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## Coupled Urban Risks: A Complex Systems Perspective with a People-Centric Focus

Min Ouyang<sup>a,b</sup>, Zekai Cheng<sup>a</sup>, Jiaxin Ma<sup>a</sup>, Hongwei Wang<sup>c,\*</sup>, Stergios Aristoteles Mitoulis<sup>d,\*</sup>

<sup>a</sup>School of Artificial Intelligence and Automation, Huazhong University of Science and Technology, Wuhan 430074, China

<sup>b</sup>Key Laboratory for Image Processing and Intelligent Control, Ministry of Education of the People's Republic of China, Huazhong University of Science and Technology, Wuhan 430074, China

<sup>c</sup>School of Management, Huazhong University of Science and Technology, Wuhan 430074, China

<sup>d</sup>School of Engineering, University of Birmingham, Birmingham B15 2TT, UK

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### ABSTRACT

The complexity of coupled risks, which refer to the compounded effects of interacting uncertainties across multiple interdependent objectives, is inherent to cities functioning as dynamic, interdependent systems. A disruption in one domain ripples across various urban systems, often with unforeseen consequences. Central to this complexity are people, whose behaviors, needs, and vulnerabilities shape risk evolution and response effectiveness. Realizing cities as complex systems centered on human needs and behaviors is essential to understanding the complexities of coupled urban risks. This paper adopts a complex systems perspective to examine the intricacies of coupled urban risks, emphasizing the critical role of human decisions and behavior in shaping these dynamics. We focus on two key dimensions: cascading hazards in urban environments and cascading failures across interdependent exposed systems in cities. Existing risk assessment models often fail to capture the complexity of these processes, particularly when factoring in human decision-making. To tackle these challenges, we advocate for a standardized taxonomy of cascading hazards, urban components, and their interactions. At its core is a people-centric perspective, emphasizing the bidirectional interactions between people and the systems that serve them. Building on this foundation, we argue the need for an integrated, people-centric risk assessment framework that evaluates event impacts in relation to the hierarchical needs of people and incorporates their preparedness and response capacities. By leveraging real-time data, advanced simulations, and innovative validation methods, this framework aims to enhance the accuracy of coupled urban risk modeling. To effectively manage coupled urban risks, cities can draw from proven strategies in real complex systems. However, given the escalating uncertainties and complexities associated with climate change, prioritizing people-centric strategies is crucial. This approach will empower cities to build resilience not only against known hazards but also against evolving and unforeseen challenges in an increasingly uncertain world.

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### 1. Introduction

The 21st century has marked the advent of the urban era, with over 60% of the global population projected to reside in cities by 2030 [1]. As engines of economic growth, cities now contribute more than 80% of the global gross domestic product (GDP) [2], underscoring their critical role in global development. However,

rapid urbanization and escalating climate change have intensified the coupled nature of risks [3]. These risks are not isolated but deeply interdependent, interacting through complex, nonlinear ways to produce outcomes far more severe than if they occurred independently [4]. This interdependence manifests as disaster chains under hazardous events. Disruptions in one domain—whether infrastructural, social, economic, environmental, or governmental—can trigger cascading failures that lead to unpredictable outcomes. These chains reveal the profound complexities (i.e., multi-scale, nonlinear, dynamic interactions among urban sub-systems) and vulnerabilities of modern cities. An illustrative

\* Corresponding authors.

E-mail addresses: [hwwang@hust.edu.cn](mailto:hwwang@hust.edu.cn) (H. Wang), [s.a.mitoulis@bham.ac.uk](mailto:s.a.mitoulis@bham.ac.uk) (S.A. Mitoulis).

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example occurred in Zhengzhou, China, in 2021. Extreme rainfall overwhelmed the city's infrastructure, flooding subway stations and causing widespread power and communication outages. The effects extended far beyond physical damage, disrupting socioeconomic activities, impairing governance, and exacerbating environmental degradation. This event highlights how failures can cascade through engineering systems and extend their impacts to other dimensions of cities [5].

The complexity of coupled risks, caused by interacting uncertainties, is inherent to cities, which function as dynamic, interconnected systems [6–8]. A disruption in one urban subsystem can ripple across other subsystems, often with unforeseen consequences, particularly as we increasingly rely on data and cyber systems. Crucially, people live and operate at the core of these systems, and their needs, behaviors, culture, and vulnerabilities shape the evolution of risks and determine the effectiveness of responses [9]. Analyzing cities as complex systems centered on human needs and behaviors is essential in understanding the complexities of coupled urban risks. This paper adopts a complex-systems perspective of cities (i.e., as dynamic, interdependent networks of urban sub-systems, shaped by human behaviors, needs, and vulnerabilities) to examine the intricacies of coupled urban risks, emphasizing the critical role of human decisions (which increasingly depend on new technologies) and behavior in shaping these dynamics. Here, *risk* is alternatively understood as the combination of hazard, exposure, and vulnerability [7,10]. Based on this framework, we structure our literature review on coupled urban risks along two dimensions: *cascading hazards* (i.e., hazardous events that occur simultaneously, in a cascading manner, and cumulatively over time [11]) in urban environments; and *cascading failures* (i.e., a chain reaction of system breakdowns in interdependent urban subsystems) across interdependent exposed systems in cities. Existing risk assessment approaches in the literature often fail to capture the complexity of these processes, particularly when factoring in human decision-making [9,12,13].

To tackle these challenges, we propose four core perspectives. First, we advocate for a standardized taxonomy of cascading hazards, urban components, and their interactions. At its core is a people-centric perspective, emphasizing the bidirectional interactions between people (specifically, residents and tourists) and the systems that serve them. This taxonomy clarifies how people contribute to and mitigate risks. Second, we call for an integrated, people-centric risk assessment framework that evaluates event impacts in relation to the hierarchical needs of people and incorporates their preparedness and response capacities. Third, we emphasize the need to continuously calibrate these models using multi-source data, advanced computation, and simulation techniques. Fourth, to manage urban risk complexities, we advocate for the prioritization of people-centric strategies—focusing on both what individuals can offer and what they can receive—alongside approaches such as guided self-organization and resilience design [4], in order to enhance adaptability amid climate change and evolving uncertainties [3]. Through the integration of these perspectives, we envision cities that are resilient not only to known hazards but also to evolving and unforeseen challenges from a cyber-physical and human-induced hazards perspective, all of which contribute to an increasingly uncertain world.

## 2. The state of the art of coupled urban risks

*Risk*, as defined in 2018 by the International Organization for Standardization (ISO 31000:2018), is the “effect of uncertainty on objectives.” Building on this foundation, *coupled risks* are the compounded effects of interacting uncertainties across multiple interdependent objectives. Coupled risks arise when individual risks are interconnected, with correlated uncertainties and impacts. They can be characterized as systemic, networked, cascading, or compounding risks [4,14]. The World Economic Forum's *Global Risks Report* [15] maps the relationships between global risks, spanning economic, geopolitical, social, environmental, and technological dimensions. While useful at a macro level, urban environments add layers of complexity,

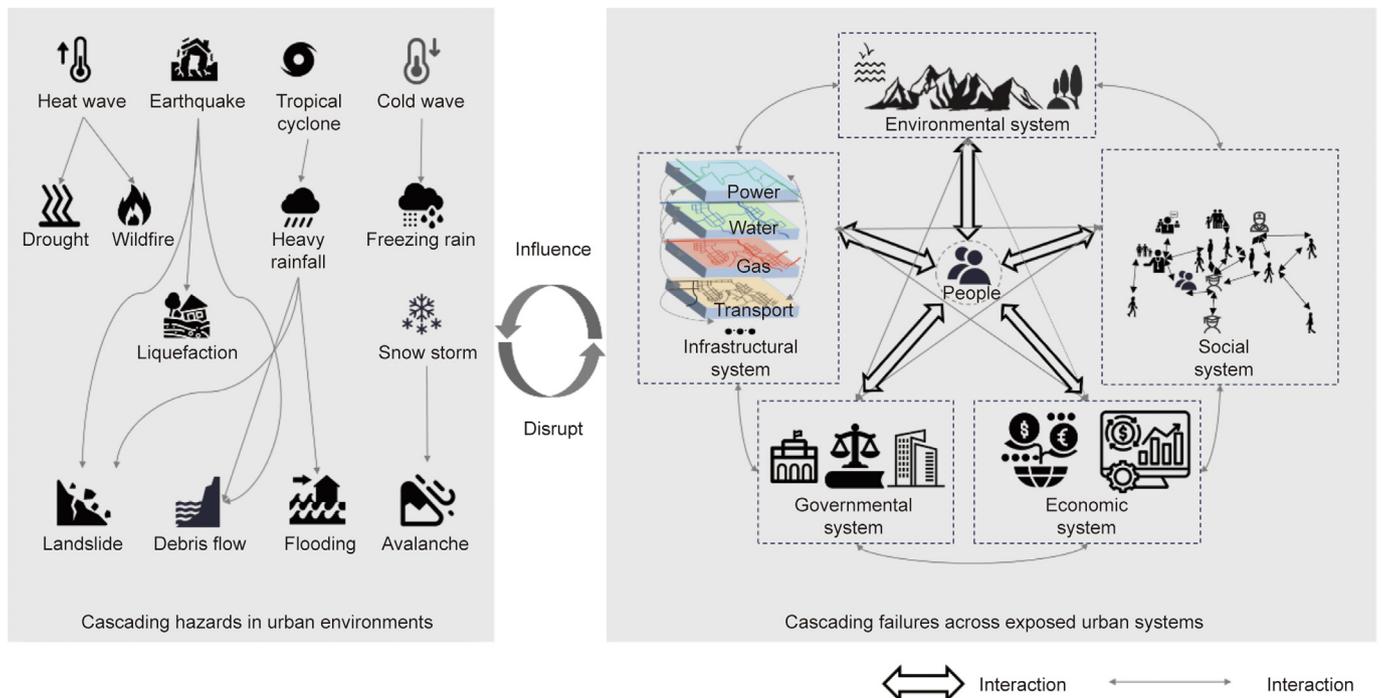


Fig. 1. Coupled urban risks manifest in two dimensions: cascading hazards in urban environments (left) and cascading failures across exposed urban systems in cities (right).

and their diverse local objectives and specificities [16] require a more granular understanding of coupled risks in cities.

A more nuanced framework of risk in urban contexts combines hazard, exposure, and vulnerability [7,10]. In this framework, *hazards* are processes or events that may cause harm; *exposure* describes the people, infrastructure and related services, and systems of assets in hazard-prone areas; and *vulnerability* refers to the conditions that increase susceptibility to impacts [1]. Building on this framework, coupled urban risks, as illustrated in Fig. 1, can be systematically understood through two critical dimensions:

(1) **Cascading hazards in urban environments.** Primary hazards trigger secondary hazards, forming chains of events that amplify risk.

(2) **Cascading failures across exposed urban systems.** Disruptions propagate through interconnected exposed systems in cities, increasing vulnerabilities and risks. Here, urban systems include infrastructural, social, economic, environmental, and governmental elements, with people at the center of their interactions.

These two dimensions form the basis for the structure of the literature review in Subsections 2.1–2.3. Subsection 2.1 focuses on cascading hazards in urban environments, Subsection 2.2 examines cascading failures across exposed systems in cities, and Subsection 2.3 explores the integrated modeling of cascading hazards and failures. These perspectives highlight how the classification of hazards can vary significantly depending on how exposed systems in cities are defined. For example, if exposed systems are defined around people, hazards may include not only natural events but also infrastructure failures such as power outages or water shortages [1].

### 2.1. Cascading hazards in urban environments

Cascading hazards illustrate how a primary event can trigger a sequence of secondary and subsequent hazards, complicating risk dynamics [17]. Research has primarily focused on natural hazards such as earthquakes, floods, and tropical cyclones, as depicted in the left part of Fig. 1. For instance, the 2010 Haiti earthquake caused landslides through soil liquefaction, while the 2011 Tōhoku earthquake triggered a tsunami that inundated coastal areas. These events also uncover the complexity inherent in cascading hazards: Specific events within hazard chains—triggered by a common primary hazard—can vary dramatically based on geographic, climatic, and infrastructural contexts [12].

Despite this complexity, many studies oversimplify cascading hazard assessments and quantify the hazard consequences using simple metrics such as exposed population [18–21], casualties [22], displacement [23,24], damaged buildings, and infrastructure assets [25–27]. These assessments often fail to capture cascading failures within and across other exposed systems in cities, which might have profound impacts on social stability, economic functions, and overall urban risks.

### 2.2. Cascading failures across exposed urban systems

Understanding cascading failures across exposed urban systems is equally important as grasping cascading hazards. Many studies mainly consider interdependent infrastructure systems in cities as exposed systems, where failures in one infrastructure system propagate through others. McDaniels et al. [28] analyzed infrastructure failure interdependencies (IFIs) under a major electrical power outage by examining the August 2003 northeastern North American blackout, the 1998 Quebec ice storm, and three 2004 Florida hurricanes and found that significant IFIs included effects on heating, ventilation, and air conditioning (HVAC) in buildings; water systems; health systems; and road transportation.

Beyond empirical studies, quantitative frameworks such as agent-based, system dynamics, and network-based models have been employed to simulate these failures across interdependent infrastructure systems [29,30]. However, many models simplify the hazard impacts on infrastructure system components and treat component failures as random events [31], targeted attacks [32], or single hazard-induced events [33]. These simplifications arise from disciplinary silos and a lack of interdisciplinary collaboration, and thus result in insufficient modeling of the complex, nonlinear interactions between cascading hazards, failures, and losses as a result of urban system vulnerabilities and being myopic to the role of peoples' response in cascading failures.

### 2.3. Integrated frameworks for understanding coupled urban risks

Several studies have attempted to integrate cascading hazards in urban environments and cascading failures across exposed systems in cities into unified frameworks. Montoya-Rincon et al. [34] explored the vulnerabilities of interdependent power and water systems under hurricanes and subsequent flooding hazards. Hassan and Mahmoud [35] examined the compounded effects of

**Table 1**  
Several disaster chains during the 2021 extreme rainfall event in Zhengzhou, China.

Disaster chain No.	Event description	Event progression
1	Flooding interrupted Subway Line 5 due to power outage	Extreme rainfall → Urban drainage system overload → Subway flooded → Power lost → Water breached barriers → Subway tunnels flooded
2	Fatal incident in Beijing–Guangzhou Expressway Tunnel resulted in 6 dead and 247 cars submerged	Extreme rainfall → Tunnel flooding → Traffic paralysis → Inadequate closure → Loss of life and property damage
3	Guojiazui Reservoir spillway blockage caused major flooding risk	Extreme rainfall → Hydrological failure → Illegal construction blocked spillway → Reservoir overflow → Evacuation of 98 000 people
4	Flash flood in Wangzongdian Village resulted in 23 deaths	Extreme rainfall → Flash flood and landslide → Poor evacuation measures → Significant loss of life
5	Highways around Zhengzhou closed due to extreme weather	Extreme rainfall → Urban drainage system overload → Road traffic system temporarily halted
6	K15 Train stranded for 45 hours, affecting over 1000 passengers	Extreme rainfall → Urban drainage system overload → Rail traffic paralysis → Prolonged stranding → Power shortages
7	Water plants halted in Zhengzhou due to power outage	Extreme rainfall → Urban drainage system overload → Power system damaged → Water plants stopped operation
8	Zhengzhou Hospital lost power during severe flooding	Extreme rainfall → Power system damaged → Hospital lost power → Emergency services halted
9	Ying River flooding caused explosion in company workshop	Extreme rainfall → Water level surge → Floodwaters reacted with molten aluminum → Explosion → Buildings collapsed

wildfires and pandemics on healthcare facilities and their infrastructure systems, including transportation, electric power, and water supply systems. Dargin et al. [36] focused on the vulnerabilities of households to disruptions in the food–energy–water nexus during hurricanes and subsequent flooding hazards.

While these integrated approaches provide valuable insights, they focus narrowly on a few exposed systems in cities, often overlooking the role of human behavior and decision-making during crises. This narrow scope, coupled with challenges in acquiring high-quality time-series data for robust testing and validation, limits the capacity of these models to capture the full complexity of urban dynamics under multi-hazard conditions. Without sufficient data, it is difficult to formulate meaningful hypotheses about how urban systems respond and behave under cascading hazards; thus, it is challenging to develop accurate models that fully account for cascading risks in cities, accounting for peoples' response [6,37].

### 3. Advancing the understanding of coupled urban risks

Building on the limitations highlighted in the previous section, this section provides our perspectives on advancing the understanding of coupled urban risks. To support our arguments, we first introduce the 2021 extreme rainfall event in Zhengzhou as a real-world case study to deepen insights into the complexities of coupled urban risks [5]. Table 1 illustrates several disaster chains from this event, each occurring at different sites across the urban space and offering valuable insights into the complexities of these cascading risks. These chains are manifestations of coupled urban risks. They also demonstrate how a single primary hazard—in this case, extreme rainfall—can trigger cascading hazards and failures in a city, depending on the specific urban context. In one part of Zhengzhou, the unprecedented rainfall caused urban flooding that exceeded the capacities of the flood barriers and inundated subway stations (Chain No. 1 in Table 1). In another area, the extreme rainfall triggered flash floods and landslides, with road embankments across gullies blocking drainage, eventually collapsing and resulting in fatalities and missing persons (Chain No. 4 in Table 1). These disaster chains reveal significant variations in how coupled urban risks manifest across different sites—variations that are often insufficiently captured in existing studies. Drawing from this event, the subsequent subsections (3.1–3.3) outline three key perspectives to address gaps in the literature and advance the understanding of coupled urban risks.

#### 3.1. Developing a uniform, fine-grained taxonomy

We advocate for the development of a standardized taxonomy for cascading hazards, urban elements, and their interactions, with a people-centric focus. While the United Nation's Office for Disaster Risk Reduction (UNDRR)'s 2020 hazard definition and classification report offers a foundation for hazard identification, it does not account for cascading hazards [1]. Furthermore, classifications of existing urban elements—such as those by Batty [37], Meerow and Newell [38], Caldarelli et al. [8], and Tzachor et al. [39]—lack consistency, are coarse, and do not capture critical interactions between urban elements, especially during disruptive events. For example, cascading Chain No. 9 in Table 1 shows how floodwater reacted with molten aluminum at an industrial facility, causing an explosion, building collapses, and fatalities. This example illustrates how unforeseen interactions can lead to severe consequences, complicating efforts to manage and prevent such risks. Without a refined taxonomy, understanding how cascading hazards propagate is difficult, undermining risk assessments and disaster-management strategies such as the development of multi-hazards early warning systems (MHEWSs) [40,41].

A new taxonomy should be grounded in complex systems theory, extending the UNDRR framework to account for cascading hazards in urban contexts. It must standardize classifications for urban elements, incorporating categories beyond the typical infrastructure, social, economic, environmental, and governmental systems (e.g., to better capture the interactions exposed by Chain No. 9 in Table 1). Moreover, this taxonomy needs to extend existing classifications of infrastructure interdependencies [30], including physical, cyber, geographical, and logical interactions, and encompass all potential interactions between multiple hazards and urban elements (e.g., Chains No. 3 and No. 9 both involve logical interdependencies, but their cascading mechanisms differ significantly). Crucially, since people—who are central to cities—play a pivotal role in self-assistance and mutual aid during disruptions [9], the taxonomy must prioritize interactions between people and urban systems as well as interactions between residents, local decision-makers, and politicians. More specifically, it should clearly define and classify interactions in terms of what individuals can contribute to other urban elements for risk reduction, as well as what they can receive from these elements to mitigate their own risks. Such a taxonomy will serve as a critical foundation for improving risk assessments, enhancing data collection and loss reporting, and guiding the development of more effective MHEWSs, ultimately reducing coupled urban risks.

#### 3.2. Building a people-centric integrated risk assessment framework

We call for the development of a people-centric, integrated, and comprehensive risk-assessment framework that accounts for infrastructural, economic, social, environmental, and governmental dimensions, with a strong focus on understanding the behaviors, needs, and decision-making processes of individuals. As stated in Section 2, current risk-assessment models often focus on cascading failures across infrastructure systems, without accounting for the broader impacts on socioeconomic, environmental, and governmental systems, as well as the preparedness and response capacities of people [4,14]. However, as demonstrated by the 2021 Zhengzhou rainstorm, which impacted over 14 million people and caused widespread disruption and direct economic losses of 40.9 billion CNY, urban risks are shaped not only by infrastructure failures but also by the breakdown of essential services and social systems. Human behavior is equally critical in mitigating risk. For example, during the Zhengzhou event, rapid citizen responses saved lives; however, current models fail to capture such human–infrastructure interactions.

A people-centric integrated risk assessment framework must simulate cascading hazards and failures in cities, integrating infrastructural, social, economic, environmental, and governmental factors, while also considering individual behaviors and decision-making processes. Agent-based models (ABMs) are well-suited for this task but must be based on a uniform taxonomy of hazards, urban elements, and their interactions, with a focus on risks tied to the hierarchical needs of people during crises [42]. Additionally, certain urban systems are interconnected with broader regional and global networks, introducing boundary effects that must also be accounted for [43,44]. It is essential to note that developing such models requires leveraging data-driven approaches to reformulate hypotheses about urban dynamics, especially concerning patterns related to people's preparedness, responses and accountability. Finally, it must be emphasized that incorporating data on people's preparedness and response behaviors into a risk assessment model can significantly enhance its validation and refinement, thanks to the growing availability of real-time data about human behaviors before, during, and after crises.

### 3.3. Calibrating models with multi-source data

It will be necessary to calibrate and continuously update people-centric integrated risk-assessment models using multi-source observational data from historical events. Integrating cascading hazards in urban environments, cascading failures across interdependent urban systems, and the behaviors of people during crises introduces numerous model parameters that require calibration using data from historical and novel events. Although various data sources—such as social media, satellite imagery, mobility data, nighttime light data, and official reports—provide snapshots of system performance or loss information, each comes with inherent limitations. For instance, nighttime light data can capture power outages but only during the nighttime and in relation to energy systems [45]. Satellite imagery, while offering valuable spatial insights, often lacks the temporal resolution needed to track rapid changes during short-term events [21]. Mobility data, such as global positioning system (GPS) tracking, reveals human movement patterns but is affected by privacy concerns, sampling biases, and reduced availability during extreme events, which compromise its reliability [46,47]. Despite providing real-time insights, social media is often fragmented and subject to biases [48], making systematic large-scale analysis challenging. Official reports, on the other hand, are frequently incomplete, or too aggregated to provide the high-resolution data necessary for precise calibration [49].

As Helbing [4] emphasizes, the availability of more disaster-related data raises expectations for more accurate models. However, without proper calibration, models can become opaque rather than transparent. To address this challenge, models must be calibrated using partial observations from diverse sources, with a particular emphasis on real-time data capturing human behaviors before, during, and after crises, as well as the influence of local culture. This calibration process must resolve data fragmentation and conflicts by integrating data-mining and -processing techniques with physical models of urban systems, thereby generating post-disaster data that is spatially and temporally consistent and free from cyberthreats and biases. Furthermore, given the dynamic nature of cities [37], these models must be continuously updated to reflect changing conditions, ensuring that they remain adaptable and responsive to evolving real-world dynamics.

## 4. Strategies to cope with coupled urban risks

Building on the three core perspectives outlined in the previous section to advance our understanding of coupled urban risks, this section introduces strategies to effectively manage and mitigate these risks. Helbing [4] introduced several strategies to manage coupled risks, many of which are highly relevant to urban environments. First, making a shift from top-down control to bottom-up self-organizing approaches allows urban systems to leverage their internal adaptability and feedback mechanisms to stabilize themselves rather than relying on external control. Second, building risk-response capacity through emergency planning and the creation of backup systems that operate under different principles enhances resilience. Third, cascading failures can be contained by limiting system size and implementing dynamic decoupling, using mechanisms such as “cutoff points.” Fourth, slowing down system dynamics in rapidly evolving systems (e.g., by reducing financial transaction speeds during market crises) gives decision-makers more time to intervene. Fifth, maintaining diversity and redundancy in urban systems ensures that failure in one component does not lead to total system collapse, promoting adaptability and innovation. Finally, utilizing early warning signals to detect vulnerable components or critical fluctuations allows for preemptive actions before systemic failures occur.

While these strategies offer a robust foundation for managing the complexities of coupled urban risks, the increasing uncertainties posed by climate change, uncontrolled urbanization, and hybrid threats call for an expanded yet more flexible approach. This gives rise to our fourth perspective: prioritizing people-centric strategies. Central to this perspective is a recognition of the dual roles individuals play in effectively reducing coupled urban risks—both as proactive contributors and as recipients of critical support. To better integrate individual agency into urban risk management, this section categorizes people-centric strategies into two groups, ensuring a comprehensive approach to leveraging individual and community efforts.

### 4.1. People-centric strategies related to what individuals can offer

This category emphasizes the proactive role individuals play in reducing coupled urban risks. By harnessing the collective knowledge, resources, and efforts of people, these strategies can disrupt chain reactions that lead to compounded crises. Engaging individuals in identifying vulnerabilities and implementing solutions can effectively reduce urban risks and foster a resilient city capable of withstanding multiple interlinked threats.

Key strategies include promoting individual engagement and behavioral adaptation, where people contribute their local knowledge to designing risk maps and informing risk-reduction planning [50]. Individuals can also adjust their actions based on improved risk communication and regulations [51], playing an active role in risk management. Initiatives such as biodiversity monitoring through mobile apps encourage individuals to gather local environmental data, which helps protect urban ecosystems and informs risk-reduction strategies [52]. Projects such as “Freetown the Tree-town” engage residents in tree planting, directly mitigating risks like flooding and landslides while enhancing green spaces [52].

Strengthening social networks is another effective strategy. Individuals who build supportive relationships and accountability within their communities contribute to long-term social capital, which becomes invaluable during crises [53]. Laws and policies that promote mutual aid can also be legislated to foster a culture of collective responsibility, ensuring that individual actions actively contribute to the mitigation of interconnected urban risks [4,50]. Through these actions, individuals can not only contribute to immediate risk reduction efforts but also help cultivate a culture of resilience and collective responsibility, strengthening communities and reducing overall urban risks.

### 4.2. People-centric strategies related to what individuals can receive

This category focuses on empowering individuals by increasing their ability to cope with and respond to coupled urban risks. By providing people with timely warnings, education, and adaptive infrastructure, these strategies aim to prevent isolated incidents from escalating into widespread crises. Well-informed and well-prepared individuals are less likely to inadvertently amplify risks and are more capable of taking effective actions to mitigate cascading effects.

A central strategy is the development of people-centric MHEWSs that incorporate advanced risk-assessment models to provide real-time alerts [54,55]. Accurate predictions and timely warnings enable individuals to proactively respond to imminent threats such as earthquakes or floods [11,56]. Continuous learning and risk-awareness programs further increase individual preparedness by educating people about disaster risks and how interconnected hazards might interact [12,56]. Moreover, providing access to training and educational resources equips individuals with the skills necessary to navigate complex urban challenges [57].

Insurance schemes also offer a risk-sharing mechanism, alleviating the burdens of people during disasters by distributing risks

more equitably [51]. Fostering a sense of ownership and involvement, as well as shaping cultural norms that encourage pro-environmental actions, can further empower individuals to take responsibility for their own safety and to contribute to reducing the risks faced by their communities [13]. Through these collective strategies, individuals can become active participants in reducing coupled urban risks, ultimately enhancing the resilience of cities [52,57].

## 5. Conclusions

Urbanization and climate change are intensifying the vulnerabilities of modern cities, yet traditional risk-assessment approaches fail to effectively capture the cascading hazards and systemic failures inherent in urban environments [4]. This paper emphasizes the importance of adopting a complex systems perspective to address coupled urban risks, underpinned by four core perspectives: ① developing a standardized taxonomy that categorizes hazards, urban elements, and their interactions, thereby enhancing clarity in risk analysis; ② establishing an integrated people-centric risk-assessment framework spanning infrastructural, social, economic, environmental, and governmental dimensions, incorporating individual behaviors and decision-making processes; ③ leveraging data-driven innovations to calibrate and validate these models for dynamic urban complexities; and ④ prioritizing people-centric strategies that address both what individuals can offer and what they can receive, ensuring that risk management aligns with human needs and equity.

To translate these perspectives into actionable solutions, investment and research in several future directions are essential. First, extensive empirical case studies are needed to deepen our understanding of interactions among urban subsystems, which will support the development of the proposed taxonomy. Second, advancing the modeling and validation of people-centric risk assessment frameworks requires a focus on the dual impacts of human behavior on risk propagation and mitigation, particularly with the integration of emerging technologies such as artificial intelligence, machine learning, and digital twins, which are becoming increasingly popular and used by people through mobile technology. Third, a systematic roadmap is necessary to integrate these perspectives into practice, potentially leading to the emergence of “urban risk science,” a new interdisciplinary field bridging urban science and risk science. Finally, extending the people-centric understanding of coupled urban risks toward a broader concept of people-centric resilience will help foster sustainable, inclusive, and adaptive cities. By addressing these research and practical gaps, we can build future cities that can not only withstand the multifaceted challenges of the 21st century but also thrive, advancing the United Nation’s Sustainable Development Goals (SDGs) by fostering sustainable, inclusive, and resilient urban environments that promote equity, economic prosperity, and environmental stewardship.

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