Land Use Policy 152 (2025) 107482

Contents lists available at ScienceDirect

Land Use Policy

journal homepage: www.elsevier.com/locate/landusepol

Actionable policy responses to disaster threats – A comparative study on resilience and sustainability in global cities

Alexandru Banica [a,b], Ema Corodescu-Rosca [a], Karima Kourtit [c,*], Peter Nijkamp [d,e]

[a] Alexandru Ioan Cuza University, Iasi, Romania
[b] Romanian Academy, Iasi Branch, Romania
[c] Open University of the Netherlands (OU), Heerlen, The Netherlands
[d] University of Rijeka, Rijeka, Croatia
[e] Tsinghua University, Beijing, China

ARTICLE INFO

Keywords:
Global cities
Disasters
Threats
Resilience
Blessing in disguise hypothesis
Sustainability

ABSTRACT

This paper examines the hypothesis that preventive urban policy responses to disaster threats are likely to play a positive role in the resilient development of cities, not only by strengthening disaster mitigation and response-related adjustment mechanisms, but also by enhancing sustainability and liveability in urban areas. The study aims to test whether pressing disaster challenges for large cities prompt responses that lead to more positive outcomes than in a 'without situation'. We argue that the 'Blessing in Disguise' (BiD) hypothesis applies also to potential threats, and not just to actual disasters. In our empirical study, the development trajectories of 40 global cities – represented by the comprehensive GPCI database – are addressed from the perspective of six distinct main categories of performance variables (*Economy*, *R&D*, *Liveability*, *Cultural Interaction*, *Accessibility*, and *Environment*). The research seeks to explore the linkages between the various GPCI performance indicators and urban GDP at risk using correlation and multiple regression tools, while the systemic interactions among all variables are subsequently analysed by means of Social Network Analysis. The results highlight that the larger and poorer cities appear to be more threatened by natural disasters, while, for the wealthiest cities, manmade disasters are a more significant threat. Manmade threats also appear to be more linked to the main GPCI category scores; in particular, *Economy*, *Cultural Interaction* and, especially, *R&D* appear to be positively correlated with the magnitude of urban threats, while *Liveability* and *Environment* are less prominently (or negatively) influenced. Therefore, urban innovative policy response – in a broad sense – is an important driver of proactive resilience and positive sustainability outcomes. In conclusion, the governance of global cities should organically and strategically integrate resilience, sustainability and liveability as a common guide for short- and long-term urban development, by adopting targeted policies that anticipate and manage urban threats, from both a structural and non-structural perspective, so as to develop adaptive urban morphological and land-use functions.

1. Introduction

Human settlement systems on our planet have increasingly turned into geographically concentrated land use constellations. Nowadays we are living in '*the new urban world*' where the city has become the 'home of mankind' (Kourtit and Nijkamp, 2016). Cities are highly complex systems within systems of cities (Berry, 1964), laboratories of modernity (Nassehi, 2002), hubs of spatial development and engines of regional growth that house most of the world's population, economic activity and infrastructure. Wealth and progress are increasingly generated in large cities (including mega-cities) which are major land-use concentrations of economic activity, advanced innovation, and social and human capital accumulation (Heinrichs et al., 2012). In many countries, it is estimated that 70–80 % of the gross domestic product (GDP) is generated in urban areas (World Bank 2013a). Meanwhile, global cities might be able to display more sustainable and efficient development patterns, as per capita resource use is generally lower than in smaller settlements (due to proximity synergies and economies of scale), while lower unitary costs, high productivity and diversity of economic opportunities may create highly competitive advantages in the 'new urban world'.

The multiple interconnections emerging from the strategic economic-geographic position of global cities (Kourtit and Nijkamp,

* Corresponding author.
E-mail addresses: k_kourtit@hotmail.com, karima.kourtit@ou.nl (K. Kourtit).

https://doi.org/10.1016/j.landusepol.2025.107482
Received 1 March 2023; Received in revised form 16 January 2025; Accepted 19 January 2025
Available online 12 February 2025

2017; Brenner and Keil, 2014) allow to increase their competitiveness and economic performance, but they may also be subjected to threats, amplify vulnerabilities, and increase socio-economic losses, therefore creating an urban mega-arena of risk-taking (Büscher and Mascareño, 2011). This issue is the subject matter of the present paper.

International institutions monitoring risks and several urban scientists have argued that cities have become increasingly exposed to threats of all kinds and have created new domains of intensive risk, while urban areas with poorly planned and managed urban development are more and more exposed to new hazards and more extensive risk (UNISDR, 2002; OECD, 2018). Even though the number of victims (deaths, injuries) may have decreased, the total population exposed to natural and manmade threats and also the economic and material losses in disasters have all increased (IFRC, 2010). Clearly, cities are sometimes more affected by economic and political turbulence than by extreme disaster events such as earthquakes, pandemics or wars (Glaeser, 2022). These issues have been studied by numerous researchers; there is even a domain of economics called 'castastronomics' that measures the expected economic impacts of future catastrophes (Coburn et al., 2014).

This situation is not necessarily negative; there are also positives from being at risk, which offer opportunities for recovery and renewal processes, for creativeness, innovation, and entrepreneurship in cities (Pelling, 2003; Birkmann et al., 2010; Chang and Rose, 2012; Coaffee and Lee, 2016; Cubitt, 2022). Being exposed to increasing natural and manmade threats can make people more resilient, build powerful stakeholder cooperation systems (Torabi et al., 2018; Pacheco-Torgal and Grangvist, 2023), and open up a window-of-opportunity for resilience planning, sustainability and development, by conceiving and implementing integrated spatial development strategies which simultaneously minimize urban risks and maximize socio-economic benefits (see the case of London illustrated by Caparros-Midwood et al., 2019).

Studying the convergence between the potential of cities to face perturbations and their capacity – not only to react but also to use threats to perform better, to be more prepared, to become more sustainable and liveable – is an inspiring challenge. The present paper aims to explore the relationship between distinct urban threats and various positive policy response outcomes that may result for global cities. By using two well-known and recognized databases (the GPCI Database from the Tokyo Institute for Urban Strategies and the City Risk Database from Lloyd Cambridge), as well as complementary information from strategic documents of selected cities (in the 100 Resilient City Rockefeller Foundation framework), this study aims to demonstrate that some critical urban elements can ground an extension of the established 'Blessing in Disguise' (BiD) theory from disasters to threats or risks in large cities (Nijkamp et al., 2024). This means a shift in attention from specific, actual shock events to potential risks and threats of future events as a driver of resilience, sustainability, and liveability for global cities.

An exclusive focus on global cities – comprising large territorial urban systems that may suffer from distinct vulnerabilities – does not yet exist in the extant literature. Also a systemic perspective on three categories of risks (natural, manmade and emerging), including a wide range of disastrous events (see Section 3), is not present in contemporaneous research; most existing results focus on particular events by usually analyzing case studies. The systematic quantitative examination in the present study on the effects/threats of these kinds of disasters on each of the six dimensions of the above-mentioned GPCI Database and City Risk Database (*Economy*; *Research and Development (R&D)*; *Cultural Interaction*; *Liveability*; *Environment*; and *Accessibility*) as well as of their potential policy and land use consequences is a novel approach. According to our knowledge, such a holistic approach has not yet been performed in the prevailing literature.

The study is organized as follows. After the aims and scope sketched out above, we provide in Section 2 a theoretical and conceptual framing of the BiD hypothesis, followed by a description of the research methodology in Section 3. The results, based on correlation, regression and network analysis, are given in Section 4, followed by an exposition in Section 5 on their implications for land use and urban policy. The final section offers some concluding remarks.

2. Theoretical background

2.1. BiD perspectives on threats, risks and disasters

The literature on disaster management is rich and comprises many issues and concepts. Handling uncertainty in highly dynamic systems such as cities is one of the main concerns when addressing sustainability and global environmental, social-economic and technological changes (Dovers and Handmer, 1992; Alexander, 2021). Risks emerge from the discontinuous functioning of systems that turn into shocks when surpassing certain thresholds. They could change the state and the characteristics of the systems. Hysteresis is a term used by economists to highlight the permanent impact of shock events on the natural thresholds of systems (Coaffee and Lee, 2016). Risks are tolerable or acceptable as long as they are voluntary or desired, and have reversible impacts or remain above a specific threshold (Murphy and Gardoni, 2008). Meanwhile, hazards or threats, which are potential causes of future shocks, can be external or can be induced by intrinsic components of the system. Risks are the probability of threats causing actual losses and are influenced by vulnerability, but also by the resilience capacity of a system.

Resilience is a popular used and comprehensive concept that offers a positive perspective on threats, risks and disasters bringing together danger and hope (Sudmeier-Rieux, 2014; Pascariu et al., 2023). Resilience can be interpreted as: (1) resistance to external shocks and return to a former equilibrium state; (2) successful adaptation to a new situation by appropriate adjustments; (3) opportunity to creatively respond to perturbations by innovative actions, and by thriving in the face of new challenges (Bouchard, 2013; Cerè et al., 2017; Modica and Reggiani, 2015; Pascariu et al., 2023; Östh et al., 2018; Reggiani et al., 2022).

As a natural sequel of evolutionary resilience, prosilience and antifragility are two more recent concepts that integrate the essence of the positive perspective on threats, risks and disasters. Prosilience refers to proactive, participative and offensive strategies in relation to threats and risks, which have a stronger anticipatory character (compared with resilience). They comprise the ability of a system to be intentionally prepared to face disruptions, to learn and continuously improve in order to overcome adversity by understanding how to minimize its vulnerabilities and take advantage of the window of opportunities induced by harmful events (Hoopes, 2017; Aroca et al., 2021). Bogardi and Fekete (2018) view prosilience as a progressive increase in resilience. Closely connected and complementary to prosilience, antifragility envisages the building of systems able to thrive under uncertainty and volatility and to grow even in the context of disorder and uncertainty (Taleb, 2012; Taleb and Douady, 2013). Based on strict views on risk and performance, antifragile systems have a singular property that allows us to deal with 'unknowables', errors, and randomness (Aven, 2015). This can form a theoretical basis for both pre-disaster and post-disaster profit-taking, in relation to preparedness and transformation to be discussed below.

First, regarding preparedness, there is an abundant literature on the empirical side, but the theoretical background is rather poor (Staupe-Delgado and Kruke, 2018). There are, for instance, different types of preparedness for different threats. Barton (1969) distinguishes between preparedness for short-time impact onset stress, long-term onset stress, and chronic stress. Hart and Boin (2001) refer to "slow-burning crises" and also introduce a "cathartic" crisis which manifests slowly but terminates abruptly. However, understanding slow-burn events across urban and regional systems illustrates adaptive capacity and the ability of systems to adapt to, or absorb, economic, social and environmental change (Coaffee and Lee, 2016). More recently, Staupe-Delgado and Kruke (2018) refers to the tendency for procrastination in relation to the overall measures when it comes to slow-onset crises.

Next, transformation comprises (re)building during disaster response, developing preparedness for future similar situations, and setting the required strategies for disaster risk reduction programmes (Paton and Buergelt, 2019). It refers to the chance to get out of "path dependency" and change current development patterns creating, amplifying, or unfairly distributing risks, towards patterns that are more sustainable, resilient and equitable. It is important to identify the emerging opportunities and the cross-scale transformative trajectories, by capitalizing on multi-stakeholder, cross-sectoral opportunities and local resources, but also on global connections in order to get long-term positive results (Thomalla et al., 2018). The most prominent hypothesis of transformation related to disaster risk management is known as 'Blessing in Disguise' (BiD). It was tested by several scholars who analyzed the long-run benefits of urban disasters (Borsekova and Nijkamp, 2019; Bănică et al. 2020). The economy, infrastructure, and services can be affected by natural and manmade risks, but their rebuilding is seldom seen as a solution to lagging development (Monstadt and Schmidt, 2019). Therefore, disasters can reveal and disclose hidden opportunities for the economy and society as a whole and can act as true catalysts for radical transformations (Kreps, 1995; Oliver-Smith, 1996; Hoffman, 1999; Hoffman and Oliver-Smith, 2002; Seale-Feldman, 2020).

In direct connection to BiD, the WHO pushed forward and operationalized another concept, viz. the Building Back Better policy, which anticipates and uses crisis situations to push through previously determined development priorities (Seale-Feldman, 2020, Dube, 2020, Zhou et al., 2022). Post-disaster moments are then seen as windows of opportunity to learn and move towards "enhancing disaster risk reduction" (Imperiale and Vanclay, 2021). From this point of view, disaster is no longer (only) a challenge, while risk management no longer means avoiding risks but deliberately seeking them out. The background is that capitalism and regional economies are driven by 'creative destruction' brought by the actors' pursuit of change in order to maximize surplus value (Schumpeter, 1950). Moreover, disasters can be advantageous if they are local (creating "profitable differences"), or if they are treated as such (Cubitt, 2022). Clearly, in case of disaster risk the saying "think global, act local" translates into actions that can provide local sustainability and liveability.

Next, crisis thinking is sometimes also promoted as an instrument for improving the quality of systems, including global cities. The World Bank acknowledges 'that crises and subsequent reconstruction programs provide opportunities to change the status quo and behaviours that contribute to underlying vulnerabilities' (World Bank 2013b: 13). Meanwhile, there are scholars who defend the idea that territories under risk should encourage crisis thinking instead of disaster thinking (Cubitt, 2022). This is also a kind of "creative destruction"; positive outcomes can be obtained without the actual disaster happening, only by introducing "crisis thinking" to policymakers and all relevant stakeholders. This can push things forward, but only if it succeeds to improve capacities and capabilities of systems.

From a general contingency perspective, the risk is the probability that capabilities are reduced (Murphy and Gardoni, 2010). However, risks and disasters can also contribute to building capabilities and capacities (Anantasari et al., 2017). The societal impact of a disaster is measured in terms of its impact on the selected capabilities of individuals within the society. Therefore, a capabilities-based approach provides a meaningful theoretical background on resources which is necessary not just for recovery but also for long-term sustainability in practice. A sustainability perspective implies therefore that efforts are made not only for rebuilding or maintaining assets but also for enhancing the quality-of-life of members of the communities (possibly) affected by disasters in the short and long term. (Gardoni and Murphy, 2008). These capacities and capabilities, i.e. the community characteristics, are those which stimulate change and positive outcomes and not the risk or the disaster itself which is only the catalyst (Paton and Buergelt, 2019). This also implies increasing the attractiveness, sustainability, resilience and liveability of cities. For this, individuals, communities, and institutions need to move from being "crisis fighters" to becoming "proactive and systematic risk managers." Preparing, adapting and transforming in order to tackle risk could pay off abundantly (World Bank 2013b). In fact, changing and improving is a must for cities to remain competitive, and not lose advantage to other urban centres (Ichikawa et al., 2017). Therefore, being exposed and having to deal with risk can represent an opportunity for competitiveness and sustainability.

As a positive co-evolution of interacting spatial-economic, social, cultural and physical/environmental subsystems, place-based sustainability can be affected by urban risks. Meanwhile, balanced development of all urban dimensions can also create new opportunities from the viewpoint of reducing urban risks (Diappi et al., 1999). From this perspective, risk-sensitive urban development (Roslan et al., 2021) that emerges from a systemic view of the city including all relevant policy and planning dimensions can be the key to tackling urban risks while improving the quality of people's lives. These ideas are compatible with the new framework envisaged by Joseph and McGregor (2020), based on "the new trinity of governance", where resilience is the main concept used to address the threats that surround cities; it is an operationalized framework of sustainability, while the focus on well-being and development can be regarded as a positive outcome of well-managed crises (Joseph and McGregor, 2020, Bănică et al. 2021). It is clear that disaster management has become a rich research field. Our study will address in particular the positive effects of preventive policy in urban areas.

2.2. The BiD hypothesis and the multivariate GPCI database – an overview

The BiD effect of risk on different aspects of development included in the above mentioned GPCI database (*Economy*, *Research and Development*, *Cultural Interaction*, *Livability*, *Environment*, and *Accessibility*) has been documented in some recent studies (as we will highlight in this section), although as yet no systematic, multi-city and multi-risk analysis has been performed, to the best of our knowledge. We will now discuss the role of these six GPCI elements in more detail.

In spite of the general negative economic impact of natural disasters (Klomp and Valckx, 2014; Shabnam, 2014), both at national (Songwathana, 2018; Anttila-Hughes et al., 2013; Flowers, 2018) and subnational levels (Aguirre et al., 2022; Zhang et al., 2021), there is also evidence on possible positive economic effects (Chhibber and Laajaj, 2008). Construction and manufacturing industries benefit from natural disasters, due to their role in the short-term physical reconstruction process (Koerniadi et al., 2016; Hsiang, 2010). Floods (Fomby et al., 2013; Leiter et al., 2009; Qureshi et al., 2019), and earthquakes (Fomby et al., 2013) have been reported to have positive economic impacts, as long as their intensity stays moderate. However, according to Hallegatte and Dumas (2009), there is no direct economic growth induced by disasters, unless it is based on adopting innovations; Crespo Cuaresma et al. (2008) report, via a cross-country analysis, the catalyzing effect of natural disasters in the technological improvement of the countries' production base. Owusu-Sekyere et al. (2021) demonstrate that a positive impact on economic growth may manifest itself one year after the disaster, but this outcome is highly dependent on the quality of institutions, financial conditions and openness to international markets. In any case, we may assume that the economic system produces outcomes that are positively related to the good management of urban disaster risks.

Disaster risk can – in addition to positive economic outcomes – also foster innovation. The Sendai Framework for Disaster Risk Reduction has favored disaster risk reduction (DRR) research (Izumi et al., 2019) and many joint-research projects are being developed for building effective DRR instruments (Baills et al., 2020; Freddi et al., 2021). Besides, disaster-led engagement in R&D of businesses is becoming necessary and frequent (Mavrodieva and Shaw, 2019), while the social corporate responsibility goal can accelerate this engagement (Bajwa et al., 2021). Hu et al. (2018) indicate that Chinese climatic disasters have contributed to an increase in DRR related patents, but also in other fields, suggesting a spillover effect in the R&D sector in Chinese provinces. Some survey-based studies on firms also found clear disaster-led increase in innovation activities (Usugami and Abe, 2012; Rao et al., 2021). Thus, innovation and R&D may be assumed to play in general also a positive role.

Next, there is also evidence that disaster risk can enhance the liveability of communities. Many studies have revealed improvement of living conditions after natural disasters: better located houses and safer water sources in Somalia after the 2004 tsunami (Manyena et al., 2011); a new, more liveable form of shanty town at Port-au-Prince, following the 2010 earthquake (Petter et al., 2020); improvement of buildings' resistance and public awareness in Kathmandu, after the earthquake in 2015 (Platt et al., 2020); etc. On the other hand, risk plays an important role in reshaping the social fabric and creating new forms of governance (Zaidi and Pelling, 2015), as shown for the outskirts of Port-au-Prince after the 2010 earthquake (Engle, 2018) or in Bangkok after the 2011 floods (Stanton-Geddes, 2013). Becker and Reusser (2016) argue the significant social change which occurs gradually during disaster recovery and reconstruction, while Monteil et al. (2020) and Aldrich (2012) illustrate the changes in social capital in the recovery process. Besides this, citizens' engagement in DRR at local level lead to innovative forms of cooperation, strengthen the community spirit, and enhance preparation for future disaster events (López-Gunn et al., 2021; Hicks et al., 2019).

Disaster risk can also be an important driver of environmentally-friendly policies, especially via nature-based solutions for urban areas (Kabisch et al., 2017). Ecosystem-based adaptation to different kinds of disasters in cities has proved its efficiency: Rio de Janeiro (Sandholz, Lange, and Nehren, 2018); Sao Paolo (Young et al., 2019); and Nagpur (Dhyani et al., 2018).

Less evidence exists on the role of disaster risk in the cultural performance of places. Some evidence refers to the potential role of risk conditions in contemporary cities in fostering artistic creativity (Barbosa, 2021), to community-led heritage reconstruction after a disaster (Shrestha, 2021), and to an increased touristic attractiveness of places after disasters (Huang et al., 2020).

Finally, *accessibility* is not directly influenced by disaster risk. However, rebuilding efforts can improve the resilience of transport infrastructures (Croope and McNeil, 2011; Caldera et al., 2021), but this can be hindered by an inappropriate design of insurance systems, as Tonn et al. (2021) report for the US.

The GPCI database comprises of six main observable components that in a mutually interwoven linkage pattern mirror the broader socio-economic profile (or performance) outcomes of urban systems. Clearly, one might narrow down these six forces to more conventional profile indicators, notably *Economy* and *R&D*. However, in that case the broader welfare implications of disaster incidences and disaster threats – as incorporated in the BiD hypothesis – would be missed out. And therefore, in the present study the 'broader' welfare approach (i.e. 'beyond GDP'; see Jones and Klenow, 2016) is adopted. However, in our econometric-statistical and network data analysis, we will also pay separately attention to distinct *economic* and *R&D* dimensions whenever appropriate.

Finally, it should be noted that the six GPCI data categories are not only influenced by disaster risks and threats, but may in turn also act as cornerstones for mitigating disaster risks and threats. This is also reflected in the conventional difference between prevention strategies and actual disaster management. This bi-directional interaction maps out the systemic nature of disaster management. This observation has implications for our research methodology, which finally leads to the necessity to employ systemic Social Network Analysis.

3. Research methodology

To test the BiD hypothesis on the positive role of threats in fostering global cities' paths towards higher socio-economic performance (in our case, increasing sustainability, competitiveness, and liveability), a heterogeneous sample of global cities was examined in our empirical study, using two large appropriate databases.

Our exploration started with the Lloyd's *City Risk Index* produced by the Cambridge Centre for Risk Studies as a proxy for the threat and risk intensity level. This Index quantifies the possible annual costs of shocks on 300 of the world's leading cities responsible for around 50 % of global GDP by modelling more than 12000 scenarios. The Cambridge Centre for Risk Studies (2016) proposes a probability-weighted loss (expected loss) model of economic output that could be expected due to the manifestation of the different shocks. From the 23 types of threats covered by this index, 19 were included in our assessment and divided into three main categories: natural (Drought, Earthquake, Flood, Freeze, Heatwave, Tsunami, Volcano, Wind storm); manmade (Market crash, Nuclear accident, Oil price shock, Power outage, Sovereign default, Terrorism); and emergent (Cyber-attack, Human pandemic, Plant epidemic, Solar storm). The risk was expressed in terms of probability-weighted expected losses to the economy of cities from all threats (GDP@Risk). Our approach considers the potential extreme events that threaten more than 5 % of cities' GDP or can produce more than $1 billion in losses. The GDP data and projections were based on the Oxford Economics assessment, while the final index also includes a city rate of recovery (Coburn et al., 2015).

As mentioned before, the development patterns of cities and their progress in terms of sustainability, competitiveness and liveability were derived from the GPCI database created by the Mori Memorial Foundation's Institute for Urban Strategies in Tokyo since 2008 and updated yearly until 2023. The index comprises 70 indicators divided into six indicator groups that measure, benchmark, and compare the overall power of 40 of the world's leading cities according to the six GPCI dimensions – *Economy*; *Research and Development (R&D)*; *Cultural Interaction*; *Liveability*; *Environment*; and *Accessibility* (Ichikawa et al., 2017). The average scores of each indicator were used to calculate the cities' function-specific ranking which was included in the total GPCI index. The relationship between these dimensions and indicators, on the one side, and urban risks data, on the other side, was next tested over a period of 10 years (2012–2021).

Based on the six GPCI dimensions (see Fig. 1), we present first a Hexagon model; this is a performance indicator module tracing the conditions that may mirror the sustainability and liveability of cities as a "side-effect" of natural and manmade risk exposure. It is an updated and modified version of the Pentagon model earlier developed as a framework for evaluating multidimensional programme outcomes within a systems-thinking perspective (see e.g., Nijkamp and Pepping, 1998; Capello et al., 1999; Nijkamp and Yim, 2001; Nijkamp, 2008).

Fig. 1 maps out the force field of three distinct types on urban threats in the context of the performance of cities (measured in six GPCI dimensions) in relation to the level of GDP adjusted for risk or threats. These calculations for each of the 40 GPCI cities were performed using the data provided by the above Cambridge Center for Risk Studies. This means that for each level of GDP related to a given city we are able to calculate the proportion of GDP that is subjected to risk and that may have an impact on investments to cope with disaster risks. In the centre of the hexagon in Fig. 1 we find XXQ, which stands for the highest quality of urban life measured through sustainability, resilience and livability indices. The conceptual foundation of the XXQ principle can be found in a study by Nijkamp (2008) and will not be repeated here.

In our operational approach to test the BiD hypothesis we will adopt three methodological steps:

- a linear correlation analysis between GDP at risk and the six GPCI indicators (both individually and collectively) (Subsection 4.2.)

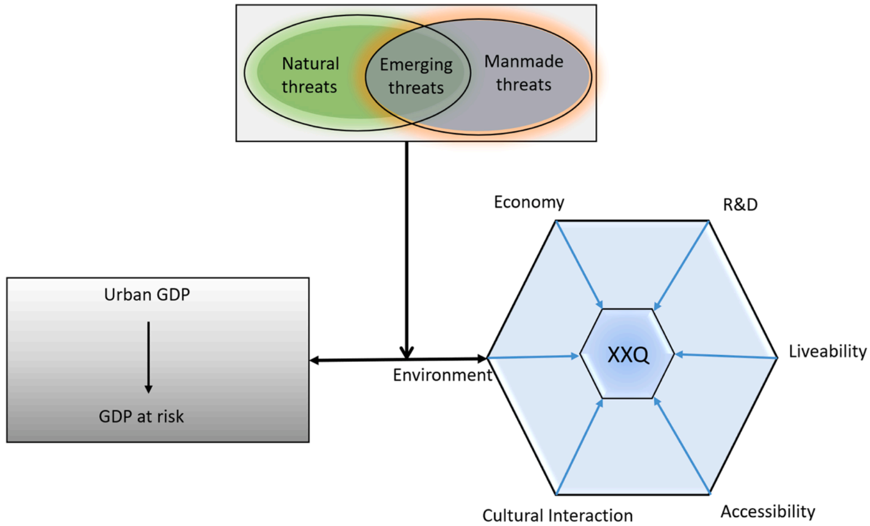


Fig. 1. The cities at risk framework: opportunities for resilience, sustainability, and liveability (Source: own representation).

- a multiple regression analysis between GDP at risk (as endogenous variable) and the GPCI indicators (as explanatory variables) in order to explore the role GPCI indicators play in shaping GPCI at risk (see Araiza-Aguilar et al., 2020). Thus, in this stage we test the mono-causal relationship between GDP at risk and the GPCI indicators (Subsection 4.3.)
- an application of (Social) Network Analysis in order to identify the interdependent multi-causal links in a complex network configuration between GDP at risk and GPCI variables from an exploratory systemic perspective (Subsection 4.4.). We will employ here a quantitative Network Analysis performed in JASP; an open access statistical software supported by the University of Amsterdam. This method was developed in R based on network graphs and is used to examine relations between discrete entities through modelling interactions between large numbers of variables (Han and Dawson, 2020). Therefore, dimensions of the six GPCI categories (including a specific focus on *Economy* and *R&D*) were tested in relation to the GDP at risk and its components, for all 40 cities concerned.

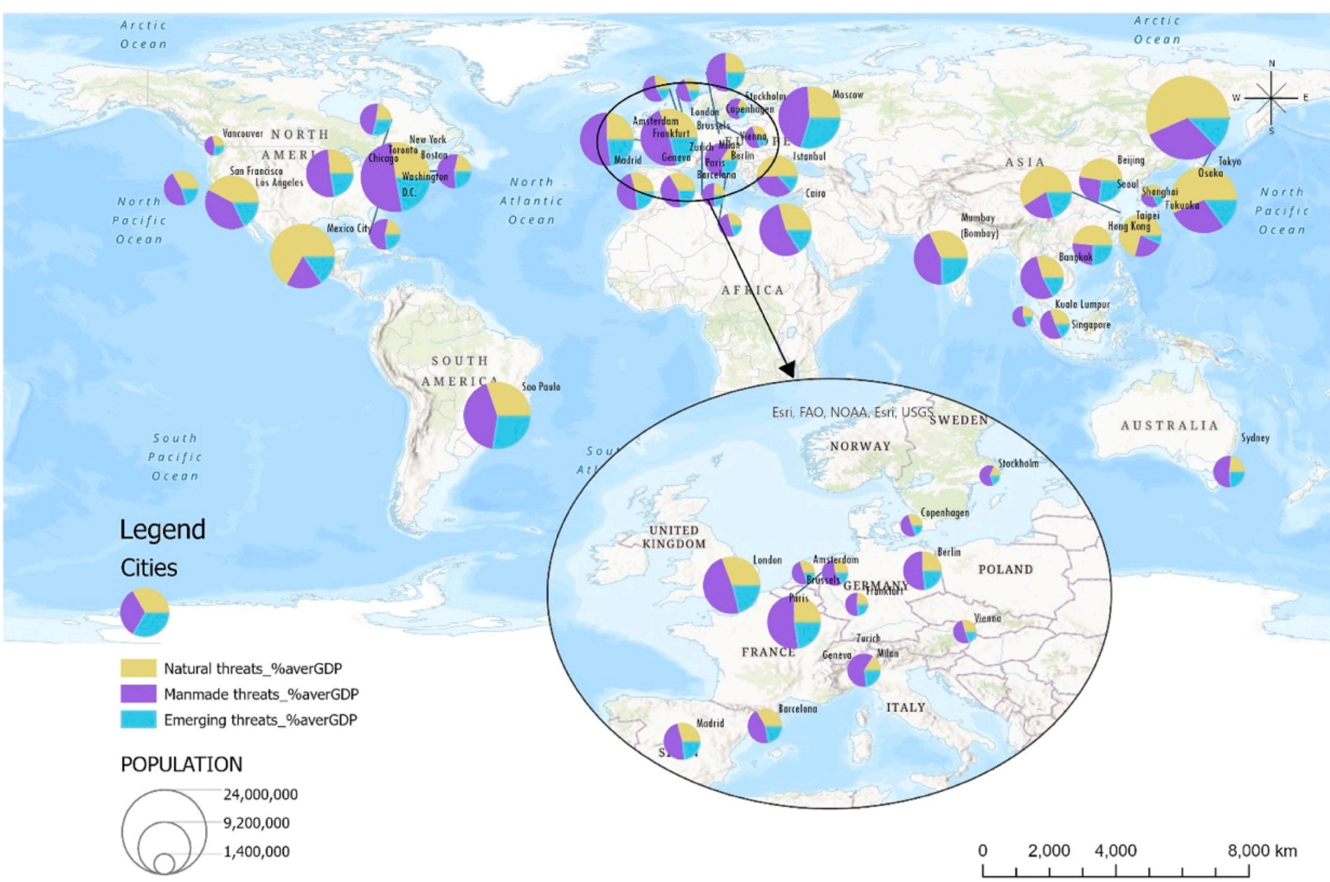


Fig. 2. Map of selected cities including a share of GDP at risk by type of threat (own representation) Data source: Banica et al# (2024).

It seems plausible that *Economy* and *R&D* play a pronounced role in our BiD analysis. And therefore, we zoom in more specifically on these two critical GPCI variables. In the next stage, the empirical results are confronted with quantified resilience goals and actions. We have used here the assessment framework proposed by the selected 40 GPCI cities in their strategies and also articulated in the 100 Resilient Cities (100RC) network platform. This network of cities, selected and funded by The Rockefeller Foundation, is the largest coordinated effort to implement resilience thinking into city planning processes internationally. The accumulated data and experience are valuable for grounding and explaining the results of our BiD approach. Our findings will now be presented in Section 4.

4. Empirical results

4.1. Mapping of cities

Cities face various challenges that are heterogeneous in frequency, magnitude, intensity, duration, and extent. The annotated world map of the 40 GPCI cities under consideration is presented in Fig. 2. We note that natural disasters continue to represent most of the total GDP at risk in global cities, because several cities will potentially incur very high losses from natural disasters (933.7 billion compared with 830.1 billion in case of all 40 selected cities), but the share of manmade disasters' losses becomes dominant locally in the majority of cities (29 out of 40 cities are mainly exposed to manmade threats). Moreover, the current growth of manmade threats is expected to continue in the future. Natural threats remain dominant in Eastern Asian cities and other particular cities (for example, Mexico City). A corresponding ternary diagram (or Möbius triangle) is provided in Annex A1, in order to illustrate the various positions of the GPCI cities according to the three types of risks.

Some descriptive statistics are given in Fig. 3. It is also evident from Fig. 3 that the disaster risk patterns differ according to city size and urban level of economic development. While the larger and the poorer cities are more threatened by *natural* disasters, the wealthiest cities appear to be more exposed to *manmade* disasters; the smaller cities are relatively less confronted with emergent threats, but the manmade threats are expected to create more damage in the future. We will now proceed with a multiple correlation analysis of GDP at risk and GPCI indicators in Subsection 4.2.

4.2. Results of multiple correlation analysis

Multiple correlation analysis focuses on the relationships between the GDP at risk and the various performance outcomes of the 40 GPCI cities across time so as to explore the existence of various linkages in the context of our BiD test. The results will briefly be discussed here, while the full results of this analysis can be found in Annex A2

In 2012, *Economic performance* was linked to high values of GDP at risk, but the relationship appears to become weaker over time. In general, the cities exposed to natural threats, in terms of both absolute and relative values, had less positive economic dynamics (correlation coefficients −0.312 and −0.314). The relationship is not significant for natural and emergent risks. These results complement some evidence on the negative impact of disasters on economic growth (Aguirre et al., 2022; Flowers, 2018; Klomp and Valckx, 2014), by suggesting a similar relationship engendered by a risk situation, not by an actual disaster, in the case of global cities.

Nevertheless, *R&D* remained highly positively correlated with the total GDP at risk, especially in the case of manmade and emergent disasters, suggesting that *R&D* and urban innovation may be stimulated by urban threats. Such an increase in *R&D* activities may originate from the above-mentioned DRR research (see Section 3) on disaster-prone cities and regions (Freddi et al., 2021; Hu et al., 2018; Izumi et al., 2019), acknowledging the urgent need for agents to cope with unexpected situations (Rao et al., 2021; Usugami and Abe, 2012). However, when relative values for the level of threat are considered (share of GDP at risk), the relationship becomes negative – the high values are related to low R&D performance.

Cultural interaction appears to be highly correlated with manmade and emergent threats, but not with natural threats, and emerges more in developing/Asian countries. The risk, especially from manmade disasters, is also higher in cities with either a lower performance in *R&D* (-0.358) or in the case of cities that decreased their *R&D* allocation after 2019. On the contrary, natural risks are associated with a positive trend for *Cultural interactions*, between 2015 and 2019, and a negative one in recent years, due to the pandemic.

Even though *Liveability* of all global cities increased during the last decade, it is negatively correlated with urban threats, suggesting that urban risks are higher in countries with a lower level of well-being, or that the potential positive impacts of disasters often stay behind the socially or economically deprived populations (Ahmed et al., 2018; Güzey, 2016; Song et al., 2019), thereby decreasing (or increasing at a slower pace) the general *liveability* of communities. Social justice concerning disasters is therefore an issue also for the global, powerful cities, where inequalities can sometimes be striking and affect the general *liveability* of the city. That relationship is most prominent in 2019 in the case of all types of threats. Similarly, the correlation is significant and negative for the *Environmental* indicators, as the urban threats are higher in cities with lower environmental performance.

Improvements in *Environmental and Liveability dimensions* with disaster risk can also be distilled from the information provided by the Rockefeller Foundation employing the 100 Resilient City Network. The resilience strategies elaborated by some of the analysed cities (14 out of 40) within this framework tend to focus most of their goals and actions/projects on the *Environment* and *Liveability* pillars. However, when looking at the dynamics of GPCI indicators, the progress is different across the two dimensions: for the *Liveability* dimension, all 14 cities recorded significant improvements between 2015 and 2021 (after launching the strategy), with Sydney, Mexico City, Singapore, London, Los Angeles, Bangkok and Barcelona being the "champions" in this respect (improvement by more than 20 %), but the *Environment* dimension dynamics is different among the cities. Bangkok suffered an important deterioration (-19.8 %), despite the comprehensive set of eight projects proposed in the strategy in this respect. The more developed Canadian cities made little progress or witnessed a slight decline (0.23 % for Toronto and −3.05 % for Vancouver). On the contrary, Seoul and Mexico City made important progress, with an improvement of *environment* indicators by 12 % and 24.62 %, respectively. For the case of Mexico City (a city with a considerable GDP at risk – 14.86 %, dominated by natural threats), this performance can be associated with the strong commitment to the *environment* dimension across the entire strategy: it includes 18 projects distributed across four out of five strategic pillars proposed by the city and covering issues such as urban mobility, water management, ecosystem conservation, and pollution control.

From the above empirical results, we conclude that the outcomes confirm largely the BiD hypothesis as specified above, with a particularly pronounced role of the *Economy* and *R&D* indicators.

4.3. Results of multiple regression analysis

A multiple regression analysis provides a more in-depth perspective on the relationship between GDP at risk in 2015 and the GPCI dimensions across time (as policy outcomes). Given the nature of the database, we can only perform a multiple regression analysis from GPCI variables to GDP at risk. The summary regression results (summarized here as coefficient estimates of the best model for the risk category concerned, i.e. with a sufficient significance level) resulting for four years taken into account are displayed in Table 1.

Clearly, such regressions can be repeated for each risk category. Similar regression models were therefore tested by using natural risks,

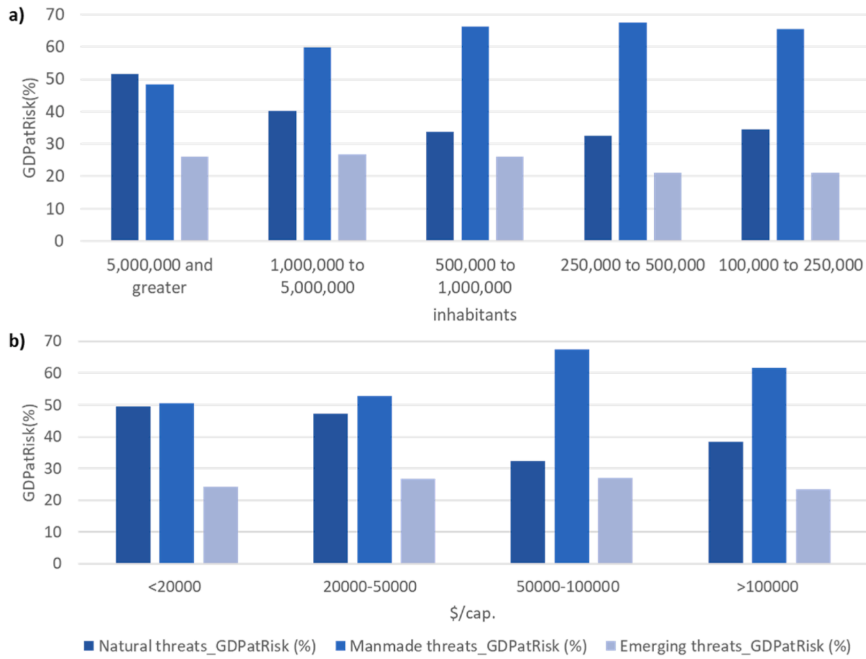


Fig. 3. GDP at risk: (a) by population size of the cities for each category of threats; (b) by $/cap. of the cities for each category of threats.

Table 1
Regression results for the dependent variable GDP@risk (2015), based on evolving GPCI moderators (2012–2021) (The table is based on the models' equations that can be also found in Annex 2, Table A2.3.).

	Intercept	Economy Coeff.	R&D Coeff.	Cultural Interaction Coeff.	Environment Coeff.	Liveability Coeff.	Accessibility Coeff
2012	97.02	-	0.32	-	−0.48	-	-
2015	84.64	-	0.58	−0.15	−0.40	-	-
2019	-	204.06	0.32	0.20	-	0.53	-
2021	-	115.78	0.55	-	-	−0.25	0.32

manmade risks and emergent risks for the total estimation in absolute terms (in billions) and in relative terms (share of GDP) (see Annex A3). The growth in *environmental* performance is clearly correlated with a lower share of manmade risk, but a higher share of emerging risks. Clearly, cities facing higher emerging risks decreased more in the last two years, owing to *environmental* performance efforts. The regressions also show the most important factors in the four years (2012, 2015, 2019 and 2021) chosen as relevant representations for the last decade.[1]

The regression includes the GPCI sectors as independent variables, exhibiting interesting results. Both the total GDP at risk and the GDP at risk from manmade threats are significantly explained by the independent variables included in the model. This also applies to natural threats, except in 2021 due to the impact of the COVID-19 pandemic. The emergent threats are linked to the general development of cities, but not to the response variables. A positive association between threat level and *R&D* is stable across all four regressions. In the first period, the higher GDP at risk is related to lower *environmental* performance, but in the last 4 years, other factors emerged, such as *liveability* (lower in the case of cities under higher threat); *economy* (lower performing economies were more under threat in 2019) and *cultural interaction* (unclearly related) or even *accessibility* (more accessible cities seem to be more vulnerable to threats in 2021). The GDP at risk from natural threats is also explained by a high performance in *R&D* (mostly in 2015) and poor *environmental performance* (especially until 2015), but also by lower values of *liveability* (especially in the second period 2019–2021). In the case of manmade threats, *R&D* is a very influential factor. Higher anthropogenic risk is meanwhile related to lower *economic* performance and lower *liveability*, especially in recent years, but unexpectedly also to higher *cultural interaction*.

In relative terms, the total GDP at risk appears to be more influenced by a lower growth rate of *R&D*, but positively correlated with the growth rate of *cultural activities* and *environmental* performance. It is noteworthy that, although *R&D* is present in most regression models when it comes to all threats, manmade threats are mostly correlated with *Economy* and *R&D*. When looking at the weight of each dimension, *Economy* remains the most correlated factor with both total and manmade threats, closely followed by *R&D*, which is more linked to natural threats (Fig. 4). In a few model experiments, Social and Cultural components of urban systems, as well as *Liveability*, appeared to be more prominent in relation to natural threats, whereas *Accessibility* and *Environment* are the least present in any of the estimated models. More detailed results can be found in Annex A3.

4.4. Results from network analysis

As noticed above, the force field of urban evolution exhibits a complex interdependent pattern. And therefore, in addition to statistical and econometric experiments, it is pertinent to adopt a broader systemic perspective based on Network Analysis (as explained in Section 3). We start with an aggregate Network Analysis of various risk indicators vis-a-vis the six main GPCI indicators (see Fig. 5). Next, we will adopt a

[1] The first year (2012) marks the beginning of the 10-year period of assessment; 2015 is the beginning of the Lloyd Cambridge evaluation of urban GDP at risk (2015–2025); 2019 is the last year before the pandemic, and 2021 is the last year with data records and the end of the analyzed decade.

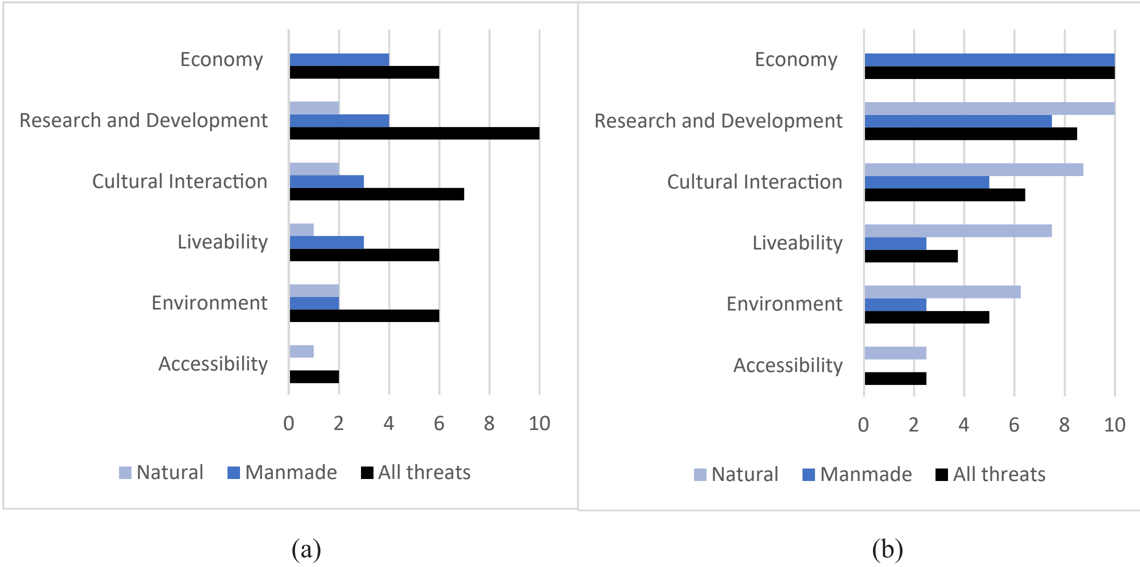


Fig. 4. (a) Frequency of domain inclusion in validated regression models; (b) Priority score (1−10) of domain inclusion in validated regression models.

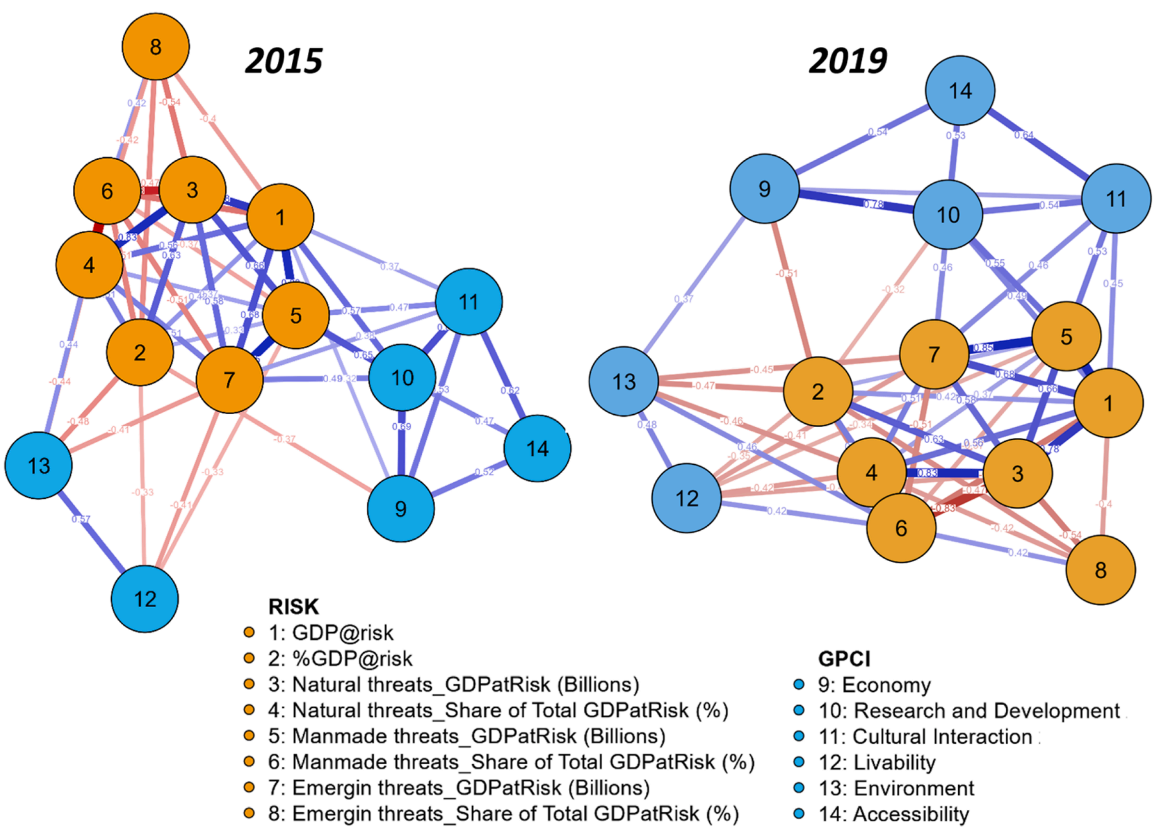


Fig. 5. Network plots for 2015 and 2019 mapping out relations between City Risk components and GPCI dimensions (Made in JASP, JASP Team 2024).

quantitative network approach using GPCI sub-indicators (each of the 6 GPCI dimensions is decomposed into sub-indices). This allows also a more detailed and separate analysis of the *Economy* and *R&D* GPCI dimensions (see Fig. 6).

The results will now be concisely presented, starting with an overall aggregate Network Analysis (see Fig. 5). Looking at two different years, 2015 and 2019, one observes various stable configurations, but also changes within the network, including the risk indicators and the GPCI indexes. The *Economy* index is directly and significantly correlated with a low share of GDP at risk. *R&D* developed in 2019 a less intense but still significant relationship with GDP at risk (-0.32), while it appears to be also positively correlated with a more pronounced recurrence of man-made risks (0.55), but also with GDP at risk in absolute value. These last three indicators are also positively correlated with *Cultural Interaction*. *Liveability* and *Environment* appear to have high values in cities exposed to manmade risks, but with a low share of the GDP, while natural and emerging risks do not represent a significant factor. *Accessibility* is not significantly related to any of the risk domain components.

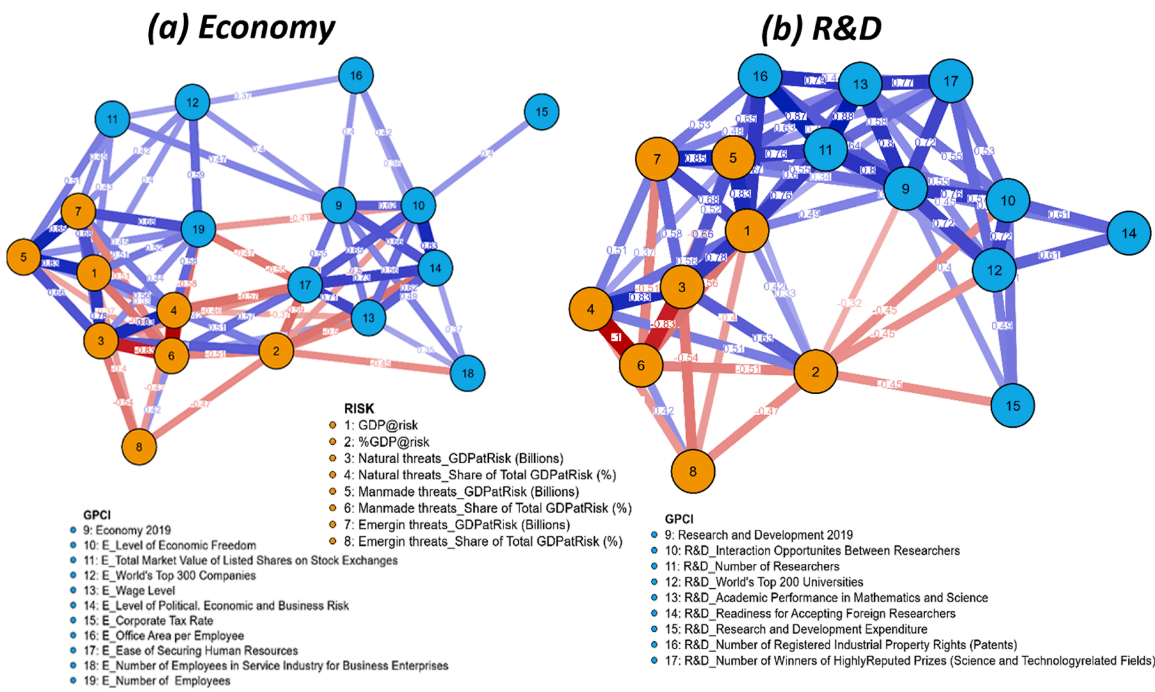


Fig. 6. Network plots for 2019 mapping out relations between City Risk components and GPCI *Economy* (a) and *R&D* (b) dimensions (Made in JASP, JASP Team 2024).

Regarding the yearly dynamics, we notice that *Economy* remains the most strongly correlated variable with both natural and manmade threats, closely followed by *R&D*. When looking more in-depth at these two dimensions (see Fig. 6) by analysing the elementary variables that composed the entire spectrum by using the above-mentioned Network Analysis, both negative and positive feedback are present. The significance of statistical relationships between the City Risk components and *Economy* indicators is rather diverse: the presence of a highly qualified, adaptable and secure workforce is clearly linked to a lower share of GDP at risk, whereas the emerging risks are more impactful on cities with a higher number of employees and a high total market value.

Concerning *R&D* (see Fig. 6), the results appear to show a negative correlation between the share of GDP at risk and research and academic expenditures and performance. It is also noteworthy that cities are more threatened by manmade risks, and with a higher total GDP at risk, accommodate more researchers, and produce more innovations (higher number of patents). The highest expected influence and the strength in each of the two networks show the significance of elementary variables such as the Level of Political, Economic and Business Risk (6a) and Research and Development Expenditure (6b), but also the overall high contribution of manmade threats to increase Economic and *R&D* capacities.

Regarding the remaining four GPCI domains, the importance of *Cultural Interaction* has increased between 2012 and 2021, and so did the indicators from the *Liveability* domain, while *Environmental* indicators lost their relative importance and *Accessibility* did not play a significant role. More detailed results on *Economy* and *R&D* can be found in Annex A4. The relative growth over the last ten years (2012–2021) in intensity of threats (low, medium, and high) allows to infer also challenging qualitative propositions that need to be further tested (see Table 2).

Medium-sized natural and manmade disaster risks and high emergent threats appeared to provide the highest growth in all six dimensions. Cities subject to medium natural or manmade threats showed positive dynamics for *R&D*, *Cultural Interaction*, and *Liveability* indicators. In the case of global cities under the highest emergent threats, one can also add the *Environment* to these dimensions. One can interpret this in two ways: the emergent threats mainly occur in cities that are more dynamic and competitive, but also, these cities become more sustainable and liveable as they are confronted with these risks. The growth rates of *Economy*, *Accessibility* and *Environmental* indicators

Table 2
Average growth rate of GPCI dimensions on different levels of disaster risk (GDP at risk: low 20 %-40 %, medium 40 %-60 %; high 60 %-80 %).

	Economy	R&D	Cultural interaction	Liveability	Environmental	Accessibility
Natural threats						
-low level	+ +	+ +	+ +	+	+ ++	+
-medium level	+ +	+ +	+ ++ +	+ ++	+ ++	-
-high level	+	-	+ +	+ +	+ +	+
Manmade threats						
-low level	+	-	+ +	+ +	+ +	+
-medium level	+ +	+ +	+ ++	+ ++	+ ++	-
-high level	+ +	+ +	+ +	+	+ ++	+
Emerging threats						
-low level	+ +	+	+ +	+ ++	+ ++	-
-medium level	+ +	+ +	+	-	+ ++	-
-high level	+ +	-	+ ++ +	+ ++ +	+ ++	+ ++

Legend: slight decline (between 0 and −10 %) - -; slight growth (0–10 %) - + ; moderate growth (10–20 %) - + +; high growth (20–40 %) - + ++ ; very high growth (>40 %) - + ++ +

(except for the case indicated before) are not correlated or negatively correlated, with higher threats in most cases.

5. Land use and urban policy implications

Despite their usual image of power and competitiveness, global cities appear to show threat levels from extreme events; they do often not fully exploit the opportunities for development opened up by this risk situation. Such cities are characterized by their strategic geographical position and extensive worldwide networks. However, their competitiveness also depends on – and is supported by – their inner structure and land use (physical environment, infrastructure, built-up areas).

Threats can accelerate profound changes or contribute to delaying others; they can produce positive and negative transformations. The 'resilience dividend' (Fung and Helgeson, 2017) is a concept that integrates possible or real turbulences with positive outcomes related not just to saving lives and avoiding losses but to unlocking even more the economic potential of cities and, meanwhile, capitalizing on an extensive range of other co-benefits (social, cultural, environmental, institutional).

Being confronted with a threat can change the economy of global cities, as they will be the first to suffer from perturbations that appear in urban systems, which diffuse and amplify due to their multiple network connections. Meanwhile, global cities are also the most responsive and most adaptive urban systems that can make up for rapid adjustments or capitalize on and gain from a turbulent market, as shown by the results of our analysis. However, this calls for changes in urban policies relating to industrial and service dynamics and remodelling of urban structures and functions. Meanwhile, a transition from adaptation to urban transformation is a challenging path. There is always some inertia and delay effect between socio-economic indicators dynamics and the physical transformation of cities.

Cultural interaction is also one of the main attributes of global cities linked to their globalisation, i.e. both local and global identity. These cities continue to be leading performers in cultural and academic areas, while they attract qualified human capital and major events; they are able to increase their capacities despite the multiplication of threats, although necessary security measures may be more enhanced.

Another positive outcome of risks of disasters relies on strengthening communities and human interaction and connections that can create more vibrant urban environments. From the viewpoint of *Liveability*, global cities are not necessarily the best cities to live in, as they are often faced with many social and environmental issues, which are sometimes inadequately addressed. However, increasing citizens' appreciation of city life can be attained by simultaneously considering the "body" of the city's physical natural and built environment and functions in conjunction with its "soul," i.e. its social features and perceptions (Kourtit et al., 2022). From a social perspective, threats put pressure on tackling disparities, discrimination and inequalities, which embody significant vulnerabilities and may increase losses. Addressing the issues of poor neighbourhoods, slums and informal settlements that continue to plague even some of the most competitive cities is a part of the "old" urban agenda (see Millennium Development Goals from 2000) and are often not sufficiently fulfilled.

A local perspective on land use planning should also be more present in global cities from the developed world, where manmade or emergent threats (e.g. power outages, terrorism, cyber-attacks, pandemics etc.) can pose severe problems to communities; improving their self-sustaining capacity in the case of a partial or total loss of connection to different kinds of networks becomes then crucial.

Micro-scale improvements on *liveability* and *environmental* conditions, especially at the neighbourhood level (such as proximity to commerce and services, walkable environments, community learning and support centres aiming at building local informal networks), may be integrated into land-use planning strategies so as to prepare local communities to respond in case of disasters and to reduce the impact of specific global-city nuisances they face. Various actionable measures are proposed in the urban resilience strategies supported by the 100 Resilient Cities network. Meanwhile, the recent concept of a 15-minute city (Moreno, 2024; Allam et al., 2022), first applied in Paris, is a path to planning self-sufficient, sustainable districts that may assure modularity that will be organised in a polycentric interconnected urban network. Planning smart and green transport systems will improve urban mobility and accessibility. This approach aims to contribute to increasing the sense of community and will impact all above hexagon model dimensions, while providing more resilience in the case of a sudden extreme event.

Global cities are at the forefront of the pressure humanity puts on the environment, while their competitive economic profile keeps a constantly high ecological footprint. No city, not even a global city, is entirely safe; cities in all corners of the world are exposed to different risks; in particular, they are all facing climate risks. Therefore, climate change adaptation is among the prominent policies and planning priorities for the future. By this, global cities are also "the escalators of environmentally-benign and climate-positive development" (Kourtit et al., 2022, p. 2). Urban policy in such cities should be more focused on proactive, long-term measures to prevent and mitigate the effects of potential threats, even if they did not happen yet (but are included in the city risk profile). Such a proactive approach, including modularity and redundancy in land use planning, is crucial in these global cities, as they (usually) host a large population, complex local infrastructure networks, interconnected international hubs, and significant flows of people, goods and services, while their perturbation can trigger widespread effects.

The safe-to-fail concept (Ahern, 2011) can also be applied in managing global cities, when it comes to land use planning. Some areas are more exposed to threats, and decision-makers may consider minimising losses when a shock would appear. Cities should plan for worst-case scenarios and be prepared to tackle unexpected events. An adaptive model of planning buildings, infrastructures, and urban land use in general, would include learning by doing, capitalising on the opportunities and shaping experiments and innovations that will not produce serious damages, if a failure appears (Lister, 2007).

Over the past years, resilience, prosilience and antifragility have become some main keywords in modern policy. However, it has to be complemented and integrated within a sustainable development policy framework in a form which becomes effective when major disasters such as COVID-19 occur. Global cities appeared to be gateways of COVID-19 to their respective countries (da Silva Corrêa and Perl 2022), and centres of pandemic cases, while many of the current dynamics of global cities are related to pandemic effects which have changed working styles, life styles, economic and cultural activities, and have started to become visible in the urban landscape, changing land uses and functions, urbanisation patterns, urban mobility etc (Majewska et al., 2022). Accelerated digitalisation and the green transition will also transform global cities into a smart(er) and (more) sustainable cites (Yigitcanlar and Kamruzzaman, 2018; Allam and Jones, 2021). Dispersion and urban sprawl trends are continuing (cities tend to blossom even more in the suburbs), while the 'new normal' will provide a mix between working from home and going to the office. However, interactions between people and businesses in the city's urban core (which hosts corporate headquarters and dominates the trade and economy of large surrounding areas), one of the essential attributes of global cities, will remain important even in the context of increasing threats.

6. Conclusions

Overall, our large-scale empirical exploratory study on disaster threat management produces important evidence on the initial BiD hypothesis on actual urban catastrophes.

Our results confirm existing evidence in the often-fragmented literature and adds various novel findings, too. Each global city included in the GPCI database is subject to a unique mixture of threats and vulnerabilities. The poorer and larger cities are more threatened by natural disasters, while the wealthiest cities are more exposed to manmade disasters. Natural disasters continue to dominate the GDP at risk, but manmade threats recorded a recent significant growth which is expected to continue.

Global cities confronting medium-sized and diverse/heterogeneous natural and manmade threats display the best opportunities to increase their performance. Meanwhile, no risk and very high risk either produce no impact (no opportunities) or create too much pressure and losses, with negative consequences for a longer period.

The emergent threats (Cyberattacks, Human pandemic, Plant epidemic) challenge the largest and most dynamic global cities, but it remains to be seen if they will serve as opportunities for even more growth or if they will have predominantly negative effects.

R&D is the main dimension of our Hexagon model that is fostered by higher threats and consequent risks, followed by *Cultural interaction* and *Liveability*. Therefore, there is positive feedback within the analysed systems: risks trigger innovation, cultural and social interactions and liveability, but a better performance in these domains can also induce risks. In the case of *Economy* and *Environment*, the relationship is strong but predominantly negative. Regarding *Accessibility*, the results are inconclusive.

This analysis of 14 urban resilience strategies highlighted those improvements in environmental quality and liveability in a complex risk landscape are related to dedicated objectives and actions in these strategies (as, for instance, elaborated in the 100 Resilient City Network). Therefore, to achieve a positive transformation while being at risk, a key mediating role is played by awareness at the local level, followed by the capacity to plan and implement projects accordingly (at least for the *Environment* and *Liveability* dimensions).

However, it is difficult to demonstrate an unambiguous direct causal relationship between the magnitude of natural, manmade or emergent threats and the improvement of cities' resilience, sustainability, and liveability (due to actionable policy responses). As other confounding explanatory factors may be involved in the dynamics of development dimensions (targeted urban policies; the regional, national, and international context; the interactions with other cities, with their hinterland or with other global cities etc.), future research may focus on modelling these aspects, based on more extensive databases. Moreover, the extensive database and the research methodology are based on standard historical indicators, using descriptive statistics and MLP to test the BiD research based on secondary data. Using aggregate indicators for main GPCI dimensions may incorporate some bias for specific cities. Therefore, the conceptual framework proposed in our paper, can be extended and used in future empirical studies based on a combination of primary and secondary data, in order to better address the causal mechanism of change behind each component of the Hexagon model.

In synthesis, the empirical evidence from this study supports largely our Blessing-in-Disguise (BiD) hypothesis for urban disaster risks. However, from our big databases it appears that not all outcomes are entirely unambiguous. It seems plausible that BiD opportunities need to be more envisaged by urban policymakers, by considering threats and consequent risks as part of integrated resilience-sustainability-liveability development strategies and planning decisions.

CRediT authorship contribution statement

Banica Alexandru: Writing – review & editing, Writing – original draft, Visualization, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Nijkamp peter:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Methodology, Investigation, Formal analysis, Conceptualization. **CORODESCU-ROSCA Ema:** Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis. **Kourtit Karima:** Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

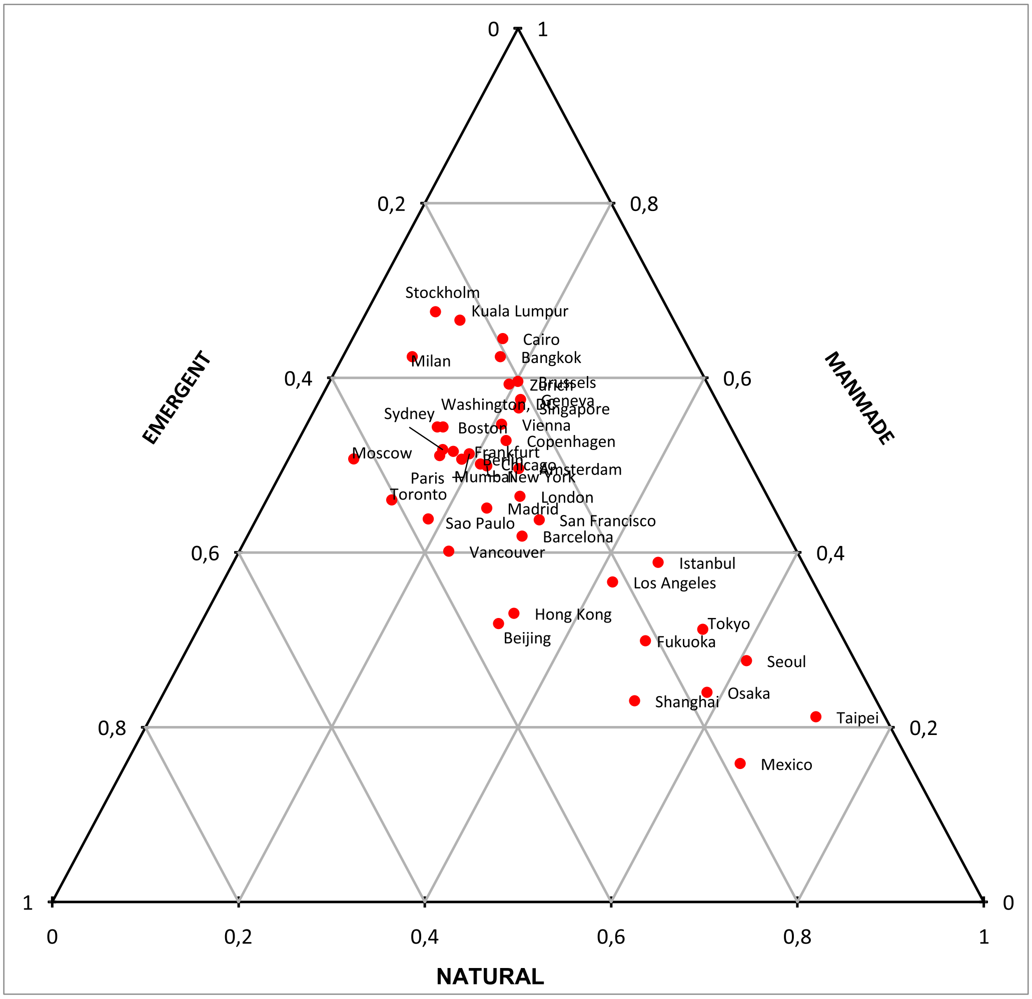
Declaration of Competing Interest

- No conflict of interest exists.
- We wish to confirm that there are no known conflicts of interest associated with this publication.

Acknowledgement

Karima Kourtit and Alexandru BANICA acknowledge support from the City Focus: Future Organisation of Changes in Urbanisation and Sustainability' (CF23/27.07.2023), financed by the Romanian Ministry of Investment through the National Recovery and Resilience Plan (PNRR-III-C9–2023 - I8_round) and supported by the EU NextGeneration programme. Karima Kourtit acknowledges support from the HORIZON-CL2–2022-TRANSFORMATIONS-01 Programme, under grant agreement No. 101094546.

Annex A1. Ternary diagram – gdp at risk (%) in relation to the types of threats



Annex A2. Results of multiple correlation analysis

Table A2.1
Correlation Matrix (Pearson)

Variable s	Total GDPatRisk (Bill.)	Share of Average annual GDP (%)	Natural threats_GDPatRisk (Billions)	Natural threats_l GDPatRisk (%)	Manmade threats_GDPatRisk (Billions)	Manmade threats_GDPatRisk (%)	Emergin threats_GDPatRisk (Billions)	Emergin threats_GDPatRisk (%)
Total Score 2012	0.234	−0.178	0.151	0.016	**0.342**	−0.016	0.240	−0.075
Total Score 2015	0.226	−0.167	0.134	−0.044	**0.356**	0.044	0.227	−0.061
Total Score 2019	0.166	−0.261	0.063	−0.120	**0.331**	0.120	0.221	0.037
Total Score 2021	0.218	−0.209	0.118	−0.043	**0.364**	0.043	0.266	0.009
Economy 2012	**0.329**	−0.073	0.279	0.178	**0.350**	−0.178	**0.382**	0.002
Economy 2015	0.286	−0.054	0.257	0.176	0.277	−0.176	0.284	−0.074
Economy 2019	0.124	−0.179	0.066	−0.049	0.209	0.049	0.177	0.068
Economy 2021	0.118	−0.172	0.060	−0.047	0.206	0.047	0.185	0.083
Research and Development 2012	**0.430**	−0.100	0.291	0.078	**0.604**	−0.078	**0.468**	−0.084
Research and Development 2015	**0.473**	−0.066	**0.323**	0.087	**0.658**	−0.087	**0.502**	−0.116
Research and Development 2019	**0.402**	−0.117	0.274	0.076	**0.563**	−0.076	**0.469**	−0.018

(*continued on next page*)

Table A2.1 (*continued*)

Variable s	Total GDPatRisk (Bill.)	Share of Average annual GDP (%)	Natural threats_GDPatRisk (Billions)	Natural threats_l GDPatRisk (%)	Manmade threats_GDPatRisk (Billions)	Manmade threats_GDPatRisk (%)	Emergin threats_GDPatRisk (Billions)	Emergin threats_GDPatRisk (%)
Research and Development 2021	**0.428**	−0.087	0.295	0.106	**0.591**	−0.106	**0.501**	−0.030
Cultural Interaction 2012	0.182	−0.208	0.037	−0.072	**0.427**	0.072	**0.343**	0.067
Cultural Interaction 2015	0.216	−0.223	0.057	−0.048	**0.478**	0.048	**0.391**	0.057
Cultural Interaction 2019	**0.348**	−0.102	0.206	0.091	**0.546**	−0.091	**0.475**	−0.023
Cultural Interaction 2021	**0.313**	−0.145	0.161	0.038	**0.540**	−0.038	**0.434**	−0.017
Liveability 2012	−0.202	0.040	−0.061	0.012	**−0.434**	−0.013	**−0.503**	−0.217
Liveability 2015	−0.217	−0.108	−0.135	−0.164	**−0.328**	0.163	**−0.401**	−0.025
Liveability 2019	**−0.391**	**−0.404**	**−0.376**	**−0.372**	**−0.330**	**0.372**	**−0.394**	0.154
Liveability 2021	−0.268	−0.251	−0.235	−0.255	−0.271	0.255	**−0.354**	0.029
Environment 2012	−0.229	**−0.359**	−0.211	−0.250	−0.211	0.250	**−0.332**	−0.117
Environment 2015	−0.267	−0.282	−0.262	**−0.439**	−0.214	**0.439**	**−0.415**	−0.027
Environment 2019	−0.305	−0.302	−0.291	**−0.452**	−0.261	**0.452**	**−0.451**	0.005
Environment 2021	−0.186	−0.220	−0.149	−0.248	−0.216	0.248	−0.306	0.014
Accessibility 2012	0.221	−0.026	0.164	0.057	0.281	−0.057	0.207	−0.097
Accessibility 2015	0.231	0.039	0.180	0.065	0.277	−0.065	0.221	−0.096
Accessibility 2019	0.200	−0.072	0.141	0.014	0.270	−0.014	0.264	0.019
Accessibility 2021	0.235	−0.024	0.190	0.094	0.269	−0.094	0.252	−0.050
Total_Growth rate (%) (2012–2021)	−0.025	−0.079	−0.088	−0.194	0.104	0.092	0.115	0.267
Total_Growth rate (%) (2015–2021)	−0.052	−0.087	−0.075	−0.063	0.006	−0.049	0.115	0.221
Total_Growth rate (%) (2015–2019)	−0.252	−0.290	−0.283	−0.296	−0.133	0.151	−0.017	**0.389**
Total_Growth rate (%) (2019–2021)	0.195	0.191	0.197	0.220	0.146	−0.216	0.173	−0.111
Total_Dif Growth rate (2015–2019)/(2019–2021)	0.289	**0.313**	0.312	**0.334**	0.178	−0.231	0.113	**−0.335**
Econ_Growth rate (%) (2012–2021)	−0.289	−0.195	−0.301	−0.226	−0.198	0.221	−0.305	0.117
Econ_Growth rate (%) (2015–2021)	−0.264	−0.266	**−0.315**	−0.296	−0.102	0.207	−0.166	0.292
Econ_Growth rate (%) (2015–2019)	−0.258	−0.304	**−0.312**	**−0.314**	−0.091	0.229	−0.169	0.294
Econ_Growth rate (%) (2019–2021)	−0.070	0.019	−0.076	−0.064	−0.042	0.052	−0.035	0.052
Econ_Dif Growth rate (2015–2019)/(2019–2021)	0.161	0.242	0.200	0.207	0.048	−0.148	0.111	−0.198
R&D_Growth rate (%) (2012–2021)	0.062	0.041	0.006	−0.119	0.157	0.064	0.233	0.150
R&D_Growth rate (%) (2015–2021)	−0.104	−0.025	−0.065	0.021	−0.159	−0.109	0.010	0.140

(*continued on next page*)

Table A2.1 (*continued*)

Variable s	Total GDPatRisk (Bill.)	Share of Average annual GDP (%)	Natural threats_GDPatRisk (Billions)	Natural threats_l GDPatRisk (%)	Manmade threats_GDPatRisk (Billions)	Manmade threats_GDPatRisk (%)	Emergin threats_GDPatRisk (Billions)	Emergin threats_GDPatRisk (%)
R&D_Growth rate (%) (2015–2019)	−0.256	−0.124	−0.174	−0.021	**−0.358**	−0.111	−0.141	0.236
R&D_Growth rate (%) (2019–2021)	0.306	0.148	0.235	0.169	**0.376**	−0.131	**0.319**	−0.143
R&D_Dif Growth rate (2015–2019)/(2019–2021)	**0.336**	0.163	0.238	0.077	**0.452**	0.054	0.238	−0.262
Cult_Growth rate (%) (2012–2021)	0.257	0.139	0.215	0.172	0.278	−0.183	0.292	−0.064
Cult_Growth rate (%) (2015–2021)	**0.367**	**0.460**	**0.389**	**0.335**	0.238	−0.275	0.164	−0.261
Cult_Growth rate (%) (2015–2019)	**0.420**	**0.632**	**0.489**	**0.380**	0.187	−0.302	0.165	**−0.313**
Cult_Growth rate (%) (2019–2021)	−0.150	−0.294	−0.221	−0.143	0.023	0.138	−0.091	0.076
Cult_Dif Growth rate (2015–2019)/(2019–2021)	**−0.392**	**−0.610**	**−0.470**	**−0.357**	−0.147	0.291	−0.163	0.281
LIVEAB_Growth rate (%) (2012–2021)	0.005	−0.302	−0.154	**−0.334**	**0.318**	0.242	**0.318**	**0.315**
LIVEAB_Growth rate (%) (2015–2021)	−0.007	−0.123	−0.083	−0.123	0.145	0.117	0.152	0.069
LIVEAB_Growth rate (%) (2015–2019)	−0.085	−0.234	−0.181	−0.220	0.122	0.167	0.162	0.195
LIVEAB_Growth rate (%) (2019–2021)	0.192	0.277	0.242	0.215	0.047	−0.128	−0.004	−0.250
LIVEAB_Dif Growth rate (2015–2019)/(2019–2021)	0.134	0.286	0.230	0.254	−0.087	−0.182	−0.137	−0.245
Env_Growth rate (%) (2012–2021)	0.138	0.180	0.145	−0.025	0.091	−0.095	0.155	0.217
Env_Growth rate (%) (2015–2021)	0.159	0.137	0.207	0.227	0.027	**−0.363**	0.283	0.123
Env_Growth rate (%) (2015–2019)	−0.150	−0.161	−0.142	−0.051	−0.129	0.016	−0.181	0.084
Env_Growth rate (%) (2019–2021)	0.221	0.215	0.264	0.246	0.083	**−0.349**	**0.351**	0.059
Env_Dif Growth rate (2015–2019)/(2019–2021)	0.228	0.228	0.258	0.208	0.115	−0.272	**0.340**	0.011
Access_Growth rate (%) (2012–2021)	−0.005	−0.010	−0.001	−0.015	−0.010	−0.053	0.095	0.122
Access_Growth rate (%) (2015–2021)	−0.063	−0.144	−0.065	−0.009	−0.042	−0.068	0.043	0.136
Access_Growth rate (%) (2015–2019)	−0.139	−0.259	−0.157	−0.180	−0.071	0.067	0.054	0.278
Access_Growth rate (%) (2019–2021)	0.080	0.123	0.100	0.213	0.023	−0.196	0.000	−0.131
Access_Dif Growth rate (2015–2019)/(2019–2021)	0.158	0.281	0.183	0.259	0.071	−0.155	−0.045	−0.300

Values in bold are different from 0 with a significance level alpha= 0.05

Table A2.2
Results of multicollinearity tests of the regression analysis (VIF - Variance inflation factor, T – tolerance)

	2021		2019		2015		2012	
	T	*VIF*	*T*	*VIF*	*T*	*VIF*	*T*	*VIF*
Economy	0250	4003	0313	3198	0436	2291	0416	2401
Research and Development	0229	4362	0247	4046	0364	2744	0292	3425
Cultural Interaction	0346	2890	0348	2876	0385	2596	0392	2549
Livability	0451	2216	0488	2050	0587	1703	0589	1697
Environment	0541	1847	0462	2163	0616	1623	0703	1423
Accessibility	0386	2594	0451	2216	0490	2042	0390	2564

Table A2.3
The equations of the regression models -(see also. The regression results - Table 1)

GDP@risk (2012)= 97.02 + 0.32 ×R&D−0.48 ×Environment;
GDP@risk (2015)= 85.64 + 0.58 ×R&D−0.15 ×Cultural Interaction−0.4 ×Environment;
GDP@risk (2019)= 204.06 ×Economy+ 0.32 ×R&D+ 0.20 ×Cultural Interaction−0.53 ×Liveability;
GDP@risk (2021)= 115.78 ×Economy+ 0.55 ×R&D−0.25 ×Liveability+ 0.32 ×Accessibility.

Annex A3. Test statistics for regression models for four distinct years

Testing the models for multicollinearity showed acceptable VIF values below 5 and a tolerance T > 0.1 for all models (see Annex A2). However, given the p-value of the F statistic computed in the ANOVA table and given the significance level of 5 %, not all models appeared to be equally valid; only some of them appear to be significantly better than the basic mean would suggest.

		GDPatRisk (Bill.)	GDPatRisk (%)	Nat_threats _GDPatRisk (Bill.)	Nat_threats _GDPatRisk (%)	Man_threats _GDPatRisk (Bill.)	Man_threats _GDPatRisk (%)	Emerg_threats _GDPatRisk (Bill.)	Emerg_threats _GDPatRisk (%)
2012	R^2	**0.274**	**0.213**	**0.164**	0.151	**0.565**	0.151	**0.524**	0.052
	F	**6.786**	**3.156**	**3.540**	2.073	**8.585**	2.076	**9.370**	0.977
	Pr > F	**0.003**	**0.037**	**0.039**	0.122	**< 0.0001**	0.121	**< 0.0001**	0.386
2015	R^2	**0.377**	0.216	**0.304**	**0.349**	**0.576**	**0.349**	**0.527**	0.044
	F	**7.056**	2.337	**3.717**	**6.263**	**15.828**	**6.266**	**13.017**	0.822
	Pr > F	**0.001**	0.075	**0.013**	**0.002**	**< 0.0001**	**0.002**	**< 0.0001**	0.448
2019	R^2	**0.399**	**0.206**	**0.239**	**0.274**	**0.617**	**0.274**	**0.579**	0.050
	F	**5.653**	**4.675**	**5.643**	**6.806**	**13.720**	**6.807**	**11.684**	0.954
	Pr > F	**0.001**	**0.016**	**0.007**	**0.003**	**< 0.0001**	**0.003**	**< 0.0001**	0.395
2021	R^2	**0.345**	0.112	0.211	0.117	**0.594**	0.117	**0.495**	0.031
	F	**4.476**	1.468	2.277	1.543	**12.460**	1.544	**8.340**	0.575
	Pr > F	**0.005**	0.240	0.081	0.221	**< 0.0001**	0.220	**< 0.0001**	0.568

* validated models– in bold

Annex A4. Network analysis results

Table A4.1
Network Analysis - *Economy* Outcomes

Summary of Network		
Number of nodes	**Number of non-zero edges**	**Sparsity**
19	71 / 171	0.585

Centrality measures per variable				
	Network			
Variable	**Betweenness**	**Closeness**	**Strength**	**Expected influence**
GDP@risk	−0.142	0.383	0.921	1.149

(*continued on next page*)

Table A4.1 (*continued*)

Centrality measures per variable				
	Network			
Variable	Betweenness	Closeness	Strength	Expected influence
%GDP@risk	1.657	1.072	1.083	−1.843
Natural threats_GDPatRisk (Billions)	0.115	0.793	1.015	0.329
Natural threats_Share of Total GDPatRisk (%)	−0.656	0.776	0.987	−0.231
Manmade threats_GDPatRisk (Billions)	−0.656	−0.244	0.216	1.128
Manmade threats_Share of Total GDPatRisk (%)	−0.785	0.776	0.987	−2.316
Emergin threats_GDPatRisk (Billions)	−0.399	0.107	0.397	1.147
Emergin threats_Share of Total GDPatRisk (%)	−0.785	−0.993	−0.995	−1.487
Economy 2019	1.657	0.620	0.348	1.105
E_Level of Economic Freedom	2.171	0.424	0.176	0.630
E_Total Market Value of Listed Shares on Stock Exchanges	−0.142	−0.622	−1.001	0.405
E_World's Top 300 Companies	−0.785	−0.849	−1.237	0.191
E_Wage Level	−0.271	0.612	0.315	0.129
E_Level of Political. Economic and Business Risk	−0.785	0.444	0.084	0.807
E_Corporate Tax Rate	−0.785	−2.384	−2.049	−0.546
E_Office Area per Employee	−0.785	−1.635	−1.396	0.046
E_Ease of Securing Human Resources	1.015	1.125	0.745	−0.175
E_Number of Employees in Service Industry for Business Enterprises	−0.785	−1.168	−1.330	−0.365
E_Number of Employees	1.143	0.764	0.738	−0.103

Clustering measures per variable				
	Network			
Variable	Barrat	Onnela	WS	Zhang
Manmade threats_Share of Total GDPatRisk (%)	0.451	0.535	0.341	0.381
Emergin threats_GDPatRisk (Billions)	0.381	0.636	0.294	0.441
Emergin threats_Share of Total GDPatRisk (%)	1.634	1.490	1.763	2.091
GDP@risk	0.024	0.093	−0.065	0.037
%GDP@risk	−0.641	−0.705	−0.592	−0.681
Economy 2019	−0.745	−0.831	−0.776	−0.846
E_Level of Economic Freedom	−0.396	−0.428	−0.523	−0.352
E_Total Market Value of Listed Shares on Stock Exchanges	−1.051	−1.094	−0.980	−0.738
E_World's Top 300 Companies	−0.538	−0.660	−0.523	−0.413
E_Number of Employees	−0.335	−0.251	−0.269	−0.366
E_Number of Employees in Service Industry for Business Enterprises	1.634	1.048	1.763	1.248
E_Wage Level	−0.004	−0.075	−0.015	−0.037
E_Ease of Securing Human Resources	0.031	0.330	0.112	−0.077
E_Office Area per Employee	0.156	−0.241	0.239	0.370
E_Corporate Tax Rate	−2.885	−2.878	−2.808	−2.913
E_Level of Political. Economic and Business Risk	0.538	0.684	0.457	0.317
Natural threats_GDPatRisk (Billions)	0.652	1.086	0.620	0.444
Natural threats_Share of Total GDPatRisk (%)	0.451	0.535	0.341	0.381
Manmade threats_GDPatRisk (Billions)	0.644	0.725	0.620	0.713

Table A4.2
Network Analysis - *R&D* Outcomes

Summary of Network		
Number of nodes	Number of non-zero edges	Sparsity
17	70 / 136	0.485

Centrality measures per variable				
	Network			
Variable	Betweenness	Closeness	Strength	Expected influence
GDP@risk	2.015	1.269	1.400	0.733
%GDP@risk	1.277	−0.134	−0.160	−1.315
Natural threats_GDPatRisk (Billions)	0.096	0.370	0.565	−0.024
Natural threats_Share of Total GDPatRisk (%)	−0.643	−0.689	−0.369	−0.592
Manmade threats_GDPatRisk (Billions)	−0.200	0.882	0.935	0.870
Manmade threats_Share of Total GDPatRisk (%)	−0.643	−0.689	−0.369	−2.197
Emergin threats_GDPatRisk (Billions)	−0.643	0.371	0.263	0.389
Emergin threats_Share of Total GDPatRisk (%)	−0.643	−1.600	−1.519	−1.534
Research and Development 2019	2.606	1.183	1.391	1.164
R&D_Interaction Opportunites Between Researchers	−0.052	0.175	−0.082	0.226
R&D_Number of Researchers	−0.200	1.281	1.105	1.218

(*continued on next page*)

Table A4.2 (*continued*)

Centrality measures per variable

Variable	Network Betweenness	Closeness	Strength	Expected influence
R&D_World's Top 200 Universities	−0.347	−0.087	−0.230	0.144
R&D_Academic Performance in Mathematics and Science	−0.052	0.789	0.671	0.968
R&D_Readiness for Accepting Foreign Researchers	−0.643	−1.731	−1.825	−0.468
R&D_Research and Development Expenditure	−0.643	−1.482	−1.745	−0.728
R&D_Number of Registered Industrial Property Rights (Patents)	−0.643	0.721	0.239	0.720
R&D_Number of Winners of HighlyReputed Prizes (Science and Technology related Fields)	−0.643	−0.630	−0.272	0.425

Clustering measures per variable

Variable	Network Barrat	Onnela	WS	Zhang
Manmade threats_Share of Total GDPatRisk (%)	0.771	0.633	0.678	0.353
Emergin threats_GDPatRisk (Billions)	−0.134	0.058	−0.163	0.200
Emergin threats_Share of Total GDPatRisk (%)	1.472	0.680	1.569	1.499
GDP@risk	−0.891	−0.812	−0.887	−0.816
%GDP@risk	−1.846	−2.177	−1.618	−1.812
Research and Development 2019	−1.276	−1.195	−1.265	−1.166
R&D_Number of Researchers	−0.298	0.164	−0.371	−0.179
R&D_World's Top 200 Universities	−0.854	−0.988	−0.881	−0.927
R&D_Academic Performance in Mathematics and Science	0.077	0.559	0.010	0.143
R&D_Readiness for Accepting Foreign Researchers	1.472	1.930	1.569	2.080
R&D_Research and Development Expenditure	1.472	0.535	1.569	0.672
R&D_Number of Registered Industrial Property Rights (Patents)	0.689	1.239	0.678	0.823
R&D_Number of Winners of HighlyReputed Prizes (Science and Technologyrelated Fields)	0.269	0.203	0.233	0.633
R&D_Interaction Opportunites Between Researchers	−0.858	−0.863	−0.881	−0.973
Natural threats_GDPatRisk (Billions)	−0.337	−0.092	−0.336	−0.603
Natural threats_Share of Total GDPatRisk (%)	0.771	0.633	0.678	0.353
Manmade threats_GDPatRisk (Billions)	−0.497	−0.504	−0.585	−0.277

Data availability

Data will be made available on request.

References

Aguirre, P., Asahi, K., Diaz-Rioseco, D., Riveros, I., Valdés, R.O., 2022. Medium-run local economic effects of a major earthquake. J. Econ. Geogr. https://doi.org/10.1093/jeg/ibac010.

Ahern, J., 2011. From fail-safe to safe-to-fail: Sustainability and resilience in the new urban world. Landsc. Urban Plan. 100 (4), 341–343. https://doi.org/10.1016/j.landurbplan.2011.02.021.

Ahmed, S., Nahiduzzaman, K.M., Hasan, M.M.U., 2018. Unpacking challenges and reflecting on unjust transitions. Cities 77, 142–157. https://doi.org/10.1016/j.cities.2017.11.012.

Aldrich, D.P., 2012. Building resilience social capital in post-disaster recovery. University of Chicago Press, Chicago.

Alexander, D.E., 2021. On evidence-based practice in disaster risk reduction. Int. J. Disaster Risk Sci. 12, 919–927. https://doi.org/10.1007/s13753-021-00381-3.

Allam, Z., Jones, D.S., 2021. Future (post-COVID) digital, smart and sustainable cities in the wake of 6G: Digital twins, immersive realities and new urban economies. Land Use Policy 101, 105201. https://doi.org/10.1016/j.landusepol.2020.105201.

Allam, Z., Moreno, C., Chabaud, D., Pratlong, F., 2022. Proximity-based planning and the "15-minute city": A sustainable model for the city of the future. The Palgrave Handbook of Global Sustainability. Springer International Publishing, pp. 1–20. https://doi.org/10.1007/978-3-030-38948-2_178-1.

Anantasari, E., Daly, M., Glassey, P., Grace, E., Coomer, M., Woods, R., 2017. Disaster Risk Reduction (DRR) Capacity and Capability of Local Government in Indonesia. In: Djalante, R., Garschagen, M., Thomalla, F., Shaw, R. (Eds.), Disaster Risk Reduction in Indonesia. Springer, Berlin, pp. 127–155. https://doi.org/10.1007/978-3-319-54466-3_5.

Anttila-Hughes, J., Keith, J., Hsiang, S.M., 2013. Destruction, disinvestment, and death: Economic and human losses following environmental disaster. SSRN Electron. J. https://doi.org/10.2139/ssrn.2220501.

Araiza-Aguilar, J.A., Rojas-Valencia, M.N., Aguilar-Vera, R.A., 2020. Forecast generation model of municipal solid waste using multiple linear regression. Glob. J. Environ. Sci. Manag. https://doi.org/10.22034/GJESM.2020.01.01.

Aroca, P., Kourtit, K., Nijkamp, P., 2021. Prosilience trajectories for phoenix regions. East. J. Eur. Stud. 12, 76–98. https://doi.org/10.47743/ejes-2021-SI04.

Aven, T., 2015. The concept of antifragility and its implications for the practice of risk analysis. Risk Anal. 35 (3), 476–483. https://doi.org/10.1111/risa.12279.

Baills, A., Grandjean, G., Maspataud, A., Ettinger, S., Abad, J., Dias, N., Albris, K., Hemmers, J., Clegg, G., Martucci, C., 2020. The espresso action database: Collecting and assessing measures for disaster risk reduction and climate change adaptation. Int. J. Disaster Risk Reduct. 48, 101599. https://doi.org/10.1016/j.ijdrr.2020.101599.

Bajwa, S., Dabral, A., Chatterjee, R., Shaw, R., 2021. Co-producing knowledge innovation through thematic incubators for disaster risk reduction and sustainable development in India. Sustainability 13 (4), 2044. https://doi.org/10.3390/su13042044.

Banica, A., Kourtit, K., Nijkamp, P., 2024. Natural hazards and threats: A blessing in disguise hypothesis. Oxf. Res. Encycl. Nat. Hazard Sci. https://doi.org/10.1093/acrefore/9780199389407.013.509.

Bănică, A., Kourtit, K., Nijkamp, P., 2020. Natural disasters as a development opportunity: A spatial economic resilience interpretation. Rev. Reg. Res. 40, 223–249. https://doi.org/10.1007/s10037-020-00141-8.

Bănică, A., Muntele, I., Istrate, M., 2021. Sustainability, resilience and wellbeing convergences for place-based approaches. Territ. Identit-.-. Dev. 6 (2), 25–46. https://doi.org/10.23740/TID220212.

Barbosa, L.L., 2021. Chaos and innovation in design for disaster resilience. In: Raposo, D., Neves, J., Silva, J., Correia Castilho, L., Dias, R. (Eds.), Advances in Design, Music and Arts. Springer, Berlin, pp. 507–518. https://doi.org/10.1007/978-3-030-55700-3_35.

Barton, A., 1969. Communities in disaster: A sociological analysis of collective stress Situations. Doubleday, New York.

Becker, S.L., Reusser, D.E., 2016. Disasters as opportunities for social change: Using the multi-level perspective to consider the barriers to disaster-related transitions. Int. J. Disaster Risk Reduct. 18, 75–88.

Berry, B.J.L., 1964. Cities as systems within systems of cities. Pap. Reg. Sci. 13 (1), 147–163. https://doi.org/10.1016/j.ijdrr.2016.05.005.

Birkmann, J., Buckle, P., Jaeger, J., Pelling, M., Setiadi, N., Garschagen, M., Fernando, N., Kropp, J., 2010. Extreme events and disasters: A window of opportunity for change? Analysis of organizational, institutional and political changes, formal and informal responses after mega-disasters. Nat. Hazards 55 (3), 637–655. https://doi.org/10.1007/s11069-008-9319-2.

Bogardi, J.J., Fekete, A., 2018. Disaster-related resilience as ability and process: A concept guiding the analysis of response behavior before, during and after extreme events. Am. J. Clim. Change 7, 54–78. https://doi.org/10.4236/ajcc.2018.71006.

Borsekova, K., Nijkamp, P. (Eds.), 2019. Resilience and Urban Disasters: Surviving Cities. Edward Elgar Publishing, Cheltenham.

Bouchard, G., 2013. Neoliberalism in Québec: The response of a small nation under pressure. In: Hall, P.A., Lamont, M. (Eds.), Social Resilience in the Neoliberal Era. Cambridge University Press, New York, pp. 267–292. https://doi.org/10.1017/CBO9781139542425.016.

Brenner, N., Keil, R., 2014. From global cities to globalized urbanization. Glocalism. J. Cult., Polit. Innov. 3, 1–17. https://doi.org/10.12893/gjcpi.2014.3.3.

Büscher, C., Mascareño, A., 2011. Mechanisms of systematic risk production. In: Heinrichs, D., Krellenberg, K., Hansjürgens, B., Martínez, F. (Eds.), Risk Habitat Megacity. Springer, Berlin, pp. 39–63. https://doi.org/10.1007/978-3-642-11544-8_3.

Caldera, S., Mostafa, S., Desha, C., Mohamed, S., 2021. Integrating disaster management planning into road infrastructure asset management. Infrastruct. Asset Manag. 8 (4), 219–233. https://doi.org/10.1680/jinam.21.00012.

Cambridge Centre for Risk Studies, 2016. Cambridge global risk index 2017. University of Cambridge, Cambridge.

Caparros-Midwood, D., Dawson, R., Barr, S., 2019. Low carbon, low risk, low density: Resolving choices about sustainable development in cities. Cities 89, 252–267. https://doi.org/10.1016/j.cities.2019.02.018.

Capello, R., Nijkamp, P., Pepping, G., 1999. Sustainable cities and energy policies. Springer, Berlin.

Cere, G., Zhao W., Rezgui, Y. et al. (2017), Multi-objective Consideration of Earthquake Resilience in the Built Environment: The Case of Wenchuan Earthquake, 2017 International Conference on Engineering, Technology and Innovation (ICE/ITMC), Madeira, Portugal, 513-520, doi: 10.1109/ICE.2017.8279929.

Chang, S.E., Rose, A., 2012. Towards a theory of economic recovery from disasters. Int. J. Mass Emergencies Disasters 30 (2), 171–181. https://doi.org/10.1177/028072701203000202.

Chhibber, A., Laajaj, R., 2008. Disasters, climate change and economic development in sub-saharan Africa: Lessons and directions. J. Afr. Econ. 17 (2), ii7–ii49. ⟨http://documents.worldbank.org/curated/en/741071468007194538/Disasters-climate-change-and-economic-development-in-Sub-Saharan-Africa-lessons-and-future-directions⟩.

Coaffee, J., Lee, P., 2016. Urban Resilience. Macmillan, London.

Coburn, A.W., Bowman, G., Ruffle, S.J., Foulser-Piggott, R., Ralph, D., Tuveson, M. (2014), *A Taxonomy of Threats for Complex Risk Management*, Cambridge, Centre for Risk Studies, University of Cambridge, Cambridge, ⟨https://www.jbs.cam.ac.uk/centres/risk/publications/managing-multi-threat/a-taxonomy-of-threats-for-complex-risk-management/⟩.

Coburn, A.W., Evan, T., Foulser-Piggott, R., Kelly, S., Ralph, D., Ruffle, S.J., Yeo, J.Z., 2015. World City Risk 2025: Part I Overview and Results. Cambridge, Centre for Risk Studies, University of Cambridge, Cambridge.

Crespo Cuaresma, J., Hlouskova, J., Obersteiner, M., 2008. Natural disasters as creative destrcution? Evidence from developing countries. Econ. Inq. 46 (2), 214–226. https://doi.org/10.1111/j.1465-7295.2007.00063.x.

Croope, S.V., McNeil, S., 2011. Improving resilience of critical infrastructure systems postdisaster: Recovery and mitigation. Transp. Res. Board 2234 (1), 3–13. https://doi.org/10.3141/2234-01.

Cubitt, S., 2022. Turning disaster into crisis. Int. J. Cult. Stud. 25 (3–4), 260–267. https://doi.org/10.1177/13678779221084720.

Da Silva Corrêa, L., Perl, A., 2022. Global cities, hypermobility, and Covid-19. Cities 122, 103537. https://doi.org/10.1016/j.cities.2021.103537.

Dhyani, S., Lahoti, S., Khare, S., Pujari, P., Verma, P., 2018. Ecosystem based disaster risk reduction approaches (EbDRR) as a prerequisite for inclusive urban transformation of nagpur City, India. Int. J. Disaster Risk Reduct. 32, 95–105. https://doi.org/10.1016/j.ijdrr.2018.01.018.

Diappi, L., Bolchi, P., Franzini, L., 1999. Urban sustainability: Complex interactions and the measurement of risk. Cybergeo. https://doi.org/10.4000/cybergeo.1240.

Dovers, S.R., Handmer, J.W., 1992. Uncertainty, sustainability and change. Glob. Environ. Change 2 (4), 262–276.

Dube, E., 2020. The build-back-better concept as a disaster risk reduction strategy for positive reconstruction and sustainable development in Zimbabwe: A literature study. Int. J. Disaster Risk Reduct. 43, 101401. https://doi.org/10.1016/j.ijdrr.2019.101401.

Engle, J., 2018. Stories of tragedy, trust and transformation? A case study of education-centered community development in post-earthquake haiti. Prog. Plan. 124, 1–34. https://doi.org/10.1016/j.progress.2017.04.001.

Flowers, B., 2018. The Economics of Natural Disasters. Federal Reserve Bank of St. Louis, St. Louis.

Fomby, T., Ikeda, Y., Loayza, N.V., 2013. The Growth Aftermath of Natural Disasters. J. Appl. Econ. 28 (3), 412–434. https://doi.org/10.1002/jae.1273.

Freddi, F., Galasso, C., Cremen, G., Dall'Asta, A., Di Sarno, L., Giaralis, A., Gutiérrez-Urzúa, F., et al., 2021. Innovations in earthquake risk reduction for resilience: Recent advances and challenges. Int. J. Disaster Risk Reduct. 60, 102267. https://doi.org/10.1016/j.ijdrr.2021.102267.

Fung, J.F., Helgeson, J.F., 2017. Defining the resilience dividend: Accounting for co-benefits of resilience planning (NIST TN 1959; p. NIST TN 1959). Natl. Inst. Stand. Technol. https://doi.org/10.6028/NIST.TN.1959.

Gardoni, P., Murphy, C., 2008. Recovery from natural and manmade disasters as capabilities restoration and enhancement. Int. J. Sustain. Dev. Plan. 3 (4), 317–333. https://doi.org/10.2495/SDP-V3-N4-317-333.

Glaeser, E.L., 2022. Urban resilience. Urban Stud. 59 (1), 3–35. https://doi.org/10.1177/00420980211052230.

Güzey, Ö., 2016. The last round in restructuring the city: Urban regeneration becomes a state policy of disaster prevention in Turkey. Cities 50, 40–53. https://doi.org/10.1016/j.cities.2015.08.010.

Hallegatte, S., Dumas, P., 2009. Can natural disasters have positive consequences? Investigating the role of embodied technical chang. Ecol. Econ. 68 (3), 777–786. https://doi.org/10.1016/j.ecolecon.2008.06.011.

Han, H. and Dawson, K.J. (2020), JASP, https://doi.org/10.31234/osf.io/67dcb.

Hart, P., Boin, R.A., 2001. Between crisis and normalcy: The long shadow of post-crisis politics. In: Rosenthal, U., Boin, R.A., Comfort, L.K. (Eds.), Managing Crisis: Threats, Dilemmas, Opportunities. Charles C. Thomas, Springfield, pp. 28–46.

Heinrichs, D., Krellenberg, K., Hansjürgens, B., Martínez, F., 2012. Synthesis: An integrative perspective on risks in megacities. In: Heinrichs, D., Krellenberg, K., Hansjürgens, B., Martínez, F. (Eds.), Risk Habitat Megacity. Springer, Berlin, pp. 65–86. https://doi.org/10.1007/978-3-642-11544-8_16.

Hicks, A., Barclay, J., Chilvers, J., Armijos, M.T., Oven, K., Simmons, P., Haklay, M., 2019. Global mapping of citizen science projects for disaster risk reduction. Front. Earth Sci. 7, 226. https://doi.org/10.3389/feart.2019.00226.

Hoffman, S.M., 1999. The regenesis of traditional gender patterns in the wake of disaster. In: Oliver-Smith, A., Hoffman, S.M. (Eds.), The Angry Earth: Disaster in Anthropological Perspective. Routledge, New York, pp. 174–191. https://doi.org/10.4324/9781315298917-29.

Hoffman, S.M., Oliver-Smith, A. (Eds.), 2002. Catastrophe & Culture: The Anthropology of Disaster. School of American Research Press, J. Currey, Oxford. https://doi.org/10.2307/25606126.

Hoopes, L., 2017. Prosilience: Building your resilience for a turbulent world. Dara Press, Brooklyn, NY.

Hsiang, S.M., 2010. Temperatures and cyclones strongly associated with economic production in the caribbean and central America. Proc. Natl. Acad. Sci. 107 (35), 15367–15372. https://doi.org/10.1073/pnas.1009510107.

Hu, H., Lei, T., Hu, J., Zhang, S., Kavan, P., 2018. Disaster-mitigating and general innovative responses to climate disasters: Evidence from modern and historical China. Int. J. Disaster Risk Reduct. 28, 664–673. https://doi.org/10.1016/j.ijdrr.2018.01.022.

Huang, L., Yin, X., Yang, Y., Luo, M., Huang, S., 2020. Blessing in disguise': The impact of the wenchuan earthquake on inbound tourist arrivals in Sichuan, China. J. Hosp. Tour. Manag. 42, 58–66. https://doi.org/10.1016/j.jhtm.2019.11.011.

Ichikawa, H., Yamato, N., Dustan, P., 2017. Competitiveness of global cities from the perspective of the global power city index. Procedia Eng. 198, 736–742. https://doi.org/10.1016/j.proeng.2017.07.125.

IFRC, 2010. Focus on Urban Risk. International Federation of Red Cross and Red Crescent Societies.

Imperiale, A.J., Vanclay, F., 2021. Conceptualizing community resilience and the social dimensions of risk to overcome barriers to disaster risk reduction and sustainable development. Sustain. Dev. 29 (5), 891–905. https://doi.org/10.1002/sd.2182.

Izumi, T., Shaw, R., Djalante, R., Ishiwatari, M., Komino, T., 2019. Disaster risk reduction and innovations. Prog. Disaster Sci. 2, 100033. https://doi.org/10.1016/j.pdisas.2019.100033.

JASP Team 2024, (Made in JASP, JASP Team 2024 (JASP, Jeffrey's Amazing Statistics Program) (official webpage: https://jasp-stats.org/)).

Jones, C.I., Klenow, P.J., 2016. Beyond GDP? Welfare across countries and time. Am. Econ. Rev. 106 (9), 2426–2457. https://doi.org/10.1257/aer.20110236.

Joseph, J., McGregor, J.A., 2020. Wellbeing, Resilience and Sustainability: The New Trinity of Governance. Macmillan, Palgrave.

Kabisch, N., Korn, H., Stadler, J., Bonn, A., 2017. Nature-Based Solutions to Climate Change Adaptation in Urban Areas: Linkages between Science, Policy and Practice (eds.). Springer, Berlin.

Klomp, J., Valckx, K., 2014. Natural disasters and economic growth: A meta-analysis. Glob. Environ. Change 26, 183–195. https://doi.org/10.1016/j.gloenvcha.2014.02.006.

Koerniadi, H., Krishnamurti, C., Tourani-Rad, A., 2016. Natural disasters – Blessings in disguise? Singap. Econ. Rev. 61 (01), 1640004. https://doi.org/10.1142/S021759081640004X.

Kourtit, K., Nijkamp, P., Türk, U., Wahlstrom, M., 2022. City love and place quality assessment of liveable and loveable neighbourhoods in rotterdam. Land Use Policy 119, 106109. https://doi.org/10.1016/j.landusepol.2022.106109.

Kourtit, K., Nijkamp, P., 2016. Exploring the 'new urban world. Ann. Reg. Sci. 56, 591–596. https://doi.org/10.1007/s00168-015-0717-6.

Kourtit, K., Nijkamp, P., 2017. Critical performance factors for large world cities – In search of qualitative causal patterns by means of rough set analysis. Region 4 (1), 51. https://doi.org/10.18335/region.v4i1.118.

Kreps, G., 1995. Disaster as systemic event and social catalyst: A clarification of subject matter, 255–24 Int. J. Mass Emergencies Disasters 13. https://doi.org/10.1177/028072709501300304.

Leiter, A.M., Oberhofer, H., Raschky, P.A., 2009. Creative disasters? Flooding effects on capital, labour and productivity within european firms. Environ. Resour. Econ. 43 (3), 333–350. https://doi.org/10.1007/s10640-009-9273-9.

Lister, N.-M., 2007. Sustainable large parks: Ecological design or designer ecology? In: Hargreaves, G., Czerniak, J. (Eds.), Large Parks. Architectural Press, NJ, pp. 35–54.

López-Gunn, E., Swinkels, J., Anzaldúa, G., Bea, M., Conceição Colaço, M., Deksne, M., Lalaj, N., McDonald, H., Rica, M., 2021. Communities of innovation for climate change adaptation and disaster risk reduction: Niche creation and anticipation. Sustainability 13 (9), 5180. https://doi.org/10.3390/su13095180.

Majewska, A., Denis, M., Jarecka-Bidzińska, E., Jaroszewicz, J., Krupowicz, W., 2022. Pandemic resilient cities: Possibilities of repairing polish towns and cities during

COVID-19 pandemic. Land Use Policy 113, 105904. https://doi.org/10.1016/j.landusepol.2021.105904.
Manyena, S.B., O'Brien, G., O'Keefe, P., Rose, J., 2011. Disaster resilience: A bounce back or bounce forward ability? Local Environ. 16 (5), 417–424. https://doi.org/10.1080/13549839.2011.583049.
Mavrodieva, A.V., Shaw, R., 2019. Enabling private sector engagement in disaster resilience in south and east asia. Risk, Hazards Crisis Public Policy 10 (4), 466–483. https://doi.org/10.1002/rhc3.12175.
Modica, M., Reggiani, A., 2015. Spatial economic resilience overview. Netw. Spat. Econ. 15 (2), 211–233. https://doi.org/10.1007/s11067-014-9261-7.
Monstadt, J., Schmidt, M., 2019. Urban resilience in the making? The governance of critical infrastructures in german cities. Urban Stud. 56 (11), 2353–2371. https://doi.org/10.1177/0042098018808483.
Monteil, C., Simmons, P., Hicks, A., 2020. Post-disaster recovery and sociocultural change: Rethinking social capital development for the new social fabric. Int. J. Disaster Risk Reduct. 42, 101356. https://doi.org/10.1016/j.ijdrr.2019.101356.
Moreno, C., 2024. The 15-Minute City. John Wiley, New York.
Murphy, C., Gardoni, P., 2008. The acceptability and the tolerability of societal risks: a capabilities-based approach. Sci. Eng. Ethics 14 (1), 77–92. https://doi.org/10.1007/s11948-007-9031-8.
Murphy, C., Gardoni, P., 2010. Assessing capability instead of achieved functionings in risk analysis. J. Risk Res. 13 (2), 137–147. https://doi.org/10.1080/13669870903126259.
Nassehi, A., 2002. Dichte Räume. Städte als Synchronisations- und Inklusionsmaschinen. In: Löw, M. (Ed.), Differenzierungen des Städtischen. Leske and Budrich, Opladen, pp. 211–232.
Nijkamp, P., 2008. XXQ factors for sustainable urban development: A systems economics view. Rom. J. Reg. Sci. 2 (1), 1–34.
Nijkamp, P., Banica, A., Kourtit, K., 2024, May 22. Natural hazards and threats: A blessing in disguise hypothesis (Last modified (blank)). *Oxf. Res. Encycl. Nat. Hazard Sci.*. https://doi.org/10.1093/acrefore/9780199389407.013.509.
Nijkamp, P., Pepping, G., 1998. A meta-analytical evaluation of sustainable city initiatives. Urban Stud. 35 (9), 1481–1500. ⟨https://www.jstor.org/stable/43084048⟩.
Nijkamp, P., Yim, H., 2001. Critical success factors for offshore airports – A comparative evaluation. J. Air Transp. Manag. 7 (3), 181–188. https://doi.org/10.1016/S0969-6997(01)00003-5.
OECD, 2018. Improving the evidence base on the costs of disasters. Assessing the Real Cost of Disasters. OECD, *Paris*, pp. 15–37.
Oliver-Smith, A., 1996. Anthropological research on hazards and disasters. Annu. Rev. Anthropol. 25, 303–328. https://doi.org/10.1146/annurev.anthro.25.1.303.
Östh, J., Reggiani, A., Nijkamp, P., 2018. Resilience and accessibility of swedish and Dutch municipalities. Transportation 45, 1051–1073. https://doi.org/10.1007/s11116-017-9854-3.
Owusu-Sekyere, E., Lunga, W., Karuaihe, S.T., 2021. The impact of disasters on economic growth in selected southern africa development community countries. ', *J. Disaster Stud.* 13 (1), a1081. https://doi.org/10.4102/jamba.v13i1.1081.
Pacheco-Torgal, F., Grangvist, C.-G., 2023. Adapting the Built Environment for Climate Change (eds.). Elsevier, Amsterdam.
Pascariu, G.C., Tiganasu, R., Kourtit, K., Nijamp, P. (Eds.), 2023. Resilience and Regional Development. Edward Elgar, Cheltenham.
Paton, D., Buergelt, P., 2019. Risk, transformation and adaptation: Ideas for reframing approaches to disaster risk reduction. Int. J. Environ. Res. Public Health 16 (14), 2594. https://doi.org/10.3390/ijerph16142594.
Pelling, M., 2003. Natural Disasters and Development in a Globalizing World. Routledge, London.
Petter, A.-M., Labbé, D., Lizarralde, G., Goulet, J., 2020. City profile: Canaan, Haiti - a new post disaster city. Cities 104, 102805. https://doi.org/10.1016/j.cities.2020.102805.
Platt, S., Gautam, D., Rupakhety, R., 2020. Speed and quality of recovery after the gorkha earthquake 2015 Nepal. Int. J. Disaster Risk Reduct. 50, 101689. https://doi.org/10.1016/j.ijdrr.2020.101689.
Qureshi, M.I., Yusoff, R.M., Hishan, S.S., Ferdous Alam, A.S.A., Zaman, K., Rasli, A.M., 2019. Natural disasters and malaysian economic growth: Policy reforms for disasters management. Environ. Sci. Pollut. Res. 26 (15), 15496–15509. https://doi.org/10.1007/s11356-019-04866-z.
Rao, Y., Hu, Z., Sharma, S.S., 2021. Do managers hedge disaster risk? Extreme earthquake shock and firm innovations. Pac. -Basin Financ. J. 70, 101673. https://doi.org/10.1016/j.pacfin.2021.101673.
Reggiani, A., De Graaff, T., Nijkamp, P., et al., 2022. Resilience: An evolutionary approach to spatial economic systems. Netw. Spat. Econ. 2, 211–229. https://doi.org/10.1023/A:1015377515690.
Roslan, A.F., Fernando, T., Biscaya, S., Sulaiman, N., 2021. Transformation towards risk-sensitive urban development: A systematic review of the issues and challenges. Sustainability 13, 10631. https://doi.org/10.3390/su131910631.
Sandholz, S., Lange, W., Nehren, U., 2018. Governing green change: Ecosystem-based measures for reducing landslide risk in Rio de Janeiro. Int. J. Disaster Risk Reduct. 32, 75–86. https://doi.org/10.1016/j.ijdrr.2018.01.020.
Schumpeter, J.A., 1950. Capitalism, Socialism and Democracy. Harper-Collins, New York.
Seale-Feldman, A., 2020. The work of disaster: Building back otherwise in post-earthquake nepal. Cult. Anthropol. https://doi.org/10.14506/ca35.2.07.
Shabnam, N., 2014. Natural disasters and economic growth: A review. Int. J. Disaster Risk Sci. 5 (2), 157–163. https://doi.org/10.1007/s13753-014-0022-5.
Shrestha, R., 2021. Community led post-earthquake heritage reconstruction in patan – issues and lessons learned. Prog. Disaster Sci. 10, 100156. https://doi.org/10.1016/j.pdisas.2021.100156.
Song, J., Chang, Z., Li, W., Feng, Z., Wu, J., Cao, Q., Liu, J., 2019. Resilience-vulnerability balance to urban flooding: A case study in a densely populated coastal city in China. Cities 95, 102381. https://doi.org/10.1016/j.cities.2019.06.012.
Songwathana, K., 2018. The relationship between natural disaster and economic development: A panel data analysis. Procedia Eng. 212, 1068–1074. https://doi.org/10.1016/j.proeng.2018.01.138.
Stanton-Geddes, Z., 2013. 2011 Floods: how about the Poor?'. Bangk. Post. July 23, 2013.
Staupe-Delgado, R., Kruke, B.I., 2018. Preparedness: Unpacking and clarifying the concept. J. Contingencies Crisis Manag. 26 (2), 212–224. https://doi.org/10.1111/1468-5973.12175.
Sudmeier-Rieux, K.I., 2014. Resilience – An emerging paradigm of danger or of hope? Disaster Prev. Manag.: Int. J. 23 (1), 67–80. https://doi.org/10.1108/DPM-12-2012-0143.
Taleb, N.N., 2012. Antifragile: Things that Gain from Disorder. Random House, New York.
Taleb, N.N., Douady, R., 2013. Mathematical definition, mapping, and detection of (Anti) fragility. Quant. Financ. 13, 1677–1689. https://doi.org/10.48550/arXiv.1208.1189.
Thomalla, F., Boyland, M., Johnson, K., Ensor, J., Tuhkanen, H., Gerger Swartling, Å., Han, G., Forrester, J., Wahl, D., 2018. Transforming development and disaster risk. Sustainability 10 (5), 1458. https://doi.org/10.3390/su10051458.
Tonn, G., Reilly, A., Czajkowski, J., Ghaedi, H., Kunreuther, H., 2021. U.S. transportation infrastructure resilience: Influences of insurance, incentives, and public assistance. Transp. Policy 100, 108–119. https://doi.org/10.1016/j.tranpol.2020.10.011.
Torabi, E., Dedekorkut-Howes, A., Howes, M., 2018. Adapting or maladapting: Building resilience to climate-related disasters in coastal cities. Cities 72, 295–309. https://doi.org/10.1016/j.cities.2017.09.008.
United Nations International Strategy for Disaster Reduction (UNISDR), 2002. Natural disasters and sustainable development: Understanding the links between development. Environ. Nat. Disasters 5. ⟨http://www.johannesburgsummit.org/⟩ (background Paper).
Usugami, J., Abe, H., 2012. A Case Study on the Relationship Between Disasters and Innovation. In: Proceedings of the 7th European Conference on Innovation and Entrepreneurship, 1 and 2. Inst Politecnico Santarem, Escola Super Gestao & Tecnologia, Portugal, pp. 689–694.
World Bank, 2013a. Planning, Connecting, and Financing Cities – Now: Priorities for City Leaders. World Bank, Washington, DC.
World Bank, 2013b. World Development Report 2014: Risk and OpportunPaity – Managing Risk for Development. World Bank, Washington, DC.
Yigitcanlar, T., Kamruzzaman, Md, 2018. Does smart city policy lead to sustainability of cities? Land Use Policy 73, 49–58. https://doi.org/10.1016/j.landusepol.2018.01.034.
Young, A.F., Marengo, J.A., Martins Coelho, J.O., Scofield, G.B., de Oliveira Silva, C.C., Correa Prieto, C., 2019. The role of nature-based solutions in disaster risk reduction: The decision maker's perspectives on urban resilience in são paulo state. Int. J. Disaster Risk Reduct. 39, 101219. https://doi.org/10.1016/j.ijdrr.2019.101219.
Zaidi, R.Z., Pelling, M., 2015. Institutionally configured risk: Assessing urban resilience and disaster risk reduction to heat wave risk in London. Urban Stud. 52 (7), 1218–1233. https://doi.org/10.1177/004209801351095.
Zhang, Z., Cui, P., Hao, J., Li, N., Zeng, Z., Liu, Y., Zou, Q., Huang, C., Wu, S., 2021. Analysis of the impact of dynamic economic resilience on post-disaster recovery 'secondary shock' and sustainable improvement of system performance. Saf. Sci. 144, 105443. https://doi.org/10.1016/j.ssci.2021.105443.
Zhou, B., Zhang, H., Evans, R., 2022. Build back better: A framework for sustainable recovery assessment. Int. J. Disaster Risk Reduct. 76, 102998. https://doi.org/10.1016/j.ijdrr.2022.102998.