SUPPORTING DECISION –
MAKING FOR RESILIENT CITIES

RESIN Conceptual Framework

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Contents

1. Executive summary

This report focuses on the RESIN Conceptual Framework (RCF). It provides an overview of the scope and purpose of the framework, and the collaborative process by which it was developed.

The RCF has been designed to guide and support the RESIN project and the various tasks being undertaken within it. The principal goal of the project is to develop approaches to enhance the resilience of Europe's cities and urban critical infrastructure to extreme weather and climate change. The RCF underpins RESIN by establishing a context for the project and clarifying the key concepts, and the relationships between them, that the project is developed around.

The RCF comprises two distinct, but interconnected, systems and their processes; the urban system and the adaptation planning system. Experience or awareness of climate risks initiates an adaptation planning process. This process may lead to the development of adaptation actions, and then these actions can be implemented within the urban system to build climate resilience. It is also recognised that, in order to be accepted by a broad range of stakeholder groups and effectively implemented within urban systems, adaptation actions must do more than just build climate resilience. Given the cross cutting nature of climate risks, adaptation actions should also acknowledge and respond to the challenges and potential opportunities faced by urban areas in the twenty-first century.

Five key themes are described within this report which provides further insights into the scope of the RCF and equally the RESIN project itself which the framework has been designed to guide and support. These are:

1. Urban Systems
2. Multiple Drivers of Change
3. Climate Risk
4. Adaptation Planning
5. Supporting Adaptation and Resilience

The RCF positions the RESIN project within the field of urban climate change adaptation and resilience. It also clarifies the practical nature of the project, exemplified by the involvement of four case study cities as project partners, and its ultimate aim of building the resilience of European cities to the changing climate.

2. Introducing the RESIN conceptual framework

The principal goal of the RESIN project is to support cities and urban areas in adapting and becoming more resilient to climate change. In doing so, RESIN focuses particularly on urban critical infrastructure. The RESIN Conceptual Framework (RCF) has been developed to describe, shape and orientate the work being undertaken within the RESIN project.

The creation of the RCF followed an iterative and collaborative process to develop a framework that adopts a multi-disciplinary perspective and presents the vision of the RESIN partnership. This reflects the notion that adaptation and resilience, as central concepts guiding the RESIN project, should be viewed as learning processes rather than static outcomes to be achieved.

Conceptual frameworks have variously been defined as:

- "…a network, or "a plane," of interlinked concepts that together provide a comprehensive understanding of a phenomenon or phenomena" (Jabareen 2009: 51);
- "…a conception or model of what is out there that you plan to study, and of what is going on with these things and why" (Maxwell 2013: 39);
- A conceptual framework "…explains, either graphically or in narrative form, the main things to be studied— the key factors, concepts, or variables—and the presumed relationships among them" (Miles and Huberman 1994: 18).

It is clear from these definitions that a conceptual framework is essentially an outline of the key concepts, and the connections between them, that structure a study or research project. Building on these definitions, there are three aims for the RCF. These are:

- **Setting the scene** - establishing an overarching context for the project and its various work packages.
- **Improving understanding** – clarifying project concepts and the relationships between them.
- **Project organisation, evaluation and implementation** - helping RESIN partners to structure and develop learning from their activity in the project.

This report continues with a description of the process followed to develop the RCF (Section 3). The RCF is then presented and described, and further information on key themes related to the framework is provided (Section 4). The report concludes with a summary of key points relating to the form and function of the RCF (Section 5).

3. Developing the RESIN Conceptual Framework

The RCF has been developed collaboratively based on inputs from the RESIN partners achieved via:

- An online questionnaire completed during July and August 2015.
- A workshop undertaken in Manchester on the 29th September 2015.
- A workshop undertaken in Bratislava on the 11th November 2015.
- Discussions with RESIN partners throughout the process of developing the RCF.

Appendix A includes details of these elements of the RCF methodology approach and their key outcomes. In addition to the collaborative working with the RESIN partners, a review was undertaken of existing adaptation and resilience frameworks to inform the development of the RCF. The key findings of this review are also available in Appendix A.

Based on an analysis of outputs from the review of existing conceptual frameworks and the consultation with RESIN partners, the objectives and scope of the RCF were clarified. The main objectives are:

- To clarify key RESIN project concepts and identify the principal relationships between them.
- To provide a high level overarching context for the project to operate within, including facilitating mid-project evaluation and learning.
- To inform and complement the RESIN project work packages and their related tasks.

The thematic scope of the RCF was established as encompassing:

- Urban systems, with critical infrastructure forming the key sub-system of interest sitting within a complex and interconnected urban system.
- Climate change as the principal ‘driver of change’, whilst recognising that climate change is one of multiple interacting hazards and drivers on urban systems.
- The provision of decision support for adapting and building the resilience of cities and their critical infrastructure to risks associated with extreme weather and climate change.

4. Understanding the RESIN Conceptual Framework

The RCF focuses on urban climate change adaptation and resilience. Adaptation and resilience are complementary processes that can aid urban areas in preparing for, coping with and responding to challenges (and potential opportunities) posed by the changing climate. Adaptation strategies and actions are developed and implemented in response to climate risks, building the climate resilience of urban systems. The RCF (Figure 1) brings together two processes connected to this agenda, each of which influences and is influenced by a related system.

- The left hand loop centres around the urban system, and reflects the process by which climate risks are generated and then responded to with the aim of building the resilience of the system to future hazards and drivers.
- The right hand loop reflects the process of adaptation planning. It is focused around an adaptation planning system that encompasses stakeholder networks and governance frameworks. The process leads to the development of adaptation options to implement within the urban system, which aim to build climate resilience (in addition to supporting the achievement of other socio-economic and bio-physical objectives and priorities).

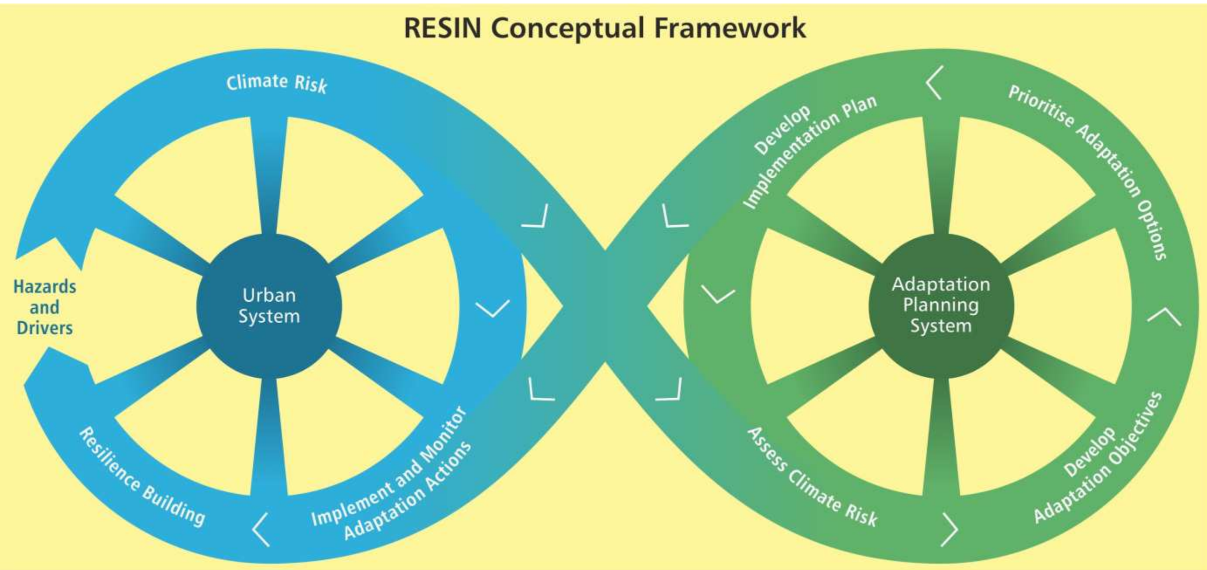

Figure 1: The RESIN Conceptual Framework

The RCF identifies two principal links between the urban system, adaptation planning system and their related processes. These represent two points of close connection between the two systems, which can also be referred to as the science-policy interface. The RESIN project involves close collaborative working between research partners and case study cities to develop and share knowledge on climate adaptation and resilience. Strengthening the science-policy interface is therefore an important element of the project. Within the RCF, climate risks arise as a result of climate and non-climate drivers and hazards interacting with and impacting on vulnerable elements of the urban system. Alternatively, awareness and knowledge of risks may be enhanced by their occurrence elsewhere or via related studies. The emergence of risks initiates an adaptation planning process and it is here that the two cycles link for the first time.

The adaptation planning process is focused on assessing climate risks and developing adaptation objectives linked to reducing the severity of risks faced by the urban system. Processes to adapt to climate change and build urban climate resilience may be ongoing due to heightened awareness of risks because of ongoing research studies and/or previous experience of climate hazards. It is not expected that a city would come to this process *without* prior knowledge of adaptation planning. A city may already have worked through stages of the adaptation planning process and may have generated some learning on climate risks and the implementation of adaptation options. The anticipated outcome(s) of the adaptation planning process is, rather, an *implementation plan* to progress targeted actions that build climate resilience within the urban system and constituent sub-systems. It is here that the adaptation planning cycle connects into the urban system cycle for a second time. The implementation (and subsequent monitoring) of actions, if effective, increases the resilience of the urban system to potential future hazards.

The RCF also emphasises that adaptation and resilience are not simply end-goals to be achieved within urban areas. Adaptation and resilience are ongoing and evolving processes that can incrementally transform urban areas towards a better adapted and more resilient state. The RCF can be viewed as a continuous feedback loop where learning generated by experience and/or heightened awareness of climate risks starts an adaptation planning process which then leads to the implementation of actions to lessen future risks by building urban resilience.

The RCF, as the title suggest, is conceptual; the generation of, and response to, urban climate risks is, in practice, complex and non-linear. As a result, there are several caveats associated with the RCF. The framework should ultimately be viewed as a stylised representation of how urban climate adaptation and resilience systems and processes interconnect. The key caveats are:

- **Accepting a climate risk may not result in action.** A climate risk, perceived or experienced, may not always stimulate an adaptation planning process in response. There may be barriers that separate the climate risk and adaptation planning cycles, limiting their potential to connect and create resilience building actions. These barriers may encompass issues such as a lack of political will to respond to risks and limited capacity (e.g. financial, technical) to assess risks and then develop and implement responses.

- **The cycles may not connect.** As a result of the barriers described above, the two cycles may not connect and instead operate independently leading to ineffective outcomes. Equally, as noted above, there may not be an adaptation planning process in some cases. In this event, climate risks can have a negative effect on the socio-economic and biophysical elements of an urban system with a reactive response to return to business as usual or no response to adapt and build resilience. The urban system is therefore no better prepared for future climate hazards and associated risks.
- **The process of moving between stages within the cycles is variable.** The connection between climate hazards and climate risks is automatic; a climate hazard will impact on certain elements of the urban system and generate risk. In contrast, moving from assessing climate risk to developing and implementing adaptation objectives requires deliberate steps to be made by decision makers in partnership with other actors, such as committing capacity and resources. The two cycles, and the various stages within them, are therefore driven by different forces.
- **The cycles may not be completed.** As a result of the challenges associated with moving between different stages of the cycles, they may not be completed. For example, the adaptation planning process may stop after the assessment of climate risks and not progress to the development of adaptation objectives. This could be due to political or socio-economic barriers. Further, resilience building may not occur in the urban system without a deliberative process of adaptation planning.
- **Adaptation and resilience do not take place in isolation.** In urban areas, adapting and building resilience to climate change are processes that influence, and are influenced by, other ongoing activities. These may relate to a diverse range of issues and themes from economic development and health, to transport and water management. The achievement of adaptation and resilience goals may therefore take place via integrating with ongoing and prospective planning processes and activities related to other urban issues and themes.

Despite these caveats, it is the connection between the RCF's risk and response loops that lies at the heart of the RESIN project.

Several key themes are central to the RCF and are discussed on more detail below. They are:

- Urban Systems
- Multiple Drivers of Change
- Climate Risk
- Adaptation Planning
- Supporting Adaptation and Resilience

Each of these themes is central to the RESIN project, and building urban climate resilience more generally. *Urban systems* are the focus of the project, which are impacted on *by multiple drivers of change*, of which climate change is the key focus for the project. *Climate risk* emerges as a result of drivers of change impacting on the urban system, which require an *adaptation planning* response in order to support urban areas in *adapting and building resilience* to the changing climate.

4.1. Urban Systems

'A city', according to complexity theorists, may be 'represented as a set of interacting subsystems or their elements' (Batty 2009: 1042). The RCF takes such a systems perspective, focusing on climate risk and resilience processes and outcomes in urban systems. Urban systems are complex, and display multiple interconnections and interdependencies across sectors, spatial scales and temporal scales. As a result urban systems are often viewed conceptually. For example, the European Environment Agency (EEA) identifies environmental, technical and societal sub-systems interacting within a broader urban system (Figure 2). Similarly, Da Silva et al. (2012) perceive cities as dynamic and porous systems interacting with their 'enabling environment'. The notion of an enabling environment covers aspects of cities relating to ecosystems, infrastructure, institutions and knowledge that are both spatial (e.g. rural hinterlands) and non-spatial (e.g. national and supra-national policies), and may be located and governed beyond the city's administrative boundary (Da Silva et al. 2012). The process of developing climate change adaptation and resilience approaches must recognise the sectoral and spatial complexity that characterises urban systems. In doing so, this can encourage the development of responses that target not just climate resilience, but also other urban socio-economic, technical and biophysical objectives.

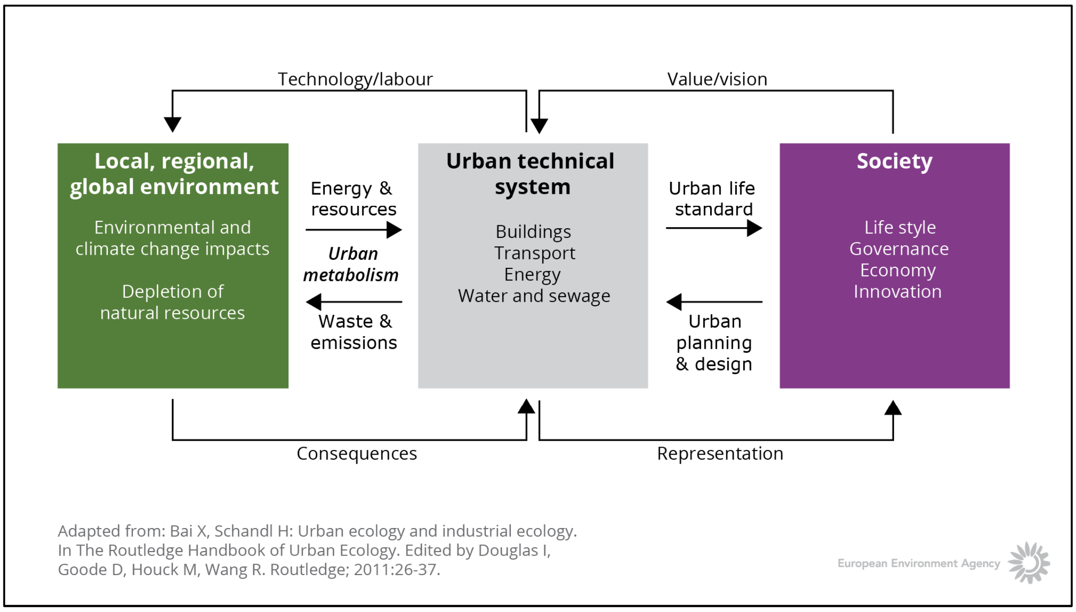

Figure 2: Urban systems and their sub-systems. Source: EEA 2015.

Urban critical infrastructure, the core focus of the RESIN project, can be viewed as a subsystem of cities, although it is not always planned and operated as such. Urban critical infrastructure may be defined as:

> "An asset, system or part thereof located in an urban area which is essential for the maintenance of vital societal functions, health, safety, security, economic or social well-

being of people, and the disruption or destruction of which would have a significant impact in an urban area as a result of the failure to maintain those functions" (Rome et al. 2015; adapted from the European Commission 2008).

Urban critical infrastructure and the associated risks of climate change are, as yet, not well-researched (Rome et al. 2015). Definitions are therefore not widely available or consistently applied. The RESIN project emphasises the need to take a systemic view of urban critical infrastructure, situating it as a sub-system within urban areas (Rome et al. 2015). Urban critical infrastructure also has interacting sub-systems (energy, water, transport, the built environment, and so on). Figure 3 provides a depiction of how urban critical infrastructure is understood within the RESIN project. Here, built (e.g. roads, power stations), technical (e.g. ICT and telecommunications networks), social (physical elements such as schools and hospitals and non-physical elements such as governance and policy frameworks), and blue and green (e.g. natural landscapes, urban parks, rivers, and reservoirs) infrastructure are all 'critical' to urban areas. Climate risks to urban critical infrastructure elements, which are connected and can therefore experience cascading effects, can be detrimental to urban areas. From the perspective of urban climate change adaptation and resilience, identifying and responding to these risks is therefore necessary; a process which the RESIN project aims to support.

Given the complexity that characterises urban areas, and their constituent sub-systems, the conclusion can therefore be to view urban areas as a 'system of systems'. Similarly, ecosystems can be viewed as being composed of a hierarchy of interacting subsystems. Each subsystem is shaped by its own processes and, in cities and ecosystems alike, there is evidence of co-evolution, learning and adaptation across interacting systems, subsystems and spatial scales. This is significant as learning is an important element of climate change adaptation and resilience (Berkhout et al. 2006, Tschakert and Dietrich 2010).

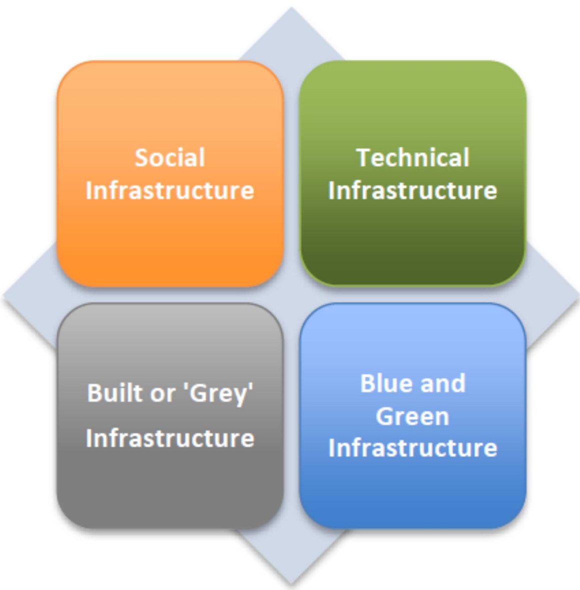

Figure 3: Infrastructure of the urban system. Source: Rome et al. 2015.

Given this systemic view of urban areas, urban systems and their constituent elements, the study of social-ecological systems[1] is relevant to RESIN and the RCF. This field has flourished over the past two decades and links to earlier disciplines of urban ecology and industrial ecology (Binder et al.., 2013; Evans, 2011; Pickett et al.., 2011). Social-ecological systems developed as an approach to explore integrated, interdisciplinary frameworks that consider ecological systems and social systems as 'coupled' and interacting (Berkes and Folke, 2000; Binder et al.., 2013; Collins et al.., 2010; Gunderson and Holling, 2002; Newell et al.., 2005; Turner et al.., 2003; Walker et al.., 2004; Young et al.., 2006). Social-ecological systems are understood to be nonlinear and stochastic (or unpredictable). As a result, feedback loops, threshold behaviour, tipping points, and cascading effects become important concepts to understand social-ecological systems.

The RCF views cities as social-ecological systems impacted and shaped by a range of drivers of change including demographic change, economic processes and climate change. City systems and their constituent sub-systems must be resilient to these forces, or risk being negatively affected and unable to function effectively. Increased emphasis is being placed on the application of a social-ecological systems approach to progress towards more resilient and sustainable urban futures (Andersson et al. 2014, Grove 2009, Schewenius et al. 2014). Indeed, resilience is a key element of social-ecological systems, and the RCF aims to acknowledge this by taking a systems perspective to the relationship between urban areas, climate risks and adaptation and resilience responses.

Other literature considers socio-technical systems, such as the multi-level perspective (Geels 2002) and transition management (Rotmans et al. 2001), where the focus on systemic transitions towards sustainable forms of technologies. Here, the dynamics of transitions are covered over a long period of time and take account of the interplay between social factors with technological development: society and technology co-evolve. At a higher level, there are many synergies between treating cities as social-ecological systems and social-technical systems particularly around the governance challenges that are faced. However, concepts such as resilience require attentive 'translation' (Smith and Stirling 2008: 11). In social-ecological research, resilience can be defined as the ability of a structure to function in the face of shocks and stress, which implies a degree of flexibility. Technologies are considered to the extent that they can help resilience but there is little appreciation of the dynamics of socio-technical change (Mendizabal et al. 2016). In the socio-technical literature, the structure is often an artefact, and resilient qualities relate to its ability to sustain performance in the face of stress, which does not imply transformation from its original state. It is therefore important not to confuse the two separate definitions of resilience; one that relates to structure and the other to function (Berkes et al. 2003, Smith and Stirling 2008).

4.2. Multiple Hazards and Drivers

Complex systems, which include cities, are dynamic (Leach et al. 2010, Ravetz 2000), constantly influenced by multiple interacting drivers of change and related hazards. Drivers of change may be categorised into six broad themes; social, technological, environmental, economic, political and values

[1] Other terms include socio-ecological systems and human-environment relations

(STEEPV) (Loveridge 2002). They influence the form and function of social-ecological systems (such as cities), whose development trajectories may therefore be uncertain (Carter et al.. 2015, McHale et al.. 2015, Pickett et al. 2001, Ruth and Coelho, 2007).

Drivers influence how cities contribute to climate change and how they are affected by it (Grimm et al. 2008), in addition to how they may respond to related threats and opportunities. Climate change, and related hazards such as floods and heat waves, is an important driver of change influencing cities. However, it is important to note that climate change may not be the key driver of change in some situations, with other socio-economic and biophysical factors being more influential on climate change adaptation and resilience issues and processes in urban areas. Nevertheless, climate change is the key driver of interest for the RESIN project. It is here that RESIN connects to climate change adaptation and differs from Disaster Risk Reduction (DRR), which looks beyond weather and climate and addresses multiple natural hazards. Although there is increasing interest developing closer connections between climate change adaptation and DRR, both within and beyond the RESIN project, their objectives and processes are not always consistent (Birkmann et al. 2009, Mitchell et al. 2010). The shift within the IPCC's approach between their 4th and 5th Assessment Reports, moving from a vulnerability to a risk based framework, can be viewed, in part, as an attempt to overcome these inconsistencies and bring adaptation and DRR closer together (EEA 2012).

Climate change hazards interact with other drivers of change that influence urban systems. This interaction, and the wider scope of drivers influencing urban systems, is central to the RCF. This relationship will be considered at different points within the RESIN project through the use of scenario planning, acknowledging that both climate risks and adaptation responses are influenced by ongoing and prospective socio-economic and environmental processes. The connections between climate change and other socio-economic and biophysical drivers of change can be understood conceptually from a systems perspective. In practice, however, tracing the connections between multiple interacting drivers and their cascading consequences is challenging. Temperature rise, for example, may exacerbate the urban heat island effect, which derives in part from the form and function of urban areas (Gill et al. 2008), with potential negative consequences for people and infrastructure. Similarly, urban development and associated surface sealing, driven by demographics and economics amongst other factors, can increase surface water runoff volumes following a rainfall event and hence increase flood risk. With increases in rainfall volume and intensity projected for some locations due to climate change, this poses a major risk to some cities. In addition, climate change may act as a multiplier, enhancing the implications of drivers of change on urban systems, which may be positive or disruptive depending on the particular driver of change.

Although it is clear that drivers of change exert a significant influence on cities, there are major uncertainties about the direction and the adequacy of data relating to trends and processes such as the indirect effects of climate change (McHale et al. 2015, Revi et al. 2014). There are also uncertainties regarding the implementation of adaptation options and the extent to which they will achieve their intended objectives. Nevertheless, decision makers must continue to develop forward plans in the face of uncertain drivers of change and associated data gaps regarding adaptation options. The need to consider the implications of sometimes ambiguous and undefined long-term drivers of change on present day decisions and actions is a key feature in today's diverse and interconnected world. Urban climate change adaptation and resilience is a field in which this is particularly important due to the wide range of variables that influence risks associated with extreme weather and climate change and associated responses, and also the development and implementation of adaptation responses.

To cope with uncertainties, the prevailing evidence-based approach to decision making should be supplemented with qualitative techniques such as pathway and scenario development and horizon scanning (Carter and White 2012, Pelling 2010). These methods are designed to enhance awareness of sometimes long term and intangible drivers of change, aspects which may be more difficult to recognize and predict in an urban setting, yet should still contribute to forward planning and decision making to build urban climate resilience. Given that urban areas face a constantly shifting socio-economic and biophysical environment, pathways and scenario-based approaches have an important role to play in climate change adaptation and resilience (Haasnoot et al. 2013, Pelling 2010, Wise et al. 2014).

4.3. Climate Risk

Climate risk is central to the RCF. Urban areas face risks from a range of hazards and drivers, yet the focus of the RESIN project is on those risks linked to the changing climate. The risk concept is well established across different disciplines (Cohen 2001, Dow et al. 2013, Ericson 2005, Giddens 1999). Risk is central to leading adaptation and resilience frameworks such as the IPCC's, and sits at the heart of their most recent assessment report on climate change impacts, adaptation and vulnerability (Burkett et al. 2014). Taking this approach also supports RESIN's focus on concepts linked to climate risk (including hazard, exposure and vulnerability), which are relatively well defined from a risk perspective. The IPCC's latest assessment report conceptualises risk in this way, as depicted in Figure 4 where risk is visualised as a function of weather and climate hazards, the degree to which a 'receptor' is exposed to a hazard and the vulnerability of the receptor to the hazard should it be exposed to it. It is notable that the IPCC's conceptualisation of risk also highlights the influence of climate and socio-economic processes on risk.

Several themes are central to understanding how risks associated with extreme weather and climate change arise in cities. Multiple interacting socio-economic and biophysical drivers of change impact on and shape cities, and will continue to do so. Climate change is one such driver. Related hazards and longer term shifts in the climate including floods, droughts and heat waves generate physical (e.g. damage to infrastructure) and socio-economic (e.g. loss of business revenue) impacts on urban systems. Although extreme events are of particular concern due to the magnitude of impacts they can generate (IPCC 2012), incremental changes to the climate or a sequence of less severe events can nevertheless pose major challenges to urban areas. The assessment of future hazard frequency and severity can be informed by the consideration of climate change scenarios, such as those prepared by the IPCC. Climate change scenarios highlight that different climate futures (and therefore hazard patterns and intensities) are possible depending on factors including greenhouse gas emissions.

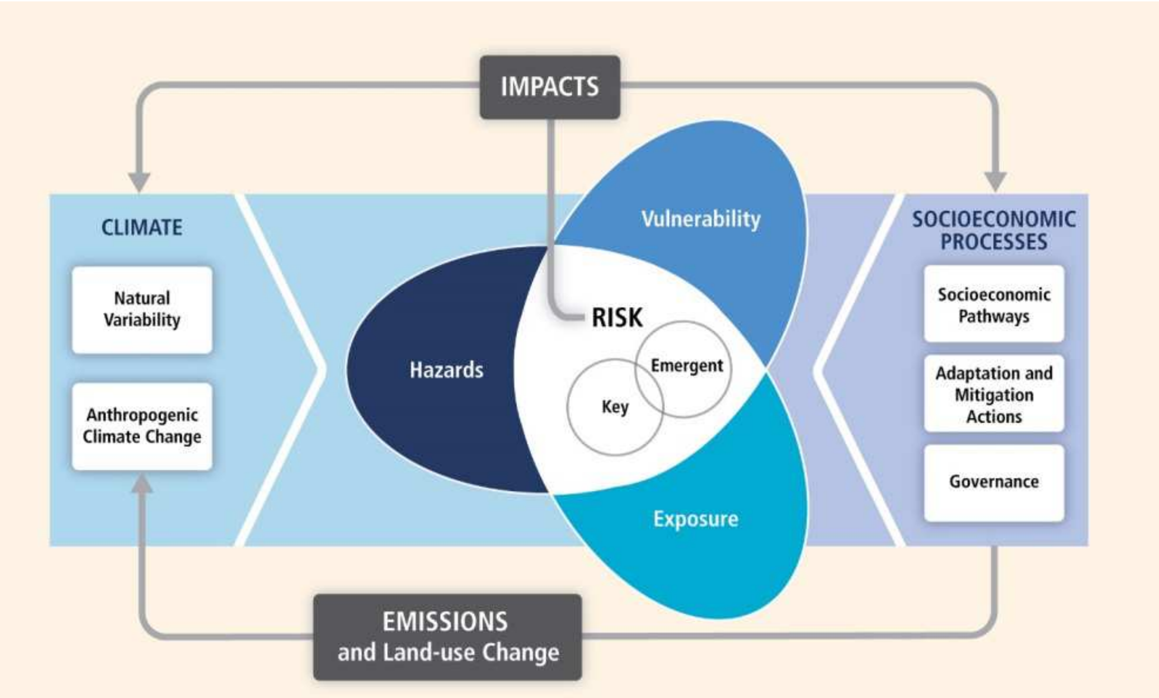

Figure 4: Conceptualization of risk by the IPCC. Source: IPCC 2014b.

The nature of urban climate change impacts depends on how vulnerable 'receptors' (e.g. people, infrastructure) are to a hazard event or gradual changes in the climate. Vulnerability concerns how sensitive or susceptible to harm receptors are to hazards, and also their capacity to cope with and adapt to impacts that may arise (Connelly et al. 2015). As such, vulnerability is influenced by political and institutional factors, such as political will to address climate change or capacity (which particularly concerns financial, technical and human resources) to develop adaptation responses. Vulnerability also relates to socio-economic issues including the age and economic status of citizens. Regarding infrastructure specifically, there are factors relating to design, age and level of maintenance that influence vulnerability to climate hazards. Collectively, the complex interplay between these factors provides an indication of the level of vulnerability to climate hazards. The IPCC's risk framework demonstrates that the level of risk facing urban areas from climate change can shift over time due to changes in vulnerability driver by socio-economic processes.

In cities, risks are generated when climate hazards (and other drivers of change) interact with elements of urban systems. The severity of climate risks essentially relates to the likelihood of a receptor being exposed to a hazard and the extent to which the receptor is vulnerable to harm or damage from a hazard event if it occurs. Within climate risk frameworks (such as the one used by the IPCC), where a vulnerable receptor is exposed to a hazard, this generates a high level of risk. However, where the intensity or severity of a hazard is low or a receptor is either not exposed or vulnerable to the hazard (due to low sensitivity to harm and/or high capacity to adapt), the level of risk is consequently lower. It is important to note that risk can change over time driven by change to factors that influence climate change hazard, exposure, and vulnerability. The assessment of climate risks, informed by a sound vulnerability assessment, is a key element of adaptation planning processes where adaptation responses are developed and implemented in response to climate risks. Given that risk changes over time, and also that society's perception of risk will alter, flexible and adaptable strategies and approaches are needed to build urban climate resilience.

In certain cases, climate change many generate opportunities as well as risks within urban systems. For example, a warming climate may enable new businesses to develop, and higher temperatures may reduce the need for space heating in some areas. However, in the majority of cases, climate change will have negative implications for urban areas, particularly when the indirect effects of climate change in other regions and countries are considered (Foresight 2011). It is also notable that climate change can act as a multiplier, and worsen the impact of other drivers on urban systems. For example, higher temperatures may exacerbate health problems in some urban areas.

4.4. Adaptation Planning

The right hand loop of the RCF represents an adaptation planning process, which surrounds an adaptation planning system. The IPCC uses the term 'adaptation assessment' to describe the practice of identifying and evaluating adaptation options (IPCC 2014a). Adaptation planning is broader and involves a wider process that moves from the assessment of climate risks through to the development of an implementation plan for selected adaptation actions. This process is influenced by an adaptation planning system, encompassing stakeholder networks and governance frameworks, which is substantially shaped by the availability of resources. As a result, adaptation planning is a diverse process and; "…there is no single approach for assessing, planning and implementing adaptation measures" (Fussel 2007: 267).

Adaptation planning is ultimately a decision-making process to select appropriate adaptation options to adapt and build resilience to climate change. The adaptation planning process will often result in a suite of options being developed, which complement each other and work together collectively to address different aspects of climate risks (and opportunities) and related vulnerabilities. The RESIN adaptation planning process follows four main stages:

1. *Assess climate risk.* Initially is it necessary to develop a good understanding of risks to the urban system caused by climate change and (extreme) weather events. It is also important at this early stage to identify relevant stakeholders to engage in the adaptation planning process, and to assess their roles and commitment to support the adaptation planning process.
2. *Develop adaptation objectives.* Here it is necessary to define and reach agreement amongst stakeholders on the goals and general approach of the adaptation planning process. Alternative courses of action may also be considered. The purpose of this stage is to

develop targets, priorities and guidance for subsequent stages of the process, taking into account local opportunities and constraints (e.g. financial, legal, and organisational).

3. *Prioritise adaptation options.* The goal of this stage in the process is to identify adaptation options to achieve the adaptation objectives developed previously. It is ultimately necessary to prioritise amongst these options, considering issues including their effectiveness and costs/benefits.

4. *Develop implementation plan.* This stage focuses on developing plans to support the implementation of priority adaptation options. Issues covered by these plans include resource allocation and timelines, as well as monitoring and reporting requirements to track the progress and performance of implemented options. Monitoring and evaluation are important as adaptation and resilience are learning processes.

The adaptation planning system concerns the institutional and regulatory context that shapes the process of decision making that is focused on developing adaptation responses. This system, around which the adaptation planning process revolves, encompasses stakeholder networks and governance frameworks. These frameworks actively shape and influence the process of making adaptation and resilience decisions. Their operation is shaped by factors including the availability of resources (financial, technological and human), the political will to take action to build climate resilience, attitudes to climate risk, and the social and cultural acceptability of different adaptation options. Stakeholder networks and governance frameworks are briefly introduced below.

- **Stakeholder networks:** A stakeholder can be defined as a: “person or organization that can affect, be affected by, or perceive themselves to be affected by a decision or activity” (definition adapted from ISO 31000:2009). Given the multi-sectoral and multi-scalar character of climate risks and resilience, there are numerous potential stakeholders that might be affected. As a result, the strength of networks between relevant groups of stakeholders is central to the effective development and implementation of adaptation responses. Involving a range of stakeholders in the adaptation planning process can support the development of collaborative outputs that benefit from a diversity of knowledge, experience and perspectives. This can also raise the knowledge and awareness of related issues amongst different groups and increases the likelihood of plans and actions being applied effectively in practice. Awareness raising and lobbying by non-governmental organisations, local environmental groups, and other relevant individuals and organisations are an important aspect of strengthening stakeholder networks and triggering action.

- **Governance frameworks:** The development and implementation of adaptation actions is influenced by governance frameworks, encompassing legislation, regulations, and guidance that can support adaptation and resilience action. Their existence is not essential to making progress, although governance frameworks can help to motivate and guide action, particularly where adaptation takes place at larger scales. A key example is spatial planning systems, which provide fora for developing plans and regulations to guide land use development and change, usually via consultative and consensus seeking processes. As spatial planning creates a negotiation space, it enables collaborative approaches to governing urban areas in the context of achieving adaptation and resilience goals to emerge. Governance frameworks are an important element of adaptation planning where strategies should target urban areas and the interdependencies between their different sub-systems across time scales and spatial scales.

A cross cutting theme influencing adaptation planning systems is the availability (or lack) of resources. Resource issues encompass themes including having the knowledge, data, skills and time available to understand climate risks and responses, and also to develop strategies to monitor and evaluate implemented adaptation options to facilitate learning. Resource issues can place barriers on the effective development and implementation of adaptation actions in urban areas. Barriers will differ from place to place. They may include practical issues including a lack of supportive legislative or policy frameworks, a lack of data to assess climate risks and evaluate adaptation responses and limited resources for the implementation, maintenance, monitoring and evaluation of adaptation actions in practice. Barriers may relate to more intangible issues linked to assessing and responding to urban climate risks. Here, issues such as complexity, connectivity, uncertainty, and non-linearity are relevant.

4.5. Supporting Adaptation and Resilience

The intended outcome of the adaptation planning process, represented by the right hand loop of the RCF, is the identification of adaptation actions to move the urban system towards a more resilient state. The UNISDR (2009) has set out a number of essential characteristics of resilient cities. These include elements of capacity building and taking action. Building capacity can involve approaches such as developing legislative and regulatory frameworks, nurturing stakeholder networks to work collaboratively and raise awareness of climate change adaptation and resilience, and enhancing research capability in the field. Building capacity is often, but not always, a necessary precursor to support the delivery of actions. Adaptation and resilience actions may involve physical measures to adapt urban areas to the changing climate, for example installing flood defences to protect infrastructure and enhancing urban green spaces and environments such as parks and river corridors. Less tangible actions are also relevant such as accessible insurance schemes for residents and businesses located in areas at risk of flooding, and strengthening emergency responses to extreme weather events. Although resilient cities may exhibit certain characteristics and processes, it is important to acknowledge that a resilient city will nevertheless have a different meaning depending on the perspective of the individual, community or organisation engaged in its definition, and also that notions of resilient cities will likely change over time.

There is a tension between various definitions of resilience in the context of cities and climate change. Indeed, there are different interpretations of what becoming more climate resilient actually means in practice. Klein et al. (2003) suggest that resilience should reflect the degree to which a system can absorb an external shock and remain in the same state, and also its capacity for self-organisation. Other definitions of resilience from the climate change and disaster resilience fields similarly emphasise issues such as ‘returning to normal operations’ and ‘the preservation and restoration of…essential basic structures and functions’ (NIAC 2009, UNISDR 2009). However, defining climate resilience in this way, in effect as returning to and maintaining the pre-hazard state, runs counter to the dynamism that characterises urban systems. Here, there is a clear need to integrate both resilience and adaptation perspectives in strategies to respond to the changing climate. Indeed, cities continually evolve over time, which may suggest the need for a more experimental and progressive view of urban climate resilience centred around the capacity to 'bounce forwards' following a hazard event (Davoudi et al. 2013). Here, the systemic and structural factors that contributed to the generation of climate risks are recognised and addressed, which will involve adaptation responses. In contrast, remaining in the same state, or 'bouncing back' to the pre-hazard state, will do little to make an urban area more resilient to future climate change hazards. This is because features of the urban system that potentially contributed to the generation of risks, such as certain land use patterns or policy frameworks, remain unchanged. This reflects back on the importance of learning as noted above, and also the need to view adaptation as not just responding to climate risks, but as a transformational process (Pelling 2011).

The approach taken to defining and subsequently operationalising resilience has a bearing on the RCF. Where resilience building encompasses an adaptation planning process, the potential exists to develop of a suite of proactive adaptation options to implement within the urban system. From the perspective of the RCF, this represents joining the climate risk and adaptation planning cycles. In contrast, a reactive approach where piecemeal actions are implemented within the urban system without the support of a deliberative adaptation planning process is likely to deliver less effective resilience outcomes. Within the RCF this would represent separating the two cycles, and the adaptation planning cycle may not even exist in such a situation.

The RCF emphasises that in order to build urban climate resilience, the climate risk and adaptation planning cycles need to be integrated. In doing so, climate-resilient pathways may be developed, which the IPCC define as: "iterative processes for managing change within complex systems in order to reduce disruptions and enhance opportunities associated with climate change" (IPCC 2014a: 120). Methods to support a pathways approach to adaptation and resilience decision making have been developed. For example, Haasnoot et al. (2013) propose the development of 'dynamic adaptive policy pathways' in order to support planning under conditions of uncertainty, which characterises the urban adaptation and resilience agenda. Ultimately, a climate resilient city is not an end-point to be achieved but an overarching set of goals and principles and associated actions.

5. Conclusions

The RCF visualises the key concepts around which the RESIN project is formed. As it will be used to help structure and communicate the project and its various work packages, it was important to involve the RESIN partners directly in its development. As such, the RCF is primarily focused on supporting the RESIN project, the key goal of which is to assist cities and urban areas in adapting and becoming more resilient to climate change. Given the cross-cutting nature of the adaptation and resilience agendas, related strategies and actions can also support broader urban goals linked to themes including social wellbeing and economic prosperity.

A number of other conceptual frameworks exist that have been designed specifically to support adaptation and resilience. These generally cover similar issues linked to the assessment of risk, including climate change hazard, exposure, vulnerability and adaptive capacity. The RCF aims to complement and not compete with these existing frameworks. The RCF reflects the emphasis of the RESIN project on supporting the development and implementation of actions to build the resilience of urban areas to climate change. Other projects and initiatives with a focus on adaptation and resilience may benefit from the RCF and its approach to connecting the urban system with the process of adaptation planning.

6. References

Andersson, E., Barthel, S., Borgström, S., Colding, J., Elmqvist, T., Folke, C., Gren, A. 2014. Reconnecting cities to the biosphere: stewardship of green infrastructure and urban ecosystem services. Ambio 43(4): 445-453.

Batty, M. 2009. Cities as complex systems: scaling, interactions, networks, dynamics and urban morphologies. In: Encyclopaedia of Complexity and Systems Science, vol. 1. Edited by R. Meyers. Berlin: Springer: 1041-1071.

Berkes, F., Folke, C. 2000. Linking social and ecological systems for resilience and sustainability, in: Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience. Cambridge University Press, Cambridge, pp. 1 – 26.

Berkes, F., Colding, J.F., Folke, C. Eds. 2003. Navigating nature's dynamics: building resilience for complexity and change. Cambridge University Press, Cambridge

Binder, C.R., Hinkel, J., Bots, P.W.G., Pahl-Wostl, C. 2013. Comparison of frameworks for analyzing social-ecological systems. Ecology and Society 18 (4): 26. Available at: http://www.ecologyandsociety.org/vol18/iss4/art26/

Birkmann, J., Tetzlaff, G., Zentel, K-O. Eds. et al. 2009. Addressing the challenge: recommendations and quality criteria for linking disaster risk reduction and adaptation to climate change. DKKV Publication Series 38, Bonn.

Burkett, V.R., A.G. Suarez, M. Bindi, C. Conde, R. Mukerji, M.J. Prather, A.L. St. Clair, and G.W. Yohe. 2014. Point of departure. In: Climate change 2014: impacts, adaptation, and vulnerability. Part A: global and sectoral aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCr acken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 169-194.

Carter, J.G., White, I. 2012. Environmental planning in an age of uncertainty: the case of the Water Framework Directive. Journal of Environmental Management 113: 228-236.

Carter, J.G., Cavan, G., Connelly, A., Guy, S., Handley, J., Kazmierczak, A. 2015. Climate change and the city: Building capacity for urban adaptation. Progress in Planning 95, 1–66.

Cohen, M.J. 2001. Risk in the modern age: social theory, science, and environmental decision-making. Palgrave, New York.

Collins, S.L., Carpenter, S.R., Swinton, S.M., Orenstein, D.E., Childers, D.L., Gragson, T.L., Grimm, N.B., Grove, J.M., Harlan, S.L., Kaye, J.P., others. 2010. An integrated conceptual framework for long-term social-ecological research. Frontiers in Ecology and the Environment 9: 351–357.

Connelly, A., Carter, J., Handley, J., Rome, E., Worst, R., Voβ, N. 2015. Vulnerability assessments: definitions, indicators and assessments. State of the art report (4), The RESIN project. Available at: http://www.resin-cities.eu/fileadmin/user_upload/D1_1_SOTAVulnerability_UNIMAN_2015-11-30.pdf

Da Silva, J., Kernaghan, S., Luque, A. 2012. A systems approach to meeting the challenges of urban climate change. International Journal of Urban Sustainable Development 4: 125–145.

Davoudi, S., Brooks, E., Mehmood, A. 2013. Evolutionary resilience and strategies for climate adaptation. Planning Practice and Research 28: 307–322.

Dow, K., Berkhout, F., Preston, B.L. 2013. Limits to adaptation to climate change: A risk approach. Current Opinion in Environmental Sustainability 5: 384–391.

European Commission (EC). 2008. EC Council directive 2008/114/EC of 8 December 2008 on the identification and designation of European critical infrastructures and the assessment of the need to improve their protection. OJEU, European Commission.

Ericson, R. 2005. Governing through risk and uncertainty. Economy and Society 34: 659–672.
EEA, 2012a. Urban Adaptation to Climate Change in Europe: Challanges and Opportunities for Cities together with Supportive National and European Policies (No. No. 2/2012). European Environment Agency, Copenhagen.
European Environment Agency. 2015. Urban systems. The European Environment - state and outlook 2015. (European Briefings). European Environment Agency, Copenhagen. Available at: http://www.eea.europa.eu/soer-2015/europe/urban-systems
Evans, J.P. 2011. Resilience, ecology and adaptation in the experimental city. Transactions of the Institute of British Geographers 36: 223–237.
Foresight International Dimensions of Climate Change. 2011. Final Project Report. London: The Government Office for Science.
Fussel, H M. 2007. Adaptation planning for climate change: concepts, assessment approaches and key lessons. Sustainability Science 2: 265-275.
Geels, F.W. 2002. Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. Research Policy 31: 1257–1274.
Giddens, A. 1999. Risk and Responsibility. The Modern Law Review 62.
Gill, S.E., Handley, J.F., Ennos, A.R., Pauleit, S., Theuray, N., Lindley, S.J. 2008. Characterising the urban environment of UK cities and towns: A template for landscape planning. Landscape and Urban Planning 87: 210–222.
Grimm, N.B., Faeth, S.H., Golubiewski, N.E., Redman, C.L., Wu, J., Bai, X., Briggs, J.M. 2008. Global change and the ecology of cities. Science 319: 756–760.
Gunderson, L., Holling, C. 2002. Panarchy: understanding transformations in human and natural systems. Island Press, Washington, DC.
Grove, M. 2009. Cities: managing densely settled social-ecological systems. In: et al.Principles of ecosystem stewardship. Resilience-based natural resource management in a changing world. Edited by Chapin III, F.S., Cofinas, G.P., Folke, C. Springer-Verlag, New York.
Haasnoot, M., Kwakkel, J.H., Walker, W.E., ter Maat, J. 2013. Dynamic adaptive policy pathways: A method for crafting robust decisions for a deeply uncertain world. Global Environmental Change 23: 485–498.
Intergovernmental Panel on Climate Change (IPCC). 2012. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley. Eds.]. Cambridge University Press, Cambridge, UK, and New York, NY, USA.
Intergovernmental Panel on Climate Change (IPCC). 2014a. Annex II: Glossary [Mach, K.J., S. Planton and C. von Stechow (eds.)]. In: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, pp. 117-130.
Intergovernmental Panel on Climate Change (IPCC). 2014b. Climate Change 2014: impacts, adaptation, and vulnerability. Part A: global and sectoral aspects. contribution of working group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White. Eds.]. Cambridge University Press, Cambridge, United Kingdom and New York, USA.
ISO 31000:2009 (en). Risk management — Principles and guidelines. Available at: http://www.iso.org/iso/home/standards/iso31000.htm
Jabareen, Y. 2009. Building a conceptual framework: philosophy, definitions and procedure. International Journal of Qualitative Methods 8(4): 49-62.

Klein, R. J. T., Nicholls, R. J., Thomalla, F. 2003. Resilience to natural hazards: how useful is this concept? Environmental Hazards 5(1): 35–45.

Leach, M., Scoones, I., Stirling, A. 2010. Dynamic sustainabilities: technology, environment, social justice. Abingdon and New York, Earthscan.

Loveridge, D. 2002. The SteepV acronym and process – a clarification. Manchester Business School, University of Manchester.

Mendizabal, M., Abajo, B., Martínez, A., Gutiérrez, L., García, G., Paz, J., Feliu, E. 2016. D8.1: Factors of transition and their dynamics, The RAMSES Project. Available at: http://www.ramses-cities.eu/index.php?eID=tx_nawsecuredl&u=0&file=fileadmin/fe_file_repository/08_Workpackage_8/Deliverable%208.1/RAMSES_D8.1.pdf&t=1456403549&hash=f52053e7b78e909d4729ed7ac4a9bbfb6c7e8643

Maxwell, J. 2013. Qualitative research design: an interactive approach. Sage Publications, Los Angeles, London, New Delhi, Singapore, and Washington D.C.

McHale, M.R., Pickett, S.T.A., Barbosa, O., Bunn, D.N., Cadenasso, M.L., Childers, D.L., Gartin, M., Hess, G.R., Iwaniec, D.M., McPhearson, T., Peterson, M.N., Poole, A.K., Rivers, L., Shutters, S.T., Zhou, W. 2015. The new global urban realm: complex, connected, diffuse, and diverse social-ecological systems. Sustainability 7: 5211–5240.

Miles, M. B., Huberman, A. M. 1994. Qualitative data analysis: An expanded source book, second edititon. Newbury Park, CA, Sage.

Mitchell, T., Van Aalst, M, Villanueva, P. 2010. Assessing progress in integrating disaster risk reduction and climate change adaptation in development processes. Institute of Development Studies, Brighton.

National Infrastructure Advisory Council (NIAC). 2009. Critical infrastructure resilience: final report and recommendations, Department of Homeland Security (US).

Newell, B., Crumley, C.L., Hassan, N., Lambin, E.F., Pahl-Wostl, C., Underdal, A., Wasson, R. 2005. A conceptual template for integrative human–environment research. Global Environmental Change 15: 299–307.

Pelling, M. 2010. Adaptation to climate change: from resilience to transformation. Routledge, London and New York.

Pickett, S.T.A., Cadenasso, M.L., Grove, J.M., Boone, C.G., Groffman, P.M., Irwin, E., Kaushal, S.S., Marshall, V., McGrath, B.P., Nilon, C.H., Pouyat, R.V., Szlavecz, K., Troy, A., Warren, P. 2011. Urban ecological systems: Scientific foundations and a decade of progress. Journal of Environmental Management 92: 331–362.

Pickett, S.T.A., Cadenasso, M.L., Grove, J.M., Nilon, C.H., Pouyat, R.V., Zipperer, W.C., Costanza, R. 2001. Urban ecological systems: Linking terrestrial ecological, physical, and socioeconomic components of metropolitan areas. Annual Review of Ecology and Systematics 32: 127–157.

Ravetz, J. 2000. City-Region 2020: Integrated planning for a sustainable environment. Earthscan, London.

Revi, A., Satterthwaite, D.E., Aragón-Durand, F., Corfee-Morlot, J., Kiunsi, R.B.R., Pelling, M., Roberts, D.C., Solecki, W. 2014. Urban areas, in: Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girma, B., Kissel, E.S., Levy, A.N., MacCracken, S., Mastrandrea, P.R., White, L.L. Eds. 2014. Climate change 2014: impacts, adaptation, and vulnerability. Part A: global and sectoral aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel of Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 535–612.

Rome, E., Voss, N., Connelly, A., Carter, J.G., Handley, J.F. 2015. Urban critical infrastructure systems. State of the art report 1, The Resin Project. Available at: http://www.resin-cities.eu/fileadmin/user_upload/D1-1_UCIsystems_Fraunhofer_2015-11-30.pdf

Rotmans, J., Kemp, R., van Asselt, M. 2001. More evolution than revolution. Transition management in public policy Foresight 3(1): 15-31.
Ruth, M., Coelho, D. 2007. Understanding and managing the complexity of urban systems under climate change. Climate Policy 7: 317–336.
Schewenius M, McPhearson T, Elmqvist T. 2014. Opportunities for increasing resilience and sustainability of urban social-ecological systems: insights from the URBES and the cities and biodiversity outlook projects. Ambio 43(4): 434-444.
Smith, A., Stirling, A. 2010. The politics of socio-ecological resilience and sustainable socio-technical transitions. Ecology and Society 15(1): 11. Available at: http://www.ecologyandsociety.org/vol15/iss1/art11/
Tschakert, P., Dietrich, K. 2010. Anticipatory learning for climate change adaptation and resilience. Ecology and Society 15(2): 11. Available at: http://www.ecologyandsociety.org/vol15/iss2/art11/
Turner, B.L., Kasperson, R.E., Matson, P.A., McCarthy, J.J., Corell, R.W., Christensen, L., Eckley, N., Kasperson, J.X., Luers, A., Martello, M.L., Polsky, C., Pulsipher, A., Schiller, A. 2003. A framework for vulnerability analysis in sustainability science. Proceedings of the National Academy of Science 100: 8074–8079.
United Nations Office for Disaster Risk Reduction (UNISDR). 2009. Terminology on disaster risk reduction. UNISDR, Geneva.
Walker, B., Holling, C.S., Carpenter, S.R., Kinzig, A. 2004. Resilience, adaptability and transformability in social–ecological systems. Ecology and Society. 9: 5.
Wise, R.M., Fazey, I., Stafford Smith, M., Park, S.E., Eakin, H.C., Archer Van Garderen, E.R.M., Campbell, B. 2014. Reconceptualising adaptation to climate change as part of pathways of change and response. Global Environmental Change 28: 325–336.
Young, O.R., Lambin, E.F., Alcock, F., Haberl, H., Karlsson, S.I., McConnell, W.J., Myint, T., Pahl-Wostl, C., Polsky, C., Ramakrishnan, P.S., Schroeder, H., Scouvart, M., Verburg, P.H. 2006. A portfolio approach to analyzing complex human-environment interactions: institutions and land change. Ecology and Society. 11 (2): 31. Available at: http://www.ecologyandsociety.org/vol11/iss2/art31/

7. Appendix A – Details of the RCF approach

This appendix includes details of the process that was followed to develop the RCF.

7.1. Review of Existing Frameworks

A review of existing adaptation and resilience frameworks was undertaken, and encompassed those contained within reports and literature from international organisations, research institutes, consultancies and academic journals.

Based on the review, several objectives appear to underpin the development and use of adaptation and resilience conceptual frameworks, with some frameworks addressing more than one objective. They are:

- ***Understanding*** climate change adaptation and resilience through clarifying the relationships between different elements of these agendas.
- Providing a structure to guide the ***assessment*** of vulnerability to climate change or the nature of prominent climate impacts and risks.
- Guiding decisions linked to ***identifying options*** for adapting and building resilience to climate change.

These objectives highlight that a key role of conceptual frameworks is decision support. The review also identified several notable distinctions between existing adaptation and resilience frameworks. These include:

- Frameworks adopt different structures. They are generally either linear, cyclical or are based around an alternative design (e.g. Venn diagrams).
- Some, but not all, frameworks focus on visualising different stages in the process of identifying a strategy or action to adapt or build resilience.
- The complexity of frameworks varies in terms of the number of concepts they include and the intensity of the connections between these concepts.
- Some frameworks are dynamic, whereas others are more static in nature. Within a dynamic framework there is recognition of the potential influence of climatic and non-climatic drivers on themes such as vulnerability and risk. Static frameworks place these themes within a closed system and do not account for the influence of external drivers on the system.

- The majority of frameworks are generic, although some focus on a specific system. These are generally resilience frameworks, where the primary system of interest is cities or urban areas.
- Some framework are designed to be applied by policy makers, practitioners or researchers to support decision making, whilst others are intended to be purely explanatory in nature.

The review provided valuable insights into the form and function of existing conceptual frameworks, and helped to clarify issues framing the RCF.

7.2. RESIN Partner Questionnaire

At an early stage in the development of the RCF, an online questionnaire was completed by nine RESIN partners to establish their understanding of the scope and purpose of the RESIN project. Key findings were:

- The goal of the project was confirmed as supporting the development and implementation of adaptation and resilience strategies and actions for cities and their critical infrastructure(s).
- The development of standardised assessment and decision support approaches to enhance adaptation and resilience in cities was regarded as central to the project.
- The thematic focus of the project is on weather and climate hazards (not all potential hazards) and their impacts on urban systems, particularly critical infrastructure.
- Partners tended to take a conventional view of infrastructure that is ‘critical’ to urban areas, focusing on hard or technical infrastructure sectors including transport, water and energy. However, some references to green infrastructure and social infrastructure were made.
- Partners recognised that a range of different factors influence the resilience of urban areas to climate change. This is indicative of a systems perspective of urban areas.

7.3. RESIN Partner Workshops

Two workshops were undertaken with RESIN partners in order to inform the development of the RCF. The first was held in Manchester on the 29th September 2015. This helped to confirm the key themes defining the scope of the RESIN project, some of which were raised in the questionnaire responses. These were:

- The central goal of the project is to collaboratively support and build the capacity of stakeholders and decision makers in adapting and building resilience to climate change.
- Complex city systems sit at the centre of the project.

- Critical infrastructure is the city sub-system of focus for the project.
- Climate change is the key ‘driver of change’ being considered within RESIN.
- The importance of non-climate drivers (e.g. demographics, economics, and governance) and their interaction with the changing climate was recognised.
- Assessing climate change vulnerabilities, impacts, risks and adaptation responses is central to the project.
- The integration and standardisation of adaptation and resilience approaches and relevant disciplines is a key methodological aspect of the project.

In addition to the thematic focus of the RESIN project, several other notable issues were raised regarding the form and function of the RCF.

- The framework must be able to communicate beyond the RESIN consortium to external audiences.
- The framework should provide an overarching context for the RESIN project. It was also noted that it should provide ‘hooks’ into the projects work packages.
- Risk provides a strong foundation for the RCF as it is a concept that is well established across different approaches and disciplines related to adaptation and resilience.
- The IPCC’s risk-based framework provides a useful reference point given its high profile and widespread application.

A prototype RCF was presented and discussed during a second meeting in Bratislava on the 11th November 2015. The key message emerging from the discussion was that the themes structuring the framework are broadly correct. But, the prototype framework needed to be simplified and clarified in order to be relevant to a wider range of audiences (particularly city decision makers). Also, it was established that there should be one framework, not multiple frameworks.