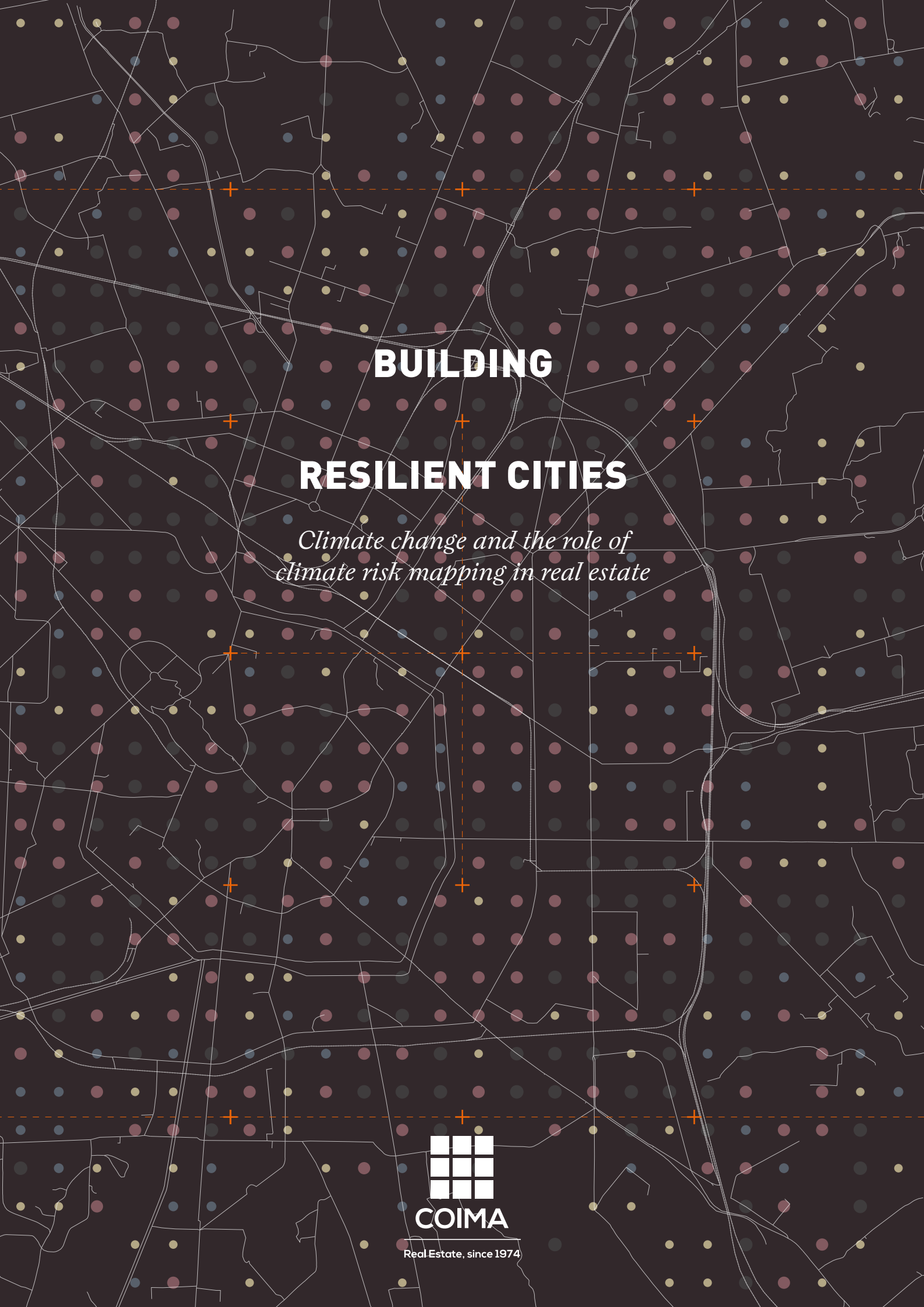


The background is a dark grey map with a network of thin white lines representing roads or boundaries. Overlaid on this is a grid of small, semi-transparent colored dots in shades of purple, blue, and yellow. A prominent orange dashed crosshair is centered on the page, with small orange plus signs at its intersections.

BUILDING

RESILIENT CITIES

*Climate change and the role of
climate risk mapping in real estate*



COIMA

Real Estate, since 1974



Aerial view of the City of Milan

Abstract

As climate change accelerates, real estate developers face mounting challenges in safeguarding investments and ensuring sustainable urban growth. This whitebook, led by COIMA with contributions from the Iuav Research Team, explores the pivotal role of climate risk mapping and assessment in urban development. By leveraging advanced methodologies and data-driven insights, developers can better understand and mitigate risks such as flooding, urban heat islands, and extreme weather events. This volume provides practical frameworks, real-world examples, and actionable strategies for incorporating climate resilience into urban design, ensuring that cities not only adapt to but thrive in an era of unprecedented environmental change.

Glossary of Acronyms

AI - Artificial Intelligence

ARPA - Agenzia Regionale per la Protezione dell'Ambiente

BAM - Biblioteca degli Alberi Milano

CMCC - Centro Euro-Mediterraneo sui Cambiamenti Climatici

COP - Conference of the Parties

CRVA - Climate Risk and Vulnerability Assessment (Valutazione del Rischio Climatico e della Vulnerabilità)

ESG - Environmental, Social, and Governance (Ambientale, Sociale e di Governance)

EU - European Union (Unione Europea)

FRMP - Flood Risk Management Plan (Piano di Gestione del Rischio Alluvioni)

GIS - Geographic Information Systems (Sistemi Informativi Geografici)

GRESB - Global Real Estate Sustainability Benchmark

HVAC - Heating, Ventilation, and Air Conditioning (Riscaldamento, Ventilazione e Condizionamento dell'Aria)

IPCC - Intergovernmental Panel on Climate Change (Gruppo Intergovernativo sul Cambiamento Climatico)

LST - Land Surface Temperature (Temperatura della Superficie Terrestre)

NDVI - Normalized Difference Vegetation Index (Indice di Vegetazione di Differenza Normalizzata)

NBS - Nature-Based Solutions (Soluzioni Basate sulla Natura)

NPV - Net Present Value (Valore Attuale Netto)

PGRA - Piano di Gestione del Rischio Alluvioni

POE - Post-Occupancy Evaluation (Valutazione Post-Occupazione)

PPP - Public-Private Partnerships (Partenariato Pubblico-Privato)

PRI - Principles for Responsible Investment (Principi per l'Investimento Responsabile)

RCP - Representative Concentration Pathway (Percorso Rappresentativo di Concentrazione)

SBTi - Science Based Targets initiative (Iniziativa degli obiettivi basati sulla scienza)

SDG - Sustainable Development Goals (Obiettivi di Sviluppo Sostenibile)

SFDR - Sustainable Finance Disclosure Regulation (Regolamento sull'informativa di sostenibilità dei servizi finanziari)

SUDS - Sustainable Urban Drainage Systems (Sistemi Urbani di Drenaggio Sostenibile)

TCFD - Task Force on Climate-related Financial Disclosures (Forza operativa per le informazioni finanziarie relative al clima)

UHI - Urban Heat Island (Isola di Calore Urbana)

UNEP - United Nations Environment Programme (Programma delle Nazioni Unite per l'Ambiente)

UNEP FI - United Nations Environment Programme Finance Initiative (Iniziativa Finanziaria del Programma delle Nazioni Unite per l'Ambiente)

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Authors



Stefano Corbella

C.Eng. MCIBSE Sustainability Officer - COIMA

Stefano Corbella is Sustainability Officer at COIMA and a UK Chartered Engineer (C.Eng, MCIBSE) with over 20 years of experience in engineering consultancy, asset management, and ESG strategy. He leads the integration of sustainability across COIMA’s real estate platform, overseeing decarbonisation roadmaps, EU Taxonomy and SFDR compliance, and sustainable finance frameworks. Stefano has advised international clients on asset-level decarbonisation and major urban regeneration projects in London and Milan, including Portanuova. He served on the Advisory Board of the Politecnico di Milano’s DABC Department until 2024 and is currently a member of ULI Europe’s Sustainability Product Council and the Sustainability Council of Assoimmobiliare.



Francesco Musco

Director of Research, Università Iuav di Venezia

Francesco Musco is an urban and environmental planner with a PhD in Analysis and Governance of Sustainable Development from Ca’ Foscari University of Venice. He is a Full Professor of Urban and Environmental Planning at the Department of Architecture and Arts at Iuav, where he teaches courses such as "Spatial Planning for Climate Change," "Urban Design," and "Maritime Spatial Planning." As Director of Research (2021-2024) and co-leader of the UNESCO Chair on Heritage and Urban Regeneration, Francesco focuses on integrating multidisciplinary approaches to spatial planning and sustainability, with emphasis on bottom-up public policies. He has led several EU-funded projects and plays a significant role in international research networks. His scope for this trip includes fostering collaborations on urban planning and climate resilience and exploring joint research opportunities between Iuav and Tongji University.



Carlo Federico dall’Omo

Research Manager and Coordinator of the UNESCO Chair in Heritage & Urban Regeneration – Università Iuav di Venezia

Carlo Federico dall'Omo, with a PhD in Architecture, City, and Design, specializes in managing climate change adaptation and the built environment. As the Research Manager at Iuav, Carlo oversees EU-funded projects in Horizon, Prima, Interreg, and Life programs, with a focus on territorial governance and climate resilience. He co-coordinates the UNESCO Chair in Heritage & Urban Regeneration and serves as a Climate Ambassador for the European Climate Pact. He is a member of the UNFCCC Roster of Experts on Climate Adaptation.



Umberto Galli

Sustainability & Product Innovation Manager - COIMA

Umberto Galli, specialized in Building Systems Engineering at Politecnico di Milano, developed technical and design expertise by collaborating with engineering and architecture firms and by participating in the management of construction sites in Italy and abroad. In his role as Sustainability & Product Innovation Manager at COIMA, he plays a strategic role in integrating sustainability and product innovation throughout the entire real estate development cycle, supporting decision-making, design, construction, and operational processes. He coordinates ESG due diligence activities, EU Taxonomy alignment assessments, energy strategies and innovative construction solutions, contributing to the definition and implementation of COIMA’s sustainability and climate resilience strategy.



Vittore Negretto

Architect and Research Manager, Università Iuav di Venezia

Research manager and adjunct professor in urban planning and climate change adaptation at the Iuav University of Venice. Holds a PhD in planning and urban resilience. His work focuses on the intersection between spatial planning and climate change, particularly urban resilience, adaptation strategies, and sustainable transformation processes. He has led or contributed to major initiatives funded by LIFE, INTERREG, H2020, and Horizon Europe (Mission Adaptation), integrating planning with climate risk reduction, nature-based solutions, and urban regeneration. He serves as an Innovative Action Expert for the European Urban Initiative and as a consultant for subnational authorities, private companies and international cooperation initiatives by the World Bank.



Nicola Romanato

Urban Planner and Researcher, Università Iuav di Venezia

Nicola Romanato specializes in Planning and Policy for Cities, Environment, and Landscape. His research at Iuav’s Planning and Climate Change LAB focuses on urban resilience and strategies for mitigating the effects of intense rainfall and climate change vulnerability. He is currently enrolled in a national PhD program in Earth Observation, aimed at developing a core methodology to study the application of a new Urban Digital Twin model to support planning processes and policy design within a complex, climate-adaptive framework.



Matteo Rossetti

Architect and Researcher, Università Iuav di Venezia

Matteo Rossetti specializes in studying urban and architectural design processes, focusing on the relationship between climate adaptation strategies and the preservation of urban spaces. His research is directly informed by the DNSH (Do No Significant Harm) climate vulnerability principles established under EU Directive 2021/2139. He supports the Iuav Foundation by fostering competitiveness and cooperation between universities and businesses to strengthen the transfer of knowledge and innovation.

COIMA

COIMA SGR is a leading independent asset management company specializing in real estate investment, development, and management with a strong focus on sustainability and urban regeneration. Based in Milan, COIMA manages over €10 billion in real estate assets through a platform that integrates investment, development, and property management.

COIMA is recognized for its leadership in sustainable urban transformation, having developed landmark projects such as Portanuova, one of the most advanced smart and sustainable districts in Europe. The company aligns its strategy with international ESG frameworks including EU Taxonomy, SFDR, SBTi, and GRESB, and is actively implementing decarbonization roadmaps and impact measurement frameworks across its portfolio.

Through partnerships with public and private institutions, COIMA drives long-term value creation that combines climate goals, social inclusion, and financial performance, positioning itself as a key player in the transition towards impact-driven real estate.

IUAV

Università Iuav di Venezia is one of the leading universities in Europe in the fields of architecture, design, fashion, visual arts, urban and regional planning, and theatre. Established in 1926 as one of the first Architecture Schools in Italy, Iuav combines a renowned tradition with a strong commitment to permanent innovation, while putting the design process at the core of the whole educational experience.

It has long term and significant experience in complex fields: from architecture to urban design, from technology to water and energy management, from economics to local development, from heritage to peace consolidation. This expertise is further recognized by the UNESCO Chair in Heritage and Urban Regeneration, which it holds. Iuav deploys a multidisciplinary approach to design strategies and solutions addressed at heterogeneous issues. From the economic, social, and environmental complexity of the ongoing transition to resilient and sustainable models, to the reduction of carbon footprint and climate adaptation. It has been recognized as Observer from UNFCCC and UNEP, furthermore, is part of the AESOP, SDSN and joined the European Climate Pact.



Piazza Duomo, City of Milan

Preface



Galleria Vittorio Emanuele, City of Milan

Climate change represents one of the most complex and pervasive challenges of our time, with growing impacts on the safety, livability, and competitiveness of European cities. Europe is warming at twice the global average rate, with particularly severe effects in urban areas, where heatwaves, floods, extreme weather events, and droughts put communities' wellbeing and real estate investments at risk (European State of the Climate, 2024).

For the real estate sector, these phenomena translate into a dual necessity: on the one hand, protecting assets and ensuring operational continuity; on the other, actively contributing to the transformation of cities into resilient and inclusive systems. In this framework, the Climate Risk & Vulnerability Assessment (CRVA) emerges as a key tool, capable of bridging scientific analysis with the strategic and operational needs of real estate stakeholders.

The CRVA can serve several complementary functions:

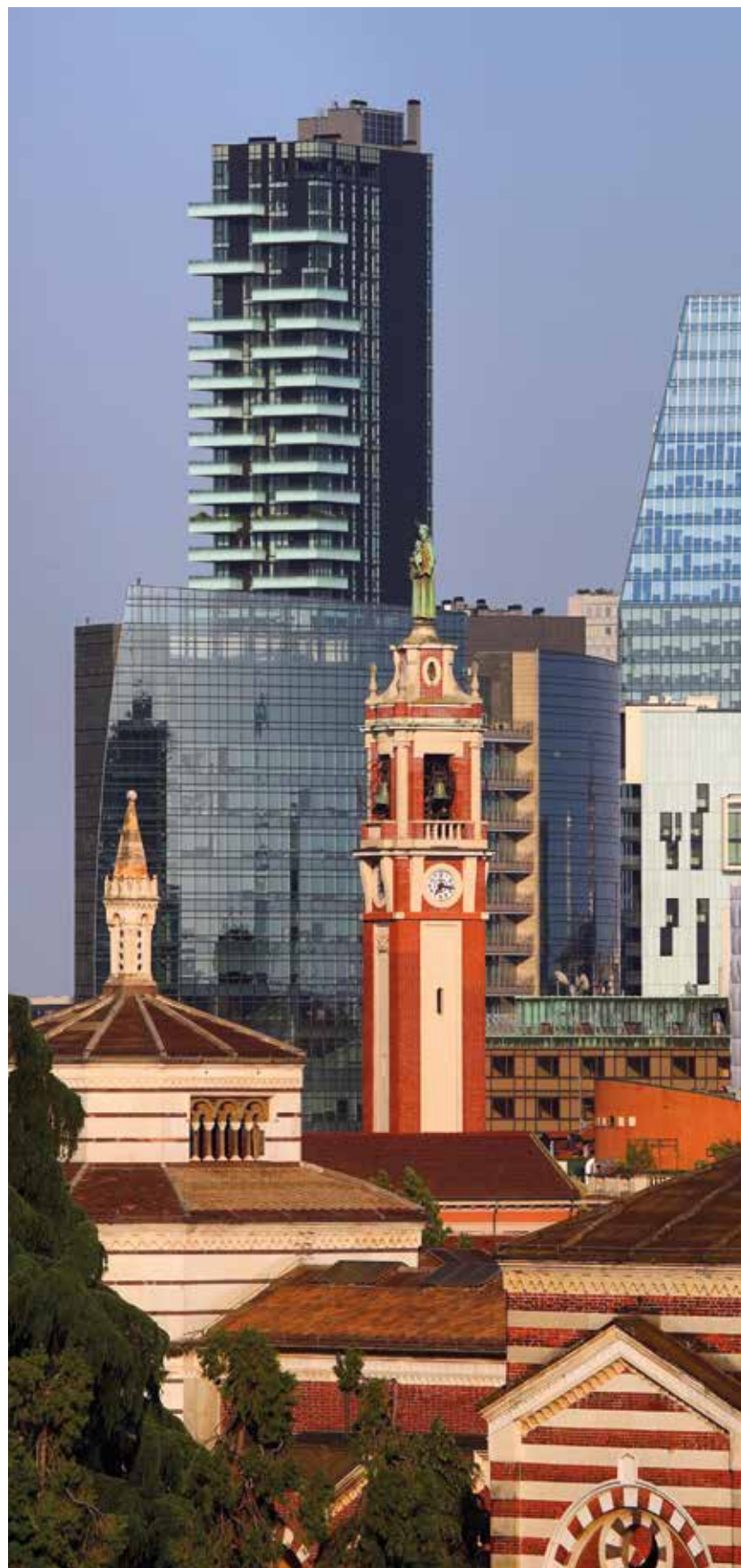
- provide a baseline assessment of existing vulnerabilities in complex urban contexts,
- support the modeling of technical, landscape, and management solutions to reduce exposure and sensitivity,
- measure the effectiveness of implemented or planned interventions,
- act as a decision-support tool for territorial planning, integrating urban plans and local adaptation strategies (Master Adapt, 2017),
- strengthen investment processes throughout the entire lifecycle, from due diligence at the acquisition stage to the sale of an asset, where demonstrable climate resilience can represent a measurable economic premium (BBP, 2022).

Experiences across Italy and Europe confirm the urgency of adopting systematic methodologies for climate risk analysis and management. The EU technical guidance on adapting buildings offers an operational framework for embedding resilience in design and retrofitting processes (EU-level technical guidance, 2023), while national and local instruments – such as the Po Basin Flood Risk Management Plan (PGRA) for the Seveso River (PGRA Milano, 2017) and the CLIMA Milano report (Comune di Milano, 2021) – highlight the relevance of applying these methods at the urban scale.

At market level, CRVA adoption is increasingly embedded within the ESG and risk management ecosystem, aligning with the expectations of institutional investors, insurers, and supervisory authorities. Publications by PRI and UNEP/MunichRe stress how climate risk analysis has become an integral part of real estate and financial due diligence, as well as a criterion for credit access and asset valuation (UNEP/MunichRe, 2024; PRI, 2021). Academic research further underlines the connection between climate risk and property values: the UNEP FI study “Climate Risk and Commercial Property Values” (Clayton et al., 2021) shows that risks are transmitted through multiple channels – from cash flows (rents, operating and insurance costs) to capitalization rates (risk premiums, liquidity and insurability) and financing conditions (margins, lending willingness).

Finally, it must be recognized that the implications of climate change extend well beyond the real estate industry. Research by the Bank of Italy [Banca d'Italia, 2022] has highlighted how climate shocks can affect productivity, investment, employment, and public finances across multiple sectors, including agriculture, manufacturing, energy, and tourism. These macroeconomic impacts inevitably reverberate on urban development and territorial planning, amplifying the strategic importance of resilience in real estate as a cornerstone of broader societal and economic stability.

This whitebook, developed by COIMA with the contribution of the Iuav Research Team, aims to provide a reference framework for understanding and applying CRVA in real estate investments and urban development. Its objective is twofold: to foster the adoption of a scientific and operational approach to climate resilience, and to stimulate dialogue between developers, asset managers, public institutions, and local communities. In doing so, it highlights how urban resilience is not only essential to safeguard assets but also a decisive factor in ensuring sustainable economic growth and social wellbeing in an era of profound environmental transformation.



City of Milan

Introduction: Integrating Climate Risk into Urban and Real Estate Strategies

*1.1 The Urgency of Climate Change as a Game-Changer
in urban areas*

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1.1 The Urgency of Climate Resilience in urban areas

Overview of climate change impacts on urban areas: rising temperatures, flooding, extreme weather events

Urban areas are experiencing increasingly intense effects of climate change, with direct consequences on the built environment and the real estate sector. As the urban footprint expands and climate-related risks escalate, the combined impact is undermining the physical integrity, economic value, and long-term viability of real estate assets—particularly in high-exposure zones. Understanding the nature and scale of these climate impacts is a necessary first step toward developing effective strategies for adaptation and resilience.

Rising Temperatures

Cities tend to retain more heat than the surrounding rural areas, causing the phenomenon of the Urban Heat Island (UHI). This effect can raise average urban temperatures by about 5–6 °C (with peaks up to 8–10 °C in large cities) compared to peri-urban areas (Cheng & Li, 2023). These conditions increase outdoor thermal discomfort, worsen air quality, and sharply increase energy demand for summer cooling and health risks related to heat. It is well documented that UHI significantly contributes to the high energy demand of the real estate sector, where extreme temperatures mean less comfortable buildings and higher operating costs, causing stress to both the infrastructure and productivity (Tostevin e Chilton, 2025).

River, coastal and pluvial flooding

The increase in extreme precipitation is exposing cities to more severe flash and river floods, while coastal cities are exposed to sea level rise and marine incursions. Exceptional rainfall events often overwhelm urban drainage infrastructure, causing neighborhood flooding and disruptions to essential services. As climate change is already intensifying flood risks in many regions, with a trend expected to increase (Wu et al., 2024), real estate properties in flood-prone areas are experiencing significantly increased physical and economic vulnerability.

The market is beginning to price in these risks: it has been observed that the increased frequency of extreme events (such as major floods) is already influencing real estate price dynamics in high-risk areas, where persistent value declines are being recorded over time. In regions historically unaccustomed to such events, post-disaster real estate shocks can last longer, slowing down transaction recovery and market liquidity. This indicates that a significant portion of real estate value is “climate-risked” and could erode as awareness of hazards (and thus buyer and lender caution) increases. Beyond immediate damage to buildings, repeated

flooding undermines the long-term profitability of assets: business interruptions (for commercial properties), remediation costs, rising insurance deductibles, and depreciation of real estate collateral in financial portfolios. In coastal areas, sea level rise further aggravates the risks: some cities - such as New York, Shanghai, and Jakarta, among others - are even experiencing subsidence phenomena that, combined with rising seas, make expensive defense interventions essential to keep entire neighborhoods habitable (Savills, 2025).

Emerging climate threats

In addition to heat and flooding, other extreme events affect the urban and real estate fabric. Intense storms and hurricanes cause structural and building envelope damage, casualties, power outages, and transport blockages, paralyzing entire metropolitan areas. The immediate impact is tangible: flooded or uninhabitable buildings, critical infrastructure out of service, and evacuated neighborhoods (Muldoon-Smith & Greenhalgh, 2019). Wildfires, increasingly frequent and intensified by prolonged droughts and extreme heat, are now affecting several Mediterranean and Southern European regions, encroaching on peri-urban areas, destroying homes, and displacing entire communities.

Countries such as Greece, Italy, Spain, and France have witnessed record-breaking fire seasons in recent years, with devastating impacts on both natural ecosystems and urban fringes (Muldoon-Smith & Greenhalgh, 2019). In this context, climate-related disasters are exacerbating credit and market risks in the real estate sector: homeowners may struggle to meet mortgage obligations after losing their properties, while investors face declining asset values. These effects are already visible: for instance, in southern European regions hit repeatedly by wildfires or floods, properties are showing signs of devaluation and reduced insurability (Muldoon-Smith & Greenhalgh, 2019; Savills, 2023). Similarly, in coastal or low-lying areas increasingly affected by flooding and sea level rise, a “climate risk discount” is starting to emerge, with price reductions reflecting growing market awareness (Wu et al., 2024).

Risk shaping the real estate market

Climate change poses a multidimensional threat for European cities and their real estate sectors. It affects operational costs including insurance and maintenance expenses, as well as asset valuation and long-term financial performance. If left unmanaged, these risks may trigger cascading effects: declining urban attractiveness in high-risk zones with potential population and business outflows, growing difficulty in securing financing or insurance for exposed properties, and mounting pressure on public budgets for recovery and reconstruction. Proactive adaptation to emerging urban climate regimes is therefore no longer optional as preventing higher future costs is a strategic necessity (Savills, 2023).

To respond the real estate sector is progressively combining mitigation strategies, which tackle the causes of climate warming through measures such as, for example through low-emission buildings, with adaptation strategies, which reduce the vulnerability of buildings and cities to ongoing changes.

A fundamental first step is to bring climate risk analysis systematically into urban and real estate planning. One of the most widely used tool for this is the Climate Risk and Vulnerability Assessment (CRVA). It provides a structured evaluation of climate threats, such as extreme heat, flooding, storms, and the vulnerability of assets and communities, both today and under future scenarios. When well conducted, a CRVA forms the founding baseof any adaptation plan: it identifies where risks are

highest, clarifies their likelihood and potential magnitude, and offers evidence to guide decisions (CDP 2022).

For real estate actors, this means mapping property portfolio against climate hazards, conducting climate stress tests on individual buildings, and identifying intrinsic vulnerabilities such as, for example, critical equipment on ground floors in flood-prone areas, mobile elements in the façade that may be vulnerable to intense wind phenomena or poorly performing roofs in challenging climates.

Yet significant inertia persists. For many companies in the sector, climate risk remains a blind spot, and only around one in five has developed a plan to address physical climate impacts. This underlines the urgency of mainstreaming tools such as CRVA. Embedding climate risk into investment appraisals and real estate valuations enables stakeholders to anticipate impacts rather than respond only after disasters occur. It also helps to guide preventive measures and ensures greater transparency across the market.

1.2 Vision for Resilient Urban Growth

Urban planning and real estate development shall undergo a major transformation in response to the increasing frequency and severity of climate-related events. Resilience shall no longer be treated as a niche consideration, but as a foundational element in shaping sustainable, future-ready cities. Integrating climate adaptation into real estate strategies shall ensure that urban assets are protected, communities remain livable, and investments can withstand and thrive under shifting environmental conditions. Embedding climate adaptation within urban growth requires a structured and proactive approach, merging scientific insight with practical implementation. The real estate sector shall play a pivotal role in this transition, holding both the capacity and responsibility to shape the built environment to meet climate challenges. By leveraging methodologies such as Climate Risk and Vulnerability Assessments (CRVA), aligning with regulatory frameworks like the EU Taxonomy, and collaborating with academic institutions, stakeholders shall contribute to establishing a new standard of climate-responsive development.

From City to Asset: Embedding Climate Adaptation into the Real Estate Lifecycle

As climate adaptation becomes central to urban investment strategies, COIMA has taken a proactive step by commissioning to the IUAV University of Venice a Climate Risk and Vulnerability Assessment (CRVA) for the city of Milan, the city where its portfolio is most concentrated and where future developments are planned. The CRVA integrates regional climate projections, urban morphological data, and indicators of social and environmental vulnerability to provide a comprehensive picture of climate risks at both city and asset level.

The results of this analysis have informed feasibility assessments in the development phase while also guiding long-term asset management and maintenance strategies. By embedding adaptation measures into operational practices, resilience shall remain a priority across the entire building lifecycle, enabling dynamic responses to evolving climate conditions and reducing the costs of inaction.

To ensure methodological rigor, COIMA partnered with IUAV, tailoring the assessment to the specific climatic and urban context of Milan. This collaboration strengthens decision-making at early design stages as well as ongoing performance monitoring and maintenance planning.

At the same time, COIMA has aligned its development and asset management processes with the EU Taxonomy criteria for sustainable economic activities. This alignment not only supports compliance and transparency but also facilitates the identification and implementation of effective adaptation solutions consistent with broader sustainability objectives.

Through this integrated approach—comprehensive risk mapping, scientific partnership, and regulatory alignment—COIMA illustrates how private sector actors could contribute to climate-resilient urban development. The case of Milan demonstrates how resilience can be embedded as a core principle across all phases of asset stewardship, from acquisition and design to long-term management and value creation.

Long-term benefits of climate-informed urban design

The long-term benefits of integrating climate adaptation into urban design and management shall extend well beyond the real estate sector, delivering value not only to developers and asset managers but also to the broader community. By embedding climate-informed strategies, real estate stakeholders are more likely to protect asset value, safeguard tenants, reduce operational risks, and meet investor and regulatory expectations, while simultaneously contributing to healthier, safer, and more inclusive cities.

From a development perspective, incorporating resilience from the outset shall significantly improve project viability and community functionality. Climate-informed design enables the integration of durable, heat-resistant materials, high-performance façades, adaptive HVAC systems, and energy infrastructure capable of withstanding peak stress events. Passive design strategies—such as natural ventilation, thermal mass, and integrated shading—shall reduce dependency on mechanical cooling, lowering both operational costs for owners and exposure to heat stress for residents and workers. These measures provide dual benefits: improved building performance under extreme conditions and reduced lifecycle costs, while also enhancing eligibility for green finance instruments that support public and private climate goals.

Importantly, the societal benefits of adaptation extend beyond asset-level performance. Greener public spaces, improved microclimates, and enhanced infrastructure resilience contribute to reduced urban heat island effects, better air quality, and stronger social cohesion. These outcomes directly benefit residents, workers, and visitors, positioning resilience as a public value rather than solely a private advantage.

There is also growing convergence between climate adaptation and market demand. Institutional investors, lenders, and tenants increasingly prioritize resilient assets that demonstrate proactive risk management and compliance with emerging sustainability frameworks. Such assets typically achieve stronger ESG ratings, enjoy preferential access to capital, and contribute to the collective progress toward climate adaptation goals set at municipal, national, and international levels.

Ultimately, climate-informed urban design and asset management shall foster long-term value creation, regulatory alignment, and reputational strength for developers, while also generating environmental, social, and economic benefits for the wider community. In doing so, resilience becomes not only a strategic advantage for the real estate industry but also a shared foundation for more sustainable and equitable urban futures.

1.3 Market Trends and Emerging Opportunities

Climate change is demonstrating that it has the capacity to reshape the fundamentals of real estate. Asset performance is no longer defined solely by location or architectural quality, but increasingly by the ability to withstand climate stress and adapt to shifting environmental conditions. Regulatory frameworks, investor mandates, and tenant expectations are converging to make resilience a decisive factor in determining long-term value.

For developers and asset managers, this shift highlights that resilience shall be treated as a prerequisite for risk-adjusted returns, asset liquidity, and competitiveness. Embedding adaptation into design, operations, and asset management not only mitigates risks but also creates opportunities for innovation and differentiation in a crowded market.

At the same time, institutional investors are actively redirecting capital toward assets and portfolios that demonstrate measurable resilience. In this context, climate adaptation is evolving into a defining criterion of market attractiveness, influencing individual asset valuations and shaping the positioning of entire urban districts.

Investor Demand for Resilient Assets

Capital allocation decisions are guided by the balance between expected returns and exposure to risks. Climate hazards—flooding, heat stress, windstorms, and drought—are now manifest in tangible ways, especially in climate-sensitive regions such as Southern Europe. Their growing visibility makes resilience a priority not only for institutional investors but also for property owners, public administrations, and local communities.

Integrating resilience into real estate is no longer a matter of compliance or reputation; it has become a central element of risk-adjusted value creation. Developers and asset managers who anticipate risks, implement adaptation measures, and monitor performance are better positioned to protect value, maintain operational continuity, and attract long-term capital.



Risk Mitigation and Operational Continuity

Systematic climate risk management enhances asset durability, reduces damage and downtime, and safeguards safety and livability—transforming risk control into long-term value creation.



Market Competitiveness and Value Creation

Resilient assets enhance comfort, cut operating costs, and improve performance—driving higher occupancy, premium rents, long-term appreciation, and stronger liquidity.



Regulatory Compliance and Investor Confidence

Alignment with frameworks (EU Taxonomy, TCFD, national strategies) ensures compliance, builds stakeholder trust, and makes resilience a strategic advantage in capital allocation and financing.



Strategic Advantage Through Innovation

Resilience drives innovation through adaptive materials, renewables, digital tools, and nature-based solutions—creating co-benefits and new benchmarks for competitiveness and leadership.



Castello Sforzesco, City of Milan

The Role of Climate Resilience in Attracting Institutional Investment

Institutional investors are increasingly treating resilience as a core investment criterion. Developers and managers that demonstrate the ability to assess vulnerabilities, adopt adaptive measures, and provide robust governance are recognized as trusted partners for long-term capital allocation.

In regions exposed to high climate risk, projects that combine rigorous methodologies with adaptive urban strategies present a compelling value proposition. These initiatives not only mitigate investor concerns over exposure but also align with broader public policy and societal objectives. At the urban scale, cities that succeed in embedding resilience into their planning and infrastructure shall gain a competitive advantage: by offering safer, healthier, and more livable environments, they become more attractive destinations for global capital, businesses, and talent.

The convergence of science, policy, and finance underscores how resilience can unlock new pathways for growth, strengthen asset performance, and create durable partnerships between private actors, public administrations, and international markets. In this sense, climate resilience is not only a risk management tool but a strategic lever for shaping the next generation of competitive, investment-ready cities.



City of Milan

Public-Private Partnerships for Urban Resilience

Public-private partnerships (PPPs) should represent a cornerstone of climate-resilient urban development. When designed and governed effectively, such collaborations should allow public authorities to benefit from private sector innovation, expertise, and capital, while enabling developers and asset managers to align their strategies with broader municipal and regional adaptation goals. Well-structured PPPs should provide the framework within which resilience becomes both a shared public good and a driver of long-term value for private stakeholders.

Potential areas of collaboration

Experience to date suggests that PPPs could deliver significant benefits if conceived with scale and integration in mind:

- Green and blue infrastructure: partnerships should promote urban forests, floodable parks, permeable pavements, and stormwater retention systems capable of mitigating both flooding and overheating.
- Resilient infrastructure networks: joint investment should support climate-proofed energy grids, mobility systems, and district-level water management that ensure service continuity during extreme events.
- District-scale regeneration: collaborative planning between municipalities, research institutions, and real estate actors should enable projects that simultaneously reduce climate exposure and enhance biodiversity, accessibility, and the quality of public spaces.

Opportunities for alignment with adaptation strategies

As cities and regions define pathways to mitigate heat stress, reduce flood risk, and pursue net-zero targets, real estate stakeholders should be positioned to act as partners in implementation. Greater alignment with municipal climate plans could:

- Facilitate project approvals by demonstrating compliance with adaptation frameworks,
- Unlock incentives and co-financing from public and multilateral sources,
- Strengthen reputational standing by delivering community-oriented, climate-positive solutions.

At the same time, PPPs should provide the platform for testing and scaling innovative solutions—nature-based systems, renewable energy integration, or climate-positive mobility—at neighborhood and district level. By engaging proactively with public authorities, the private sector should help shape cities that are not only more resilient to climate risks but also more inclusive, livable, and competitive.



Portanuova, Milano

Climate Risk Mapping: From Science to Practice in Real Estate and Urban Planning

2.1 What is the Morpho-Climatologic Mapping in CRVA assessments?

pag. 29

2.2 Benefits for Citizens and Developers

pag. 32

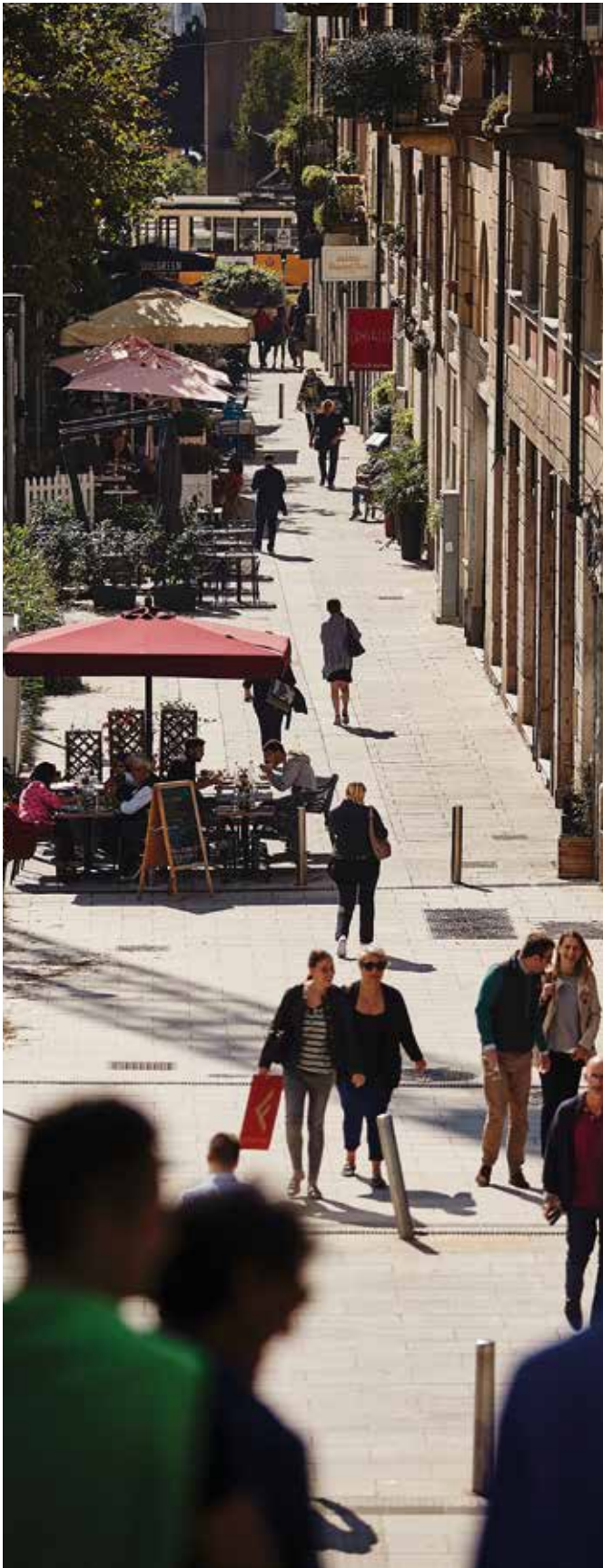
2.3 Inspiration from Advanced Methodologies

pag. 41

Climate Risk and Vulnerability Assessment (CRVA) is still a relatively new practice, particularly within real estate and urban planning. While the scientific community has long relied on climate models, satellite observations, and meteorological datasets, their systematic use in shaping development strategies and asset management remains at an early stage. In recent years, several software solutions have emerged that combine global climate projections with localized data—ranging from land cover and morphology to socio-economic indicators—making climate information more accessible to practitioners.

Yet, a standard methodology for applying CRVA in real estate and urban contexts has not fully emerged. Different tools rely on varying data sources, levels of spatial resolution, and analytical approaches, which makes comparability and consistency across projects difficult. It is reasonable to expect that, as the interest of investors, regulators, and urban authorities continues to grow, data availability will increase, and modeling practices will gradually converge toward more harmonized standards.

Against this backdrop, the present report outlines the methodology adopted to conduct CRVA in the context of Milan, with the intent to share a replicable framework and contribute to a wider industry dialogue. The approach links spatial climate analysis with morphological vulnerability assessment, offering developers, asset managers, and policymakers a practical tool to anticipate risks, prioritize adaptation measures, and guide investment decisions. By making the methodology transparent, the objective is to support discussion across the sector and advance the integration of climate resilience into real estate and urban development practices.



Portanuova, Milano

2.1 What is the Morpho-Climatologic Mapping in CRVA assessments?

Climate change is demonstrating that it has the capacity to reshape the fundamentals of real estate. Asset performance is no longer defined solely by location or architectural quality, but increasingly by the ability to withstand climate stress and adapt to shifting environmental conditions. Regulatory frameworks, investor mandates, and tenant expectations are converging to make resilience a decisive factor in determining long-term value.

For developers and asset managers, this shift highlights that resilience shall be treated as a prerequisite for risk-adjusted returns, asset liquidity, and competitiveness. Embedding adaptation into design, operations, and asset management not only mitigates risks but also creates opportunities for innovation and differentiation in a crowded market.

At the same time, institutional investors are actively redirecting capital toward assets and portfolios that demonstrate measurable resilience. In this context, climate adaptation is evolving into a defining criterion of market attractiveness, influencing individual asset valuations and shaping the positioning of entire urban districts.

Definition and its role in understanding vulnerabilities

Climate analysis alone sometimes falls short in effectively supporting practical adaptation actions. While the use of climatological scenarios is a well-established approach in both scientific literature and regulatory frameworks (ISPRA 2020), it is equally important to integrate this with methodologies that offer concrete evidence related to the morphological vulnerabilities of the territory. The CRVA approach integrates multiple climate variables to translate climate phenomena into urban-specific vulnerabilities. The selection of key variables—temperature, wind, and precipitation, and flood risk—is based on their demonstrated impact on the morphology and functioning of urban systems. In dense and complex urban environments, these climate variables do not act in isolation. Instead, they interact with the built form—its materials, geometry, orientation, and land cover—to amplify or mitigate climate impacts. Their analysis supports both strategic planning and early risk screening for real estate investment under ESG-aligned frameworks.

The effectiveness of CRVA relies strongly on a solid knowledge base, especially regarding water management, heat-related phenomena, and other climate impacts. Key reference sources include IPCC reports, established scientific literature, and Italy's National Strategy for Climate Change Adaptation prescriptions. Building on this foundation, a morpho-climatic assessment approach has been developed to understand how the built environment setting contributes to the accumulation, generation, and intensification of specific climate-related impacts. These impacts are framed as macro-drivers, aligning closely with the EU checklist (2021/2139) and ISPRA guidelines, which highlight urgent phenomena such as urban heat islands and flooding.

By assessing vulnerabilities related to climate-related risk, developers can screen multiple locations, priorities interventions, and align projects with long-term adaptation strategies.

The survey conducted is intended as an operational tool for the implementation of practical climate change adaptation measures, supporting defining their size, shape, location and scope with the aim of reducing sensitivity and increasing adaptive capacity.

At the same time, this assessment approach serves both as an analytical and monitoring tool for implemented actions. The morpho-climatic approach also enables the integration of the climatological time series, such as those of Copernicus, ARPA Lombardia, and CMCC, with local-scale operational interventions and territorial management measures. This connection supports spatial prioritisation and a more evidence-based planning logic, which is critical for urban design and real estate investment in a context of growing climate uncertainty.

Managing water runoff in urban areas has become increasingly urgent as climate change intensifies the frequency and severity of extreme rainfall events

Unlike natural systems, where rainwater is gradually absorbed into the soil, cities are dominated by widespread impermeable surfaces that accelerate runoff, overwhelming existing drainage infrastructure. Urban drainage and sewer systems struggle to cope with peak volumes during heavy rains, leading to localized flooding, infrastructure strain, and service disruption. These events expose the limitations of existing conventional systems, particularly where collectors and stormwater networks are undersized or only occasionally maintained. When intense rainfall exceeds drainage capacity, runoff can no longer be efficiently channeled, resulting in dangerous surface flooding and cascading impacts on mobility, buildings, and critical services. Urban adaptation must therefore focus on upgrading stormwater infrastructure and systematically implementing Sustainable Urban Drainage Systems (SUDS) and Nature-Based Solutions (NBS) that slow down and disperse water flows. Mapping urban exposure to surface runoff and pluvial flooding is essential in climate risk assessment, supporting early-stage decisions in design, investment, and long-term resilience planning.

Wind, often considered a secondary climate variable, acquires renewed relevance when examined through the lens of morphological vulnerability

Within the CRVA framework, wind is understood not merely as a meteorological phenomenon but as a spatial force that interacts with urban form and it's shaped, redirected, and amplified by the city's three-dimensional structure. The integration of spatial data enables the reconstruction of building heights and density distributions, allowing for the identification of areas susceptible to urban canyoning effects, where strong winds are funneled between buildings, increasing mechanical stress on façades and elevating the risk to pedestrians and infrastructure. This interaction between built morphology and atmospheric dynamics produces critical exposure patterns for both public safety and asset durability. Furthermore, green infrastructure, while being essential for mitigating urban heat, is itself vulnerable to high winds, particularly in densely built areas. Tree species, planting strategies, and maintenance practices must therefore be carefully calibrated to avoid generating new risks. By treating wind as a structural variable, the CRVA expands the scope of climate risk evaluation, introducing a dimension of verticality and aerodynamics often absent from conventional assessments. This holistic view supports integrated adaptation strategies, where heat, water, and wind are considered in relation to the physical form of the city—unlocking new criteria for urban planning, insurance models, and climate-resilient real estate investment.



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2.2 Benefits for Citizens and Developers

A structured Climate Risk and Vulnerability Assessment (CRVA) and the mapping of climate hazards shall deliver value not only to developers and investors but, above all, to citizens. By making risk exposure spatially visible and transparent, climate mapping empowers communities and local authorities to understand vulnerabilities at the neighborhood or district scale. Citizens gain awareness of potential threats—such as flooding, overheating, or wind stress—and can engage more actively in adaptation choices that affect livability, safety, and long-term urban quality.

For developers and asset managers, the benefits are equally significant, since they are the stakeholders best positioned to translate risk assessments into concrete adaptation strategies. One of the most immediate advantages is early-stage site screening: by overlaying climate hazard maps with project locations, developers can identify hotspots of vulnerability before committing major resources. This helps avoid unforeseen adaptation costs and reduces the risk of investing in sites where climate exposure could undermine performance, value, or compliance with planning requirements.

When integrated into the design and planning process, climate data also inform critical decisions on orientation, material selection, landscape planning, and energy systems. Urban heat islands, for example, can be mitigated by targeted green infrastructure, while flood-prone areas may require elevated ground floors, drainage buffers, or permeable paving. In this way, climate mapping becomes a means of increasing resilience without compromising architectural quality or functionality—delivering benefits both to end users and to long-term asset value.

From an ESG perspective, structured climate risk assessment supports transparent disclosure and alignment with international frameworks such as the EU Taxonomy and TCFD. This reinforces accountability, builds trust with institutional investors, and ensures that real estate products meet evolving financial and regulatory expectations. Moreover, the ability to compare exposure levels across sites and regions allows developers to allocate resources more efficiently and plan strategically for the long term.

Ultimately, CRVA and climate mapping serve as shared tools for resilience. Citizens gain greater awareness of risks and the possibility of safer, more livable environments; developers gain actionable intelligence to design, manage, and adapt assets effectively. Together, these outcomes align private investment with public benefit, making resilience a collective driver of sustainable urban development.

Climate Risk Mapping as a Shared Tool for Cities, Citizens, and Investors

Traditional zoning regulations or environmental reports are no longer sufficient in a context of accelerating climate change. Developers, investors, urban planners, and public authorities alike shall adopt a forward-looking approach that incorporates future climate dynamics into both project-level decisions and city-wide strategies.

For instance, sites in low-lying areas with poor drainage and high imperviousness may face escalating pluvial flood risk as extreme rainfall events become more frequent. Similarly, districts affected by urban heat island effects and limited vegetation may experience growing challenges

for energy efficiency, public health, and overall livability. By integrating climate data at an early stage, developers can reduce exposure to unanticipated costs and align projects with investor expectations for resilience. At the same time, public authorities shall integrate these analyses into urban policy, ensuring that land-use plans, infrastructure programs, and adaptation strategies are designed with climate risk in mind—and that this knowledge is made accessible to citizens and market actors.

Beyond excluding unsuitable sites, climate risk mapping at the urban scale allows for cross-comparison of locations and investment scenarios. The integration of morpho-climatic variables—such as elevation, land cover, surface permeability, and microclimate conditions—provides a detailed understanding of how climate stressors interact with the built environment. For public administrations, this evidence offers the basis to prioritize vulnerable neighborhoods for adaptation measures and to design transparent planning tools. For developers and investors, the same data highlights opportunities where targeted interventions can effectively reduce risks and increase asset value over time.

From a portfolio perspective, climate mapping enables investors to categorize assets by exposure, anticipate retrofitting costs, and refine assessments of risk-weighted returns. A site attractive in terms of location or zoning may still require significant investments in flood mitigation, stormwater management, or passive cooling strategies. Integrating such knowledge early helps avoid underestimating future operational and insurance costs, while directing capital toward projects that are resilient by design.

Ultimately, embedding Climate Risk and Vulnerability Assessments (CRVA) into both public policy frameworks and private investment decisions shifts the paradigm from reactive to proactive risk governance. Public authorities shall play a key role in collecting and disseminating climate data, enabling citizens to be aware of the risks that affect their communities, and empowering developers and investors to act on solid evidence. This shared approach ensures that resilience delivers benefits across scales: protecting individual assets, strengthening urban infrastructure, and improving the safety and quality of life of citizens.

Climate-Informed Design: Using Risk Mapping to Align Public and Private Interests

Beyond site selection, climate risk mapping shall serve as a critical input for shaping design strategies that respond directly to local vulnerabilities. By translating spatial risk patterns into actionable knowledge, developers, design teams, and public authorities can create buildings, infrastructure, and public spaces better adapted to the realities of a changing climate.

Urban heat islands, for example, may be mitigated through shading strategies, reflective materials, tree planting, and building orientation—all informed by 30m-resolution temperature and land cover data. In flood-prone areas, design responses may include permeable surfaces, elevated ground floors, retention basins, and resilient drainage systems.

Wind-prone zones may require tailored positioning and reinforcement of tall structures and vegetation, based on analysis of urban form and prevailing wind flows. These interventions not only reduce risks but also improve urban livability, protect communities, and enhance long-term asset performance.

To maximize value, this approach must be embedded across all design phases—from early massing studies to construction detailing. Risk-sensitive morphology, such as optimizing orientation to reduce solar gain or adjusting street canyons for natural ventilation, can be derived directly from localized climate risk indicators. Likewise, microclimatic modeling fed by satellite

and ground-based data enables precise, context-specific interventions. Not all reflective surfaces, for example, perform equally across settings; effectiveness depends on geometry, surrounding albedo, and prevailing winds. Here, the precision of climate data becomes indispensable for making cost-effective and technically sound choices.

Risks and Benefits of Climate Adaptation for the Real Estate Sector

The escalating impacts of climate change—including rising temperatures, intensified flooding, and more frequent extreme weather events—pose critical challenges for the real estate sector. Addressing these challenges requires structured and science-based adaptation strategies that strengthen resilience, safeguard asset value, and, above all, protect communities.

A thorough examination of available literature, encompassing scientific publications, industry analyses, and insights from banking, insurance, and real estate stakeholders, underscores the necessity for proactive adaptation strategies that balance risks with investment opportunities. Climate-related risks facing the real estate sector are typically categorized as physical, transition, and regulatory-financial risks. Physical risks, as highlighted by the United Nations Environment Programme Finance Initiative (UNEP FI, 2023), include direct impacts from events such as hurricanes, flooding, and wildfires, which threaten structural integrity and operational continuity. These hazards negatively impact property values and cash flows, demanding immediate attention and mitigation through resilient design and infrastructure enhancements. Transition risks arise as global economies progressively shift towards low-carbon and sustainable models (McKinsey & Company 2022) stresses that real estate assets failing to align with emerging environmental standards face potential obsolescence and depreciating value. Stakeholders must, therefore, integrate climate risk assessments into their asset and portfolio evaluations to ensure sustained relevance and profitability.

Alongside these risks, important benefits can arise for real estate developers who proactively integrate climate adaptation. Investments in resilient infrastructure help safeguard assets, while also supporting long-term functionality, occupant well-being, and stable returns.

For instance, developments such as Florida’s Babcock Ranch, a community specifically designed with climate resilience in mind, have successfully illustrated the marketability and value-added potential of sustainability-driven investments (TIME, 2022). Moreover, incorporating sustainable and resilient features into real estate developments creates substantial market differentiation and competitive advantage. Innovative urban planning concepts like "sponge cities," employ green infrastructure to manage urban flooding effectively and enhance the appeal and functionality of properties. Such strategies resonate with environmentally conscious tenants and investors, driving higher demand and improved asset valuations.

For example, the implementation of sponge city strategies in Sanya, on China’s Hainan Island—including permeable pavements and restored wetlands—has strengthened urban flood resilience while simultaneously supporting the local economy through eco-tourism and sustainable seafood industries. (Financial Times, 2024).

Access to specialized financial instruments, notably green financing such as green bonds, further incentivizes developers to pursue sustainable and resilient projects. These financial products typically offer favorable terms and help align economic profitability with ecological sustainability, facilitating the growth of adaptive and resilient real estate projects. To effectively leverage these opportunities, investors and developers must rigorously integrate climate risk assessments into their due diligence processes, ensuring comprehensive evaluation during transactions (Bloomberg Law, 2022).



Aerial view of the Castello Sforzesco and the Duomo, City of Milan

Building Resilient Architecture

Resilient architecture is a rapidly evolving field focused on designing buildings and infrastructures capable of withstanding or adapting to climate-related stress, ensuring continuity of function even under extreme conditions. This involves a combination of physical protection measures, passive bioclimatic principles, and innovative design solutions. In Europe and the Mediterranean, resilience is increasingly integrated into architectural practice as a response to risks such as extreme heat, flooding, wildfires, and coastal erosion.

Several cities already offer relevant examples. In Rotterdam, adaptive building strategies are widely applied in low-lying districts, with elevated ground floors, waterproof materials, and integrated rainwater systems—such as green-blue roofs and stormwater basins—helping neighborhoods withstand episodes of heavy precipitation and surface flooding. In Barcelona, new developments frequently integrate shading systems, natural ventilation, and cool materials to mitigate the urban heat island effect. In Athens and Lisbon, building codes and design practices are increasingly focused on reducing wildfire vulnerability in peri-urban areas through vegetation buffers, fire-resistant cladding, and passive protection systems.

Architectural adaptation strategies vary according to the specific hazard. In flood-prone areas, solutions include elevated structures, water-resistant materials, and efficient rainwater collection systems. In wildfire-exposed zones, fire-resistant façades and vegetation clearance perimeters are key. To cope with extreme heat, architects across Mediterranean cities are reintroducing bioclimatic principles, applying shading devices (e.g., pergolas, brise-soleil), reflective surfaces, natural ventilation strategies (such as courtyards or wind towers), and highly insulated or ventilated roofs. These approaches not only improve comfort but also reduce reliance on mechanical cooling, directly lowering energy consumption and emissions.

Bioclimatic architecture in particular provides a proven set of passive solutions to counteract extreme heat and the urban heat island effect. Shading strategies alone can lower indoor heat loads by up to 3°C, while water-cooled roofs have demonstrated reductions of 5–6°C (IPCC, 2022). In arid and semi-arid climates, vernacular techniques such as wind towers and solar chimneys can reduce indoor temperatures by as much as 10–14°C (Ghaffarianhoseini et al., 2019). These passive measures align adaptation with mitigation by reducing energy demand and greenhouse gas emissions.



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Globally, architects and engineers are increasingly combining vernacular knowledge with modern technologies to design buildings that remain safe, comfortable, and functional under climate stressors (IPCC, 2022). This approach is consistent with the logic of Climate Risk and Vulnerability Assessments (CRVA), which identify local hazards (heatwaves, floods, wildfires) and guide the selection of design solutions tailored to each context.

Investing in resilient architecture is not only a technical necessity but also an economic strategy. Buildings that integrate resilience—through elevated foundations in flood-prone zones, high-performance insulation in hot climates, or fire-resistant materials in wildfire-exposed areas—are increasingly considered lower-risk assets. They may command market premiums due to enhanced reliability, lower operational costs, and stronger insurability (GREEN, 2023). Cost-benefit

analyses reinforce this logic: in the United States, for example, investments in flood-control levees have been shown to raise the net present value (NPV) of protected real estate by more than 2.8% (GREEN, 2023). While context-specific, these findings demonstrate that proactive adaptation consistently yields long-term savings, particularly in European and Mediterranean cities facing intensifying flooding, overheating, and coastal risks.

In summary, resilient architecture represents a fundamental shift in the design paradigm. Buildings can no longer be planned for “ordinary” conditions but must be designed to withstand and recover from extreme events, continuing to serve communities even under stress. CRVA frameworks provide the evidence base for prioritizing these adaptation measures, ensuring that resilience is embedded at both the building and urban scales, and advancing the transition toward sustainable, climate-ready cities.

Nature-based solutions and sustainable urban design

In Mediterranean cities, nature-based solutions (NBS) and climate-aware urban planning are increasingly recognized as essential to address escalating risks such as heatwaves, droughts, and flooding. Unlike purely technical “grey” approaches—such as flood barriers, drainage pipes, or intensive air conditioning—NBS provide multiple co-benefits, mitigating hazards while improving environmental quality, public health, and social wellbeing (UN-Habitat, 2021; IPCC, 2022).

A central strategy is the renaturalization of urban environments through the integration of green and blue infrastructure—public parks, tree-lined streets, ecological corridors, green roofs, vegetated façades, and restored canals—into the compact urban fabric typical of Mediterranean cities. These measures play a crucial role in cooling microclimates, regulating stormwater, and enhancing ecological resilience, particularly in dense historic centers with limited open space. Cities such as Barcelona, Athens, Marseille, and Milan are expanding urban forests, greening rooftops, and planting in overheated districts to counteract the urban heat island effect (Cohen et al., 2021). Evidence shows that vegetated surfaces can lower air temperatures by up to 2°C and improve thermal comfort indices by more than 10°C under certain conditions (UN-Habitat, 2021).

Beyond cooling, NBS are fundamental for urban water management. Across the Mediterranean, municipalities are increasingly implementing Sustainable Urban Drainage Systems (SUDS)—rain gardens, bioswales, permeable pavements, and retention basins—adapted to local climatic and hydrological conditions. Such measures reduce runoff, relieve pressure on aging sewer networks, and mitigate flash flooding intensified by climate change (ISPRA, 2020; EU Technical Guidance on Adapting Buildings to Climate Change, 2020). Examples from Barcelona, Thessaloniki, and Bologna show how integrating SUDS in residential areas reduces water accumulation and local flood risks. Artificial wetlands along urban peripheries, piloted in southern France and coastal Italy, act as natural reservoirs that absorb excess stormwater while enhancing biodiversity.



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Although the concept of the “sponge city” originated in China, its principles are being reinterpreted in Mediterranean contexts, where impermeable surfaces and terrain constraints exacerbate runoff and flood risks. In Lisbon and Genoa, for instance, hybrid strategies are emerging: public plazas designed to serve as floodable basins, multifunctional parks acting as retention areas, and ecological corridors connecting fragmented green spaces (Financial Times, 2024). These approaches illustrate the added value of grey-green integration, as already demonstrated in Rotterdam, where storm surge barriers are coupled with parks and blue roofs that manage heavy rainfall (UNEP/Munich RE, 2020).

In parallel, preventive spatial planning is becoming more prominent. Hazard mapping and climate scenario modeling—tools promoted by CDP (2022) and UNEP FI (2023)—are increasingly used to adapt zoning rules and guide development away from erosion-prone or flood-exposed coastal areas,

such as Palermo or Marseille. Measures include shifting building lines, transferring development rights, and adapting masterplans to integrate CRVA outputs (Master Adapt, 2018).

In essence, climate urbanism in the Mediterranean seeks to transform cities into proactive systems of resilience. Greener neighborhoods, multifunctional public spaces, and ecological corridors regulate microclimates, reduce hazard exposure, and improve livability. These approaches not only support local climate adaptation but also advance broader international frameworks such as the EU Green Deal, the EU Taxonomy (Regulation 2021/2139), and UN-Habitat’s “green urbanism” vision, which promote inclusive, low-emission, and circular development models. Achieving this transformation will require political commitment, intersectoral cooperation, and a renewed culture of innovation—but the result is a safer, healthier, and more inclusive Mediterranean city, equipped to face the extremes of a changing climate.



Bosco Verticale, Portanuova - Milano

Technological innovation and smart solutions for climate-resilient real estate

As climate risks grow more frequent and severe, digital technologies and innovative materials are transforming how resilience is embedded in real estate. Leveraging advanced data, predictive modeling, and smart systems enables stakeholders to anticipate vulnerabilities, design adaptive assets, and manage risks across the entire property lifecycle.

Data and digital platforms. Big data analytics and artificial intelligence (AI) are reshaping risk management. High-resolution predictive models can simulate future heat, flood, or wind stress scenarios on a building-by-building basis, helping developers and asset managers identify hotspots and prioritize adaptation measures. AI-driven platforms tailored for real estate now generate climate-adjusted risk maps and score assets against future threats—such as projected flood depths or extreme heat by 2050. These insights are increasingly integrated into pre-acquisition due diligence, enhancing portfolio resilience. In parallel, the financial sector is advancing catastrophe models and climate stress testing to refine credit risk assessments and insurance underwriting, directly influencing the cost of capital and insurability of climate-exposed assets.

Design and construction processes. Parametric modeling tools allow developers to test thousands of design permutations, optimizing building orientation, form, and materials for thermal comfort and energy efficiency. This approach reduces long-term operating costs while aligning with climate adaptation goals.

Innovative materials and systems. A new generation of building materials is reinforcing resilience:

- Heat mitigation: high-albedo coatings, smart glazing systems, and phase-change materials stabilize indoor temperatures and lower cooling demand.
- Flood resilience: permeable concrete and water-retentive surfaces help manage urban runoff.
- Energy resilience: distributed generation systems—such as photovoltaic panels combined with storage—ensure continuity of essential services during grid outages, particularly for multi-unit or critical infrastructure.
- Water management: dual-pipe systems and rainwater harvesting mitigate drought stress and reduce reliance on potable water supplies.

Governance and community engagement. Beyond hardware, digital platforms now enable citizen participation in resilience planning. Residents can provide feedback on local climate stresses—such as perceived heat discomfort or recurrent flooding—feeding directly into design and management workflows. These participatory mechanisms align real estate strategies with community needs, improving acceptance, reputation, and long-term asset value.

In sum, technological innovation is expanding the toolbox available for climate-resilient real estate. By combining predictive analytics, adaptive design processes, advanced materials, and participatory governance, developers and asset managers can move from reactive adaptation to proactive, evidence-based resilience—strengthening both asset performance and community well-being.

2.3 Inspiration from Advanced Methodologies

As urban development becomes increasingly exposed to climate change, the challenge is not whether to use scientific methods, but how to make them accessible and actionable for real estate practice. Climate science—rich in high-resolution models, vulnerability indices, and impact simulations—has traditionally remained in academic or policy circles, often too complex for developers, investors, or design professionals to apply directly. Emerging frameworks such as the Climate Risk and Vulnerability Assessment (CRVA) address this gap by translating climate data into spatially explicit outputs that can be read and acted upon within project workflows.

The value of CRVA lies in its ability to transform abstract climate awareness into project-based intelligence. Rather than prescribing predefined solutions, it provides diagnostic insights that help stakeholders identify site-specific vulnerabilities and tailor adaptation strategies accordingly. For example, overheating risks may suggest corridors of shade or reflective materials, while flood-prone contexts point toward permeable pavements or retention basins. The strength of these tools is their methodological accessibility: they allow real estate actors to engage with robust climate science without needing to be experts themselves.

This accessibility is amplified by the development of decision-support instruments:

- A Climate Risk Screening Grid helps compare potential sites based on hazard exposure, clarifying trade-offs between adaptation costs and investment potential.
- A Design Guidance Matrix links specific vulnerabilities to adaptive design responses, enabling context-sensitive choices at the project stage.
- A Prioritization Map highlights urban districts where overlapping risks—such as heat stress combined with low vegetation cover—require concentrated interventions.

Such instruments not only guide individual site development but also inform portfolio-level planning, helping investors balance risks, allocate resources, and strengthen long-term resilience strategies.

Crucially, these tools are designed to evolve. As new climate data from sources such as Copernicus, ARPA, or CMCC becomes available, screening grids, guidance matrices, and prioritization maps can be updated, ensuring that adaptation strategies remain aligned with changing climate realities. This creates a feedback loop between monitoring, decision-making, and implementation, reinforcing adaptive governance at both the asset and city scales.

By tailoring scientific methodologies into accessible formats, CRVA and similar approaches function as enablers of climate-responsive urbanism—bridging the gap between data, design, and investment in ways that are both rigorous and practical.



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Climate Risk and Vulnerability Assessment: A Multi-Scale Approach for Milan

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Climate Risk and Vulnerability Assessment: A Multi-Scale Approach for Milan

COIMA’s portfolio is substantially concentrated in the City of Milan, and future investment plans will continue to focus on this urban context. Recognizing this concentration of exposure, COIMA considered essential to understand how climate change could impact both our existing assets and the projects that may be undertaken in the coming years. To structure such an analysis with scientific rigor, COIMA commissioned IUAV University of Venice, whose expertise in climate and urban systems provided the foundation for a comprehensive Climate Risk and Vulnerability Assessment (CRVA).

The study was designed to operate across multiple scales of analysis, reflecting the different dimensions at which climate impacts materialize:

City scale

City scale to analyze the climatic and morphological drivers shaping Milan and identify systemic vulnerabilities that affect the city as a whole.

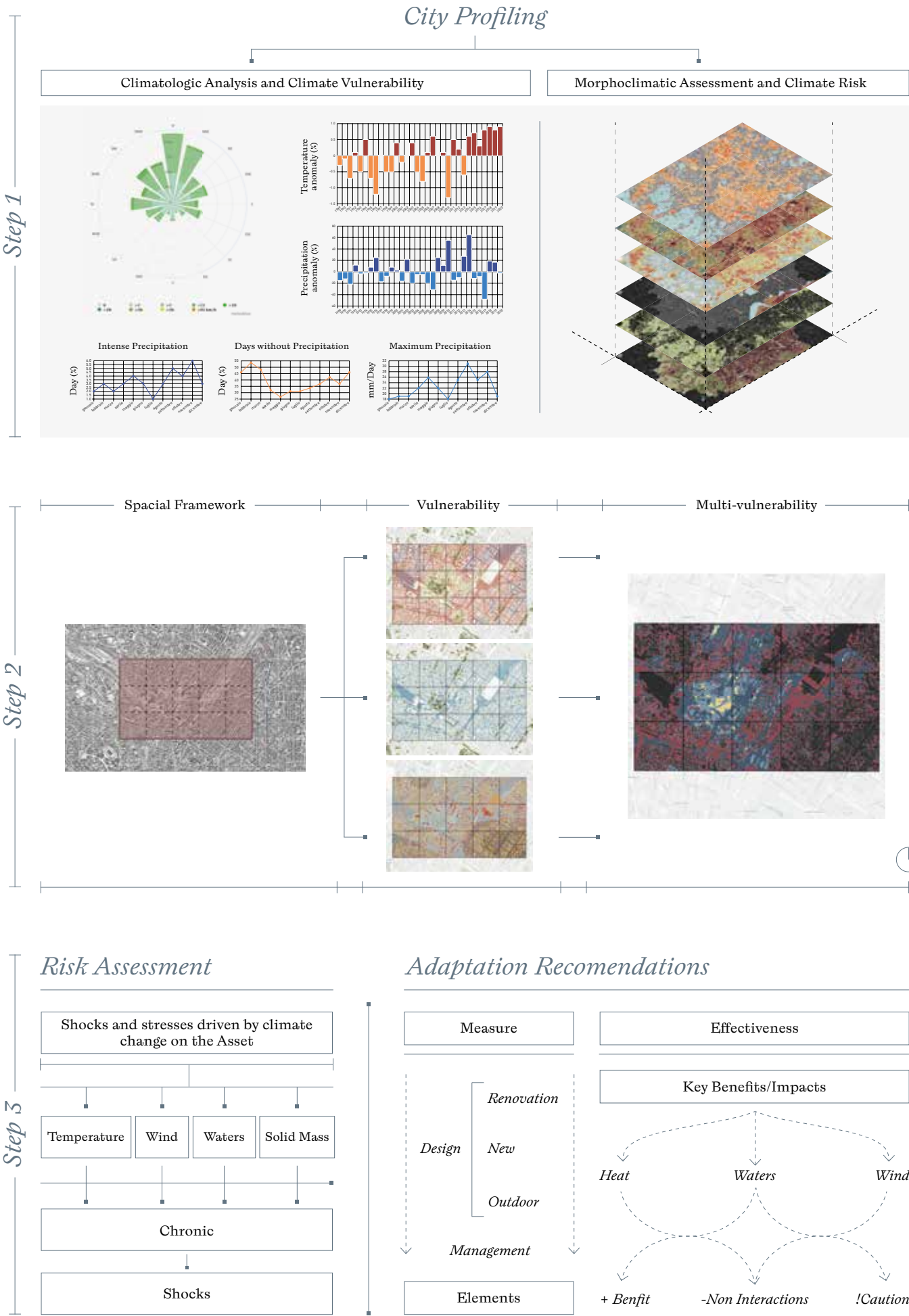
District scale

District scale to assess how climate dynamics interact with morphological and social characteristics at the neighborhood level, highlighting localized risks and opportunities for targeted adaptation

Building scale

Building scale to focus on assets within the Fund portfolios, where risk evaluations and adaptation strategies can directly inform management, redevelopment, and long-term value creation.

This multi-scale approach provides both a strategic overview and the operational detail necessary to embed climate resilience into the real estate lifecycle.





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The city-scale analysis delivers a long-term perspective on Milan’s climate challenges, highlighting macro-level issues such as heat stress, pluvial flooding, and wind exposure. This insight is critical not only for assessing the resilience of the operational portfolio, but also for informing future investment choices and identifying districts that may require more attention.

During the due diligence phase for acquisitions, the model can be applied at a district scale to provide higher resolution assessments. This allows developers and investors to detect localized vulnerabilities—such as flood-prone zones, urban heat hotspots, or canyon wind effects—that may not be visible at the city level but could significantly affect performance and risk-adjusted returns.

The analysis then extends to the building scale whenever investments involve redevelopment or new construction. Here, CRVA findings are translated into detailed vulnerability profiles and adaptation strategies to be integrated into project design. Measures may include façade improvements, green infrastructure, passive cooling, or advanced water management systems, ensuring that resilience becomes an integral part of the construction or retrofit process.

For assets already under management, adaptation strategies are embedded into property management practices. Monitoring protocols for climate-related events and an internal database of climate impacts have been introduced, creating a structured process for both reactive interventions and proactive learning. This systematization strengthens the evidence base for decision-making, supports ongoing resilience improvements, and informs long-term portfolio planning.

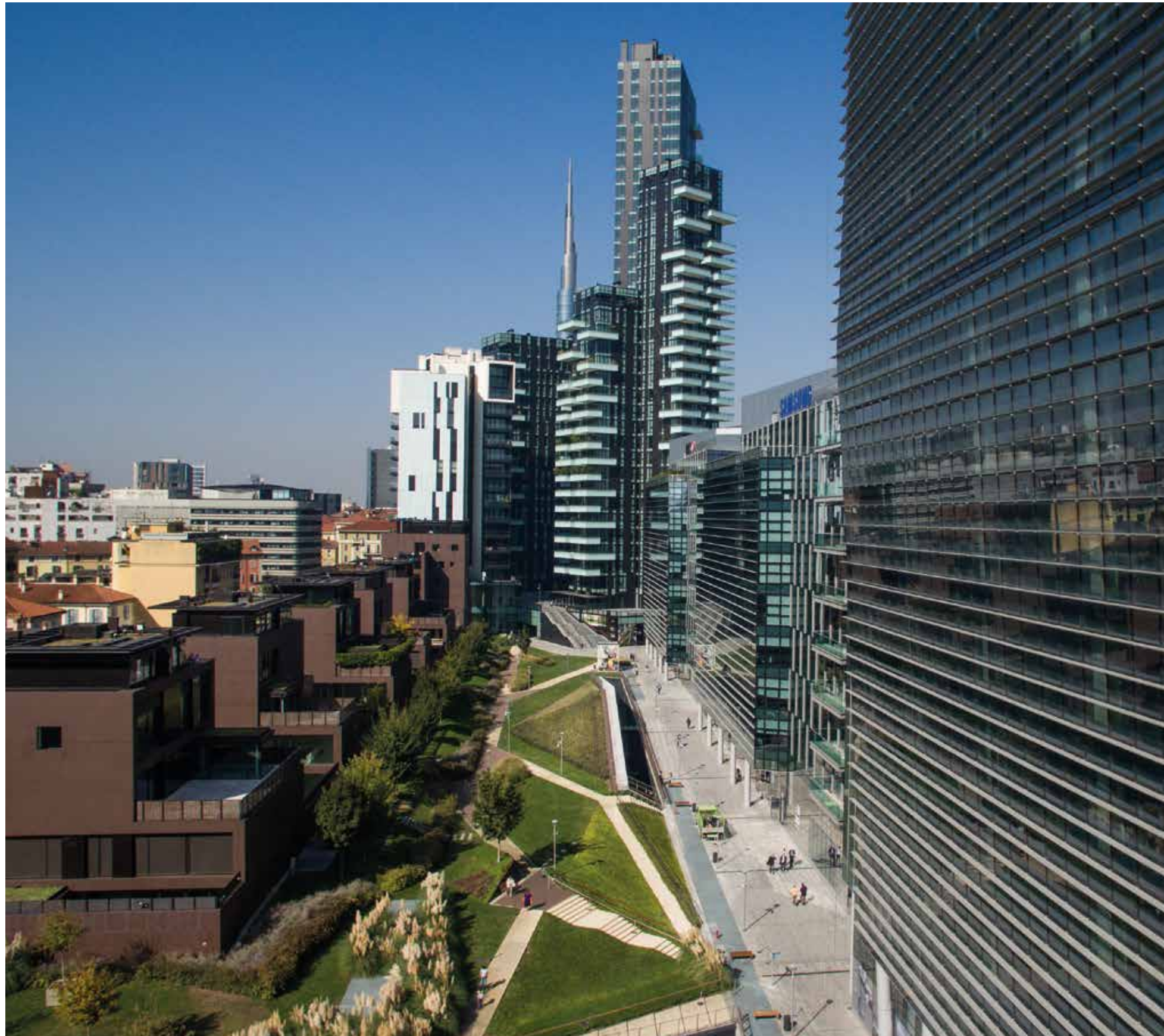
Through this iterative and multi-scale approach, the study demonstrates how CRVA can evolve from a diagnostic tool into an operational framework—supporting decision-making at every stage of the real estate lifecycle. From city-wide planning to district-level due diligence, from asset design to long-term management, CRVA provides a structured methodology to align investment strategies with the realities of a changing climate.

3.1 Step 1: Assessing Climate at City scale

How to gather data on temperature trends, flooding potential, and extreme weather events

Climate risk assessment begins with the collection and analysis of high-quality data related to current and projected climate conditions within the whole urban systems. This includes morphological parameters such as land use, building distribution and density, environmental features and surface type, as well as climatic drivers, such as temperatures, precipitation trends and wind patterns. Through the interaction of morphological and climate parameters, the assessment can define a climate city profile in which climatic shocks and chronic stresses are identified, as visible in the following table:

	Temperature	Winds	Waters	Solid mass
Chronic	Changing temperature (air, freshwater, marine water)	Changing wind patterns	Changing precipitation patterns and type (rain, hail, snow/ice)	Coastal erosion
	Heat stress		Precipitation or hydrological variability	Soil degradation
	Temperature variability		Ocean acidification	Soil erosion
	Permafrost thawing		Saline intrusion	Solifluction
			Sea level rise	
			Water stress	
Shocks	Heat waves	Cyclone, hurricane, typhoon	Drought	Avalanche
	Cold wavw/frost	Storm (including bliz zards, dust and sand storms)	Heavy precipitation (rain, hail, snow/ice)	Landslide
	Wildfire	Tornado	Flood (coastal, fluvial, pluvial, ground water)	Subsidence
			Glacial lake outburst	

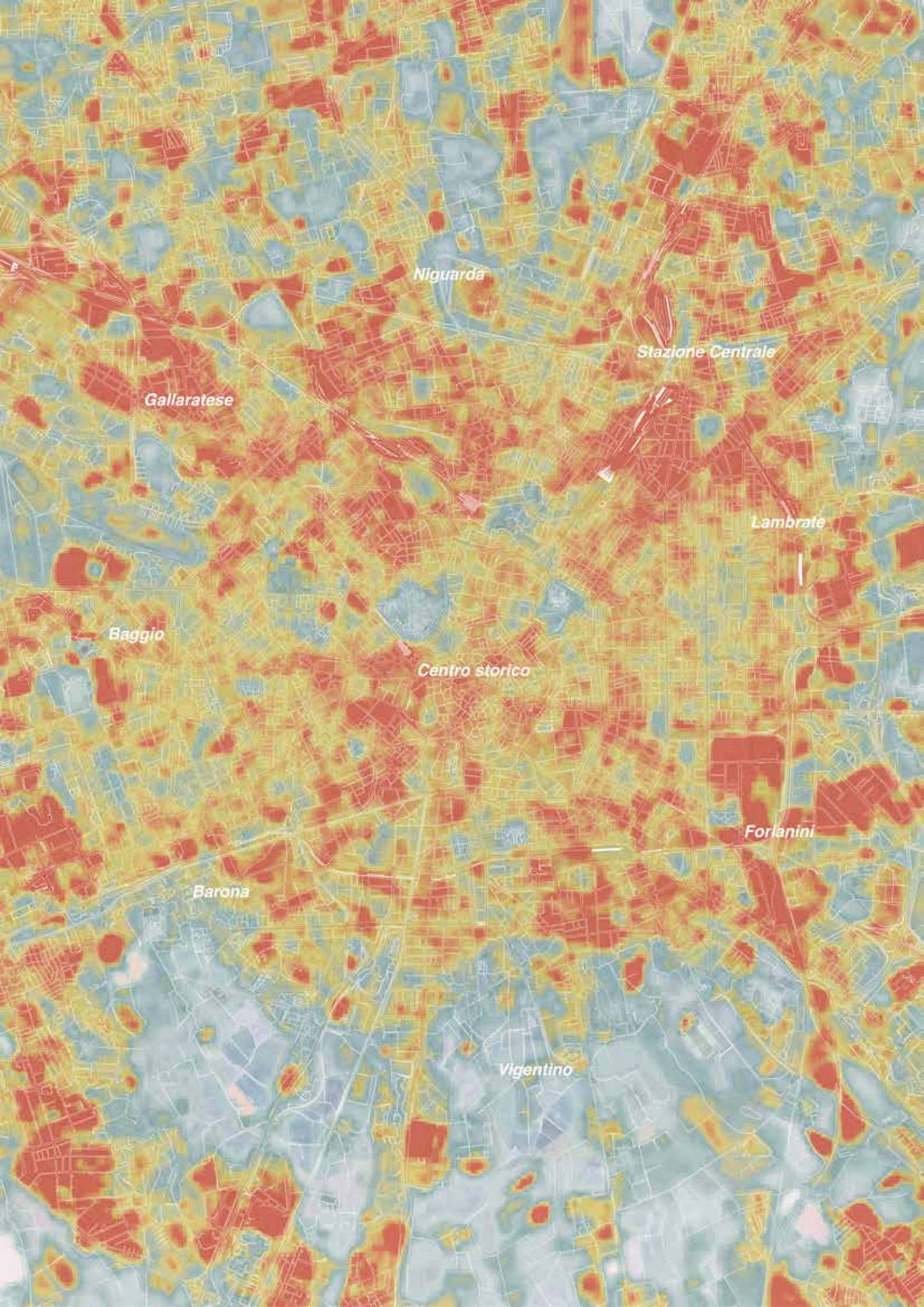


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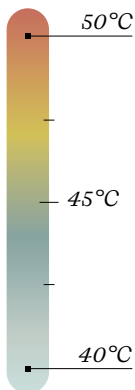
A set of digital tools and decision-support systems support accurate and actionable analysis:

- Geographic Information Systems (GIS) for spatial analysis and layered vulnerability mapping: represent multimodal digital mapping platforms that are capable of overlaying multiple types of geographic information onto a single digital map. The system works by allowing users to stack layers of different data types - such as building density, elevation, waterways, infrastructure, and more - creating a comprehensive visualization where relationships between various elements become clearly visible. The primary purpose of GIS in vulnerability mapping is to identify areas most susceptible to climate risks by combining different datasets. For example, when assessing flood vulnerability, GIS can overlay flood-prone zones with building footprints. This creates color-coded maps that visually represent risk levels across different geographic areas, enabling planners and decision-makers to prioritize resources and interventions where they're most needed.
- Climate projection models based on IPCC RCP 4.5 and RCP 8.5 scenarios: are sophisticated computer-based simulations that predict how Earth's climate will change over the coming decades. These models rely on Representative Concentration Pathways, with RCP 4.5 representing a moderate scenario where greenhouse gas emissions peak around 2040 and then gradually decline, while RCP 8.5 represents a more pessimistic pathway where emissions continue rising until 2100. The computer models process millions of calculations, taking into account factors like future CO₂ emissions, ocean currents, water cycle dynamics, and atmospheric interactions, based on the IPCC scientific reports. These simulations generate predictions for all over the world. In this process, many variables as temperature changes, precipitation patterns, and extreme weather events are analyzed. The final result provides crucial information for adaptation planning such as determining where to build flood defenses, how to modify agricultural practices, or where to relocate vulnerable infrastructure at global scale.
- Remote sensing tools such as multispectral satellite imagery to evaluate terrain and vegetation: captures specialized photographs of Earth that extend far beyond what the human eye can perceive. While traditional photography captures visible light in red, green, and blue wavelengths, multispectral imaging also records near-infrared, thermal infrared, and other specific spectral bands. This technology works on the principle that different materials - vegetation, water, soil, concrete - reflect light in unique patterns across these various wavelengths, creating distinctive spectral signatures. Healthy vegetation, for instance, reflects strongly in near-infrared wavelengths, allowing satellites to create detailed maps of forest health and detect vegetation stress long before problems become visible to the human eye.

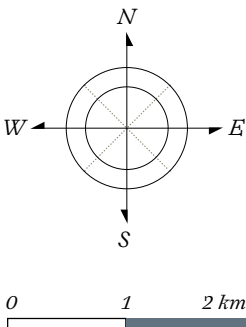
These tools enable developers to adopt a risk-informed development process from the outset, aligning land use planning with long-term climate safety.



Legend



Distribution of Maximum thermal values over 44 different tiles of the city of Milan and the immedia surroundings. The results has been recorded by Landsat 8 during summer 2023 (Jun-Sept) around 10:00 am.



Assessing Climate Risks: A City-Scale Overview for Milan

Maximum Land Surface Temperature Analysis - Summer 2023

This map shows the distribution of anthropogenic heat in the city of Milan, as detected by the Landsat-8 satellite during the summer of 2023. The analysis focuses on maximum values in order to exclude temporary fluctuations and to improve the statistical reliability of the dataset. The images were reprocessed to a spatial resolution of 30 meters per pixel, taking as reference the hottest period of the year.

The color scale indicates temperature differences:

- Dark red areas represent the hottest zones, where surface temperatures exceeded 50 °C at around 10 a.m. (the acquisition time of the satellite images).
- Yellow areas show intermediate values, close to the city average.
- Blue-grey areas correspond to cooler zones, with maximum values around 45 °C.

From the map, it is clear that the densest urban sectors—the city center, major infrastructures such as Stazione Centrale and the airport areas, as well as highly built-up districts like Gallarate, Lambrate, and Forlanini—experience the highest surface temperatures. These heat peaks are linked to the concentration of impermeable materials, lack of shade, and limited vegetation cover.

By contrast, parks, tree-lined avenues, and peri-urban rural areas register significantly lower maximum temperatures. Vegetation, through evapotranspiration, plays a crucial role in cooling the microclimate and mitigating the effects of extreme heat.

This representation highlights the contrast between compact urban fabric and green or rural areas, underlining how urban form and land use strongly influence the intensity and distribution of heat stress.

Assessing Climate Risks: A City-Scale Overview for Milan

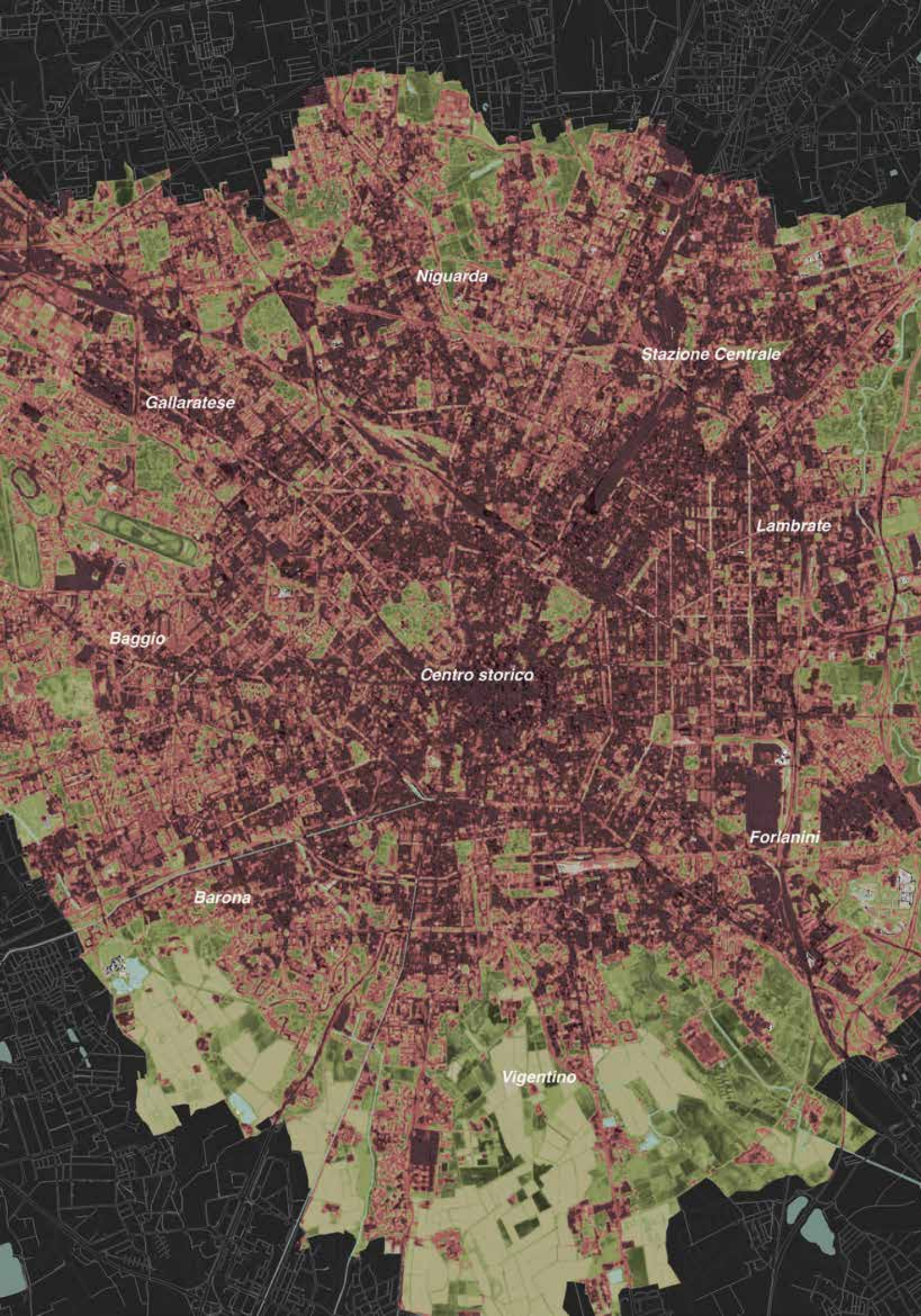
Imperviousness from Urban Atlas

This map illustrates the degree of soil sealing in the city of Milan, based on the Urban Atlas dataset. Imperviousness refers to the percentage of land covered by artificial surfaces such as asphalt, concrete, and buildings, which prevent water from infiltrating into the ground. High levels of imperviousness increase runoff during rainfall events, often overwhelming drainage systems and amplifying the risk of urban flooding.

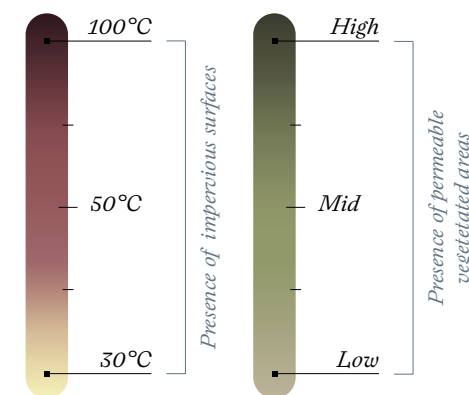
The color scale provides a clear reading of surface conditions:

- Dark brown to red tones represents the highest levels of imperviousness (close to 100%), typical of the Centro storico and other dense districts such as Stazione Centrale, Lambrate, Gallarate, and Forlanini. These areas are almost entirely sealed by built-up surfaces, leaving minimal capacity for water absorption.
- Lighter brown shades indicate medium imperviousness, often corresponding to mixed-use or less compact neighborhoods.
- Green tones show areas with vegetation and permeable surfaces, identified through the NDVI (Normalized Difference Vegetation Index). These zones, including parks, peri-urban areas, and the agricultural land around Barona and Vigentino, naturally absorb rainwater and mitigate runoff.

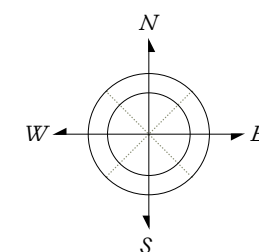
The contrast between the dark, highly sealed core of Milan and the greener, more permeable edges highlights how urban form directly shapes hydrological vulnerability. Where hard surfaces dominate, even moderate rainfall can translate into rapid runoff and potential flooding. Conversely, the presence of vegetation and permeable soils plays a crucial role in regulating stormwater and reducing flood risks.



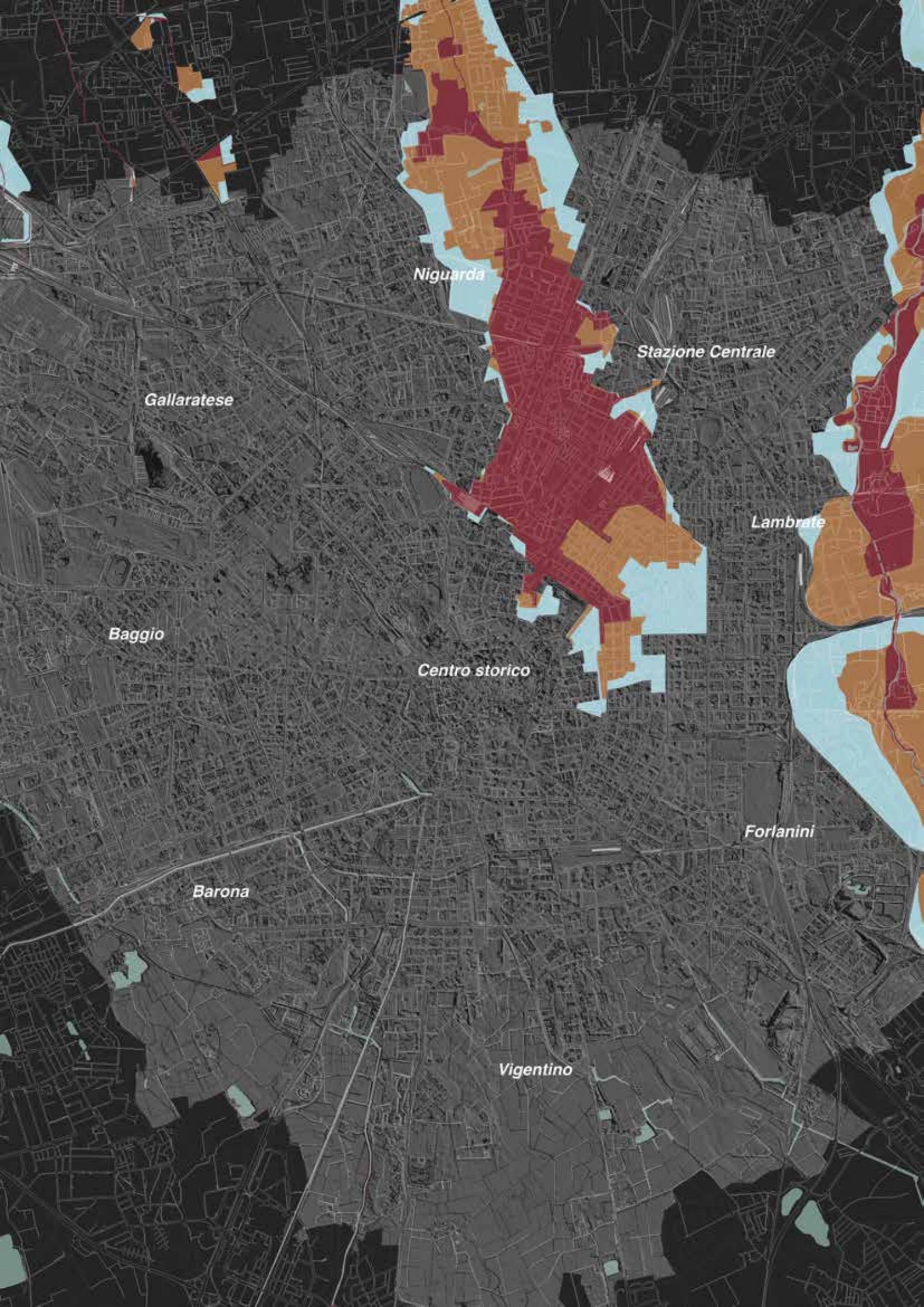
Legend



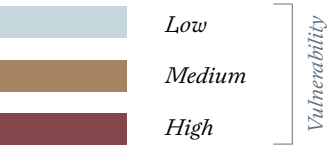
Imperviousness: from green to red, the shading indicates the permeability rate for pixels of approximately 100 m². This indicator is directly related to the extent of impervious surfaces—such as asphalt, concrete, and other materials that prevent water from infiltrating the ground—but it also accounts for green and permeable areas.



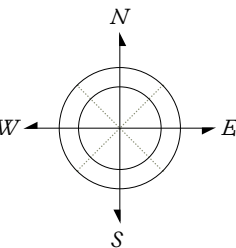
0 1 2 km



Legend



In the UE, the Water Framework Directive (WFD) 2000/60/CE provides for Basin Authorities to outline a risk scenario for their territory. The PGRA (Flood Risk Management Plan) of Po river defines risk geometries from 1 to 4 considering parameters related to social, economic and landscape exposure of the context.



0 1 2 km

Assessing Climate Risks: A City-Scale Overview for Milan

Risk Classes from Flood Risk Management Plan

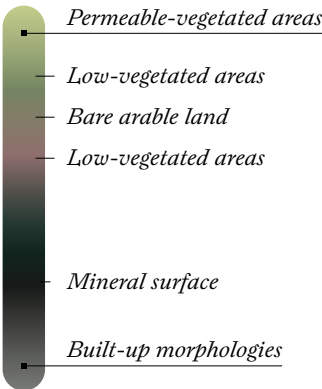
This map illustrates the risk classes related to flooding in Milan, as outlined in the Flood Risk Management Plan (FRMP). The map on the facing page provides information on the potential negative consequences of flooding based on various criteria, such as the hazard probability, the number of people who might be affected, impact on infrastructure and critical facilities, effects on the environment, historical and cultural assets, the distribution and types of economic activities in the area, and the presence of potentially polluting facilities and protected areas. The map uses a color scale to represent different classes of risk based on exposure to flood events, distinguishing between areas with low, medium, and high risk.

- High-risk areas are depicted in dark red tones, with zones such as Niguarda, Stazione Centrale, and the northern part of the historic center of Milan showing high vulnerability. These areas are prone to flooding due to their proximity to the Seveso River, which flow through the city, and the high value of assets that could be affected in the event of overflow. Another hotspot can be seen east of Milan, where the Lambro River generates risks and impacts of varying magnitude based on the exposed elements it intersects, having a high potential impact area in Lambrate.
- Medium-risk areas are represented in orange tones and are primarily located in zones that are not immediately adjacent to major watercourses but still present significant vulnerability. These areas are subject to a combination of flood probability and the importance of the assets and infrastructure present.
- Low-risk areas are highlighted in light blue, where flood exposure is minimal. These zones tend to be further away from rivers and have a lower density of vulnerable infrastructure to flood events.

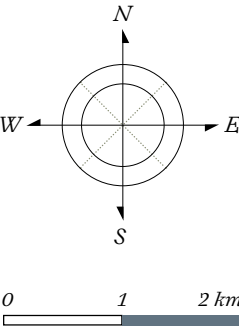
The contrast between high-risk and low-risk areas highlights the varying ability of regions to absorb the impacts of flooding events, reflecting a difference in territorial vulnerability and the distribution of critical assets. Overall, the presence of watercourses and the distribution of risk across different parts of the city suggest the need for targeted protective measures, especially in areas with higher exposure, such as the historic center and zones adjacent to the Seveso and Lambro rivers.



Legend



Normalized Difference Vegetation Index: an indicator of vegetation presence and health calculated for pixels of approximately 100 m². NDVI values range from -1 to 1 values, between 0,4 and 1 indicate healthy, dense vegetation, while values near 0 suggest sparse or stressed vegetation.



Assessing Climate Risks: A City-Scale Overview for Milan

Permeable Areas Distribution

This map illustrates the distribution of permeable areas in Milan, derived from the Normalized Difference Vegetation Index (NDVI). The NDVI provides a measure of vegetation health and density, using a 10m/pixel resolution from satellite imagery captured during the summer months of June to September 2023. The NDVI index helps to assess vegetation vitality and identifies areas under stress due to higher temperatures and lack of rainfall, which are more prominent during the summer.

The map uses a color gradient to distinguish between different levels of vegetation presence and permeability. Areas with high vegetation are represented in shades of green, indicating well-established greenery, such as parks, tree-lined streets, and other public or residential green spaces. These areas not only contribute to improving air quality but also play a vital role in absorbing water and mitigating flood risks, offering natural resilience to the urban landscape.

Lighter green tones represent less vegetated zones or areas where the vegetation does not respond as effectively to climatic stress, while darker tones indicate impermeable or mineral surfaces, such as roads, buildings, and other urban infrastructure. These areas, typically characterized by their inability to absorb water, are more prone to runoff during rainfall, exacerbating the risk of urban flooding.

The spatial distribution of permeable areas underscores the role of urban greenery in managing climate shocks and stresses, particularly heat and stormwater. As seen on the map, the central parts of the city, including districts like Niguarda and the historic center, display a lower presence of vegetation compared to the more peripheral areas, which may have higher permeability due to the presence of green spaces and agricultural land.

By highlighting areas with varying vegetation densities, this map helps to visualize the relationship between urban form and the ability to manage climatic pressures. The green zones are key to enhancing the city’s natural infrastructure, providing both ecological and hydrological benefits.

Assessing Climate Risks: A City-Scale Overview for Milan

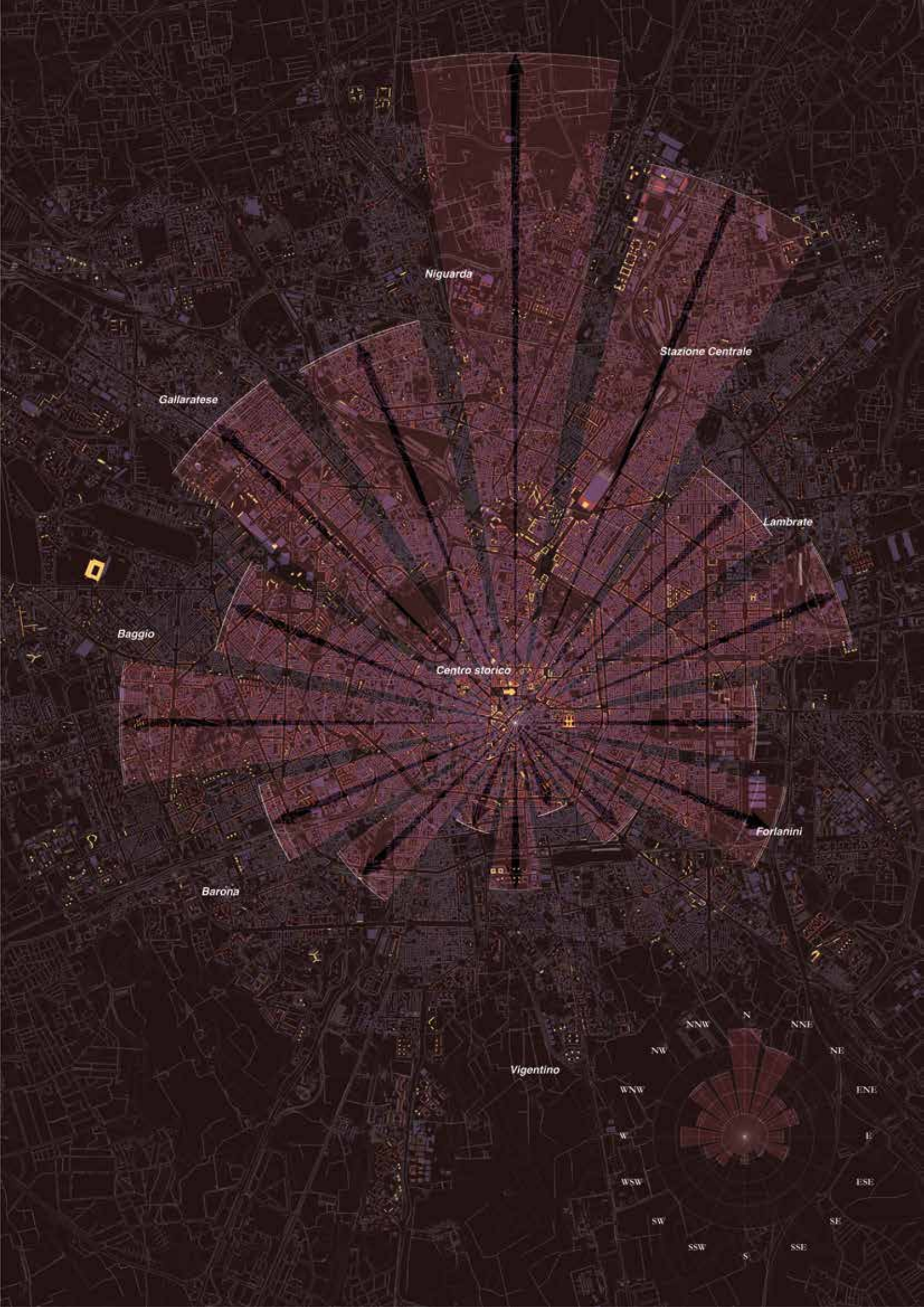
Wind-related extreme Events Building Elevation

This map illustrates the potential influence of the wind over Milan, categorizing architectural structures based on their height. The map's design employs a color gradient to represent different height ranges, ranging from 1–8 meters in the darkest shades to those reaching 35-200 meters in the lightest tones. It provides a clear visual of Milan's built environment, helping to understand its vertical urban fabric and its interaction with seasonal and extreme weather patterns, particularly wind.

The map is structured radially following the wind patterns and frequencies, with concentric segments emanating from the city's center, the "Centro Storico." The darker hues, which indicate taller buildings, are concentrated around central and key urban zones such as Stazione Centrale, Niguarda, and parts of the historic city center. These areas are home to taller office buildings, residential blocks, and commercial spaces, resulting in a higher building elevation. This dense development contrasts with the outer suburbs, where lower-rise buildings are more common, represented in darker tones (1–8 meters).

The radial classification allows for a visual representation of building heights across Milan's districts, with the concentric zones highlighting how architectural height varies based on proximity to the city center and major transportation hubs. For instance, the northern and southwestern sectors, such as Lambrate and Forlanini, feature more low-rise buildings, signifying less dense development compared to areas closer to the city's core.

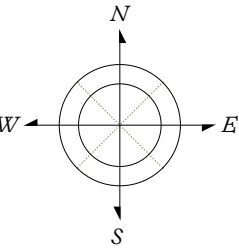
Understanding the distribution of building elevations is crucial for urban planning, especially when considering factors like wind impact and climate resilience. Taller buildings, especially those concentrated in the central and highly urbanized areas, are more exposed to extreme weather conditions such as strong winds. In Milan, seasonal wind patterns, particularly the chillier northern winds in winter and the lighter southwest breezes in summer, are influenced by the city's architecture. Taller structures, with their increased exposure, are more vulnerable to these wind gusts, which may cause damage or increase the risk of structural stress during severe weather events.



Legend

	1-8	Building Heights
	9-24	
	25-32	
	33-200	

Classification of architectural elements by height, aimed at assessing their varying levels of exposure to direct impacts from extreme wind events. This classification helps identify which components of the built environment are more vulnerable, allowing for better risk evaluation and targeted mitigation strategies.



0 1 2 km

Assessing Climate Risks: A City-Scale Overview for Milan

Urban Compactness

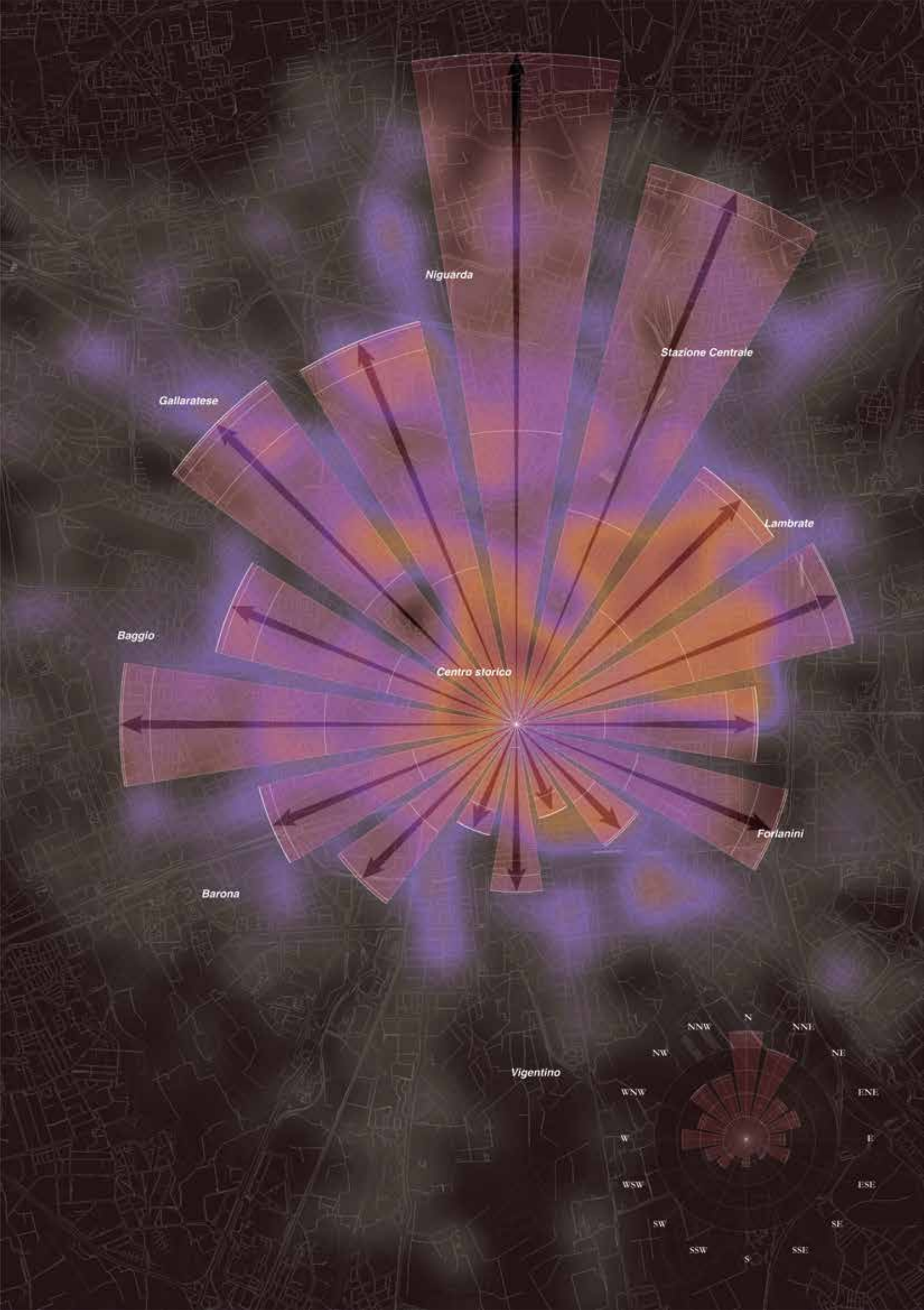
This map provides a visual representation of urban corridors in Milan, combining data on city density with the effects of prevailing wind directions. The goal is to depict not only the direct risks associated with wind exposure but also the secondary or indirect impacts that arise from urban density. These indirect risks include the increased vulnerability of densely populated areas to wind-driven disturbances, such as structural damage, impacts on infrastructure, and threats to human safety.

The map uses a Kernel Density methodology to analyze how urban density interacts with elevation across the city. Areas with higher urban density, represented in warm hues (red, orange and purple), are clustered around the city center (Centro Storico) and extend outward in radial sectors. These dense zones are particularly susceptible to the secondary effects of wind, which can create turbulence and exacerbate the risks posed by tall buildings, poorly constructed properties, and under-maintained green spaces. In contrast, areas with lower density, represented in cooler hues (light purple and gray), generally experience less intense impacts from these wind-driven risks.

The highest urban density zones, seen primarily in the central and northwestern sectors, are the most exposed to both direct and indirect wind risks. As wind patterns travel through these dense areas, buildings and infrastructure can amplify the effects of storms or gusty winds, leading to greater consequences on the ground. These areas are more prone to issues such as pedestrian exposure, structural damages to buildings and vegetation.

In comparison, the outer parts of Milan, such as Forlanini, Barona, and Vigentino, display lower levels of compactness and, consequently, a reduced risk from wind effects. These zones have fewer tall buildings and a greater proportion of low-rise structures, mitigating the spread of wind disturbances.

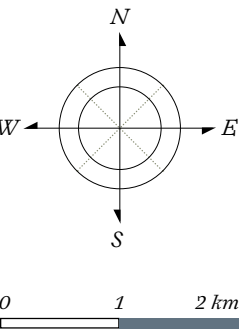
Overall, the map not only visualizes the city's urban form but also highlights the need to account for both direct and indirect wind risks. Understanding the interplay between urban compactness and wind patterns is crucial for urban planning, as it helps identify vulnerable areas where interventions might be necessary to protect both people and property from the complex impacts of wind and urban density.



Legend



Classification of the secondary level of wind-related risk, derived from an analysis performed using Kernel Density estimation. The assessment highlights how wind exposure varies across the urban fabric, exploring the relationship between city density and different altitude classes to better understand patterns of vulnerability.



3.2 Step 2: Assessing Climate Risks at district level

The second stage of the CRVA study moves from the city-wide assessment to the district scale, providing a more granular perspective on climate risks and vulnerabilities. This level of detail is particularly important for COIMA, as it focuses on neighborhoods considered strategically relevant—either because they already host assets or developments within the managed portfolio, or because they represent potential targets for future investment.

The district-level analysis was structured around a grid of 500-meter clusters, developed by intersecting the city’s cartography with spatial climate data. This methodology allows for the precise identification of buildings located within each cluster, and for the characterization of the specific climate conditions that shape their vulnerability profiles.

By operating at this intermediate scale, the CRVA provides actionable insights that complement both the broad perspective of the city-scale analysis and the precision of building-level assessments. For example, during the due diligence phase of acquisitions, the framework enables the identification of the relevant cluster in which a property is located and the evaluation of the local climate context—such as exposure to urban heat islands, flooding risk, or wind

stress. This approach helps anticipate adaptation needs, avoid unforeseen costs, and position investments within a clear environmental and morphological framework.

In this way, the district-scale analysis represents a critical bridge: it connects systemic climate risks observed at the city scale with the localized realities that influence the resilience and long-term performance of individual assets.

Sources and data

The analyses conducted in this document make use of different information basins. Some data refer to spatial and alphanumeric information already in possession of the Municipal Administrations (basic cartographic themes and general thematic cartography), while others come from remote sensing surveys and elaborations after specific field surveys, conducted by the municipality during the assembly of its database.

The database construction logic allowed to elaborate an integrated cognitive and interpretative framework on the relative types of impact. The interdisciplinary investigation process revised information bases, providing the essential elements for initiating the technical-scientific analysis phase.

Category	Description	Formats	Source	Processing
Basic cartographic themes	Buildings, road networks, rivers Digital Terrain Model	Vector and raster	City of Milan open dataset	- Construction of baselines - Density ratios
Thematic Cartography	Land use and land cover	Vector	Regional open dataset	- Thematizations - Queries or overlay analysis
Remote sensing	Satellite images	Raster	Satellite data: Landsat 8, Sentinel-2 (open data)	Graphic indicators LST (30m resolution), NDVI (10m resolution)



Portanuova, Milano

Case study: Portanuova as a benchmark for integrating climate insights into design

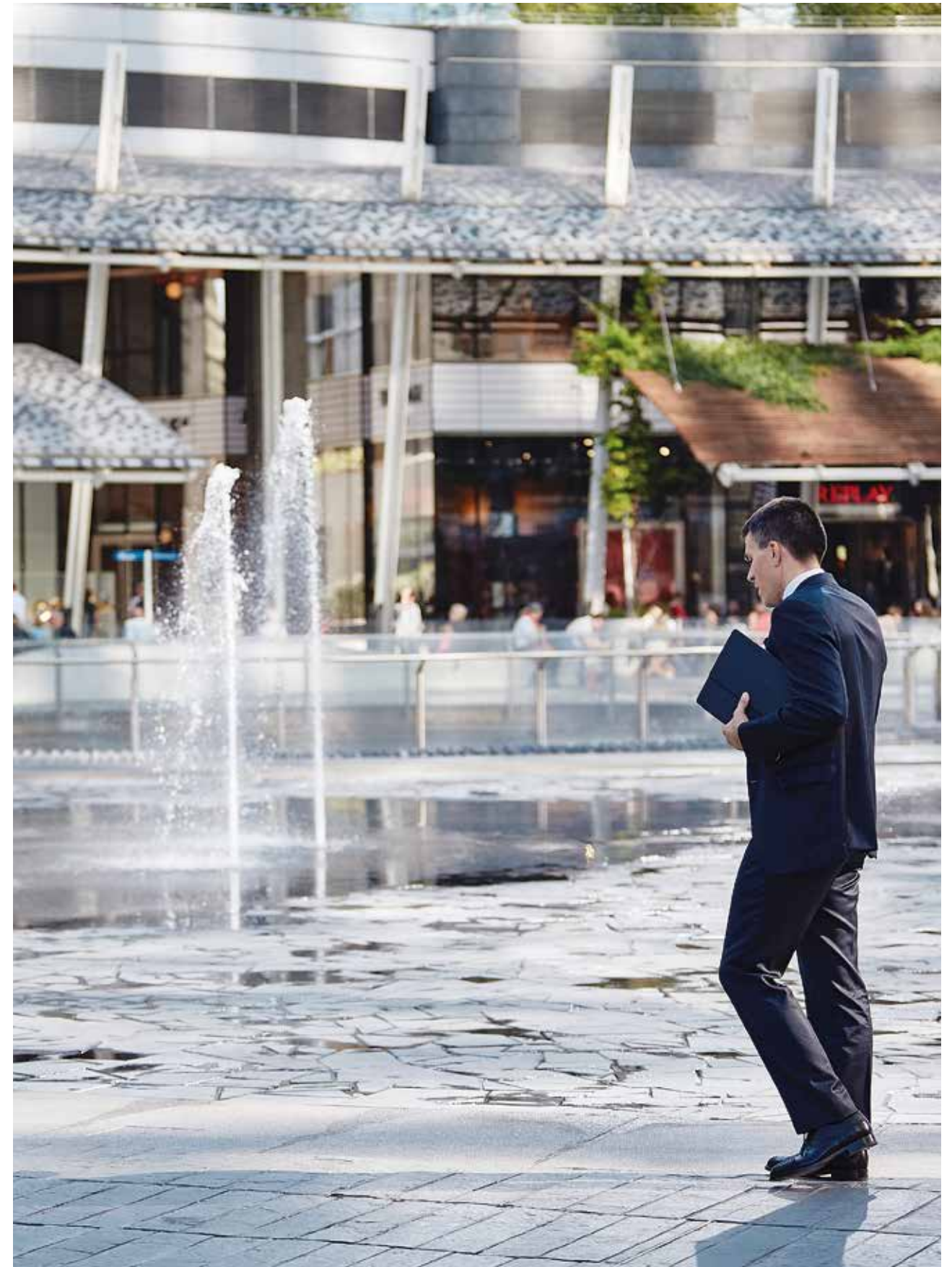
Portanuova is an urban district located in the center of Milan, developed on a former industrial and railway area that had long been underutilized. Over the past two decades, it has undergone a large-scale regeneration process that has reshaped its functions and identity. Today, the area combines residential buildings, office towers, retail activities, cultural spaces, and extensive public areas, including Piazza Gae Aulenti and the Biblioteca degli Alberi Milano (BAM) park.

The district is strategically positioned within Milan's urban fabric, directly connected to the city's transport networks and adjacent neighborhoods such as Garibaldi, Isola, and Varesine. Portanuova has progressively evolved into a mixed-use hub where business, services, and everyday life coexist, reflecting broader trends in sustainable and integrated urban development.

The analyses carried out and the mapping of vulnerabilities across the city of Milan confirm that certain elements of climate adaptation are already visible in some of its neighborhoods. In particular, the following section focuses on Portanuova, where assessments were conducted down to the building scale and adaptation strategies were identified. The city-wide risk mapping clearly highlights the effectiveness of green infrastructure in mitigating urban overheating, and Portanuova provides concrete evidence of this dynamic. The extensive use of greenery, the design of open spaces, and the adoption of light-colored, high-reflectance surfaces on building roofs and paved areas all contribute to reducing heat accumulation and improving overall urban resilience.

The Portanuova Cluster analysis delivers comprehensive spatial insights by identifying key urban elements within Portanuova and examining how they relate to climate risks, effectively connecting city-wide assessments with detailed, building-level observations. Following IPCC guidelines, a targeted vulnerability assessment examines the cluster's built environment, focusing on three critical dimensions: sensitivity to climate stressors, adaptive capacity, and overall vulnerability levels. This evaluation proves essential for understanding Portanuova's specific environmental challenges and the morphological factors that drive them.

The analysis then advances to detailed risk quantification, measuring Portanuova's exposure to various climate hazards. By integrating vulnerability data with risk assessments, the study develops targeted adaptation strategies that synthesize previous findings to guide strategic climate planning for the cluster. This comprehensive methodology enhances Portanuova's urban resilience through advanced mapping and assessment techniques that support effective adaptation measures. The integrated approach—combining spatial analysis, vulnerability assessment, and risk evaluation—offers crucial insights into Portanuova's requirements and potential for sustainable, climate-resilient urban development.



Portanuova, Milano

Case study: Portanuova as a benchmark for integrating climate insights into design

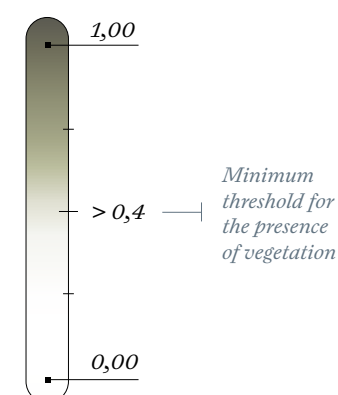
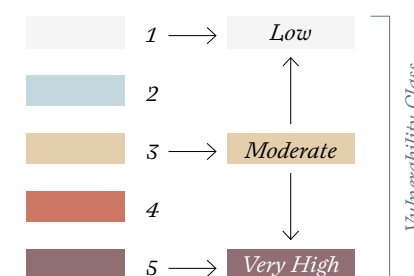
Temperature Vulnerability Assessment

Heat, space, and risk: designing or reshape climate-smart real estate

The UHI vulnerability assessment is modeled through an estimate of Land Surface Temperature (LST) obtained from Landsat-TM satellite images. The distribution is expressed in degrees Celsius for each statistical reference unit (pixel). LST is an indicator used for quantifying local heat retention, which in turn affects both environmental and economic vulnerability. By combining satellite-derived LST with morphological descriptors of the built environment, this assessment captures how different urban fabrics respond to heat waves. This is particularly relevant in identifying which areas are structurally predisposed to thermal stress due to land sealing, compact morphology, or absence of vegetation. The methodological innovation lies in the capacity to operationalize spatial vulnerability, moving from passive observation to actionable information. This enables designers and investors to identify critical heat accumulation zones, target interventions as example increasing shading or changing surfaces.

Capturing the thermal dynamics of the city requires more than recording peak temperatures—it demands a structured interpretation of how heat persists, accumulates, and impacts different areas over time. Maximum surface temperatures reveal where the city reacts most violently to climate stress—hotspots where infrastructure, materials, and human activities concentrate and amplify heat. Yet these extreme events, although significant, offer only part of the picture. It is in the analysis of average surface temperatures that we begin to understand the chronic dimension of heat exposure—how buildings and surfaces store and slowly release thermal energy, shaping the daily microclimate and long-term livability of neighborhoods.

Legend



Case study: Portanuova as a benchmark for integrating climate insights into design

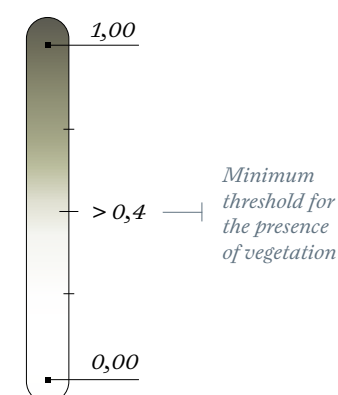
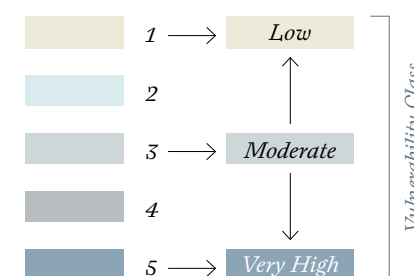
Flooding Vulnerability Assessment

Built to drain or to flood? Urban imperviousness and climate-morphological risk screening

The assessment of imperviousness in urban areas is not simply a measure of land cover, it is a way to decode how cities absorb, deflect, or exacerbate the effects of changing precipitation regimes. As rainfall events grow more intense and erratic due to climate change, the inability of urban surfaces to absorb water becomes a central vulnerability. In this light, the spatial distribution of impermeable materials—concrete, asphalt, rooftops—emerges as a morphological proxy for hydrological stress. What makes this analysis powerful within the CRVA framework is its capacity to link urban form to climate function: the way a neighborhood is built becomes a key indicator of how it will respond under pressure.

In Milan, mapping impermeability does more than identify surface types—it reveals a logic of accumulation and fragility. Depressed areas and sealed surfaces accelerate runoff, increase pollutant transport during “first flush” events, and overload drainage infrastructure. But when this imperviousness map is overlaid with data on vegetation health (through NDVI - Normalize Difference Vegetation Index) and building density, a more shaded picture emerges: one that shows not just where risk exists, but where resilience can be built. Green surfaces become ecological assets but also hydraulic regulators, mitigating both flood and heat risks through evapotranspiration and infiltration. The real innovation lies in using these patterns to inform urban retrofitting and investment strategies. Nature-based solutions—like green roofs, rain gardens, and permeable pavements—can now be spatially prioritized based on empirical vulnerability. This turns what was once a passive mapping of sealed land into an active design instrument for climate adaptation.

Legend



Case study: Portanuova as a benchmark for integrating climate insights into design

Risk Classes from FRMP - Food Risk Management Plan

At a broader scale, the hydraulic risk maps produced by the Po River Basin Authority complement this morphological reading by introducing dynamic flood scenarios. By considering not only flood probability but also the density of people, the presence of critical infrastructure, industrial legacies, and environmental sensitivities, these maps ground local permeability analysis within a regional system of exposure. In Milan, the Seveso and Lambro river corridors stand out as converging points of geomorphological risk and socio-economic exposure. Here, imperviousness is no longer just a material property—it becomes a strategic indicator for CRVA screening, influencing zoning choices, insurance costs, and long-term asset viability. Altogether, this approach does not isolate climate risk as an abstract external force—it embeds it within the material and spatial logic of the city. And in doing so, it enables planners, developers, and institutions to move from reactive protection to proactive transformation of the built environment.

When examining river overflow risk, the Po River Basin Authority identifies areas with a significant potential for flooding and those exposed elements likely to be affected.

The maps outline the urban areas that could be impacted by different river overflow flooding scenarios and the resulting four classes of vulnerability (none, low, medium and high). In the case of the Portanuova Cluster, the hazard is carried by the presence of the Seveso River, which results in a very high risk in most of the district. In recent years, the Po River Basin Authority has revised its risk maps for this river, and the highest level of risk now includes significant urban portions surrounding the Seveso River.

Legend

	R.1. →		Low
	R.2. →		Medium
	R.3. →		Moderate
	R.4. →		Very High

Risk Degree

Case study: Portanuova as a benchmark for integrating climate insights into design

Wind Vulnerability Assessment

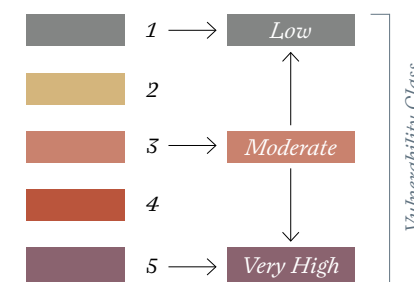
Wind as a structural variable: mapping urban morphologies for resilient development

Wind is often left out of climate risk assessments, but in cities it plays a double role: it can help cool down streets and clean the air in normal conditions yet cause serious damage during storms or extreme weather. Within the CRVA framework, wind is not treated as a marginal phenomenon but rather as a structural variable whose interactions with the urban form reveal significant risk patterns. The study conducted in Milan reframes wind exposure not merely as a climatic condition, but as an effect co-produced by urban density and building height. Using municipal cartographic data to reconstruct the three-dimensional structure of the city, the analysis mapped the relationship between built form and aerodynamic behavior, identifying areas where the concentration of tall buildings may create canyoning effects—that is, narrow corridors where wind is funneled and amplified, increasing the risk of damage to facades, rooftops, balconies, and street-level elements.

This spatial reading of vulnerability goes beyond standard meteorological models. It captures how specific architectural typologies, morphologies, and land use patterns can intensify the physical force of wind and its consequences for real estate assets. The implications are manifold: critical infrastructures, high-rise clusters, and even open public spaces can be variably exposed depending on their geometric configuration. Wind risk thus becomes a design and investment parameter—one that affects material durability, maintenance cycles, insurance premiums, and safety planning. Moreover, wind analysis is crucial in managing green infrastructure, which, while essential for heat mitigation, may become a liability when exposed to violent gusts. Trees, particularly in dense areas or along canyon-like streets, require careful species selection, anchoring systems, and long-term maintenance planning. This dual reading—where wind both supports and threatens climate resilience—underscores the need for integrated adaptation strategies that address multiple variables simultaneously.

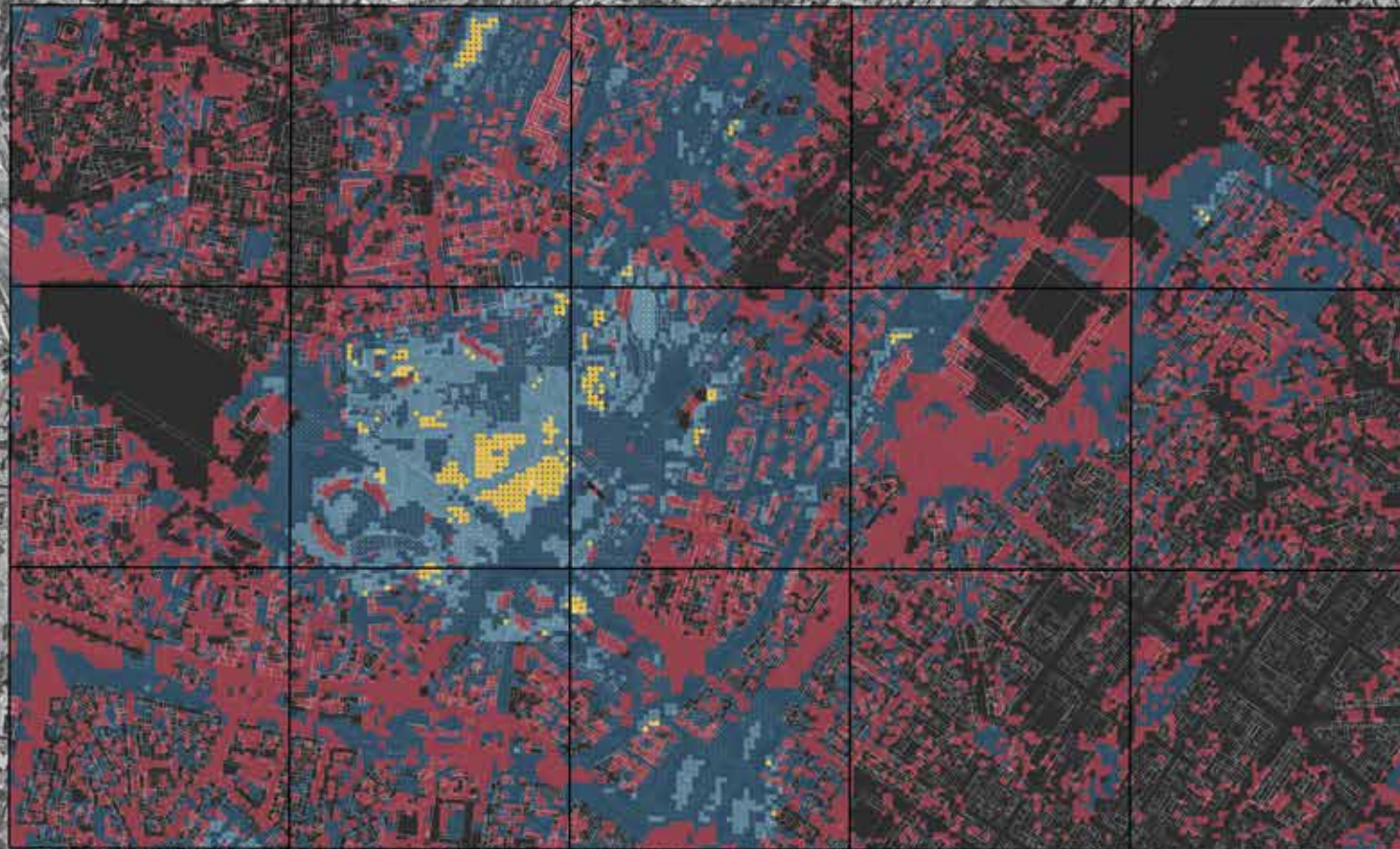
The assessment of vulnerability to high wind phenomena involves examining different components that concern the interaction between high wind and the building stock, specifically in its height, distance, and orientation characteristics. The vulnerability to high wind phenomena is generally moderate for the Portanuova cluster, with some vulnerability peaks in dense areas and tall buildings.

Legend

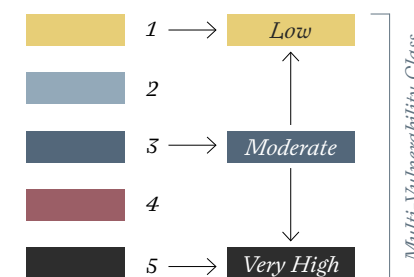


* Tree vegetation

Case study: Portanuova as a benchmark for integrating climate insights into design



Legend



Multi-vulnerability Assessment: Climate Driver Overall

The overall assessment as a multi-lens approach to evaluate the urban climate impacts

The overall assessment of vulnerabilities arising from different drivers - heat, water and wind - provides a comprehensive view of the interactions between various environmental factors. For the Portanuova cluster, the overall vulnerability to different phenomena varies significantly from place to place.

The image opposite depicts the very high overall vulnerability class in dark grey. This classification predominantly affects the northern portions of the cluster, where buildings exhibit particularly dense typologies. In these areas, the compact urban fabric drives vulnerability to strong winds, causes significant temperature accumulation, and generates substantial rainwater runoff. Numerous open spaces also fall within this vulnerability class, especially in the southern areas where specific local conditions create high vulnerability values between buildings, along streets, and at intersections. The remaining urban areas generally exhibit moderate vulnerability levels at most, benefiting from favorable local conditions. Throughout extensive areas, the beneficial role of vegetated spaces in reducing overall vulnerability becomes clearly apparent. Piazza della Repubblica, Viale Zara, Viale Restelli, BAM park, and Piazza IV Novembre all demonstrate low vulnerability levels due to vegetation's positive contributions in moderating high summer temperatures, managing local runoff, and reducing urban fabric density. These positive effects extend beyond vegetated areas themselves, becoming more pronounced where vegetation is abundant and leading to reduced vulnerability in surrounding zones. Even where vegetation density is insufficient to generate substantial vulnerability reduction, it still produces measurable positive effects on individual water, heat, and wind vulnerabilities that become evident when aggregated in the overall vulnerability assessment.

This comprehensive vulnerability analysis underscores the importance of integrated risk management in urban areas. For higher vulnerability zones, multi-faceted mitigation strategies are crucial, addressing each aspect of environmental vulnerability. The moderate to high-vulnerability areas require tailored approaches, considering their unique environmental and urban characteristics. The findings highlight the need for holistic and adaptive urban planning, focusing on reducing vulnerabilities and enhancing resilience against a range of environmental risks. Effective management of overall vulnerability in the Portanuova Cluster is essential for ensuring the long-term safety and sustainability of the area.

3.3 Step 3: Assessing Climate Risks at building level

The third step of the CRVA process moves from the district to the building scale, where risks and adaptation strategies are analyzed for specific assets. Even in cases where existing buildings will be demolished and replaced, this level of assessment remains essential. It highlights the critical climate scenarios that characterize the site and its immediate surroundings, providing design teams with evidence-based guidance for incorporating resilience measures into new developments.

At building scale, CRVA integrates localized data on temperature, flooding, and wind vulnerabilities with morphological and land-use characteristics. For example, analysis may show that sites surrounded by impermeable surfaces are more prone to pluvial flooding; industrial brownfields may accumulate heat, exacerbating local thermal stress; and dense street canyons may intensify wind corridors. These insights not only describe the climate exposure of the area but also point to specific design strategies that can reduce vulnerability and enhance long-term performance.

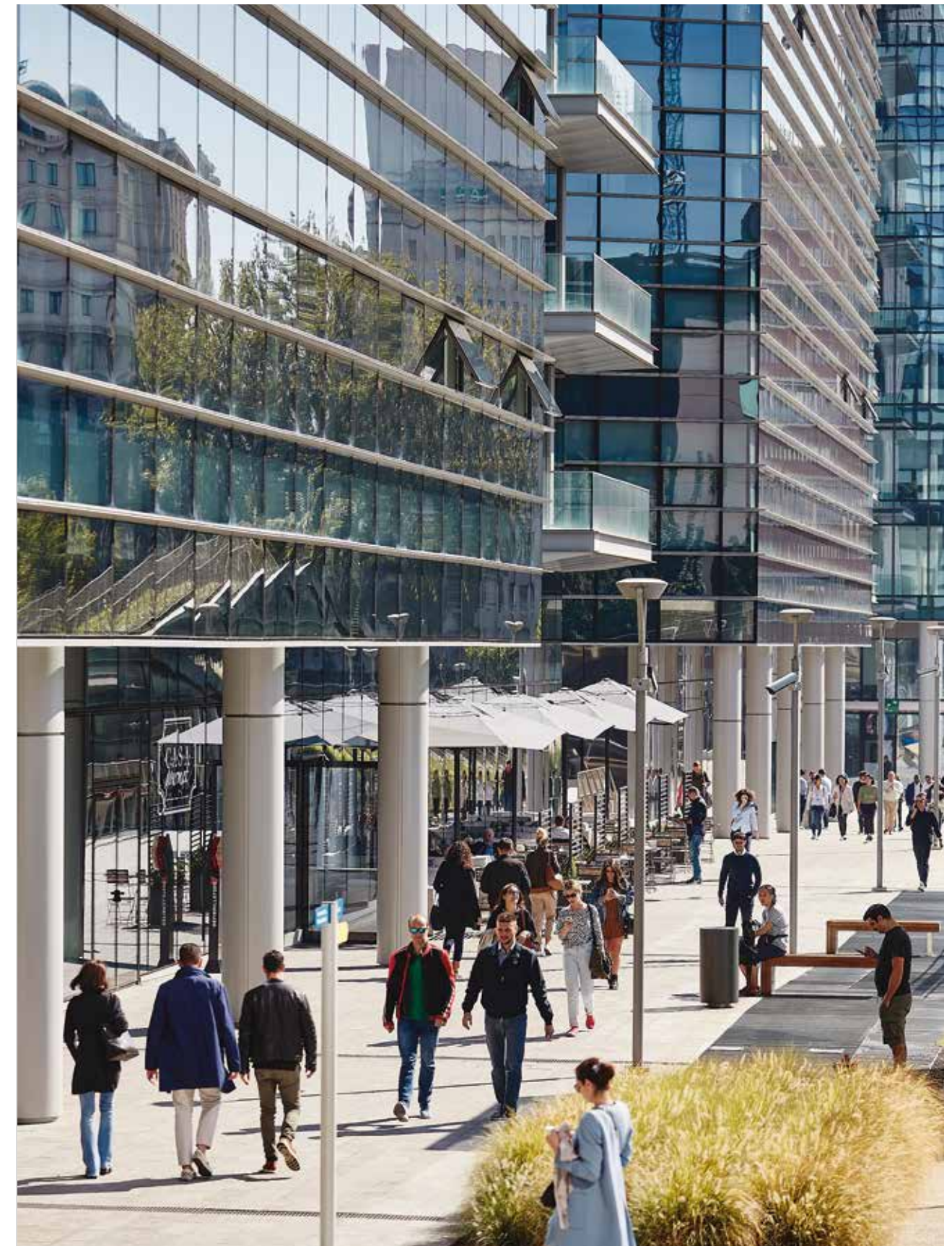
The building-scale CRVA also develops adaptation recommendations, typically presented as a suite of measures together with an indication of their effectiveness. These may include:

- For heat: reflective and light-colored materials, shading devices, green roofs, and tree planting to reduce thermal loads.
- For flooding: permeable pavements, rain gardens, infiltration trenches, and retention basins to manage excess water.
- For wind: reinforced façades, wind-sensitive landscaping, and optimized building orientation to reduce turbulence and mechanical stress.

Beyond physical interventions, the analysis often highlights management and operational practices—such as HVAC system maintenance, vegetation care, or localized emergency protocols—that extend resilience across the asset’s lifecycle.

While the building-scale analysis is critical for asset-specific strategies, in projects of substantial scale such as urban regeneration, the district-level CRVA becomes particularly important. At that scale, the model not only evaluates current site conditions but also anticipates how masterplans may reshape the area, while capturing the microclimatic interactions of the surrounding neighborhood.

Together, the district and building perspectives ensure that climate resilience is embedded at both the macro and micro levels of urban development, bridging broad vulnerability mapping with asset-specific design intelligence.



Portanuova, Milano

Case Study: Pirelli 35 – Integrating CRVA into Design, Construction, and Management

The redevelopment of Pirelli 35 represents an example of how strategies for decarbonization and climate adaptation can be combined within a real estate project. The intervention preserved over 80% of the existing structure, reducing new construction volumes and limiting the use of raw materials, with a consequent reduction in embodied carbon. The building has been designed as a fully electric system, using ground water heat pumps and renewable sources that provide more than 65% of its energy needs. High-performance façades, automation, and advanced control systems contribute to lowering energy demand, while certified renewable energy procurement allows the building to reach Net Zero operational emissions.

The project also adopted circular procurement principles, including the use of Cradle2Cradle-certified materials, and incorporated flexible layouts to support multiple space configurations. These approaches contributed to the building obtaining certifications including LEED Platinum, WELL Gold, WiredScore Gold, and nZEB classification.



Pirelli 35, Portanuova - Milano

Findings of the CRVA Analysis

The Climate Risk and Vulnerability Assessment (CRVA) for the building was conducted on the basis of its configuration prior to the planned redevelopment works. This step was essential to understand how the asset might be affected by future climate conditions and to identify possible interventions capable of mitigating exposure to risk.

The analysis revealed several critical aspects. In terms of heat vulnerability, the building is situated in an urban context marked by extensive impermeable surfaces, which intensify the urban heat island effect. This condition places the asset in a medium-to-high vulnerability class, calling for particular attention to measures that can limit overheating.

With regard to flooding, the site lies in an area of high impermeability and inadequate drainage capacity, leading to a significant risk of pluvial flooding during extreme rainfall events.

The assessment also highlighted a moderate level of wind vulnerability. The local urban morphology, characterized by dense building patterns, can generate canyon effects, requiring careful façade design and continuous monitoring to prevent structural or safety issues.

Taken together, these findings outline an overall risk profile that underscores the importance of implementing targeted adaptation strategies. Such strategies are not only relevant during the design and construction phases of redevelopment but also need to be embedded in the long-term management of the asset.

Shocks and chronic stresses driven by climate change on the Asset

	Temperature	Winds	Waters	Solid mass
Chronic	Changing temperature (air, freshwater, marine water)	Changing wind patterns	Changing precipitation patterns and type (rain, hail, snow/ice)	Coastal erosion
	Heat stress		Precipitation or hydrological variability	Soil degradation
	Temperature variability		Ocean acidification	Soil erosion
	Permafrost thawing		Saline intrusion	Solifluction
			Sea level rise	
			Water stress	
Shocks	Heat waves	Cyclone, hurricane, typhoon	Drought	Avalanche
	Cold wavw/frost	Storm (including bliz zards, dust and sand storms)	Heavy precipitation (rain, hail, snow/ice)	Landslide
	Wildfire	Tornado	Flood (coastal, fluvial, pluvial, ground water)	Subsidence
			Glacial lake outburst	

Case Study:
Pirelli 35 –
Integrating
CRVA into Design,
Construction,
and Management

Temperature Vulnerability
Assessment

Legend



Flooding Vulnerability Assessment

Legend



Case Study:
Pirelli 35 –
Integrating
CRVA into Design,
Construction,
and Management

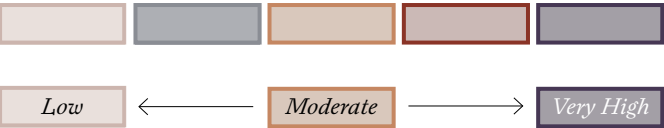
Wind Vulnerability Assessment

Legend



Risk Vulnerability Assessment

Legend



Case Study: Pirelli 35 – Integrating CRVA into Design, Construction, and Management

Adaptation Strategies Implemented and Planned

The findings of the CRVA were translated into a comprehensive set of actions, addressing both the design and construction of the building as well as its long-term management and operation.

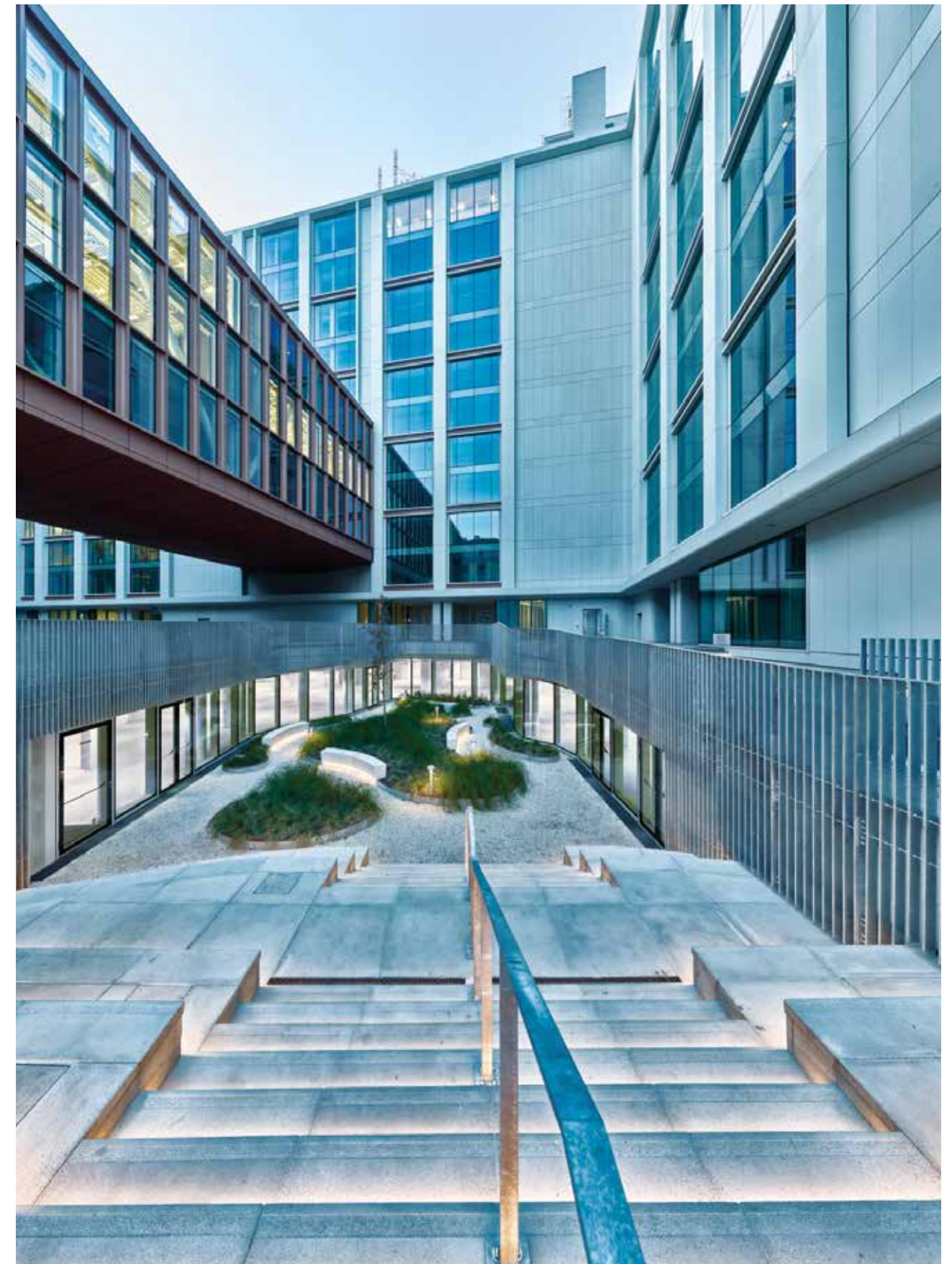
During the design and construction phase, several measures were introduced to enhance the building's resilience. The use of light-colored and reflective materials was prioritized to reduce heat gain, while the installation of photovoltaic panels serves as mitigating overheating. To further improve comfort, external shading devices and high-performance glazing were integrated into the envelope design. Water management was addressed through permeable surfaces, rain gardens, and infiltration systems capable of slowing and dispersing stormwater during extreme rainfall events. At the same time, the simplification of façade elements and the adoption of impact-resistant glazing were identified as key strategies to reduce the asset's vulnerability to strong winds.

Adaptation measures also extend into the management and operations phase, ensuring that resilience is not limited to the building's physical structure but is embedded into daily governance.

Smart building management systems will regulate shading, ventilation, and cooling in real time, informed by weather forecasts and environmental monitoring. Regular maintenance protocols have been defined for HVAC systems, shading devices, and drainage networks, safeguarding their performance over time.

Drone-based inspections will allow for rapid assessments of façades and rooftops after extreme weather events, providing a safer and more efficient alternative to manual checks. Outdoor management has also been included, ensuring that green elements contribute effectively to cooling and stormwater control without generating additional risks, such as wind exposure or structural damage.

Together, these measures illustrate how the CRVA informed an integrated approach to resilience, connecting the design, construction, and operational stages to ensure that the building can adapt dynamically to a changing climate.



Pirelli 35, Portanuova - Milano

3.4 Climate Change: From Design to Management

Establishing systems to track climate impacts and continuously update designs and operations

For real estate asset managers, preserving value over time is a central priority—an objective shared by the public sector, which must also safeguard the resilience of urban systems and cultural heritage. Climate Risk and Vulnerability Assessments (CRVA) provide the analytical foundation to design and construct buildings capable of withstanding future climate risks. As shown in the previous chapter, numerous measures can be integrated during construction or renovation, while urban regeneration projects create additional opportunities to implement district-wide interventions with benefits that extend beyond individual assets to neighborhoods, cities, and the broader community.

Yet resilience does not end at delivery. Cities contain buildings that are centuries old—some over a thousand years—which carry not only monetary but also artistic and cultural value. These assets often present unique vulnerabilities, stemming from their age, construction techniques, or delicate decorative elements. Addressing climate risks for such buildings requires ongoing management strategies that balance protection with preservation.

COIMA, in evaluating the climate vulnerabilities of its portfolio, has recognized that long-term management is essential to ensure buildings can withstand extreme events. Climate adaptation must therefore be treated as an ongoing process, extending well beyond the design and construction phases.

Resilience in operation. Developers and asset managers should establish systems that monitor environmental performance, detect emerging risks, and guide responsive maintenance and improvement measures over time. Monitoring frameworks may include:

- Real-time environmental sensors (temperature, humidity, precipitation, air quality)
- Energy and water usage tracking tools
- Post-occupancy evaluation (POE) surveys to assess user experience under climate stress conditions
- Periodic risk reassessment using updated climate models and projections

This dynamic approach ensures that buildings and districts continue to function as intended under evolving climate scenarios and operational demands.

Harnessing technology. Advanced technologies further strengthen adaptive capacity:

- Digital twins simulate building performance and inform proactive maintenance strategies
- AI-powered diagnostics detect inefficiencies and provide early warnings of climate-related impacts
- Drone-based inspections for façades, roofs, photovoltaic systems, and green infrastructure
- Centralized dashboards that integrate data streams and provide alerts, benchmarks, and adaptation recommendations

Embedding resilience in governance. Beyond technical tools, procedural adaptation must become part of daily operations. This includes emergency response plans, seasonal maintenance cycles, and occupant communication procedures that ensure resilience is embedded into everyday management.

From static design to dynamic systems

By integrating monitoring and adaptation into asset management, buildings and districts shift from static designs to living systems—capable of evolving with climate realities, user needs, and regulatory expectations. In this way, resilience becomes not a one-time achievement but a continuous process, safeguarding both economic value and community well-being across generations.

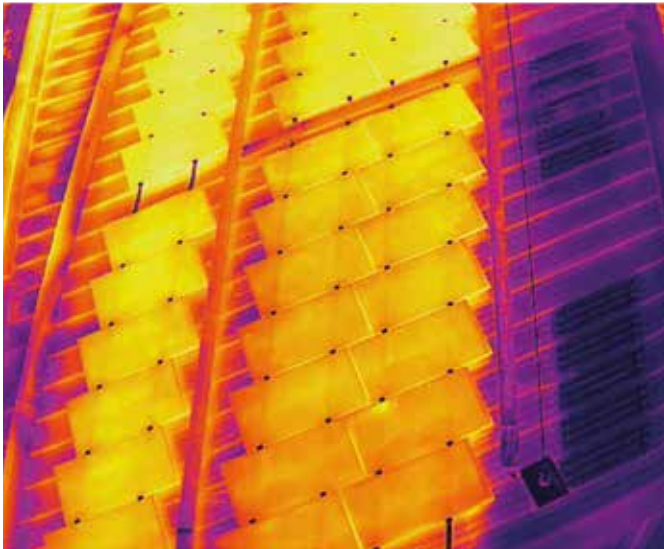


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Case Study: Drone-based inspections for roofs, façades, and green infrastructure

Starting in 2024, COIMA launched a monitoring program for building roofs and façades using drones. The drones are equipped with artificial intelligence and machine learning software capable of identifying and flagging damage or malfunctions on façades and rooftops, replacing the costly and time-consuming task of manual inspection.

To date, the drones have conducted 23 flights, capturing approximately 74,000 images. These were quickly processed by the software, which detected anomalies and classified them according to different levels of urgency. This approach has proven particularly effective following extreme weather events—which can damage assets and pose risks to pedestrians and residents—as well as in the inspection of photovoltaic panels, where it helps identify issues that compromise their integrity and performance.



Above, Aerial inspection and thermography using drones for the automatic detection of anomalies in photovoltaic systems.
Below, Verification of the maintenance status of building roofs through aerial inspection with drones for the detection and automatic classification of anomalies.



Above, Drone for inspecting facades and roofs equipped with technology for recognizing anomalies and malfunctions.
Below, Inspection flight with drones controlled by a specialized operator.



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The Path Forward: Shaping Resilient Cities

From Milan to other cities: a replicable methodology

The CRVA approach applied in Milan demonstrates that climate risk can be systematically assessed, measured, and translated into actionable strategies. While outcomes will naturally differ across geographies—reflecting local climatic, morphological, and social conditions—the methodological framework remains replicable. This reinforces the idea that resilience is not bound to a single city but can become a shared practice, adaptable to different urban contexts and investment portfolios. Public-private partnerships (PPP) will be essential to scale this approach, aligning the actions of developers, local authorities, infrastructure providers, and communities.

Commitment to climate-informed design and management

Real estate developers and asset managers have both an opportunity and a responsibility to shape the cities of the future. Integrating resilience into planning, architecture, and operations ensures that urban environments remain livable and inclusive, even under increasing environmental stress. This is not only about physical adaptation but about embedding climate intelligence into the entire lifecycle of buildings and neighborhoods—from acquisition and design to construction, management, and long-term stewardship.

Climate-informed development also aligns with the expectations of investors, regulators, and citizens. It ensures that assets are robust, resource-efficient, and capable of maintaining long-term value, positioning the real estate sector as a catalyst for systemic transformation toward climate-resilient urban ecosystems.

Collaborating with research and science

The evolving nature of climate risks requires science-based, interdisciplinary approaches. Partnerships with academic and research institutions—such as the collaboration with IUAV in Milan—are critical for refining methodologies, integrating climate scenario modeling, and tailoring adaptation strategies to specific contexts. These collaborations ensure that resilience frameworks remain scientifically robust, policy-relevant, and practical for real estate application.

Looking ahead, the real estate sector must move from minimizing risks to actively building adaptive capacity. Future developments will need to anticipate disruptions and incorporate resilience into every layer: passive and active design measures, nature-based systems, digital monitoring technologies, and operational protocols that evolve over time.

At the same time, resilience must extend beyond assets to communities. Engaging with occupants and local stakeholders, strengthening communication, and embedding inclusive processes will be essential for ensuring that resilience is not only technical but also social.

The role of partnerships

To achieve this vision, PPPs will be indispensable. Coordinated efforts between private actors and public authorities can:

- align resilience objectives across scales,
- accelerate regulatory approvals and adaptation incentives,
- unlock co-financing mechanisms, and
- enable data-sharing platforms that guide collective action.

By leveraging these partnerships, cities can accelerate innovation and scale systemic change, ensuring that adaptation measures provide benefits not only for real estate value but also for the safety, wellbeing, and inclusivity of urban communities.

Closing perspective

Climate risks are no longer abstract—they are measurable, visible, and increasingly urgent. The path forward requires understanding them, integrating them into every decision, and acting collectively to adapt. By adopting this forward-looking approach and working in close cooperation with institutional and civic actors, real estate professionals can help deliver climate-adaptive cities—where resilience is not just a technical requirement, but a shared value embedded in how places are conceived, built, and sustained.



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Authors

Stefano Corbella, Francesco Musco (Scientific Coordinator), Carlo Federico Dall’Omo, Umberto Galli, Vittore Negretto, Nicola Romanato, Matteo Rossetti



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