytical orientation.

i). The bottom-up analysis focuses on particular elements or situations to get a full grasp of a topic. The bottom-up approach examines the fundamental and qualitative parameters/factors of the study issue from a "micro" perspective to identify those that give a better description of the phenomenon, particularly from a future perspective. It permits the progressive identification and rearrangement of a system's components, allowing knowledge of each part's function as well as the right manner to utilize and integrate it into the larger system. In the present study, it is used to examine pilot cases that are thought to be representative of a wider global environment, as was expected by the argumentations in the next Subsect. 2.2.

ii). The top-down approach starts from a broad perspective of the object of analysis and gradually delves into specific details and aspects [28, 29] After defining an overall picture of the problem under inquiry and identifying its components from a "macro" viewpoint using the top-down method, an attempt is carried out to manage and comprehend how the many pieces are related to the whole.

In the present research the combined use of *i*) and *ii*) allows for the use of the indications generated by the two approaches in a non-unidirectional manner; however, by comparing and combining them, significant common components can be identified and integrated on the basis of the discovered functionalities, as well as possible innovative paths of experimentation. Using both *bottom-up* and *top-down* to define the overall reference set for selecting indicators to be used in specific urban sustainability assessments provides a more comprehensive and balanced assessment-view [30].

The synoptic framework underlying the proposed integrated analytic technique is shown in Fig. 1.

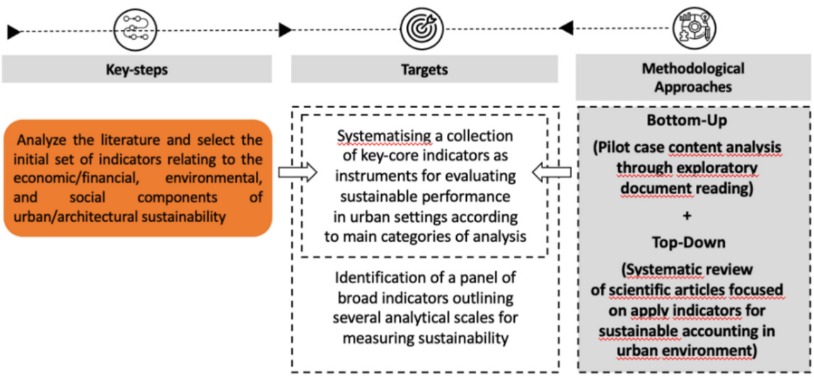

Fig. 1. Key-steps, Target and Methodological approach

The two approaches *i*) and *ii*) have been concurrently utilized in this study to establish a panel of general indicators that may be used at various analytical scales to assess the sustainability [31]. The articulation of the individual steps of two methodologies have been illustrated and shown in Fig. 2 at the conclusion of Subsect. 2.3.

2.2 *Le Lignon* Pilot Case

The modernist housing complex Le Lignon, located in the city of Vernier in the canton of Geneva, Switzerland, and designed by Georges Addor, Dominique Julliard, Louis Payot, and Jacques Bolliger, is used as a pilot case to demonstrate good practice redevelopment. Built between 1964 and 1971, with a reinforced concrete structure built using the “tunnel form” technology and 125,000 square metres of curtain wall panelling in wood, aluminium, and glass, this complex is one of the most monumental neighbourhoods in the world and the first in Switzerland. With 2,700 flats (used for a heterogeneous mix of housing forms, from subsidised rent to condominium ownership), plenty of green spaces, and public and private services, it was originally designed to quickly address the housing needs of about 10,000 people. It covers an area of 70 acres (28 ha), reflecting the architectural directions and logic of industrialised social housing typical of 1960s architecture. Its impressive architecture, which consists of two towers with 26 and 30 stories each, as well as a linear building with a Y-shaped design that extends 1,065 m, ensures double orientation, maximum sunlight for each apartment, and the integration of green spaces and a variety of community amenities (like shops, schools, a medical centre, and a rooftop swimming pool).

A Conservation Plan de site, an urban-scale protection measure intended to preserve the architectural unity of the buildings, the planning design, and the landscape quality of exterior spaces, was adopted by the Canton of Geneva in 2009, formally establishing the complex's value as a cultural asset. Between 2008 and 2011, the Canton of Geneva faced issues related to energy consumption. To address these issues, an Applied Research Project led by Professor Franz Graf and Giulia Marino of the Laboratoire des Techniques et de la Sauvegarde de l'Architecture Moderne (TSAM) at the Ecole Polytechnique Fédérale de Lausanne, along with a working group comprised of representatives of building owners, identified and developed appropriate solutions that collectively and holistically address the goals of respecting original material identity (Heritage), reducing energy consumption (Energy), considering the investment potential of the individual owners of the properties (Economy). The multi-criteria approach used in project research has sparked significant interest in Europe and North America, as described in several scholarly publications [32, 33], as well as it has received several awards and recognitions, among which: "European Heritage Awards/Europa Nostra Awards" (2013) [34] and good practice of the CoE21 Strategy' from the European Cultural Heritage Strategy for the 21st Century, Council of Europe" (2018) [35].

The library of model solutions compatible with the adopted guiding criteria, which was created by the study, validated by the participating public administrations, and added to the Plan de Site, has developed into an operational and flexible guiding and control tool that combines comprehensive implementation prescriptions and the thermal performance of the component parts to be used for the various levels of intervention that will be implemented gradually in accordance with the needs, preferences, and financial means of the occupants. This is a true instruction manual for the preventive maintenance and upkeep of buildings and common spaces, on which are based the intervention solutions to be implemented in the complex's many restoration shops, which are currently undergoing a multi-phase makeover. Despite covering 28 hectares, only 8 percent of the district's total area is built up. This arrangement facilitates the development of large green spaces, preserving the forest heritage along the Rhone and the Nant des Grebattes. The result is a rich biodiversity that has a lasting and visible impact on the social life of the neighborhood. In recognition of its importance, Le Lignon was also included in the Federal Inventory of Swiss Settlements to be Protected in 2021, under the auspices of the Swiss Conference and the Federal Law on Nature and Landscape Protection.

According to what has been pointed out, the redevelopment of the Le Lignon social housing neighborhood was chosen as a best practice example by a panel of experts and used as a pilot case to develop the bottom up approach for identifying and measuring sustainability on a micro scale.

2.3 Implementing the Two-Way Research Methods

As stated, the analytical procedure for analysing source databases, extracting and interpreting data from them, and creating a panel of indicators for gauging urban sustainability is divided into two parallel processes: i) top-down and ii) bottom-up.

The steps taken to construct the bottom-up method were as follows:

- starting with a careful examination of the document specific to the pilot case, which contains comprehensive details about the pre- and post-redevelopment circumstances. Making use of this paper facilitates comprehension of both the location's distinctive features and the overall redevelopment activities. It makes it easier to identify the key variables that are necessary to define a set of sustainability indicators that span several dimensions. Therefore, it is feasible to explore the various facets of sustainability, including the technical, typological, social, and environmental facets that are documented in the analysis document; the variables are specified by their kind (categorical/ordinal, numeric/continuous), unit of measurement, and usable source for computation. Each variable is also assigned to the appropriate sustainability category (economic, financial, environmental, social, or cultural).

With the top-down approach a systematic review of national and international literature is proposed to identify the key indicators used to assess sustainability in urban environments, in order to compare them with those identified in the bottom-up process. The systematic literature review requires the delineation of the key issues to be studied in relation to urban sustainability [36–38]. This involves carefully defining the research questions in line with the objectives of the study.

In particular, the following was done:

- identifying the databases to be used in the literature search and, therefore, the selection of keywords that can identify research articles aligned with the objectives of the study, such as "urban sustainability assessment", "urban sustainability indicators" and "sustainability indicators". The establishment of exclusion criteria that are applied to the acquired articles ensures that only those directly relevant to the objectives of the study are retained. This selection process results in a set of scientific studies relevant to the work. Articles without a complete set of indicators and those that are not relevant to the top-down urban scaling approach are excluded;
- selecting articles gather a range of information data. Specifically, since the indicators are the main object of analysis, the proposed methodology involves collecting the following data: the year of publication of the article, the title of the article, the main objective, the categories of sustainability considered and variables/indicators used, and, for each indicator, the type of methodology (e.g., quantitative or qualitative), the mode of measurement, the unit of measurement, the spatial scale, and the sustainability services/disadvantages associated with each indicator.

Figure 2 illustrates the many phases and outputs of the top-down and bottom-up approaches used to provide answers to the evaluation questions posed in the introduction. The results obtained from the comparison and union of the outputs obtained from the combined use of the two methods are described in Sect. 3.

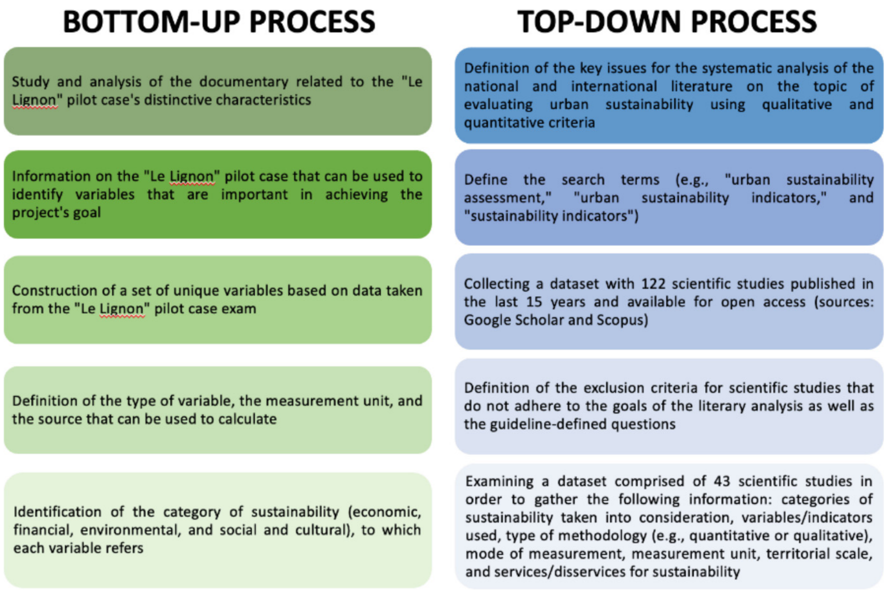

Fig. 2. Steps in both top-down and bottom-up processes

3 Results

The integration of the results obtained from the application of the two approaches mentioned above facilitated the formulation of a set of essential sustainability indicators. In fact, the *bottom-up* approach applied to the *Le Lignon* pilot case allows the identification of initial indicators that allow to capture the specificities that should be taken into account while redeveloping social housing areas constructed between the 1970s and the 1990s. The *top-down* approach, on the other hand, allows to identify, from the literature analysis, sustainability indicators of a more general nature. An initial comparison of the results obtained from the application of the two approaches allows them to be validated and allows the systematic organization of a collection of key indicators as tools for assessing the sustainable performance of urban areas at different scales and according to the main categories of analysis: environmental resilience, socio-cultural adequacy and economic and financial sustainability.

An extract of the total number of indicators identified is shown in the Fig. 3. For each of them, the unit of measurement is indicated, as well as the type of variable, specifying whether it is numeric/continuous, categorical/nominal, or whether it is a variable to be calculated. In addition, the sources of the indicators are made explicit, specifying whether they are official sources (e.g. statistical institute, territorial real estate market agency, etc.) or from a survey.

The environmental resilience category within the framework outlined includes key indicators for assessing the impact of urban development on the environment. Specifically, these indicators provide an assessment of the overall environmental quality of

					SUSTAINABILITY CATEGORY					
N.	Variables	Is it indispensable data to acquire?	Unit of measure	Type of variable	Enviromental	Economic-financial	Socio-cultural	Source	Source in Italy	Possible combination of variables
1	Number of dwellings for non self-sufficient people	x	n.	Numeric/continuos			x	from relief		Housig typology by users type
2	Cost of construction	x	€	Numeric/continuos				from relief		
3	Cost of renovation project	x	€	Numeric/continuos				from relief		
4	Minimum temperature (Year based)	x	°C	Numeric/continuos	x			from climatic analysis		
5	Maximum temperature (Year based)	x	°C	Numeric/continuos	x			from climatic analysis		
6	number of parking lot	x	n.	Numeric/continuos		x	x	from relief		in relation with 13
7	number of garage		n.	Numeric/continuos		x	x	from relief		in relation with 13
8	Building typology		type	Categorical/nominal		x	x			
9	number of commercial space typology	x	n.	Numeric/continuos		x		from relief		in relation with 13
10	Employment status of residents		n	Numeric/continuos		x	x	Statistics Institute	ISTAT	in relation with 13
11	Is the project a masterpiece?	x	Yes or no	Categorical/ordinal		x	x			
12	Does the Upcycling involves the residents?	x	Yes or no	Categorical/ordinal		x	x			
13	Are the architects specialist in Upcycling?		Yes or no	Categorical/ordinal		x	x			
14	Is the project fittable for The UpCycling?	x	Yes or no	Categorical/ordinal		x	x			
15	Is the type of construction usual in the area?	x	Yes or no	Categorical/ordinal	x	x	x			
16	Are the clients Private or Public?	x	Yes or no	Categorical/ordinal		x				
17	Gross internal floor area	x	m²	Numeric/continuos	x			from relief		
18	extension of the green area	x	m²	Numeric/continuos	x			from relief		10/9
19	extension of the built area	x	m²	Numeric/continuos	x			from relief		10/9
20	Density of the building/the area	x	ab/ha	to be calculated	x					13/11
21	Number of inhabitants		n.	Numeric/continuos	x	x	x	from relief		13 -16 age pyramid
22	number of family members		m²	Numeric/continuos			x	from relief		
23	sqm for inhabitant	x	m²	to be calculated	x	x	x			
24	Age of inhabitant	x	n.	Numeric/continuos		x	x	Statistics Institute		
25	number of houses		n.	Numeric/continuos		x	x	from relief		in relation with 13
26	number of commercial space		n.	Numeric/continuos		x	x	from relief		in relation with 13
27	Construction technologies for natural risk minimazing	x	n.	Numeric/continuos	x	x		from relief		
28	Sources of renewable energy system	x	n.	Numeric/continuos	x	x		from relief		
29	minum sqm for residential	x	m²	Numeric/continuos		x		from relief		in relation with 13
30	Systems of water recycle	x	n.	Numeric/continuos	x	x		from relief		
31	number of residential typology		n.	Numeric/continuos		x		from relief		in relation with 13
32	average sqm for residential		m²	to be calculated		x				
33	maximum sqm for residential		m²	Numeric/continuos		x		from relief		in relation with 13
34	average sqm for commercial		m²	to be calculated		x				
35	minum sqm for commercial		m²	Numeric/continuos		x		from relief		in relation with 13
36	maximum sqm for commercial		m²	Numeric/continuos		x		from relief		in relation with 13
37	Average temperature (Year based)		°C	Numeric/continuos	x			from climatic analysis		
38	relative humidity	x	%	Numeric/continuos	x			from climatic analysis		
39	wind condition	x	m2/s	Numeric/continuos	x			from climatic analysis		
40	Rain precipitation (average)		mm	Numeric/continuos	x			from climatic analysis		
41	Minimum Rain precipitation		mm	Numeric/continuos	x			from climatic analysis		
42	Maximum Rain precipitation		mm	Numeric/continuos	x			from climatic analysis		
43	local radiation average value			Numeric/continuos	x			from climatic analysis		
44	exposure of the apartments	x		dummy variable	x			from relief		

Fig. 3. Extract of the total number of indicators identified (N/C: Numeric/continuous, C/O: Categorical/ordinal)

urban areas in terms of sustainability of resource use and ecosystem health. For example, temperature-related indicators have been included that provide insight into the state of the atmospheric environment. Land use indicators are also included in this category, that provide information on the spatial distribution of built and green areas in relation to the total area under analysis, facilitating the assessment of the environmental impact of different land uses. The environmental resilience category also includes indicators related to building technologies, which provide information on the impact that the built environment can have on the surrounding environment.

The socio-cultural suitability category involves a set of indicators designed to assess various dimensions of urban life related to social and cultural dynamics. These indicators shed light on social dynamics, cultural diversity, and the general well-being of individuals in the urban context. Within this category, indicators are represented by a number of critical aspects such as the quality and accessibility of educational institutions, the availability of health services, and safety conditions as measured by crime rates. In addition, measures such as the amount of green space in the city and the distance to public transportation and public services provide insight into the accessibility and impact of these spaces on the well-being and connectedness of urban residents. Indicators focused on the regeneration project are also involved in the category of the socio-cultural suitability, which provide information on residents' perceptions of the project.

The economic and financial sustainability category provides a comprehensive assessment of the district's resource management and overall economic vitality. This category includes employment considerations, with indicators analyzing unemployment rates, employment opportunities, and local job creation. Indicators of residential market and rental values are also in this category, as well as average costs associated with water supply and heating and cooling services. In relation to the regeneration project, this category involves indicators that measure the investment costs of interventions, while also providing information related to building maintenance, including the cost and frequency of such maintenance.

4 Conclusions

The growing importance of urban sustainability requires a careful assessment of urban regeneration initiatives in the broader context of sustainable development. Despite the availability of numerous indicator-based tools and frameworks designed to assess these interventions, the challenge lies in adapting these indicators to different scales of analysis in a context characterized by abundance and generality. To address this complexity, this research has proposed a methodology to bridge the measurability gap at different scales.

Beginning with an in-depth examination of the redevelopment intervention of the district of the *Le Lignon* as a best practice pilot study, the methodology adopts a dual approach. First, a *bottom-up* strategy is used to identify an initial set of elementary variables that involve the unique features of the case in analysis. Simultaneously, a *top-down* approach is used to identify key sustainability indicators derived from existing literature.

A comparative analysis of the results derived from these two approaches has generated a set of indicators, that provide a framework for measuring the urban sustainability of interventions, offering a perspective specifically adapted to the case under consideration. Regarding the analyzed case study, as the initiatives are carried out in a public housing complex, the characteristics and the needs are specific, affecting both the scale of the building and the broader urban context that must address the immediate requirements of the neighborhood.

It is crucial to point out that the proposed methodology, although it has been developed starting from the characteristics of the specific case study, is replicable for different urban regeneration interventions and located in other territorial contexts, due to its ability to systematically capture the specificities that distinguish urban regeneration initiatives in different market locations.

An initial comparison of the results obtained from the simultaneous application of the two approaches makes it possible to mutually validate the information first obtained from the in-depth study of the specific case with the more general information obtained from the literature review. In order to prove the general validity of the information that emerged from this comparison, future research activities will include a validation phase. This will involve administering questionnaires to professionals, including technicians and operators in the construction and real estate sectors, as well as environmental and social experts. This step aims to strengthen the reliability and applicability of the results.

References

1. Poon, C.S.: Reducing construction waste. Waste Manage. **27**(12), 1715–1716 (2007). https://doi.org/10.1016/j.wasman.2007.08.013
2. Huang, L., Wu, J., Yan, L.: Defining and measuring urban sustainability: a review of indicators. Landscape Ecol. **30**, 1175–1193 (2015). https://doi.org/10.1007/s10980-015-0208-2
3. Opoku, A., Akotia, J.: Urban regeneration for sustainable development. Constr. Econ. Build. **20**(2), 1–5 (2020). https://doi.org/10.5130/AJCEB.v20i2.7191
4. Rosado-García, M.J., Kubus, R., Argüelles-Bustillo, R., García-García, M.J.: A new European Bauhaus for a culture of transversality and sustainability. Sustainability **13**(21), 11844 (2021). https://doi.org/10.3390/su132111844
5. UN General Assembly, Transforming our world: the 2030 Agenda for Sustainable Development, 21 October 2015, A/RES/70/1. https://www.refworld.org/docid/57b6e3e44.html. Accessed 7 May 2024
6. Klopp, J.M., Petretta, D.L.: The urban sustainable development goal: indicators, complexity and the politics of measuring cities. Cities **63**, 92–97 (2017). https://doi.org/10.1016/j.cities.2016.12.019
7. Vaidya, H., Chatterji, T.: SDG 11 Sustainable Cities and Communities: SDG 11 and the New Urban Agenda: Global Sustainability Frameworks for Local Action. Actioning the Global Goals for Local Impact: Towards Sustainability Science, Policy, Education and Practice, pp. 173–185 (2020)
8. Rodrigues, M., Franco, M.: Measuring the urban sustainable development in cities through a Composite Index: the case of Portugal. Sustain. Dev. **28**(4), 507–520 (2020). https://doi.org/10.1002/sd.2005
9. Hunt, D.V., Lombardi, D.R., Rogers, C.D., Jefferson, I.: Application of sustainability indicators in decision-making processes for urban regeneration projects. Proc. Inst. Civil Eng. - Eng. Sustain. **161**(1), 77–91 (2008). https://doi.org/10.1680/ensu.2008.161.1.77

10. Sala, S., Ciuffo, B., Nijkamp, P.: A systemic framework for sustainability assessment. Ecol. Econ. **119**, 314–325 (2015). https://doi.org/10.1016/j.ecolecon.2015.09.015
11. Pupphachai, U., Zuidema, C.: Sustainability indicators: a tool to generate learning and adaptation in sustainable urban development. Ecol. Ind. **72**, 784–793 (2017). https://doi.org/10.1016/j.ecolind.2016.09.016
12. Kaur, H., Garg, P.: Urban sustainability assessment tools: a review. J. Clean. Prod. **210**, 146–158 (2019). https://doi.org/10.1016/j.jclepro.2018.11.009
13. Verma, P., Raghubanshi, A.S.: Urban sustainability indicators: challenges and opportunities. Ecol. Ind. **93**, 282–291 (2018). https://doi.org/10.1016/j.ecolind.2018.05.007
14. Michalina, D., Mederly, P., Diefenbacher, H., Held, B.: Sustainable urban development: a review of urban sustainability indicator frameworks. Sustainability **13**(16), 9348 (2021). https://doi.org/10.3390/su13169348
15. Guarini, M.R., Chiovitti, A., Battisti, F., Morano, P.: An integrated approach for the assessment of urban transformation proposals in historic and consolidated tissues. In: Gervasi, O., et al. (eds.) Computational Science and Its Applications – ICCSA 2017. ICCSA 2017. LNCS, vol. 10406, pp. 562–574, 195069. Springer, Cham (2017). https://doi.org/10.1007/978-3-319-62398-6_40
16. Guarini, M.R., Morano, P., Sica, F.: Integrated ecosystem design: an evaluation model to support the choice of eco-compatible technological solutions for residential building. Energies **12**, 2659 (2019). https://doi.org/10.3390/en12142659
17. Morano, P., Guarini, M.R., Sica, F., Anelli, D.: Ecosystem services and land take. A composite indicator for the assessment of sustainable urban projects. In: Gervasi, O., et al. (eds.) Computational Science and Its Applications – ICCSA 2021. LNCS, vol. 12954, pp. 210–225, 265069. Springer, Cham (2021). https://doi.org/10.1007/978-3-030-86979-3_16
18. Merino-Saum, A., Halla, P., Superti, V., Boesch, A., Binder, C.R.: Indicators for urban sustainability: key lessons from a systematic analysis of 67 measurement initiatives. Ecol. Ind. **119**, 106879 (2020). https://doi.org/10.1016/j.ecolind.2020.106879
19. Dizdaroglu, D.: The role of indicator-based sustainability assessment in policy and the decision-making process: a review and outlook. Sustainability **9**(6), 1018 (2017). https://doi.org/10.3390/su9061018
20. Agol, D., Latawiec, A.E., Strassburg, B.B.: Evaluating impacts of development and conservation projects using sustainability indicators: opportunities and challenges. Environ. Impact Assess. Rev. **48**, 1–9 (2014). https://doi.org/10.1016/j.eiar.2014.04.001
21. Endreny, T., Sica, F., Nowak, D.: Tree cover is unevenly distributed across cities globally, with lowest levels near highway pollution sources. Front. Sustain. Cities **2**, 16 (2020). https://doi.org/10.3389/frsc.2020.00016
22. Adewumi, A.S.: Enhancing urban regeneration at the neighbourhood level: the role of sustainability assessment frameworks. Emerald Open Res. **1**(5) (2023). https://doi.org/10.1108/EOR-05-2023-0005
23. Berardi, U.: Beyond sustainability assessment systems: upgrading topics by enlarging the scale of assessment. Int. J. Sustain. Build. Technol. Urban Dev. **2**(4), 276–282 (2011). https://doi.org/10.5390/SUSB.2011.2.4.276
24. Boyle, L., Michell, K., Viruly, F.: A critique of the application of neighborhood sustainability assessment tools in urban regeneration. Sustainability **10**(4), 1005 (2018). https://doi.org/10.3390/su10041005
25. Nesticò, A., Passaro, R., Maselli, G., Somma, P.: Multi-criteria methods for the optimal localization of urban green areas. J. Clean. Prod. **374**, 133690 (2022). https://doi.org/10.1016/j.jclepro.2022.133690
26. Yigitcanlar, T., Dur, F., Dizdaroglu, D.: Towards prosperous sustainable cities: a multiscalar urban sustainability assessment approach. Habitat Int. **45**, 36–46 (2015). https://doi.org/10.1016/j.habitatint.2014.06.033

27. Mayer, A.L.: Strengths and weaknesses of common sustainability indices for multidimensional systems. Environ. Int. **34**(2), 277–291 (2008). https://doi.org/10.1016/j.envint.2007.09.004
28. Fraser, E.D., Dougill, A.J., Mabee, W.E., Reed, M., McAlpine, P.: Bottom up and top down: analysis of participatory processes for sustainability indicator identification as a pathway to community empowerment and sustainable environmental management. J. Environ. Manage. **78**(2), 114–127 (2006). https://doi.org/10.1016/j.jenvman.2005.04.009
29. Semeraro, T., Zaccarelli, N., Lara, A., Sergi Cucinelli, F., Aretano, R.: A bottom-up and top-down participatory approach to planning and designing local urban development: Evidence from an urban university center. Land **9**(4), 98 (2020). https://doi.org/10.3390/land9040098
30. Jeličić, J.A., Rapaić, M., Kapetina, M., Medić, S., Ecet, D.: Urban planning method for fostering social sustainability: Can bottom-up and top-down meet? Results Eng. **12**, 100284 (2021). https://doi.org/10.1016/j.rineng.2021.100284
31. UN, Geneva UN Charter on Sustainable Housing (2015). https://unece.org/housing/charter. Accessed 7 May 2024
32. Tostões, A.: Modern Heritage: Reuse. Renovation. Restoration. "CITÉ DU LIGNON", pp. 106–115. Birkhäuser, Berlin, Boston (2022). https://doi.org/10.1515/9783035625097
33. Graf, F., Marino, G.: Modern and green: heritage, energy, economy. Docomomo J. **44**, 32–39 (2011). https://doi.org/10.52200/44.A.ZLENV5L1
34. European heritage, Europa Nostra Awards. https://www.europeanheritageawards.eu/winners/housing-complex-lignon-architectural-study-intervention-strategies/. Accessed 7 May 2024
35. Council of Europe, Culture and cultural heritage, Strategy 21-Good practices. https://www.coe.int/en/web/culture-and-heritage/-/the-housing-complex-of-lignon. Accessed 7 May 2024
36. Morano, P., Tajani, F., Guarini, M.R., Sica, F.: A systematic review of the existing literature for the evaluation of sustainable urban projects. Sustainability **13**(9), 4782 (2021). https://doi.org/10.3390/su13094782
37. Guarini, M.R., Battisti, F.: Social housing and redevelopment of building complexes on brownfield sites: the financial sustainability of residential projects for vulnerable social groups. Adv. Mater. Res. **869–870**, 3–13 (2014). https://doi.org/10.4028/www.scientific.net/AMR.869-870.3
38. Pera, A.: Assessing sustainability behavior and environmental performance of urban systems: a systematic review. Sustainability **12**(17), 7164 (2020). https://doi.org/10.3390/su12177164