SMART MATURE RESILIENCE

D1.3 MULTIDISCIPLINARY LITERATURE SYNTHESIS

Linköping University | March 2016

REVIEWED VERSION | 18/11/2016

Deliverable title	Multidisciplinary Literature Synthesis
Deliverable no.	D1.3
Work package	1
Dissemination Level	Public
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Date	31/03/16
File Name	D1.3.SMR_Final.docx
Revision	
Reviewed by (if applicable)	
Revision date	18/11/16
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This document has been prepared in the framework of the European project SMR – SMART MATURE RESILIENCE. This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement no. 653569.

Funded by the Horizon 2020
programme of the European Union

EXECUTIVE SUMMARY

Increasing resilience to crises and disasters is a topic of highest political concern worldwide. Cities and communities need methods and tools to prevent and manage the effects of natural hazards such as floods, storms, earthquakes, volcanoes and tsunamis as well as man-made threats, such as accidents and terrorism. The aim of the Smart Mature Resilience project is to deliver a Resilience Management Guideline to support city decision-makers in developing and implementing resilience measures in their cities in order for the cities to form an emerging resilience backbone for Europe. The overall objective of WP1 is to obtain an overview of current practice in urban resilience and EU sectorial resilience approaches, to identify, synthesize and assess the main challenges and best practice of today.

This report is the result of the work carried out in the first, second and third tasks in WP1 of SMR. The report includes summaries of D1.1 in terms of (1) a systematic literature review of urban resilience, (2) a review of world-wide reports, approaches and indicators related to urban resilience and, (3) a city survey of approaches and challenges for our SMR partner cities. The report also summarises work conducted in D1.2, specifically, (1) a systematic literature review of three problem areas (resilience in critical infrastructure (CI), climate change (CC) and social dynamics (SD)), (2) a review of EU project reports, and (3) a repository of policies, metrics and best practices.

With regards to the analysis and synthesis of resilience approaches in D1.3, the report provides a working definition on urban resilience based on reviewed literature. Moreover, the report presents the SMR City Framework (SCF) – a theoretical perspective on city resilience based on contemporary theories in Resilience Engineering. An operationalization of SCF is also provided that can direct the development of a maturity model for SMR as well as focusing design of tools, instruments and standards in the SMR project. The report is finalised with a discussion of implications for the SMR project.

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1 INTRODUCTION

Smart Mature Resilience (SMR) is a multi-disciplinary research project working toward increased city resilience in Europe. Researchers and city representatives come together to enhance cities' capacity to resist, absorb and recover from the hazardous effects of climate change. Seven partner cities are included in the SMR project, three of them will implement the Resilience Management Guideline, and the other four will be engaged in the pilot implementations as peer reviewers. A Resilience Management Guideline and a set of practical tools are piloted in this core group of cities strengthening the nexus of Europe's resilient cities. Through their participation in project workshops and their peer reviewing activity, the cities will all feel ownership of the tools and the Resilience Management Guideline and become early adopters. The goal of the SMR project is to further reach out to more cities, in a first step to cities part of established networks (such as UNISDR, European members in 100 Resilient Cities of the World), and then to other European cities (see Figure 1). This report provides a literature overview of current research on urban resilience, review reports from organisational bodies and cities worldwide on resilience implementation. Moreover, the report provides a working definition of urban resilience based on reviewed literature. Additionally, the report presents the SMR City Framework (SCF) – a theoretical perspective on city resilience based on contemporary theories in Resilience Engineering. An operationalization of SCF is also provided that can support the development of a maturity model for SMR a well as focusing design of tools, instruments and standards in the SMR project.

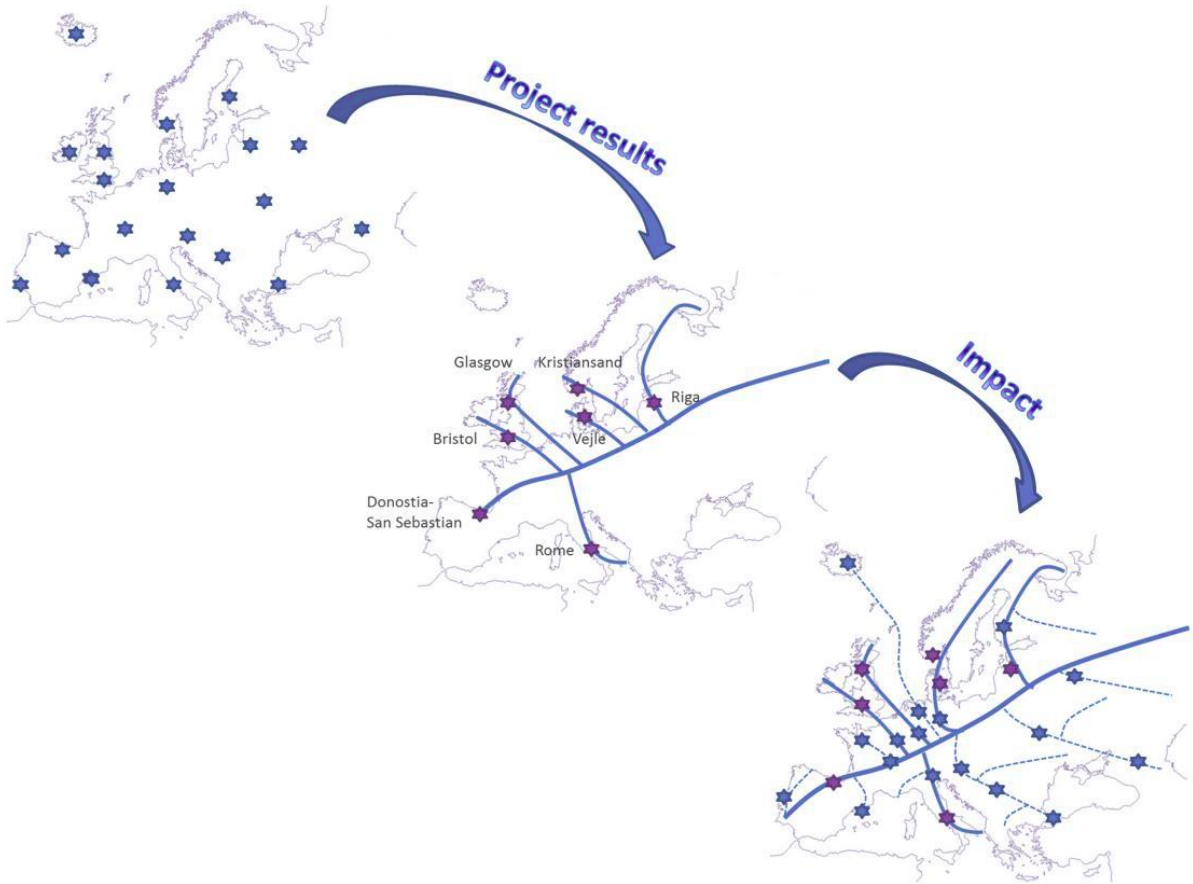

Figure 1. The emergence and growth of a resilience backbone, first as direct result and then, over time as impact of the project.

1.1 PURPOSE AND SCOPE

The notion of resilience is used in a variety of research fields and the definitions of resilience vary from descriptions of one system to another. The goal of WP1 is to analyse resilience approaches and summarise their main elements. Moreover, an additional objective is to provide a working definition, model and operationalization of city resilience. These elements will become inputs for future work in the SMR project.

This deliverable provides an overview of theoretical concepts and approaches found in WP1. These concepts have been synthesised into a resilience model and framework for cities that will act as a theoretical basis for SMR.

1.2 RELATIONSHIP WITH OTHER TASKS

As illustrated in Figure 2, D1.1 and D1.2 are closely related, providing literature reviews of work related to urban resilience in different sectors. In D1.3 the work from the two previous deliverables has been synthesised, offering a common framework for continued work in the SMR project. In Task 1.4 (D1.4) this framework will be discussed with our academic and city experts, and should be seen as the first stepping stone toward operationalisation of the concepts and terms, to later be translated into the SMR tools in later WPs.

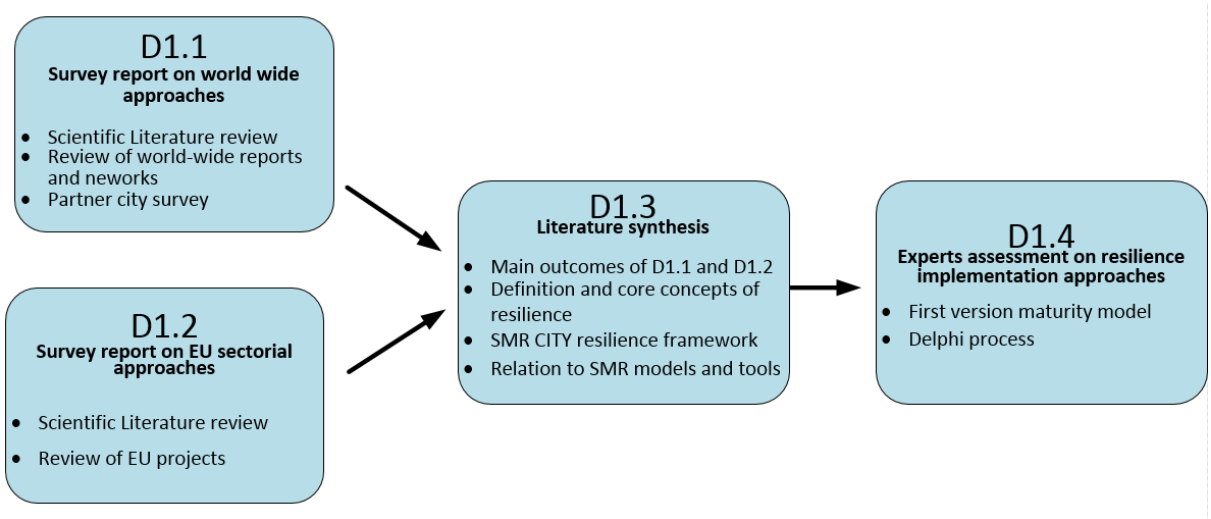

Figure 2: Workflow of WP1 and information sharing with related SMR tasks.

The work in these reviews will be further used throughout the project, as is shown in the Figure 3.
The diagram illustrates the information usage produced by WP1 to other WPs especially WP2, WP3, WP4, and WP6. Each WP is depicted as a box consisting of its corresponding tasks. The information usage is portrayed through arrows linking different tasks: the white arrows (A1-A4) represent the information from T1.1 to other tasks, the blue arrows (B1-B6) represent the information from T1.2 to other tasks, the gray arrows (C1-C10) represent the information, after the findings in T1.1 and T1.2 were aggregated. The light orange arrows (D1-D3) represent the information from WP2 to other WPs including WP1. In this section links of arrows C and D are outlined. For A and B arrows, please see D1.1

and D1.2 respectively. The light orange arrows (D1-D3) represent the information from WP2 to other WPs including WP1.

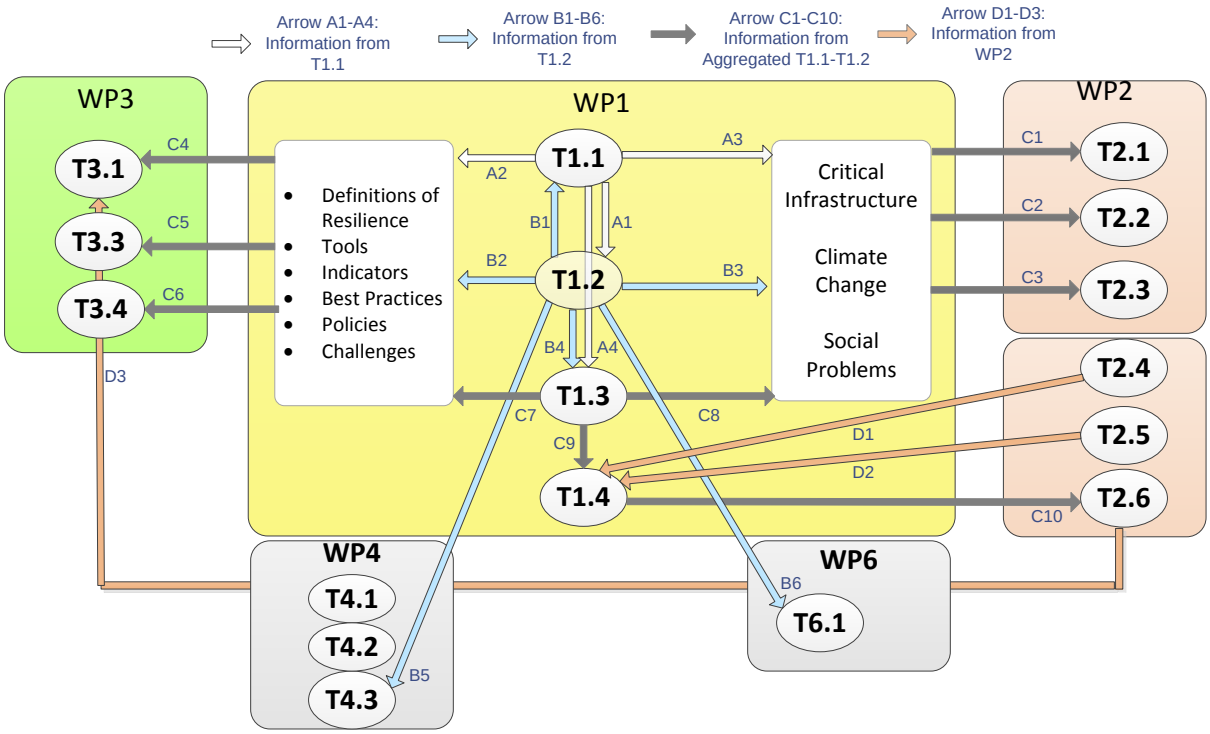

Figure 3. Information flow from WP1 to other WPs

- The arrows C1, C2, and C3 represent the inputs and preliminary information from literature in the three problem areas: CI, CC and SD provided by T1.1, T1.2 and T1.3 in advance of each workshop preparation, i.e. T2.1 (CI), T2.2 (CC) and T2.3 (SD).
- The arrows C4, C5 and C6 represent the information consumptions from aggregated results obtained from WP1, for example, by aggregating the indicators from WP1 to the revised version of Maturity Model (T3.1), indicators needed for System Dynamics model (T3.4), and policies to be included in the Resilience building policies (T3.3).
- The arrows C7 and C8 represent aggregated, synthesized information in T1.3 that covers main findings from T1.1 and T1.2 (arrow C7), including the three problem areas: CI, CC, and SD (arrow C8).
- The arrow C9 connecting T1.3 and T1.4 indicates the information summary flows from T1.3 to T1.4 to be used for Delphi process and design, which included questions on perspectives, approaches and indicators of resilience

- The arrow C10 connecting T1.4 and T2.6 indicates the information from Delphi process (T1.4) to be taken into account in the development of the maturity model (T2.6).
- The arrows D1 and D2 to T1.4 represent additional information and support for the Delphi Design (T1.4) especially from the results of the holistic resilience report (T2.4) and resilience requirements from the cities (T2.5).
- The arrow D3 connecting T2.6 to T3.1 represents the improvement of the maturity model in T2.6, which is not only based on Delphi process and other workshop activities in WP2, but also from the worldwide survey, EU sectorial surveys and synthesize reports.

1.3 STRUCTURE OF THE DOCUMENT

Chapter 2 offers an overview of the context and background resulting in the work presented in this report. In Chapter 3, the main outcomes from Task 1.1 are discussed. Chapter 4, similarly, offers a description of results from T1.2. Chapter 5 provides a definition of urban resilience based on the reviewed literature. In Chapter 6, we present the SMR City Resilience Framework and its operationalization. The remaining chapter is a discussion how results from WP1 relates to upcoming tasks, instruments and tools in SMR. Figure 4 shows the structure of the report.

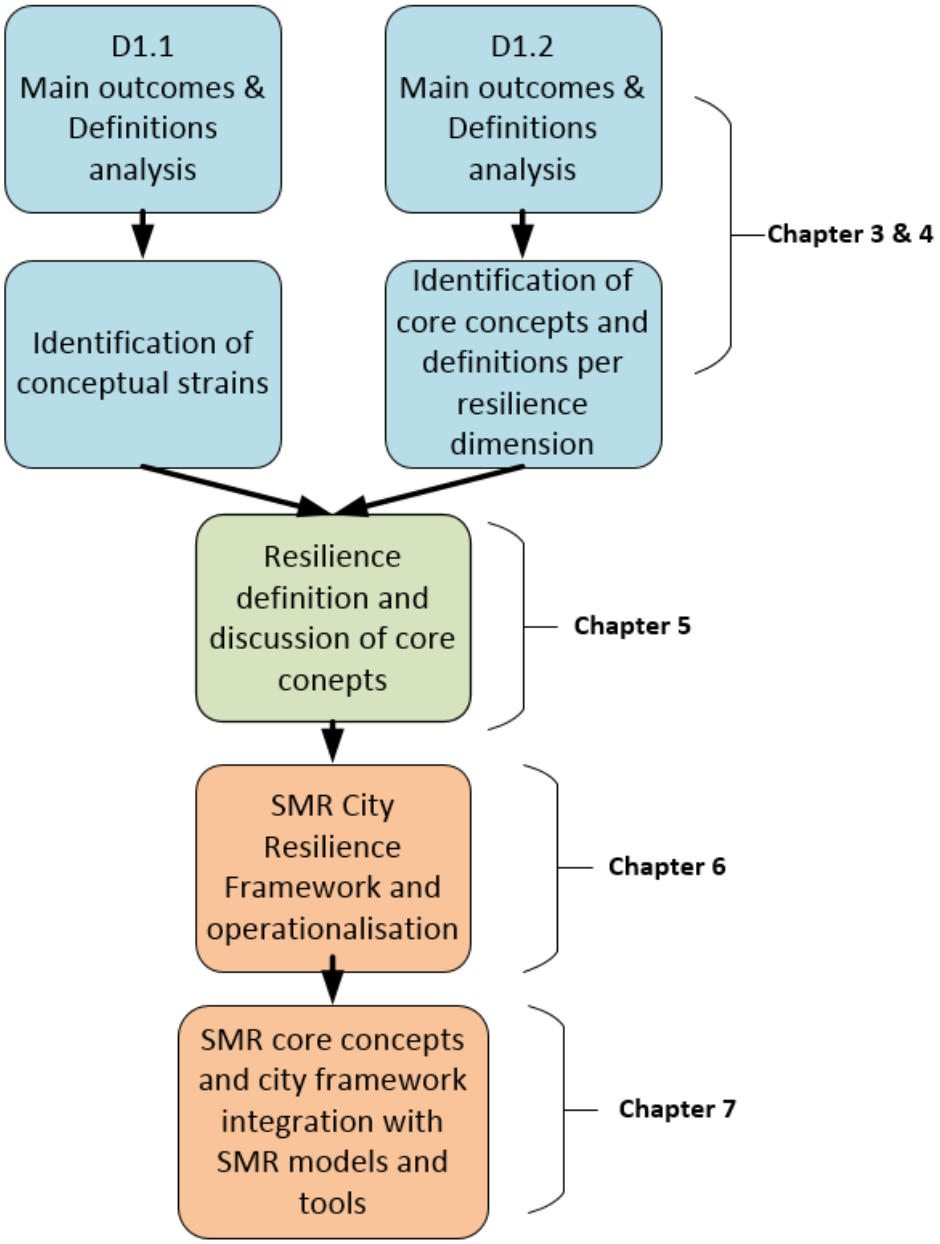

Figure 4: The structure of Deliverable 1.3.

2 CONTEXT AND BACKGROUND

Increasing our resilience to crises and disasters is a topic of highest political concern worldwide. Cities and communities need methods and tools to manage the effects of natural hazards such as floods, storms, earthquakes, volcanoes and tsunamis as well as man-made threats such as accidents and terrorism. The term resilience can be defined as a systems' ability to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner (UNISDR, 2009). Having this ability will relate to many sectors and areas of community management: its governance, infrastructure, finance, design, social and economic development, and environmental /resource management (ICLEI: Resilient Communities Program Concept, 2002). This Horizon 2020 project aims to develop a basis for a general guideline on resilience assessment and implementation to increase EU and its Member States and Associated Countries resilience to crises and disasters. The aim of the Smart Mature Resilience project is to deliver a Resilience Management Guideline to support city decision-makers in developing and implementing resilience measures in their cities in an overall European perspective. The Resilience Management Guidelines will provide a robust shield against man-made and natural hazards, enabling society to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of essential structures and functions. Moreover, a set of tools will be developed that will operationalise the resilience concept and crucial interdependent supporting structures of the Resilience Management Guidelines:

1) A Resilience Maturity Model defining the trajectory of an entity through measurable resilience levels;

2) A Systemic Risk Assessment Questionnaire that, beyond assessing the entity's risk, determines its resilience maturity level;

3) A portfolio of Resilience Building Policies that enable the entity's progression towards higher maturity levels;

4) A System Dynamics Model allowing to diagnose, monitor and explore the entity's resilience trajectory as determined by resilience building policies; and

5) A Resilience Engagement and Communication Tool to integrate the wider public in community resilience, including public-private cooperation.

Beyond delivering the validated Resilience Management Guidelines and the five supporting tools, the SMR project establishes a European Resilience Backbone consisting of vertebrae (adopters, from fully

committed through direct project participation to alerted potential adopters). The SMR project's powerful impact maximizing measures will assist the implementation of the Resilience Management Guidelines by consolidating the resilience vertebrae as mutually supporting functional units of the European Resilience Backbone. The five tools operationalising the five crucial interdependent supporting structures of the Resilience Management Guidelines will be commercialised, targeting users in Europe and beyond.

The overall objective of WP1 is to obtain an overview of current practice in urban resilience and EU sectorial resilience approaches, to identify, synthesize and assess the main challenges and best practice of today. This will be achieved through a worldwide survey of approaches and a literature overview of state-of-the-art resilience research to synthesize and ensure common ground of concept, methods and approaches.

This deliverable targets the objectives in WP1 of deepening our knowledge on how to define, develop, implement and evaluate resilience approaches in the urban context. The work presented summarises earlier work in WP1 and provides a synthesis in the form of a working definition, a theoretical framework with an operationalization of city resilience. The work presented is important for the development of a Resilience Management Guideline, Maturity Model and related instruments in SMR that will be used to define the trajectory of an entity through measurable resilience levels.

3 MAIN OUTCOMES FROM D1.1

3.1 INTRODUCTION

Deliverable 1.1 (D1.1) contains an analysis of worldwide approaches to resilience. The report includes:

1. A systematic literature review of urban resilience,
2. A review of world-wide reports and networks related to city resilience, and
3. A survey of how cities world-wide work with resilience, including our SMR partner cities.

D1.1 aims to deepen our understanding of resilience in the context of cities. It provides a basis for the SMR project to operationalise the concept of resilience to a practical level and city context as a basis for overall European resilience.

Below is a summary of the findings in D1.1. The summary includes main outcomes of "perspective on resilience", including outcomes of the definitions analysis and approaches for resilience. The last section offers a discussion on the main conceptual "tensions" found in the literature. These have been used as a guideline for developing the resilience definition.

3.2 PERSPECTIVES AND APPLICATIONS OF RESILIENCE

Due of the multidisciplinary nature of resilience there have always been several perspectives and applications of resilience. The following provides a summary of the evolution and standpoints of Resilience.

Folke (2006) reviewed the literature and found that there were three major branches of resilience viewpoints: single equilibrium, multi equilibrium and non-equilibrium (adaptive cycles). *The single equilibrium model* has become the most common within the areas of networks and built infrastructure, often encompassing systems that have many measurable variables. For this type of resilience, most challenges to the system will lie within an accepted margin of performance; this is sometimes referred to as the *robustness* (a concept similar to *Absorption*) of the system (Bruneau et al., 2003). The time it takes to return to normal is the *rapidity* (similar to *Recovery*) of the system. The system uses built-in *redundancies* to be able to return to its favoured state. The system may also be *resourceful*, in that it

has a capacity to modify itself for a possible situation. This can be done by prioritising or using different resources, e.g. monetary or human, to compensate for the disturbance.

Multiple equilibriums and bouncing forward often come into play when describing more complex systems, such as disaster resilience or road and transportation networks of a city. Consider a city plagued by constant traffic jams. By investing in public transportation and making it easier to bike, the city moves from one equilibrium (where the chief mode of transport is by car) to another (where the citizens use public transport and/or bikes to a much higher degree). In this conception of resilience, it may not be desirable to return to the previous state, as the same vulnerabilities will be reproduced. It may not even be possible to return to a previous equilibrium point. The idea is instead to "bounce forward", in an effort to rid the system of the non-essential parts and to reinvent itself (Malalgoda, Amaratunga, & Haigh, 2014). In this broader view of resilience, the history of the system becomes important. When the system bounces forward it may adopt policies or make investments that will be hard or expensive to change in the future. This is sometimes referred to as 'lock-in'. However, the question remains if the new point of equilibrium is more resilient or not, or if the vulnerabilities have simply shifted. The kind of vulnerabilities that exists for cars might not exist for public transportation, but the loss of traffic may cause a loss of income and business for the city, and thus create new vulnerabilities.

In disaster resilience, which is mostly concerned with short-term and extreme events, a *multi-equilibrium* view is common within definitions. The multi-equilibrium models may describe a community's ability to absorb the impact of storm or to quickly recover from a storm (e.g., two days after the storm no debris could be seen on the streets and life was back to normal). However, even if things are back to normal relatively quickly it might not be a desirable state. Instead of bouncing back from an event they can learn from the event and therefore 'bounce forward' to a new equilibrium.

Non-equilibrium models are gaining increased attention. In this view, resilience can be described as adaptive cycles, and these models are used in definitions of resilience coping with complex, dynamic and highly interconnected systems. In these models, the equilibriums themselves are not the most interesting factors; rather it is the processes that shape the change in the system that get modelled. A system moves through different phases and all parts of the system go through adaptive cycles. These adaptive cycles are nested within larger cycles. The nested cycles push for change and restructuring of the larger cycles and the larger cycles provide restrictions and also stability for the nested cycles (Pendall, Foster, & Cowell, 2010).

3.2.1 DEFINING URBAN RESILIENCE

In the literature review 119 articles were reviewed on the topic of urban resilience and disaster resilience. Results from the study showed that 62 of the articles used an explicit definition of resilience (for a word cloud of the most frequently used words, see Figure 5), 29 articles were review articles that tried to either tie together the differing ideas of resilience or to problematize some aspect of resilience, and 26 articles simply lacked an explicit definition and often assumed that the reader was familiar with the concept. Of the 62 articles with explicit definitions the most cited source of the definition is Holling (1973), perhaps because of its historical implications, as it is often credited as the first work using resilience to describe socio-ecological systems. Other often cited definitions is the definition from UNISDR (2009) and from Bruneau et al., (2003). Various researchers working within the socio-ecological tradition (e.g. Folke, 2006; Gunderson, 2010) often refer to each other but use their own personal definitions of resilience.

Figure 5: Word cloud for all explicit definitions of resilience.

The explicit definitions often target a specific dimension or area of resilience. The dimensions are listed in Table 1 and show that the most common definitions target community resilience and disaster resilience. This is followed by a general system resilience, socio-ecological resilience and economic resilience. It should be noted that many of the community resilience definitions stem from the viewpoints in socio-ecological resilience.

Table 1. Distribution of resilience dimensions

Resilience Dimensions	No. of articles
Community	19
Disaster	18
System (general)	11
Socio-Ecological	5
Economic	3

The articles using explicit definitions were extracted and analysed from a number of different viewpoints (see D1.1 for more information). The most common concepts used in urban/disaster resilience definitions are absorb, recover and adapt (or a variation of this word, see Table 2).

Table 2. Word variations

Behaviours	Clustering of word variations
Adapt	Accommodate to, Transform, Reorganize, Change
Absorb	Maintain function, Resist, Mitigate, Respond to, Cope
Recover	Re-establish, Bounce back, Regenerate, Rebound, Spring back

Figure 6 illustrates the percentage of the explicit definitions that used one or several of these concepts. Most of the definitions included are either during or after an event, or a combination of the two (86%). Many definitions (40%) included the abilities of being able to adapt, absorb and recover, while other included, for example absorb and recover (13%), adapt and absorb (11%), or only adapt (10%). A few (6%) include self-organising. Another term that was emphasised in the socio-ecological viewpoint (which is a non-equilibrium view of resilience) stressed the ability to adapt and also the ability to *self-organise*.

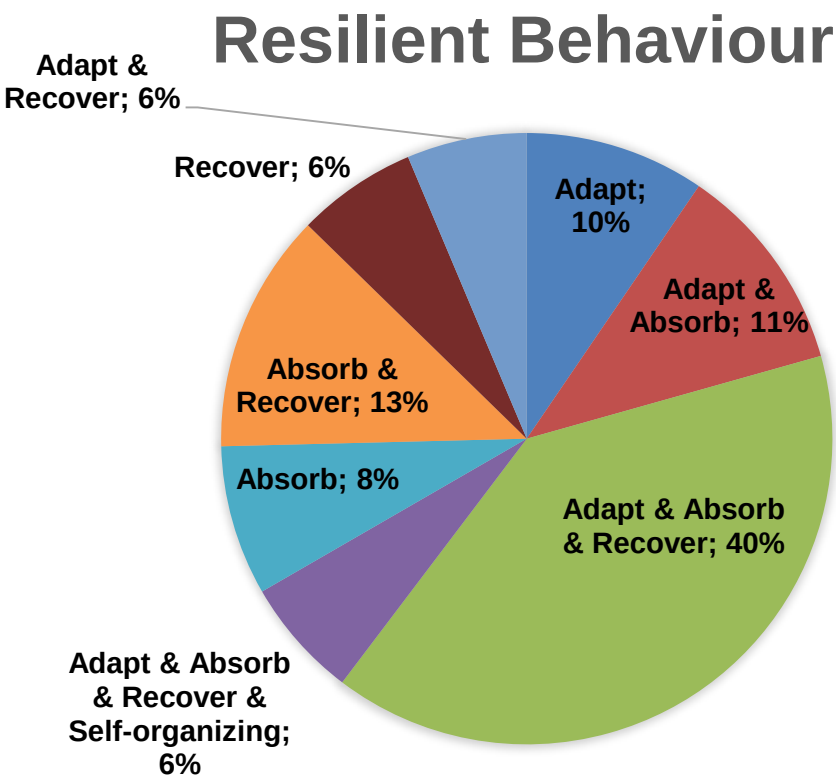

Figure 6. Overview of resilient behaviours. Based on the review of 62 definitions found in literature an analysis of resilient behaviours has been performed. The Figure illustrates the percentage of the behaviours that used one or several of these concepts.

An analysis of temporal aspects (Figure 7) of resilience shows that most definitions see resilience as something that happens or occurs during and after an event. In 72% of the definitions, resilience occurs during or after an event. In 48% of the definitions, it occurs during and after. Resilience before the time of an event is seen in 28% of the definitions. The combination of before, during and after is used in 14%. The definitions paint a picture of resilience as something that comes into play primarily during or after an event.

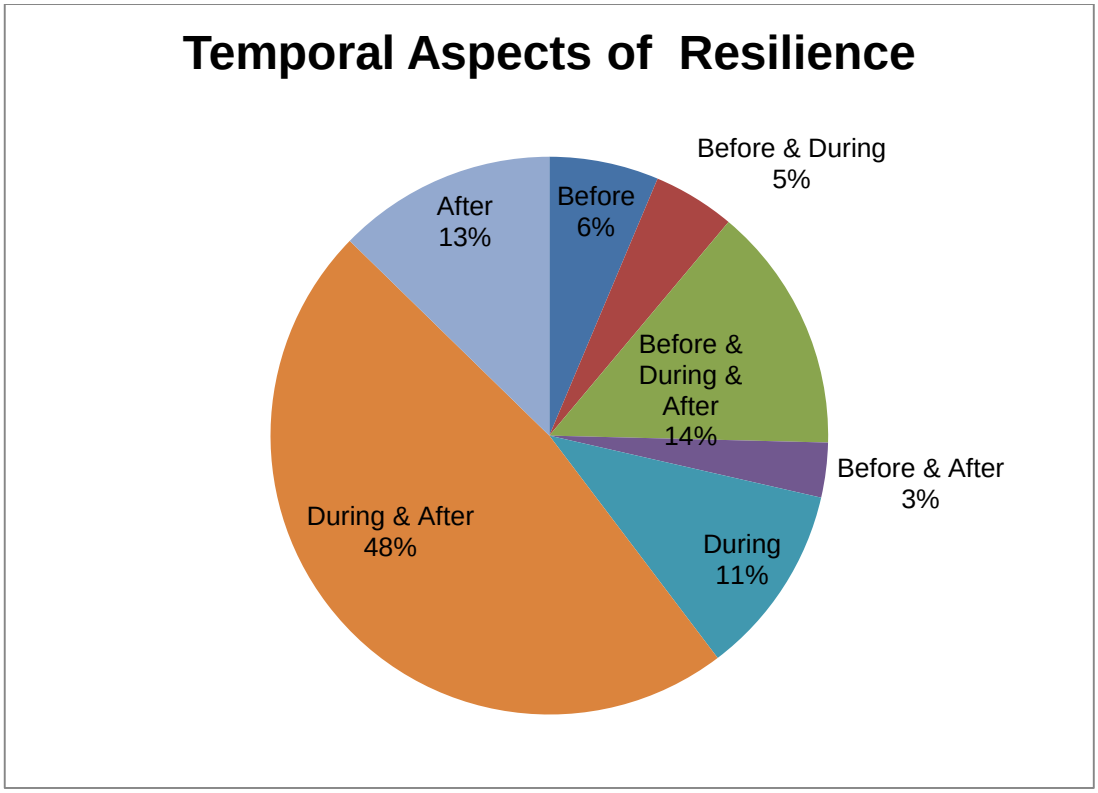

Figure 7. Overview of temporal aspects. Based on the review of 62 definitions found in literature an analysis of resilient behaviours has been performed. The Figure illustrates the percentage of the temporal aspects that used one or several of these concepts.

Disaster and Community have a larger focus on recovering after an event compared to general systems and socio-ecological systems (89% and 75% vs. 64% and 60%, respectively). Community and socio-ecological both included aspects of adaption in their definitions (90% and 100%), while Disaster and general Systems tended toward a lower degree (74% and 64%). More pragmatic and applied dimensions such as Disaster and Community resilience see resilience as something to be prepared before an event (44% and 35%, respectively) compared to more abstract dimensions such as systems and socio-ecological systems where the number is 0%. For a more complete discussion see D1.1 Section 3.

3.2.2 CONCEPTUAL "TENSIONS"

The literature shows that there are a number of complex issues regarding the definition and operationalisation of resilience in the urban context. Throughout the reviewed literature we have identified a number of conceptual "tensions", which involve theoretical concepts that are used and applied in relation to urban and disaster resilience and that are applied inconsistently or in an unclear way. These conceptual "tensions" include: "the notion of equilibrium", "resilience behaviours: flexibility

vs. robustness", "time aspects", and "urban resilience boundaries". Each of these tensions is discussed below:

The notion of equilibrium

In early models, systems (e.g., eco-systems, social systems, organisations, etc.) are conceived as having one or more stable states or points of equilibrium (Bruneau et al., 2003). Resilience, in this sense, is the system's ability to remain at or near the equilibrium point, while being pushed or pulled in another direction. In later models, it is acknowledged that following a disturbance, a system never goes back to the exact same point it was before the disturbance. The models then included the description of how a system moves from one equilibrium point to the next, and adapted to fit the on-going situation (e.g. Malalgoda et al., 2014). In the late 1990s, several disciplines moved away entirely from the equilibrium model, where a system has one or more stable states, to a non-equilibrium model, which emphasizes the continuous change of the system (e.g. Walker & Cooper, 2011). In this view, change is the most important aspect of any natural system and resilience becomes the ability of a system to adapt into a more suitable configuration.

Resilience Behaviours

The analysis of definitions shows that there are differences in the definitions regarding which behaviours characterise resilience (see Figure 5). Many definitions (46%) included all three categories of abilities; adapt, absorb and recover. Others included only absorb and recover (13%), adapt and absorb (11%), or only adapt (10 %). The different behaviours suggest different viewpoints and objectives. The category of "recover" suggests that there is an objective to "get back" to a previous state following a disturbance, the category "absorb" suggests that a city is robust and can handle a disturbance without changing its basic structure and the category "adapt" suggests a change in structure to cope with the new demands. It is not clear from the definitions in which sense the abilities should be targeted at "recovering" following an event, compared to its ability to "adapt" and change in the face of disturbance. The two concepts include different theoretical underpinnings, have different objectives and means to reach these goals a definition and thus pose a challenge when used concurrently in definitions.

The category "absorb" suggests another approach, as resilience is regarded as a systems ability to cope with disturbances without changing its basic structure. However, it could be argued that some part of the system should be robust (i.e. absorb) against highly probable events, for example levees that protect vital parts of the community from flooding. At the same time other parts may benefit more from being flexible and easily adaptable, such as work processes, communication channels and use of resources (e.g., boundary-spanning). An aspect of resilience that the socio-ecological dimension pushes for is the

ability to self-organise (which found in 6% of the definitions). When faced with a surprising and new threat, the kind of threat that tests resilience, the old hierarchies and ways of communication in the community might need to change in order to be able to effectively respond. Flexible ways of working and communicating together can form the backbone of a resilient community.

Results from the city survey show that the city respondents were more focused on robustness rather than flexibility. Plans and action include improving abilities to mitigate disturbance and identify ways to control known threats. The problem areas identified are closely linked to previous disturbance and improving abilities to cope with similar situations. Resilience strategies were thus targeted towards stability rather than flexibility. The focus is on planning for the known and predictable problems rather than the surprising, unknown problems that resilience is touted as a possible solution to.

Temporal aspects

The time aspect in resilience definitions is another area where differences are found. The most common descriptions are during or after an event, which individually are used in 78% and 79% of the definitions and used together in 62% (Figure 6). This finding highlights the influence from disaster literature and the emergency response mind set. The category “before” is only seen in 28% of the definitions. This observation means that a disaster, or near disaster, needs to occur to make the changes to society that would have made it more resilient to the disaster that just occurred. This effect can be described as a sudden evolutionary pressure to adapt (Simmie & Martin, 2010). Adaption is a reaction to this pressure and it necessarily starts to push the system after the disaster.

The idea of resilience as the ability to prepare and look forward (anticipate) is less in focus. By anticipating potential pressures, adaptations of the system, mitigation of disturbances and dampened effect of disaster can take place. Anticipatory abilities require a system not only to respond when something goes wrong, but also includes abilities to foresee future needs and manage long-term stresses and trade-offs in a more efficient way. To act before something turns into a serious problem can save lives and prepare society for possible future events.

Urban Resilience boundaries

Defining boundaries for the system that is to be examined presents another challenge, which is not well discussed in literature, or described in common urban resilience definitions. One aspect includes how the urban system is defined; it could be, for example geographical boundaries (city or region limits), or by temporal aspects such as election periods or plans that stretch over a predetermined amount of time. Using geographical boundaries may be limiting as much of the interconnectedness that make up the

complex cities and infrastructure in today's society. Everything from roads, electrical power, water management, and social movements are more often than not affected by sources outside that geographical boundary. Temporal aspects have the benefit that involve governance and laid out plans and will have a significant impact on the analysed system. However, they do not offer clear system boundaries.

One way to tackle the dilemma is to identify what needs to be protected. The resilience literature often stresses the need to specify "resilience against what?" (e.g. Pizzo, 2015). A city may be efficient at restoring power following a power outage but have little resources to get snow off the roads following a snowstorm. This kind of resilience might lead cities into lock-ins that make it hard to adapt towards new circumstances. To identify what to be resilient against thus includes pinpoint what should be protected. Examples of core values include keeping citizens safe, ensuring access to medical aid, etc. Maintaining the core values involves for instance functioning communication channels, abilities to rapidly allocate particular recourses and flexible organisation structure. By shifting focus from the outside threat to the core values, the suggested solutions will also shift. To frame the problem in this way promotes solutions that are more flexible and better adapted to protect what the local community actually treasures rather than locking in infrastructure and resources to prepare towards a specific event. It is important to note that strengthening preparedness for one type of event may create vulnerabilities for other. For example, during a heat wave in Paris the many air conditioners caused the overall temperature to raise 3 degrees, hitting those citizens who could not afford a cooling system.

3.3 METHODS AND APPROACHES

This section includes summaries of approaches from the academic literature, the city survey and the worldwide reports that were analysed in D1.1.

URBAN RESILIENCE APPROACHES – MAIN FINDINGS

- Frameworks are broad and generic
- There is a lack of consensus and unification of central themes
- The literature identifies an absence of links between different dimensions of resilience
- The large variety of indicators makes comparisons of the frameworks challenging
- Frameworks are useful on a conceptual and theoretical level, but still far from being available for practical use
- It is of great importance to raise awareness and educate citizens on disaster risk
- There is a need to strengthen disaster risk governance
- The importance of investing in risk reduction
- The importance of enhancing responsiveness

3.3.1 ACADEMIC APPROACHES

The literature review identified 22 resilience frameworks. These were later summarized and analysed (for a full analysis, see D1.1 chapter 3.2.5). The frameworks were analysed according to the objective of the framework, their central concepts and indicators, their intended target area, whether it has been applied or not, and whether or not there were any particular or outstanding features in the framework.

Most of the frameworks are broad and generic with an aim to create a more general or holistic model for urban and community resilience, linking different theoretical concepts (Birkmann et al., 2013; Lei, Wang, Yue, Zhou, & Yin, 2014), or areas of the urban environment together (Carpenter et al., 2012; Desouza & Flanery, 2013). The gaps identified by the authors are in many cases related to the complexity of the urban context and the appreciation that resilience resides at multiple layers in multiple dimensions. To fill the identified gaps, some frameworks are in certain cases expansions of previous definitions and models (e.g. Carpenter et al., 2012; Desouza & Flanery, 2013) or a unification of them (e.g. Ainuddin & Routray, 2012; Cimellaro, Reinhorn, & Bruneau, 2010; Lei et al., 2014). Other frameworks aim for more specific aspects such as geographical conditions (Zhou, Wang, Wan, & Jia, 2010), economic indicators (Sherrieb, Norris, & Galea, 2010; Simmie & Martin, 2010) and disaster preparation (Cutter et al., 2008; Stewart, Kolluru, & Smith, 2009).

Central attributes may emanate from theoretical concepts such as, vulnerability, uncertainty, diversity and trust (e.g. Ainuddin & Routray, 2012; Carpenter et al., 2012; Cutter et al., 2008; Jabareen, 2013; Lei et al., 2014; Restemeyer, Woltjer, & van den Brink, 2013; Simmie & Martin, 2010), or concrete areas of the urban environment such as social, economic and geographical (e.g. Sherrieb et al., 2010; Stewart et al., 2009; Zhou et al., 2010) or a mix of the two (e.g. Birkmann et al., 2013). Other variants also exist such as reducing cities into different elements (e.g., planning, spatial, temporal, cognitive elements) (e.g. Desouza & Flanery, 2013; Fox-Lent, Bates, & Linkov, 2015). The engineering frameworks focus on capabilities to robustness, absorption and recovery (e.g. Cimellaro et al., 2010; McDaniels, Chang, Cole, Mikawoz, & Longstaff, 2008; Ouyang, Dueñas-Osorio, & Min, 2012; Rodriguez-Nikl, 2015). The strategy-oriented frameworks use a somewhat different approach and include guidelines describing particular abilities and processes required to achieve resilience (e.g. Berkes, 2007; Kuhlicke, 2013; Singh-Peterson, Salmon, Baldwin, & Goode, 2015; Somers, 2009).

Therefore, there is a rather significant disconnect between the frameworks being developed in the academic world and real-world application. Because of the complexity and diversity of the urban environment it is quite difficult to create frameworks that cover multiple areas. As most of the frameworks found in the review were entirely theoretical it is also challenging to identify what must be changed or altered before they can be taken into the field. The frameworks that have been tested or applied to a case are often much more specific, covering a distinct context, such as flooding.

3.3.2 WORLD-WIDE REPORT SURVEY

An analysis of worldwide approaches, including plans developed by RC100 was also carried out (for a full review see D1.1 chapter 4). The study included a review of reports from organisational bodies and cities worldwide on resilience implementation, evaluation, metrics, best practices, and policies. A total of 23 reports were analysed, covering the following areas:

- Resilience definitions and policies
- International commitments, initiatives & networks
- Services and tools to support urban resilience
- Local strategies

From the studies it is clear that the resilience frameworks are abstract and high-level, which that there is a lot of work requires to contextualise and implement the frameworks in a city. Moreover, a large part of existing frameworks for urban reliance still seem to focus mainly on Risk Management; that is, Safety I issues, and on specific issues like climate adaptation. Main point of the analysis includes:

Understanding and education on disaster risk. Raising the awareness of both the public, local governments, as well as different stakeholders in the community of the benefits of reducing risk at the urban level (e.g. Council-of-Europe, 2012). Ensure that both education programs and risk reduction training is in place in both schools as well as communities. Create pathways that allow cities to exchange knowledge and resources between cities.

Strengthen disaster risk governance. Including risk reduction in urban planning and development at the decision-making level. Places demands on local governments to budget for disaster risk mitigation, thus making it part of the community (e.g. Da Silva & Moench, 2014). Commitment by the local government is pivotal for success, as is the development of local alliances in order to distribute roles across various departments, thus increasing preparedness across the entire community.

Investing in risk reduction. A budget must allow for spending on risk reduction so that the community can be prepared (e.g. UNISDR, 2015). Investing in infrastructure, e.g. flood drainage, as well as sustainability measures to mitigate effects of climate change is necessary. Investing in mitigation measures may benefit the community in the long term. Installing early warning systems and emergency management capacity, as well as maintaining alliances through drills and exercises contributes to the preparedness of the community.

Enhancing responsiveness. Apply and enforce realistic, risk-compliant building regulations and land use planning principles (e.g. Cocchiglia et al., 2012). Identify safe land for low-income citizens and develop upgrading of informal settlements, wherever feasible. Protect natural buffers and ecosystems to mitigate effects of detrimental events, e.g., flooding. After any disaster, ensure that the needs of the survivors are in place at the centre of reconstruction with support for them and their community organisations to design and help implement responses, including rebuilding homes and livelihoods.

3.3.3 CITY SURVEY ANALYSIS

Resilience strategies and concrete actions of 17 cities included in the RC100 cities worldwide were analysed and summarized. Approaches taken by the cities included gathering accurate information about the system through *multiple sources*, such as, the community, businesses, and other cities. For example, building new infrastructure with the aim of lowering their vulnerabilities, may take into account the holistic nature of such infrastructure. Infrastructure can serve as recreation, but should also be sustainable in the face of crises. An *ecological method* is also common in the resilience strategies. The perspective implies that instead of trying to control every aspect of the natural world one should move

with it. For example, a river could be allowed to temporarily overflow, as long as it is done in a safe way. Although these approaches create damages, such as reduced mobility in the city in the short term, the intention is that in the long term more severe disruptions can be avoided.

During the fall 2015, a survey of the city partners in the SMR project was completed. The purpose of this study was to get a first-hand overview of practical resilience implementation approaches, critical infrastructures and the current challenges in these cities. A basic, open-ended questionnaire was developed in collaboration with Tecnun, DIN, and CIEM that comprised ten questions - with a set of sub-questions – that concerned key resilience concepts in relation to critical infrastructures. The goal of the study was to get an overview of the cities approach to resilience and their challenges, the inquiries were both broad and specific and concerned key infrastructures, external dependencies, past failures, policy making, preparedness plans, concrete work practices, etc. The questionnaires allowed for free-text answers.

The SMR partner cities' infrastructure sits within complex national and global frameworks with inherent co-dependencies and weak points. Most of the cities stated that electric power, water supply and communications (transport and ICT) are of key importance to secure. Much of policy and the related decision-making regarding the critical infrastructures are outside the jurisdiction of the cities, which inhibit their response to disasters and problems. The dependencies, numerous stakeholders (subcontractors) and legal frameworks render managing the infrastructures at the local level difficult. A present strategy in the resilience work is to seek better communication among different stakeholders and to pool resources locally and regionally. Moreover, some of the cities have implemented incident reporting and sensing systems to locate potential threats and problems in their infrastructure. General threats to the infrastructure across cities cannot be found in the material, but are specific to the cities local conditions and risks. Local work and preparedness seems to be biased towards local conditions and previous experiences of failures and problems. The city survey says little regarding specific organisational setups of the resilience work in participating cities. Follow up studies are needed, preferable using interview or workshops methods. Current challenges include improving communication with the citizens, handling local treats with fully resources local providers, defining the boundaries in which the cities should work, and improving lacking ICT for maintenance.

3.3.4 SUMMARY – THE URBAN RESILIENCE PROCESSES

In this section findings from the different studies are combined to offer a description of what is important in working with urban resilience. Key points are summarised in the table below and further discussed below.

URBAN RESILIENCE PROCESSES – KEY POINTS

- Defining resilience dimensions and system boundaries is challenging
- Monitoring and assessment are central abilities for resilience
- Stakeholder collaboration is difficult but under-utilized
- Support from responsible agents and political leaders are critical for the success of urban resilience
- Policy capital and knowledge sharing between all city sectors is necessary to facilitate urban resilience
- Involving the public may alter its behaviour which in turn leads to a more resilient

Resilience dimensions and system boundaries

An analyst must define meaningful boundaries and parameters of the areas to be measured. This could be for instance geographical and temporal boundaries. One of the boundaries to be considered is the spatial boundaries (definition of space) such as the city or region to be studied. A second challenge is defining time, what are the starting and ending points? Planning for the short term is relatively easy, such as preventing damage from earthquakes or cut costs in certain areas. Long-term resilience, on the other hand, is a much more complex concept that requires a continuous stream of both funds as well as research.

Monitoring and assessment

The ability to monitor and assess the impact of changes requires the identification of what data is suitable to analyse, which, when dealing with interdependent systems such as cities and communities, can be challenging (Ahern, 2011; EEA, 2012; Teodorescu, 2015). Each challenge, from responding to a rapid influx of immigrants or flooding to addressing issues of prolonged economic decline, should be associated with expectations of regional performance. To improve resilience there must be an activity agenda in place.

Collaboration between stakeholders

Investigation of the collaboration between scientists and decision makers through a number of cases found that decision makers typically use the research-based knowledge insufficiently and researchers typically produce insufficient knowledge that is directly applicable (Ahern, 2011; Weichselgartner & Kasperson, 2010). Problems identified include divergent objectives, needs, scope, and priorities; different institutional settings and standards, as well as differing cultural values, understandings, and mistrust.

Decision Makers/Policies

Support from responsible agents and political leaders are critical for the success of urban resilience (Berkes, 2007; Tobin, 1999). Further, it requires cooperation between decision makers of different stakeholders (Tobin, 1999). The lack of knowledge about local policy makers could also be related to the fact that for many organisations adaptive and resilience plans are not embedded in the culture (Boin & McConnell, 2007; Kavanaugh, 2015), thus creating a barrier for transformation.

Political capital is another pressing issue (Boin & McConnell, 2007; Restemeyer et al., 2013), as is the need for regulatory frameworks and planning and policy momentum (Malalgoda et al., 2014). Multinational co-operation may take priority over the relationships between decision makers and the local level, making local community resilience increasingly vulnerable to the interest of multi-national co-operations (Tobin, 1999). Strengthening the local community also requires that the national government increases the ability of local governments (Davies, 2015; Djalante, Holley, Thomalla, & Carnegie, 2013; Malalgoda et al., 2014). Benefits of such an approach is aimed at strengthening local preparedness and response, improving the sharing of knowledge and experiences between stakeholders and improving the capacities of the local government (Djalante et al., 2013).

Social engagement

Resilience in urban environments is heavily influenced by the people living in it. More vulnerable citizens make a society increasingly hazard-prone (Perks, 2013; Tobin, 1999). By changing the behaviour and social practice, vulnerability may decrease, which in turn will increase resilience (Fainstein, 2015; Harman, Taylor, & Lane, 2015; Jabareen, 2013; Restemeyer et al., 2013; Somers, 2009; Zaidi & Pelling, 2015). Social inequalities, in turn, lead to increased vulnerabilities, thus affecting the resilience of a community (Tobin, 1999; Zaidi & Pelling, 2015). It was also found that the citizens' perception of their vulnerability actually made them more vulnerable (Adger, 2006), a factor that is likely to affect the more vulnerable part of society when change is necessary. Mental barriers such as denial or the downgrading of future threats can be found at all levels of society. Further, it is noted that it is often the most vulnerable

citizens that are not included in the decision-making process (Boin & McConnell, 2007), thus enforcing their sense of being vulnerable.

Having well-informed citizens and by promoting self-protective behaviour, a community could also limit its vulnerability, as well as free up valuable resources during a crisis (Keogh, Apan, Mushtaq, King, & Thomas, 2011; Restemeyer et al., 2013; Somers, 2009). To create resilience, it is thus not sufficient to only create new policies, it is also critical to have support from the community in order to make changes (EEA, 2012; Larsen & Gunnarsson-Östling, 2009). Social capital, i.e. effective networks for communication at local communities as well as with decision makers, is a key factor (Restemeyer et al., 2013; Tobin, 1999).

3.4 POLICIES AND INDICATORS

In the academic literature there is a large variety of indicators used in the frameworks, which reflects the lack of consensus and unification on urban resilience and its central themes. It also reflects the vast number of aspects that are important to resilience and that there are many ways to increase resilience, depending on the area of interest. Frameworks also vary in how the indicators are applied. Most provide a conceptual map, linking different concepts and attributes. However, many offer little or no guidance on how to translate the high level concepts to practical use, and only suggest that more specific indicators must be identified in the local context (e.g. Ainuddin & Routray, 2012; Carpenter et al., 2012; Cimellaro et al., 2010; Cutter et al., 2008; Lei et al., 2014; Miles, 2015; Ouyang et al., 2012; Ouyang, 2014; Rodriguez-Nikl, 2015; Singh-Peterson et al., 2015; Stewart et al., 2009). In other frameworks a process description is given (still high level), such as multiple stages or phases (Simmie & Martin, 2010), cyclical models (e.g. Pendall et al., 2010; Walker & Cooper, 2011; Vogel, Moser, Kasperson, & Dabelko, 2007), a mapping between various dimensions or characterisations (Larkin et al., 2015; McDaniels et al., 2008; Sherrieb et al., 2010; Zhou et al., 2010) or strategies to guide implementation of the concepts (e.g. Berkes, 2007; Desouza & Flanery, 2013; Jabareen, 2013; Kuhlicke, 2013; Restemeyer et al., 2013; Somers, 2009).

In the analysis of worldwide reports, qualitative and quantitative indicators, policies, guidelines and tools have been identified to guide resilience implementation. The indicators are largely focused on disasters, and more specifically climate change. Qualitative measurements are more general, demonstrating the importance of prosperity in multiple areas to increase resilience, such as finances, education, networks, social stability, health and leadership. In the worldwide city strategy analysis it is commonly stated that policy making should take resilience into account. By being more aware of resilience aspects in the everyday work better decisions are anticipated. A common vulnerability that

is addressed with policy making is climate change. Many cities have policies to either reduce energy usage, switch to renewable energy, or both to combat rising levels of greenhouse gasses. There are many plans on how to use new technologies to find new indicators and to build new assessment tools to measure them in the resilience strategies. Many cities are aiming to pool different metrics together and map or visualize these metrics in new ways that will give them better understanding of their vulnerabilities.

3.5 SUMMARY AND CONCLUSIONS

Results from D1.1 showed that numerous perspectives and definitions of resilience can be found in the literature. The analysis indicates that research frameworks for urban resilience are abstract and difficult to directly apply to the urban planning and decision-making process. Moreover, the current resilience models do not do sufficient justice to the link between different dimensions of resilience aspects that affect cities, such as social and economic. Since the concept of resilience is general, a challenge will be to define boundaries, dimensions, and tools for city resilience in order for the perspective to be useful for community professionals. The study also reveals structural prerequisites and problems to implement resilient cities; political and financial support are important and much of policy and the related decision-making regarding the resilience is outside the jurisdiction of the city councils. Nevertheless, in the future, for operationalization of the resilience concept it is important to consider previous efforts made by organization bodies outside research as well as including city professionals in this work.

4 MAIN OUTCOMES FROM D1.2

The objective of D1.2 was to complement the worldwide survey on the resilience concept, approaches and challenges reported in D1.1, with the literature review of EU sectorial approaches. D2.1 helps to shape a wider understanding of the concept of resilience, how resilience has been applied and used in EU sectorial approaches with focus on its application in an urban and European context. The results from this review will contribute to the implementation of a Smart Maturity Resilience (SMR) Model and SMR tools. The report contains an analysis of European Sectorial approaches to resilience and includes:

1. A systematic literature review of three problem areas covered in SMR project: resilience in critical infrastructure (CI), climate change (CC) and social dynamics (CD),
2. A review of EU project reports both FP7 and H2020 in the area of Secure Societies and Climate Change related to resilience in these three problem areas and the city resilience is a part of the focus, and
3. A repository of policies and best practices as well as metric and indicators identified from this review.

In this section we present the main outcomes of the report, divided into the three sections of critical infrastructure, climate change and social dynamics.

4.1 PERSPECTIVES AND APPLICATIONS OF RESILIENCE

In this section an overview of the perspectives of resilience found in the review of EU project reports are provided. They are structured according to the three focus areas: Critical infrastructure, Climate Change and Social Dynamics.

4.1.1 CRITICAL INFRASTRUCTURE

From Critical Infrastructure (CI) approach resilience is viewed from a technological standpoint. CI sectors identified include energy, transport, agriculture, water, communications, oil, gas, health, security and finance. The review shows that there is a large variety of policy suggestions and practice for CI resilience across the EU projects.

Main topics discussed in the resilience critical infrastructure literature concern (1) dependencies and interdependencies, (2) cascading effects and (3) risk and vulnerability analysis, (4) protection and cyber-attacks and (5) Critical Infrastructure and Urban Resilience. A summary of the main outcomes of each topic is provided below.

Dependencies and Interdependencies

In CI dependencies and interdependencies are a critical component to analyse. A *dependency*, in this setting, is the relationship between two products or services in which one product or service is required for generation of the other product or service. The dependency may be functional, which means when the state of a system is dependent on the output(s) of another system It may also be *geographical*, that is, systems that are located in the same area and where changes in the local environment can create state changes in all of them or *logical*, that is, when a state change in one system results in a state change in another, without any of the other dependencies occurring, e.g. due to human decisions and actions. An *interdependency* is defined as the mutual dependency of CI. An interdependency can also manifest as interdependen*cies*, that is, complex dependencies between organizations in one CI sector. For example, in energy sector supply chain, intra-dependencies occur among producer, transmission system operators, distribution operators, consumer, shipper, trader, and supplier.

Cascading effects

A *cascading effect* is a disruption of one critical infrastructure that may lead to a series of disruptions in other critical infrastructures due to the dependencies between the critical sectors. Cascading effects can be caused by the failure within a single CI service (e.g. electric power transmission grid to electric power distribution grid) or across CIs. Consequences may affect multiple levels, including, for example, technical, organisational, social, human, economic and environmental. Cascading effects can also manifest as cascading hazard or cascading crisis, where the effect can be seen from source events that link to hazard event, or the interdependencies and relationships between different sectors and actors involved in crisis management respectively. To increase resilience an understanding and mapping of dependencies and interdependencies that may lead cascading effects should be carefully analysed. One way to do this is to use stress-test methods**.**

Risk and vulnerability

Risk is the potential for consequences where something of value is at stake and where the outcome is uncertain. In risk analysis, common questions are: What can go wrong? What is the likelihood that something will go wrong? What are the consequences? Risk analysis is conducted to develop strategies for mitigating hazardous impacts, and risk assessment is also about contingency planning. In the CI

literature risk is often linked to vulnerability in the sense that to achieve CI resilience reliable and effective vulnerability management is required. Managing risks can be done through, for instance, adaptation (risk avoidance), coping (meeting short-term basic need and function of the system), mitigation (action to reduce hazard), and risk transfer (shifting financial consequences).

Critical Infrastructure resilience and protection

Critical infrastructure resilience is the ability of a CI to "mitigate hazards, contain the effects of disasters when they occur, and carry out recovery activities in ways that minimize disruption and potentially mitigate the effect of future disasters" (Lange, Sjöström, & Honfi, 2015). Concepts that characterise CI resilience include:

- robustness (damage avoidance continued service provision of a physical asset),
- redundancy (backup/duplicate systems, equipment and supplies),
- resourcefulness (diagnostic and damage detection technologies, availability of equipment and materials for restoration and repair), and,
- rapidity (optimization of the time to return to pre-event functional levels).

In recent literature resilience concept in CI resemble the UNISDR resilience notion, i.e., "The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of essential basic structures and functions." Example of H2020 projects applying resilience for CI are: IMPROVER[1], RESILIENS[2], DARWIN[3], and RESOLUT[4].

In the literature CI resilience is often related to CI protection (see Section 3.1 in D1.2). Vulnerability and resilience are used in combination to nuance the concepts of resilience. Applying the concept of resilience in CI has allowed the perspective that Critical Infrastructure cannot fully be protected, simply because it is too costly. Resilience is viewed as a means to acknowledge this and identify new approaches to protecting the CIs.

SmartGrid and Cyber Attack concern how to enable people to discover and recover from attacks, losses and security failures. Well-organized simultaneous cyber-attacks to smart-grid infrastructure can trigger a sequence of cascading events, leading to a system blackout. An effective measure to address this

[1] http://improverproject.eu/
[2] http://resilens.eu/
[3] http://www.h2020darwin.eu/
[4] http://www.resolute-eu.org/

issue is to prevent, detect and mitigate malicious activities. In other words, the SmartGrid communications networks should be reliable and resilient. When city moves toward Smart City, the disaster resilience and the effort to mitigate disaster may want to consider this aspect as an important part of the city's CI resilience. Concerning terrorism and increasing resilience, capacities required to deal with a terrorist attack at each stage of the disaster risk-management cycle and an examination of the different elements that need to be considered by organisations and communities in preparing for and responding to terrorism.

Critical Infrastructure and Urban Resilience

CI plays an important role in urban resilience. An urban system must identify vulnerable areas in the urban environment and develop methods for planning and design of large-scale infrastructures. Approaches to increase resilience include, for example, establishing resilient infrastructure and building, understanding how people interact with buildings and built-in environment, allow them to respond and adapt to hazards.

4.1.2 CLIMATE CHANGE

Reports on climate change focus on a number of key themes, the major ones include risk and vulnerability, disaster impacts, city/urban sustainability and city/urban strategies and policies. Top five threats as mentioned in the literature include: (1) flooding, (2) general extreme weather, (3) droughts, (4) earthquakes and (5) rainfall (see Figure 25 in D1.2 for more details).

Climate change and urban resilience

The TURAS project has suggested transition strategies and scenarios to enable European cities and their rural areas to build resilience. As the core of the activities is to embrace the concept of social-ecological resilience into urban planning (Crowe & Foley, 2013). Central socio-ecological concepts include diversity, complexity, and spontaneity; decentralization, alternative technologies; public participation and a vision of the future. TURAS project also relates urban resilience to sustainability (Collier et al., 2013) where the following (summaries) points should be taken into account:

- the ability to adopt and change, enable flexible governance, collaborative decision-making and behavioral change towards resilient and sustainable cities
- a driver of urban policy towards a more integrated, multi-disciplinary and open planning system with community stakeholders as central to the planning process and planners as innovative
- as urban green policy is increasingly being used as a tool to enhance urban resilience and sustainability supporting biodiversity and ecosystem services

- as mobilizing social capital, (scarce) economic and environmental resources while seeking to work with planning stakeholders on the egalitarian way

CC and Technology Support

There are two projects in our CC literature linking in specific the CC issue and technology support, i.e. SMARTeST[5], and ToPDAd[6]. The SMARTeST project concerns the flood events in Europe and worldwide and points out that the existing flood defence structures do not guarantee a sufficient protection level for people and properties. The use of resilience is thus only used in connection with floods and how to mitigate effects of floods and recover following a flood event. An important factor to note is that there are no coherent regulatory frameworks or standards for flood resilience. From institutional and policy perspective, the responsibility for flood risk management and flood resilience are often fragmented, coupled with limited funding for tackling this issue. Socially, certain sectors of society have less capacity or knowledge to respond to flood risk than others, and culturally there is a resistance to flood resilience technologies; many are unaware of flood risk and do not believe that these technologies protect them. A set of guidelines have been developed to increase preparedness for floods for decision makers and household (see policy section in 4.3.1 in D1.2 for further definition of the measures). The ToPDAd projects listed relevant changes through technology support that will benefit the energy sector by increasing energy efficiency (see D1.2 for details)

CC Adaptation, Adaptive and Multilevel Governance

In short, *governance* can be described as "intergovernmental relationships". A more elaborate definition from the CapHazNet[7] project includes "*the sum of the many ways individuals and institutions, public and private, manage their common affairs. It is a continuing process through which conflicting or diverse interests may be accommodated and co-operative action may be taken. It includes formal institutions and regimes empowered to enforce compliance, as well as informal arrangements that people and institutions either have agreed to or perceive to be in their interest*" (CGG, 1995). Governance can be found at all levels, including local, national and global. Main characteristics of governance include, for example, multiple actors, networks and partnerships (no longer single sovereign authority), new forms of authority and control (based on diplomacy and management) and multilevel governance and issues of scale.

[5] www.floodresilience.eu
[6] http://www.topdad.eu/
[7] http://www.caphaz-net.org/

Further, there is a difference between governance and the local government. The local government is about activities of the local authority such as legislation, financial and political processes. Governance, on the other hand, has external dimensions since it can cover partnership, interaction, dialogue, conflict among citizens and organisations.

When it comes to natural hazards, the relationship between levels of governance has also become increasingly important, as shown in international cooperation in the area of disasters such as Global Disaster Information Network. The HFA (Hyogo Framework for Action) points out the importance of 'good governance' and 'international and regional cooperation' to support actions at local levels. CapHazNet summarises the implication of shifts to governance for the governance for natural hazard with a focus on "new" types of governance such as capacity to organise international agreements and cooperation, the ability of actor-networks and including the private sector, NGOs and individuals. Partnership is necessary when the government cannot react alone on specific changes. Shifting from government to governance allows society to act effectively, and partnership can bring together ideas and resources for better results.

Guidelines for the role of local governments in disaster risk reduction, based on UNISDR (2010) guidelines, Rigaud, Clemenceau, Engelbach, Wendt, & Dubner (2015) include:

- To play a central role in coordinating and sustaining a multi-level, multi-stakeholders platform and to promote disaster risk reduction in the region or for a specific hazard.
- To effectively engaged local communities and citizens within disaster risk reduction activities. Citizens are seen as extremely important since the good disaster reduction plan may fail without citizen's engagement.
- To strengthen their own institutional capacities and implement practical disaster risk reduction action
- To devise and implement innovative tools and technique for disaster risk reduction

4.1.3 SOCIAL DYNAMICS

The social dynamics term is applied and discussed in the three areas:

1. *Urbanization, poverty and unemployment*: social issues that are triggered by social disruption and social unrest in the cities such as urbanization, poverty, unemployment, asylum seekers and integration, and social vulnerability.
2. *Refugee and integration*: social dynamics in term of problems that affect human due to climate change such as disease, health, and human adaptive capacity.

3. *Terrorism and social unrest*: human and social dynamics in crisis and disaster situations how the resilience play a role in this context. It is seen from the perspective of individual and community resilience.

Urbanization, Poverty and Unemployment

The literature identifies a number of factors that contribute to challenges relating to social issues following disasters in an urban environment (see Section 5.2.2 in D1.2). One important matter is the perception of the citizens toward threats, such as the ability to protect against natural disasters. The literature mentions that there is a need for better understanding of interrelations and social dynamics of risk perception, preparedness, and impacts. From a preparedness perspective, it is important to note intangible impacts of natural hazards and disasters and the need for increased post-disaster support and recovery.

Other factors concern the changes being made in today's world where more and more people are moving to urban areas, which affects the disparities in wealth and socio-economic status. The density of infrastructure and number of people living in at-risk areas in increasing, and there is a conflict between socio-economic land use and hazard mitigation policy intensified land use, which and the further increases economic and financial cost of disasters.

Refugee and Integration

A big debate in many European today concerns the integration and accommodation of immigrants. The education for asylum seeker is dominated by a focus on human capital and issues related to the work-life situation, with a strong emphasis on improving subject areas. However, as identified in the literature a main challenge for immigrants is not subject area related, but interpersonal relationship and limitations in social networking (see Section 5.2.3 in D1.2). Resilience in this group is mostly built within one's own family because interaction with others is uncertain and subject to change.

Resilience for immigrants thus concerns the individual's and his/her family's capacity to resist adversities iotdeeply rooted religious belief contributes for generosity or altruistic behaviour, which in turn may increase the psychological resilience of these individuals.

Terrorism and Social Unrest

In the literature, terrorism and social unrest were mostly discussed as a scenario. The following are suggestions for restorative work following a terrorist attack (see Section 5.2.4 in D1.2 for detailed overview):

- Alleviate the risk of panic
- Allow the survivors to assess their situation and provide the authority in charge of the crisis management with information
- Allow the authorities to provide information and instructions to the survivors
- Allow the survivors to help themselves while waiting for rescue (In the terrorism issue resilience building also means increased preparedness the individual and society)
- Prepare for evacuation

Health and Human Adaptability to CC

Human health issues due to climate change cover various aspects including direct impacts such as air quality and ultraviolet radiation. Other issues include effects of the changes such as environmentally induced migration and food-safety issues such as food- and vector-borne diseases and water-related issues.

The impact of CC such as heat waves, are unevenly distributed across the regions of Europe and can be additional burdens for lower income groups and certain vulnerable groups, such as children, those working outdoors, the elderly, people with disability. There is a projection that the demand for health services may increase beyond the capacities, and, therefore, adaptive capacity is important in the sense of emergency preparedness and response.

Social vulnerability and resilience

Social vulnerability is “the characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recovery from the impact of a natural hazard” (Blaikie, Cannon, Davis, & Wisner, 2007). Social vulnerability, lack of resilience conditions and social sensitivity may have an impact on the second order effects (indirect impact) when a hazard event strikes an urban centre. Attempts have been made to assess the social vulnerability with respect to the natural hazard, examples include social and Infrastructure Flood Vulnerability Index (SIFVI) and the Spatial Multi-Criteria Analysis (SMCA).

Social resilience is commonly described as the opposite of vulnerability, and to increase social resilience is to decrease social vulnerability. Increasing social resilience can be done externally at a governance level such as policies, and measures targeting areas of social inequality. Other efforts preparing individuals through education and building motivation and a sense of responsibility within the communities to manage and mitigate their own risk (particularly a requirement for flood hazard).

Social capacity is seen as particularly important for groups that are the most vulnerable due to, e.g., economic pressures, age, and disabilities.

Individual and Community Resilience

Recently, the concept of individual resilience has shifted from merely concerning physiological effects toward more about the dynamic processes that occur within the social and ecological environment at multi-interdependent scales, a *psychosocial* perspective. In the psychosocial context, individual resilience is defined as "*a person's capacity for adapting psychologically, emotionally and physically reasonably well and without lasting detriment to self, relationships or personal development in the face of adversity, threat or challenge*" (Juen et al., 2015). The individual citizen is, from the empowerment perspective, important especially in crisis communication, so that they are prepared and more resilience in the disaster situation.

Community resilience should cover community access to a diversity of resources and capacities (e.g. socio-political, financial, physical, human); the capability to act effectively in the mitigation of risks and impacts; mutual learning from experience; collaboration; and the need to understand local contexts. In terms of disaster risk management, these components should be understood not simply as factors that can be associated with and resourced through straightforward civil-protection mechanisms, but as much broader based resources, capacities and capabilities more normally associated with the concept of social protection (emBRACE[8]).

4.1.4 RESILIENCE DIMENSIONS AND DEFINITIONS

From the projects reviewed, there is a clear transition before and after the EU policy on Adaptation Strategy to Climate Change was launched in 2013. Prior to 2013 resilience was commonly described and defined in relation to vulnerability, where vulnerability was viewed as the "lack of resilience". City as a resilience unit analysis does not appear in the literature and metrics and indicators developed are intended for assessing risks and vulnerabilities against climate change, natural disaster or extreme weather events. However, some efforts are made to include adaptation concept in the projects. Further, governance is new concept that has been embraced by resilience concept, for example, risk governance, Public Private Partnership (PPP) and Public Public Partnership (PuP) are important part of resilience. Following 2013 and the EU policy on Adaptation Strategy to Climate Change the use of the

[8] http://www.embrace-eu.org/

term resilience has increased and been transformed as a more central concept. Projects working in connection with the adaptation strategy also applied the resilience concept.

Resilience dimensions' analysis

An analysis of definitions used on different resilience "dimensions" offers tentative definition suggestions. A synthesis of the core concepts used in the definitions of each layer was used to develop the definitions (See D1.2, section 6.3.1 for more details).

TENTATIVE DEFINITION OF EACH RESILIENCE DIMENSION

CI RESILIENCE from CI Literature

Resilient infrastructure can resist damage and loss of function, absorb, adapt to, or rapidly recover from a potentially disruptive event, can quickly restore its continuity and support city's CI-based services.

CI RESILIENCE from CC Literature

Critical Infrastructure Resilience ability to make improved CI plan by carefully positioning of buildings in relation to the topography and the defined flood pathways, and by the sympathetic design of landscaping features. It also covers the ability and reliability of the energy system to cope with the potential damage from extreme weather events, and the capacity to manage the CC impacts on the variability in the available resources (wind, water and sun).

COMMUNITY AND SOCIAL RESILIENCE from CI Literature

Community and Social Resilience refers to a network of individual's adaptive capacity, including capability to detect abnormal events, to prepare and plan, self-organise, inform the local government, mobilise resources. It also comprises capability to cope with disruption, and capability to resist, adapt and recover from it. Collaboration capacity with the neighbourhood in the city and forming social cohesion to withstand hazard will be part of community and social resilience.

COMMUNITY AND SOCIAL RESILIENCE from CC Literature

The capacity of individuals, communities or societies potentially exposed to hazards to adapt, be flexible, and bounce-back by resisting or changing behaviours, taking-up innovations, organising itself in order to continuously exist, reach and maintain an acceptable level of functioning and structure.

This capacity also covers the capability to combat social vulnerability, enhance perceived risk, sense of responsibility, and learn from the previous hazards which can be improved through education and training.

URBAN OR CITY RESILIENCE from CI Literature

The urban or city resilience consists of a mixture of resilient built-in environment, resilient design, resilient citizens, and resilient organisations. Resilient built environment should be designed, located, built, operated and maintained in a way that maximizes the ability of built assets, associated support systems (physical and institutional) and the people that reside or work within these built assets, to withstand, recover from, and mitigate the impacts of extreme natural hazards and human-induced threats.

The citizens in the city should be able to handle and respond to unexpected situations resulting from malfunctioning CIs, changes of social, economic and environmental stresses, and also be proactive during a crisis and have the ability to recover by themselves. The organisations at the city level have capacity to support all transformation by rapid changes taking place in urban key areas.

URBAN OR CITY RESILIENCE from CC Literature

Urban resilience covers the identification of the unpredictable, non-deterministic processes and disturbances that a landscape or city may be vulnerable to, understanding of how different areas have varied responses to a disturbance, and learning about the past and possible future scenarios in terms of direct and indirect consequences, frequency and scale. It covers the capacity of European cities to cope with CC impacts such as the flood risks by improving water management, disaster management, and spatial planning**.**

SOCIO-ECOLOGICAL SYSTEM RESILIENCE from CC Literature

Socio-ecological system resilience can be interpreted in two ways: The time it takes for recovering to a quasi-equilibrium state following disturbance ('engineering resilience' or 'elasticity'), or the capacity of ecosystems to absorb disturbance without collapsing into a qualitatively different state that is controlled by a different set of ecological processes. It is the ability to learn from catastrophic events and to adapt reactively and proactively to changing environmental conditions, to learn what disturbance, inherent discontinuities and uncertainties that can be tolerated so that the system can be adapted and adjusted so that it still functionally persists.

ORGANISATIONAL/LOCAL GOVERNMENT RESILIENCE from CI Literature

Organisational resilience covers all management capacity such as planning, leadership, training, experience, and information management. It includes the capacity to improvise, innovate and expand the operations between impact and early recovery and the capability to conduct proper risk assessment and risk management.

ORGANISATIONAL/LOCAL GOVERNMENT RESILIENCE from CC Literature

Local Government Resilience is the capability of organisation to coordinate and sustain multi-level, multi-stakeholders platform to promote disaster risk reduction; capability to engage local communities and citizens in disaster risk reduction activities; capability to strengthen institution, capacities and implement practical disaster risk reduction actions; and capacity to implement tools and techniques for disaster risk in the prevention, preparedness, response and recovery**.**

INDIVIDUAL RESILIENCE from CI Literature

Individual resilience is a person's own resilient capabilities—the adaptive capacity of individuals to react or adapt positively to hazards or unexpected events.

ECONOMIC RESILIENCE from CI Literature

Economic resilience is the capacity to reduce direct and indirect losses, maintaining function such as continuous production.

ECONOMIC RESILIENCE from CC Literature

Economic resilience is the ability of society to adapt to the impacts from climate change and damages from hazards which also depending on wealth in addition to social, cultures, norms, practices. It should be able to maintain economic vitality and meet climate targets.

CBRNE RESILIENCE from CI Literature

Capability of the responders to detect CBRNE events, to respond and to recover from occurring incidents**.**

COMMUNICATION RESILIENCE from CI Literature

Communication resilience is the capacity to provide communication infrastructure in a steady state. In addition, citizens have capacity to absorb and preparedness to make use of different crisis management communication technologies to withstand hazards.

FLOOD RESILIENCE from CC Literature

Flood Resilience is the capacity of the European regions to cope with the flood risks: water management, disaster management, spatial planning. It can be achieved by three types of adaptation measures: anticipatory or pro-active interventions, opportunistic interventions and reactive interventions.

A capability of being resilient against flood at the household level by suggesting the importance knowing the risk in order to make a decision on whether or not necessary to protect property.

4.2 APPROACHES AND METHODS

Approaches and methods identified in D1.2 are identified based on the bottom-up approach, i.e. by examining the perceived challenges in the individual EU project. In other words, the approaches are more about the common problems where resilience concepts are relevant.

In the CI literature, Risk and vulnerability are the most common themes discussed. Afterwards, cascading effects, CI failures and breakdown, interdependence and dependence come as the main perspective for looking at the CI. In addition, there are some literature discussing the following topics: CI CBRNE threat, CI protection, CI European resilience management guidelines, CI cyber-attacks, security attacks, CI service recovery/ CI stability, CI contingency planning and business continuity, CI preparedness.

In the CC literature, similarly to the CI literature, risk and vulnerability are the most common themes discussed in the literature since risk and vulnerability are always the main starting point for discussing resilience. Policies, strategies, and actions are difficult to formulate without the knowledge of what is vulnerable in the system components, infrastructures or geographical areas, and what kind of risks that follow the detected vulnerabilities. Next, disaster impacts, city or urban sustainabilities and city or urban strategies and policies are identified. Technology support for climate change and dependencies are two the least discussed topics.

In the SD literature, it is found that the main themes or problems as intertwinned between human and 'space' (city, urban, towns), as follows:

- the increasing economic and financial cost of disasters;
- the perception that it is not possible to protect against all natural disasters;
- the density of infrastructure and number of people living in at-risk areas;
- intensified land use and increasing conflicts between socio-economic land use and hazard mitigation policy;
- the need for better understanding of interrelations and social dynamics of risk perception, preparedness, and impacts;
- disparities in wealth and socio-economic status; and
- a realization of the importance of the intangible impacts of natural hazards and disasters and the need for increased post-disaster support and recovery.

Regarding the methods, the D1.2 review focuses on the methods used for conducting research on resilience, and not about the method on how resilience should be applied, as the latter is more related to the policy issues. We found the following research methods are often used in these three problem areas:

- Scenario analysis
- Case study
- Field survey
- Risk analysis, risk assessment, vulnerability and hazard assessment, Susceptibility analysis
- Literature Review/ Desk Survey
- Interview (Depth interview, focus group)
- Requirement specification analysis
- Foresight e.g. Delphi
- Quantitative (Statistical analysis, pre-post analysis)
- Modelling (Agent-based model, simulations)
- Multi-Criteria analysis
- Mapping GIS,
- Web and tool development

4.3 POLICIES AND INDICATORS

There are two policies that are discussed in D1.2, i.e. EU sectorial policies representing the top-down approach and policies that are identified from the bottom-up approach when exploring relevant EU project reports. In this case, D1.2 identifies a set of policies that have been referred, implemented, proposed or intended to be formulated at the end of the project, in the three problem areas. In the analysis process, all identified policies and indicators were categorised further into various units of analysis such as at individual level, organizational or governmental level, community level and at the national level, whenever it is possible.

At the higher level of EU sectorial policies, resilience is mentioned in a very limited way. In the Regional and Cohesion Policy Sector, resilience becomes a part of the regional investment strategy, particularly as a part of Energy Union and Climate priority area. The resilience initiatives are intended for preventing climate change risks. Thus resilient cities mostly mean the ability of cities to anticipate the adverse effects of climate change and take actions to minimize the damage. In EU Environmental policy, the resilience has to do with ecology and environment. In the EU public health policy, the resilience is interpreted as capacity building against health threats, and as an individual capacity to cope with the effect of climate changes. In EU transport policy, resilience is applied for the continuity plan of infrastructure in the case of disruption, and robust infrastructure against climate change. In EU energy policy and EU Trans-European Networks Policy, again resilience is linked to the climate action and a support for resilient economy. In EU Industrial policies, resilience is linked to the security level of ICT infrastructure. In EU Social Employment Policy, resilience is used to refer to social or societal resilience.

In Critical Infrastructure areas, most policies identified are predominantly related to the national and organisational or governmental policies, as it is understandable that formal institutions are mostly responsible for helping the citizens and public and private entities to protect their critical infrastructures through laws or set of organisational rules.

Examples of policies related to CI are:

- CI safety design and construction, and maintenance,
- CI data acquisition and monitoring system and crisis response equipment,
- CI organisational procedures for crisis management,
- CI top management commitment and crisis manager preparation,
- CI operator preparation,
- CI crisis response budget,

- External crisis response equipment,
- First responder preparation,
- Government preparation,
- Trusted network community,
- Crisis regulation and legislation, and public crisis response budget,
- Societal situation awareness,
- Safety and security policy, the agencies and officials responsible for natural disasters must also be prepared for terrorism,
- Developing risk-based approach (risk management, risk-vulnerability approach) and resilience thinking and adaptive approach,
- Adapting organisations to the cross-border nature of the Internet and cybercrime/terrorism,
- Introducing cyber security as a society culture need,
- Development of training and awareness tools, and
- Utilising privacy enhancing technologies.

Beyond the policies for organisations and government, there are only a few policy examples intended for other target groups. For instance, there is a case of policy support in planning for large-scale incidents, where the community will be part of it. However, still, the policy itself is a part of the wider public policy. Note that identified policies in CI area are not so much related to the urban context.

In the climate change literature, identified policies are more related to the urban and cities. In addition, more policies are intended for changing behaviour of stakeholders, communities, and individuals, especially when come to the adaptation to the climate change, such as water issue. Examples of policies are:

- Planning and implementation of local adaptation strategies
- Mainstreaming of adaptation concerns into other policy areas
- Spatial integration of adaptation needs through urban planning
- Local emergency plans
- Allocation of municipal resources and raising of other funds
- Upgrading local infrastructure to make it resilient to climate change
- Engaging civil society and private actors
- At Regional level: Providing incentives, funding, and authorisation to enable local action
- Addressing inter-municipal and urban-rural relations of climate change impacts and vulnerabilities
- Developing and implementing with cities regional approaches

In the social dynamics area, policies for potential voluntary engagement, organised volunteers, semi-organised individuals, and “non-organised” individuals as well as for enhancing awareness and preparedness are identified. Policies on public engagement or community empowerment are recommended to be a part of societal crisis management, which eventually strengthen community resilience. Regarding the indicators, D1.2 also identified a set of indicators in the three problem areas: critical infrastructure, climate change and social dynamics. Table 3-5 present the most important indicators.

Table 3. Indicators in the CI literature

Aspects	Indicators
Technology	- the ability to resist damage and loss of function and to fail in a safe way. - the physical components that add redundancy.
Organisation	- capacity, planning, training, leadership, experience, - information management that improve disaster-related organisational performance and problem solving.
Social	- encompasses population and community characteristics that render social groups either more vulnerable or more adaptable to hazards and disasters. Social vulnerability indicators include poverty, low levels of education, linguistic isolation, and a lack of access to resources for protective action, such as evacuation.
Economic	- the capacity to reduce both direct and indirect economic losses resulting from disasters

Table 4. Indicators of Community Resilience

Aspects	Indicators
Transport	- On time performance. - Avoidable delays. - Passengers carried. - Back to normal" carrying load. - Resumption to normal airport flight schedule. - Recovery times. - Degree of availability of CI system. - Energy: Extent of damage incurred.

Emergency Services	- Extent of assets, infrastructures or systems damage. - Number of assets back online (in operation).
Government bodies:	- Service provision (coverage).
Resilience qualities:	- robustness, - redundancy, - resourcefulness, and - rapidity.

Table 5. Indicators of Good Governance

Aspects	Indicators
Governance (actors, institutional arrangements and organisations)	- Education, research, awareness and knowledge - Information and communication - Culture and diversity - Preparedness - Response - Protection - Exposure, experience, and impact severity - Resources - Health and well-being/ livelihood - Economic - Adaptive capacity - Coping Capacity - Innovation and Capital - Infrastructure and Technical
Social Capital	- **Equitable treatment of all partners** (equal right in decision making process, equal vote for partnership) - **Communication and information** (a transparent communication, existence of platform for communication exchange, amount of information material on risk management) - **Participation (**Amount of partners from each sector, amount of periodic formal meetings of stakeholders, implementation of monitoring process**)**

	- **Knowledge** (existence of educational programs for society, percentage of trained individuals, existence of subject on regional risk) - **Trust (in stakeholder, partners)** (Existence/knowledge about influences on trust/beliefs, existence of longstanding cooperation, experiences of mutual conflict) - **Rules and norms in society** (Solidarity in society: amount of donations, mobilisation of volunteers
Human Capital	- **Skills and competencies** (level of education, amount of practical measures I private household, % membership in NGO and governmental organisations)
Political Capital	- **Transparency and trust in political actions: (**Periodic submission of new laws or decrees in a public document, Percentage of population taking part in elections, Periodic statistical surveys published - reflecting the opinions of the population in regards to governmental work, Existence of comprehensive anti-corruption policy Existence of laws/declarations, etc. in order to provide legal basis for the freedom of media**)** - **Regulatory framework: formal rules and norms** (Permanency of risk related laws/regulations (time period), periodic revision and updates of laws and regulations concerning the protection against hazards and the management of disasters, existence of emergency plans (level of detail), existence of obligation to obtain insurance, existence of risk maps)
Financial Capital	- **Disaster funds (**amount of disaster expense of total environmental budget, amount of existing disaster funds in risk area, ratio public-private funding on disaster funding, % household having insurance in specific threat in risk areas, % damages covered by insurance) - **Risk of impoverishment** (-Number of enterprises with insurance related to the specific threat in risk areas, Existence of rights of compensation (offered by the government), amount of these compensations, Quality of supply of public goods in general)
Environmental capital	- **Regeneration of environment:** Percentage of ecological compensation area per total area

4.4 SUMMARY AND CONCLUSIONS

The work in D1.2 is aimed at a deepening our understanding of European dimension of Urban Resilience. The report provides a basis for the SMR project when operationalising the concept of resilience to a practical level and city context as a backbone for resilience of European cities.

Results show the different applications of resilience concepts in EU sectorial policies and projects in each problem area. The analysis in the Critical Infrastructure (CI) area shows that resilience is only used interchangeably or together with protection concepts, although there is a growing attention on the connections across CI sectors where the interdependencies and cascading effects play a role. Recent studies include the concept of adaptive capacity to CC link to CI by, for example, taking into consideration whether or not the CI facilities are located in hazard-prone areas. The link between CC and resilience further includes governance and financing dimension at a city level. However, the operationalization and assessment of city resilience is still lacking. Similarly, in the area of social dynamics and resilience there are not many practical examples of implementation and operationalisation. Challenges identified include: adaptive capacity to CC and human health; social vulnerability, and how to increase social resilience of these vulnerable groups (e.g., how to integrate the asylum seekers into the European society), the individual ability to cope with and recover from hazards. At the end of D1.2 a link between all the most prominent dimensions and indicators that have been identified from the EU projects and policies with respect to these three problem areas are summaries, as a repository to build further the European Resilience Management Guidelines.

5 DEFINITION OF SMR CITY RESILIENCE

5.1 INTRODUCTION

In this section the SMR City resilience definition is presented. First, a background section is provided, outlining considerations made in developing the definition. Second, the SMR City resilience definition and SMR City strategies are presented, including a commentary on core concepts used in the definition. The definition aims to ensure joint understanding between SMR partners on viewpoints and strategies for improving City resilience. To this end, the definition has been iteratively developed and involved all project partners in discussions and reviews.

SMR Definition City Resilience

"is the ability of a City or region to resist, absorb, adapt to and recover from acute shocks and chronic stressed to keep critical services functioning, and to monitor and learn from on-going processes through city and cross-regional collaboration, to increase adaptive abilities and strengthen preparedness by anticipating and appropriately responding to future challenges"

5.2 BACKGROUND

Today many cities in use the definition by the UNISDR, which is why this definition was a starting point to develop the SMR definition. The UNISDR definition has been modified to harmonise the conceptual tensions and include the SMR core concepts, tools and resilient strategies.

The UNISDR Resilience Definition: "*The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions*."

Although the definition has undergone major changes, the difference is mainly found in the parts of the definition that include foresight for Cities to adapt not only in response to hazards, but also in anticipation of future needs and increase adaptive abilities. Two main aspects have been taken into consideration in developing the definition for resilience in the SMR project. These include:

1. Conceptual tensions identified in the resilience definitions analysis in D1.1
2. Core concepts identified in SMR city workshops in D2.3

Conceptual tensions from resilience definition analysis

The literature shows that there are a number or complex issues regarding the definition and operationalisation of resilience in an urban context. We have identified four conceptual "tensions", that is, theoretical concepts that are used and applied in relation to urban and disaster resilience and are applied inconsistently or in an unclear way. The conceptual "tensions" include: "the notion of equilibrium", "time scale", "resilience behaviours: flexibility vs. robustness" and "urban resilience boundaries". Each of these tensions are discussed in detail in Section 3.3.5. Table 6 shows the stance taken in each of these four areas.

Table 6. Conceptual tensions and stance taken in development of the resilience definition

Conceptual tensions	Stance description
The notion of equilibrium	Non-equilibrium stance taken, CITIES are viewed as complex and adaptive systems. Focus is on preserving critical services, and increasing adaptive capacity.
Resilience behaviours: flexibility vs robustness	CITIES require a combination of robust and flexible structures, with an emphasis on the readiness to be flexible and adapt to unexpected events
Time scale: shocks and stresses	Emphasises that resilience must be understood across temporal scales, including abilities to re-organise in the face of disturbance (acute shocks) and includes a focus on monitoring and anticipating to adapt to future needs (chronic stresses).
City resilience boundaries	What constitutes a CITY may differ from region to region. Focus is on identifying what needs to be protected, as a basis for identifying boundaries. Essential networks are socio-ecological and socio-technical. These should be understood in terms of economy, governance and culture. Boundary-spanning (collaboration across regions) is emphasised as essential for resilience.

Core concepts identified in SMR city workshops

Figure 8 shows the core concepts identified in the SMR city workshops (see D2.3 for more information). Table 7 offers a description how each of the core concepts are considered in the SMR definition.

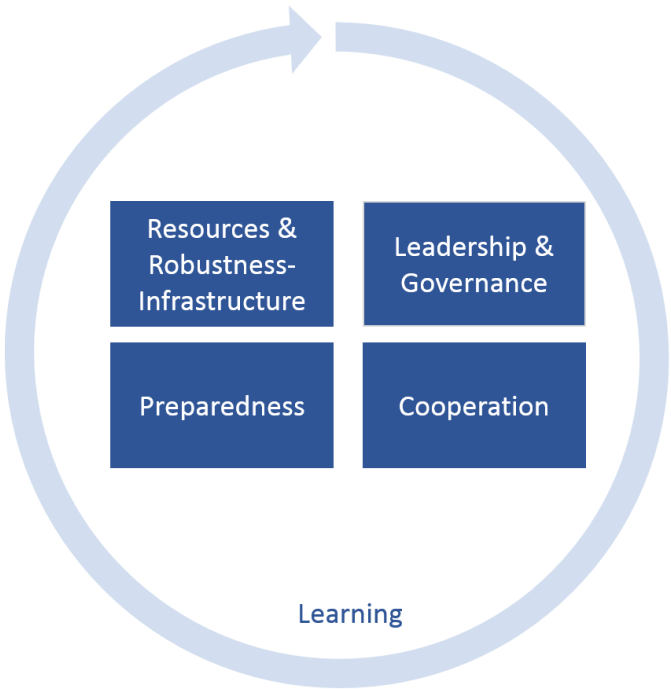

Figure 8. Five resilience dimensions of the SMR project

Table 7. Description of the five resilience dimensions of the SMR project

Core Concepts	Description
Resources & Robustness-Infrastructure	The CITY requires robustness to *resist and absorb* hazards through the preservation and restoration of its essential infrastructures and functions. This requires redundancy, risk management and continues work on decreasing vulnerabilities.
Preparedness	*Preparedness* for future needs by foresight; that is, anticipating future needs and making appropriate system adaptations. Preparation can be done at all levels of society, from individuals and communities to leaders and governments. It also includes being prepared for the unexpected, such as increasing flexibility and the cities adaptive capacity.
Leadership & Governance	Leadership and Governance reflect the decision-making level of the city. Commitment by the leaders is seen as essential for success. Its commitment is seen through the City abilities to build robustness, collaborate and adapt to future needs.
Cooperation	City and cross-regional collaboration necessary, including stakeholders within the city and across regional sectors (including the European region). Cooperation is also done at community level such as volunteer groups and citizens ability to self-organise.
Learning	Learning is achieved through monitoring of past events and on-going processes to make predictions about future needs.

5.3 SMR DEFINITION OF CITY RESILIENCE

In the box below, the SMR definition of urban resilience is presented. The definition is carefully worded to address the conceptual tensions identified in literature in D1.1 and the core concepts of the SMR project: resources and robustness infrastructure, preparedness, leadership and governance, cooperation and learning. The definition of resilience reflects the viewpoints of resilience SMR project,

that is, what we are working toward. To improve resilience SMR is developing management guidelines through five different tools. Thus, there is a close link between the definition of resilience and the development of the tools. To make this link more visible four city strategies have been developed, demonstrating how the tools address target points of CITY resilience.

The SMR City Resilience Definition

"is the ability of a CITY or region to resist, absorb, adapt to and recover from acute shocks and chronic stressed to keep critical services functioning, and to monitor and learn from on-going processes through city and cross-regional collaboration, to increase adaptive abilities and strengthen preparedness by anticipating and appropriately responding to future challenges"

The SMR strategies

1. An adaptive capacity through the process of continuously balancing robust and flexible structures. Robust structures absorb or block disturbances and flexible structures enable a repertoire of shared modes and resources to manage unplanned and unexpected events/stresses.

Tools: Through the Maturity Model and Portfolio of Policies a trajectory is defined, including policies to guide the work of balancing robust and flexible measures. Through the Systems Dynamics Model the progress can be monitored and options explored to further improve the development toward improving resilience.

2. Anticipating future events and continuously learning about the changing risk landscape through an in-depth knowledge of risk interdependencies and, thus, developing/adjusting appropriate risk mitigation strategies

Tools: Through the Systemic Risk Assessment Questionnaire the risk landscape is mapped out, further determining the resilience maturity level.

3. Resilience community building through city and cross-regional collaboration on shared visions, plans and policies for the city to function as a unit (vertebra) of society's resilience backbone

Tools: Through the Resilience Engagement and Communication Tool integration with the wider public and private companies is facilitated.

4. Anticipating future challenges to proactively implement changes and enable flexible and adaptive transitions to cope with the expected and unexpected events, through the ability to analyse evolving scenarios

Tools: Through the Portfolio of policies new adaptive structures defined, enabling proactive management. Through the Systems Dynamics Model and Risk Assessment Questionnaire diagnoses of current levels of strengths and risks can be defined and future scenarios explored.

5.3.1 COMMENTARY ON CONCEPTS USED IN THE DEFINITION

CITY

The definition and constituents of a CITY differs from region to region. Although there is no agreement on how a city is distinguished from a town in general English language meanings, many cities have a particular administrative, legal, or historical status based on local law[9]. Categorisation of a CITY is, just as any system, never definitive, but can be done in many ways, depending on the interest and perspective of the stakeholder/researcher (Hall & Fagan, 1968). So although a CITY is an objective things, it is subjective insofar that a system, and its environment, is defined by the interest analyst for a particular given context (Ackoff, 1971; Hall & Fagan, 1968).

A city always has some form of local government, as well as developed infrastructure. It differs from a country or larger area in that it may have local challenges that are unique to it. Geographical boundaries may be drawn based on, for example, economic or political boundaries. A geographical region is commonly defined by jurisdiction, e.g., national or city/region boarders. City regions may however differ greatly, in geographical areas, affecting greatly the needs, goals, and cooperation requirements. A larger urban system (also called metropolis) may include a relatively small, but densely populated region, and include several tows/cities with separate administrative functions and different mayors. Metropolises are further associated with having multiple suburbs. A region can also include a large geographical area with a city, small towns and farmland, but still be part of the same administrative function.

[9] https://en.wikipedia.org/wiki/City. Retrieved 2016-11-14

Examples of networks within the CITY that may be considered include; socio-ecological, socio-technological and socio-economical. *Socio-ecological* networks include an understanding the interplay between the urban environment and its ecosystem. *Socio-technological* systems concern primarily the built environment, such as communication networks, electricity, water and other critical infrastructures. *Socio-economical* networks include the flow of resources and finical capital of the systems. Important to note is also keeping intact and have an understanding for the heritage and local knowledge, and thus include social and cultural aspects of the urban environment.

Resist and absorb

The robustness of a city, or the ability to resist or absorb, can manifest itself in several different ways. In the most acute sense it is the ability to cope with the disturbance by using available resources to mitigated and dampen the effects of a disturbance. Increasing robustness typically means to expand the set of disturbances the system can withstand. It may also be manifested in the built environment, and how well the construction and barriers of a city can cope with natural and man-made hazards (e.g., dams against flooding and earthquake safe buildings).

It is important to distinguish between shocks and stresses when judging absorptive capacity. Shocks are shorter in duration and may put a lot of pressure on available resources during the event. Stresses, on the other hand, are slow progressing and require a different set of coping mechanisms, more like sustainability. Also, some stresses can be tackled locally and other must be recognised and dealt with globally.

Adapt and recover

Having work processes and a work culture that incorporates and promotes adaptive structures such as flexibility may lead to abilities to handle many unexpected disturbances. Adaptive capacity should be achieved through the process of continuously balancing robust and flexible structures. Robust structures absorb or block disturbances and flexible structures enable a repertoire of shared modes and resources to manage unplanned and unexpected events/stresses (Strategy 1). Communication structures and leadership strategies that allow for several different uses are required, so that these can be utilized in ways that are not predetermined. Outside capital may be considered as a resource during an extraordinary event, even though they do not have a place in the strategy beforehand. This, in return, enables a faster recovery period. Note, that recovering does not mean that the system must return the way it was prior to the event, but that it may change based on the accommodations made.

Shocks and long-term stresses

To assess and improve CITY resilience meaningful temporal boundaries must be identified. Temporal boundaries include defining the time scale to be assess/improved; what is the starting and ending point? At what point in time do we assess resilience in a specific area? The discussion on temporal aspects often includes if it is acute shocks (short term) or stresses (long term). Planning for the short term involves, for example, preventing/recovering from natural hazards such as a flooding or an earthquake. Long-term resilience, on the other hand, is a much more complex concept that requires a continuous stream of both funds and research (anticipatory abilities, monitoring).

With the goal to keep the city functioning

What constitutes the essential infrastructures and functions will vary from one city to another. One should first consider what is important and should be protected in the given region. Which core values are of the biggest importance? It could be objectives such as a functioning infrastructure, making sure everyone has access to health care, making sure the elderly is safe, etc. Prioritising and making trade-offs is a common concern, as during severe events it is likely to be very difficult to maintain all values, and so a hierarchical order could be applied to the situation. The core ability of the resilient system is to maintain the core functions as changes are made, either by short-term shocks, or by long-term stresses.

Learn from on-going processes

A city must have abilities that to continuously monitor and assess on-going event (short term) and overall functions and strategies (long-term). Monitoring abilities includes not only disturbances, such as the progress of a flood or the effect of global warming, but also organisational processes and changes to improve efficiency and flexibility. Monitoring requires anticipating future events and continuously learning about the changing risk landscape through an in-depth knowledge of risk interdependencies and, further, developing/adjusting appropriate risk mitigation strategies (Strategy 2).

City and cross-regional collaboration

An important part of the SMR project is to build strong networks and support among CITIES. Resilience community building is done based on shared visions, plans and policies for the city to function as a unit (vertebra) of society's resilience backbone (Strategy 3). A main finding in the literature and during the SMR workshops (D2.1, D2.2 and D2.3) has been the importance of collaboration between key stakeholders both within and across cities and regional sectors. Challenges that may occur when collaboration is lacking include divergent objectives, needs, scope, and priorities, which are all key for the abilities to respond to change.

Anticipation, adaptive abilities and preparedness

Anticipating future challenges is done to proactively implement changes and enable flexible and adaptive transitions to cope with the expected and unexpected events. This may be done through, for example, risk assessment and analyse evolving and future scenarios (Strategy 4). Anticipation is a key aspect in that it promotes a gradual change towards possible scenarios so that when they occur, the region is already prepared to handle some of the consequences. It should be expected that unexpected variables will occur, and systems should be prepared not to be “failure safe” but “safe-to-fail”. Preparedness such as training for known scenarios can increase abilities and may leave more resources for scenarios that are unexpected.

5.4 CONCLUSIONS

By consolidating the literature on urban resilience and the outcomes of the SMR workshops a definition for city resilience in the SMR project has been developed. The definition harmonises the conceptual tensions identified in the literature and includes the core concepts for city resilience identified in the workshops; resources and robustness infrastructure, preparedness, leadership and governance, cooperation and learning.

The SMR resilience definition takes into consideration conceptual tensions, core concepts of the SMR project and reflects the viewpoints and strategies of the SMR project. The definition encompasses resilience as the ability to be robust and absorb shocks, and as the ability to adapt and transform to cope with continuous change and future challenges. At the core of a resilience perspective is the ability to adapt, which includes the ability to adapt the process of balancing between being robust to cope with known events disruptions and having flexible structures ready for unexpected events and change. Strategies to achieve increased resilience include monitoring and learning about the risk landscape and developing/adjusting risk mitigation strategies, building strong networks for city and cross-regional collaboration, and analysing future scenarios to facilitate flexibility and transformation in a continuously changing environment.

6 SMR CITY FRAMEWORK

6.1 INTRODUCTION

This section presents the SMR City Framework (SCF). This *general* model is suitable to understand urban resilience as a complex adaptive system and understand what affects adaptive capacity. The model is based on six main functions found in contemporary resilience engineering research: *anticipation, monitoring, response, recovery, learning,* and *self-monitoring*. The model is useful both for envisioning new resilience methods and metrics, as well as for engineering and evaluating resilient systems. In Section 6.3, we operationalise SCF into a set of concrete actions for city managers to work with resilience concretely.

6.2 THE FRAMEWORK

6.2.1 ADAPTIVE CAPACITY AND CORE GOALS

Central to all resilient cites and city management processes is their *adaptive capacity,* that is, their ability to take actions to protect its core goals. This mean that cities', often under dynamic conditions, must re-prioritize and replace less important objectives that are not instrumental to the core goals. As events and stresses unfold, they represent a set of limitations and new objectives for the city decision makers. There may be different costs associated dealing with new limitations and objectives, particularly late in a process, which may result in the need to make difficult trade-offs. It is of particular importance to notice that some core goals may become critical only in certain context, during particular kinds of events and stresses. Nevertheless, any municipal organisation that states they are resilient needs to define their core regulatory goals.

6.2.2 RESILIENCE FUNCTIONS

Fundamental in SCF are *six resilience functions* that characterise general capacities that a city needs to have with regards to their core goals. Figure 9 shows part of SCF. The six functions are arranged in a circular fashion in this model, placing the functions where their output can be used at the earliest, in relation to unfolding events.

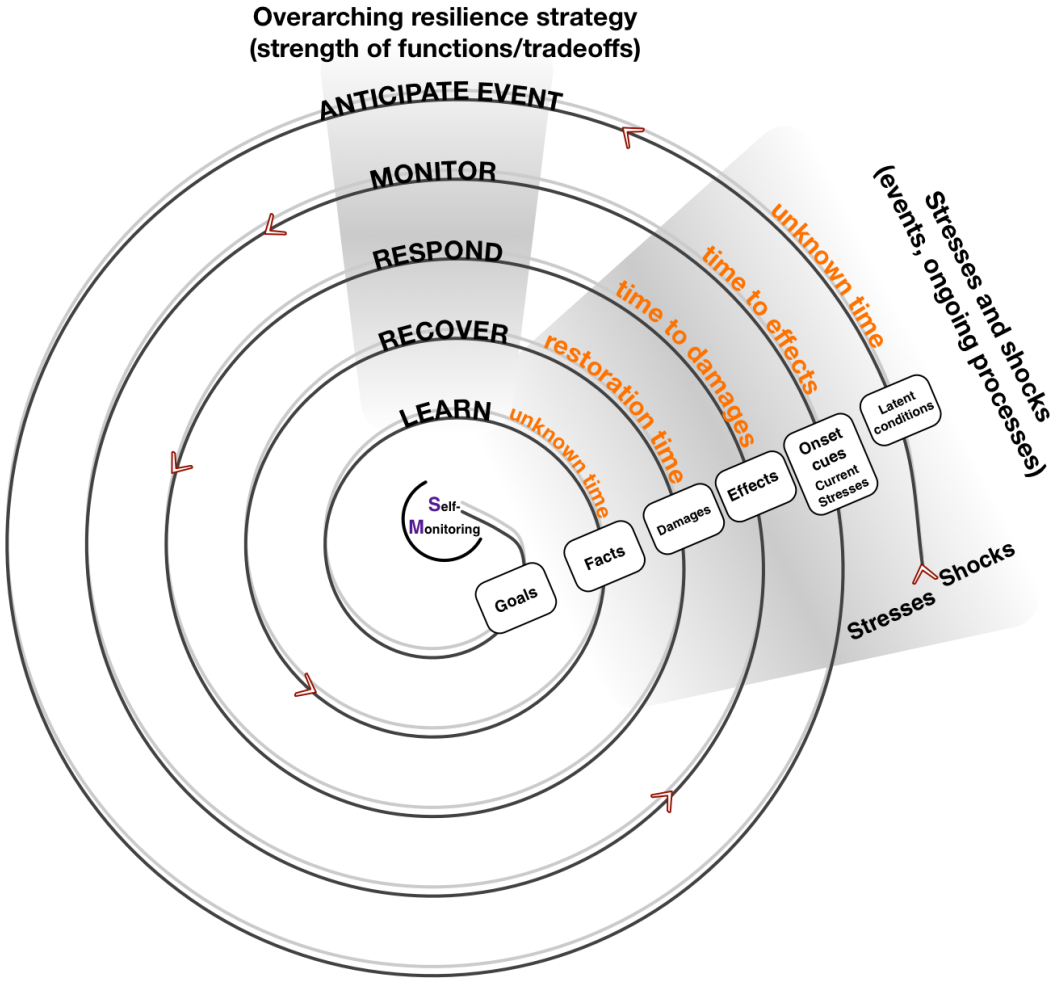

Figure 9: The SCF model. The general model is suitable for understanding municipality resilience as a complex adaptive system. The model is based on six main functions found in contemporary resilience engineering research: *anticipation, monitoring, response, recovery, learning,* and *self-monitoring*.

In this model, *anticipation* is a pre-requisite for the ability of establishing, at the earliest point, functions for monitoring the onset of events, functions for event detection, preparing suitable modes of operation during response, and immunizing against threats that are completely avoidable. *Monitoring* is a pre-requisite for detecting the onset of events. Subsequently, abilities to detect effects of events may be adjusted and mobilised, response capabilities may be adjusted and mobilized, and effects may, in some cases, be entirely avoided by some manoeuvre. Initiating *response* is a pre-requisite for the ability to detect direct effects of events, respond to events through the current repertoire of action, to take control of events. Since damage may nevertheless occur, initiation of *recovery* is a pre-requisite for re-establishing damaged functions for detection of effects and damaged modes of operation. *Learning* is then a pre-requisite for adjusting functions for event detection and modes of operation, and feeds into the self-monitoring function at the centre of the model. Finally, at the core of this model, *self-monitoring*

refers to the ability to monitor and adjust all other functions continuously, a pre-requisite for the ability to maintain the core abilities of the model. Whereas the sequential nature of unfolding events potentially triggers the functions in the model in such a way that it provides pre-requisites for adjusting its functionality against threats, self-monitoring describes the resilience of the system against threats to its intrinsic ability to adapt and respond, as a whole.

6.2.3 ANTICIPATING

A city can have transient adverse events in terms of *latent conditions* and long-term on-going chronic stresses. Anticipation—expectations on what potentially occurs in a city in the short and long term—is crucial for detecting and coping. This resilience function largely depends on *requisite imagination,* a term coined by Westrum (2006) Requisite imagination refers to the ability to foresee/predict future problems – a skill that is very hard to assess in advance. Nonetheless, it is essential for city preparedness – and for the ability to adapt and adjust response processes in advance of events. Moreover, it is also important to accept and anticipate that we cannot foresee all future events, and thus cities' need to prepare to be unprepared.

However, having specific response capabilities for specific threats are not proofs of strong resilience, since new emerging threats may nevertheless later expose the system to new vulnerabilities. It is the *active process* of anticipation and adjustment that is the exhibit of resilience – rather than adjustments per se. Both adjustment of stability (e.g. immunization) and adjustment of response capabilities (e.g. new response modes) may result from anticipation. Since anticipating is difficult, cities' anticipating capability is generally low or missing and in many cases left to top city managers and to the crisis management level.

6.2.4 MONITORING

A city's monitoring capacity is guided by anticipation and the core goals one has to protect. Local agendas (core goals) as well as national and EU-level legislation set what is monitored. Hence, many municipalities have already ´sophisticated technical functions established for monitoring different threats such as air quality and water level sensors. Important in monitoring is also citizens. Nevertheless, the monitoring functions should be set up to protect the core goals.

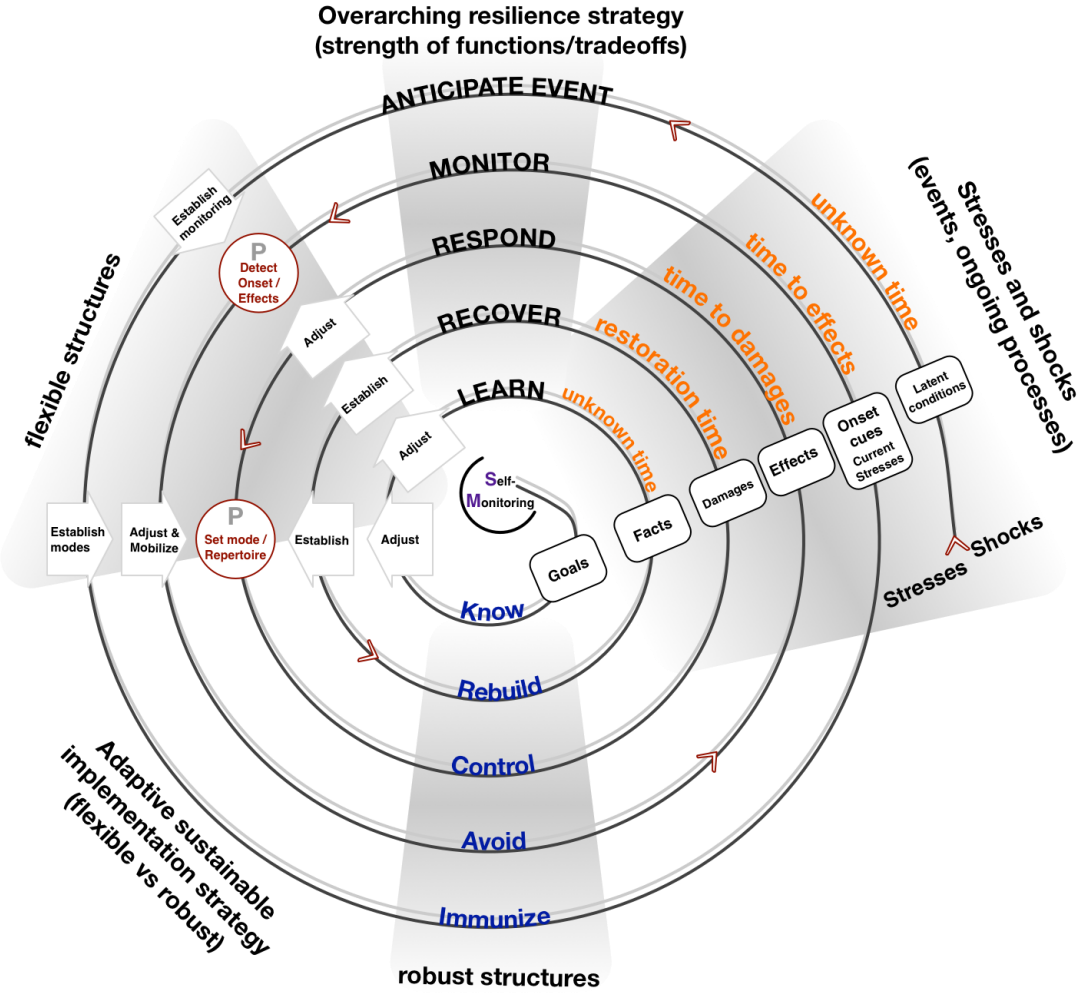

Figure 10: SCF highlights the importance of having both flexible response modes and robust structures such as barriers integrating Safety-I and Safety-II perspectives. This approach strengthens the cities' ability to handle both the unknown and known stresses and risks.

Figure 9 shows how monitoring is dependent on detection based on onset cues of an upcoming event. These are important prerequisites to adjust and mobilize response modes. Although it would certainly be possible to also establish modes of what capacities are required as a result of monitoring, on-going events then may constrain action possibilities more severely than if modes are established based on anticipation (less time). To actually make use of a monitoring function adequately, resources must also be mobilized. However, for complex situations, monitoring may only foster partially mobilization at the outset, creating more adequate response modes as onset cues become more pressing.

There is an important dimension to monitoring, namely the *ability to interpret and assess the signs correctly of an upcoming problem* once it is detected. *Requisite interpretation* (Johansson, Lundberg 2010; Lundberg, Johansson 2006; Lundberg, Johansson, 2007) is a term used to illustrate an

organization's ability to recognize that something that goes outside of the routine means has actually occurred, and initiate, strengthen, or coordinate a process of adaptation in response to emerging events. This is particularly a problem in inert organisations such as in city management processes and in political processes where views and priorities diverge. Moreover, a particular problem, with regards to city resilience, is to design monitoring functions that for less expected events; it may be required to process data that rarely contain information that is needed, to interpret information that is rarely encountered, or even interpret common information in a new way.

6.2.5 RESPONDING

Successful response—to control situations so that negative effects are avoided—requires the ability to detect particular effects of events, and to have suitable response actions (that may first have to be adjusted and mobilized). To successfully act on a problem, there must be a *response mode*; *sufficient practices and resources* in terms of physical *assets and knowledge* and an *ability to coordinate those resources* in meaningful ways. As Figure 10 indicates, as soon as an event has been anticipated, response capacity can be prepared and evaluated. However, capacity may be mobilized much later, for example, after the first damage has been detected. But if executed later, new events, side effects and constraints can be more severe. In particular, response-through-control may require fast mobilization of resources, since it may be impractical to be ready-to-act on every potential contingency at all times. Mobilization may be severely constrained by events, e.g. since the physical distance between resources and events may cause considerable, and sometimes present critical, delays.

With regards to resilience, events can be *regular*, *irregular* and *unexampled* (Westrum, 2006). Ideally city response systems should be designed so that what occurs very often is prepared, while what happens irregularly may require mobilization, and the unexampled may also require establishing capacities. Although this is not a strict rule, it shows that by design, systems may not have functions that are prepared, ready to respond to every contingency at all times, e.g. due to the cost and effort involved, and due to the impossibility to anticipate every contingency.

Systems that need to be adaptive *during* response face an additional set of challenges compared to those that can rely on adaptation in advance of events. Firstly, to cope with side-effects of being resilient (see Lundberg, Rankin 2014), secondly to prepare structures for being resilient (see Rankin, Lundberg, Woltjer, Rollenhagen, Hollnagel 2014). Furthermore, there is a problem of anticipating and detecting side-effects of adjustments that are made to cope with events (Lundberg J, Rankin, 2014). Those side effects need to be differentiated from side effects from the response activities per se, for instance side effects from usage of chemical means to control an outbreak of insects.

An important observation is that side-effects also may appear, or rather be interpreted as, changes in the state of the situation that emerge from outside of the system rather than a side-effect of own actions. This may lead to a vicious circle of misunderstanding, where the actions taken generate more side-effects, which in turn distort the interpretation of what is happening – eventually leading to a situation where the system forms a positive feedback loop that only causes more confusion (Hollnagel 1998).

Further, for regular events, it may be possible to control events through regular line organizations. However, some large-scale events may rely on the formation of hastily formed networks of organizations. As pointed out elsewhere (Lundberg, Törnqvist, Nadjm-Tehrani, 2014), a particular challenge for hastily formed networks is to establish conversation spaces. That includes both technologies and practices for communication.

6.2.6 RECOVERY

In traditional crisis response and emergency response literature, it is common to refer to recovery as one of the four core activities (McLoughlin, 1985; Altay, Green, 2006; Galindo G, Batta, 2013). Recovery refers to both short-term restoration, such as removing trees blocking roads, and to long-term restoration of destroyed infrastructure. What makes this central is the notion of “bouncing back”, to recover from negative events that have occurred (Manyena, 2006). Although this may refer to response activities, it is also important to consider dealing with effects that have passed through layers of defence and caused damage (Birkland, Waterman, 2009).

It should be noted that as a notion of resilience, recovery should not merely be about bouncing back to how things were, but forward to a state that is well-adjusted to actual circumstances and foreseen threats, as seen during recovery. In “creative destruction”, damaged parts are replaced by new constructs that have other abilities that are less damage-prone than their predecessors. Such forced design iterations are often an important driver for safety. In some respects, this is an illustration of Safety I, especially when re-construction focuses on immunization and increased robustness, rather that focussing on general abilities.

Successful recovery also refers to restoring functions facilitating resilience. During recovery, to bounce forward, new functions must be established, whereas to bounce-back previous functions need to be re-mobilized. Successful recovery may thus be a pre-requisite for continued response during events, as well as to regain or establish capacities after events.

6.2.7 LEARNING

Organisational learning is central to resilience (Hollnagel, 2009; Comfort, Namkyung, Ertan, Scheinert, 2010). If a city fails to learn from experienced events, negative or positive, it will spend unnecessary resources in all functions outside the learning part of SCF spiral the next time it faces a similar event. Firstly, learning promotes the ability to monitor as it helps focus attention. In some cases, monitoring functions may even have been unavailable before an event has happened, but are introduced as an effect of the fact that the system has learned from its experience. There are numerous examples of this, such as earthquake and tsunami warning systems that have been installed *after* severe events. Learning may thus be critical to bounce-forward after events, including learning from events that have affected other systems. In the same way, anticipation is affected. This may however not only be positive as events that have been experienced as significant can bias anticipation in a way that cannot be justified in terms of for example the actual likelihood of the same event.

Perhaps most importantly, learning helps the system improve its response to an event. By gathering and reflecting upon incidents, crises, and accidents, the cities may improve its barriers and procedures for coping with an event or even re-configure its structures to better withstand known disturbances. Also, ways of applying recovery actions can be improved to better meet the demands and serve as a basis for a swift return to normal operations.

Learning is ideally a continuous function, at least from a resilience perspective, but in many real situations, learning emerges as a consequence of major disturbances, i.e. ad-hoc. Learning can therefore be based on feedback as well as feed forward. To prepare for resilience, it is important to capture conditions that have previously enabled local resilience. The system may then avoid that conditions for resilience are removed as a side-effect of other changes to the organization. Conditions may instead be strengthened and spread (Rankin, Lundberg, Woltjer, Rollenhagen, Hollnagel, 2014). To summarize, the learning function can adjust the basis for detecting as well as actually be the basis for changing the existing repertoire/mode of control (see Figure 9).

6.2.8 SELF-MONITORING

Recent research has shown that the ability to change may at times demand more than just having core abilities at some point in time – resilience may require the ability to maintain the core abilities through adaptive processes during adverse conditions, in addition to preserving core system goals. This problem is sometimes referred to as the Matryoshka problem (Lundberg, Johansson, 2005) to emphasize that is a hard problem to tackle, since success cannot be guaranteed merely by using a new system to monitor

the old system. The system is then vulnerable to that new system being damaged, and that system in turn then would need to be monitored. Although the problem is hard, perhaps impossible to completely solve, it presents a major challenge for cities that need to be resilient.

As described in the example below, for instance in reflections by field staff on the Swedish crisis response missions after the Asian Tsunami of 2004, this problem was a major concern (Lundberg, Rankin, 2014). In our model, we refer to this new, tentatively important ability of the system to monitor its core functions for resilience as self-monitoring. Without self-monitoring, all or individual core functions that facilitate resilience may deteriorate or even cease to function, seriously reducing the resilience of the system (Lundberg, Rankin, 2014).

If a city, through self-monitoring, realize that it can no longer maintain its core resilience functions through the existing structures, it must find a way to transit those functions to a new structure, either by prepared measures, or by invention. As the city is a part of the environment in which it operates, it both shapes and is being shaped by the same environment. The self-monitoring function compares the value of success metrics (the effect of actions in the environment) with desired values, while reflecting upon its own resilience. If the current way of operating is deemed inappropriate, the system, based on its understanding of the situation, may choose to change its inner mechanisms to maintain success. Self-monitoring thus needs to be continuous versus change – with slow changes, continuity may be assured by self-monitoring at larger intervals. Self-monitoring may be a centralized or distributed process, executed before, after, or during events.

6.3 OPERATIONALISATION

This section describes an operationalization, in a set of stages and questions, on how cites can deploy SCF in a city management and resilience planning contexts. As SCF is iterative, the stages describe a set of recurring city management tasks. The method focuses on core values to protect, resilience functions/strategies, assessment and load balancing.

Step 1: Identify core values and regulatory goals

As we have discussed, a city's monitoring capacity is guided by anticipation and the core goals one has to protect. Therefore, it is important that cities define their core goals and local agendas. As a city includes many systems, including socio-ecological and socio-technical several analyses may be performed. Many municipalities have both processes and formal regulatory frameworks that state explicitly what these core goals are. Typically, cities today focus on critical local infrastructures such as water/electricity distribution networks and emergency services etc. However, due to the dynamic nature

of human endeavours and external factors such as climate change etc. there is a continuous need in municipalities to reassess the core goals on a regular basis. Existing approaches such as risk analyses, and the upcoming SMR Systemic Risk Questionnaire, may be suitable instruments to assess parts of the above, given insights of their weaknesses in terms of anticipating the unexpected and unexampled (Safety-1). Nevertheless, municipal processed that work with their core regulatory goals are needed. Typically, one needs to ask the following questions:

- Have we defined, prioritized and communicated our core values? What do we want to protect and be resilient against?
- Have we identified connections between threats and core values?
- Have regional and national cities similar core values? Can resource pooling and knowledge sharing be archived?

Step 2. Identify key stakeholders

Identifying stakeholders is important to be able to set roles and responsibilities and improve formal and informal communication during response. Typically, one has to answer the following:

- Have we identified who is responsible with and outside our organization (stakeholders) and who will protect the core values?

Step3a. Resilience function allocation

In Step 3, the city considers abilities to protect its core values by means of the SCF resilience functions. For each core value, each resilience function is allocated to responsible parties, that is, the functions; anticipating, monitor, respond, recover, learn, and self-monitor. Typically, this exercise needs to answer the following questions:

- Do we have all resilience functions covered for each core value?
- Who is responsible for the different resilience functions in the municipal structure?
- Is the function integrated or is it scattered among different sub groups? Regarding the latter, how is the function coordinated?
- What resilience function is seen as the most important functions with regards to the core goal? What function gets most resources?

Step 3b. Identifying resilience strategies (flexibility vs. robust structures)

In this stage, the goal is to further investigate the resilience functions in terms of the strategies they rely on. The main question is if the resilience function is predominately based on *flexible or robust structures* (see Figure 10). Flexible structures refer to the city's ability to quick *dynamically set together modes and resources* to manage a resilience function whereas robust structures refer to resilience through more static/passive constructions such as ready-to-use resources (e.g., barriers, vaccine etc.). This exercise elucidates strengths and weaknesses in the city's resilience. The exercise should result in a list of resilience functions and their foundation in terms of flexible or robust strategies.

Step 4. Local and regional load balancing for resilience development

The *distribution of resources among resilience functions* affects cities' in both the long and short term. Typically, a city can have allocated a lot of resources to *one* resilience function and less to others, that is, having a skewed internal resource allocation. This can affect resilience negatively. If a city has advanced tools to predict future needs and potential disturbances, monitoring can be targeted and resources to respond can be made more efficient. If, on the other hand, predict future incidents and potential consequences is challenging in the region due to uncertainty, putting a lot of resources into response may be valuable. Hence, the task in Step 4, for the city management, is to *map, assess and appropriately distribute available resources* among the resilience functions and local stakeholders. To assess strengths and weaknesses in each function a set of indicators and tools can be used. Hence, the goal is to take informed management decisions on how to strengthen weak resilience functions, re-allocate resources and re-distribute responsibilities of core values/areas. Additionally, since there often are weak points and that municipally resources are finite, boundary spanning and further load balancing may be needed on the regional, national and EU-levels (see Figure 11). To conclude, the result from this stage is an action

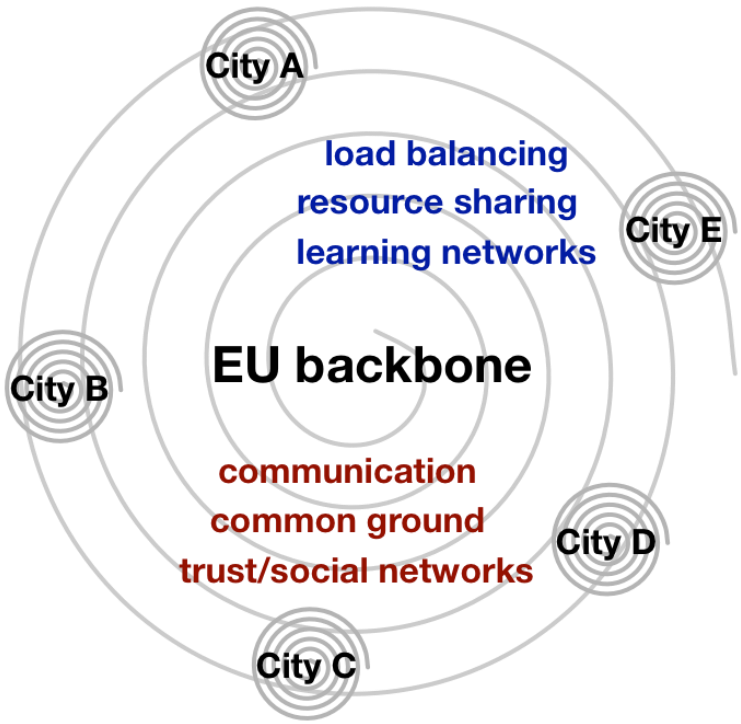

Figure 11: Cities have different strengths and weaknesses with regards to resilience functions. They also have different resources available. Load balancing within and among cities in terms of resource and knowledge sharing is important to improve resilience.

plan for resilience implementation that covers all core values, allocate resources and responsible parties, as well as stating how external load balancing is achieved. The latter is a matter of supporting resource/knowledge sharing and communication locally, regionally and on the EU-level.

7 DISCUSSION AND CONCLUSIONS

This section describes results synthesized from different efforts made in WP1. Overall, based on the literature studies and city surveys performed in WP1 four key areas of importance to strengthen municipality resilience have emerged:

1) First, identifying, setting up and balancing city resilient processes and strategies locally and regionally are seen as important.
2) Second, establishing boundary spanning, resource pooling and cooperation within local organizations, regional cities, and with European cities that has common agendas and core values to protect.
3) Third, it is important to establish flexible structures to support resilience functions in the SMR Resilience Model to be able to adapt to on-going situations.
4) Fourth, we emphasize the importance of secure formal and informal communication channels and common ground across all levels in the municipality

These areas are discussed first discussed from a theoretical standpoint using the SCF model. Second we discuss key results and implications from WP1 more generally.

Balancing city resilient processes and strategies

Five main abilities describe the core function of resilience in the SCF model: anticipating (what to expect), monitoring (what to look for), responding (what to do), recovering (how to re-gain functionality) and learning (knowing what happened) and self-monitoring. The *distribution of resources among functions* play an important role in determining a cities resilient strengths and vulnerabilities in both the long and short term. Typically, a city can have allocated a lot of resources to one resilience function and less to others, that is, having a skewed resource allocation. For example, how does our abilities to anticipate affect our ability to monitor or respond with regards to a core value? If a city has advanced tools to predict future needs and potential disturbances, monitoring can be targeted and resources to respond can be made more efficient. If, on the other hand, predict future incidents and potential consequences is challenging in the region due to uncertainty, putting a lot of resources into response may be valuable. Hence, the task for the city management is to assess and appropriately distribute available resource among the resilience functions. To assess strengths and weaknesses in each function a set of indicators and tools can used.

This assessment should also identify the strategies that are used to achieve each function. For example, how robust (immune) is the system compared to being flexible? With good predictions (anticipating) our possibilities to be robust (immunize) are increased. If we are not able to immunize well against potential hazards our strategies should focus on preparedness to respond and re-build. However, prior to the assessment it is advisable to define the scope in relation to the defined core values since a city includes complex socio-ecological and socio-technical systems. Nevertheless, this assessment provides city decision-makers with important knowledge to make informed cost-effective choices and manage trade-offs (economical, political).

Boundary spanning and regional load balancing

Improving city resilience is not solely a local issue. Resource pooling, such as sharing resources in term of equipment, ideas, and approaches can also increase resilience. Regions should draw on each other strengths, SCF provides a perspective on this: as we discussed above, a city may show imbalances between resilience functions, but these could potentially be balanced across cities regionally. For example, one city may develop advanced response mechanisms while other areas can offer guidance on how to learn from previous events and anticipate future needs. To achieve the above, regional decision makers should identify strengths and weaknesses in their city and assess how they relate to cities in the region. The goal is to identify collaborative possibilities in terms of sharing resources and knowledge. Moreover, establishing concrete modes for resource sharing at the operational level must be established such as resource location, time to relocate resources as well as political agreements and processes for resource sharing. A challenge for resource sharing is if several places are affected. Hence, agreements on these situations should be part of the collaboration.

Flexible structures and modes to handle the unexpected

Since anticipation is difficult cities need to have a flexible response capacity. Key to flexibility is to have adaptive structures to cope with unexpected events. To assess a city's flexibility, an analysis is performed on its ability to adjust different resilience functions and strategies in the SCF model. This report is not the medium for presenting a full method for this. However, several capacities and areas must be analysed by the city managers:

- Identify how siloed resources can be used flexibly for varying tasks and for different functions (resilience culture, ownership, trust)
- Boundary-spanning in terms of resource pooling as a means to be more flexible (see point above)
- Assess trade-off between functions and strategies to ensure adaptive capacity

- Building trust in formal and informal networks locally and regionally

Cross-level communication and common ground

For any organisation, information sharing and adequate feedback from work process is important to decision-makers. However, studies in WP1 show that a common problem in participating municipalities is the silo mentality. This issue can potentially reduce capacity in a range of resilience functions, and particularly, affect flexibility and the cities means to handle the unexpected. Hence, with regards to resilience, it is very important that city decision makers assess these issues concretely. Cross-sectorial training to handle unexpected events is promoted here as well as shared telephone lists and redundant communication channels across sectors and units etc. Moreover, trust and managerial culture is a factor that must be assessed to increase communication channels across a municipality.

7.1 INTEGRATION OF SCF AND SMR MODELS AND TOOLS

SCF and the SMR Maturity Model

The synthesis of WP1, SCF and its operationalization relates to the SMR maturity model in several ways; First, SCF indicates that resilient cities should decide on its core values, that is, their regulatory goals on what to protect. A maturity model could integrate processes or provide process indicators that indicate that such goals are in place. Moreover, a city needs to have established work processes that match resilience functions and strategies, for each core value, as well as having these assigned to responsible parties. This can be made in several stages with respect to its sophistication (c.f., balancing). Moreover, a maturity model should also assess the city's communication and resource sharing capability inside and outside the own organisation (load balancing). Moreover, analysis of what should be included in a maturity model should consider the above discussed four key areas.

SCF and the 100RC indicators

The twelve indicators presented by Arup in the Rockefeller 100 Resilient Cities Programme (Arup, 2014) are important general attributes and performance indicators of a resilience city. They are focussed on the *output of actions*, not the actual work processes and policies required to achieve resilience. SCF and its operationalization, however, focus on the *underlying work processes, actions and to some degree policies* one must implement in a city to accomplish many of the goals of 100RC. Indicators 3-

5[10] and 8-12[11] clearly relates to SCF. For example, SCF is related to the 100RC Leadership and Strategy category with indicators effective leadership and management, empowered stakeholders, and integrated development planning. Moreover, SCF is related to the Infrastructure and Environment category with indicators on reliability mobility and communications as well as continuity of critical services. Additionally, relationships can be seen to indicators safeguards to human life and health, collective identity and mutual support and social stability and security. Our model can be said assess these areas by providing a general management process framework.

SCF and its relationship with SMR instruments and tools

Work in WP1 and the SCF model, indicate that engagement tools should foster formation of resilience functions for core values and aid decision makers in assessing these functions locally. Moreover, they should have a design focus on facilitating boundary spanning aspects such as resource and knowledge sharing locally, regionally, nationally and on the EU levels. The systemic risk questionnaire can surely be a valuable instrument to assess city risk. This tool could be designed to identify core values to protect in Step 1 in the SCF operationalization. Moreover, SCF and its operationalization provide a coherent terminology with regards to city resilience as well as a set of processes that can be standardised and evaluated.

The SMR city workshops and the dimensions identified in these provide a *bottom-up* perspective on urban resilience. However, SCF provides a theoretical and *top-down* perspective based on resilience engineering concepts. The following discussion is an attempt to interpret the bottom-up dimensions using SCF: With regards to *Resources & Robustness-Infrastructure*, the city has decided on core goals, that is, what infrastructures and city functions that are of importance to protect. Modes in terms of resources as well as responsible organisations and procedures have been set up. Moreover, monitoring capacity such as sensor systems and communications from sub functions/organisations are in place. Resisting something refers to SCF to have robust structures that can withstand external forces (robustness) whereas to absorb refers in the model to having flexible capacity to handle the unexpected. To preserve a core value refers to having response capacity and restoration can be seen as capacity to recover from an undesired state. The latter, as discussed above, also requires resources and modes. Regarding redundancy, this term, in the SCF model, refers to additional capabilities and modes (physical and knowledge) of the city system, and this also relates to boundary spanning and resource sharing

[10] 3: Safeguards to human life, 4: Collective identity and mutual support, 5: Social stability and security.

[11] 8: Continuity of social services, 9: Reliable mobility and communications, 10. Effective leadership and management, 11: Empowered stakeholders, 12: Integrated development planning.

that can strengthen capacities. *Leadership and Governance* (self monitoring) can, from the SCF model, be seen as the managerial approaches to achieve resilience in terms of defining core values and resilience functions for the core values as well as establishing general capability. This means establishing responsible parties for different functions and assess load balancing issues (resource sharing) locally and regionally. Policies must be set to facilitate the formation of functions and ensure that silos are assessed. *Preparedness,* in SCF terms is having monitoring capability and, as discussed, having set up modes to protect the core values. This is not a static activity, hence, it is important to set up processes that assess city preparedness for different areas. Moreover, anticipation is part of preparedness. *Cooperation* can be interpreted on many levels in SCF; anticipating, monitoring and response etc. Nevertheless, cooperation is about establishing modes and roles as well as having clear communication channels among different local and regional actors. Cooperation, as discussed above is also related to load balancing and resource sharing both within the city, locally, and in the EU. Finally, *learning* – a concept found in both SCF and in the SMR dimensions – is in SCF related to the adjustments and focus set on individual resilience functions. For example, with regards to chocks, a city needs to have anticipation capability and have learnt from previous events to be able to set up modes for action. With regards to city stresses, needed are appropriate monitoring and modes set up rather than anticipation capability. Furthermore, SCF points to the importance of pre-emptive actions (robust structures) to lessen the impact of stresses, for example, implementation of reforms and long-term initiatives to approach social issues.

7.2 KEY FINDINGS AND IMPLICATIONS

7.2.1 ACADEMIC PERSPECTIVES ON RESILIENCE

The academic literature demonstrates a large variety in the approaches used for resilience, reflecting a lack of consensus and unification on the notion of urban resilience. It also reflects the vast number of aspects that are important to resilience and that there are many ways to increase resilience, depending on the area of interest. Although all frameworks are within urban resilience, the dimensions of resilience included and the area(s) of application in the frameworks varies. The most common topic is natural hazards/climate change, possibly reflecting the concern raised in today's society. Frameworks that target natural hazards also tend to mention that the framework can be used for other areas, such as man-made hazards or organisational resilience. Community resilience appears to be a somewhat separate topic, focusing on the population and social factors compared to the more "holistic" or "general" models of urban resilience. The large variety of attributes/indicators makes comparisons of the frameworks challenging. Although the areas of application on a high level are similar, the cases described vary considerably, as well as the how the concepts are implemented. The main difference

found is coupled to the social-ecological models vs the engineering models, which can be seen as different strands in resilience. Suggested strategies for implementation and/or specific indicators are in some cases provided, but these are still very high level and in all cases rather laborious work would be required to make local interpretations of the framework concepts.

In academic literature, urban and disaster resilience includes multiple sub-fields, such as community, disaster, general system, and economic resilience. Definitions vary between and within the different sub-fields, demonstrating that authors within the same sub-field may have varying views and focus on resilience based on the theoretical perspectives taken. In disaster resilience there is a greater focus on "bouncing back", that is, to recover from an event and resilience is the ability to get back to the way it was before in the most efficient way. In infrastructure and engineering resilience the definitions tend to focus on the ability to "absorb" disturbances. In community and socio-ecological resilience, on the other hand, resilience is more focused on the ability to adapt to on-going circumstances.

The literature reviewed in WP1, including academic literature, key world-wide reports, city survey, EU project-reports and EU sectoral policies, shows, a fragmented picture of how the concept of resilience is applied in an urban setting. Different definition, goals, assumptions and approaches are used, creating conceptual tensions and challenges in unifying resilience research and initiatives. However, there are also several factors that unify work in resilience. It is the attempt to cope with and understand systems with intricate dependencies and interconnectivities. Systems that are vulnerable to unforeseen events and disasters, and where there is an abundance of factors and interests affecting them, ranging from profits and power to environmental issues and resources. The common challenge is to understand what makes some systems or system parts break down, where others manage to sustain basic functioning.

The different goals and theoretical perspectives have different implications on how to focus research and applications of resilience. It can be argued that different aspects of the resilience concept are suited for different dimensions of urban resilience, as goals may vary between different parts of the urban system. It is, however, of importance to be aware of the differences of the underlying assumptions when applying different definitions.

Implications for the SMR project

- ✓ Different viewpoints of resilience are found in the definitions, objectives, measurements and improvements for the CITIES. As a project consortium, it is necessary to carefully consider and discuss with all project partners about the objectives, viewpoints and strategies used in the SMR project, to ensure joint understand of the conducted work.

- ✓ In literature and initiatives multiple dimensions within urban resilience have been identified, including, e.g., infrastructure, economy, individual citizens and emergency and disaster response. When developing tools for SMR, considerations should be made for how different dimensions are represented and the effect they have on each other. Questions may include: Which dimensions are included? What are the dependencies between them? Can a sub-group be analysed in isolation? Understanding different dimensions will aid the process of defining the “Resilience Backbone”.

7.2.2 FRAMEWORKS AND EU POLICIES

The top-down worldview report study analysed non-academic resilience frameworks. From this study, it is clear that the resilience frameworks are abstract and high-level which makes resilience difficult to implement in everyday work. Moreover, the lion part of existing frameworks for urban resilience still seem to focus on Risk Management, that is, Safety-I issues and on specific issues like climate adaptation. This finding is backed by our study of actions in 18 cities that indicated that there is no common approach or method to implement resilience in the studied cities. Standing out is the preliminary OECD framework on resilience, and to lesser extent, the 100RC framework. The OECD framework builds on the 100RC and acknowledges many of the critical aspects of resilience providing a Safety-II perspective; highlighting aspect such as flexibility assessing unknown risks, cohesion and cross-sector collaborations, city integration as well as the importance of having a diverse industry and innovative local economy. The report describes a framework for resilience, how to measure resilience, and policies helping managers to implement resilience. However, missing still is guidance of how to integrate resilience into *exiting city management and routine city processes*. To our knowledge are concrete tools such as suggestions on checklists, routines and educational material for city managers non-existing to support everyday work with regards to resilience implementation. One viable suggestion in the frameworks studied, is to implement a designated special unit that is responsible for resilience in the city (c.f., RC100). However, from our standpoint this can also be counterproductive if resilience is seen as “yet another project”. The goal should be to integrate the approach in everyday operations in every service and sector in the city: from kindergarten, public transportation, schools to the emergency services. Hence, these special units should function as *cross-department educational units* that foster resilience thinking in the entire city - not being responsible for resilience in the city since this is a task of the distributed urban system.

At the higher level of EU sectorial policies, resilience is mentioned in a very limited way. In *the Regional and Cohesion Policy Sector*, resilience is part of the regional investment strategy, particularly as a part

of Energy Union and Climate priority area. The resilience initiatives are intended for preventing climate change risks. Thus resilient cities mostly mean the ability of cities to anticipate the adverse effects of climate change and take actions to minimize the damage (Safety-I). *In EUs Environmental policy*, resilience has to do with ecology and environment. *In the EU public health policy*, resilience is interpreted as capacity building against health threats, and as an individual capacity to cope with the effect of climate changes. *In the EU transport policy*, resilience is, similarly to academic research on infrastructure and engineering applied, focused on the sustainability of infrastructure in the case of disruption, and robust infrastructure against climate change. *Regarding the EU energy policy and EU Trans-European Networks Polic*y, again resilience is linked to the climate action and a support for resilient economy. Moreover, in the EU Industrial policies, resilience is linked to the security level of ICT infrastructure. Finally, in EU Social Employment Policy, resilience is used to refer to social or societal resilience.

EU has no formal authority over urban policy, although some efforts have been initiated to foster the development of EU cities such as regulation improvements, creating workable financial instruments and creating a European platform for urban knowledge exchange, although it has been placed under the Regional and Cohesion policy. Some efforts have been initiated to put the Urban Dimension in EU policies. EU Urban one-stop shop is launched and overview of achievements in urban and city area are collected in a single page, but apparently none about city resilience. “Climate adaptation in cities” is the closest point found in this urban one-stop shop. Further, there are active networks already for knowledge and experience sharing between cities regarding sustainable urban development, involving a significant number of city participants (approximately 500 cities) in different countries in Europe such as URBACT, UDN, and IUC. Currently, the European Urban Agenda is more about a joint effort of EU Commission, Member States and European Cities Networks to strengthen the recognition of the urban dimension by European and national policy actors.

Implications for the SMR project

- ✓ Consider policies and strategies that promote operationalisation of resilience concept as a management practice in a city setting, covering various services, stakeholders, and entities in the city. It is important that resilience is not perceived as just one aspect of, for example, climate changes, but rather an everyday operational stance.
- ✓ SMR methods and tool should approach the problems of cohesion and cross-organisational collaboration as well as integration of resilience thinking in existing city management processes
- ✓ There is a need to unify the resilience concept at the EU-level. The concept today is fragmented in different sectors and links between dimensions are missing. The EU resilience management guidelines can offer a way to consolidate different EU sectoral policies and build

a comprehensive resilience framework applicable for multiple EU sectors using CITIES as a base.

7.2.3 CITY APPROACHES TO RESILIENCE

The bottom-up city survey investigated how resilience is planned and implemented in cities worldwide. The resilience strategies and cites reviewed were all part of the 100RC project. Therefore, a similar resilience perspective was used by cities, even though we found that implementation and contextualization varied.

Monitoring and getting information of possible problematic issues in the city were important and this include gathering accurate information through IT systems (e.g., flooding sensors) and multiple viewpoints from citizens, businesses, and other cities. Resilience thinking is for many cities a way of thinking holistically about their actions. For example, when building new CIs, the approaches are multidimensional and multi-purpose. Moreover, a principle of RC100 cities in our study was to work *with* nature, not against it, for example, allowing a river to temporarily overflow, as long as it is done in a safe way. The city survey also showed how cities collaborate regionally sharing resources and setting up improved communication channels among stakeholders. This strategy of load-balancing is important to be able to handle unexpected events regionally. Moreover, the study indicated that there are complexities also to collaboration with numerous stakeholders and that legislation, with regards to CI, is outside the justification of the cities. Therefore, it is devised, in order to improve resilience, national, regional, and local boards are set up to implement measures and policies, to solve the more pressing city needs. The latter is particularly important to handle crisis situations.

Implications for the SMR project

- ✓ SMR tools could support cities identifying links between different resilience functions (i.e., strengths and weaknesses in their resilience approach to core values). Identifying the dependencies between them can be done in, for example, systemic risk assessment questionnaire and system dynamics model. Questions may include: how do changes in one the dimensions important for resilience affects other parts? Where should CITY efforts be focused?
- ✓ Networks of learning and sharing resilience best practices, such as the RC100, provide useful guidance for tool development in SMR. In addition to considering existing networks sustainable urban development networks can also be considered for promoting ideas on resilient cities.

- ✓ The indicators identified in this review can be transferred further for defining indicators of Resilience Maturity Model and System Dynamics modeling tool. The collection of the best practices referred in the literature can further be used to guide operationalization of EU resilience management guidelines. The SCF model and standards referred in the WP1 reports will help to identify relevant processes and terminology in the standardization activities of SMR. The identified resilience dimensions and their detailed components can be used for building a comprehensive framework as how to build the "resilience backbone".
- ✓ Approaches taken by cities today should be a source of inspiration for the SMR project. This includes multi-purpose approaches (e.g., a building is designed for recreation and to withstand sever damage), or an ecological approach (e.g., the river is allowed to flow over, as long as it is done in a safe way).

7.2.4 CHALLENGES AND NEXT STEPS

A challenge identified in all reviewed literature is finding the balance between high-level concepts and context-specific actions. Another one is identifying the dependencies and interdependencies between different sub-systems that constitute a CITY. The depth of the challenge can be identified in fragmentation of the reviewed approaches, indicators and policies.

In EU sectorial approaches, policies are very general, and therefore complementary bottom-up approaches are needed to help us operationalize the concept of resilience and disaster resilience. As part of the work in this work package is a review on research products that are exploring the-state-of-the-art, implementations, and applications of resilience in different EU joint research projects. Together with previous work, SMR aims to take one more step to contribute to meet the goals of relevant EU policy sectors. Resilience also must work from bottom-up providing work processes and practical tools. At a city level, resilience elements and work processes in horizontal and vertical dimensions should be targeted, to gradually become what can be called holistic resilience of a CITY. In turn, CITIES should act as role-models across regions and nations, to further increase Pan-European resilience.

In the academic literature, the challenge of high-level concepts is frequently identified; how to go from theory to practice, that is, from normative to descriptive applications of resilience. Today high-level concepts are used, which then must be translated into the local context. The benefit of using high-level concepts is that it offers a way to see the complexity and vast amount of processes and stakeholders involved and the flow between them. The downside of more general models is that they must be translated to a specific context, which can be cumbersome and challenging. Challenges include untangling and defining multiple dimensions and parameter. The complexity of cities, with multiple

interconnected factors and the dynamic and rapidly changing society makes boundary setting both a critical process but also a source for potential problems. Identifying the right scope, the influencing factors and how these are linked is a major challenge. In this sense, the conceptual frameworks are useful on theoretical level, but still far from being available for practical use.

In the world-wide reports, a critical challenge identified was to collaborate with all stakeholders, in particular, citizens and the private sector. To increase resilience, city management must, according to the OECD report, work together with both national and regional governments because the issues that need to be resolved include many stakeholders and sectors. Moreover, investing in a broad diverse and innovative industry and community network development improve capacity to rebound from challenges, crises and shocks. Today, city management is seen as fairly rigid and it is anticipated that more adaptive governance approaches are need that are flexible and innovative to tackle future problem (Brunner et. al. 2005; Dietz et al. 2003; Folke et al. 2005, Djalante et. al., 2013). The idea, then, from a resilience perspective is to strengthen the mechanisms that foster flexibility, multi-stakeholder/cross-organisational collaboration and learning (ibid).

Implications for the SMR project:

- ✓ Tools can support initiatives on both top-down (high-level policy) and bottom up (local initiatives). A balance between the two is advisable.
- ✓ There is a consensus in literature that research and initiatives in urban resilience has overlooked important couplings between different dimensions of community management, including both the social and physical aspects.
- ✓ For the SMR-project the broad scope of resilience means that the focus areas must be clearly specified to allow a contextual setting for work on resilience guidelines and tools. At a first instance guidance from literature can mainly be given on a high level. Once more specific objectives and contexts are identified, literature can again be advised to help guide continued development. Further, several theoretical advances must be made within the SMR project to achieve the project objectives, including defining the viewpoints, scope, indicators and measurements that reflect the SMR resilience definition and scope.
- ✓ Models and tools developed in SMR should acknowledge and support both Safety I and Safety II perspectives. A focus on general capacities, flexibility and multi-stakeholder collaboration across private and public sector will increase resilience and adaptive capacity.
- ✓ Flexible city management processes that foster learning with regards to handling unexpected events is suggested. Policies and metrics should focus on cohesion, communication, flexibility and integration of resilience into exiting city organisation, budgeting and financing processes.

8 SUMMARY AND KEY TAKE AWAY POINTS

This report presents the work performed so far in WP1 in the SMR project. This includes main outcomes from D1.1 and D1.2, the development of a city resilience definition for the SMR project and a synthesis of outcomes from D1.1 and D1.2 in terms of a resilience model (SCF) based on contemporary Resilience Engineering concepts.

MAIN CONTRIBUTIONS

- ✓ Summaries of main outcomes of D1.1 and D1.2
- ✓ Identification of conceptual "strains" in resilience definitions
- ✓ A working definition of urban resilience for the SMR project
- ✓ Working definitions of resilience layers for the SMR project
- ✓ A synthesis of outcomes from D1.1 and D1.2 in terms of a resilience model (SCF) based on contemporary Resilience Engineering
- ✓ An operationalization of a resilience model for urban resilience
- ✓ Discussion of SCF integration into SMR models and tools
- ✓ Discussion on implications for the SMR project

Results from D1.1 showed that numerous perspectives and definitions of resilience can be found in the literature. A number of conceptual "tensions" have been identified, that is, an inconsistent or unclear theoretical concepts which are used and applied in relation to urban and disaster resilience. These conceptual "tensions" include: "the notion of equilibrium", "resilience behaviours: flexibility vs robustness" "temporal aspects", and "urban resilience boundaries". The tensions are discussed and harmonised in the SMR city resilience definition. The analysis in D1.1 further shows that research frameworks for urban resilience are abstract and far from being a practical tool for operationalisation. Further, the "fuzziness" of the resilience concept forms a challenge in defining boundaries, dimensions, and tools for city resilience. Nevertheless, in the future, for operationalization of the resilience concept it is important to consider previous efforts made by organisation bodies outside research as well as including city professionals in this work.

In D1.2 applications of the resilience concept in EU sectorial projects in critical infrastructure, climate change and social dynamics are presented. The analysis in Critical Infrastructure (CI) shows that

resilience is only used interchangeably or together with protection concepts (Safety-I), although there is a growing attention on the connections across CI sectors where the interdependencies and cascading effects play a role (Safety-II). Results from the analysis of Climate Change (CC) and resilience show that the operationalisation and assessment of city resilience in relation to climate change is still lacking. Similarly, in the area of social dynamics and resilience there are not many practical examples of implementation and operationalisation. Challenges identified include: adaptive capacity to CC and human health; social vulnerability, and how to increase social resilience of these vulnerable groups and the individual ability to cope with and recover from hazards.

A main contribution from WP1 is a definition of CITY resilience and SMR strategies for the SMR project. By consolidating the literature on urban resilience and the outcomes of the SMR workshops a definition for city resilience in the SMR project has been developed. The definition harmonises the conceptual tensions identified in the literature and includes the core concepts for city resilience identified in the workshops; resources and robustness infrastructure, preparedness, leadership and governance, cooperation and learning. The definition should be viewed as work-in-progress and will, if necessary, be altered during the project's lifespan.

The SMR City Resilience Definition

"is the ability of a CITY or region to resist, absorb, adapt to and recover from acute shocks and chronic stressed to keep critical services functioning, and to monitor and learn from on-going processes through city and cross-regional collaboration, to increase adaptive abilities and strengthen preparedness by anticipating and appropriately responding to future challenges"

The report further presented a synthesis of outcomes from D1.1 and D1.2 in terms of a resilience model (SCF). The model is based on six main functions found in contemporary resilience engineering research: anticipation, monitoring, response, recovery, learning, and self-monitoring. The model is useful both for envisioning new resilience methods and metrics, as well as for engineering and evaluating resilient systems. SCF can be seen as a general model that specify the underlying work processes that must be established to increase city resilience. The model was operationalised into a set of concrete steps that can be used by city and safety managers to work with resilience more concretely. Overall, based on the literature studies and city surveys performed in WP1 four key areas of importance to strengthen city resilience have emerged. First, identifying, setting up and balancing city resilient processes and strategies locally and regionally are seen as important. Second, establishing boundary spanning,

resource pooling and cooperation within local organizations, regional cities, and with European cities that have common agendas and core values is important. Third, it is important for cities to establish flexible action modes be able to adapt to on-going situations. Fourth, we emphasize the importance of secure formal and informal communication channels and the significance of having common viewpoints with regards to resilience across all levels in the municipality. This point is also related to integration of resilience in ordinary city management processes. The report was finalised with (1) a discussion on how these key areas relate to SCF and how SCF can be integrated into the SMR models and tools, and (2) WP1 key findings and implications for SMR.

Key Take Away Points

- ✓ SMR consortium should carefully consider and discuss the objectives, viewpoints and strategies used in the SMR project, to ensure joint understand of the conducted work. This task has largely been done as part of WP1 and is presented in Chapter 5, defining SMR city resilience and SMR strategies.
- ✓ Tool developers for SMR should consider how different resilience functions and dimensions are represented and how they affect each other. Questions may include: Which dimensions are included? What are the dependencies between them? Can a sub-group be analysed in isolation? Understanding different dimensions will aid the process of defining the “Resilience Backbone”.
- ✓ There is a consensus in the literature that research and initiatives in urban resilience has overlooked important couplings between different dimensions of community management, including both the social and physical aspects. Identifying dependencies between them can be done in, for example, in the systemic risk assessment questionnaire and in the system dynamics model. The EU resilience management guidelines can offer a way to consolidate different EU sectoral policies and build a comprehensive resilience framework applicable for multiple EU sectors, using CITIES as a base.
- ✓ Approaches taken by cities today should be a source of inspiration for the SMR project. This includes multi-purpose thinking (e.g., a building is designed for recreation and to withstand sever damage), and ecological approaches (e.g., a river can be allowed to flow over, as long as it is done in a safe way). Networks of learning and sharing resilience best practices, such as the RC100, provide useful guidance for tool development in SMR. In addition to considering existing networks, sustainable urban development networks can also be considered for promoting ideas on resilient cities.
- ✓ The indicators identified in this review can be transferred further for defining indicators of Resilience Maturity Model and System Dynamics modeling tool. The collection of the best

practices referred in the literature can be used to guide operationalization of EU resilience management guidelines. The SCF model and standards referred in the WP1 reports will help to identify processes and terminology for the standardization activities in SMR. The identified resilience dimensions and their detailed components can be used for building a comprehensive framework as how to build “resilience backbone”.

- ✓ SMR tools should approach and support initiatives both top-down (high-level policy) and bottom up (local initiatives). A balance between the two is advisable.
- ✓ For the SMR-project the broad scope of resilience means that the focus areas must be clearly specified to allow a contextual setting for work on resilience guidelines and tools. At a first instance guidance from literature can be given on a high level. Once more specific objectives and contexts are identified, WP1 reports can again be consulted to help guide continued development.
- ✓ Models and tools developed in SMR should acknowledge and support both Safety-I and Safety-II perspectives. A focus on general capacities, flexibility and multi-stakeholder collaboration across private and public sector will increase resilience and adaptive capacity. Flexible city management processes that foster learning with regards to handling unexpected events is suggested. Policies and metrics should focus on cohesion, communication, flexibility and integration of resilience thinking and practices into exiting city organisation, budgeting and financial processes.

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