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THE URBAN DOMINO EFFECT: A CONCEPTUALIZATION OF CITIES' INTERCONNECTEDNESS OF RISK

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Abstract

Cities are both *at* risk and the *cause* of risk. The interconnectedness of urban features and systems increases the likelihood of complex disasters and a cascade or 'domino' effect from related impacts. However, the lack of research means that our knowledge of urban risk is both scarce and fragmented.

This paper presents a framework for understanding and addressing urban risk. It examines the unique dynamics of risk in urban settings and exemplifies its particularities with data and analysis of specific cases. From this, it identifies improvements both in the content and indicators of the successor to the Hyogo Framework for Action (HFA2) that will be adopted in 2015.

While it is common to see disasters as 'causes', and the destruction of the built environment as 'effects', this paper highlights that the intricate links between cities and disasters cannot be described by a unidirectional cause-and-effect relationship. The city–disasters nexus is a bidirectional relationship, which constantly shapes, and is shaped by, other processes (such as climate change). This paper demonstrates how the characteristics of the urban fabric (physical/ spatial, environmental, social, economic and political/ institutional) and related systems increase risk by: (i) intensifying hazards or creating new ones, (ii) exacerbating vulnerabilities, and (iii) negatively affecting existing response and recovery mechanisms. We argue that in-depth knowledge of the links between cities' characteristic features, related systems and disasters is indispensable for addressing root causes and mainstreaming risk reduction into urban sector work. It enables city authorities and other urban actors to improve and adapt their work without negatively influencing the interconnectedness of urban risk.

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1 Introduction

Cities are both *at risk* and *the cause of risk*. While historically (and often currently) they are seen as places of refuge from environmental change (Pelling 2003; Wamsler 2014), recent decades have been characterized by increasing numbers of major and small-scale urban disasters (IPCC 2012; UNISDR 2012).

The interconnectedness of urban features, urban systems and related flows increases the likelihood of complex disasters and may create a cascade (or 'domino' effect) of impacts (United Nations 2012; WEF 2012; Little 2002; GAR 2011; GAR 2013). Risk dynamics in urban settings are poorly understood and, consequently, their root causes are seldom addressed (Becker 2012; Wisner et al. 2004; Helbing 2013; Wamsler 2014). This is reflected in the report of the Fourth Session of the Global Platform for Disaster Risk Reduction, which states that 'urban risk needs to be more fully understood' (UNISDR 2013a, 2).

This paper presents a framework for understanding and addressing urban risk. It examines risk dynamics in urban settings and exemplifies its particularities with data and analysis of specific cases. It identifies improvements both in the content and indicators of the successor to the Hyogo Framework for Action (HFA2) that will be adopted in 2015.

2 Research modality

Both recent and older literature on urbanization, city ecology and urban climate comfort was analysed to identify the links between urban form, urban systems and related flows, and their relation to risk.[1] The paper offers concrete examples of: (a) the interconnectedness of risk, and (b) policy interventions (identified from the literature and on-the-ground research carried out by the authors). While overall, the research takes a global approach, it also includes a range of illustrative country-specific examples.

This paper is based on two broader research projects entitled 'Forecasting Societies' Adaptive Capacities to Climate Change' (Lutz 2008) and 'Cities, Disaster Risk and Adaptation', funded by the *European Research Council* and *Resilient Regions*, respectively, and it presents key aspects of related results. More detail can be found in Wamsler 2014; Wamsler et al. 2013; Wamsler et al. 2012; and Wamsler and Brink 2014.

The basic concepts used for this research are presented in Box 1.

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[1] Related literature used for the framework described in Section 3 includes: Abbott 2012; Adam 1988; Baehring 2011; Baker 2012; Benton-Short and Short 2008; Alexander 2010; Bicknell et al. 2009; Bosher 2008; Brenner and Keil 2006; Bulkeley 2013; Bulkeley and Betsill 2003; da Silva et al. 2012; Dodman 2009; EEA 2012; Emmanuel 2005; Givoni 1998; Hall and Pfeiffer 2000; Hodson et al. 2012; IFRC 2010; Kay et al. 1982; Koch-Nielsen 2002; Konya and Swanepoel 1980; Lederbogen et al. 2011; LeGates and Stout 2000; McGranahan et al. 2007; Mitchell 2003; Mumford 1968; O'Brien and Leichenko 2008; Olgay 1963; Pelling 2003; Pelling and Wisner 2009; Roaf et al. 2005; Roberts et al. 2009; Salmon 1999; Sanderson 2000; Satterthwaite 2007; Satterthwaite 2008; Shaw and Sharma 2011; Simmel 1960; Tacoli 2012; UNHABITAT 2011; UNHABITAT 2007; UNHABITAT 2010a; UNHABITAT 2010b; Weber 1966; Weber 1966; White et al. 2013;Wisner et al. 2004; Worldwatch Institute 2007; and Yu 2006.

concepts and definitions

s that occur in cities (i.e. in an urban rather than rural context) are called urban disasters, ı there is no commonly accepted definition of what is meant by the terms 'urban' and 'city'. is generally viewed within the perspective of a rural–urban continuum spanning villages, small econdary (or medium-sized) cities, metropolitan areas and megacities (Wamsler 2014; UN s Division n.d.). In this paper the words 'urban' and 'city' are used interchangeably.

er is a "*serious disruption of the functioning of a community or a society involving widespread material, economic or environmental losses and impacts, which exceeds the ability of the community or society to cope using its own resources*" (UNISDR 2009, 9). Disasters are ıly understood as the result of an interaction between so-called 'natural' hazards and vulnerable ns (UNISDR 2009; Wisner et al. 2004). They are the outcome of *continuously present* risk ns.

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risk refers to risk related to both climatic and non-climatic hazards (see below). It is the lity or likelihood that a disaster occurs, and is determined by the same factors (i.e. the ion between hazards and susceptible conditions) (IPCC 2012; UNISDR 2009). A more ıensive conception of disaster risk is useful for understanding the interconnectedness of risk n urban areas – before, during and after a potential disaster. [a] Here, disaster risk has four ents, namely: (a) hazards, (b) vulnerability, (c) incapacity to respond, and (d) incapacity to (Wamsler 2014).

ι reduction

risk reduction (DRR) is the "*concept and practice of reducing disaster risks through systematic o analyse and manage the causal factors of disasters, including through reduced exposure to , lessened vulnerability of people and property, wise management of land and the environment, roved preparedness for adverse events*" (UNISDR 2009, 10). From our understanding of disaster above), this definition of DRR can be operationalized as:
d reduction and avoidance (i.e. measures to reduce or avoid hazards);
rability reduction (i.e. measures to reduce the susceptibility of the affected location in order to vithstand hazards);
nse preparedness (i.e. measures to improve post-impact response mechanisms and structures);
ery preparedness (i.e. measures to improve post-impact recovery mechanisms and structures) er 2014).
k reduction includes climate change adaptation (see Disaster risk and Resilience).

hazards include floods, windstorms, droughts, fires, heat and cold waves, sea level rise (water and landslides (IPCC 2012; IPCC 2007). Non-climatic hazards include earthquakes and volcanic ıs.

ster risk perspective, resilience refers to "*the ability of a system, community or society exposed* people's livelihoods, savings and physical capital; natural resources; resource degradation; levels of health and wellbeing; and conditions of equality, peace and security. However, it also depends on people's and institutions' *reaction* to the hazard, in the form of disaster response and disaster recovery. For operational reasons it is helpful to separate risk related to the susceptibility of the location, from risk related to the capacity of people to react (see above).

Source: Adapted from Wamsler 2014
Note: [a] The usefulness of a comprehensive risk definition for understanding interconnected urban risk will become clear in Section 3.3 The influence of cities on disasters.

3 The city–disasters nexus: A framework for understanding and addressing the inter-connectedness of urban risk

The city-disasters nexus provides a framework for understanding and addressing the inter-connectedness of urban risk. There is a widespread perception that disasters are an (uncontrollable) cause and the destruction of the built environment is an effect (Bosher 2008). Consequently, planning responses are often limited and focus on physical/ spatial aspects and the post-disaster context (Bosher 2008; UNISDR 2011; Wamsler 2014). The reality is, however, more complex.

Urbanization brings about profound changes, which distinguish urban and rural areas (LeGates and Stout 2000; Mumford 1968; UNHABITAT 2011; UNHABITAT 2007; Weber 1966). Cities are characterized by distinctive physical/ spatial, environmental, socio-cultural, economic and political/ institutional features. It is necessary to understand these features in order to systematically and comprehensively analyse the reciprocal relationship between cities and disasters.

3.1 Characteristics of cities

Urbanization finds its visible expression in the **urban fabric**. This is characterized by the distinctive **physical/spatial features** shown in Table 1.[2]

[2] Note that the characteristics described in Tables 1–4 are only an indication and do not apply to all cities.

Physical/spatial features	Distinctive urban characteristics
Population density	Population density and overpopulation (increased) Access to marginal areas (reduced)
Land coverage and vegetation	Built-up surface area (increased) Size, location and distribution of green and recreational areas (reduced) Tree coverage (reduced) Access to affordable space (reduced) 'Consumption' of land (including rural land) (increased)
Architecture	Height of buildings (increased) Differences in the height of buildings (more varied) Construction materials and colours (different; more influential e.g. of streets) Construction techniques (less traditional, more advanced) Shape of buildings (more varied and/or more restricted)
Organization of structures in space	Distance between buildings (reduced) Concentration and interdependence of buildings, services and technical infrastructure (increased) Concentration and interdependence of political and economic centres (increased) Orientation of buildings (more restricted) Street layout and street orientation (denser, more restricted)
Relationship between buildings and topographic aspects	Proximity to large bodies of water (reduced) Relation to nearby hills and valleys (more difficult to account for) Sloping terrain (more difficult to account for)
Infrastructure	Infrastructure network and connectivity (increased, more congested) Dependency on infrastructure network (increased) Flows (e.g. material and people) (increased)

Table 1 The urban fabric. Source: Adapted from Wamsler 2014.

Many of the environmental, socio-cultural and economic issues that make urban and rural areas different can be attributed to the physical features of the urban fabric described above. This becomes obvious when looking at the **environmental** changes caused by urbanization. These changes manifest in the **urban ecosystem**, which is characterized by distinctive features related to precipitation; wind; temperature; air quality; humidity; solar radiation; soil; water bodies; flora; fauna; noise; waste and waste water (Table 2) (Adam 1988).

Most of the environmental factors listed in Table 2 are directly related to the characteristics of the urban fabric. For example, sealing green areas for construction and high population density result in (amongst other things) increased energy use, emissions and heat. The latter, known as the "heat island effect" is the result of heat storage, radiation and outlet air from heating, industrial processes, traffic, etc. (Adam 1988).

Precipitation, wind, temperature, air, humidity and solar radiation are the abiotic ecological factors of the typical **urban climate**. The urban climate is generally rainier, less windy, hotter, more polluted, less humid and cloudier than surrounding areas (Adam 1988; Emmanuel 2005; Givoni 1998; Kay et al. 1982; Koch-Nielsen 2002; Konya and Swanepoel 1980; Olgay 1963; Roaf et al. 2005; Salmon 1999) although there are many intra-city differences (e.g. localized wind currents and turbulence).

Environmental features	Distinctive urban characteristics
Precipitation	Rainfall (increased) Snowfall (reduced)
Wind	Wind speed and exchange (reduced) Local wind circulation, gusts and turbulence (increased)
Temperature	Temperature (increased)
Air quality	Emissions (increased) Dust particles (increased)
Humidity	Air humidity (reduced) Fog and cloudiness (increased) Evaporation (reduced)
Solar radiation	Amount of natural lighting (reduced) Intensity of solar radiation (reduced)
Soil	Ground sealing and compression (increased) Soil quality (reduced)
Water bodies	Ground water level (reduced) Ground water quality (reduced) Surface water quality (reduced) Water flows (more regulated) Dependency on other (rural) areas for ecosystem services
Flora	Vegetation cover (reduced) Biodiversity of vegetation (different, specific city vegetation) Growing season (increased) Vegetation forms (generally reduced, but specific forms on facades, roofs, etc.) Dependency on other (rural) areas for ecosystem services
Fauna	Species biodiversity (generally reduced, overpopulation of some species)
Noise	Noise (increased)
Waste and wastewater	Amount of waste (increased) Type of waste (more hazardous) Waste water (increased waste water and increased mix of rainwater and backwater)

Table 2 The urban ecosystem and climate. Source: Adapted from Wamsler 2014

At first sight the **socio-cultural features** that characterize urban areas are less clearly connected to the physical changes caused by urbanization. They manifest in a characteristic **urban society and culture** (**urban life**), which has distinctive features related to family structures; social cohesion; social inequality; public participation; values; and population diversity (Table 3) (LeGates and Stout 2000; Wirth 1938; White et al. 2013; Abbott 2012; Lederbogen et al. 2011).

Socio-cultural features	Distinctive urban characteristics
Family structures	Nuclear family structures (increased) Extended family structures (reduced) Female-headed households (increased/reduced)
Social cohesion	Sense of community (reduced) Sense of family and family obligations (reduced) Local leadership structures (reduced) Social interaction (increased) Anonymity (increased)
Social inequality	Segregation of population groups (increased) Gender equality (increased)
Public participation	Public participation (reduced)
Values and habits	New value systems (increased individualism, etc.) Traditional/ indigenous knowledge (reduced) Secularization (increased) Consumerism (increased, e.g. increased consumption of meat, fast food, energy) Life pace (increased) Formal education (increased) Illiteracy (reduced)
Population diversity	Population diversity/ heterogeneous communities (increased)
Health and security	Health status (generally increased; certain health problems, e.g. obesity, and time-related stress may increase) Violence and organized crime (increased)

Table 3 Urban society and culture. Source: Adapted from Wamsler 2014.

However, an in-depth analysis shows that several of these socio-cultural aspects are directly linked to the physical/ spatial features of the urban fabric. For example, high population density, overpopulation, lack of affordable space and the lack of green and recreational areas can influence family structures, social cohesion and the sense of community. In overcrowded conditions, issues such as competition for space and poor infrastructure (e.g. lack of, or leaking waste water pipes) can generate conflicts between neighbours. Likewise, the failure of infrastructure to provide adequate water, sanitation, drainage, roads and footpaths increases the health problems, workload and insecurity of residents, especially women (IFRC 2010; Tacoli 2012). For example, houses that lack water and sanitation force girls and women to seek toilets or washing areas away from their homes, and inadequate transportation infrastructure forces citizens to cross insecure areas (Tacoli 2012; Amnesty International 2010). Furthermore, difficult access to urban areas, together with a lack of public leisure space can isolate certain groups (such as the elderly and women with small children) and make them even more bound to their compact homes.

Finally, urbanization leads to **economic, political and institutional** changes. These manifest in **the urban economy** and **governance system** which, unlike in rural areas, relies upon non-agricultural (vs. agricultural) incomes and a money (vs. subsistence) economy; and which is characterized by urban-specific livelihood practices; resource availability; public expectations; and public reliance on institutions and social security systems (Table 4) (LeGates and Stout 2000; UNHABITAT 2011; UNHABITAT 2007; Pelling 2003).

Economic, political and institutional features	Distinctive urban characteristics
Agricultural versus non-agricultural incomes	Agricultural versus non-agricultural incomes (reduced)
Subsistence versus money economy	Subsistence versus money economy (reduced) Dependency on (rural) food market (increased) Monetary income (increased) Prices of goods and services (increased) Income and employment opportunities (increased/less equal) Labour as a critical asset (increased)
Urban livelihood practices	Specialization versus diversification (increased; overexploitation of natural assets increased) Working space (reduced) Use of housing as a productive asset (increased)
Resource availability	Resource availability (increased) Resource distribution (less equal)
Control power	Control of compliance with legal frameworks (increased)
Institutions	Presence and concentration of institutions and access to their services (increased)
Public expectations	Public expectations (increased)
Public reliance on institutions and social security systems	Public reliance on institutions, urban governance and social security system (increased)

Table 4 The urban economy and governance. Source: Adapted from Wamsler 2014.

Here again, interconnections with the urban fabric are manifold. Space restrictions make it impossible for citizens to be self-subsistent or rely upon agriculture as their main source of income. Likewise, growing food (in combination with another job) as a diversification strategy is rarely viable.

The spatial concentration of political and economic centres translates, on the one hand, into more resources and jobs (although they are not equally accessible) and, on the other hand, to increased expectations and reliance on institutions and social security systems. An example is the large number of urban migrants, who have moved far away from social safety nets such as the (extended) family. Many citizens thus rely on public authorities to solve their problems, rather than taking any risk reduction actions themselves (Leonardsen 2012; Wamsler and Lawson 2012).

In sum, urbanization leads to a characteristic urban fabric, ecosystem and climate, society and culture, and economy and governance system. The physical/ spatial, environmental, socio-cultural, and economic and political features of cities influence each other. A comprehensive analysis of the city–disasters nexus needs to take all of these factors into account (Image 1).

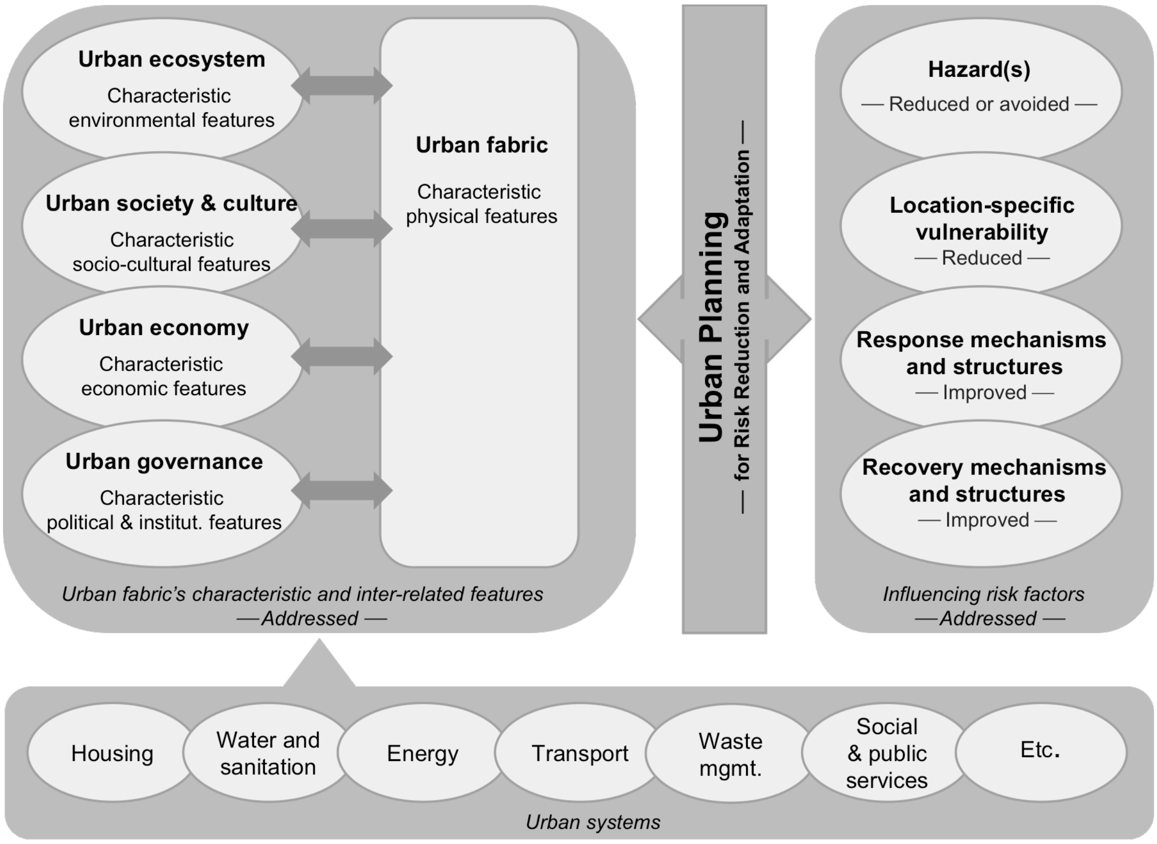


Image 1 The city–disasters nexus: city features, urban systems and risk factors

3.2 Urban systems – sectors and related institutions

The physical/ spatial, environmental, socio-cultural, economic and political/ institutional features of cities described in Section 3.1 are directly linked to urban systems. These systems provide the functions that support the everyday life of cities (e.g. housing, water and sanitation, energy, transportation and telecommunication, environment and natural resource management, social, cultural, educational and economic services). Urban systems thus form an integral part of everyday life.

Urban systems directly shape, and are shaped by the features of cities. However, they share many internal interfaces and are increasingly interconnected. For instance, the density and spatial concentration of housing can negatively affect access to services and service efficiency (e.g. transportation, energy, water and waste management). Inadequate roads and public transport can put pressure on hospitals due to traffic accidents, pollution and morbidity (Ranhagen and Groth 2012). Importantly, many urban systems depend on the constant provision of water, electricity and fuel (see Box 2 and Image 2).

Furthermore, as urban societies become 'smarter', more and more critical activities rely on information and communication technology, which, in turn, requires electricity to function (Chapman et al. 2013) (Box 2). Even actions aimed at making cities 'climate smart' (in the sense of mitigating climate change) contribute to the interconnectedness of urban systems and sectors. For example, transport electrification increases the sector's dependence on the energy sector (Chapman et al. 2013).

An event that illustrates society's high dependence on electricity was the 2002 Akalla tunnel fire in Stockholm, Sweden, which caused a major blackout. As a result, parts of the Metro system failed, which led to a challenging evacuation of passengers through tunnels and increased traffic on the streets above (where dysfunctional traffic and streetlights created another problem). Telephone landlines, mobile phone networks and IT networks stopped working, lifts had to be manually evacuated and many code locks became useless. Water and sewage pumps stopped, as did refrigerators and freezers, causing food to spoil (Becker 2012; Deverell 2004).

These examples show that the effect of one urban system on another can be either direct, such as the disruption of a critical flow (e.g. electricity), or based on longstanding processes (such as urbanization). Furthermore, interdependencies can be the result of events that occurred in a distant place or time. An example is the provision of improved (or unequal) access to education, where the effects on the social or economic system may only become visible once the affected generation has reached adulthood (Lutz 2011). As Becker (2012) argues, complex dependencies between urban entities "do not only allow the effects of an unwanted event to cascade throughout society, [but] also transmit the effects of human decisions and action, for good and for bad, and make it difficult for us to foresee the actual effects of our policies and practice."

Box 2 Interconnected urban risk and systems: The case of Stockholm

A risk and vulnerability assessment conducted by Stockholm's County Administrative Board in 2012, identified a number of critical dependencies contributing to the interconnectedness of risk. A ***critical dependency*** is defined as ***a dependency that is crucial for societal functions to work***; it is characterized by a direct and lasting impairment to a dependent activity, should a provider activity be disrupted. Such impairments can occur if the dependent activity lacks buffers and, thus, durability.

The assessment acknowledged that certain dependencies would always exist in modern society, such as that on ***electricity***. Electricity and ***electronic communications*** are often difficult to separate because they are highly interdependent. Electricity is required for electronic communications to work; in turn the electricity sector is dependent on functional electronic communications.

Furthermore, to handle an extraordinary event, there is often a high dependency on ***transport and roads***. Unusable roads make it difficult to re-establish elementary functions, such as the ***supply of goods***. The transport sector depends heavily on the ***fuel supply***, which, in turn, depends on electricity (for fuel pumps to work). Access to fuel is a prerequisite for running ***standby generators*** during a power shortage. Reserve power is an important resource that can mitigate the consequences of a prolonged power outage. In the County, critical societal functions were also very dependent on ***public transportation***. Widespread disruption to public transport has a direct impact on the ***production and delivery of services***.

To manage a crisis and to keep residents informed during a crisis, ***information***, or rather the ***ability to inform***, is another critical dependency. If the public cannot be provided with information, there is a high risk of misconceptions and rumours being spread that can aggravate an already serious situation.

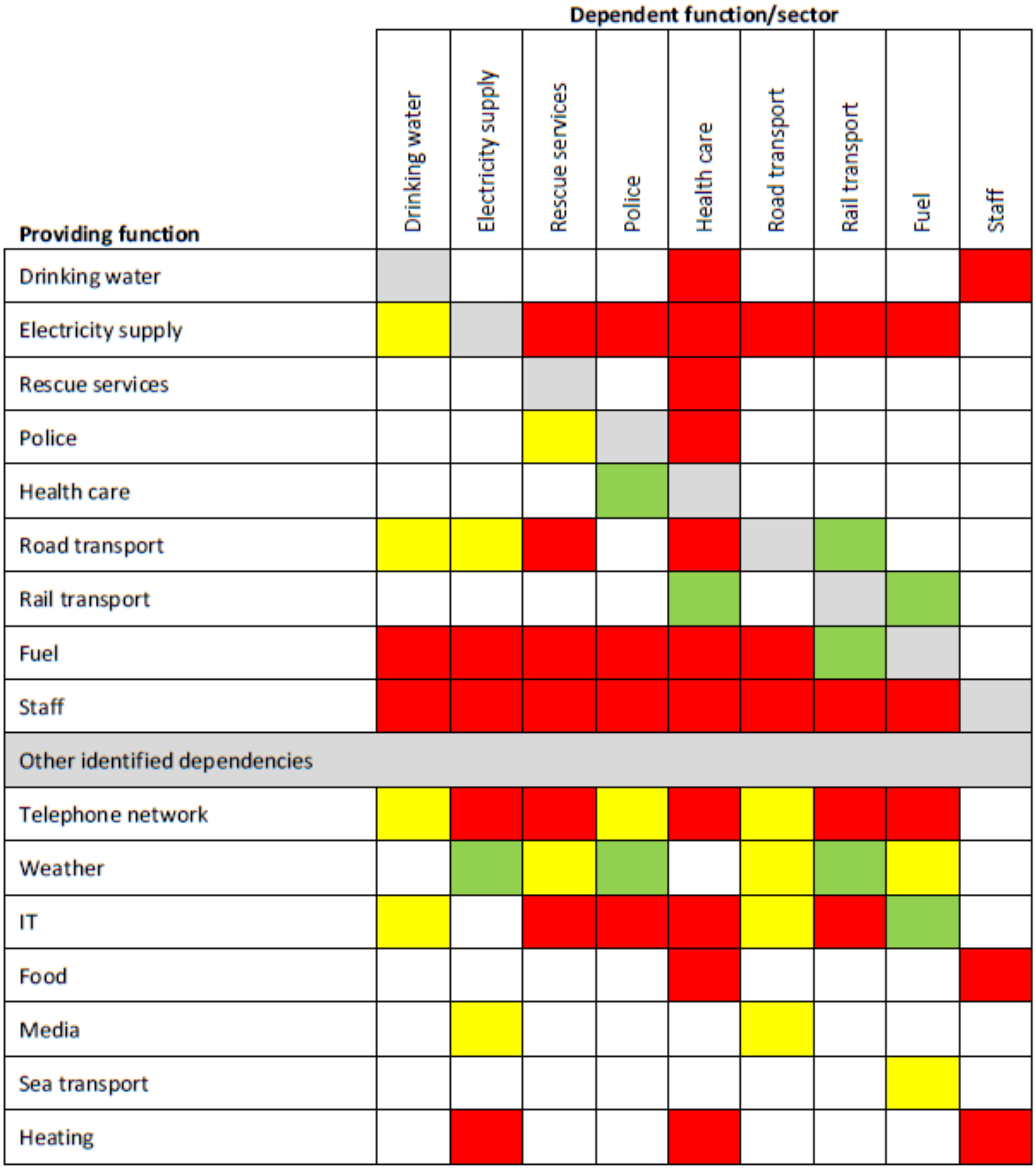
Finally, ***drinking water*** was seen as the county's most important commodity as people depend on it for survival.

The assessment also highlighted that ***the individual citizen*** is first and foremost responsible for their own health and safety. Most people are, however, not accustomed to dealing with crises. In urban areas, many people regard ***access to cards and cash*** as important in managing a crisis. Therefore, the cash supply is another important function to maintain.

Source: Adapted from Länsstyrelsen i Stockholms län, 2012

On a more positive note, the adequate consideration of the interfaces between urban systems can stimulate synergies (Hodson et al. 2012). Examples include: integrated land use, mixed-use structures, green areas, public spaces, mobility and energy systems and risk reduction infrastructure. Another example is local collection of rain and stormwater that can enhance greening, ecosystem services and micro-climates, and increase the attractiveness of the built environment (Ranhagen and Groth 2012).

Consequently, local and regional authorities have started to analyse critical dependencies in their contingency plans, in order to identify related outcomes. A simple example of a dependency analysis is shown in Image 2 (Green and Bodén 2011).



1.

Image 2 shows that electricity, fuel and staff are critical dependencies for almost all functions, and the function that depends on the highest number of providing functions is healthcare.

The rising complexity and interconnectedness of society is partly attributable to processes such as: (a) increased efficiency and optimization, (b) diversification of the stakeholders responsible for maintaining critical functions (due to privatization, outsourcing and other attempts to increase cost-effectiveness), and (c) an increasingly competitive environment in which buffers and margins are often minimized for short-term financial gain (Becker 2012). As an example, in Sweden, public services such as water, electricity and healthcare are increasingly provided by private companies. Municipal authorities thus have less direct influence on how they are delivered, which makes risk-reduction measures more difficult to put in place (Carlsson-Kanyama et al. 2013). Meanwhile, much of the private sector is hesitant to engage in risk reduction and adaptation, as it does not want to give the impression that it has "given up" on emission reduction (Sunér Fleming 2013).

To make matters worse, urban systems are highly linked to, and dependent on, rural systems. Urban–rural linkages refer to the two-way flow between urban and rural areas consisting of people (e.g. moving or commuting between urban and rural settlements), money (e.g. financial remittances from the city to rural family members), goods (e.g. agricultural products flowing from rural-based producers to urban markets, and manufactured or imported products flowing from urban centres to rural settlements), infrastructure (e.g. shared roads), information (e.g. about prices and employment opportunities), and water and waste (e.g. shared river systems or urban waste that is disposed of in rural areas). These spatial flows coincide with other flows such as agriculture, manufacturing and services, which are crucial for a vibrant local economy (Tacoli 2003).

The functioning of urban systems is directly linked to urban institutions. These are fundamental in every society – and particularly so in urban areas. Institutional competence is crucial for achieving structural changes and enduring improvement. However, whereas urban risk factors are becoming increasingly interconnected, urban institutions are not following the same pattern. City design is typically based on the separation of functions into distinct systems, sectors and institutions, and little attention is paid to the links between them (Ranhagen and Groth 2012). In fact, urban institutions tend not to communicate with each other, lack integration, have contradicting goals or policies and even compete for funds (Wamsler 2014; Groven et al. 2012; Biesbroek et al. 2009).

3.3 The influence of cities on disasters

A comprehensive and theoretically substantiated understanding of urban disasters requires establishing the links between the characteristic features and systems of cities (presented in the previous sections) and factors that influence disaster risk. As described in Box 1, the factors that influence risk are: (a) hazards; (b) location-specific vulnerabilities; (c) disaster response mechanisms and structures; and (d) disaster recovery mechanisms and structures (Image 1) (Wamsler 2014).

In the following sections, the three aspects shown in Image 1 (urban features, urban systems and the factors that influence risk) are analysed to show how urban risk is shaped before, during and after disasters.

3.3.1 Influence of the urban fabric on hazard exposure

The urban fabric has an influence on both the type and occurrence of hazards. The urban fabric can exacerbate hazards, and ultimately increase the occurrence of disaster in the following ways:

1. Intensification of existing hazards through changes to the urban climate that result in increased rainfall, higher temperatures, localized wind turbulence and gusts (Adam

1988). There are clear vertical and horizontal intra-city differences. For example, flash floods may only affect a few streets in a community.

2. Direct creation of new hazards (e.g. fires and landslides) caused by architecture, the organization of structures in space, urban livelihood practices, etc. For example, fire can be caused by unsafe electrical connections, antennas or electrical equipment on top of buildings that attracts lightning (Worldwatch Institute 2007). Landslides can be a direct consequence of the organization of structures in open space, for example building on watersheds that modify hydraulic regimes and destabilize slopes.

3. Expansion of the urban fabric (caused by high population density and a lack of suitable inner-city land) into hazard-prone areas (e.g. near to rivers or on steep slopes) or closer to other environmental hazards (e.g. toxic disposal sites, industrial or dangerous areas). This is true for both urban areas in general and individual sites, where lack of space means that building on slopes, close to landfills, or other potential hazards cannot be avoided.

4. Increased potential for compound hazards due to the proximity of land intended for physical/ spatial and social functions to that used for economic functions (e.g. residential, industrial and transport purposes) (EEA 2012).

5. Creation of new hazards through emissions. High emissions directly increase heat and reduce air quality. They also indirectly create new hazards through their contribution to climate change that reshapes hazard occurrence both globally and locally, e.g. increased rainfall, snowfall, wind speed, temperature, droughts, heat and cold waves, and even earthquakes due to the melting of permafrost (Turpeinen et al. 2008). Climatic change may outweigh any potentially positive effects of the urban climate (such as reductions in snowfall and overall wind speed, or higher winter temperatures). See also Section 3.5.

6. Dynamic urbanization processes that lead to constant changes in hazard patterns.

3.3.2 Influence of the urban fabric on vulnerability

In addition to its influence on hazards, the urban fabric can exacerbate location-specific vulnerabilities, and ultimately increase the occurrence of disaster in the following ways:

1. Direct creation of vulnerabilities as many physical/ spatial features of the urban fabric are themselves vulnerability factors. Examples are the high concentration and interdependence of populations, buildings, services, infrastructure, and economic and political centres. Cities concentrate large numbers of people, many of whom are highly vulnerable. These include poor and marginalized groups and individuals who have been weakened by conflict, malnutrition, HIV/AIDS or other diseases and who often seek a better life in cities.

2. Indirect creation of vulnerabilities through the urban fabric’s influence on social, economic and political/ institutional characteristics. Examples include:

- Inadequate construction materials and techniques and the orientation of structures in space. This can partially be attributed to high densities and space restrictions, which constrain the layout, design and location of buildings. For example, a lack of space can make it difficult to adapt buildings to high winds or the direction of the sun (e.g. to catch a breeze or avoid direct mid-day sun), and building sites might not allow deep foundations (to withstand landslides). However, inadequate construction materials and techniques can also be attributed to social, economic and political/ institutional factors that characterize urban life, the urban economy and urban governance systems. An example is informal settlements and the unwillingness (or inability) of politicians or local residents to invest in risk reduction and adaptation measures.
- Inadequate waste and waste water treatment infrastructure, which can lead to blocked drains, soil erosion, water-damaged walls and create breeding grounds for disease (e.g. by attracting vectors such as mosquitos and rats). This leads to increased risk and means that floods, landslides, earthquakes and disease have a greater impact.
- Economic specialization (as opposed to diversification), which makes populations vulnerable to the impact of disasters.
- Lack of social interactions with neighbours, which negatively affects social cohesion and consequently, any communal efforts to reduce and adapt to increased risk.

3. Creation of a domino effect where damage and secondary hazards that are created by the concentration, density and combination of all types of vulnerability factors, quickly spread (EEA 2012).

4. Destruction of (natural) hazard protections such as windbreaks, flood walls, floodplains, slope stabilization, fresh air corridors or vegetation.

5. Increased vulnerability due to the population's inability to prioritize and take measures to reduce, or adapt to increased risk. This is mainly due to the influence of the urban fabric on socio-economic factors (resulting in stressors such as urban violence or food insecurity) and ecological factors (that have a negative impact on health and wellbeing).

6. Constant changes in vulnerability patterns, which are due to dynamic urbanization processes (reshaped buildings and expansion of communities) and are difficult keep track of. Moreover, the vulnerability of urban populations is more heterogeneous than that of rural communities. This can be seen in terms of sources and levels of income, habits, household size and composition, housing types, access to services, etc.

3.3.3 Influence of the urban fabric on response and recovery mechanisms and structures

The urban fabric can also have a negative effect on response and recovery mechanisms, and ultimately increase the occurrence of disaster in the following ways:

1. Increased requirements for functional and complex response and recovery mechanisms. This is due to the huge population of cities, whose inhabitants live in vast and multifaceted urban settings.

2. Increased vulnerability of response and recovery mechanisms as disasters also affect centralized operations (i.e. manpower, services, infrastructure, economic resources and governance structures).

3. Seriously hampered ability to transport, collect, house or access the affected population. Emergency access, supplies, evacuation and resettlement are difficult due to inadequate and/ or damaged buildings, lack of space, the remoteness of some areas and other socio-economic factors. For example, a dense urban fabric containing multi-storey buildings translates, if destroyed, into an enormous quantity of falling objects and rubble that blocks streets, makes public areas unsafe and requires a major logistical effort for secure disposal.

4. Additional and specialized response and recovery functions (e.g. for rubble clearance and security).

5. Lack of (accessible, affordable) space and other socio-economic factors makes housing populations affected by a disaster especially challenging. Experience shows that emergency shelter, refugee camps and post-disaster (re-)settlements do not work well if constructed far away from former homes and livelihoods, although cities often do not offer other secure solutions (Baehring 2011).

6. Concentrations of people who cannot participate in response or recovery efforts due to ecological factors that have a negative impact on health and wellbeing. Examples include:

   - Noise and other urban stressors: People are already stressed before the disaster and cannot handle additional stress factors.
   - Pollution, lack of light, inadequate water and sanitation, and lack of green space cause illness.

7. Increased vulnerability due to ecological factors that reduce the capacity of people and institutions to respond and recover. Examples are:

   - Reduction of natural lighting, fog and cloud; reduced visibility when no electric light is available.
   - Noise: people cannot hear warnings.

8. Increase of vulnerability factors that have a negative influence on response and recovery (due to the influence of the urban fabric on socio-economic factors). These include fewer interactions with neighbours, exclusion and segregation, little sense of community, lack of local leadership structures, economic specialization, etc. For example, the exclusion and segregation of residents in marginal areas means that people do not receive disaster warnings or are unwilling to use emergency shelter (Wamsler et al. 2012).

9. Constant changes to the composition and layout of the urban fabric, which make it difficult to access up-to-date information (such as databases and maps) required for response and recovery

This analysis shows that physical/ spatial, socio-cultural, economic and political/ institutional aspects of the urban fabric can influence hazards, vulnerabilities, and response and recovery mechanisms. These determinants of disaster risk and impacts therefore need to be addressed as a part of a sustainable urban risk reduction and adaptation strategy.

3.4. Disaster impacts on cities

The impacts of disasters on cities relate to the characteristics and interconnectedness of its features and systems (see Sections 3.1 and 3.2). In addition, they are strongly influenced by climate change (see Image 3 and Section 3.5).

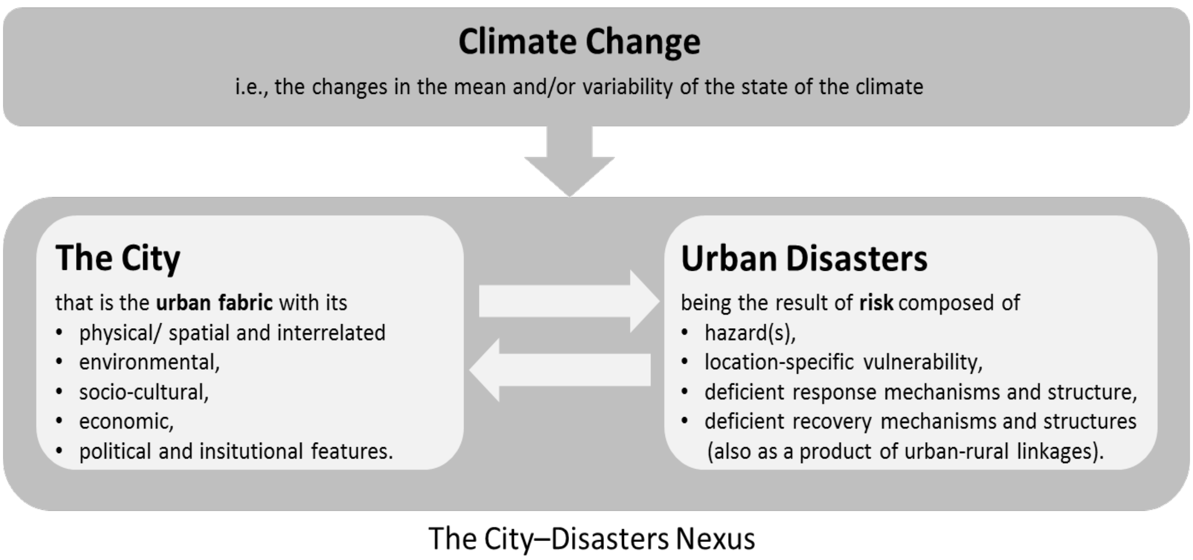


Image 3 The city–disasters nexus: cities, disasters and climate change. Source: Adapted from Wamsler 2014.

All urban sectors are exposed to disasters and climate change. Table 5 illustrates how they are impacted.

Urban sector	Disaster and climate change impacts – further increasing urban risk
Housing, recreation and cultural heritage	Destruction of housing, which is typically most affected by disasters (Jacobs and Williams 2011) Damage to, or loss of, parks and other recreation sites (e.g. playgrounds in flood-prone areas) Damage to, or loss of, heritage sites, having negative effects on people's identity, tourism and, thus, cities' economic development Damage to, or loss of, land and real estate (due to sea level rise, landslides, erosion, melting permafrost, etc.) Modification of the landscape (due to changes in the course of rivers or slopes, etc.) following earthquakes or landslides Population density increases (e.g. environmental refugees) and overpopulation due to destroyed housing stock Increased depreciation and wear of construction materials (e.g. stone and metal) due to greater climate variability
Water and sanitation	Damage to, or destruction of, water and sanitation infrastructure Negative impacts on the availability and quality of water (due to sea-water ingress, salinization and shifts in demand and supply, etc.), which aggravate conflicts between end users (the general public, the private sector, etc.) Contamination of drinking water wells Overburdened wastewater and sanitation systems
Energy	Destruction of power lines and other energy infrastructure Reduced cooling efficiency of thermal power due to higher air and water temperatures and/ or lower water levels (Mideksa and Kalbekken 2010) Changes in wind power and hydropower (due to changes in precipitation and wind patterns, etc.) Increased and/ or changing demand for heating and cooling, leading to increased energy use and blackouts Electricity failure and power outages that disrupt other vital urban services such as health care, transport and water supply
Transportation and telecommunications	Destruction of roads, railways, bridges, pipelines, ports, data sensors and telecommunication networks Blocked access to homes or settlements Poor road/ transport conditions (due to heat, ice, wind, etc.) and more accidents (due to insecure thoroughfares)
Environment and natural resource management (including waste management)	Impacts on the urban ecosystem that are directly linked to human wellbeing, (e.g. temperature, air quality, humidity, vegetation growth, pollen levels and disease vectors such as mosquitos) Impact of drought and/ or new pests on urban vegetation (due to a warmer climate) (Tubby and Webber 2010); impacts on natural protection against disasters (e.g. permeable surfaces and wetlands)

Table 5 Impacts of disasters and climate change on urban sectors that lead to increasing risk. Source: Adapted from Wamsler 2014.

3.4.1 Disaster impacts on the urban fabric

Many disaster and other climate change impacts have direct and visible effects on the urban fabric, they include:

- Damage to, or destruction of, building stock (including a reduction in residential and commercial buildings, cultural heritage, etc.) (e.g. Jacobs and Williams 2011)
- Depreciation and wear of construction materials
- Damage to, or loss of, land (real estate, parks, etc.)
- Modification of topographic features (river courses, sloping terrain, etc.) (e.g. Singh Kadka 2013)
- Malfunctioning or complete destruction of technical and social infrastructure (water supply, sanitation, energy, transport, communication, education and health services, etc.) (IFRC 2010)
- Increase in population density and overpopulation due to destroyed houses and migration from other areas. (Cf. Table 5)

These impacts on the urban fabric are closely interlinked with its environmental, socio-cultural, economic and political/ institutional features.

3.4.1.1 Links with the urban ecosystem

Examples of the close interrelation between disaster impacts on the urban fabric and the urban ecosystem include:

- Damage to the urban fabric leading to aggravated environmental degradation. Examples include the destruction of wastewater pipes that contaminates groundwater, or damage to nuclear plants, factories and transport vessels leading to the release of hazardous chemicals (IFRC 2010)
- Damages to the integrity of urban ecosystems, which affect the urban fabric and in turn aggravate existing hazards and loss of ecosystem services. A concrete example is the destruction of, or damage to, urban vegetation, which can reduce access to recreation sites, reduce air quality, increase the risk of landslides and lead to heat stress (e.g. Wilkinson et al. 2013).

3.4.1.2 Links with urban society

Examples of the close interrelation between disaster impacts on the urban fabric and urban society and culture include:

- Destruction of schools, housing and personal belongings that impacts the formal education of children and, over time, urban societies as a whole (Wamsler et al. 2012)
- Aggravation of social stresses such as disease and psychological shocks, which affect urban development at all levels. Concrete examples are community distress, family disruption, sexual or gender-based violence (West 2006), burglaries, increased overpopulation and illnesses caused by wastewater entering houses (see following)
- Increased vector and water-related diseases and reduced food security caused by destroyed or inadequate infrastructure (including streets, water and energy supply) (IFRC 2010)

- Forced eviction of slum dwellers who are affected by disasters when city or national authorities use disaster impacts as a pretext for slum eradication (IFRC 2010)
- Destruction of architectural heritage, which undermines the collective quality of life and identity (UNESCO 2013)
- Increased number of climate refugees, including city-to-city migration (WEF 2012).

3.4.1.3 Links to the urban economy and governance

Examples of the close interrelation between disaster impacts, the urban economy and governance structures include:

- Disruption of local and household economies that impact personal investments in improvements to living conditions (e.g. housing and settlements) and push already vulnerable groups further into poverty (IFRC 2010)
- Destruction of productive assets such as home-based workshops
- Governance problems, resulting in aid budgets that are skewed towards the recovery of a particular group or sector and increase urban inequalities (IFRC 2010)
- Aggravation of political stresses that lead to increased corruption, bureaucracy, political conflicts and rivalry, and affect construction quality and urban development at all levels.

3.4.1.4 Links to urban planning practice

The following disaster impacts hinder sustainable development and pose challenges for urban planning practice:

- Increased pressure for land and housing
- Increased numbers of people that depend on assistance from city authorities (e.g. access to rented housing, maintenance of houses and infrastructure) due to the erosion of livelihoods, savings and physical capital at the household level
- Changes to city landscapes, which affect future planning (e.g. infrastructure development)
- Increased need for resources for specific (already planned) urban developments due to disaster impacts such as environmental contamination (polluted soil, wells, etc.)
- Inability to execute urban development programmes such as land legalization, due to increased and unacceptable risk levels
- Reduced functioning of urban institutions that are directly or indirectly affected by disasters, due to damaged office buildings, staff death, injuries or leave, or damaged institutional reputation
- Death, (temporary) disablement or migration of key workers (and the workforce in general) at the national, municipal, community and household level, leading to an erosion in social capital for urban planning and governance at all levels
- Disruption to the national economy and related governance functions due to post-disaster expenses and relocation of development investments (e.g. budgets for sustainable access to safe housing, drinking water and sanitation being reallocated to emergency issues)

- Impacts on national fiscal and monetary performance, indebtedness, income distribution and higher levels of poverty, all of which negatively influence the provision and financing of housing and infrastructure at all levels
- Lower output from damaged or destroyed public assets and infrastructure, resulting in fewer resources that can be reinvested in the built environment
- Increased activity in both the formal and informal construction industry, due to rehabilitation and reconstruction efforts that creates challenges for building controls
- The need to build on response and recovery efforts for sustainable development, e.g. temporary housing for disaster victims that must be transformed into, or replaced by, permanent solutions

The analyses presented in this section show that both disasters and climate change strongly impact risk levels in cities. Box 3 shows the impact on all four risk factors. In general, when a disaster occurs, cities become exposed to a higher level of risk. It should also be noted that impacts are also felt via so-called urban–rural linkages (see Section 3.2). This means that even disasters that occur in rural areas may have serious implications for urban residents. A simple example is roads which, when impacted by disasters in rural areas, may cut off cities from vital flows.

Box 3 The impact of disasters on the urban fabric and planning mechanisms – with respect to urban risk factors

1. Impact on existing hazards. Hazard patterns change due to:
   - Intensification of existing hazards (e.g. increased land instability after earthquakes)
   - New hazards (e.g. landscape modifications, which influence issues such as proximity to the sea, rivers or declivities)
   - Colonization of new hazard-prone areas (e.g. populations that are resettled from earthquake to flood-prone areas).

2. Impact on existing location-specific vulnerability. Examples include:
   - Increase in the number of vulnerable people that need housing and services (due to increased pressure for housing and land, and the erosion of livelihoods, savings and physical capital, etc.)
   - Increased population density and overpopulation
   - Reduced quality of the urban fabric (e.g. housing stock, infrastructure and construction materials)
   - Increased poverty and urban inequality
   - Loss of urban assets and city functions that cannot be recovered (e.g. cultural heritage and land that is washed away).

3. Impact on existing response and recovery mechanisms. Examples include:
   - Fewer citizens are able to take part in response or recovery (due to long-term impacts on health, etc.)
   - Loss of the urban fabric and land needed for response and recovery (e.g. lack of space for evacuation and resettlement)
   - Temporary malfunctioning of, or interruption to, the urban fabric and city functions needed for response and recovery (e.g. street networks and centralized governance structures).

4. Impact on all risk factors (i.e. planning for hazard and vulnerability reduction and preparedness). Examples include:
   - Reduced financial resources for urban planning, risk reduction and adaptation (e.g. development budgets that are diverted to response and recovery efforts)
   - Reduced institutional capacity, due to reduced manpower, damaged infrastructure and lost reputation of urban authorities, etc.
   - Inability to execute urban development programmes (e.g. land legalization processes) due to increased and unacceptable risk levels.

Source: Adapted from Wamsler 2014

3.5 Climate change: reinforcing the city–disasters nexus

Climate change inevitably and progressively affects the interconnection between cities and disaster.

3.5.1 Global challenges to urban sustainability

Global challenges to sustainability (such as climate change, economic crises, migration and demographic growth) have direct impacts on urban sustainability (WEF 2012). However, cities face many other challenges to sustainability that are a direct outcome of their features (the physical/ spatial, environmental, socio-cultural, economic or political/ institutional characteristics that are described in Section 3.1, Tables 1–4).

Examples of **physical/ spatial sustainability challenges** are: urban sprawl, service inefficiency, lack of land for safe construction, traffic congestion, soil sealing, and informally growing settlements. The latter are characterized by overcrowding, inadequate water and sanitation systems, and poor construction. Examples of urban **environmental sustainability challenges** are: a lack of green areas and biodiversity, traffic/ industry-generated pollution, water scarcity, waste and wastewater contamination, noise, vibration and radiation. Examples of **socio-cultural sustainability challenges** are: lack of safety and security, injustice and segregation, ageing populations, loss of cultural and historical heritage, unequal access to services, disease, and traffic-related accidents. Examples of urban **economic sustainability challenges** are: lack of financial resources/ poverty, inflation and unemployment.

3.5.2 The links between cities, disaster risk and climate change

As mentioned above, the close interconnection between cities and disasters described in Sections 3.2–3.4 is reinforced by climate change, resulting in a vicious feedback loop of increasing urban risk and disasters (Image 4). Feedback loops are created by: (a) the influence of climate change on disaster due to climatic extremes and variability; (b) the influence of disaster on climate change; (c) the influence of (inadequate) urban development on climate change; and (d) the influence of climate change on (inadequate) urban development, due to its impacts on all risk factors (Image 4).

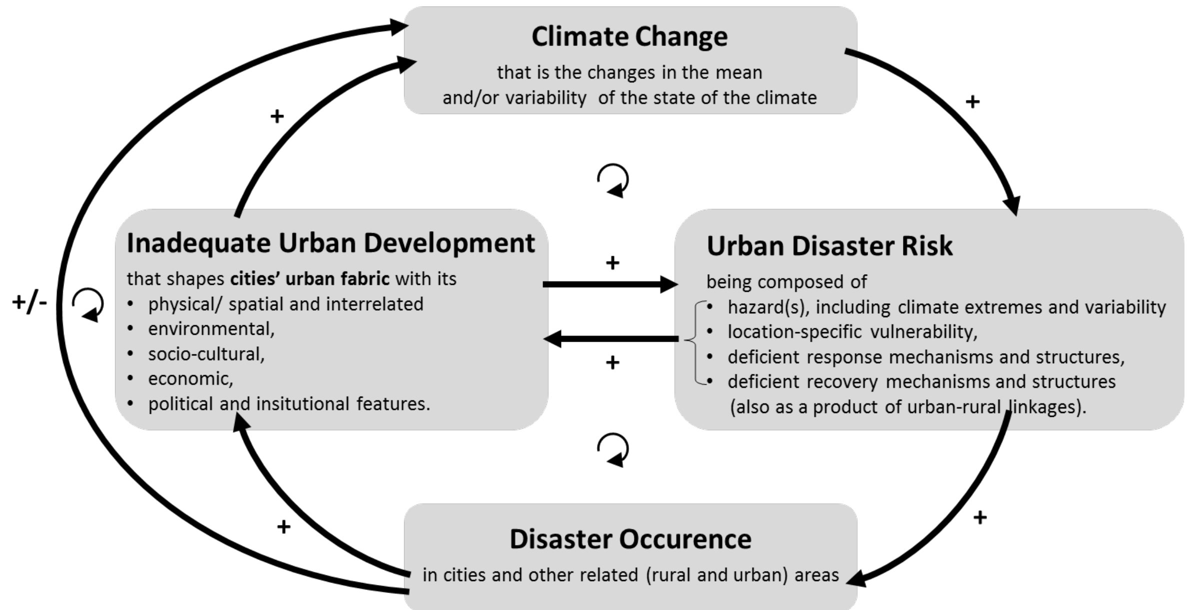


Image 4 Climate change, disaster risk, disaster occurrence and urban development.

Climate change → disasters

The first interrelation is the influence of climate change on disaster occurrence due to climatic extremes and variability. The most obvious link is the fact that climate change increases climate-related hazards (IPCC 2012). Although not all disasters are directly attributable to climate change or increased greenhouse gas emissions, climate-related disasters represent on average two-thirds of all disasters,[3] and account for almost all of the growth in the number of natural disasters since 1950 (Satterthwaite et al. 2007). To make matters worse, the urban areas already at risk from disasters are those that are most likely to be affected by climate-related hazards in the future (IPCC 2007; Moser and Satterthwaite 2008).

Disasters → climate change

The second interrelation is the influence of disasters on climate change. Disasters can increase greenhouse gas emissions and reduce global warming (see the arrow connecting disasters and climate change in Image 4). Examples are: (a) wildfires and volcanic eruptions that release carbon emissions; (b) the destruction of forests or other land-use changes that reduce carbon sinks; and (c) volcanic dust and gases resulting from eruptions that can lead to a reduction of direct solar radiation and thus global cooling (USGS 2012).[4]

Urban development → climate change

The third interrelation is the influence of (inadequate) urban development on climate change. Many sources claim that cities are responsible for 75–80 per cent of global greenhouse gas emissions (Munich Re Group 2004; O'Meara 1999; Stern 2006; UNHABITAT 2011; World Bank 2010). However, these claims understate the contribution of rural areas, arising from agriculture, deforestation, business and households (Satterthwaite 2008). Irrespective of the numbers, urbanization in general and inadequate urban development in particular have a high impact on the carbon cycle, through the emission of greenhouse gases and aerosols, solid waste and land-use changes (e.g. the creation of impermeable surfaces, the filling of wetlands and the fragmentation of ecosystems) (UNHABITAT 2011). In contrast, well-planned city development has the potential to mitigate climate change. More compact cities, which use cleaner energy and are less dependent on motorized transport have higher energy efficiency and thus produce fewer greenhouse gases.[5]

The systems shown above (Image 4) provide the functions and services that support the everyday life of cities including housing, water and sanitation, energy, transportation and telecommunication, environment and natural resource management, and social, cultural, and educational and economic services.

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[3] Retrieved from http://www.emdat.be 2012-10-19.

[4] In the short term, cooling can lower the global temperature before the warming trend resumes; therefore, climate change can be delayed by several decades (Tjiputra and Otterå 2011).

[5] Although wealthy cities generally consume more energy than those in poor, low- and middle- income nations, some cities in high-income countries, such as Stockholm (Sweden) and Barcelona (Spain), now produce fewer carbon emissions than others in low-income countries (UNHABITAT 2011; UNHABITAT 2008).

Climate change → (inadequate) urban development

The fourth interrelation is the influence of climate change on (inadequate) urban development. Climate change negatively impacts urban development in many ways. Table 1 provides an overview. The most obvious and visible impact is the destruction of the urban fabric (including housing, infrastructure and services). Other impacts are less apparent and relate to increased climate variability. An illustrative example is the expected increase in temperature and rainfall in hot/ humid climates, which is likely to increase dampness in dwellings (as the ground beneath the house becomes more humid). This can become unbearable, and have a significant impact on the well-being of residents (Davoudi et al. 2009). Other examples are rising temperatures, which thaw out permafrost causing the ground to shrink, and rising sea levels, which cause water tables to rise and undermine the foundations of buildings (Wamsler 2008). The result is not only damage to structures (such as railway tracks, highways and houses) but also landslides and erosion. Moreover, scientists have pointed out that melting permafrost is likely to release large quantities of carbon, thus contributing to global warming and the creation of yet another destructive feedback loop (Zimov et al. 2006).

Climate change has other impacts. These affect urban development through their negative influence on location-specific vulnerabilities and response and recovery mechanisms. Examples are: food shortages and breakdowns in water and energy supply that may exacerbate tensions between end-users, a higher incidence of infectious disease, and other impacts on air quality, road safety, etc. Related urban–rural linkages are manifold. An example is the millions of environmental refugees who have fled from rural to urban areas. Increased migration, and the accompanying loss of livelihoods, conflict and social disruption, are climate change-related factors that are believed to contribute to the spread of HIV/AIDS (UNAIDS 2008; UNHABITAT 2010b). Other factors are increased poverty and malnutrition, which can force the population to choose between buying medication or food. The erosion of human, social and institutional capital, which undermines HIV/AIDS prevention work and access to healthcare and education (UNAIDS 2008) also plays a role. These examples clearly show how climate change can affect not only existing vulnerabilities but also response and recovery mechanisms and, in turn, negatively influence urban development (Image 4).

Some other examples illustrate how response and recovery mechanisms and structures can be negatively influenced by climate change, resulting in increasing risk and additional challenges for urban development (Image 4). Insurance claims resulting from damage due to climatic extremes may put pressure on insurance companies to raise premiums or even refuse insurance. Similarly, the loss of the labour force or institutional capacities – either due to the disaster itself, or to other disaster-related factors (such as the spread of HIV/AIDS) – can severely hamper response and recovery mechanisms. Moreover, the arrival of migrants, increases the number of people who need to be cared for during disaster response and recovery.

It is clear that climate change and (planned and unplanned) urbanization are deeply intertwined, and can adversely affects each other. The resulting vicious feedback loops are shown in Image 4 in the form of a causal loop diagram. However, while it is clear that urban risk reduction and adaptation planning needs to be seen through a particular 'lens' to ensure that risk is adequately addressed, the interactions between the urban fabric, climate change and disasters described in this section are often too complex to be able to assert with any degree of certainty, whether a particular pattern is negative or positive in dealing with urban disaster. For example, neither a compact, nor a distributed urban fabric has any intrinsic value in risk reduction or adaptation to (changing) climatic conditions. The local setting, its geographic location and associated hazard conditions (e.g. high temperatures, high humidity, winds or floods) determine what urban fabric is most appropriate. The planning paradox is that an urban fabric that exacerbates climate change can, at the same time, be well adapted to it. Conversely, an urban fabric that mitigates climate change may not adapt well to increasing risk or disasters (see Section 3.2). In the literature on sustainable development and climate change, the concepts of adaptation and mitigation often appear as two sides of the same coin, leading to an implicit (but wrong) association between sustainable urban forms and disaster-resilient cities.

4 Discussion and conclusions

How do we conceive of cities in an era of increasing numbers of disasters and climate change? Cities can be perceived both as *at risk* and *as risk*, i.e. they are themselves at risk and they are also the cause of risk. While intrinsically, cities are at no greater risk than rural areas, the lack of attention given to them in development and risk research, policy and practice has clearly translated into lost opportunities to protect cities and a failure to adequately address the risk they do face. It is clear that cities have assets that can be used to address disasters and climate change – but they are only useful if they are not themselves impacted, and can be mobilized for risk reduction and adaptation planning.

Subtle differences in the urban fabric and planning processes have a significant effect on the exposure of a city to hazards (including climatic extremes and variability), and how it can withstand, counteract or overcome these hazards. Disasters are not one-off events caused solely by hazards, but are generated by complex and interacting development processes in which the urban fabric plays a major role. The physical/ spatial, environmental, socio-cultural, economic and political/ institutional features and related systems that characterize urban environments can increase risk by intensifying hazards or creating new ones; they can also exacerbate vulnerabilities and negatively affect response and recovery mechanisms.

4.1 A framework for understanding and addressing the interconnectedness of urban risk

This study shows that the intricate linkages between cities on one hand, and disasters on the other, cannot be described by a unidirectional cause-and-effect relationship. The city–disasters nexus is a bidirectional relationship. It is based on links between the characteristics of cities, urban systems and risk factors, and constantly shapes and is shaped by other processes such as climate change. This can result in both 'virtuous circles' (having favourable results) and 'vicious circles' (having unfavourable results).

Image 5 provides a framework for understanding and addressing urban risk. On the one hand, it illustrates how global and local challenges to sustainability manifest themselves at city level (Section 3.5) through interactions between (physical and non-physical) urban characteristics (Section 3.1), related systems and sectors (Section 3.2) and risk factors (Section 3, especially 3.3 and Box 1). On the other hand, it illustrates opportunities to create synergies for sustainable urban risk reduction by linking its features.

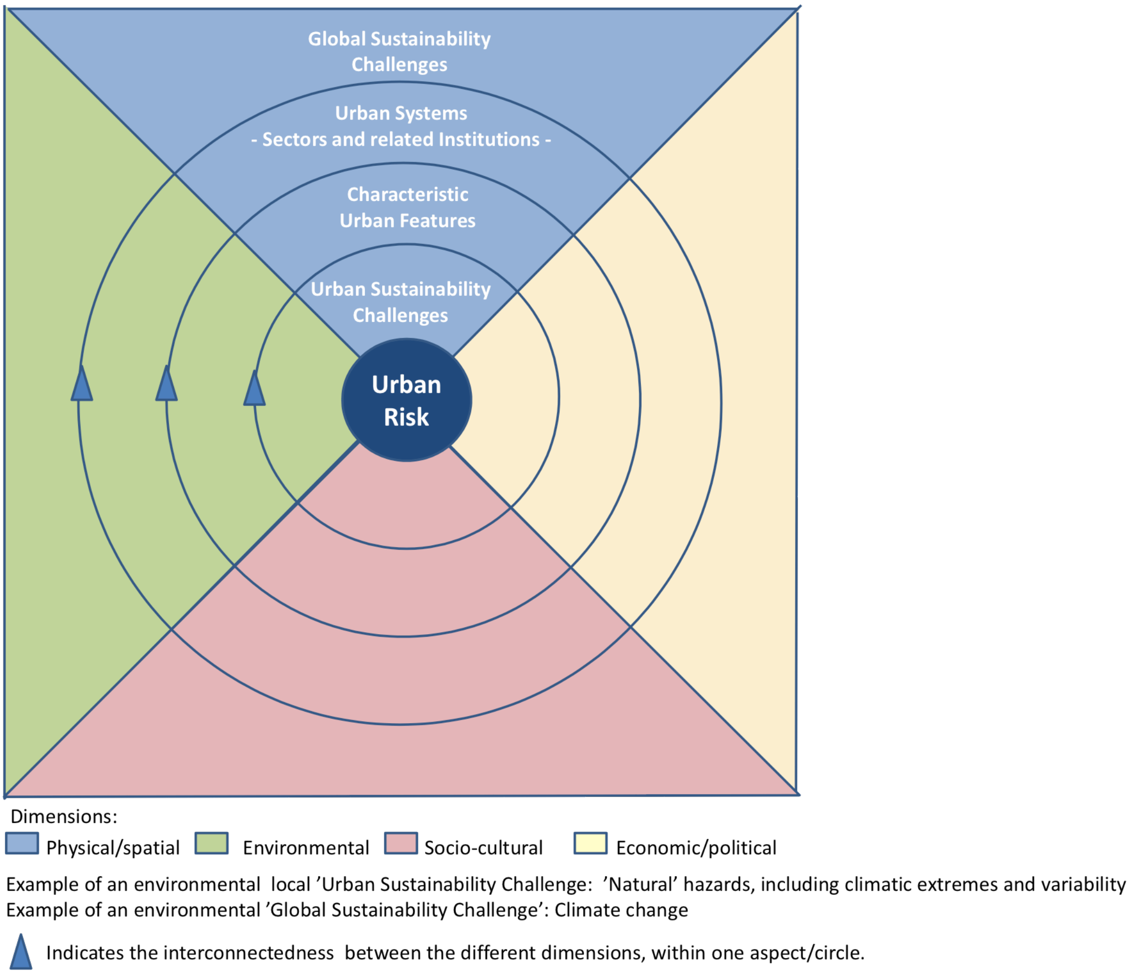

Image 5 A framework for understanding and addressing (the interconnectedness of) urban risk

On this basis, urban risk reduction and adaptation planning needs to include measures that address all four types of risk factor (hazards, vulnerability, incapacity to respond and incapacity to recover). At the same time, it must target both the physical and non-physical features of the urban fabric, which can turn cities into risk hotspots. Such a sustainable transformation can only be achieved if risk reduction is mainstreamed and becomes an integral part of urban planning practice. Box 4 provides an overview of mainstreaming strategies and their link to the framework described above.

In-depth knowledge of the city–disasters nexus is required to mainstream risk reduction and adaptation into urban planning practice. This would allow urban actors to act upon increasing risk and, ultimately, create cities that are more resilient to disasters. This includes understanding not only how disasters and climate change affect cities but also how the characteristics of cities influence climate change, risk and disaster occurrence. In this context, both urban–rural differences and urban–rural links must be closely examined, which reminds us that risk reduction cannot be seen as a part of either a uniquely urban or rural agenda.

Box 4 Strategies/levels for mainstreaming risk reduction and adaptation

Strategies/levels I-II: Integration at local programme level
FOCUS: Citizens and settlements (e.g. urban development programmes) | ADDRESSES: Interconnectedness between urban features and local sustainability challenges | AIM: To maximize the potential of urban settlements to reduce risk.

Add-on risk reduction (Strategy I): Implementation of specific programmes or programme components that are explicitly and directly aimed at reducing risk (and are not part of the implementing body's sector-specific, day-to-day work).

Programmatic mainstreaming (Strategy II): Modification of sector-specific programme work to reduce the likelihood of any programme measure actually increasing risk, and to maximize the programme's potential to reduce risk.

Strategies/levels III-IV: Integration at institutional level
FOCUS: The organization (e.g. city authorities) | ADDRESSES: Urban sectors and systems | AIM: institutionalization of DRR; DRR as a standard procedure.

Organizational mainstreaming (Strategy III): Modifications to organizational management, policy, legislation, working structures and project implementation tools to ensure the integration of risk reduction at the local programme level and to further institutionalize it.

Internal mainstreaming (Strategy IV): Modifications to an organization's operations and its internal policies so that it can reduce its own risk (to premises, staff, etc.) and ensure its continuous functioning during adverse events.

Strategies/levels V-VI: Integration at inter-organizational level
FOCUS: Other urban actors (including educational bodies and citizens) | ADDRESSES: Interconnectedness between urban sectors, systems and stakeholders | AIM: Creation of a multilevel system for governing risk and increased science–policy integration.

Inter-organizational mainstreaming for risk governance (Strategy V): Promotion of cooperation between existing (urban) actors for capacity development and the harmonization of risk reduction efforts (e.g. by citizens, the private sector, and organizations working in disaster response, recovery and development).

Educational mainstreaming (Strategy VI): support for a conceptual shift in the philosophy that drives sector-specific education, in order to incorporate risk reduction into the activities of professionals (e.g. planners) and increase science–policy integration.

The mainstreaming strategies presented in Box 4 can assist city authorities and other urban actors to take a wider perspective when dealing with disasters and climate change. They support the ideas that underlie urban flow/ dependency analyses, and systems thinking related to urban resilience. Approaching cities from a systems perspective contrasts with earlier approaches, which have focused on the analysis of single organizations in order to drive sector-specific specialization and improve technical performance (Ranhagen and Groth 2012).

As the urban system becomes more complex, the risk of systemic breakdown increases; however there are also more opportunities to create synergies for sustainable risk reduction (cf. WEF 2012). Synergies can be achieved by linking different dimensions and sectors – for instance integrated land use, mixed-use structures, green areas, public spaces, mobility, energy systems and risk reduction infrastructure (cf. Ranhagen and Groth 2012).

4.2 Recommendations for the successor framework to the HFA

On the basis of this paper, it is highly recommended that the successor to the HFA places increased emphasis on:

1. the interconnectedness of physical and non-physical urban risk, which is a key challenge to sustainability;
2. the importance of urban risk reduction and its role in sustainable urban development; and
3. the comprehensive mainstreaming of risk reduction into urban planning and related sector-specific work.

In this context, it is crucial for HFA2 to pay special attention to:

a. global responsibility for urban risk and risk reduction (alleviation of global risk reduction needs);
b. the need for interdisciplinary, multi-sectoral and systems thinking (for urban sustainability);
c. the involvement of urban dwellers and the private sector; and
d. the support of highly vulnerable groups (the urban poor).

Making cities safe from disasters and the impact of climate change, and enhancing their resilience is everybody's business and a current challenge to sustainability. The framework for understanding and addressing the interconnectedness of urban risk presented in this paper provides a solid foundation for the formulation of HFA2 and the development of indicators. It is based on an analysis of the changes caused by urbanisation and the multi-faceted problems it entails for risk reduction, and presents urban risk reduction as a way to achieve sustainable urban development. It shows that (a) the physical/ spatial, environmental, socio-cultural, economic and political/ institutional characteristics of the urban fabric are interlinked and connected to a range of urban systems; and therefore (b) disaster-resilient cities require a multi-sectoral approach that breaks the negative feedback loop that leads to increased risk, and builds on synergies between urban systems and sectors. Nevertheless, it is only a starting point.

Urban risk, challenges and solutions need to be better understood and investigated (cf. UNISDR 2013b) and should be a high priority for HFA2. Wealth in high-income countries can drive urban risk in low-income countries, and risk reduction may create global feedback loops that remain to be explored (Wamsler 2013). Further research needs to be supported. If the aim is to have a resilient planet with resilient people, then HFA2 must include enforceable targets and increased accountability from governments in low-, middle- and high-income nations to ensure an environment that supports local risk reduction and also ***alleviates urban risk reduction needs at a global level***.

In addition, the links between physical and non-physical risk requires special attention in further investigating and addressing the interconnectedness of urban risk. Although current HFA literature on indicators recognizes that non-physical risks must also be taken into account (United Nations 2008), the mid-term HFA review found that governments did not comprehensively consider underlying social and economic risk factors (UNISDR 2011). This relates to the failure of the HFA to support comprehensive risk reduction mainstreaming (cf. Oxfam 2013). A more ***comprehensive mainstreaming of risk reduction into urban planning and related sector-specific work*** thus needs to be a priority in HFA2 (see Box 4 and Image 6).

The need for specialized urban knowledge for risk reduction goes hand in hand with the need for ***a more interdisciplinary and multi-sectoral approach***. This should integrate not only the fields of disaster risk reduction, development and climate change adaptation (cf. UNISDR 2013b), but also urban sustainability studies. In this context, systems thinking, inter-disciplinary research and trans-disciplinary collaboration are crucial in order to narrow the gap between local-level realities, science and policy. Achieving more disaster-resilient cities requires a multi-sectoral approach that builds on existing synergies between urban systems and sectors.

The ***increased involvement of urban dwellers and the private sector*** in disaster risk reduction is another crucial measure for better dealing with the interconnectedness of urban risk. This is especially urgent at a time when important societal functions are increasingly outsourced to private stakeholders (see Section 3.2). In addition, whereas the city provides improved access to services and an opportunity to improve socioeconomic status, certain urban characteristics also contribute to concentrating large numbers of vulnerable people (see Section 3.3.2). In line with others recommendations for HFA2 (e.g. Oxfam 2013; UNISDR 2013b), the successor framework must support urban risk reduction and ***give special attention to highly vulnerable groups***. This can be achieved by applying an 'urban lens' to reveal and address the mechanisms that put the urban poor at risk.

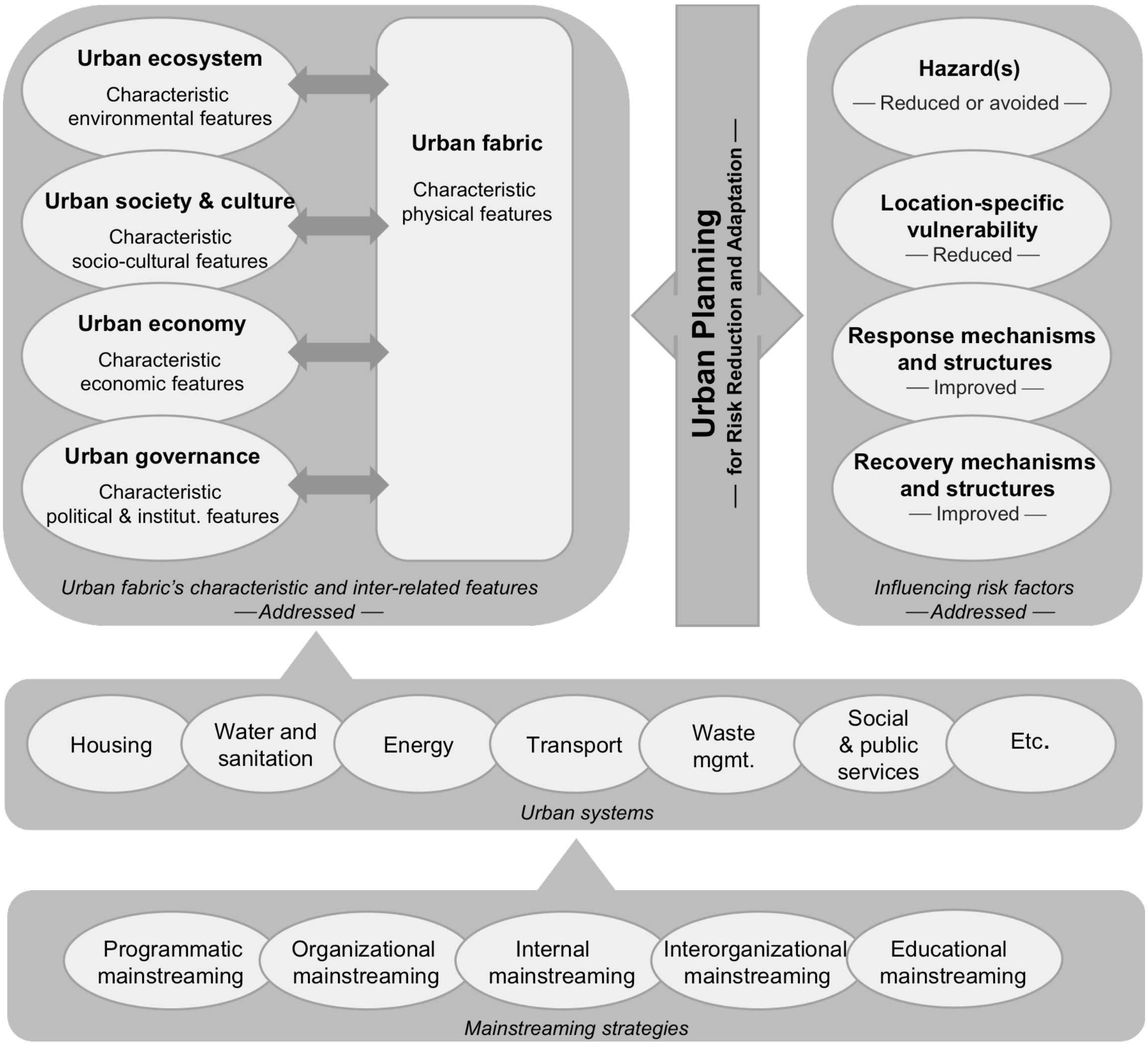

Image 6 Mainstreaming strategies and their link to sustainable risk reduction planning

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