OpenMind Journal of Multidisciplinary Innovation & Development
Vol. 2, Issue – 3, (May-Jun) 2026
ISSN: 3108-2920 (Online)

Research Article

Beyond Carbon: Integrating Physical Climate Risk Scoring into Zoning and Development Approval Processes for Urban Investment Resilience

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***Related declarations are provided in the final section of this article*

ARTICLE INFORMATION

Received: **20 May 2026**

Accepted: **15 Jun 2026**

Published: **20 Jun 2026**

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Abstract

Urban development patterns increasingly expose communities and investment assets to escalating climate-related hazards, yet existing zoning and development approval processes remain predominantly focused on carbon mitigation rather than physical climate risk reduction. This conceptual paper addresses this critical gap by developing a comprehensive framework for integrating physical climate risk scoring into zoning and development approval processes to enhance urban investment resilience. The study employs a conceptual research methodology based on systematic literature review and theoretical synthesis across urban planning, climate science, and real estate investment. The analysis reveals that current zoning frameworks inadequately incorporate forward-looking climate hazard data, leading to continued development in high-risk areas and escalating financial exposure. The conceptual framework proposes a multi-stage risk scoring methodology that integrates location-specific hazard data, vulnerability assessments, and adaptation capacity considerations into planning approvals and zoning decisions. The framework identifies three core components: hazard identification and characterization, exposure and vulnerability assessment, and risk scoring integration into regulatory decisions. The study concludes that integrating physical climate risk scoring into zoning and development approvals can reduce urban vulnerability, protect investment values, and guide development toward climate-resilient locations. This paper contributes to emerging scholarship on climate-adaptive urban planning and resilient real estate investment by providing theoretical foundations for policy development and practical guidance for planners, developers, and investors.

Keywords: Physical climate risk; Zoning; Development approvals; Urban resilience; Climate hazard scoring; land-use planning; Investment resilience; Adaptation; Risk assessment; Regulatory frameworks

Introduction

Urban development patterns are increasingly misaligned with escalating climate-related hazards, yet zoning and development approval processes remain predominantly focused on carbon mitigation rather than physical climate risk reduction (OECD, 2025). Physical climate hazards including flooding, sea-level rise, extreme heat, and wildfires are becoming more frequent and severe, exposing communities and investment assets to unprecedented financial and human costs (Addoum et al., 2024). The built environment, representing a substantial portion of global investment wealth, stands at the frontline of climate impacts, yet the mechanisms through which physical risks are incorporated into land-use planning and development approvals remain inadequately developed (Coulson et al., 2024). Across Europe and Central Asia, urban development between 1985 and 2020 progressively occurred in flood-prone zones, exposing communities and local economies to sudden physical and financial shocks (OECD, 2025). This trend reflects a systemic failure to integrate forward-looking climate risk assessments into planning frameworks that shape urban development patterns and investment decisions (Warren-Myers & Hurlimann, 2022).

The concept of climate hazard zoning has emerged as a critical tool for managing development in high-risk areas and guiding investment toward safer locations (UN-Habitat, 2022). Climate hazard zoning integration represents a systematic land-use planning methodology that explicitly incorporates projections of future climate-related risks into regulatory frameworks governing development and infrastructure placement (Sustainability Directory, 2025). This process necessitates the spatial articulation of hazard zones, coupled with the application of differentiated standards for permissible activities within those zones, aiming to reduce exposure and vulnerability (Sustainability Directory, 2025). Effectively, it is a preventative adaptation strategy designed to minimize potential damages and promote resilient community design through anticipatory governance (Sustainability Directory, 2025). However, implementation remains inconsistent across jurisdictions, with many communities' lacking data-driven understandings of where their zoning allows development in hazardous areas and what changes would encourage housing development that is resilient to current and future climate conditions (Urban Institute, 2025).

Physical climate risk scoring provides a methodological foundation for integrating climate considerations into planning decisions (Hirsch et al., 2015). Physical risk assessment uses past and forward-looking hazard data and digital tools to produce market-useful information, enabling stakeholders to understand and manage climate-related risks and opportunities

(OECD, 2025). The assessment of physical climate-related risks relies on granular, location-specific data on hazards, exposure, and vulnerability, best supported by transparent, verifiable asset-level information such as property damage history and hazard map disclosure (OECD, 2025). Digitalization enables real-time monitoring of building performance and risk exposure, and scenario analysis provides a common language for testing both physical hazards and transition pathways under alternative futures (OECD, 2025). Despite these advances, many existing risk-assessment practices remain constrained by incomplete or inconsistent data, a lack of forward-looking indicators, and limited comparability across markets, with 58% of real estate investors citing the absence of granular, property-specific data as a key barrier (OECD, 2025).

Policy frameworks for integrating climate risk into planning are evolving but remain fragmented across jurisdictions (Akhtyrska & Fuerst, 2024). Regulatory measures such as minimum performance standards for energy and carbon can set clear baselines for sustainable construction, while financial incentives including subsidies and tax deductions can complement these rules and help offset transition costs (OECD, 2025). However, risk assessments are often conducted at an aggregate level rather than reflecting local conditions, data remain siloed or incomplete, creating asymmetries that hinder effective action, and risk transfer tools such as insurance provide financial protection but do not necessarily lead to investment in mitigation or adaptation of buildings for resilience (OECD, 2025). The OECD Future-proof Real Estate Investment Survey confirms that 58% of respondents cited the absence of granular, property-specific data, 49% pointed to unreliable or inconsistent methodologies, and nearly one-third underlined gaps in location-based hazard information or unclear regulatory guidance (OECD, 2025). These gaps underscore the need for comprehensive frameworks that integrate physical climate risk scoring into zoning and development approval processes.

Low-income households are frequently concentrated in high-risk locations such as floodplains, heat-exposed districts, or informally built settlements, with limited capacity to absorb losses or finance relocation (OECD, 2025). Planning decisions that account for high-risk groups can reduce disproportionate burdens and protect vulnerable communities from recurrent financial shocks (OECD, 2025). Incorporating the needs of vulnerable communities into planning decisions can reduce disproportionate burdens and protect them from recurrent financial shocks (OECD, 2025). Equity considerations are therefore essential to climate risk integration, ensuring that the benefits of resilient development are distributed fairly and that vulnerable populations are not left behind (Vanhuyse et al., 2023). This study contributes to emerging scholarship on climate-adaptive urban planning and resilient real estate investment by providing theoretical foundations for policy development and practical guidance for planners, developers, and investors (Bienert, 2016).

Literature Review

1. Physical Climate Risk Assessment in Urban Planning

Physical climate risk assessment has evolved from a niche academic exercise to a critical business and investment function for companies, financial institutions, governments, and households (OECD, 2025). Today's climate-related risk assessment landscape is characterized by rapid innovation, methodological diversity, and an increasingly sophisticated ecosystem of tools that are often unevenly applied and lack transparency (OECD, 2025). A growing list of regional and international frameworks and standards guide this process for the private sector, including the Task Force on Climate-related Financial Disclosures (TCFD), the International Sustainability Standards Board (ISSB) standards, and the Corporate Sustainability Reporting Directive (CSRD) (OECD, 2025). These frameworks turn climate evidence into financial decisions, structured around governance, strategy, risk management, metrics and targets, and scenario analysis (OECD, 2025). However, their application to land-use planning and zoning decisions remains limited, with most disclosure frameworks operating at the corporate rather than property level (Savills, 2025).

Hazard identification and characterization represent the foundation of physical climate risk assessment, requiring granular, location-specific data on climate hazards, exposure, and vulnerability (Hirsch et al., 2015). The IPCC defines vulnerability as the degree of criticality determined by the inherent qualities of the system that may have a detrimental effect on the severity of the impacts faced by the system, as well as its overall performance and ability to respond (IPCC, 2022). Adaptation involves adjusting to actual or expected climate impacts to reduce harm or exploit benefits, while resilience is the capacity of systems to cope with hazards in ways that enhance adaptation (IPCC, 2022). These conceptual distinctions are important for understanding the different dimensions of climate risk and the appropriate policy responses. Physical risks are assessed using past and forward-looking hazard data, including flood maps, wildfire risk assessments, heat island analysis, and sea-level rise projections, with digital tools producing market-useful information for decision-making (OECD, 2025).

Transition risks, by contrast, arise from regulatory, technology, and market shifts, best assessed using science-based decarbonization pathways that align sector or asset-level trajectories with scientific evidence to limiting global warming (OECD, 2025). Place-based governance frameworks, such as zoning rules, building codes, planning approvals, and enforcement practices, are critical as they determine how and when assets may become stranded or markets disrupted (OECD, 2025). The integration of physical and transition risk analysis, aided by international frameworks, digitalization, and scenario planning, enables testing resilience across different futures (OECD, 2025). However, significant gaps remain in the practical application of these assessment approaches to zoning and development approval processes, with most risk assessments conducted at an aggregate level rather than reflecting local conditions (OECD, 2025). The OECD Future-proof Real Estate Investment Survey confirms that 49% of respondents cited unreliable or inconsistent methodologies as a key barrier to effective risk management (OECD, 2025).

2. Climate Hazard Zoning and Development Restrictions

Climate hazard zoning represents a systematic land-use planning methodology that explicitly incorporates projections of future climate-related risks into regulatory frameworks governing development and infrastructure placement (Sustainability Directory, 2025). This process necessitates the spatial articulation of hazard zones, coupled with the application of differentiated standards for permissible activities within those zones, aiming to reduce exposure and vulnerability (Sustainability Directory, 2025). Effectively, it is a preventative adaptation strategy designed to minimize potential damages and promote resilient community design through anticipatory governance (Sustainability Directory, 2025). Within sustainability frameworks, climate hazard zoning integration functions as a crucial component of adaptive capacity building, directly addressing the need for proactive risk management in the face of escalating climate change impacts (Sustainability Directory, 2025). Its implementation supports ecological preservation by directing development away from sensitive areas and reducing the likelihood of habitat fragmentation or ecosystem service disruption (Sustainability Directory, 2025).

Land-use restrictions represent a primary mechanism for implementing climate hazard zoning, with total restrictions recommended where extreme risk exists and partial restrictions for areas with moderate risk (UN-Habitat, 2022). Total restrictions may prohibit any development in high-risk areas, while partial restrictions may allow certain uses such as agriculture but not human habitation in flood zones, restrict development densities, or permit development on the condition of developers covering the cost of required adaptation measures (UN-Habitat, 2022). Denmark's Planning Act 2007 provides that a local plan may contain provisions on keeping an area free from new construction if buildings may be exposed to collapse, flood, or other damage that may endanger users' life, health, or property (UN-Habitat, 2022). Finland's Planning and Building Act 1999 prohibits the construction of buildings in the shore area of the sea or of a body of water without a local detailed plan (UN-Habitat, 2022). Japan's Act on Special Measures concerning Urban Reconstruction allows local governments to designate areas as vulnerable to disasters such as floods, tsunamis, and storm surges and prohibit construction of residential buildings in disaster red zones (UN-Habitat, 2022).

Public land buffers provide another mechanism for preventing development in vulnerable and hazard-prone areas, creating an area of land abutting sea or rivers which is public and cannot be developed or used by private individuals (UN-Habitat, 2022). South Africa's Integrated Coastal Management Act 2009 creates coastal public property to protect sensitive ecosystems and to protect people, property, and economic activities from risks arising from dynamic coastal processes, including the risk of sea-level rise (UN-Habitat, 2022). Colombia's Decree 2811 of 1974 introduces public land buffers through Article 320, stating that private individuals may be subject to easements between their property and hydrological systems, and Article 330 determining buffer zones in the periphery of the park system (UN-Habitat, 2022). Setback requirements establish building restrictions that set a distance from a boundary line within which a landowner is prohibited from building or expanding structures, with coastal setbacks prescribed distances to a coastal feature within which all or certain types of development are prohibited (UN-Habitat, 2022). Spain's 1988 Coastal Law establishes a 100-metre setback line from the edge of the Marine Terrestrial Public Domain, reduced to 20 metres in urban areas, and prohibits permanent developments within the setback zone (UN-Habitat, 2022).

3. Risk Scoring Methodologies and Integration Frameworks

Risk scoring methodologies quantify inherent danger to inform proactive risk elimination, crucial for designing sustainable systems that operate within planetary boundaries (Sustainability Directory, 2025). Hazard scoring provides a systematic approach to evaluating climate risks, using standardized metrics and transparent methodologies to support decision-making (Hirsch et al., 2015). Predictive hazard surface generation creates dynamic, spatially explicit forecasts of environmental risks to inform proactive adaptation and systemic resilience in a changing climate (Sustainability Directory, 2025). These methodologies enable the translation of climate science into actionable planning information, supporting both public and private sector decision-making (OECD, 2025). The Climate Hazard Exposure Index provides a composite measure of hazard exposure, integrating multiple hazard types and vulnerability factors to support risk assessment and prioritization (Sustainability Directory, 2025).

The Climate-Resilient Development Index (CRDI) provides a prototype quantitative methodology to describe how residential zoning relates to hazard exposure, enabling communities to quantify how much of their housing stock is located in hazard-prone areas relative to the amount of housing that could be developed in less exposed areas (Urban Institute, 2025). The CRDI outputs answer critical questions about how a community's zoning code allows for ample housing in areas that are less exposed to climate hazards, provides insights into how zoning relates to climate risk equity, and examines the mix of different housing types allowed in less hazardous and more hazardous areas (Urban Institute, 2025). The CRDI methodology combines sociodemographic, parcel, zoning, flood hazard, and building data to estimate existing housing development and zoned capacity for additional housing development in areas that are exposed and less exposed to flood hazards (Urban Institute, 2025). The Urban Institute pilot in Mobile County, Alabama, demonstrated that the CRDI can highlight both where more resilient zoned capacity for housing is needed and where existing zoned capacity allows new development in hazard-prone areas (Urban Institute, 2025).

A novel climate assessment framework developed in collaboration with the Italian State Property Agency supports decision-making throughout the construction lifecycle, enabling the evaluation of AS IS and TO BE conditions of real estate assets (ScienceDirect, 2025). The framework includes a pre-assessment tool to prioritize interventions during investment planning based on climatic and non-climatic drivers, an assessment tool to quantify the vulnerability levels and adaptation goals during the design phase based on Key Performance Indicators (KPIs), guidelines to periodically monitor climate hazards and effectiveness of adaptation measures over time, and a catalogue of adaptation measures categorized into grey, green, and blue solutions (ScienceDirect, 2025). Drawing from European climate policies, Green Building Rating Systems, and Resilience Rating Systems, the framework identifies KPIs tailored to climate-related hazards and physical attributes of real estate assets (ScienceDirect, 2025). The framework marks a significant advancement toward a systematic and replicable tool for integrating climate adaptation into real estate interventions, aligning with EU climate objectives and offering practical applications for public and private stakeholders (ScienceDirect, 2025).

4. Policy Pathways and Implementation Challenges

Policy pathways for integrating climate risk into planning remain fragmented, with risk assessments often conducted at an aggregate level rather than reflecting local conditions, data siloed or incomplete, and risk transfer tools providing financial protection but not necessarily leading to investment in mitigation or adaptation of buildings for resilience (OECD, 2025). The OECD Future-proof Real Estate Investment Survey confirms that climate-related risks in real estate are overwhelmingly long-term and structural, with 37% of respondents reporting that their organization expects to retain significant exposure to climate-related risks for the entire life of the asset, and only 13% accounting for long-term risks beyond 2050 (OECD, 2025). Given that commercial real estate assets often remain in use for 80 to 100 years, and climate-related risks persist throughout their lifespan, a mismatch between management needs for long-term assets and short-term financial planning is clear (OECD, 2025). This mismatch highlights the need for policy frameworks that support long-term risk assessment and adaptation planning.

Governments can support climate-related risk transfer mechanisms through dedicated financing for resilience upgrades, separate public schemes to support build-back-better approaches, and building incentives for the private sector to proactively invest in resilient infrastructure, climate-proofing measures, and innovative risk-reduction technologies (OECD, 2025). Regulators can promote building performance standards that are predictable, enforceable, and supported by financing to enable compliance across income groups, while investors and lenders can embed energy and resilience metrics directly into valuation and credit practices (OECD, 2025). Insurers and capital markets can expand coverage through instruments that incentivize adaptation rather than perpetuate vulnerability, with all strategies integrating equity safeguards so low-income households and informal settlements are not left behind (OECD, 2025). These policy pathways require coordinated action across multiple governance levels and institutional domains, with international cooperation essential for addressing the global nature of real estate finance and climate risks (OECD, 2025).

Despite growing recognition of climate risks, implementation of integrated risk scoring into zoning and development approvals remains limited, with significant gaps in data availability, methodological consistency, professional capacity, and regulatory coordination (Vanhuyse et al., 2023). The absence of granular, property-specific data was cited by 58% of survey respondents as a key barrier to effective risk management, while 49% cited unreliable or inconsistent methodologies, and nearly one-third highlighted gaps in location-based hazard information or unclear regulatory guidance (OECD, 2025). These barriers underscore the need for comprehensive frameworks that integrate physical climate risk scoring into zoning and development approval processes, with clear guidance for practitioners and decision-makers (Warren-Myers & Hurlimann, 2022). This study addresses these gaps by developing a conceptual framework for integrating physical climate risk scoring into planning processes, providing both theoretical foundations and practical guidance for implementation.

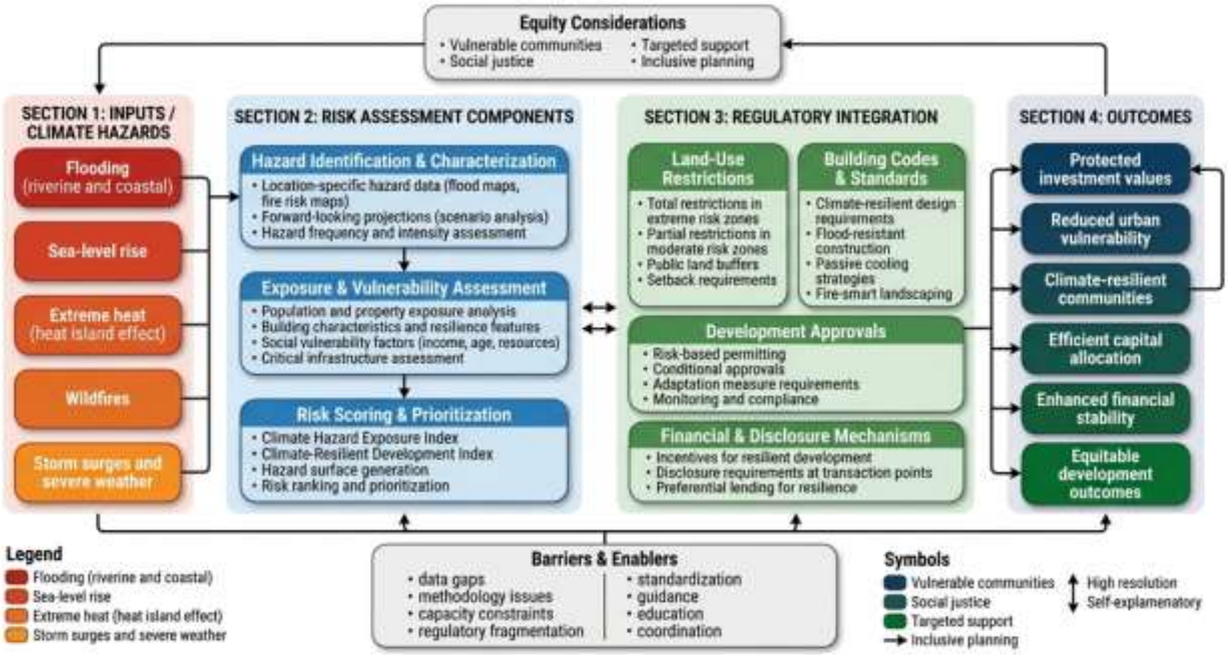

Figure: Conceptual Framework: Integrating Physical Climate Risk Scoring into Zoning and Development Approval Processes.

Methodology

This study adopts a conceptual research methodology based on systematic literature review and theoretical synthesis across multiple disciplines (Leavy, 2022). The conceptual research design enables the systematic integration of diverse literature streams to generate new theoretical insights and practical frameworks, which is particularly appropriate for emerging topics requiring theoretical elaboration before empirical investigation can proceed (Salter, 2023). This study employs a comprehensive review of existing theoretical and empirical literature, drawing from urban planning, climate science, real estate investment, and regulatory policy (Addoum et al., 2024; Coulson et al., 2024; Warren-Myers & Hurlimann, 2022). The conceptual framework is developed through iterative synthesis of key concepts, mechanisms, and relationships identified in the literature, with particular attention to hazard scoring methodologies and zoning integration mechanisms (Hunziker & Blankenagel, 2024). Secondary data from published research, policy documents, and industry reports inform the conceptual development process (Barkham et al., 2022). The resulting framework proposes a multi-stage risk scoring methodology and identifies implementation mechanisms for integrating physical climate risk into zoning and development approval processes, providing a foundation for subsequent empirical validation and practical application (Takona, 2024). This methodology aligns with established practices in conceptual research, where the goal is theory building rather than empirical testing (Leavy, 2022; Salter, 2023).

Results and Discussion

1. Conceptual Framework: Integrating Physical Climate Risk Scoring into Zoning and Development Approvals

The conceptual analysis reveals three core components essential for integrating physical climate risk scoring into zoning and development approval processes. Hazard identification and characterization constitute the first component, requiring systematic assessment of current and projected climate hazards at the property and neighborhood level (OECD, 2025). This includes analysis of flooding, sea-level rise, extreme heat, wildfires, and other climate-related hazards, with assessment of both hazard frequency and intensity across different climate scenarios and time horizons (Hirsch et al., 2015). Location-specific hazard data, including flood maps, wildfire risk assessments, and heat island analysis, are essential for identifying areas at highest risk and prioritizing intervention (OECD, 2025). Digital tools and predictive hazard surface generation enable the creation of dynamic, spatially explicit forecasts of environmental risks to inform proactive adaptation and systemic resilience (Sustainability Directory, 2025). Hazard identification requires collaboration across multiple stakeholders, including climate scientists, urban planners, and risk assessment professionals (Vanhuyse et al., 2023).

Exposure and vulnerability assessment constitute the second component, requiring evaluation of the population, property, and infrastructure exposed to identified hazards and their susceptibility to damage (IPCC, 2022). Vulnerability pertains to the degree of criticality determined by the inherent qualities of the system and may have a detrimental effect on the severity of the impacts faced by the system, as well as its overall performance and ability to respond (IPCC, 2022). Assessment of vulnerability requires analysis of building characteristics, including age, construction type, and resilience features, as well as social vulnerability factors including household income, age, and access to resources (Urban Institute, 2025). The integration of sociodemographic data with hazard and property data enables identification of communities at highest risk and prioritization of intervention (Urban Institute, 2025). Exposure and vulnerability assessment also requires consideration of critical infrastructure, including hospitals, schools, and emergency services, as well as economic vulnerability factors including property values and investment exposure (Kahn, 2017).

Risk scoring and regulatory integration constitute the third component, requiring translation of hazard, exposure, and vulnerability data into actionable planning information (OECD, 2025). Risk scoring methodologies quantify inherent danger to inform proactive risk elimination, using standardized metrics and transparent methodologies to support decision-making (Sustainability Directory, 2025). The Climate Hazard Exposure Index provides a composite measure of hazard exposure, integrating multiple hazard types and vulnerability factors to support risk assessment and prioritization (Sustainability Directory, 2025). The Climate-Resilient Development Index enables communities to quantify how much of their housing stock is located in hazard-prone areas relative to the amount of housing that could be developed in less exposed areas (Urban Institute, 2025). Regulatory integration requires embedding risk scores into zoning codes, development approval processes, and building standards, with differentiated requirements based on risk level (UN-Habitat, 2022). This includes restrictions on development in high-risk areas, requirements for resilience measures in moderate-risk areas, and incentives for resilient development in low-risk areas (OECD, 2025).

2. Implementation Mechanisms and Regulatory Integration

The conceptual analysis identifies several implementation mechanisms essential for effective integration of physical climate risk scoring into zoning and development approvals. Land-use restrictions represent a primary mechanism, with total restrictions where extreme risk exists and partial restrictions where moderate risk exists (UN-Habitat, 2022). Total restrictions may prohibit any development in high-risk areas, while partial restrictions may allow certain uses but not human habitation in flood zones, restrict development densities, or permit development on the condition of developers covering the cost of required adaptation measures (UN-Habitat, 2022). Public land buffers create areas of land abutting sea or rivers which are public and cannot be developed or used by private individuals, while setback requirements establish building restrictions that set a distance from a boundary line within which a landowner is prohibited from building or expanding structures (UN-Habitat, 2022). Integrated coastal zone management plans provide policy instruments to guide activities within the coastal zone, ensuring sustainability and climate adaptation are at the Centre (UN-Habitat, 2022).

Building codes and development standards represent a second implementation mechanism, requiring resilience measures in new construction and major renovations (OECD, 2025). Minimum performance standards for energy and carbon set clear baselines for sustainable construction and renovation, while building codes can be updated to require climate-resilient design features such as flood-resistant foundations, fire-smart landscaping, and passive cooling strategies (OECD, 2025). Disclosure requirements mandate the reporting of climate risks and resilience measures at key transaction points, such as property sale, lease, or mortgage issuance, enhancing transparency and aligning private incentives with long-term resilience objectives (OECD, 2025). Financial incentives, including subsidies, tax deductions, and preferential lending conditions, can complement regulatory measures and help offset transition costs, with well-designed instruments reducing unequal impacts on households and enterprises in high-risk locations (OECD, 2025).

Digital infrastructure and data platforms provide a third implementation mechanism, enabling access to and analysis of climate risk data (OECD, 2025). National data platforms can integrate property-level indicators such as exposure to floods or heat stress, energy performance, and building characteristics, allowing climate-related risks to link with financial, insurance, and planning systems (OECD, 2025). Making such datasets publicly accessible can improve risk visibility and enable more consistent assessments across markets, with accessible, easy-to-use, and locally relevant data supporting practical real estate decision-making (OECD, 2025). Scenario analysis provides a common language for testing both physical hazards and transition pathways under alternative futures, enabling stakeholders to assess the resilience of their strategies across different climate futures (OECD, 2025). These digital tools and platforms require investment in digital infrastructure, including mandatory energy reporting platforms and open-access digital twins that use real-time data to test scenarios (OECD, 2025).

3. Barriers and Enabling Conditions

The conceptual analysis identifies significant barriers to effective integration of physical climate risk scoring into zoning and development approvals. Data availability and quality constitute the primary barrier, as comprehensive property-level climate risk data is often lacking or of inconsistent quality, with 58% of survey respondents citing the absence of granular, property-specific data as a key barrier (OECD, 2025). Methodological inconsistency represents a second barrier, with 49% of respondents citing unreliable or inconsistent methodologies, making comparability and informed decision-making challenging (OECD, 2025). Professional capacity constitutes a third barrier, as the integration of climate risk into planning and development approvals requires specialized expertise that is often in short supply, with need for training and professional development across the planning and real estate professions (Bienert, 2016). Regulatory fragmentation constitutes a fourth barrier, as inconsistent requirements across jurisdictions create complexity and compliance burden for developers and investors operating across multiple markets (Akhtyrska & Fuerst, 2024).

Enabling conditions for effective integration include standardization of climate risk metrics and methodologies, development of industry guidance and best practices, professional education and capacity building, and regulatory coordination and harmonization (OECD, 2025). Standardization can enhance the comparability and reliability of climate risk assessments, enabling more efficient integration into planning decisions (OECD, 2025). Industry guidance and best practices can support consistent application of risk scoring methodologies and integration into professional practice (Urban Institute, 2025). Professional education and capacity building can address skill gaps and enhance the quality of climate risk assessment and integration (Bienert, 2016). Regulatory coordination and harmonization can reduce compliance burden and enhance the effectiveness of risk integration frameworks (Akhtyrska & Fuerst, 2024). These enabling conditions require coordinated action across multiple stakeholders, including governments, professional associations, and educational institutions (Warren-Myers & Hurlimann, 2022).

Equity considerations represent a critical dimension of enabling conditions for climate risk integration (OECD, 2025). Low-income households are frequently concentrated in high-risk locations such as floodplains, heat-exposed districts, or informally built settlements, with limited capacity to absorb losses or finance relocation (OECD, 2025). Planning decisions that account for high-risk groups can reduce disproportionate burdens and protect vulnerable communities from recurrent financial shocks (OECD, 2025). Including equity safeguards in risk scoring and zoning integration ensures that low-income households and informal settlements are not left behind, with targeted support for vulnerable communities including technical assistance, financial support, and community engagement (OECD, 2025). The development of mixed-income, resilient housing can address equity and regulatory risk, enhance community resilience, and respond to growing demand for just and inclusive climate action (OECD, 2025).

4. Implications for Urban Investment Resilience

The conceptual framework has significant implications for urban investment resilience, guiding development toward safer locations and reducing financial exposure to climate risks (Boland et al., 2022). Integrating physical climate risk scoring into zoning and development approvals can protect investment values by preventing development in high-risk areas and ensuring that new development incorporates resilience measures appropriate to its risk level (Kahn, 2017).

Evidence from coastal cities in China demonstrates that climate risk is increasingly capitalized into property values, with properties in high-risk areas trading at significant discounts (Huang et al., 2025). Similar effects have been documented for properties exposed to sea-level rise, extreme heat, and wildfire risk, suggesting that climate risks are increasingly priced into property markets (Dong, 2024). By integrating risk scoring into planning decisions, communities can avoid the creation of new risk exposure and guide investment toward climate-resilient locations (OECD, 2025).

The framework also has significant implications for developers and investors, providing clear signals about risk exposure and resilience requirements (Boland et al., 2022). Regulatory predictability and transparent risk assessment can reduce investment uncertainty and enable more informed decision-making, with clear guidelines for development in different risk zones (OECD, 2025). Developers can use risk scoring to identify opportunities for resilient development in low-risk areas, while avoiding high-risk locations that may face future restrictions or financial penalties (Kahn, 2017). Investors can use risk scoring to assess portfolio exposure and prioritize resilient investments, with climate-resilient assets expected to preserve value better than vulnerable properties (Addoum et al., 2024). The integration of risk scoring into zoning and development approvals thus supports both public policy objectives and private investment interests, creating aligned incentives for climate-resilient urban development (Boland et al., 2022).

The framework also has significant implications for urban resilience and community well-being, directing development away from high-risk areas and ensuring that new development incorporates resilience measures (OECD, 2025). By avoiding development in high-risk areas, communities can reduce future disaster costs and protect public safety, with significant savings in disaster response and recovery expenditures (UN-Habitat, 2022). Incorporating resilience measures into new development can reduce vulnerability to climate hazards and protect community assets, with co-benefits including improved public health and environmental quality (OECD, 2025). Equity safeguards ensure that the benefits of resilient development are distributed fairly and that vulnerable populations are not left behind, with targeted support for communities at highest risk (OECD, 2025). The framework thus supports both climate adaptation and social equity objectives, contributing to broader sustainability goals in urban development.

Conclusion

This conceptual paper has developed a comprehensive framework for integrating physical climate risk scoring into zoning and development approval processes to enhance urban investment resilience. The analysis reveals that current zoning frameworks inadequately incorporate forward-looking climate hazard data, leading to continued development in high-risk areas and escalating financial exposure. The conceptual framework proposes a multi-stage risk scoring methodology that integrates location-specific hazard data, vulnerability assessments, and adaptation capacity considerations into planning approvals and zoning decisions. The framework identifies three core components: hazard identification and characterization, exposure and vulnerability assessment, and risk scoring integration into regulatory decisions. Implementation mechanisms including land-use restrictions, building codes and development standards, and digital infrastructure and data platforms are essential for effective integration. Significant barriers including data availability, methodological consistency, professional capacity, and regulatory fragmentation must be addressed through enabling conditions including standardization, industry guidance, professional education, and regulatory coordination. The framework has significant implications for urban investment resilience, guiding development toward safer locations and reducing financial exposure to climate risks. This paper contributes to emerging scholarship on climate-adaptive urban planning and resilient real estate investment by providing theoretical foundations for policy development and practical guidance for planners, developers, and investors. Ultimately, integrating physical climate risk scoring into zoning and development approvals is essential for reducing urban vulnerability, protecting investment values, and building climate-resilient communities in an era of accelerating environmental change.

Recommendations

Based on the conceptual analysis, several recommendations emerge for integrating physical climate risk scoring into zoning and development approval processes. First, governments should mandate the use of forward-looking climate hazard maps and risk assessments in all stages of planning and property development, with zoning codes updated to reflect current and projected climate risks. Second, planners should develop and implement risk scoring methodologies that integrate multiple hazard types and vulnerability factors, with transparent and standardized metrics that enable comparability across jurisdictions. Third, regulators should update building codes and development standards to require climate-resilient design features in new construction and major renovations, with differentiated requirements based on risk level. Fourth, policymakers should establish disclosure requirements for climate risks and resilience measures at key transaction points, such as property sale, lease, or mortgage issuance, enhancing transparency and aligning private incentives. Fifth, governments should invest in digital infrastructure and open data platforms that integrate property-level climate risk data with planning and financial systems, enabling informed decision-making. Sixth, professional associations should develop training and certification programs for planners, developers, and investors in climate risk assessment and integration, building professional capacity. Seventh, policymakers should incorporate equity safeguards into risk scoring and zoning integration, ensuring that vulnerable communities receive targeted support and are not left behind. Finally, researchers should conduct empirical studies validating the conceptual framework across different hazard types, geographic contexts, and regulatory environments, strengthening the evidence base for policy development.

Article Publication Details

This article is published in the **OpenMind Journal of Multidisciplinary Innovation & Development**, ISSN: 3108-2920 (Online). In Volume 2 (2026), Issue 3 (May - June) - 2026

The journal is published and managed by **OMR PUBLICATION** .

Acknowledgements

We sincerely thank the editors and the reviewers for their valuable suggestions on this paper.

Authors' contributions

All author(s) read and approved the final manuscript.

Funding

The author(s) declare that no funding was received for this work.

Data availability

No datasets were generated or analyzed during the current study.

Declarations

Ethics approval and consent to participate

The author(s) declare that not applicable.

Consent for publication

The author(s) declare that not applicable.

Competing interests

The author(s) declare no competing interests.

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