SMART MATURE RESILIENCE

D1.1 SURVEY REPORT ON WORLDWIDE APPROACHES

Linköping University | January 2016

	Deliverable title
Deliverable no.	D1.1
Work package	1
Dissemination Level	Public
Author (s)	Amy Rankin (LiU), Magnus Bång (LiU)
Co-author(s)	Maider Sainz (Tecnun), Jaziar Radianti (CIEM), Johan Brage (LiU), Simon Rosenqvist (LiU), Leire Labaka (Tecnun), Josune Hernantes (Tecnun)
Date	29/01/2016
File Name	D1.1.SMR_Final
Revision	Final
Reviewed by (if applicable)	Alberto Terenzi (ICLEI), Leire Labaka (Tecnun), Josune Hernantes (Tecnun), René Lindner (DIN), Jose Julio Cabeza Gonzalez (CIEM), Judith Moreno (Donostia)

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 our 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 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 report is the result of the work carried out in the first task in WP1. The report includes (1) a systematic literature review of urban resilience, (2) a review of world-wide reports and networks related to urban resilience and, (3) a city survey of approaches and challenges for our SMR partner cities. The work in this task has been aimed at a deepening our understanding of resilience in the context of cities. The report will provide a basis for the SMR project when operationalising the concept of resilience to a practical level and urban context in the perspective of overall European resilience.

Results from the work in this task show 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, present models fail to account for 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 urban resilience in order for the perspective to be useful for community professionals. The study also revealed 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 future operationalizing's 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.

TABLE OF CONTENTS

1 INTRODUCTION

Smart Mature Resilience is a multi-disciplinary research project working for more resilient cities in Europe. Researchers and cities 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, 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, and discuss current practice in five RC100 cities[1].

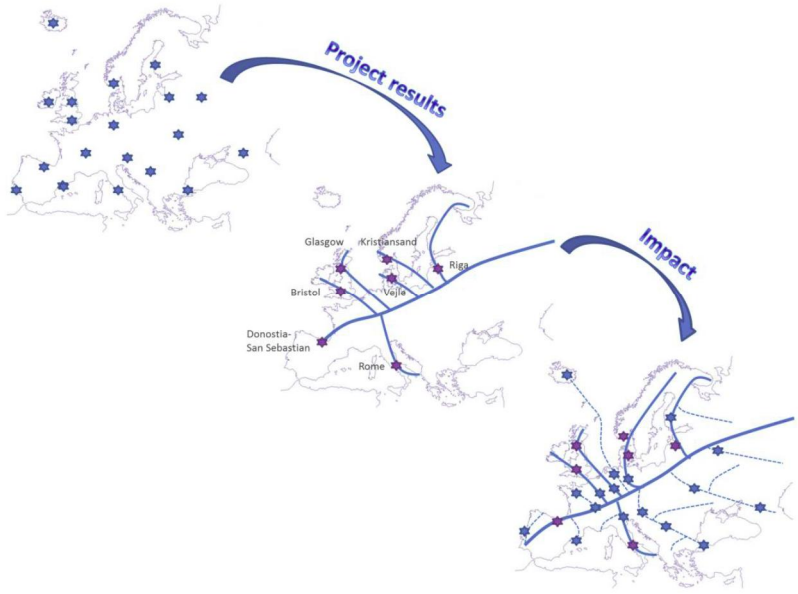

Figure 1. The emergence and growth of a resilience backbone, first as direct result and then, over time as impact of the project

[1] http://www.100resilientcities.org

1.1 PURPOSE AND SCOPE

The aim of this task is to conduct a survey of approaches of urban resilience to identify best practice used and challenges faced today. Drawing on previous work in the area of urban resilience we investigate the concept of resilience and related terms. The worldwide survey includes (1) a systematic literature review of urban resilience, (2) a review of reports and networks related to urban resilience and, (3) a city survey of the approaches and challenges for the SMR partner cities. The work in this task has been aimed at a deepening the understanding for resilience in the context of cities. It will further provide a basis to build in the SMR project as we work toward operationalising the concept of resilience in particular context.

1.2 RELATIONSHIP WITH OTHER TASKS

As illustrated in Figure 1, Task 1.1 and Task 1.2 are closely related, providing literature reviews of work related to urban resilience in different sectors. In T1.3 the work from the two tasks will be synthesized, offering a common framework for continued work in the SMR project. In Task 1.4 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. The literature review in WP1 is also related to the analysis of existing approaches and standards in T4.1 and T6.1 as information is shared and discussed.

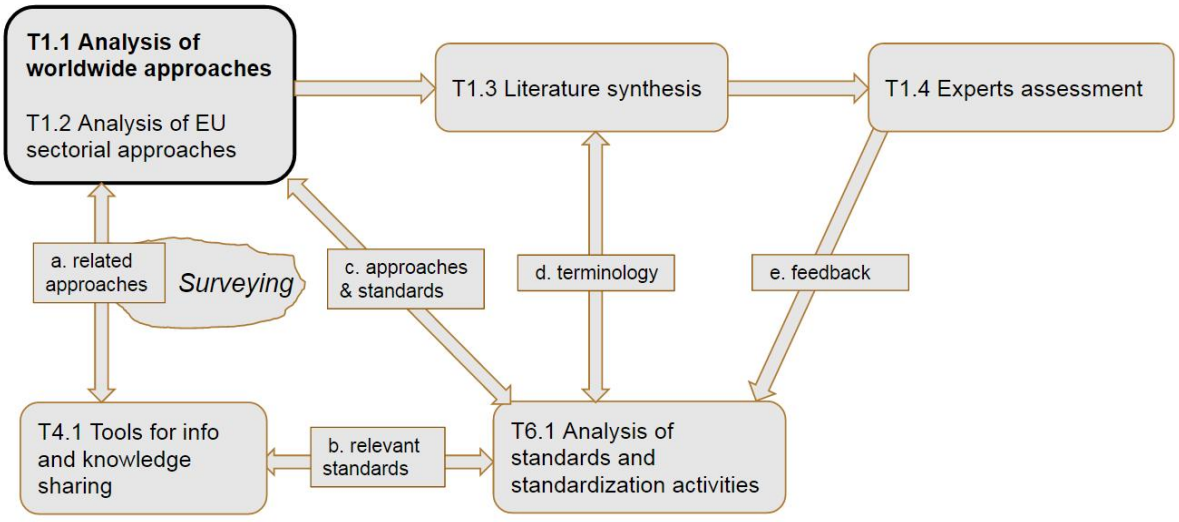

Figure 1. Workflow of WP1 and information sharing with related tasks.

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 method and results of the scientific literature review in academic journals are presented and discussed. Chapter 4 similarly offers a description of method and results for the world-wide reports reviewed as part of this task. A survey carried out in our city partners of the SMR project is presented in Chapter 5. The final Chapter 6 offers a summary and conclusions of all the chapters.

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). Being abstract is essential to break down and practically apply the resilience concept to different city and community security sectors. 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 of deepening our knowledge on how to define, develop, implement and evaluate resilience approaches in the urban context. The work presented is important for the upcoming development of an Urban Resilience Model and the above mentioned Resilience Maturity Model that will be used to defining the trajectory of an entity through measurable resilience levels.

3 LITERATURE REVIEW

The objective of the literature review is to gain an overview of how the concept of resilience is defined and applied in an urban context with a focus on crisis planning. The review will serve as a background to position coming research activities in the SMR projects. To this end three areas have been in focus in the review:

(1) Definitions and related concepts

(2) Methods and approaches

(3) Operationalisation: considerations and challenges

3.1 METHOD

The study has been guided by a systematic literature review (Kitchenham, 2004), including initial elements of a mapping study (Kitchenham, Budgen, & Pearl Brereton, 2011; Wendler, 2012). A systematic literature review aims to synthesise existing work relating to pre-defined research questions. Key features of systematic review is that a transparent research method is used with predefined strategies for how to conduct the search as well as clear inclusion/exclusion criteria (Kitchenham, 2004). A mapping study (Kitchenham et al., 2011; Wendler, 2012), on the other hand, reviews a broader topic, using high level research questions with the aim to gain an overview of literature within, for example, a particular research area.

In the initial phase of the study presented here the research questions were general and aimed at generating an overview of resilience in an urban context, and can thus be viewed as a mapping study. However, a mapping study aims to describe trends in the field and does not specifically assess the outcomes of the reviewed literature, as is done in a systematic review. Therefore, in the second part of the review the study follows a more systematic approach within pre-defined categories (see Table 2. Areas of inquiry for literature review analysis..

The objective of the literature review is to get an overview of how urban and disaster resilience is defined, discussed and applied in scientific literature today. To this end the search words selected were *urban resilien** and *disaster resilien**. Scopus database was used as it is the most widespread databases and largest searchable citation and abstract source on different scientific fields (Guz & Rushchitsky, 2009). As is summarised Table 1, a five-step procedure was used to complete the search and review.

Step 1 includes the initial search in Scopus using the pre-defined criteria. The scope of the search includes peer-reviewed journal articles published between 1990 until present (Dec 2015). The time span (from 1990 to present) was selected to give an understanding for how the concept of resilience has evolved over time. The search was carried out within the subject areas of Physical Science and Social Sciences & Humanities (thus excluding Life Science and Health Science). Only peer-reviewed articles were included. This initial search generated 2993 hits and step 2 was introduced to further narrow down the scope and include only the most relevant subject areas.

In step 2 subject areas were excluded within the initial search; these were selected based on relevance to the project. Excluded areas include: Life Science, Health Science, Medicine, Psychology, Agriculture, Arts and humanities, Computer Science, Health Professions, Multidisciplinary, Mathematics, Physics and Astronomy, Nursing, Biochemistry, Material Science, Neurology, Chemical Engineering, Immunology and Microbiology, Pharmacology, Toxicology and Pharmaceutics.

In Step 3 the scope was further narrowed down to include only the “200 most cited”, “200 most recent” and “200 most relevant” (according to Scopus relevance criteria). The number of citations were seen as an important indicator of recognition from the scientific peer community. The 200 most recent articles were included to ensure capturing the latest trends. Relevance (according to Scopus) was taken as a measure to make sure that the articles with the closest mapping to the research topic were included.

The 600 articles selected were reviewed based on title and abstract. Criteria for inclusion in the full review were based on project relevance. The objective of the review has not been to include all literature that refers to resilience in an urban setting, but to identify key literature to guide the work of conceptualising and operationalising resilience in the context of the SMR project. The review was focused on resilience within safety sciences, and thus excluded articles of resilience in the areas of, for example, infrastructure networks and individual resilience (e.g., childhood trauma). Further, articles were resilience was a sub-topic or only mentioned in passing were excluded from the review. This could be, for example, research focusing on flood or earthquake vulnerability, which uses the notion of resilience without directly referring to resilience literature.

In Step 4 all articles were quality checked by a second rater to ensure the relevance of the papers selected for the SMR project. Step 5 included a full review of the remaining articles and elicited information was inserted into google forms (see Analysis section for an overview of the information gathered)

Table 1. Procedure and search criteria for literature review.

Procedure step	Search description and criteria	Search results
Step 1 **Initial search**	**Database**: Scopus, **Keywords**: "*urban resilien*" OR "disaster resilien*",* **Search in**: Title, Abstract & Keywords **Type:** Journal article **Year:** 1990 to present **Subject area limitations**: Physical Science and Social Sciences & Humanities	2993
Step 2 **Narrow down the scope**	Search narrowed down through inclusion/exclusion of subject area based on project relevance	1498
Step 3 **Initial review**	Review title and abstract of "200 most cited", 200 most recent, "200 most relevance" (according to Scopus)	Most cited: 78 Most recent: 29 Most relevant: 21 Total: 128
Step 4 **Quality check**	Review of title and abstract is performed by one other person	Remaining: 119
Step 5 **Review of full paper**	Review of full article and insert information into Google forms	119

3.1.1 ANALYSIS

Categories for analysis were selected based on the SMR project objectives, "conduct a survey of approaches of urban resilience to identify best practices used and challenges faced today". Information regarding the main areas, presented in Table 1, was extracted from the papers and summarised in google forms. The information was collected in a spread sheet were each row represented an article and each column the topics shown in the right side of Table 2. The spread sheet was used as a tool to make cross-article comparisons and analysis.

Table 2. Areas of inquiry for literature review analysis.

Area of inquiry	Topics
Bibliographic information	Title Author Name of journal Year published Keyword
Research question and key points of inquiry	Research questions Key point summary Method (e.g., case study, literature review)
Resilience definition(s) and problem area	Resilience definition(s) Reference of resilience definition Problem areas (e.g., urban, societal, economic, natural hazard)
Related concepts	Concepts central to the article (e.g., vulnerability, sustainability)
Application of resilience	Methods/approaches for resilience Implementations/evaluations for resilience Resilience indicators/metrics Best practices/policies/guidelines for resilience Challenges for resilience
Relevance and further references	Rating system or relevance to the project Identification of key references Any other comments

3.2 RESULTS

3.2.1 INTRODUCTION

The concept of resilience was first introduced into systems theory through the work done by Holling (1973) in the field of ecology. While the field had previously viewed ecological systems as having a single stable state, or equilibrium, Holling instead posited that nature consisted of several stable states, and that the system could alternate between these stable states (Walker & Cooper, 2011). Since then the concept has steadily grown in and reached popularity in a variety of fields, such as economics, political science, psychology, disaster and safety science. Although the disciplines may seem far apart they all have some fundamental aspects and challenges in common. First of all, they all are systems with intricate dependencies and interconnectivities within and between the systems and subsystems, making them vulnerable to unforeseen events and disasters. Further, they are all subjected to an abundance of factors and interests affecting them, ranging from profits and power to environmental issues and resources. The joint challenge is to understand what makes some systems or system parts break down, where others manage to sustain basic functioning, that is, what makes them resilient.

The literature search in Scopus using the keywords “urban resilience” and “disaster resilience” reflects the exponential increase in popularity of the topic of resilience (Figure 2). Prior to 1990 there are practically no articles on the topic of urban and disaster resilience in the Scopus search. Prior to 2000 there are a few, and after 2005 there is a steady increase.

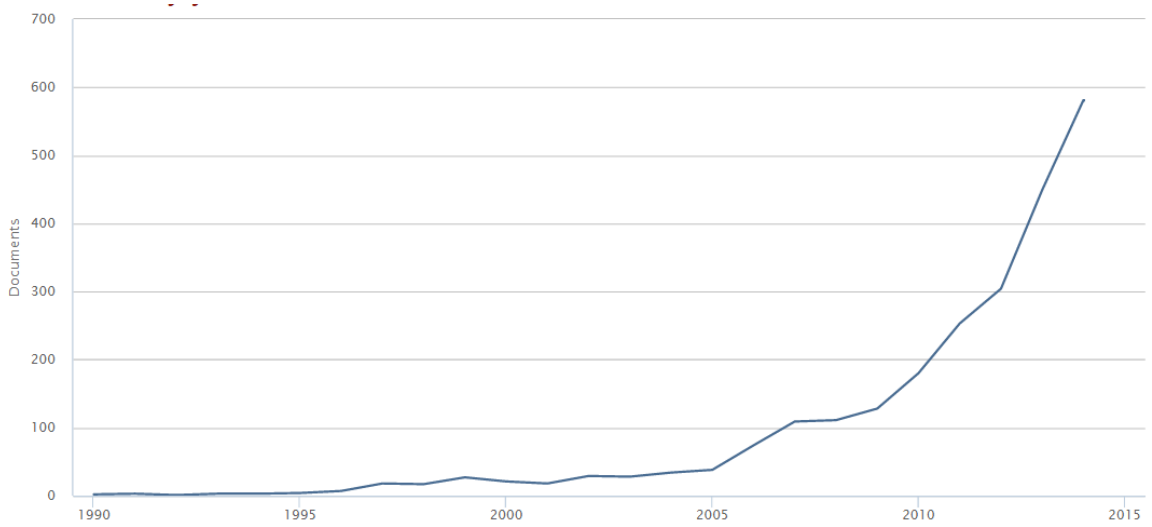

Figure 2. Number of resulting papers from the search of "urban resilience" and "disaster resilience" (title, keyword, abstract). Period: 1990 - 2016.

The top areas for the search were social sciences (52%), environmental science (37 %) and engineering (17%) and the top 5 journals were Natural Hazards, Ecology and Society, Disaster prevention and Management, International Journal of Disaster and Risk Reduction, and International Journal of Disaster Resilience and the Built environment.

Resilience may be seen as a natural development as the complexity and interconnectedness of society grows. It suggests that systems and system parts cannot be understood and analysed in isolation from the bigger picture. There is an acceptance that human ability to foresee and prepare for all possible future events is limited, that surprises will come, and that errors will be made. The aim is therefore to ensure that systems are capable of adapting enough to withstand disruptions and sustain functioning (Zolli & Healy, 2012).

The definition of resilience may vary depending on which field of research one is coming from. For example, in crisis management it generally refers to the ability and speed to which critical systems can sustain operation and be restored following an event (Manyena, 2006). In the field of disaster management resilience has become an important concept in the past decade (Lei, Wang, Yue, Zhou, & Yin, 2014). The interest in this field beyond the scientific community can further be shown in the UNISDR (United Nations International Strategy for Disaster Reduction) proposed framework that aim to increase community resilience by reducing vulnerabilities: “Hyogo Framework for Action 2005-2015 (HFA): Building the Resilience of Nations and Communities to Disasters”. This document has since been updated for the period 2015-2030 in the Sendai Framework for Disaster Risk Reduction (UNISDR, 2015). The following section expands on the concepts and definitions found within the literature review.

3.2.2 RESILIENCE VIEWPOINTS

Resilience from three perspectives

Due of the multidisciplinary nature of resilience there have always been several interpretations of the term. Folke (2006) reviewed the literature and found that there were three major branches: single equilibrium, multi equilibrium and adaptive cycles. Pendall, Foster, & Cowell (2010) echo these classifications and Simmie & Martin (2010) write about the same classifications, although their starting point is from an economic perspective.

Aldunce, Beilin, Handmer, & Howden (2014) also found three “storylines” that, at least on a higher level of abstraction, map to these three perspectives. The storylines they found were: ”Mechanistic/Technocratic”, “Community based”, and “Sustainability”. They note that the first “reflects

an engineered approach to resilience" similar to the single equilibrium model. The second has its roots in psychology and social resilience and focuses on the actors within the community. The sustainable view corresponds with Folke and Holling's ecological view with a focus on system properties and how the system changes over time.

Single equilibrium and bouncing back

The single equilibrium model has become the most common within what is often called resilience in the areas of networks and built infrastructure. In the simplest of terms, an engineered system is more often than not under a high degree of control and tends to operate at or near an equilibrium point (see Figure 3 for illustration). Most perturbations to the system will lie within an accepted margin of performance; this is sometimes referred to as the *robustness* of the system (Bruneau et al., 2003). When a disturbance has occurred, the system attempts to return to the state it was at before the disturbance occurred, rather than a new state. This is referred to as the system's ability to *bounce back*. In the rare occasions that the system is pushed outside of these acceptable limits, the focus is on returning to normal operating function within the margin of the system as quickly as possible. The time this takes is the *rapidity* of the system. This goal can be accomplished in, primarily, two different manners. A system can have built-in *redundancies* which allows it to draw from secondary components in order to still fulfill its primary function when its primary components have been impeded by the disturbance. The system may also be *resourceful*, in that it has a capacity to modify itself for a possible situation (ibid.). This can be done by prioritising or using different resources, e.g. monetary or human, to compensate for the disturbance.

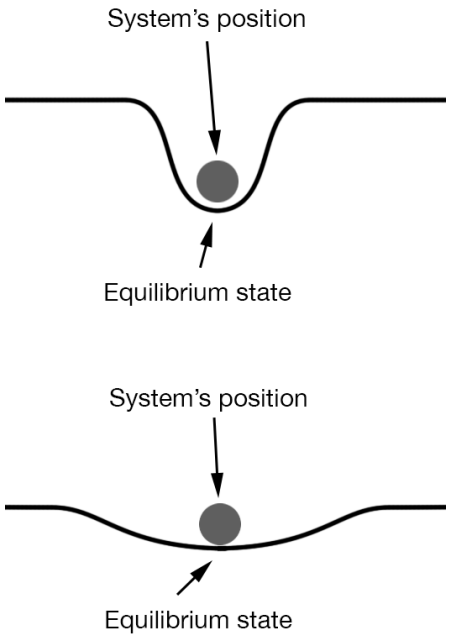

Figure 3. The top illustration shows a highly stable system, where the possibility of leaving the equilibrium point is difficult due to the high level of force that is needed to climb the hills. The bottom illustration, on the other hand, shows a system that that requires less force to be moved out of the equilibrium valley and is therefore less resilient.

Underlying concepts have been expanded to include scenarios with multiple events and cascading effects (Zobel & Khansa, 2014). Walker & Westley (2011), although not strictly within the engineering tradition, have advanced the idea of a post disaster time threshold. If recovery is not achieved within a specified time, there is increasing risk that negative impacts, such as cascading effects will occur. For example, if electricity is out for more than a certain amount of hours the batteries in cellular towers will lose power and thus, the communication will be affected. Hagen, Tzanetakis & Watson (2015) have also identified six different types of cascading effects: the disruption of pre-existing relations of information, organisation, and supply, disturbance relations, pre- disaster conditions, and the malfunctioning of legal and regulatory relations. The cascading effects may push the system further out from the equilibrium, thus affecting the rapidity of the system. They note that cascading effects can have its roots both in the events of the disaster and in the pre-existing structure. When planning for resilience one should therefore attempt to take these potential cascading effects into account.

Multiple equilibriums and bouncing forward

The single equilibrium model is an accurate description for certain areas of research, most notably engineering and infrastructure, where the system either performs its function or not. However, a complete model of society would be lacking if it relied entirely on a single equilibrium model. Similar to the single equilibrium model these systems are also modeled on their robustness, rapidity, etc. Should these systems be pushed out of their equilibriums they may fall, or strive, towards other points of equilibrium (see Figure 4). In this conception of resilience it may not be desirable to return to the pre-disaster state since you will then reproduce the same vulnerabilities. It might 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).

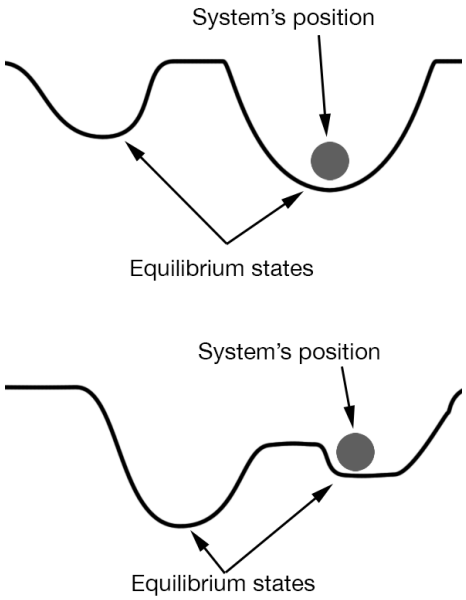

Figure 4. The top illustration shows a system in a resilient state within a multi equilibrium model. The bottom illustration shows a less stable equilibrium point. The second system requires less force in order to be pushed out of its state. However, if it manages to push itself, through the expenditure of capital, into the deeper valley next to it then it will be in a more stable state.

A system's history also affects its possible future states. While a system moves across a plane, bouncing from equilibrium to equilibrium the decisions made at each bounce influences where it may end up. Pendall et al. (2010), describe "lock-ins" that a system may fall into. Adopting a certain standard may for example lead to much of the infrastructure depending on that particular standard. The system can

then not shift to a new standard without considerable cost for adapting to the rest of the infrastructure. The system is therefore locked-in to that particular standard.

Adaptive cycles

Holling later expanded the multiple equilibrium model into the adaptive cycle model (Walker & Cooper, 2011). In this conception, the equilibriums themselves are not interesting; rather it is the processes that shape the change in the system that is under investigation. A system moves through four phases of (1) exploitation and rapid growth, (2) consolidation and conservation, (3) release, and (4) reorganisation, see Figure 5. During the first phase systems gain capital, or resources. During the second phase the methods of acquiring capital is entrenched until an event occurs that causes the release of capital and in the last stage, subsequent reorganisation of the system happens (Pendall et al., 2010).

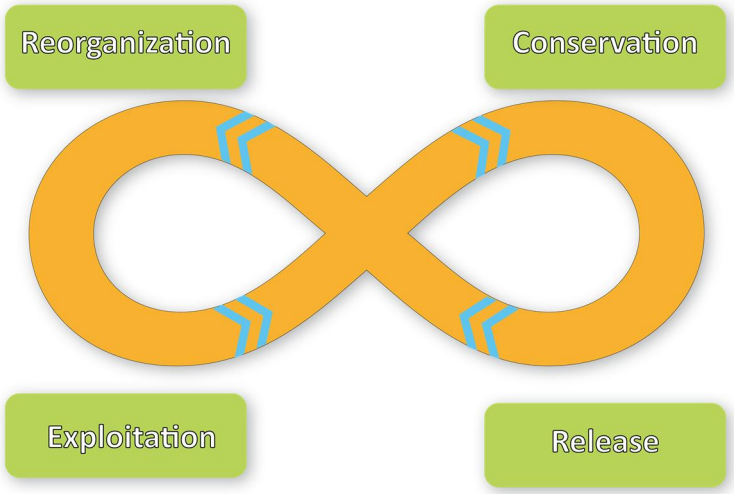

Figure 5. The four stages of the Adaptive Cycle Model, adapted from Holling (2001).

A socio-ecological system described by adaptive cycles can no longer be thought of as having any stability since it is in constant change (Desouza & Flanery, 2013a; Folke, 2006). The relevant aspect is instead how the system acquires capital and how it can exchange its capital for the resources needed for continued existence or growth.

Capital is critical for a system to renew itself after a crisis (Gunderson, 2010). Capital is not necessarily financial capital, but can also include social capital (Gunderson, 2010; Masten & Obradovic, 2008), political capital (Restemeyer, Woltjer, & van den Brink, 2013), human and knowledge capital (Simmie & Martin, 2010), and natural capital such as trees or fertile soils (Gunderson, 2010). Capital in this sense

is anything that can be traded for something else, for example, high social capital can be traded for a well-paying job that returns higher financial capital.

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 et al., 2010).

The imagined systems are vast and interconnected in complex ways which makes modelling them an almost impossible task. Even if they were possible to be modeled, the models would have very little predictive power because of the huge number of influences that exist. It also removes all human agency or even the possibility to work towards a goal. Human decisions often expect a linear answer from a non-linear system (Pendall et al., 2010).

3.2.3 DEFINITIONS OF RESILIENCE

The definitions used in the reviewed articles have been categorised into three groups (Table 3. Defintions categories). The first group includes the definition of authors that have expressed a definition of resilience used in the research. The second group are named the “exploratory” group. In this group resilience or aspects of resilience are discussed and attempts made to clarify the concept of resilience, however, no distinct definition is provided. Similarly, the third group do not apply a specific definition. This group generally discuss different definitions of resilience in the introduction, underlining the disparate use of the concept.

Table 3. Defintions categories

Definition used in article	Count
Explicit definition	62
Exploring definitions	29
Non-specific definition	26

Explicit definitions

An analysis of the definitions in the first group can be found in Table X and Y. The definitions have been categorised and described according to four different areas: (1) dimensions, (2) temporal aspects (3)

characterisations (4) behaviours. Table X shows an overview of all definitions and table Y offers comparison of definitions in different dimensions (see Table R).

The *dimension* refers to the field of resilience in question, largely based on the research areas of the authors. Fields include e.g. disaster resilience, community resilience, socio-ecological resilience and system resilience. The *temporal aspects* identify if resilience is described as something that occurs before, during, or after an event. The *characterisations* include a description of resilience as a property, process, capability, ability, capacity, or characteristics. The fourth group depicts the resilient behaviour when experiencing a disruptive event, that is, if it absorbs, adapts, recovers, or self-organizes. As several terms often are used interchangeably for all groups, they have been clustered into categories (Table 4. Categories clusters).

Table 4. Categories clusters

Category	Contains
Community	Community, City, Urban, Society
Disasters	Disasters, Crisis, Natural hazards
Socio-ecological	Ecological, social, social and ecological
Other	Governance, Infrastructure, Organisation, Resilience Engineering
Adapt	Accommodate to, Transform, Reorganize, Change
Absorb	Maintain function, Resist, Mitigate, Respond to, Cope
Recover	Re-establish, Bounce back, Regenerate, Rebound, Spring back

Table 5. Analysis of Resilience definitions (general)

		Characteristics						Temporal aspects			Behaviours			
	No. of articles	Property	Process	Characte-ristics	Capability	Ability	Capacity	Before	During	After	Adapt	Absorb	Recover	Self-organizing
Total	62	5%	3%	2%	3%	40%	35%	29%	77%	77%	74%	77%	71%	6%

Table 6. Analysis of resilience definitions (clustered dimensions)

		Characteristics						Temporal aspects			Behaviours			
Resilience Dimensions	No. of articles	Property	Process	Characte -ristics	Capability	Ability	Capacity	Before	During	After	Adapt	Absorb	Recover	Self-organizing
Disaster	18	0%	0%	6%	6%	50%	28%	44%	83%	83%	72%	78%	89%	0%
Community	19	0%	5%	0%	0%	35%	30%	35%	70%	80%	90%	75%	75%	5%
System (general)	11	18%	0%	0%	9%	27%	55%	0%	91%	82%	64%	100%	64%	9%
Socio-Ecological	5	0%	0%	0%	0%	40%	60%	0%	100%	100%	100%	100%	60%	40%
Economic	3	0%	33%	0%	0%	67%	0%	0%	67%	33%	33%	67%	0%	0%

MOST COMMON BEHAVIOURS IN RESILIENCE DEFINITIONS

- ✓ Absorb shocks
- ✓ Ability to adapt
- ✓ Ability to recover or ”bounce-back”

The most common behaviour used to describe resilience was the ability to absorb the impact of the event (Table 5). For example, Berkes (2007) definition reflects an understanding of resilience as an ability to resist outside forces: *“...the capacity of a system to absorb recurrent disturbances, such as natural disasters, so as to retain essential structures, processes and feedbacks”* (ibid., p. 284).

The second most common notion was the ability to adapt. While many of the definitions use a passive notion of resilience, the system reacts to some event; the definitions that also included adaption often stressed the need for a more active role of the policymakers or the system as a whole to shape its own future. Manyena (2006) similarly brings a focus on adaptation and learning to the forefront: *"The argument presented in this paper suggests that disaster resilience could be viewed as the intrinsic capacity of a system, community or society predisposed to a shock or stress to adapt and survive by changing its non-essential attributes and rebuilding itself”* (ibid., p. 443).

The third most used concept was the system's ability to recover or bounce back to the pre-disaster state. An example can be seen in Zhou et al. (2010, p. 28), where they state that *“disaster resilience can be defined as the capacity of hazard-affected bodies (HABs) to resist loss during disaster and to regenerate and reorganize after disaster in a specific area in a given period”*.

Table 6 shows that the most common dimensions in the literature are disaster and community resilience, making the dimensions difficult to compare. Also important to note is that many, but not all, definitions in the community dimension incorporates theory from socio-ecological systems. These influences are not visible at the level of the definitions but can be seen referenced in the broader discussion or the research paper. However, definition of community and socio-ecological offer valuable differences as the subject matter of the latter is often broader and more abstract. Socio-ecological definitions tend to be more focused on the interplay between people and environment while the definitions in the community dimensions focus more heavily on social aspects.

Temporal aspects

Resilience is most often described as something that occurs during and event and after an event (both of which are 77%). An exception being the Economic dimension where only 33% describe resilience as something happening after an event (note small sample). Only in 29 % of the definitions refer to resilience as something occurring before an event. Further, it is only in the dimensions of Disaster and Community resilience (44% and 35%, respectively) that it is found. This can be contrasted to System, Socio-Ecological, and Economic (0%, 0%, 0%).

Characterisations

Most popular are descriptions of resilience as an Ability or Capacity (40% and 35%, respectively). Resilience as a Property of the system was only found in the Systems dimension, where it was mentioned in 18% of the definitions. Only two definitions, one in the community dimension and one in the economic dimension described resilience as a Process. Two definitions in the disaster dimension and seven definitions in the community dimension do not describe the character of resilience.

Behaviours

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%). This may be viewed as an indication of the heavy influence socio-ecological thinking has had on the community dimension. Self-organising was most frequent in Socio-ecological definitions, although this trend should be viewed with caution due to low sample size.

Although there are rather small samples in this category, 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%.

Exploratory articles

The exploratory articles aim either to have a discussion on specific aspects of resilience or to synthesize various branches of resilience. The literature can broadly be grouped together based on the methods used by the authors to synthesize the definitions. The identified groups are: Synthesis, Bottom-up, Historical, Political, Knowledge production, Sustainability, Vulnerability. For a full table, see Annex 3. Resilience definitions - Exploratory

Several synthesizes are made of definitions from one of more fields in to a common framework (Berkes, 2007; Chelleri, Waters, Olazabal, & Minucci, 2015; Masten & Obradovic, 2008; Miles, 2015; Weichselgartner & Kelman, 2015; Zobel, 2011). For example: Chelleri et al., (2015) aims to synthesise definitions for sustainability and disaster management. Historical origins and contexts of resilience are explored by Amico & Currà, (2014), Folke, (2006) and Pendall et al., (2010). In the Political grouping Fainstein, (2015) and Walker & Cooper, (2011) criticise resilience from a political perspective by pointing out neoliberal ideologies inherent in the concept. Bottom-up processes are used in four of the article, where attempts are made to clarify how practitioners in the field view resilience (Aldunce et al., 2014; Aldunce, Beilin, Howden, & Handmer, 2015; Campanella, 2006; Weichselgartner & Kasperson, 2010). Knowledge production and what can be considered as valid knowledge is examined by two authors. They examine how generalizable solutions are as they are often studied in a specific context (Evans, 2011; Vogel, Moser, Kasperson, & Dabelko, 2007). Resilience and Vulnerability is the main concern for some authors (Baker, 2009; Birkmann et al., 2013; Füssel, 2007). The remainder of the papers in the exploratory group fit either into several categories, or none. Fuchs (2009), for example could fit into the historical group, the synthesising group and the vulnerability group.

No specific definitions

The non-specific group do not offer a specific definition of resilience. Most of the authors produce a discussion on different viewpoints of resilience and what they believe are relevant aspects of the term. These discussions, however, do not express the use of a particular definition. The reason for this could be that the authors are aware of the fuzzy, and sometimes conflicting, definitions of resilience and expect their audience to have an implicit sense of what the concept entails. For some it might also be that a clear definition is less relevant to their goal, which might be more pragmatic and applied. One thing to note is that this group contains a big proportion of national and international organisations and that they are often concerned with sustainability.

3.2.4 RELATED CONCEPTS

The two concepts, *vulnerability* and *sustainability,* are often used in conjunction with resilience. In the following paragraphs these two concepts will be discussed in relation to resilience.

Vulnerability

This term has, like resilience, been criticized for being vague (Adger, 2006). However, it is more concretely defined and often used as a proxy for resilience, especially by those who come from the

engineering perspective. Some scholars consider vulnerability the opposite of resilience (e.g. Berkes, 2007; Chelleri, Waters, Olazabal, & Minucci, 2015; Cimellaro, Reinhorn, & Bruneau, 2010; Fuchs, 2009; Smit & Wandel, 2006). Here, resilience and vulnerability are two opposite ends of the same axis. If a system is high in vulnerability it is also low in resilience and if its vulnerability is low then its resilience is high.

There are several definitions of vulnerability. Most widely cited is the definition by Adger (2006), who views vulnerability and resilience as linked concepts where vulnerability is the inherent risk for damage to a system (or part of a system), described by the equation:

vulnerability = probability * sensitivity

There are however those who conceive of vulnerability and resilience as two separate concepts. A system, from this point of view, may for example both be very vulnerable while still maintaining a high resilience. Manyena (2006), found two different streams of ideas in the literature: one stream views vulnerability as the opposite of resilience as in two sides of the same scale. The other stream sees them as two discrete phenomena. In the second definition, they point out that the elements vulnerability tends to focus on engineering and environmental sciences while the major elements in resilience tend to be in the medical or social sciences. A case study from Keogh, Apan, Mushtaq, King, & Thomas (2011) echoes this distinction. The researchers did a case study on an Australian community that frequently experienced flooding. In vulnerability literature recommendations for resilience were more concerned with people than buildings since their concerns were “Promoting resident responsibility to prepare for floods” and “Getting additional professionals to help with overtime”.

Sustainability

Sustainability and resilience are, like vulnerability, intertwined. The most common (Rodriguez-Nikl, 2015) definition of sustainability comes from the Brundtland-report and states that sustainability is:

“*Meeting the needs of the present without compromising the ability of future generations to meet their own needs*” (World Commission on Environment and Development, 1987). Another opinion states that resilience is necessary but not sufficient for sustainability (Rodriguez-Nikl, 2015). Therefore, in order to achieve sustainable cities, one also needs to create resilient cities.

In sustainability, there has been a focus on the long term effects of behaviors. Sustainability recognises that small every day behaviors and events affect the future when aggregated. In contrast, the focus on resilience, perhaps from its popularity in the disaster and natural hazards literature, has been the big

events and shorter time periods. Rodriguez-Nikl (2015), notes that infrastructures like buildings are often evaluated for their sustainability level while societies and communities are evaluated for their resilience level. Sustainability assessments usually concern what they label as “ordinary events” while resilience mostly deals with extraordinary catastrophes.

This effect has led some researchers to theorise if the rise of resilience over sustainability is due to the attractiveness of adapting the current systems instead of the much more radical alternative of transforming them (Pizzo, 2015).

In this chapter, we have described the definitions found in our literature review. While most papers use their own definition, they can still be classified by their theoretical model. Some of the definitions see resilience as being able to bounce back to a previous state while others emphasise the ability to change and adapt. Resilience is entangled with other closely related concepts as vulnerability and sustainability; some see these concepts as distinct from resilience while others see them as different sides of the same coin.

3.2.5 APPROACHES AND METHODS: FRAMEWORK ANALYSIS

In this section we review the 22 resilience frameworks identified in the literature. Key elements of each framework have been analysed and a summary has been developed (see Annex 1. Frameworks table) for the full frameworks analysis). Table 7 offers an overview of the 22 frameworks and the key feature. Below, summary of the key features, target area and application and key attributes/indicators are presented. *Key features* describe the main objective of the proposed frameworks. *Target area and application* describes the areas in which the frameworks are intended to be used and if the framework has been applied or not. *Key attributes/indicators* discuss the central concepts of the framework.

Table 7. Framework analysis table.

Authors	Framework	Description/Key feature
(Ainuddin & Routray, 2012)	Joint framework for community resilience	Joint framework for community resilience. Review and analysis of community resilience frameworks. Includes results from a household survey

(Berkes, 2007)	Identification of resilience aspects	Expands upon Folke's (ref) 4 factors to investigate how resilience aspects can help reduce vulnerability. Includes high level strategies that need to be altered to the specific context
(Birkmann et al., 2013)	The MOVE framework (Methods for Improvement of Vulnerability Assessment in Europe)	Aims to holistically assess vulnerability and resilience in response to hazards. Provides a review of previous frameworks.
(Carpenter et al., 2012)	Enabling conditions for general resilience	Focus on "general resilience" and aims to go beyond socio-ecological and includes literature on natural disasters, social vulnerability, scenario planning, and adaptive management.
(Cutter et al., 2008a)	DROP: A place-based model for community resilience	Aim to improve comparative assessments of disaster resilience at community level resilience, primarily while viewing natural hazards. Further provides models to link the concepts of resilience, adaptive capacity and vulnerability
(Cimellaro et al., 2010)	Unified reference framework	Quantitative evaluation of disaster resilience. Potential losses are measured and described.
(Desouza & Flanery, 2013b)	Resilient cities framework	Holistic approach to designing, planning, and managing for resilience by including an evaluation of cultural and process dynamics within cities and physical elements. Based on 20 case studies. Focus on flow in and out of cities. Strategies are suggested to direct the development.

(Fox-Lent, Bates, & Linkov, 2015)	Resilience Matrix (RM) framework	Minly focused on key stakeholders. Utilises local stakeholder-informed metrics aligned with the temporal stages of disaster resilience. Numbers must be localised to have meaning.
(Jabareen, 2013)	RCPF (the Resilient City Planning Framework)	The framework aims to fill the theoretical and practical gaps and answer questions regarding what cities and their urban communities should do in order to move towards a more resilient future state. Suggests both qualitative and quantitative measurements depending on definition of data.
(Kuhlicke, 2013)	Resilience as a capacity and a myth	Discussion on the usefulness of resilience for risk and disaster management to deal with unexpected events. Focus on how narrators construct a relationship between their experiences and their subsequent sense-making of these experiences
(McDaniels, Chang, Cole, Mikawoz, & Longstaff, 2008)	Conceptual framework for resilience in infrastructure	Conceptual framework for resilience within infrastructure systems after an extreme event. Measurements of robustness and rapidity in quantitative terms but describe their decision model in qualitative terms.
(Miles, 2015)	The WISC framework (Well-being, Identity, Social services and Capital)	Foundations of community disaster resilience. Offers 29 variables to classify each of the WISC. Focus on link between infrastructure resilience and community resilience.
(Ouyang, Dueñas-Osorio, & Min, 2012)	Three-stage resilience analysis framework	Mathematical model to measure infrastructure resilience. Does not include dynamic resources.

(Rodriguez-Nikl, 2015)	Conceptual framework of resilience and sustainability	A conceptual framework to understand the relationship between resilience and sustainability. Mathematical model to measure the health of a city.
(Restemeyer et al., 2013)	Strategy based framework	A strategy-based framework for assessing the flood resilience of cities. Identification of components to implement resilience strategies. Aims to move from definition to “doing” resilience.
(Stewart, Kolluru, & Smith, 2009)	Theoretical framework for community resilience	A framework of community resilience to understand the ability of impacted areas to effectively manage the consequences of disasters. Framework requires local identification of indicators.
(Sherrieb, Norris, & Galea, 2010)	Community resilience model	Measure adaptive capacities for Economic Development and Social Capital in the Norris et al. (2008)
(Simmie & Martin, 2010)	Adaptive cycle model	Entirely focused on economic aspects of resilience. A four-phase adaptive cycle model of regional economic resilience that follows a sequential cycle
(Singh-Peterson, Salmon, Baldwin, & Goode, 2015)	Shared resilience factors	Factors influencing the resilience of the Sunshine Coast – shared resilience among stakeholders. Attempts to identify which stakeholder has a high level of responsibility for which factor
(Somers, 2009)	Measures of latent resilience	Measure latent resilience in organisations. Focused on an organisation of a limited scale, not clear how it translates to something large
(Lei et al., 2014)	A conceptual framework of vulnerability,	Relationships of vulnerability, resilience, and adaptation within the disaster risk domain. Focus on

	resilience, and adaptation	disaster risk (short term), may not fit other domains with longer time scales.
(Zhou et al., 2010)	The DRLRL (Disaster Resilience of "Loss-Response" of Location)	A model for a geographic perspective of resilience. Building at various spatial levels. Offers the link to the geographical area as a determining factor of resilience.

Key features

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 (vulnerability, sustainability) (Birkmann et al., 2013; Lei et al., 2014), or areas of the urban environment together (e.g., social, physical and economic)(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 frameworks are in some 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 et al., 2010; Lei et al., 2014). Other frameworks aim for more specific aspects such as the geographical conditions (Zhou, 2009), economic indicators (Sherrieb et al., 2010; Simmie & Martin, 2010) or the preparation for a disaster (Cutter et al., 2008b; Stewart et al., 2009). Two frameworks have expressed the aim of developing frameworks that go from conceptual to the practical “doing” resilience (Jabareen, 2013; Restemeyer et al., 2013).

In most cases the authors suggest concepts which involve qualitative assessments, but quantitative measurements are also used in four of the frameworks (Cimellaro et al., 2010; McDaniels et al., 2008; Ouyang, 2014; Rodriguez-Nikl, 2015). The latter come from an engineering background and in three out of the four frameworks they focus on building infrastructure.

In four of the included articles the authors do not offer a framework with links between different concepts and sources, but rather suggest a set of strategies on how to enhance resilience (Berkes, 2007; Cefai et al., 2014; Kuhlicke, 2013; Singh-Peterson et al., 2015; Somers, 2009).

Target area and application

Although all frameworks are within the area of urban resilience, they also have specific focus areas. In Figure 6, the target areas have been summarised. In most cases the framework has more than one target area (e.g., economic and climate change).

The most popular area is “natural hazards/climate change”, followed by “community resilience”. Two frameworks focus primarily on economic resilience, and the other three use it as part of their model. All frameworks which include man-made hazards also have natural hazards as a focus area.

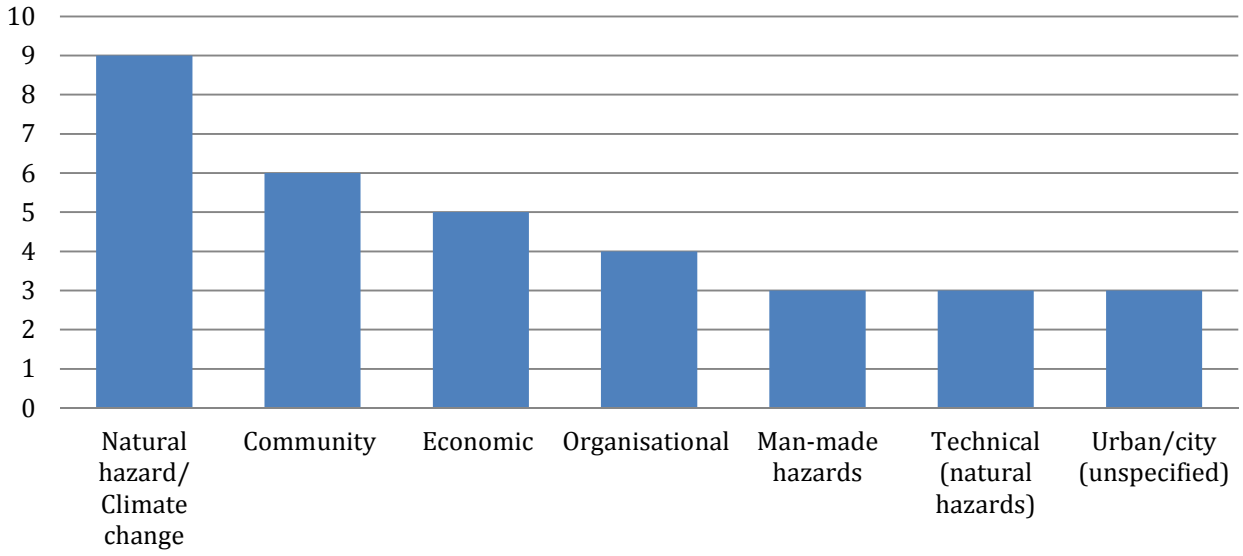

Figure 6. Focus area of the various frameworks.

Out of the 22 frameworks, 12 applied their framework to a real case, 2 offered a hypothetical illustration and discussion on the frameworks application and 8 did not apply their framework at all.

Key attributes/indicators

There is a large variety in the attributes/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.

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., 2008b; Jabareen, 2013;

Lei et al., 2014; Restemeyer et al., 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 et al., 2008; Ouyang et al., 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 et al., 2015; Somers, 2009).

Frameworks also vary in how the attributes/indicators are applied. Most provide a conceptual map, linking different concepts and attributes. However, many offer little guidance on how to translate the high level concepts to practical use, they only suggest that more specific indicators must be identified in the local context (e.g., Ainuddin & Routray, 2012; Stephen Carpenter et al., 2012; Cimellaro et al., 2010; Cutter et al., 2008b; 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 (Fox-Lent et al., 2015; McDaniels et al., 2008; Sherrieb et al., 2010; Zhou et al., 2010) or strategies to guide implementation of the concepts (Berkes, 2007; Desouza & Flanery, 2013a; Jabareen, 2013; Kuhlicke, 2013; Restemeyer et al., 2013; Somers, 2009).

3.2.6 FROM THEORY TO PRACTICE: CONSIDERATIONS AND CHALLENGES

Urban resilience is complex and dynamic in structure, and uncertain in nature. It is affected by a multiplicity of economic, social, spatial, and physical factors. Further, it requires the planning of a wide range of stakeholders, e.g. civil society, local and national governments, the private sector, and various professional communities. To this end, it can be expected that the phenomena of resilience is sometimes described as a “fuzzy concept”, that is, a concept where the boundaries of application can vary considerably, making it difficult to translate into operational terms (Pendall et al., 2010). A concern is that the concept may be too general and vague to be used as a guiding metaphor for making plans and policies (Pendall et al., 2010). However, a concept that can be applied to such a vast array of systems and contexts cannot at the same time offer a specified agenda, but is instead inherently “fuzzy”. The contribution of the resilience concept is that, as noted by Pendall et al. (2010, p. 72), it “offers novel

ways of thinking about and understanding complex phenomena, revealing new connections between seemingly disparate conceptual phenomena". It further provides a common ground between disciplines and policy makers to discuss important points (Pendall et al., 2010).

In this section, we introduce some of the considerations to be made and challenges faced in operationalizing resilience that have been identified in the literature.

Defining the scope

DEFINING THE SCOPE FOR RESILIENCE ANALYSIS

- ✓ Geographical boundaries
- ✓ Temporal boundaries
- ✓ System dimensions
- ✓ Identifying indicators and metrics

Difficulties arise when attempting to operationalise the notion of resilience, that is, going from a descriptive concept to a normative agenda. One must first define the boundaries of the region to be studied and also the multiple dimensions and parameters of time and space. Once this challenging task is performed one must identify a course of actions and set in place strategies for implementation, monitoring and assessment. A few of these difficult tasks will be discussed below.

Resilience dimensions and system boundaries

The analyst must define meaningful boundaries and parameters of the areas to be measured. This could be, e.g. geographical and temporal boundaries (Pendall et al., 2010). 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? Is it long-term or short-term? At what point can we determine an areas resilience? Temporal aspects (acute vs short/long-term stresses) are a source of complexity. Planning for the short term is relatively easy, such as preventing damage from earthquakes or cut costs in certain areas (Carpenter et al., 2012). Long term resilience, on the other hand, is a much more complex concept that requires a continuous stream of both funds and research. Further, if incentives are not constructed properly, short term needs may take priority over the long-term view needed to create resilience (Carpenter et al., 2012).

Resilience is a multidisciplinary field and the analyst must therefore further define within what dimensions resilience will be investigated, and the relation between these dimensions (Jabareen, 2013). Resilience dimensions in an urban context may include, for example, social, economic, cultural,

environmental, spatial and physical (Jabareen, 2013). Another challenge is further to isolate resilience (Pendall et al., 2010). For example, the effect of a natural hazard, such as Hurricane Katrina, has a massive impact on many areas, what do we include? Housing? Employment rates? Citizen's well-being?

The boundaries of the system largely define in which attributes we must focus on. Having a large difference in scale will affect not only how to plan and create policies for resilience, but also which aspects are important to consider. A large urban area is likely to comprise a variety of different challenges that cannot be solved using the same methods. In much the same sense, a country often cannot use the same indicators and metrics to measure resilience in multiple regions or cities.

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; Teodorescu, 2015); (European Environment Agency, 2012). Zaidi & Pelling (2015), further discuss the issue of using secondary data (e.g., how well a town is doing financially) as it does not capture critical resilience aspects such as information exchange, capacity to learn and behaviour among vulnerable groups, for example, the elderly. Also, as mentioned by Adger (2006), with reference to vulnerability, manifestations are contextual, they appear at a specific place and time, and this will look differently between and within regions and varying societal sectors. 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. Pendall et al. (2010), thus note that criteria and parameters to monitor and assess must be of relative performance. To improve resilience there must be an activity agenda in place.

Larkin et al. (2015) offer a review of implemented frameworks and their assessment tool. A main finding from this study was that all the framework tools include an assessment, but do not offer any guidance on solutions to improve the community or organisational resilience. The success of implementation of policies requires both political and social capital. Just because a plan is present, it does not guarantee successful implementation and use of local managers (Zaidi & Pelling, 2015).

A way of testing resilience is by running scenarios on events that may occur in the area. Scenarios run the risk of being highly specific and can be seen as not actually testing resilience, but rather the capacity to withstand the particular event. While this is something that must be taken into consideration, scenarios may still offer valuable knowledge. In the perhaps most obvious sense, it may aid in identifying routes

of communication previously not considered, or realising that the collaboration between certain institutions are not working as previously thought (e.g. Davis et al., 2015; Zobel & Khansa, 2014).

Central processes for resilience

Collaboration between stakeholders

CENTRAL PROCESSES FOR RESILIENCE

- ✓ Collaboration between stakeholders
- ✓ Decision Makers/Policies
- ✓ Social engagement

Contributing to difficulties in operationalizing resilience are the challenges of interdisciplinary collaboration within and between research teams and decision makers (Ahern, 2011; Weichselgartner & Kasperson, 2010). Weichselgartner & Kasperson (2010) investigated the collaboration between scientists and decision makers through a number of cases, finding that decision makers typically use the research-based knowledge insufficiently and researchers typically produce insufficient knowledge that is directly applicable. Problems identified include divergent objectives, needs, scope, and priorities; different institutional settings and standards, as well as differing cultural values, understandings, and mistrust (Weichselgartner & Kasperson, 2010).

Descision Makers/Policies

DECISION MAKERS/POLICIES

- ✓ Support from political leaders
- ✓ Managing economic pressures
- ✓ Increase knowledge and awareness in all city sectors

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). Weichselgartner & Kasperson (2010) found that research in resilience addresses the needs of decision makers in disaster management but less in other policy fields. 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 it is the need for regulatory frameworks (Malalgoda et al., 2014) and planning and policy momentum (Restemeyer et al., 2013). Identifying an appropriate scale for planning can be tricky as it is confounded

by the globalisation of economy. 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 (Malalgoda & Amaratunga, 2015; Djalante, Thomalla, Sinapoy, & Carnegie, 2012; Davies, 2015). 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., 2012).

Increasing knowledge and raising awareness in all city sectors is also a central issue for resilience. Knowledge sharing can be between many different parties such as politicians, local decision makers, civil society, grass root organisations, scientific community and private sector. In her essay of resilience and justice, Fainstein (2015) argues that by keeping citizens informed of a decision and the reasons behind it, the boundaries of what is politically possible are expanded. In the resilience city planning framework, Jabareen (2013) notes "urban governance" as one of the main four concepts, which requires inclusive decision making, open dialogue and collaboration between people and local stakeholders. Weichselgartner & Kasperson (2010) focus on knowledge sharing between the scientific community and decision makers and argues that differences often result from uncertainties in the factual knowledge, and groups tend to maintain internal coherence, which is why dialogue and boundary work is necessary. Restemeyer et al. (2013) argue that consensus building and partnership practices may bring different disciplines together and allows for new design and more integrated solutions.

Social engagement

SOCIAL ENGAGEMENT

- ✓ Social inequalities increases vulnerabilities
- ✓ Well-informed citizens with self-protective abilities

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) Perks, 2013). By changing the behavior 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). Having well-informed citizens and by promoting self-protective behavior, a community could also limit its vulnerability, as well as free up valuable

resources during a crisis (Keogh et al., 2011; Restemeyer et al., 2013; Somers, 2009). For example, involving community professionals, e.g. doctors, nurses and social workers, during a heat wave may serve to reduce public exposure (Zaidi & Pelling, 2015). Involving local stakeholders also has the benefit of building trust in a community and identifying local needs, which in turn may increase the resilience of said community (Harman et al., 2015; Restemeyer et al., 2013). Additionally, Adger (2006), found that the citizens' perception of their vulnerability also made them more vulnerable, 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 (Boin & McConnell, 2007). Further, Adger (2006) notes that it is often the most vulnerable citizens that are not included in the decision-making process, thus enforcing their sense of being vulnerable. The perception we have of our role is also a driving factor in our ability to make changes, such as seeing our lifestyle not only a disturbing factor, but as part of the solution (Larsen & Gunnarsson-Östling, 2009). To create resilience it is thus not sufficient to create new policies, it is also critical to have support from the community in order to make changes (Larsen & Gunnarsson-Östling, 2009; European Environment Agency, 2012). To gain social capital, that is, effective networks for communication at local communities as well as with decision makers, is a key factor (Restemeyer et al., 2013; Tobin, 1999). However, it is something that must be maintained and can be very time consuming.

3.3 DISCUSSION

In terms of citations the socio-ecological definitions appear to be the driving force in resilience research today. However, most of the definitions used by organisations adopt an engineering, single equilibrium, model of resilience. Arguably the most widely used definition, UNISDR (2009), fits best with a single equilibrium model. The reason for this might be that it's easier to model, it may be enough for one to answer the binary question of "does the system perform its function?". It might also be easier to pinpoint areas that need improvements to enhance the systems overall resilience. The most desirable attribute of these models might be that they describe linear cause and effect relationships. In these models it is possible to know how different parts will affect other parts, it's possible to achieve effects by making the right changes in the system.

The multi equilibrium model lacks these simple cause and effect relationships. These models describe much more intricate systems with more advanced recurrent feedback loops. The cause of an effect might not be possible to pinpoint and, therefore, striving for a given state by making changes to the system might be an exercise in futility. It is somewhat a paradox that the models more concerned with adaption don't let decisions affect the outcomes. Still the multi-equilibrium models might paint a truer

picture of the world in that the reasons for outcomes are not always knowable or are tangled in too complicated causal webs.

The question one should ask oneself when laying the theoretical foundation for a model of resilience is: is resilience something that the systems have or is it something that it does?

There is a large variety also in the attributes and indicators used in the urban resilience methods, reflecting the lack of consensus and unification of urban resilience and its central themes. It also reflects the vast amount of aspects that are important to resilience and that there are many ways to increase resilience, depending on the area of interest. Many authors in the literature argue that what is absent in frameworks for urban resilience are the links between different dimensions of resilience, including both the social and physical aspects. To address this gap the frameworks include very high-level concepts. The benefit of this is that it offers a way to see the vast amount of stakeholders involved and the flow between different areas. The downside of more general models is that they cannot be directly applied but have to be translated to a specific context. In this sense, the frameworks are useful on a conceptual and theoretical level, but still far from being available for practical use.

The area of application of the frameworks further demonstrates the wide spread of the frameworks. 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 by this topic in today's society. Frameworks which 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.

A frequent topic in the literature is the challenge of going from theory to practice, from normative to descriptive applications of resilience. The difficulties are manifold, as multiple dimensions and

parameters must be defined to implement resilience models. The complexity of cities, with multiple interconnected factors and the dynamic nature of today ever-changing society makes boundary setting a critical process but also a source for potential problems. Identifying the right scope, the influencing factors and how these are linked is one of the major challenges today. Analyses will require close monitoring, re-assessment and re-interpretations throughout all transformations made.

4 WORLDWIDE REPORTS ON RESILIENCE

4.1 INTRODUCTION

In addition to scientific literature study described above, an analysis of worldwide approaches, including plans developed by RC100 was carried out. The study included a review of reports from organisational bodies and cities worldwide on resilience implementation, evaluation, metrics, best practices and policies.

4.2 METHOD

THE WORLDWIDE REPORT STUDY

23 reports and web resources from organisational bodies and cities worldwide were analysed concerning to resilience implementation, best practices, metrics, and

The goal of the review was to deepen the understanding for on-going work in urban resilience outside the research field. 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 in the following areas:

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

This study analyses reports on climate change adaptation strategies of three European cities Rotterdam, Copenhagen and London, four ICLEI reports about Climate change adaptation, two European Environment Agency (EEA) reports about urban adaptation to climate change. Moreover, two United Nations International Strategy for Disaster Reduction (UNISDR) reports on making cities more resilient were included in the study. Additionally, the City Resilience Framework of the Rockefeller Foundation, a report from the Council of Europe on city resilience, as well as two surveys about adaptation strategies and stakeholders are also included in the review. Moreover, we assessed two reports about linking vulnerability, adaptation, and resilience science to practice and perspectives on resilience to disasters

across sectors and cultures are added. Finally, three web resources on resilience were reviewed: the Compact of Mayors[2], Carbonn[3] and UKCIP[4].

4.3 RESULTS

4.3.1 DEFINITIONS OF RESILIENCE

The resilience definition from the UNISDR is the predominant definition used in the reviewed reports: "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" (Cocchiglia et al., 2012).

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."

Urban Resilience is defined as the ability of an urban system to cope with climate and other disaster risks and sustainability challenges, while maintaining the current form and functioning (Georgi et al., 2012). A resilient city is attractive to investors and inhabitants and can turn challenges into opportunities through harnessing synergies, multiple benefits and fostering collaboration. In economic terms, urban resilience is defined as the ability of an urban area or system to provide predictable performance, that is, benefits and utility, to residents and users, and predictable returns to investors, under a wide range of often unpredictable circumstances. The definition of city resilience is given as the capacity of cities to function, so that the people living and working in cities – particularly the poor and vulnerable – survive and thrive no matter what stresses or shocks they encounter. Table 8 and Table 9 show resilience properties of resilient cities according to How To Make Cities More Resilient Report (For & Government, 2012) and City Resilience Framework (Da Silva & Moench, 2014).

[2] www.compactofmayors.org
[3] http://carbonn.org/
[4] www.ukcip.org.uk/wizard/

Table 8. Properties of resilient cities according to How To Make Cities More Resilient Report (Cocchiglia et al., 2012).

City resilience properties (Resilient Cities Report)
A city where disasters are minimized because the population lives in homes and neighbourhoods with organised services and infrastructure that adhere to sensible building codes, without informal settlements built on flood plains or steep slopes because no other land is available.
A city that has an inclusive, competent and accountable local government that is concerned about sustainable urbanisation and that **commits the necessary resources to develop capacities to manage and organise itself before, during and after a natural** hazard event.
A city where the local authorities and the population understand their risks and develop a shared, local information base on disaster losses, hazards and risks, including who is exposed and who is vulnerable.
A city where people are empowered to **participate**, decide and plan their city together with local authorities and value local and indigenous knowledge, capacities and resources.
A city that has taken steps to anticipate and mitigate the impact of disasters, incorporating **monitoring and early warning technologies to protect infrastructure,** community assets and individuals, including their homes and possessions, cultural heritage, environmental and economic capital, and is able to minimise physical and social losses arising from extreme weather events, earthquakes or other natural or human induced hazards.
A city that is able to **respond, implement immediate recovery strategies** and quickly restore basic services to resume social, institutional and economic activity after an event.
A city that understands that most of the above is also central to building resilience to adverse environmental changes, including climate change.

Table 9. Properties of resilient cities according to City Resilience Framework (Da Silva & Moench, 2014).

Properties of resilient cities (City resilience framework)

Social infrastructure properties

- Minimal human vulnerability indicated by the extent to which everyone's basic needs are met.
- Diverse livelihoods and employment facilitated by access to finance, ability to accrue savings, skills training, business support, and social welfare.

Collective identity and mutual support observed as active community engagement, strong social networks and social integration.

Health and safeguard properties

- Adequate safeguards to human life and health
- Relying on integrated health facilities and services, and responsive emergency services
- Social stability and security including law enforcement, crime prevention, justice, and emergency management.

Reduced physical exposure and vulnerability

Financial resource properties

- Availability of financial resources and contingency funds

Observed as sound financial management, diverse revenue streams, the ability to attract business investment, adequate investment, and emergency funds**.**

Planning, leadership, knowledge and management properties

- Environmental stewardship, appropriate infrastructure, effective land use planning, and enforcement of planning regulations.
- Effective leadership and management Involving government, business and civil society, and indicated by trusted individuals, multi-stakeholder consultation and evidence- based decision-making.
- Empowered stakeholders indicated by education for all, and access to up-to-date information and knowledge to enable people and organisations to take appropriate action.

Integrated development planning indicated by the presence of a city vision; an integrated development strategy; and plans that are regularly reviewed and updated by cross- departmental working groups.

Critical infrastructure properties

- Continuity of critical services indicated by diverse provision and active management, maintenance of ecosystems and infrastructure and contingency planning.

Reliable communications and mobility indicated by diverse and affordable multi- modal transport systems and information and communication technology (ICT) networks and contingency planning.

In conclusion, a resilient city is one where human vulnerability is reduced because of appropriate infrastructure, is concerned about sustainable urbanization and continuity of critical services indicated by diverse provision and active management, shares information between the different stakeholders,

reduces physical exposure and vulnerability by taking steps to anticipate and mitigate the impact of disaster and finally is able to respond, implement recovery strategies and quickly restore basic services.

4.3.2 APPROACHES TO RESILIENCE

Not all documents propose concrete approaches or methods to enhance resilience. Therefore, in this section, we analyse reports that clearly mention methods or approaches to resilience. We first present policy documents and reports and second, we summarize international commitments, initiatives and networks in the area of city resilience.

At the policy level, we have analysed five documents: the EU Adaptation Strategy (Perks, 2013) from the European Commission, the Sendai Framework for Disaster Risk Reduction (UNISDR, 2015), Resolution 339: Making cities resilient from the Council of Europe (Council-of-Europe, 2012), Urban adaptation to climate change in Europe (Georgi et al., 2012) and Adaptation in Europe (Isoard & Winograd, 2013).

THE SENDAI FRAMEWORK

A framework for Disaster Risk Reduction that aims to achieve the substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries over the next 15 years.

The Sendai Framework for Disaster Risk Reduction 2015-2030 (UNISDR, 2015) is the first major agreement of the post-2015 development agenda, with seven targets and four priorities for action. It was endorsed by the UN General Assembly following the 2015 Third UN World Conference on Disaster Risk Reduction (WCDRR). It aims to achieve the substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries over the next 15 years. Since it is a policy document, the framework proposes actions across sectors at local, national, regional and global levels in the following areas:

- Priority 1: Understanding disaster risk
- Priority 2: Strengthening disaster risk governance to manage disaster risk.
- Priority 3: Investing in disaster risk reduction for resilience
- Priority 4: Enhancing disaster preparedness for effective response and to “Build Back Better” in recovery, rehabilitation and reconstruction

Moreover, the framework also describes the role of the main stakeholders and considerations for international cooperation and global partnership.

The Resolution 339 was adopted by the Council of Europe on its plenary session, March 22, 2012 (Council-of-Europe, 2012). Based on the report, drafted by ICLEI Europe on behalf of the Congress of Local and Regional Authorities of the Council of Europe, its aim is to support the United Nations World Disaster Reduction campaign. The approach and the goal of the campaign was to implement the following steps:

- Raise the awareness of citizens and governments of the benefits of reducing risks at the urban level
- Use local government budgets in a smart way, which enhances the resilience of infrastructure and reduces disaster risk – in other words, mainstreaming disaster risk reduction into urban planning and development at the decision-making level.
- Include disaster risk reduction in participatory development and planning processes at the city level to protect critical infrastructure.

At the political level, concrete actions are recommended to the local and regional authorities in the EU member states:

1. To sign up to the UNISDR Making Cities Resilient campaign and implement a local adaptation process such as sharing best practices with other cities, developing partnerships with other local authorities in their countries, in Europe or in lower-income countries and designing innovative schemes in partnership with different players for knowledge transfers, and lobbying through city networks to increase the awareness of disaster risk reduction,
2. to adopt an integrated approach to the issues of disaster risk reduction and climate change adaptation and mitigation,
3. to improve the capacity to building resilience against climate change and natural disasters, disaster risk management and climate change adaptation, and
4. to implement programs and action plans based on the integrated management system.

Reports from Urban adaptation to climate change in Europe and Adaptation in Europe address risks and opportunities from a climate change perspective in the context of socio-economic development (Isoard & Winograd, 2013). They mainly suggest usinggreen infrastructure approaches in combination with the grey and soft adaptation measures.

Regarding commitments, initiatives and networks, we have identified 10 networks that cooperate to improve the city resilience. There are different methods and focus when implementing strategies in general. Table 10 provides a summary and description of these networks. Additionally, there are several standardization activities (e.g. within ISO/TC 292 Security and resilience) that are related to resilience, and which will be part of the deliverable 6.1 ("A report describing the existing standards and standardization activities", scheduled for month 12).

Table 10. Summary and description networks working with resilience.

Name	Description
Durban Adaptation Charter	The Durban Adaptation Charter commits local governments to local climate action in their jurisdiction that will assist their communities to respond to and cope with climate change risks thereby reducing vulnerability. **www.durbanadaptationcharter.org**
100 Resilient Cities	100RC uses the City Resilience Framework developed by Arup with the support of the Rockefeller Foundation as a lens to understand the complexity of urban systems. **www.100resilientcities.org**
Compact of Mayors	The Compact of Mayors is an agreement by city networks – and then by their members – to undertake a transparent and supportive approach to reduce city-level emissions, to reduce vulnerability and to enhance resilience to climate change, in a consistent and complimentary manner to national level climate protection efforts. Under the Compact of Mayors, cities will report their climate commitments, actions and inventories on reporting platforms which will be linked to a central repository (the carbonn Climate Registry). In general, this network with all members have commitment to reduce the climate risk according the the agreed standard. **www.compactofmayors.org**
Carbon Climate Registry (cCR)	The Carbon Climate Registry is the world's leading reporting platform for local and subnational climate action. The reporting template includes indicators related to both mitigation and adaptation. **http://carbonn.org/**
Local Government Climate Roadmap	The Local Government Climate Roadmap, a broad coalition of local government networks in response to the Bali Action Plan, is an advocacy process that began in 2007 and aims to ensure that a strong and ambitious global climate regime is designed and implemented in the post-2015 period. www.durbanadaptationcharter.org
UNISDR Making My City Resilient	The Making Cities Resilient: 'My City is getting ready!' campaign, launched in May 2010, addresses issues of local governance and urban risk. The website includes various reports and guidance materials. "The 10 Essentials" is a ten-point checklist and the building block for disaster risk reduction. **www.unisdr.org/campaign/resilientcities**

Mayors Adapt/ Covenant of Mayors	Mayors Adapt – the Covenant of Mayors Initiative on Climate Change Adaptation has been set up by the European Commission to engage cities in taking action to adapt to climate change. Cities signing up to the initiative commit to contributing to the overall aim of the EU Adaptation Strategy by developing a comprehensive local adaptation strategy and/or integrating adaptation to climate change into relevant existing plans. More advanced cities have submitted factsheets including basic information on their approaches and state of advancement. **http://mayors-adapt.eu/**
Asian Cities Climate Change Resilience Network (ACCCRN)	The Asian Cities Climate Change Resilience Network (ACCCRN) comprises practitioners and institutions committed to creating knowledge, accessing resources, and influencing agendas to build inclusive urban climate change resilience. Pioneered by the Rockefeller Foundation, ACCCRN is built on a multi-year initiative to strengthen the capacity of over 50 rapidly urbanising cities in Bangladesh, India, Indonesia, the Philippines, Thailand and Vietnam to survive, adapt, and transform in the face of climate-related stress and shocks. **http://acccrn.net/about-acccrn**
Resilient Cities Global Forum	Resilient Cities - The Annual Global Forum on Urban Resilience and Adaptation - is the global platform for urban resilience and climate change adaptation, hosted every year in Bonn. The webinars, congress proceedings and conference reports include many good practice examples. **http://resilient-cities.iclei.org/**
World Mayors Council on Climate Change	An alliance consisting of over 80 committed local government leaders concerned about climate change, the Council advocates for enhanced engagement of local governments in multilateral efforts on climate change and related sustainability issues. Membership is open to Mayors and equivalent leaders of municipal levels of government. **http://www.worldmayorscouncil.org/**

Examples of the best practices of local adaptation strategies to enhance urban resilience as outlined by three cities, i.e. London, Rotterdam and Copenhagen apparently pursue different approaches, depending upon the vulnerabilities and unique climate challenges and perceived faced by each city and perceived position as a city:

London adaptation strategy: London offers concrete actions against floods, overheating and droughts. The strategies are systematically derived from careful analysis of potential threats, risks and impacts due to climate change, and transfer these understanding into vision, policy and actions. For example to fight against the raising temperature, the mayor of London will increase the green space and vegetation that cover the city. To reduce the risk of overheating, there are set of actions that contain design guidelines for architects and developers to reduce the risk of overheating. These actions are outlined in different threats identified. London also introduces a roadmap to resilience: to improve the ability to predict and manage flood risk, to enable coherent cost-effective working, to identify the most vulnerable communities and critical assets, to introduce measure to sustain a long-term water efficiency, and using

rainwater for non-consumptive purpose, to improve response to drought and having clear target the green area coverage by 2025. In the end, the actions will lead into better London's economy, health improvement, and resilience city infrastructures.

Rotterdam adaptive measures: Rotterdam perceived itself as a delta city, which also has a role as a world port. Therefore, the climate adaptation strategies are not only for making the cities climate proof but also for providing opportunities to growth. The measures target outer-dike Rotterdam, inner-dike Rotterdam and within the dikes.

The measure in outer-dike Rotterdam is multi-layered flood protection approach such as 'flood-proof' buildings, construction of flood-proof public areas, floating communities and 'building with nature'. The protection of inner-dike Rotterdam is approached by optimising the storm surge barriers as a prevention measure. In addition, the city adopts multifunctional dikes approach by introducing the recreational routes and natural embankments. Within the dikes, the 'sponge function' of the city will be restored by implementing measures to capture and store rainwater where it falls and to delay drainage. These measures include green roofs and façades, less paving and more plants in the public streets, water squares and infiltration zones as part of the infrastructure.

Copenhagen resilience measures against climate change: Copenhagen's strategy follows the future climate scenario outlined by UN's Intergovernmental Panel on Climate Change (IPCC) to limit the emissions, in addition to the threats and risks faced by the city, especially floods. Copenhagen introduced three levels of adaptations.

In level 1, the measure aims at reducing the likelihood of the event happening, preferably to completely prevent it. At this level the establishment of dikes, building higher above sea level, local adaptation of sewer capacity, and local management of storm water are emphasised. Upon an efficient implementation of level 1 measure, then level 2 measures (e.g. the establishment of watertight basements, sandbags, adaptation of public spaces to store rainwater) and level 3 measures (e.g. extensive utilisation of basements, emergency preparedness with pumps) will not be necessary. This is also valid for any type of threats identified by the city (sea water, warming, groundwater issue, greener city, etc.).

In brief, level 1 measures try to reduce the likelihood, level 2 measures are actions to reduce the scale of hazards, while level 3 measures are intended to reduce vulnerability.

4.3.3 RESILIENCE TOOLS FOR CITIES

We have identified seven tools and toolkits that can be used to assess and work with different aspects of resilience on the city level. A summary of each tool can be found in Table 11**Error! Reference source not found.**.

Table 11. Tools and toolkits for resilience cities.

Name	Description
Changing climate, changing communities	A compendium developed by ICLEI Canada (2010) offers a simple and standardized guide for local governments to measure, monitor, report, and establish targets on greenhouse gas emission reduction. In this document, ICLEI proposes Five Milestones for Climate Adaptation methodology.
Financing the resilient city	An ICLEI white paper on the benefits of a bottom-up and comprehensive resilience investment approach to development, disaster risk reduction and climate adaptation. The approach offers in this document is demand-driven investment for resilience upgrading and suggests to approach resilience investments in bottom-up fashion. The approach is about how to create a market for resilience: 1) bottom-up planning processes for identifying vulnerabilities and risks, and linking the related risk mitigation solutions with priority performance enhancements in relevant areas or systems; 2) bottom-up technical and institutional capacity and 3) bottom-up procurement of investment.
Local governments climate adaptation toolkit	A climate adaptation toolkit developed by ICLEI Oceania to address the specific needs of individual councils. The toolkits consist of the following: • Council Questionnaire (self-directed) • Planning Workshop Template (facilitator required) • Tools Worksheet (facilitator encouraged as part of planning workshop) • Stakeholder Identification Worksheet (facilitator encouraged as part of planning workshop) • Adaptive Management Scoping Worksheet (facilitator encouraged as part of planning workshop) • Social Contract Template (facilitator encouraged as part of planning workshop) • Issue Brief and Direct Impacts (self-directed) • Conceptual Modelling Exercise and Example (facilitator encouraged) • Support Letter (self-directed) • Barriers Document (self-directed) • Risk Assessment Scenario Worksheet (self-directed) • Action Planning Workshop Template (facilitator required) • Assumptions Worksheet (facilitator highly encouraged) Action Plan Template (self-directed)

Climate Adapt Platform	This platform includes various case studies, general information and guidance material. The Urban Adaptation Support tool has been developed as the adaptation guidance for urban areas by Mayors Adapt, the EU initiative for urban adaptation to guide cities through the main steps of the adaptation process. It gives easy access relevant adaptation information, data, tools and guidance specifically tailored for urban settings in Europe. In this platform there are comprehensive collection of the guidelines that are intended for supporting cities and municipalities such as how to plan for adaptation and response, both in EU level and international guidelines. Example of guidelines are "Five steps to manage your climate risks - A Guide for Public Bodies in Scotland (2013)", "Planning for adaptation to climate change - Guidelines for Municipalities" and The Integrated Management for Local Climate Change Response: Capacity Development Package (2010). The platform provides six steps about how to use urban adaptation tool with the following steps: • Preparing the ground for adaptation, • Assessing risks and vulnerabilities to climate change, • Identifying adaptation options, • Assessing and selecting adaptation options, • Implementation, and Monitoring and evaluation.
UK CIP Adaptation Wizard	The UKCIP Adaptation Wizard is an online tool providing a 5-step methodology to support local governments in adapting to climate change. The Wizard supposedly can help cities to raise awareness about the importance of climate change and adaptation, access information, tools and resources, assess the vulnerability of the climate change, to make the case for adaptation in the organisation as well as develop and implement the climate-resilient project, programme, policy or strategy. The most important thing is that the wizard is not to provide one a customised climate adaptation strategy at the click of the button. The wizard only offers resources to develop city's specific adaptation strategy. They have clearly indicated in these 5 steps support from how to get started, provide resources about current and future climate vulnerability, the adaptation options and how to monitor the implementation of the adaptation strategy.
Local Climate Impact Profile	The Local Climate Impact Profile (LCLIP) was developed by the UK Climate Impacts Partnership (UKCIP). It is a simple tool designed to help assess exposure to weather. It can be used as a standalone tool, or as a step in a risk-based framework such as the Adaptation Wizard. The LCLIP process shows how prepared an organisation is to deal with severe weather events. The understanding about cities' current vulnerability to the weather can be a powerful catalyst to raise the awareness and improve preparedness for the future climate.
Stadtklimalotse	This is an online decision support system provided by the German Bundesinstitut für Bau, Stadt und Raumforschung (BBSR) to support the development of climate adaptation measures in city development. Based on scientific evidence a decision support system (DSS) was developed focussing on German municipalities as central actors. Stadtklimalotse contains 138 measures from 10 fields of action, 330 references to legal texts and 61 examples of the planning and implementation of measures. Stadtklimalotse supports the identification and implementation of appropriate measures for mitigation and adaptation in urban

	development. It consists of: Approaches to flexible planning, including under uncertainty. Implementation examples of planning practice: • Approaches to economic valuation of adaptation measures including implementation examples from planning practice, • Good Practice Database, • Module for self-assessment of effects of the climate change, • Considering the aspects of 'demographic change' and 'climate change,' and Improved overview of synergies and conflicts of individual measures.

4.3.4 EVALUATION

Not all documents and resources in this review provide suggestions on evaluation frameworks. However, some organisational bodies include a procedure or methodology as how to improve the resilience and describe several examples of resilience implementation or evaluation in various sectors. For example, the Pathways, players, and partnerships report (Vogel et al., 2007) showed how different actors co-operated across organisational and knowledge system boundaries in southern Africa.

Evaluations can be *formative,* aiming at improving on-going project or program, and it is often associated with forecast and mid-term evaluations. They can also be *summative* and judge the overall effectiveness of an intervention, implemented project or program. The UK CIP Adaptation Wizard provides a way to monitor and evaluate the adaptation strategy through a tool called AdaptME toolkit. It recommends to consider what aspects to evaluate, such as:

- Evaluating effectiveness,
- Assessing efficiency,
- Understanding equity,
- Providing accountability,
- Assessing outcomes,
- Improving learning,
- Improving future activities or interventions, and
- Comparing with other similar activities or interventions.

The Council of Europe's report on resilient cities (Council-of-Europe, 2012) discusses the need to conduct resilience work under a framework that ensures a holistic, integrated, inclusive and continually improving processes. It proposes a local-level process based on a framework developed by European

project CHAMP called Local Responses to Climate Change. The process tasks and cycle are the following:

- Baseline review: Available data on all relevant sustainability aspects should be collected and structured
- Target setting: to prepare the strategic programme and action plan
- Political commitment: pivotal and needs to be secured throughout the entire process
- Implementation and monitoring: all the preceding assessment, target setting and planning have the overall objective of improving the way the city functions in terms of sustainable development,
- Evaluation and reporting: It analyses what has happened during the year in order to understand why things happened or failed to succeed. It provides the politicians with a basis for taking further decisions on the targets and actions for the next year.

Second, it refers to UNISDR Making Cities Resilient Campaign through 10 points:

1. To understand and reduce disaster risk, based on participation of citizen groups and civil society, developing local alliances and ensuring that all departments understand their role in disaster risk reduction and preparedness.
2. A budget for disaster risk reduction targets different group in the communities
3. Up-to-date data on hazards and vulnerabilities, risk assessments and use these as the basis for urban development plans and decisions. Plans for city's resilience should be available to the public.
4. Invest in and maintain the infrastructure that reduces risk, such as flood drainage, adjusted where needed to cope with climate change.
5. Assess the safety of all schools and health facilities and upgrade these as necessary.
6. Apply and enforce realistic, risk-compliant building regulations and land use planning principles. Identify safe land for low-income citizens and develop upgrading of informal settlements, wherever feasible.
7. Ensure that education programs and training on disaster risk reduction are in place in schools and local communities.
8. Protect ecosystems and natural buffers to mitigate floods, storm surges and other hazards to which your city may be vulnerable. Adapt to climate change by building on good risk reduction practices.
9. Install early warning systems and emergency management capacities in your city and hold regular public preparedness drills.

10. 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.

The report on Adaptation Strategies for European Cities (Perks, 2013) proposes the following evaluation framework:

- Create a common approach allowing for a more efficient exchange and comparison between cities
- Pragmatic approaches to developing selection criteria and grouping the cities by climate hazards
- A flexible, multi-dimension approach to adaptation is required which engages all appropriate stakeholders.
- Provide resources and coordinated action for research to fill existing knowledge gaps in urban impacts and adaptation
- Work on indicators of urban vulnerability to identify regions and cities facing similar climate impacts, as well as hotspots for adaptation.
- Work on performance indicators or other benchmarks for measuring progress in adaptation in urban areas, and
- Work on costs and benefits of urban adaptation.

The Urban Disaster Risk Index presented in this report measures disaster risk from an integrated perspective and guides decision-making by considering the potential direct impacts of disasters and by identifying multiple-socio economic and capacity/resilience factors.

4.3.5 INDICATORS AND METRICS

INDICATORS AND TOOLS

Qualitative and quantitative indicators as well as policies, guidelines and tools have been developed that can guide resilience implementation.

The initiatives listed in this report have identified different indicators, however only some of them have indicated different resilience layers. Table 12 shows a set of proposed indicator groups for measuring resilience aspects of a city-community. From these indicators, many resilience frameworks for climate adaptation have concerned about the temperature changes that may lead into

drought and overheating threats and higher rainfalls or increased sea level that can cause floods to the cities. These quantitative climate indicators have frequently cited in different city adaptation strategies.

Table 12. Proposed indicators for measuring resilience aspects of a city-community.

Quantitative	Qualitative
The compact of Mayors (www.compactofmayors.com) • *Emission level of CO2, CH4* and N_2O; • **Emission from stationary energy,** • **In boundary travel and from waste** *Guide and Workbook for Municipal Climate Adaptation* • **Temperature** • **Rainfalls** • **Other climate indicators** *UKCIP 2015* • **Global surface temperature** • **CO_2 concentration** • **Rainfalls** • **Arctic sea ice, land ice** • **Sea level** *Rotterdam climate change adaptation strategy (2013)* • **Sea Level** • **Rainfalls** • **Droughts** • **Floods** *Mayor's climate change adaptation strategy (2012)* • **Effects of droughts** • **Effects of floods** • **Effects of overheating**	***City resilience framework (2014)*** • Minimal human vulnerability • Diverse livelihoods and employment • Adequate safeguards to human life and health • Collective identity and mutual support • Social stability and security • Availability of financial resources and contingency funds • Reduced physical exposure and vulnerability • Continuity of critical services • Reliable communications and mobility ***A guide to measure urban resilience risk (2015)*** • Effective leadership and management • Empowered stakeholders • Integrated development planning • Effectiveness of legislative framework • Effectiveness of institutional arrangements • Capacity building • Advocacy, Communication, Education and Public Awareness • Resiliency of Critical Services • Resiliency of Infrastructure • Emergency management • Resource Management, Logistics and Contingency planning • Hazard, Vulnerability and Risk assessment • Risk-Sensitive Urban development ***Copenhagen climate adaptation plan (2011)*** • Impacts of floods • Impacts of high sea levels Impacts of high temperatures

4.3.6 BEST PRACTICES

There is a tension between developing consensus on the methodologies used by a range of stakeholders across wide regions (posing particular challenges for comparability and regional integration) when their applicability in local contexts demands idiosyncratic adjustments. Such debate

is, however, ultimately healthy and may lead to better methodologies and framings of the problems in the regions. There is a need for scientific credibility and the need to clarify the role of 'external' agencies, stakeholders, and scientists at the outset of the process under study. Finally, there is an absence of some form of 'organisational base', or institutional 'frame' as well as clear 'rules of engagement' at the outset of such information exchanges, research activities, and interactions to build longstanding trusted relationships.

Resolution 339 "Making cities resilient" of the Europe's council can be considered as a policy/campaign (Council-of-Europe, 2012). It suggests EU member states to (1) sign up to the UNISDR Making Cities Resilient campaign (2) adopt an integrated approach to the issues of disaster risk reduction and climate change adaptation and mitigation (transport, communication, housing, urban green spaces, water and electricity supply, waste removal systems, food production, etc.) (3) boost their capacity in terms of building resilience to climate change and natural disasters, disaster risk management and climate change adaptation and (4) draw up and implement strategic programmes and action plans based on the integrated management system described in the explanatory memorandum. The documents identified in this report/policy are:

1. 40 measures in dealing with natural hazards" (2005)
2. Resolution 248 (2008) on climate change: building adaptive capacity of local and regional authorities,
3. Resolution 317 (2010) on coastal towns and cities tackling threats from the sea

On its behalf, the compact of mayors provides a climate action plan based on the following aspects:

1. Political commitment, vision, context, GHG emissions-forecast and reducing targets, implementation plan and monitoring plan.
2. Adaptation compliance requirements: First, Hazard reporting, Second, Vulnerability assessment (climate change risk assessment and climate change vulnerability assessment) and third, Climate adaptation plan minimum requirements.

The strategy toward financing resilience according to ICLEI is based on establishing local mainstreaming efforts, developing new sources of capital for quality resilience upgrades, and on developing the local institutional capacity to structure projects that are suitable for these new sources of finance. ICLEI recommends, through "The resilient cities" report of 2015, to increase awareness on climate change adaptation with outreach campaigns in vulnerable areas and expand partnerships with peer cities to learn from good practices. The City notes that long-term planning also requires long-term

financing, which means that the government must be able to follow through on its commitments and realigning priorities accordingly.

In order to achieve a substantial reduction of disaster risk, The Sendai Framework for Disaster Risk Reduction 2015-2030 (UNISDR, 2015) proposes actions across sectors at local, national, regional and global levels in the following areas:

1. Priority 1: Understanding disaster risk.
2. Priority 2: Strengthening disaster risk governance to manage disaster risk.
3. Priority 3: Investing in disaster risk reduction for resilience.
4. Priority 4: Enhancing disaster preparedness for effective response and to “Build Back Better” in recovery, rehabilitation and reconstruction.

Finally, How To Make Cities More Resilient Report (For & Government, 2012) proposed 10 steps (Table 13) to make a city more resilient comprising risk reduction, points to good practices and tools that are already being applied in different cities for resilience purposes.

Table 13. UNISDR suggestions to make cities resilient.

UNISDR steps to make cities more resilient
Put in place organisation and coordination to understand and reduce disaster risk, based on participation of citizen groups and civil society. Build local alliances. Ensure that all departments understand their role in disaster risk reduction and preparedness.
Assign a budget for disaster risk reduction and provide incentives for homeowners, low-income families, communities, businesses and the public sector to invest in reducing the risks they face.
Maintain up to date data on hazards and vulnerabilities. Prepare risk assessments and use these as the basis for urban development plans and decisions, ensure that this information and the plans for your city’s resilience are readily available to the public and fully discussed with them.
Invest in and maintain critical infrastructure that reduces risk, such as flood drainage, adjusted where needed to cope with climate change.
Assess the safety of all schools and health facilities and upgrade these as necessary.
Apply and enforce realistic, risk compliant building regulations and land use planning principles. Identify safe land for low income citizens and upgrade informal settlements, wherever feasible.
Ensure that education programmes and training on disaster risk reduction are in place in schools and local communities.

4.3.7 POLICIES

The reports suggest the need for a major programmatic initiative. We have identified numerous policies and guidelines:

- EU Adaptation Strategy
- Sendai Framework
- Urban Adaptation to Climate CHANGE
- Adaptation in Europe
- Resolution 339: Making cities resilient (Council of Europe)
- Local Agenda 21
- City Development Strategies
- Cities for Climate Protection
- Adaptation White Paper (EU)
- Directorate-General for Climate Action (DG CLIMA)
- United Nations Environment Programme (UNEP)
- Programme of Research on Climate Change Vulnerability and Impacts and Adaptation program (PROVIA)
- Climate Impact Research & Response Coordination for a Larger Europe program (CIRCLE-2)

Several political agreements like:

- Copenhagen Accords UNFCCC 2009 (20),
- Cancun agreements 2010 (including the Cancun Adaptation Framework),
- Durban Platform for Enhanced Action 2011

Different platforms, networks and conferences as:

- The Rockefeller foundation
- 100 Resilient Cities
- Mayors Adapt
- The Climate-ADAPT platform
- The compact of mayors
- United Nations Framework Convention on Climate Change (UNFCCC)
- Asian Cities Climate Change Resilience Network (ACCCRN)

- Resilient Cities Global Forum
- Worlds Mayors Council on Climate Change

Finally, London, Copenhagen and Rotterdam cities have developed their own climate-change adaptation guidelines. The aim of those Climate Change Adaptation Strategies is to assess the consequences of climate change on these cities and to prepare for the impacts of climate change and extreme weather to protect and enhance the quality of life of citizens.

4.3.8 CHALLENGES

Finally, focusing on challenges of the reports, we can identify that an important economic challenge discussed in the reports is how to finance resilience. In the climate-change field, planning and policy momentum toward implementing adaptation strategies can come to an abrupt halt as cities struggle to mobilize funding. Limited local capacity to secure and manage adaptation-funding remains an obstacle for many cities. It is important to get coherent, flexible and participatory approaches.

CHALLENGES

- ✓ Financing measures that increase city resilience
- ✓ Lack of good practical examples
- ✓ Political commitment

A general challenge about climate change is to develop a Climate change adaptation strategy in cities. It is crucial to reduce and prevent climate change impacts through early warning and disaster relief; facilitating adaptation options in a bottom up way, for example, by involving farmers, harbours and municipalities; regulating the distributional impacts of adaptation, for example, the allocation of water resources; developing, funding and regulating the maintenance of infrastructures such as dikes. The mitigation of greenhouse gasses emissions is an objective/criteria to be integrated in resilience policies.

The management of climate change is an important task, which brings socio-economic challenges. There is non-climate pressure in the urban context as population/demographic change, diversity, urbanisation and urban sprawl, consumption and urban life-style that are important socio-economic challenges for climate change adaptation. According to the Stakeholder Survey Report within the framework of the RAMSES project, the International challenges related to climate-change adaptation are:

1. Resource related challenges are generally highest rated by cities. This refers mostly to the difficulty of securing sufficient funding for adaptation activities,
2. Communicating the importance of pursuing adaptation especially to elected officials,

3. Gaining political commitment from local politicians, and
4. Lack of data.

Regarding European Union, the RAMSES project[5] (Terenzi & Wigström, 2013) found the following challenges related to resilience:

1. Lack of budget or resources,
2. Lack of a multilevel governance interface,
3. Lack of political commitment,
4. Lack of knowledge and data at city level,
5. Lack of good practice examples, and
6. Lack of peer-to-peer exchange possibilities.

On the other hand, the challenges for developing urban adaptation strategies are:

- Implementing adaptation measures,
- Involving the community,
- Assessing impacts,
- Prioritising risks,
- Creating organisational support,
- Knowledge on climate impacts,
- Communicating climate change,
- Understanding climate change.

Finally, they suggested some support needs as:

- Knowledge on finance and budgetary arrangements,
- Sectorial integration and cooperation,

[5] http://www.ramses-cities.eu

- Knowledge on developing public-private partnerships,
- Communication strategies to involve stakeholders,
- Communication between scientists and policy makers,
- Economic overview of adaptation (cost-benefit analysis),
- Knowledge on finance and budgetary arrangements, and
- Learn how to develop a business case on adaptation for policy-makers and create political commitment.

In conclusion, the most important challenges on city resilience, before going through more specific challenges, are the lack of financing resources (budget), the lack of good practices examples and finally the lack of political commitment.

5 CITY SURVEY

During the fall 2015, a survey of the city partners in the Horizon 2020 Smart Mature Resilience project (SMR) was completed (see Annex 2). Some of these partners are part of the Rockefeller Foundation 100 Resilience Cities initiative (100RC) and regarded as being progressive in the area of city resilience. 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.

5.1 METHOD

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. It was sent out to the seven city partners in SMR, five cities responded (e.g., Donostia/San Sebastian, Bristol, Veile, Kristiansand and Glasgow). The data was analysed qualitatively by LiU categorising the data. The resulting categories are not mutually exclusive.

5.2 RESULTS

5.2.1 CRITICAL INFRASTRUCTURES

Basically all cities stated that electric power, water supply and communications (transport and ICT) were of key importance to secure. However, threats to those infrastructures are not the same for the cities. The cities also reported that dependencies among different infrastructures are a problem, for example, that ICT infrastructure and communications are dependent on power. These dependencies can result in unwanted *cascading effects* in the infrastructural system when a single infrastructure fails. A common mitigation approach mentioned to increase robustness in the infrastructures was to separate systems and remove critical interdependencies among systems (de-centralisation). Many cities also mentioned emergency services and hospital resources as being important infrastructures to secure. Moreover, the cities have local and distinctive assets that need protection such as chemical plants and ports.

5.2.2 DEPENDENCIES AND COLLABORATIONS

NUMEROUS DEPENDENCIES

The dependencies, numerous stakeholders (subcontractors) and legal frameworks render managing the infrastructures on the local level difficult. A present strategy in the resilience work is to seek to better communication among different stakeholders and to pool resources locally and regionally.

The cities' infrastructure sits within a complex national and global framework with inherent co-dependencies and weak points. For example, electricity production and distribution in Bristol is provided by both national and regional bodies. The understanding of all present dependencies in the city's infrastructure is a problem and the hope is that the 100 RC programmes will deepen the understanding of the issues involved. According to Kristiansand is, for example, that hydro power in Norway is owned by the state but produced locally. Decreased local power production means that the state-owned energy company must rely on other countries and import energy. Regarding their ICT-infrastructure, Kristiansand is depending on a state-owned company. Glasgow City Council holds a budget which supplies a great deal of the required infrastructure in the city such as roads, waste water, as well as emergency health services. This means that the resilience of Glasgow not necessarily depends on external resources. Provisions for pooling resources with Scottish local authorities have been established. Vejle reports on several regional collaborations with the goal to strengthen infrastructural resilience such as the triangle collaboration area with communities Billund, Frederica, Kolding, Middlefart and Vejen.

5.2.3 RECENT FAILURES AND PROBLEMS

GENERAL PREPAREDNESS

Local work and preparedness seems to be biased towards local conditions and previous experiences of failures and problems, which might decrease the general resilience of the

Donostia/San Sebastian report on ground contamination and pollution problems (dam) as well as disasters related to transportation of dangerous goods. Extreme weather is reported to be a problem for Bristol, industrial events (fires), infrastructural failures as well as riots and past terrorism events. Economic decline has affected Bristol's resilience due to recent financial crises. This problem has had a direct impact on Bristol's means to deal with shocks and planning for long-term resilience. Kristiansand reports on a recent event that shut down several departments in the hospital including the emergency room. This problem was due to flooding. Kristiansand also report on raising unemployment figures that effect holding competence in the region. Moreover, they report on the terror attacks in Oslo and Utoja that affected the city indirectly. Here, a

problem was to get correct information on fatalities etc. Glasgow reports on severe weather impacts such as high winds resulting in floods. Ground contaminations have resulted in delayed project of development of infrastructure. Moreover, Glasgow reports unforeseen emergency events (helicopter crash) and problems related to vandalism. Finally, Vejle reports on several flooding disasters that have been due to heavy rainfall and rising sea level.

5.2.4 WORK METHODS

According to Bristol the current work processes are focused on strengthening existing organisational bodies rather than creating new ones to achieve goals set by the state. However, much of policy and the related decision-making regarding the critical infrastructures is outside the jurisdiction of the city. Bristol reported ongoing work to improve data collection from citizens to improve decision-making. Donostia reported that local emergency plans in terms of special plans, procedures and practice guidelines have been set up. With regard to the infrastructures the work is focused towards prevention and structural improvements (e.g. continuous improvement).

JURISDICTION AND SCOPE

Much of policy and the related decision-making regarding the critical infrastructures is outside the jurisdiction of the cities which inhibit their response to disasters and problems.

A present strategy in the resilience work is to seek better communication among different stakeholders and organisations (Kristiansand). They seek to improve collaborations with near cities and municipalities to improve the critical infrastructures (shared infrastructures). Changes in local policies have, in some cities, been implemented in the cities development plans. For example, Glasgow reports that new legislation requires contractors of larger development projects to plan and include sustainable water drainage systems. One city reports that improvements in working processes include ideas to centralise information centres to one centre that, according to respondents, would increase ability to gen an overview and monitor the environment (e.g., CCTV). Some cities mention that they are Resilience Labs (City as Lab) in the 100RC collaboration. This means that they are now able to test and evaluate different approaches to resilience and report back to the 100RC partners

5.2.5 BEST PRACTICES

The questionnaire shed some light on already implemented practices in the cities:

Glasgow has been forward planning and mading several initiatives; Glasgow City Development Plan (expected to be adopted 2016), Glasgow City Council's Resilience Team and Resilience Partnership,

The Traffic and Coordination Centre as well as regular network meetings with key infrastructure partners. The initiatives include new policies regarding planning across the city as well as procedures for risk monitoring, learning etc. Kristiansand report that they have implemented a national risk and analysis tool (CIM) which is, basically, used for incident reporting. Moreover, they have implemented TQM in the technical department. Risk and vulnerability analyses is on implemented approach and made when planning new industrial and housing areas. The city of Vejle has approved a new risk management plan for flooding and a plan for a resilient city. Bristol reports/ed on a range of new initiatives that are expected to improve the resilience level of the city many with a focus on flooding; they have improved monitoring capabilities nowadays using flow sensors and incident with follow up reporting (Op-Link). Some cities state that it is important to have political and mayoral engagement that champion the resilience work.

5.2.6 CHALLENGES

Generally, all cities report that it is challenging to maintain and upgrade the water and sewage systems which are expensive and difficult to adequately dimension. It is difficult to assess the overall quality and maintenance requirements of different the critical infrastructures due to information fragmentation, different players and a general lack of transparency of performance data. Stakeholders do not share data as stated by the Civil Contingency Act (difficult to enforce) and point to “commercial sensitivity”. Moreover, there are deficient communication platforms and infrastructure to facilitate collaboration on critical community infrastructures and maintenance. For example, difficulties of knowing the status and quality of their infrastructures (e.g. maintenance needs in an aging infrastructure). Worries are centred on new economic and climate change impacts related to the infrastructure, for example, related to maintenance and funding resources. Vejle’s challenges relate to problems with flooding, rain and an increased dependence on vulnerable digital solutions. Moreover, a pronounced problem is to involve civil society and companies to support the welfare readiness to possible disasters. Some cities work with radicalisation and violent extremism, increased unemployment and ways to keep competence within the region.

5.3 CONCLUSIONS

The cities' infrastructure sits within complex national and global frameworks with inherent co-dependencies and weak points. Basically, all cities stated that electric power, water supply and communications (transport and ICT) were 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 renders managing the infrastructures on 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. Threats to the infrastructure are not general to the cities with local conditions and risks that must be managed. 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.

6 SUMMARY AND CONCLUSIONS

In this section we summaries the main findings from the three studies (1) systematic literature review of urban resilience, (2) review of world-wide reports and networks related to city resilience and, (3) city survey of the approaches and challenges for the SMR partner cities.

SUMMARY OF MAIN CONCLUSIONS

- ✓ There are many definitions and perspectives of resilience used in literature
- ✓ Research frameworks for community resilience are abstract and difficult to directly apply to urban planning and decision-making
- ✓ There is a need for resilience tools to go from theory to practice
  - Defining the boundaries and dimensions for urban resilience is challenging
  - Defining the boundaries for community professionals work is challenging
- ✓ Political and financial support is an important factor to increase urban resilience
  - Much of policy and the related decision-making regarding the resilience is outside the jurisdiction of the cities which inhibit their response to disasters and problems
  - A present city strategy to improve resilience work is to seek better communication among different stakeholders and to pool resources locally and regionally.
- ✓ Social engagement is central to community resilience
- ✓ Best practices and guidelines for risk reduction and resilience have been developed by several organisations including UNISDR and cities London, Copenhagen and Rotterdam.

➔ **There are many definitions of resilience used in literature**

There are many definitions used in the literature. They can be distinguished through analysis of their underlying assumptions on the number of equilibriums. The definitions that see resilience as a single equilibrium phenomena tend to describe resilience as an ability to bounce back or retain the functionality in face of disasters or other extreme events. Definitions that base their understanding on a multi equilibrium view tend to emphasize the systems' or societies' ability to adapt, learn and change. Single equilibrium models see resilience as a passive property of the system while multi equilibrium models see it as an active process that needs to be pursued.

Resilience is a broad term and the definition varies widely depending on one's field of research, as certain aspects are more important than others. Common to most definitions of the concept is, however, that resilience deals with a system's ability to cope with unexpected events, absorb the impact of the event and recover after the event has occurred.

➔ **There is a need for resilience tools to go from theory to practice**

A frequent topic in the literature is how to go from theory to practice, that is, from normative to descriptive applications of resilience. The challenges are manifold, as multiple dimensions and parameters must be defined to implement resilience models. The complexity of cities, with multiple interconnected factors and the dynamic nature of today ever-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.

➔ **Research frameworks for urban resilience are abstract and difficult to directly apply to the urban planning and decision-making.**

In the reviewed literature there is a consensus that research in urban resilience has overlooked important couplings between different dimensions of community management, including both the social and physical aspects. To address the gap, the research frameworks include very high-level concepts, which offer a way to see the vast amount of stakeholders involved and the flow between different dimensions. The downside of the more general models of resilience is that they cannot be directly applied to urban resilience but have to be translated to specific work contexts, indicators and measurements. In this sense, the frameworks are useful on a conceptual and theoretical level, but still far from being available for practical use for the community worker.

Further, there is a large variety in the attributes/indicators used in the research frameworks, which reflects 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 the areas of application on a high level are similar, the cases described vary considerably, as well as 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.

➔ **Political and financial support is an important factor to increase urban resilience**

The literature points out other influencing factors such as the financial and political capital of the city. To make changes all these aspects come into play. Without decision-makers putting in place policies it is challenging to make a difference. This finding is further emphasized in the city survey. A main difficulty for the partner cities is that much of policy and the related decision-making regarding the resilience is outside the jurisdiction of the cities which inhibit their response to disasters and problems. The dependencies, numerous stakeholders (subcontractors) and legal frameworks renders managing the infrastructures on the local level difficult. A present strategy in the resilience work by the partner cities is to seek for better communication among different stakeholders and to pool resources locally and regionally. The strategy was echoed in the literature review as a central factor for successful implementation of policies.

➔ **Social engagement is central to urban resilience**

Resilience in urban environments is heavily influenced by the people living in it. The reviewed literature has in several instances refered to the fact that more vulnerable citizens make a society increasingly hazard prone, and that changes is the behavior and social practice is an important factor. Strategies to increase resilience should be to have well-informed citizens and promoting self-protective behavior. Involving local stakeholders also has the benefit of building trust in a community and identifying local needs, which in turn may increase the resilience of said community, as mentioned also in the city survey. To create resilience it is not sufficient to create new policies, it is also critical to have support from the community in order to make changes.

➔ **Best practices and guidelines for risk reduction and resilience have been developed by several organisations including UNISDR and cities London, Copenhagen and Rotterdam.**

There have been several tools and guidelines developed to practically support the implementation of resilient cities. These approaches to local management and resilience is an important resource when operationalising research-based models for urban resilience. Another resource is the identified ten initiatives working towards urban resilience. Moreover, qualitative and quantitative indicators have been developed by several stakeholders, outside research, to measure the urban resilience and the level of climate change risk reduction. However, quantitative indicators mostly relate to the GHG emission level. The qualitative indicators measures are focussed on the available infrastructure (legislation, organisation, leadership) and services that support resilience such as health and social stability/security.

A main challenge for urban resilience – as reported by organisational bodies outside research – is related to economy and the problem of financing resilience-supporting measures.

7 REFERENCES

Adger, W. N. (2006). Vulnerability. *Global Environmental Change*, *16*(3), 268–281. http://doi.org/10.1016/j.gloenvcha.2006.02.006

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

Ainuddin, S., & Routray, J. K. (2012). Community resilience framework for an earthquake prone area in Baluchistan. *International Journal of Disaster Risk Reduction*, *2*(1), 25–36. http://doi.org/10.1016/j.ijdrr.2012.07.003

Aldunce, P., Beilin, R., Handmer, J., & Howden, M. (2014). Framing disaster resilience: The implications of the diverse conceptualisations of "bouncing back." *Disaster Prevention and Management*, *23*(3), 252–270. http://doi.org/10.1108/DPM-07-2013-0130

Aldunce, P., Beilin, R., Howden, M., & Handmer, J. (2015). Resilience for disaster risk management in a changing climate: Practitioners' frames and practices. *Global Environmental Change*, *30*, 1–11. http://doi.org/10.1016/j.gloenvcha.2014.10.010

Amico, A. D. ., & Currà, E. (2014). The Role of Urban Built Heritage in Qualify and Quantify Resilience. Specific Issues in Mediterranean City. *Procedia Economics and Finance*, *18*, 181–189. http://doi.org/10.1016/S2212-5671(14)00929-0

Baker, S. M. (2009). Vulnerability and Resilience in Natural Disasters: A Marketing and Public Policy Perspective. *Journal of Public Policy & Marketing*, *28*(1), 114–123. http://doi.org/10.1509/jppm.28.1.114

Berkes, F. (2007). Understanding uncertainty and reducing vulnerability: lessons from resilience thinking. *Natural Hazards*, *41*(2), 283–295. http://doi.org/10.1007/s11069-006-9036-7

Birkmann, J., Cardona, O. D., Carreño, M. L., Barbat, A. H., Pelling, M., Schneiderbauer, S., … Welle, T. (2013). Framing vulnerability, risk and societal responses: the MOVE framework. *Natural Hazards*, *67*(2), 193–211. http://doi.org/10.1007/s11069-013-0558-5

Boin, A., & McConnell, A. (2007). Preparing for Critical Infrastructure Breakdowns: The Limits of Crisis Management and the Need for Resilience. *Journal of Contingencies and Crisis Management*, *15*(1), 50–59. http://doi.org/10.1111/j.1468-5973.2007.00504.x

Bruneau, M., Chang, S. E., Eguchi, R. T., Lee, G. C., O'Rourke, T. D., Reinhorn, A. M., … Von Winterfeldt, D. (2003). A Framework to Quantitatively Assess and Enhance the Seismic Resilience of Communities. *Earthquake Spectra*, *19*(4), 733–752. http://doi.org/10.1193/1.1623497

Campanella, T. J. (2006). Urban Resilience and the Recovery of New Orleans. *Journal of the American Planning Association*, *72*(2), 141–146. http://doi.org/10.1080/01944360608976734

Carpenter, S., Arrow, K., Barrett, S., Biggs, R., Brock, W., Crépin, A.-S., … Zeeuw, A. (2012). General Resilience to Cope with Extreme Events. *Sustainability*, *4*(12), 3248–3259. http://doi.org/10.3390/su4123248

Cefai, C., Matsopoulos, A., Bartolo, P., Galea, K., Gavogiannaki, M., Zanetti, M. A., … Lebre, P. (2014). Kurikul otpornosti za rane godine i osnovnu školu u Europi: Poboljšavanje kvalitetnog obrazovanja. *Croatian Journal of Education*.

Chelleri, L., Waters, J. J., Olazabal, M., & Minucci, G. (2015). Resilience trade-offs: addressing multiple scales and temporal aspects of urban resilience. *Environment and Urbanization*, *27*(1),

181–198. http://doi.org/10.1177/0956247814550780
Cimellaro, G. P., Reinhorn, A. M., & Bruneau, M. (2010). Framework for analytical quantification of disaster resilience. *Engineering Structures*, *32*(11), 3639–3649. http://doi.org/10.1016/j.engstruct.2010.08.008
Cocchiglia, M., Molin, H., Valdés, A. R., Scott, J., Jaime, V., & Aguayo, P. B. (2012). *How To Make Cities More Resilient A Handbook For Local Government Leaders*. Retrieved from http://www.unisdr.org/files/26462_handbookfinalonlineversion.pdf
Council-of-Europe. (2012). Making cities resilient - Resolution 339. Retrieved January 12, 2016, from https://wcd.coe.int/ViewDoc.jsp?id=1924609&Site=Congress&BackColorInternet=C3C3C3&BackColorIntranet=CACC9A&BackColorLogged=EFEA9C
Cutter, S. L., Barnes, L., Berry, M., Burton, C., Evans, E., Tate, E., & Webb, J. (2008a). A place-based model for understanding community resilience to natural disasters. *Global Environmental Change*, *18*(4), 598–606. http://doi.org/10.1016/j.gloenvcha.2008.07.013
Cutter, S. L., Barnes, L., Berry, M., Burton, C., Evans, E., Tate, E., & Webb, J. (2008b). A place-based model for understanding community resilience to natural disasters. *Global Environmental Change*, *18*(4), 598–606. http://doi.org/10.1016/j.gloenvcha.2008.07.013
Da Silva, J., & Moench, M. (2014). *City Resilience Framework*. Retrieved from http://www.seachangecop.org/files/documents/URF_Booklet_Final_for_Bellagio.pdf\nhttp://www.rockefellerfoundation.org/uploads/files/0bb537c0-d872-467f-9470-b20f57c32488.pdf\nhttp://resilient-cities.iclei.org/fileadmin/sites/resilient-cities/files/Images_an
Davies, T. (2015). Developing resilience to naturally triggered disasters. *Environment Systems and Decisions*, (April), 237–251. http://doi.org/10.1007/s10669-015-9545-6
Davis, S., Karikas, D., Kerstholt, J., Lindt, M. Van De, Duijnhoven, H., & Dinesen, C. (2015). *Community Resilience Model*.
Desouza, K. C., & Flanery, T. H. (2013a). Designing, planning, and managing resilient cities: A conceptual framework. *Cities*, *35*, 89–99. http://doi.org/10.1016/j.cities.2013.06.003
Desouza, K. C., & Flanery, T. H. (2013b). Designing, planning, and managing resilient cities: A conceptual framework. *Cities*, *35*, 89–99. http://doi.org/10.1016/j.cities.2013.06.003
Djalante, R., Thomalla, F., Sinapoy, M. S., & Carnegie, M. (2012). Building resilience to natural hazards in Indonesia: progress and challenges in implementing the Hyogo Framework for Action. *Natural Hazards*, *62*(3), 779–803. http://doi.org/10.1007/s11069-012-0106-8
European Environment Agency. (2012). *Urban adaptation to climate change in Europe*. Retrieved from http://www.eea.europa.eu/publications/urban-adaptation-to-climate-change
Evans, J. P. (2011). Resilience, ecology and adaptation in the experimental city. *Transactions of the Institute of British Geographers*, *36*(2), 223–237. http://doi.org/10.1111/j.1475-5661.2010.00420.x
Fainstein, S. (2015). Resilience and Justice. *International Journal of Urban and Regional Research*, *39*(1), 157–167. http://doi.org/10.1111/1468-2427.12186
Folke, C. (2006). Resilience: The emergence of a perspective for social–ecological systems analyses. *Global Environmental Change*, *16*(3), 253–267. http://doi.org/10.1016/j.gloenvcha.2006.04.002
For, H., & Government, L. (2012). *How to Make Cities More Resilient*.
Fox-Lent, C., Bates, M. E., & Linkov, I. (2015). A matrix approach to community resilience assessment: an illustrative case at Rockaway Peninsula. *Environment Systems and Decisions*, *35*(2), 209–218. http://doi.org/10.1007/s10669-015-9555-4
Fuchs, S. (2009). Susceptibility versus resilience to mountain hazards in Austria - paradigms of

vulnerability revisited. *Natural Hazards and Earth System Science*, *9*(2), 337–352. http://doi.org/10.5194/nhess-9-337-2009

Füssel, H. M. (2007). Vulnerability: A generally applicable conceptual framework for climate change research. *Global Environmental Change*, *17*(2), 155–167. http://doi.org/10.1016/j.gloenvcha.2006.05.002

Georgi, B., Isoard, S., Blaz, K., Valentin, L. F., Ronan, U., & Jol, A. (2012). *Urban adaptation to climate change in Europe*. Retrieved from http://www.klimatilpasning.dk/media/5367/eea-report-2-2012.pdf

Gunderson, L. (2010). Ecological and human community resilience in response to natural disasters. *Ecology and Society*, *15*(2), 29. http://doi.org/18

Guz, A. N., & Rushchitsky, J. J. (2009). Scopus: A system for the evaluation of scientific journals. *International Applied Mechanics*, *45*(4), 351–362.

Hagen, K., Tzanetakis, M., & Watson, H. (2015). Cascading effects in crises : categorisation and analysis of triggers. In L. Palen, M. Büscher, M. Comes, & A. L. Hughes (Eds.), *Proceedings of the 12th International ISCRAM Conference*. Kristiansand, Norway.

Harman, B. P., Taylor, B. M., & Lane, M. B. (2015). Urban partnerships and climate adaptation: challenges and opportunities. *Current Opinion in Environmental Sustainability*, *12*, 74–79. http://doi.org/10.1016/j.cosust.2014.11.001

Holling, C. S. (1973). Resilience and Stability of Ecological Systems. *Annual Review of Ecology and Systematics*. http://doi.org/10.1146/annurev.es.04.110173.000245

Holling, C. S. (2001). Understanding the Complexity of Economic, Ecological, and Social Systems. *Ecosystems*, *4*(5), 390–405. http://doi.org/10.1007/s10021-001-0101-5

Isoard, S., & Winograd, M. (2013). *Adaptation in Europe*. Retrieved from http://www.eea.europa.eu/publications/adaptation-in-europe/at_download/file

Jabareen, Y. (2013). Planning the resilient city: Concepts and strategies for coping with climate change and environmental risk. *Cities*, *31*, 220–229. http://doi.org/10.1016/j.cities.2012.05.004

Kavanaugh, E. M. and L. (2015). *Resilient Cities Report 2015 Global developments in urban adaptation and resilience*. Retrieved from http://resilient-cities.iclei.org/

Keogh, D. U., Apan, A., Mushtaq, S., King, D., & Thomas, M. (2011). Resilience, vulnerability and adaptive capacity of an inland rural town prone to flooding: A climate change adaptation case study of Charleville, Queensland, Australia. *Natural Hazards*, *59*(2), 699–723. http://doi.org/10.1007/s11069-011-9791-y

Kitchenham, B. (2004). *Procedures for performing systematic reviews*. *Joint Technical Report, Computer Science Department, Keele University*. Retrieved from http://csnotes.upm.edu.my/kelasmaya/pgkm20910.nsf/0/715071a8011d4c2f482577a700386d3a/$FILE/10.1.1.122.3308[1].pdf\nhttp://tests-zingarelli.googlecode.com/svn-history/r336/trunk/2-Disciplinas/MetodPesquisa/kitchenham_2004.pdf

Kitchenham, B. a., Budgen, D., & Pearl Brereton, O. (2011). Using mapping studies as the basis for further research - A participant-observer case study. *Information and Software Technology*, *53*(6), 638–651. http://doi.org/10.1016/j.infsof.2010.12.011

Kuhlicke, C. (2013). Resilience: A capacity and a myth: Findings from an in-depth case study in disaster management research. *Natural Hazards*, *67*(1), 61–76. http://doi.org/10.1007/s11069-010-9646-y

Larkin, S., Fox-Lent, C., Eisenberg, D. a., Trump, B. D., Wallace, S., Chadderton, C., & Linkov, I. (2015). Benchmarking agency and organizational practices in resilience decision making.

http://doi.org/10.1007/s10669-015-9554-5
Larsen, K., & Gunnarsson-Östling, U. (2009). Climate change scenarios and citizen-participation: Mitigation and adaptation perspectives in constructing sustainable futures. *Habitat International*, *33*(3), 260–266. http://doi.org/10.1016/j.habitatint.2008.10.007
Lei, Y., Wang, J., Yue, Y., Zhou, H., & Yin, W. (2014). Rethinking the relationships of vulnerability, resilience, and adaptation from a disaster risk perspective. *Natural Hazards*, *70*(1), 609–627. http://doi.org/10.1007/s11069-013-0831-7
Malalgoda C and Amaratunga D. (2015). A disaster resilient built environment in urban cities: The need to empower local governments. *International Journal of Disaster Resilience in the Built Environment*, *6*(1), 102–116.
Malalgoda, C., Amaratunga, D., & Haigh, R. (2014). Challenges in Creating a Disaster Resilient Built Environment. *Procedia Economics and Finance*, *18*, 736–744. http://doi.org/10.1016/S2212-5671(14)00997-6
Manyena, S. B. (2006). The Concept of Resilience Revisited. *Disasters*, *30*(4), 433–450. http://doi.org/10.1111/j.0361-3666.2006.00331.x
Masten, A. S., & Obradovic, J. (2008). Disaster preparation and recovery: Lessons from research on resilience in human development. *Ecology and Society*, *13*(1). Retrieved from http://www.scopus.com/inward/record.url?eid=2-s2.0-50149091123&partnerID=tZOtx3y1
McDaniels, T., Chang, S., Cole, D., Mikawoz, J., & Longstaff, H. (2008). Fostering resilience to extreme events within infrastructure systems: Characterizing decision contexts for mitigation and adaptation. *Global Environmental Change*, *18*(2), 310–318. http://doi.org/10.1016/j.gloenvcha.2008.03.001
Miles, S. B. (2015). Foundations of community disaster resilience: Well-being, identity, services, and capitals. *Environmental Hazards*, *7891*(January), 1–19. http://doi.org/10.1080/17477891.2014.999018
Ouyang, M. (2014). Review on modeling and simulation of interdependent critical infrastructure systems. *Reliability Engineering and System Safety*, *121*, 43–60. http://doi.org/10.1016/j.ress.2013.06.040
Ouyang, M., Dueñas-Osorio, L., & Min, X. (2012). A three-stage resilience analysis framework for urban infrastructure systems. *Structural Safety*, *36-37*, 23–31. http://doi.org/10.1016/j.strusafe.2011.12.004
Pendall, R., Foster, K. a., & Cowell, M. (2010). Resilience and regions: Building understanding of the metaphor. *Cambridge Journal of Regions, Economy and Society*, *3*(1), 71–84. http://doi.org/10.1093/cjres/rsp028
Perks, J. (2013). *Adaptation Strategies for European Cities: Final Report*. Retrieved from http://climate-adapt.eea.europa.eu/documents/18/11155975/Adaptation_Strategies_for_European_Cities_Final_Report.pdf
Pizzo, B. (2015). Problematizing resilience: Implications for planning theory and practice. *Cities*, *43*, 133–140. http://doi.org/10.1016/j.cities.2014.11.015
Restemeyer, B., Woltjer, J., & van den Brink, M. (2013). A strategy-based framework for assessing the flood resilience of cities - a Hamburg case study. *AESOP Young Academics Meeting 2013*, *9357*(April), 13. http://doi.org/10.1080/14649357.2014.1000950
Ricardo-AEA. (2013). *Adaptation Strategies for European Cities*. Retrieved from http://climate-adapt.eea.europa.eu/documents/18/11155975/Adaptation_Strategies_for_European_Cities_Fina

l_Report.pdf
Rodriguez-Nikl, T. (2015). Linking disaster resilience and sustainability. *Civil Engineering and Environmental Systems*, *32*(1-2), 157–169. http://doi.org/10.1080/10286608.2015.1025386
Sherrieb, K., Norris, F. H., & Galea, S. (2010). Measuring Capacities for Community Resilience. *Social Indicators Research*, *99*(2), 227–247. http://doi.org/10.1007/s11205-010-9576-9
Simmie, J., & Martin, R. (2010). The economic resilience of regions: towards an evolutionary approach. *Cambridge Journal of Regions, Economy and Society*, *3*(1), 27–43. http://doi.org/10.1093/cjres/rsp029
Singh-Peterson, L., Salmon, P., Baldwin, C., & Goode, N. (2015). Deconstructing the concept of shared responsibility for disaster resilience: a Sunshine Coast case study, Australia. *Natural Hazards*, *79*(2), 755–774. http://doi.org/10.1007/s11069-015-1871-y
Smit, B., & Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. *Global Environmental Change*, *16*(3), 282–292. http://doi.org/10.1016/j.gloenvcha.2006.03.008
Somers, S. (2009). Measuring Resilience Potential: An Adaptive Strategy for Organizational Crisis Planning. *Journal of Contingencies and Crisis Management*, *17*(1), 12–23. http://doi.org/10.1111/j.1468-5973.2009.00558.x
Stewart, G. T., Kolluru, R., & Smith, M. (2009). Leveraging public-private partnerships to improve community resilience in times of disaster. *International Journal of Physical Distribution & Logistics Management*, *39*(5), 343 – 364.
Teodorescu, H.-N. L. (2015). Defining resilience using probabilistic event trees. *Environment Systems and Decisions*, *35*(2), 279–290. http://doi.org/10.1007/s10669-015-9550-9
Terenzi, A., & Wigström, A. W. (2013). *D9.1 Stakeholder Survey Report-RAMSES Project*. Retrieved from http://www.ramses-cities.eu/fileadmin/uploads/Deliverables_Uploaded/RAMSES_Survey_report_FINAL_Public.pdf
TOBIN, G. (1999). Sustainability and community resilience: the holy grail of hazards planning? *Global Environmental Change Part B: Environmental Hazards*, *1*(1), 13–25. http://doi.org/10.1016/S1464-2867(99)00002-9
UNISDR. (2009). UNISDR Terminoology on Disaster Risk Reduction. *International Stratergy for Disaster Reduction (ISDR)*, 1–30. Retrieved from www.unisdr.org/publications
UNISDR. (2015). *Sendai Framework for Disaster Risk Reduction 2015-2030*. Retrieved from http://www.unisdr.org/files/43291_sendaiframeworkfordrren.pdf
United Nations International Strategy for Disaster Reduction (UNISDR). (2015). *Sendai Framework for Disaster Risk Reduction 2015-2030 Contents*.
Walker, B., & Westley, F. (2011). Perspectives on resilience to disasters across sectors and cultures. *Ecology and Society*, *16*(2), 2–5. http://doi.org/4
Walker, J., & Cooper, M. (2011). Genealogies of resilience: From systems ecology to the political economy of crisis adaptation. *Security Dialogue*, *42*(2), 143–160. http://doi.org/10.1177/0967010611399616
Weichselgartner, J., & Kasperson, R. (2010). Barriers in the science-policy-practice interface: Toward a knowledge-action-system in global environmental change research. *Global Environmental Change*, *20*(2), 266–277. http://doi.org/10.1016/j.gloenvcha.2009.11.006
Weichselgartner, J., & Kelman, I. (2015). Geographies of resilience : Challenges and opportunities of a descriptive concept. *Progress in Human Geography*, *39*(3), 249–267. http://doi.org/10.1177/0309132513518834
Wendler, R. (2012). The maturity of maturity model research: A systematic mapping study. *Information*

and Software Technology, *54*(12), 1317–1339. http://doi.org/10.1016/j.infsof.2012.07.007

Vogel, C., Moser, S. C., Kasperson, R. E., & Dabelko, G. D. (2007). Linking vulnerability, adaptation, and resilience science to practice: Pathways, players, and partnerships. *Global Environmental Change*, *17*(3-4), 349–364. http://doi.org/10.1016/j.gloenvcha.2007.05.002

World Commission on Environment and Development. (1987). Report of the World Commission on Environment and Development: Our Common Future (The Brundtland Report). *Medicine, Conflict and Survival*, *4*(1), 300. http://doi.org/10.1080/07488008808408783

Zaidi, R. Z., & Pelling, M. (2015). Institutionally configured risk: Assessing urban resilience and disaster risk reduction to heat wave risk in London. *Urban Studies*, *52*(7), 1218–1233. http://doi.org/10.1177/0042098013510957

Zhou, H., Wang, J., Wan, J., & Jia, H. (2010). Resilience to natural hazards: A geographic perspective. *Natural Hazards*, *53*(1), 21–41. http://doi.org/10.1007/s11069-009-9407-y

Zobel, C. W. (2011). Representing perceived tradeoffs in defining disaster resilience. *Decision Support Systems*, *50*(2), 394–403. http://doi.org/10.1016/j.dss.2010.10.001

Zobel, C. W., & Khansa, L. (2014). Characterizing multi-event disaster resilience. *Computers & Operations Research*, *42*, 83–94. http://doi.org/10.1016/j.cor.2011.09.024

Zolli, A., & Healy, A. M. (2012). *Resilience: Why things bounce back*. London, UK: Headline Publishing Group.

ANNEX 1. FRAMEWORKS TABLE

Framework type and authors presents the framework name or central concept where no name is given and the authors. *Key features* described the main objective of the proposed framework. *Key attributes/indicators* offer an overview of the framework central concepts. *Target area* describes the areas in which the framework is intended for. A*pplication* notes if the framework has been applied or not. *Comment applicability* describes particular or outstanding features of the framework.

Framework type and Authors	Key features	Key attributes/indicators	Target area	Application	Comments
Enabling conditions for general resilience Carpenter, 2012	Aims to go beyond socio-ecological and includes literature on natural disasters, social vulnerability, scenario planning, and adaptive management.	Enabling condition for general resilience: - Diversity - Modularity - Openness - Reserves - Feedback - Nestedness - Monitoring - Leadership - Trust	Urban/city resilience Economic resilience, Climate change, Man-made hazard	Not applied	Challenge is to transform this into concrete plans and action
Resilient cities framework	Holistic approach to designing, planning, and	Framework includes reducing cities into elements:	Holistic urban resilience	Not applied	Framework is developed based on 20 case studies

Desouza, 2013	managing for resilience by including an evaluation of cultural and process dynamics within cities as well as their physical elements.	- Urban system design - Planning and management - Physical and social process - Spatial and temporal Strategies for resilience: - Assume change and uncertainty - Nurture conditions for recovery and renewal after disturbance - Combine different types of knowledge for learning - Create opportunities of self-organisation			Focus on flow in and out of cities. Strategies are intended to help direct the development.
The MOVE framework (Methods for Improvement of Vulnerability Assessment in Europe)	Holistically assess vulnerability and resilience in response to hazards.	Exposure: geographical range of a hazard event - Susceptibility describes the predisposition of elements at risk to suffer harm	Natural hazards (disaster risk)	Hypothetic illustration of application on flooding and earthquake in Europe	Based on review of previous frameworks

Birkmann, 2011		- Lack of resilience (limitation of access to and mobilization of the resources) - Hazard potential occurrence of a hazard. - (multi-dimension, social, economic, physical, cultural, environmental, institutional)			
The DRLRL (Disaster Resilience of "Loss-Response" of Location) Zhou, 2009	A model for a geographic perspective of resilience	Risk (resistance/relief/loss potential) filtered through: - Social resilience (ability to respond, adaptive resilience) - Biophysical resilience (geographical context, inherent resilience) Dimensions: - Attribute (Economic, institutional, social, environmental)	Community/societal resilience, Organisational/local government resilience, Economic resilience, Natural hazard, Climate change	Case study on agricultural drought in China.	Building at various spatial levels. Offers the link to the geographical area as a determining factor of resilience.

		- Space (Community, Town, County, Province, Country) - Time (Pre-, In-, Post-, Next disaster)			
A conceptual framework of vulnerability, resilience, and adaptation Yongdeng, 2014	Relationships of vulnerability, resilience, and adaptation within the disaster risk domain.	Vulnerability (inner attribute) Resilience (reactive response) Adaptive Capacity (protective action)	Natural hazard, Climate change	Case study on agricultural drought in China	Focus on disaster risk (short term). May not fit other domains with longer time scales.
Common reference framework Cimellaro, 2010	Quantitative evaluation of disaster resilience offering unified terminology for a common reference framework.	Engineering resilience: - Capability to sustain a level of functionality or performance from a given building (quantified) - Recovery time the period necessary to restore functionality of a structure	Natural hazard	Two application for hospital network hit by earthquake	Includes only quantitative assessments. Assumptions made are only representative for the cases presented.
Three-stage resilience	Mathematical model to measure	Engineering resilience of a power grid:	Natural hazard, Man-made hazard,	Case study of the power	Does not include dynamic resources.

analysis framework Min Ouyang, Leonardo Dueñas-Osorio, Xing Min, 2012	infrastructure resilience.	- Resistance capacity - Absorptive capacity - Restorative capacity		transmission grid in USA	Mathematical model for technical resilience.
Conceptual framework of resilience and sustainability Tonatiuh Rodriguez-Nikl, 2015)	A conceptual framework to understand the relationship between resilience and sustainability	Engineering resilience: Sustainability in two dimensional graph: Quality (health of the city) Time Resilience: typically only offers a brief moment in time (but using the same indicators)	Sustainability, Resilience	Case study of a coastal town subject to sea-level rise and large storms	Focuses mainly on the link between resilience and sustainability. Mathematical model to measure the health of a city. Does not provide indicators.
Conceptual framework for resilience in infrastructure	Conceptual framework for resilience within infrastructure	- Robustness (the extent of system function that is maintained) and	Organisational/local government resilience, Natural hazard	Not applied	Measurements of robustness and rapidity in quantitative terms but describe

McDaniels, 2008	systems after an extreme event. Characteristics of a framework through the use of flow diagrams for understanding decision types that can be pursued.	- Rapidity (the time required to return to full system operations and productivity). Characterizations: - socio-technical context - pre-disaster planning - vulnerability - Hazard - Robustness - Adaptation - Rapidity - Learning		Discussion on hospitals and earthquakes from an infrastructure point of view	their decision model in qualitative terms (not applied)
RCPF (the Resilient City Planning Framework) Jabareen, 2013	The framework aims to fill the theoretical and practical gaps and answer questions regarding what cities and their urban communities should do in order to move towards a more resilient future state.	- Vulnerability Analysis matrix (uncertainty, informality, demography, spatiality) - Uncertainty Oriented Planning (Adaptation, planning, sustainable form) - Prevention (Mitigation, Restructuring, Alternative Energy)	Climate change Urban infrastructures.	Not applied	Lacks description of how to measure/evaluate the concepts Suggests both qualitative and quantitative measurements depending on definition of data

		- Urban Governance (equity, integrative, economics) Offers a set of questions/measurements for each area (p 227)			
Strategy based framework Restemeyer et al., 2015	A strategy-based framework for assessing the flood resilience of cities. Identification of components to implement resilience strategies. Aims to move from definition to "doing" resilience.	- Content (policy instruments), - Context (strategic issues, institutional structure), - Process (intellectual, social and political capital) The categories above are analysed in terms of Robustness, Adaptability, Transformability Deals with measures, strategic/institutional aspects, and different capital	Natural hazard, Climate change	Case study of flooding in Hamburg	Focused on flooding scenario

Theoretical framework for community resilience Stewart, Geoffrey T Kolluru, Ramesh Smith, Mark, 2009	A framework of community resilience to understand the ability of impacted areas to effectively manage the consequences of disasters	- Public-private relationships - Supply chain resilience - Critical infrastructure/key resources/resilience - Community resilience (economic, social)	Community/societal resilience, Economic resilience	Not applied	Framework requires local identification of indicators.
Joint framework for community resilience Ainuddin, 2012	Review of community resilience frameworks and proposes a joint framework for community resilience	Community resilience: - Vulnerability analysis (individual/community) - Risk and Perception Awareness - Resilience Analysis (social, Economic, Physical, Institutional)	Hazards and Natural disasters	Not applied	Provides and overview of previous frameworks for community resilience Results from a household survey

Resilience Matrix (RM) framework Fox-Lent, 2015	Utilizes local stakeholder-informed metrics aligned with the temporal stages of the National Academy of Science definition of disaster resilience.	Define system boundaries Identify critical functions Select indicators and generate scores - Physical - Information - Cognitive - Social - Prepare - Absorb - Recover - Adapt	Community resilience, Primarily focus on coastal areas	Application of the RM to coastal community resilience in USA.	Uses specific metrics that have a higher and lower bound for performance and scores them. Numbers must be localized to have meaning.
A place-based model for community resilience Cutter, 2008	Developed a model that can be applied to community level resilience, primarily while viewing natural hazards.	Antecedent conditions: place specific processes (inherent vulnerability, resilience) - Hazard event conditions - Coping responses - Adaptive capacity improvisation, learning (longer term) - Degree of recovery	Community resilience, Primarily natural hazards, but also other rapid onset events	Not applied	

The WISC framework (Well-being, Identity, Social services and Capital) Miles, 2015	Foundations of community disaster resilience	- Community (Well-being, Identity) - Infrastructure (Services Capitals)	Community resilience, community infrastructure	Not applied	Fairly high level, offers some suggestions on classifications for each of the WISC
Adaptive cycle model Simmie, 2010	A four-phase adaptive cycle model of regional economic resilience that follows a sequential cycle- Each phase of the cycle is associated with different degrees of resilience, connectedness and capital accumulation or release.	Economic resilience: - Reorganisation Phase (period of innovation and restructuring) - Exploitation Phase (period of growth and seizing of opportunities - Conservation phase (period of stability and increasing rigidity - Release Phase (period of decline and destruction) - Reorganisation and restructuring	Economic resilience	Applied on two cities in the UK	Entirely focused on economic aspects

Community resilience model Sherrieb, 2010	Measure adaptive capacities for Economic Development and Social Capital in the Norris et al. (2008)	Adaptive capacity of economic and social capital: - Economic development - Social capital - Community resilience Measure resources level, equity and diversity of economic development	Economic, some aspects of community resilience	Applied to publicly available data for validation	Economic indicators, some social capital such as community involvement
Measures of latent resilience Somers, 2009	Measure latent resilience in organisations	Measures for organisational crisis planning - Goal-directed solution seeking - Risk avoidance - Critical situation understanding - Ability to fill multiple roles - Reliance on information sources - Access to resources	Organisational resilience	Applied to a public works organisation	Focused on an organisation of a limited scale, not clear how it translates to something larger

Identification of resilience aspects Berkes	How resilience aspects can help reduce vulnerability.	- Foster ecological, economic and cultural diversity - Plan for changes that are likely to occur - Foster learning - Communicate the societal consequences of recent changes	General Resilience	Not applied	Expands upon Folke's (ref) 4 factors High level strategies that need to be altered to the specific context
Singh-Peterson et al., 2015	Factors influencing the resilience of the Sunshine Coast – shared resilience among stakeholders	- Environmental - Institutional – 15 factors - Infrastructure – built environment - Social – connectedness, community skills - Economic – financial capital	Natural hazards and community resilience	Case study in Australia	Attempting to identify which stakeholder has a high level of responsibility for which factor Highly localized, same factors may not apply in all urban environments
Resilience as a capacity and a myth Kuhlicke, 2013	Develops a descriptive understanding of resilience. Aim is to include diverging interests	Factors contributing to building resilience: (1) Learning to live with **change** and uncertainties, (2) Nurturing **diversity** in its various forms,	Organisations Communities Entire systems	Case study of flooding In German city	Discussion on the usefulness of resilience for risk and disaster management to deal with

	and social and political conflicts arising from these interests Factors contributing to building resilience:	(3) Combining different types of **knowledge** for learning and (4) Creating opportunity for **self-organisation** and cross-scale linkages (Kuhlicke, 2013)			unexpected events. Focus on how narrators construct a relationship between their experiences and their subsequent sense-making of these experiences

ANNEX 2. CITY SURVEY

Resilience implementation approaches, critical infrastructure, and current challenges

Questionnaire

This questionnaire is sent out to city partners in the Horizon 2020 Smart Mature Resilience project (SMR). The purpose is to get a first overview of resilience implementation approaches, critical infrastructures and the current challenges in your city. In the next phases we will likely contact you again to gain deeper insights into the specific issues regarding your city's approaches and challenges. Please, answer the questions in free text form (MS Word, pdf or scan will do). The form will take about 30 minutes to complete. Send the answers – one form per organisation – to Magnus Bång at Linkoping University, Sweden by October 21st at the latest. If text space is an issue, you can extend the form. Researchers in the SMR GROUP will handle the information confidentially. If you have provided sensitive information in the form, please send it – in paper format – with ordinary mail to:

Dr. Magnus Bang

Thank you!

Definitions and explanations

Resilience[6]

[6] European Commission. The EU approach to Resilience: Learning from food and security crises. Communication from the Commission to the European Parliament and the Council. Brussels, 3.10.2012

Resilience is the ability of an individual, a household, a community, a country or a region to withstand, to adapt, and to quickly recover from stresses and shocks.

Critical Infrastructure Sectors[7] ***(examples)***

- Energy
- Information, Communication Technologies, ICT
- Water
- Food
- Health
- Financial
- Public & Legal Order and Safety
- Civil administration
- Transport
- Chemical and nuclear industry
- Space and Research

Name of respondent:_____

Professional role of respondent: _____

Years of experience in this role: _____

Email of respondent: _____

[7] European Commission. GREEN PAPER: ON A EUROPEAN PROGRAMME FOR CRITICAL INFRASTRUCTURE PROTECTION, Brussels, 17.11.2005.

1. **Please, state and prioritize the *five* most critical infrastructures in your city:**

   1. _____
   2. _____
   3. _____
   4. _____
   5. _____

2. **How does your city's critical infrastructure *depend on resources* coming from other cities or even cities outside your country?**

3. **What kinds of *failures and disasters* has your city experienced in the past?**

4. **Did the experienced failures and disasters described under Question 3 lead to some *changes in policies* for managing the critical infrastructures? If yes, can you briefly *explain the implemented policy changes*.**

5. **What kinds of failures and possible disasters are you specifically preparing for currently?**

6. **We want to know how you *work concretely* with resilience of the critical infrastructures in your city. Please, answer the following:**

   a. **What are your primary *goals* with respect to improving the resilience of your critical infrastructures?**

b. **What *working groups* are involved in improving the critical infrastructures? Please, state the *primary stakeholders* involved in this work effort (management, operative etc.).**

c. **What are their *roles and responsibilities*?**

d. **What kinds of *work processes* (procedures and initiatives) are being set up to strengthen the *overall resilience* of the critical infrastructures in your city?**

e. **What are the *greatest challenges* regarding the resilience of critical infrastructures in your city?**

7. **What kinds of *best practice* of resilience have already been implemented to improve your city's resilience level? (For example, incident reporting, monitoring of risks etc.)**

8. **Please, state *three important current collaborations* with other cities, regions, nations, and**

the EU with respect to the strengthening the resilience of the critical infrastructure of your city.

1. _____
2. _____
3. _____

9. **What *direct safety measures* such as physical barriers related to critical infrastructures have you *already* implemented in your city to hinder and decrease effects of failures and disasters?**

10. **Please specify any sources where we can obtain more information on your city and your approach to resilience. (Internet sources, contact persons etc.)**

ANNEX 3. RESILIENCE DEFINITIONS - EXPLORATORY

year	Subject	Author	Aim of article
2015	Political	(Fainstein, 2015)	"This essay first examines how resilience is currently being defined, then discusses the way in which it obscures power relations, notes the strengths of a Marxist framework and critiques progressive attempts to circumvent power hierarchies through calls for participation." p. 158
2011	Political	Jeremy Walker, Melinda Cooper	"This article argues for the importance of a critique of the proximity between the emergent dis- course of 'resilience' and contemporary neoliberal doctrines. We demonstrate this with an analysis of the rise of resilience in the specific cases of international finance, critical infrastructure protec- tion and contemporary approaches to 'sustainable' development." p. 145
2014	Bottom-up	Aldunce, Paulina Beilin, Ruth Handmer, John Howden, Mark	"The paper first presents the analytical framework and background information on the Natural Disaster Resilience Program (NDRP) that provides the empirical material for the study. Then, it explores how the concept of resilience is framed in the literature. The paper continues by presenting and discussing the results through the interviewees' framing of

			resilience and in particular focuses on their conceptualisation of “bouncing back” within this framing." p. 253
2015	Bottom-up	Aldunce, Paulina Beilin, Ruth Howden, Mark Handmer, John	"There is a growing use of resilience ideas within the disaster risk management literature and policy domain. However, few empirical studies have focused on how resilience ideas are conceptualized by practitioners, as they implement them in practice. Using Hajer’s ‘social-interactive discourse theory’ this research contributes to the understanding of how practitioners frame, construct and make sense of resilience ideas in the context of changes in institutional arrangements for disaster risk management that explicitly include the resilience approach and climate change considerations." p. 1
2010	Bottom-up	Juergen Weichselgartner, Roger Kasperson	"This paper presents the results of a case study analysis from the knowledge domains of vulnerability and resilience. We analyzed 20 scientific assessments to provide empirical evidence for successes and failures in collaborative knowledge production, i.e., the joint creation of assessments reports by researchers and decision makers in policy and practice." p. 266
2006	Bottom-up	Thomas J. Campanella	"This article considers the recent catastro- phe in New Orleans in terms of “urban resilience,” the capacity of a city to re- bound from destruction." p. 141

2014	Historical	A. D'Amico, E.Currà	"The paper retraces the differentiation of the concept of resilience through both a review of literature and activities of international organizations, and through a possible reorganization of the framework, focusing on urban resilience in engineering systems." p. 182
2006	Historical	Carl Folke	"The resilience perspective is increasingly used as an approach for understanding the dynamics of social–ecological systems. This article presents the origin of the resilience perspective and provides an overview of its development to date." p. 253
2010	Historical	Rolf Pendall , Kathryn A. Foster and Margaret Cowell	"We survey literatures from disciplines including ecology, psychology, disaster studies, geog- raphy, political science and economics to understand how they see resilience." p. 71
2007	Knowledge production	Coleen Vogela,, Susanne C. Moserb , Roger E. Kaspersonc , Geoffrey D. Dabelkod	"What is credible, salient and legitimate knowledge, how is this knowledge generated and how is it used in decision making? Drawing on important science in this field, and including a case study from southern Africa, we suggest an alternative mode of interaction to the usual one-way interaction between science and practice often used." p. 349
2011	Knowledge production	Evans, JP	"This paper traces one particular lineage of experimentation to resilience ecology, which rejects the possibility of external control over a system, casting planning and administrative functions, and even scientists themselves, as part of a Social-Ecological System. Using insights from political ecology, laboratory studies and urban studies, the paper explores how ecologists involved with the Long Term Ecological Research Programme in the USA are embedding adaptive experiments into urban governance." p. 223

2006	Sustainablity	Geoff O'Brien, Phil O'Keefe, Joanne Rose and Ben Wisner	"Since climate change is a source of multiple hazards that threaten long-term development actions by the international community, the consensus and planning approaches that have linked development and disaster should extend to climate change. This paper shows that this extension has not yet taken place and argues that it is urgent that it does occur." p. 65
1999	Sustainablity	Graham A. Tobin	"The focus of this paper is on the role of sustainability in hazard mitigation, emphasizing the interconnectedness of many issues at di!erent spatial scales, including aspects of globalization as it pertains to local community resilience" p. 13
2007	Synthesis	Fikret Berkes	"Many natural hazards studies have focused on floods, hurricanes, earthquakes, wildfires, ice storms and other extreme weather events, examining why people move into disaster-prone areas and how they understand risk. Most research has taken either a physical or a human emphasis. I discuss an approach that integrates the two, and helps to understand uncertainty and to reduce vulnerability—the resilience approach." p. 283-284
2014	Synthesis	Juergen Weichselgartner and Ilan Kelman	"In disaster science, policy and practice, the transition of resilience from a descriptive concept to a normative agenda provides challenges and opportunities. This paper argues that both are needed to increase resilience. Webriefly outline the concept and several recent

			international resilience-building efforts to elucidate critical questions and less-discussed issues." p. 249
2015	Synthesis	Miles, Scott B.	"Furthering the state-of-the-art of community disaster resilience scholarship and practice requires synthesizing a coherence of knowledge for the sole purpose of better understanding the subject. This theoretical study attempts to affirm, challenge, extend, and interweave disaster resilience-focused literature, while cohering this knowledge with relevant non-resilience litera- ture." p. 105
2011	Synthesis	Zobel, C	"This paper presents a new analytic approach to representing the relationship between these two characteristics by extending a multi-dimensional approach for predicting resilience into a technique for fitting the resilience function to the preferences and priorities of a given decision maker." p. 394
2008	Synthesis	Masten, Ann S. Obradovic, Jelena	"Preparing societies for major disasters calls for the integration of human research on resilience with the theory and knowledge gained from other disciplines concerned with resilience in complex, dynamic systems, and particularly those systems that interact with human individuals as disaster unfolds." p. 1
2015	Synthesis	Chelleri, L. Waters, J. J. Olazabal, M. Minucci, G.	"The concept of urban resilience has so far been related mainly to climate change adaptation and disaster management perspectives. Here we aim to broaden the discussion by showing how the framework of urban resilience should be related to wider sustainability

			challenges, including i) climate change and natural hazard threats, ii) unsustainable urban metabolism patterns and iii) increasing social inequalities in cities." p. 181
2007	Vulnerability	Hans-Martin Füssel	"This paper presents a generally applicable conceptual framework of vulnerability that combines a nomenclature of vulnerable situations and a terminology of vulnerability concepts based on the distinction of four fundamental groups of vulnerability factors." p. 155
2013	Vulnerability	J. Birkmann • O. D. Cardona • M. L. Carren˜o • A. H. Barbat • M. Pelling • S. Schneiderbauer • S. Kienberger • M. Keiler • D. Alexander • P. Zeil • T. Welle	"This paper outlines a framework for multi-dimensional, holistic vulnerability assessment that is understood as part of risk evaluation and risk management in the context of disaster risk management (DRM)1 and climate change adaptation (CCA)." p. 194
2009	Vulnerability	Stacey Menzel Baker	"This essay addresses how the definitions of disaster and vulnerability serve as guides for market and policy responses and shows how a fundamental lack of understanding of what creates a disaster and what constitutes human (and consumer) vulnerability constrains the ability of individuals, communities, and institutions to mitigate and/or recover from natural hazards and the responses that follow." p. 114

2010		Gian Paolo Cimellaro, Andrei M. Reinhorn, Michel Bruneau	The concepts of disaster resilience and its quantitative evaluation are presented and a unified terminology for a common reference framework is proposed and implemented for evaluation of health care facilities subjected to earthquakes.
2007		Rose, A	"The focus of this paper is the economic dimensions of resilience. One key dimension relates to time. Another relates to the context in which resilience takes place. The concept of static economic resilience is essentially making the best of the resources available at a given point in time, as distinct from the dynamic implications of repair and reconstruction, which affect the time-path of the economy." p. 383
2009	Historical, Vulnerability	S. Fuchs	"Acknowledging different roots of disciplinary paradigms, is- sues determining structural, economic, institutional and so- cial vulnerability are discussed with respect to mountain haz- ards in Austria." p.337
2012		Syed Ainuddin, Jayant Kumar Routray	"The objective of this paper is to analyze and review the frameworks on community resilience in the context of hazards and natural disasters and propose a community resilience framework for an earthquake prone area in Baluchistan, based on the findings of an extensive research carried out on vulnerability and resilience assessment." p. 25
2008		Jon Coaffee & Peter Rogers	"Since September 11, many cities have undergone significant changes in both morphology and management as a result of the greater perceived risk of terrorist attack. Such changes have often sought to territorialise the city through the redesign of space and the

			modernisation of management systems. More recently, such 'resilience' planning is becoming increasingly focused upon how the general public can assist this securitisation process by becoming better prepared and more responsible for their personal risk management." p. 101
2003		Richard J.T. Klein, Robert J. Nicholls , Frank Thomallaa	"This paper explores the concept of resilience to natural hazards, using weather-related hazards in coastal megacities as an example. The paper draws on the wide literature on megacities, coastal hazards, hazard risk reduction strategies, and resilience within environmental management." p. 25
2012		Mette F. Olwig	"This article aims to illuminate the mutual construction of "local" and "global" understandings and practices of resilience through multi-sited processes." p. 112