SMART MATURE RESILIENCE

D1.2 SURVEY REPORT ON EU-SECTORIAL APPROACHES

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Author (s)	Jaziar Radianti (CIEM)
Co-author(s)	Jose J. Gonzalez (CIEM), Leire Labaka, Josune Hernantes, Maider Sainz (TECNUN), Amy Rankin (LiU).
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Revision Co-Authors and reviewed by	Mihoko Sakurai, Tim A. Majchrzak (CIEM), Henrik Eriksson (LiU), Bernhard Kempen, René Lindner (DIN), Igor Pyrko, Susan Howick (Strath), Vasileios Latinos (ICLEI).

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EXECUTIVE SUMMARY

Deliverable 1.2 (D1.2) is a report containing an analysis of European Sectorial approaches to resilience. The report includes (1) an overview of EU sectoral policies that is relevant for city resilience (2) a systematic literature review of three problem areas covered in SMR project: resilience in critical infrastructure, climate change and social dynamics, (3) a review of EU project reports both FP7 and H2020 in the area of Secure Societies and Climate Change related to resilience in these three problem areas and the city resilience is a part of the focus, and (4) repository of policies and best practices as well as metric and indicators identified from this review. The work in this deliverable has been aimed at a deepening our understanding of European dimension of resilience. The report will provide a basis for the SMR project when operationalising the concept of resilience to a practical level and city context as a backbone for resilience of European cities. In each problem area, we pose the following questions:

- What are the different EU policy sectors concerned with regarding resilience “in practice“?
- How have different EU projects interpreted, defined, used and applied the resilience concepts in critical infrastructure, climate change, and social dynamics sectors?
- What kinds of resilience challenges and approaches exist in the area of critical infrastructure, climate change, and social dynamics?
- How is the resilience concept applied in different EU sectorial projects?
- What are the recommended policies to increase the city resilience with respect to the critical infrastructure?
- How can the sectorial application of resilience be linked to urban or city resilience, or even to be a backbone of EU city resilience?

Results from the work of this task show the different applications of resilience concepts in EU sectorial policies and projects in each problem area. At the higher level of EU sectorial policies, resilience concept is known but fragmented across different sectors, and is not always connected to the unexpected events and disaster preparedness, neither is it a part of managerial practice. EU resilience management guidelines can be a way to integrate different EU sectorial policies and to build a comprehensive disaster resilience framework that is applicable for different EU sectors with a city at a core. In addition, the review has identified common topics in the areas of critical infrastructure resilience, climate change resilience, and social dynamics.

The analysis in critical infrastructure area shows the resilience is mostly used interchangeably or together with protection concepts, although there are more growing attention on the intertwined across

CI sectors where the interdependencies and cascading effects play a role. However, most recent projects have started to include the concept of adaptive capacity to climate change link to critical infrastructure by, e.g. taking into consideration whether or not the critical infrastructure facilities located in the hazard-prone areas.

The analysis in the climate change area shows that the transition toward the city and urban resilience in a number of climate change-related projects is evident, especially after the adoption of EU strategy for adaptation to climate change in 2013. Prior to 2013, the city resilience is often linked to resilience against floods. The recent trends show that city resilience to climate change is the interplay of three measures: the city infrastructure (grey measures), the city environment (green measures), and adapting the human behaviours (soft measures). Furthermore, analysis of climate change linking to the city resilience has touched upon the following topics: the governance (organisations, risks multilevel governance), public-private partnerships and financing the resilience.

The link between social dynamics and resilience is also an elusive one when comes to implementation and operationalisation. The problems point into several directions: it is about adaptive capacity to CC and human health; it is about social vulnerability and how to increase social resilience of these vulnerable groups in the society, including how to integrate the asylum seekers into the European society, and it is about the individual ability to cope with and recover from hazards.

Overall, there is a huge variety of policy suggestions across the numerous EU projects targeting resilience, but no consensus what can be considered as policy for enhancing city resilience and apparently no guidelines to implement it. Furthermore, operationalisation and measuring the resilience of the city is still lacking.

In the end of this document we try to link all the most important dimensions and indicators that have been identified from the EU projects and policies with respect to these three problem areas, as a repository to build further the European Resilience Management Guideline.

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1 INTRODUCTION

1.1 SMR PROJECT BASICS

Smart Mature Resilience (SMR) is a research project that aims at developing and validating European Resilience Management Guidelines using three pilot projects in three cities covering problem areas: Critical Infrastructures, climate change and social dynamics. Beyond delivering the validated Resilience Management Guideline, the SMR project establishes as a project result an emergent European Resilience Backbone consisting of adopters, from fully committed through direct project participation to alerted potential adopters. Within the SMR project the adopters are seven cities that are members of the consortium, viz. Bristol, Donostia/San Sebastian, Glasgow, Kristiansand, Riga, Rome and Vejle.

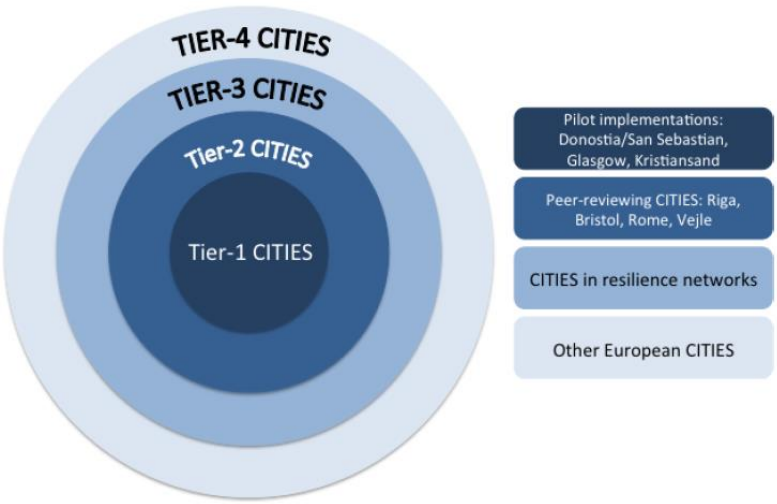

Figure 1 Circle of Sharing and Learning (Source: SMR Proposal)

A set of Resilience Management Guidelines and a set of practical tools will be implemented in Tier-1 cities (Donostia/San Sebastian, Glasgow and Kristiansand). Through their participation in the project workshops and their peer reviewing activity, the other four cities (Bristol, Riga, Rome and Vejle) will have a sense of ownership and feeling obliged of the tools and the Resilience Management Guidelines, thus becoming early adopters (Tier-2). Eventually, the SMR will reach cities in the existing resilience networks such as Mayor Adapt, 100 Resilience Cities (Tier-3), and other European cities that have not

yet been exposed to the city resilience notion (Tier-4). In short, SMR will create a resilience backbone that that is expected to have an increasing impact on European cities.

This report provides a survey overview of previous and current EU sectorial approaches on resilience, covering the three problem areas: critical infrastructure dependencies, climate change, and social problems. The report also covers EU civil protection mechanisms and related international policies, critical infrastructure protection, and the EU Adaptation Strategy to Climate Change.

1.2 PURPOSE AND SCOPE

The aim of this report is to conduct a survey of EU sectorial approaches with respect to urban resilience and European dimension of resilience. The goal is to obtain an overview of how the resilience concept is interpreted, used and applied in different EU sectors or in a cross-sectorial area, and to complete the worldwide survey that has been conducted in Task 1.1, as is explained further in Section 1.3. (T1.1 – the first task of Workpackage 1). The EU sectorial approach survey covers three parts. Firstly, a systematic review on resilience in the urban and European context based on the selected EU projects and scientific literature. Secondly, a review of the three problem areas that the SMR project is focussed on, viz. Critical Infrastructure dependencies, Climate Change and Social Dynamics. Thirdly, the identification of further metrics and indicators, best practices and preliminary suggestions for the EU dimension of resilience. Task T1.2. aims at deepening an understanding of resilience in the context of cities as a basis for gaining an overall European resilience. T1.2 will provide a basis for operationalising the concept of resilience in this particular context.

1.3 RELATIONSHIP WITH OTHER TASKS

As illustrated in Figure 2, Task 1.1 and Task 1.2 are closely related, providing literature reviews of work related to urban resilience and EU sectorial approaches to resilience. In T1.3, the work from tasks T1.1 and T1.2 will be synthesized, offering a common framework for continued work in the SMR project. In Task 1.4, this framework will be applied in a Delphi process with our academic and city experts, and should be seen as the first stepping-stone toward operationalisation of the concepts and terms, to 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 some information identified in the WP1 may be related, especially regarding relevant standards.

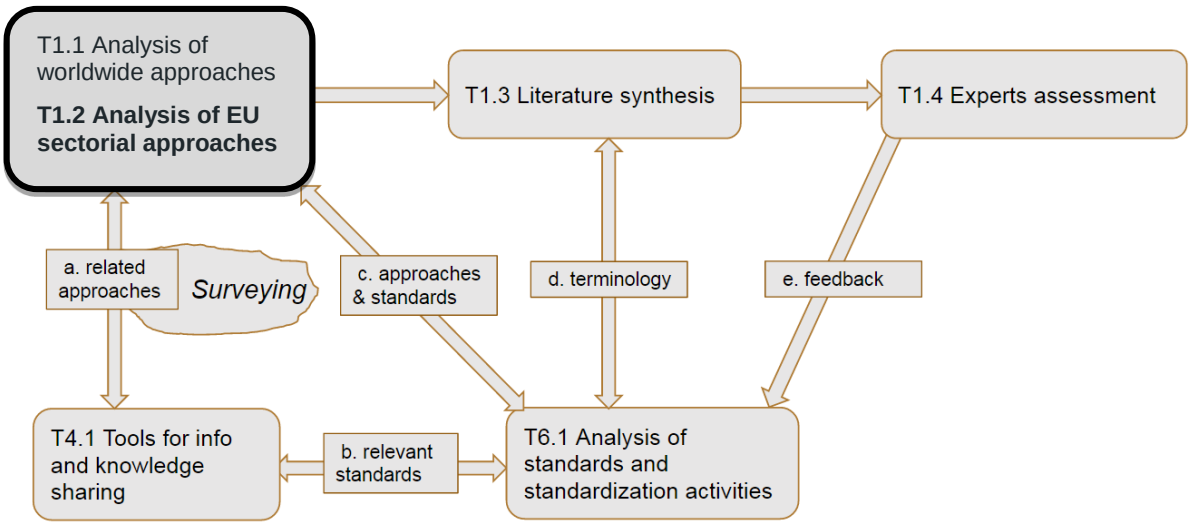

Figure 2 Workflow of WP1 and information sharing with related tasks. This report (T1.2) is marked with bold text.

1.4 SUMMARY OF DELIVERABLE 1.1

Deliverable 1.1 (D1.1) is the first deliverable produced in Workpackage 1 (WP1) and it contains an analysis of worldwide approaches to resilience. The report includes (1) a systematic literature review of urban resilience, (2) a review of worldwide reports and networks related to city resilience, and (3) a city survey of approaches and challenges for the SMR partner cities. D1.1 is aimed at a deepening the current understanding of resilience from the cities' perspective. D1.1 will inform the SMR project concerning operationalising the concept of resilience in the city context with the intention of developing European resilience.

The results from the work in T1.1 showed that numerous perspectives and definitions of resilience were found in the literature. The analysis indicated that research frameworks for urban resilience are abstract and difficult to apply directly to the urban planning and decision-making process. Moreover, the current resilience models do not explain the links between different aspects of resilience that affect cities, such as social and economic. Since resilience is a general-level concept, a challenge is to define boundaries, dimensions, and tools for city resilience, so that professionals can operationalise the offered tools. T1.1 also revealed the structural prerequisites and challenges of developing city resilience; political and financial support are important and much of policy and the related decision-making regarding the resilience is outside the jurisdiction of the city councils. Nevertheless, in the future, for operationalisation

of the resilience concept it is important to consider previous efforts made by organisation bodies outside research as well as involving city professionals in this work.

1.5 STRUCTURE OF THIS DOCUMENT

Chapter 2 presents an overview of the top down approach on the relevant EU sectorial policies and the bottom-up approaches and process used to review the relevant EU funded projects, and derive the resilience concept in the context of urban and European dimension. Chapter 3 discusses the results of the literature review related to the Resilience of Critical Infrastructure. Chapter 4 describes resilience with respect to the climate change, whilst in Chapter 5 we summarize the resilience concept in the field of social dynamics. Chapter 6 proposes the resilience aspects in both urban and European contexts as a backbone for further inputs to T1.3 and T1.4: kind of resilience dimensions, best practices and metrics that are useful or applicable for the SMR tools and the maturity model. Chapter 7 concludes all chapters and present a synopsis of the most important results from the T1.2 activities.

2 EU-SECTORIAL APPROACHES

2.1 INTRODUCTION: WHAT ARE THE EU SECTORS?

In order To place this review in context, we refer to the description of T1.2 in the SMR proposal: " *T1.2 will complement T1.1 by identifying EU sectorial approaches and best practice where resilience has already been implemented in different sectors, such as Critical Infrastructures. Key findings from these previous developments will be identified and integrated within the SMR project preliminary results. The same focus areas and resilience indicators will be used and in T1.1. Previous and current European research projects will be a relevant source of information for this task*".

At a higher level, the EU Commission accommodates different affairs in the European societies as "sectors". These sectors are arranged in the forms of institutional and policy divisions. From the institutional divisions, there are several departments and services representing each sector in EU. Currently, there are 33 departments known as Directorate-Generals (DGs), and 12 services. Each DG is classified according to the policy it deals with. Each DG plan has their own strategic plans and also contribute or responsible for a particular policy area. The DGs draft laws, manage funding initiatives at EU level, and carry out both public consultations and communication activities. From the policy divisions, there are 13 sectorial policies have been defined and grouped in EU commission, i.e.:

- Regional and cohesion policy
- Common agricultural policy (CAP)
- Common fisheries policy
- Environment policy
- Consumer protection and public health
- Transport and tourism policy
- Energy policy
- Trans-European Networks in transport, energy, and telecommunications
- Industrial policy and research policy
- Social and employment policy
- Tax policy
- An area of freedom, security and justice
- Culture, education, and sport

However, the term “sector” is clearly applied and directly used by EU to refer to policies, and not applied for referring to the organisational divisions.

2.2 REVIEW APPROACHES

In this report, we conduct a top-down and a bottom-up approach to identify how resilience development has been implemented and applied in different sectors. With regards to the top-down approach, we use the sectorial approach in terms of policy divisions in the EU. On the one hand, following the top-down approach, we select policies that are relevant for the SMR project, and the descriptions will be at a very general level (e.g. policy objectives and strategies). On the other hand, the bottom-up approach review process is also performed in this report by examining different EU-funded research projects. The aim of the latter is to gain deeper insights of the high-level policies, extracting more concrete policies, best practices, and actions in the area of resilience.

The reasons for not discussing all sectorial policies and conducting the bottom-up approach in addition for this literature review activities are as follow:

- Not all policy sectors address resilience issues.
- relevant policies are too general and it cannot be identified whether or not resilience has been implemented „in practice“
- Sometimes resilience is mentioned only superficially in policy documents, but at the project level, resilience is well-elaborated and, to some extent, it is also operationalised.
- In the cross-cutting sectors or joint research areas, resilience is explored in a more comprehensive manner that in individual sector only.
- Reviewing only the higher level policies is not expected to allow us to extract the best practice implementation from various threats and hazard scenarios.

Thus, the further reasons to review EU-funded projects are justified by the following points:

- Many research projects are defined and intended to contribute to meet policy goals of the EU 2020 strategy.
- Many frameworks to implement EU policies including resilience were inspired by comprehensive researches conducted in various EU research calls.
- Many practical examples of resilience are mostly found in the relevant EU projects, and the resilience topic has been extensively explored.

Hence, at the bottom-up approach, a proposed definition of EU Sectors is *the review on research products that explored the state-of-the-arts, implementations, and applications of resilience in different EU joint research projects that will eventually contribute to meet the goals of relevant EU policy sectors*.

2.3 OVERVIEW OF EU SECTORIAL POLICIES, A TOP DOWN APPROACH

EU sectorial policies applied for urban and city developments that are highly relevant are in the following areas: regional and cohesion, environment, public health, transport and tourism, energy, trans-European networks, industrial, and social-employment sectors. The main question to answer in this top-down review is: What are the different EU sectors concerned with "in practice"? Included in the review is the examination whether or not the resilience concept is introduced in these selected EU sectors.

2.3.1 EU REGIONAL AND COHESION POLICY

Strengthening the EU's economic, social and territorial cohesion is one of the EU's main objectives which is a part of EU Regional and Cohesion Policy. This Policy dedicates a significant proportion of its activities and budget to reducing the disparities among regions, with particular reference to rural areas, areas affected by industrial transition, and regions which suffer from severe and permanent natural or demographic handicaps. In general, cities are regulated under the regional policy, as mentioned as follow: "Regional Policy is designed for all regions and cities in EU to support job creation, business competitiveness, economic growth, sustainable development, and improve citizen's quality of life". To understand the existing urban elements in EU policies, in this section we look closer at more concrete policies and strategies.

Regional Policy is intended to support job creation, business competitiveness, economic growth, sustainable development, and improve citizens' quality of life in all regions and cities in the European Union. Regional Policy is delivered through three main funds: the European Regional Development Fund (ERDF) and the Cohesion Fund (CF) and the European Social Fund (ESF). The funds are invested in 7 areas, i.e. jobs, growth, and investment, digital single market, energy union and market, internal market, economic and monetary, justice and fundamental rights and migration. All these actions are intended to achieve five targets of Regional Policy for EU in 2020[1], as cited earlier in Section 2.2, i.e:

1. Employment[2]: 75%of the 20-64 year-olds to be employed

[1] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:em0028

[2] See further policy about Investing in jobs and growth: http://ec.europa.eu/regional_policy/sources/policy/what/investment-policy/esif-contribution/esif_contribution_communication.pdf, policy on investment in the internal market http://ec.europa.eu/regional_policy/sources/policy/what/investment-policy/esif-contribution/internal_market.pdf, and policy on investment in economic and monetary http://ec.europa.eu/regional_policy/sources/policy/what/investment-policy/esif-contribution/economic_monetary_union.pdf

2. Research & Development: 3% of the EU's GDP to be invested in R&D
3. Climate change and energy sustainability[3]:
    - Greenhouse gas emissions 20% (or even 30%, if the conditions are right)
    - 20% of energy from renewables
    - 20 % increase of energy efficiency
4. Education[4]:
    - Reducing the rates of early school leavers below 10%
    - At least 20 million fewer people in or at risk of poverty and social exclusion
5. Fighting poverty and social exclusion[5]: At least 20 million fewer people in or at risk of poverty and social exclusion

With respect to the EU urban policy, however, the EUhas no formal authority over urban policy[6], although some efforts have been initiated to foster the development of EU cities such as regulation improvements, creating workable financial instruments and creating a European platform for urban imagination and knowledge. In brief, current The European Urban Agenda is more about a joint effort of EU Commission, Member States and European Cities Networks to strengthen the recognition of the urban dimension by European and national policy actors.

The EU regional policy objectives 2014-2020 with respect to urban issues are outlined as follow:

- Urban areas are directly targeted as investment priorities.
- Some fundings are dedicated for integrated sustainable urban development, including for innovative actions.
- Strengthening an urban development network.

An EU regional policy document “Promoting Sustainable Urban Development in Europe” elaborates the achievement and opportunities that have been accomplished between 2007 and 2013 in the urban development area. The economic prosperity, promoting equality, social inclusion, regeneration of urban areas, sustainability of urban environment, urban governance and local empowerment are the priorities within that timeline, whilst Urban resilience has not yet come into the picture. There are two other closely related terms that are used frequently, i.e. security and sustainability. security, As a concept, is

[3]http://ec.europa.eu/regional_policy/sources/policy/what/investment-policy/esif-contribution/energy_union_climate.pdf
[4] http://ec.europa.eu/regional_policy/sources/policy/what/investment-policy/esif-contribution/justice_fundamental_rights.pdf. See also and policy about investing in digital market http://ec.europa.eu/regional_policy/sources/policy/what/investment-policy/esif-contribution/digital_single_market.pdf, where part of funding is dedicated for training and education with respect to ICT skills.
[5] http://ec.europa.eu/regional_policy/sources/policy/what/investment-policy/esif-contribution/migration.pdf
[6] http://ec.europa.eu/regional_policy/sources/docgener/presenta/urban2009/urban2009_en.pdf; and see also http://urbanagendaforthe.eu/urban-agenda/

discussed in terms of transport security, crime, or economic security, whereas sustainability is linked to environmental risk management, sustainable urban transport, sustainable construction, sustainable urban design and appropriate land-use planning. Likewise, topics such as disaster risks and disaster risk reduction have also not been considered yet during this period.

In the regional investment strategies 2014-2020 however, disaster resilience has been mentioned once as a part of Energy Union and Climate Priority area. It is said that EUR 6.4 billion from the ERDF and the Cohesion Fund is allocated to prevent climate change-related risks, in addition to EUR 1.1 billion for disaster resilience and the management of non-climate related risks. This will support a broad range of measures, including flood prevention and ecosystem-based measures such as green infrastructure. Risk assessments, which take climate change adaptation strategies into account, are a precondition for funding in this area.

In the document "Cities of Tomorrow: Challenges, Visions, Ways Forward", the role, threats, opportunities and future policies for cities in Europe are proposed[7].

Cities as a key for Sustainable Development • Europe is one of the most urbanised continents in the world • Cities are engines for economy, connectivity, creativity and services • Administrative boundaries are weakened • A city is a place for social progress and social cohesion, platform for democracy, environmental regeneration and engine of economic growth • Cities play a key role in Europe's territorial development	**Opportunities** • Sustainable local economies • Creating a resilient and inclusive economy • The potential of socio-economic, curtural, generational and ethnic diversity • Combanting spatial exclusion and energy poverty • A holistic approach to environmental and energy issues • Dynamic small and medium-sized cities • Attractive open public spaces
Threats to Sustainable Urban Development • Demographic change • Potential economic stagnation • Unable to provide jobs for all • Income disparities • Spatial segregation • "Society dropouts" • Urban Sprawls • Urban Ecosystem under pressure	**Response to Urban Challenges** • Holistic model of sustainable urban development • Adapted governance systems • Cities have to work across sectors • Horizontal and Vertical coordination • New governance Modes • Social Innovation • Foresight for managing transitions

The "resilience" term is introduced already in this document, with respect to the effects of climate change, especially in terms of green, ecological and environmental regeneration. Cities' resilience also means a gradual retrofitting of the existing housing stock, taking into account environmental constraints

[7] http://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/citiesoftomorrow/citiesoftomorrow_final.pdf

such as mitigation of, and adaptation to, the impact of climate change. City resilience to external events is also used to describe the city resistance against economic threats and preventing economic declines. In addition, the term resilience of natural resources is mentioned in the context of an interplay between urban centres and their surrounding regional rural space, in addition to specifying the importance of data to measure a city's environmental resilience. The tool such as foresight is considered crucial in raising awareness of both foreseeable and less predictable hazards, and eventually strengthening cities' resilience. Foresight approach can facilitate the views of multiple stakeholders on different long-term issues, risks, and consequences. It is clear that the future European cities will include resilience as a part of future strategy direction to accomplish up to 2020.

2.3.2 EU ENVIRONMENTAL POLICY

In general, EU environment policy regulates climate change and environment, water protection and management, air and noise pollution, resource efficiency and waste, sustainable consumption and production and chemicals. The European environment policy rests on the principles of precaution, prevention and rectifying pollution at source, and on the 'polluter pays' principle. In 2013, the Council and Parliament adopted the 7th EAP for the period up to 2020[8], In the 7th Environment Action Programme to 2020–"Living Well, within the Limits of Our Planet" policy document, the term "resilience" has been expressed several times, in the following context:

- Sustainable natural resources and protecting and restoring biodiversity to enhance society's resilience.
- Stronger ecological resilience, in terms of an inclusive green economy that secures growth and development, safeguards human health, provides decent jobs, reduces inequalities and preserves biodiversity.
- Enhancing the resilience of the natural capital in terms of adaptation to climate change, a resource-efficient, green and competitive low-carbon economy, and environment-related threats to health.
- Stronger resilience of forests to climate change, fires, storms, pests and diseases.
- The importance of measures to enhance climate resilience, such as ecosystem restoration and green infrastructure.

2.3.3 EU PUBLIC HEALTH POLICY

The EU Public Health Policy is based on three strategic policies:

[8] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013D1386&rid=2

- Fostering good health — to prevent diseases and promote healthy lifestyles by addressing the issues of nutrition, physical activity, alcohol, tobacco and drug consumption, environmental risks and injuries.
- Protecting citizens from health threats — to improve surveillance and preparedness for epidemics and bioterrorism and increase capacity to respond to new health challenges such as climate change;
- Supporting dynamic health systems — to help the healthcare systems respond to the challenges of ageing populations, rising citizens' expectations, and mobility of patients and health professionals.

Furthermore, the description of health policy 2014-2020 is stated in the Regulation (EU) No 282/2014[9] of the European Parliament and of the Council of 11 March 2014 on the establishment of a third Programme for the Union's action in the field of health. In this strategic policy document, the resilience term is not explicitly used. resilience is implicitly covered by the preparedness strategy and capacity building against the health threats and individual capacity to cope with the effect of climate changes.

In the recent years, however, the crisis management thinking has been incorporated in the public health policy, especially through: 1) the establishment of Executive Agency for Health and Consumers (EAHC) 2) Stengthening the rapid response capacity to react on major health threats in a coordinated manner, and 3) the improvement of health promotion and disease prevention.

2.3.4 EU TRANSPORT POLICY

The EU transport policy covers wide areas ranging from air, ground and sea transports including the transport safety and passenger rights. An overview of faced challenges and options for the EU's future transport has been discussed in the document "A sustainable future for transport: Towards an integrated, technology-led and user friendly system" [10], i.e. (a) continuing globalisation, (b) the development of relations with third countries, (c) the expansion in goods transport, (d) changes in social structures and demographic trends, (e) continuing urbanisation, (f) future commercial trends, (g) possible advances in energy, transport and communications technologies, (h) possible consequences of climate change, and (i) forthcoming changes in the field of energy supply. In this document, the resilience concept is used to describe the transport firm capacity to adapt to innovation and new market needs. In brief, the meaning is closer to economic resilience.

[9] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0282&rid=1
[10] http://www.europarl.europa.eu/RegData/docs_autres_institutions/commission_europeenne/com/2009/0279/COM_COM(2009)0279_EN.pdf

Furthermore, in the policy document Roadmap to a Single European Transport Area — Towards a competitive and resource-efficient transport system [11], several objectives are defined, among other things are:

- to reduce greenhouse gas emissions by at least 60% compared with 1990 levels by 2050 without affecting transport growth and impairing mobility
- reducing greenhouse gas emissions by at least 20% between 2021 and 2030.
- sets out vision on future transport (e.g. road freight transport, shifting 30% of freight to rail or waterborne transport by 2030 and more than 50% by 2050; tripling the length of the existing high-speed rail network by 2030 and moving the majority of medium-distance passenger transport to rail by 2050; establishing a fully functional multimodal TEN-T in the EU by 2030, with a high-quality and high-capacity network by 2050 and a corresponding set of information services, etc.).
- set up a Single European Transport Area
- enforcement of social, safety, security and environmental rules, minimum service standards and users' rights
- introduce new technologies and encourage changes in behaviour in order to make mobility more sustainable.
- allocate substantial, diversified sources of funding for transport sector including the intelligent pricing systems.

In this document, the concept of resilience is introduced, in a more specific way, i.e. as a mobility continuity plan requirement in responding to the previous disaster experience of ash cloud crisis and the extreme weather events. There is the need for the increased resilience of the transport system through scenario development and disaster planning. The document also mentions the importance to prioritise EU funding for infrastructure that is resilient to the possible impact of climate change and that improves the safety and security of users. The priorisation should cover climate resilience of the overall transport infrastructure refuelling/recharging stations for clean vehicles, and the choice of construction materials. Overall, it can be concludeds that resilience is used both in the context of disaster management and in the context of physical properties of transport infrastructure that can resist against the climate change.

[11] http://www.europarl.europa.eu/RegistreWeb/search/simple.htm?reference=COM_COM(2011)0144

2.3.5 EU ENERGY POLICY

The EU energy policy regulates internal energy market, energy efficiency, renewable energy and nuclear energy. Europe faces several challenges in the area of energy, for instance:

- increasing import dependency,
- energy variety,
- unstable and expensive energy prices,
- increasing energy demand,
- security risks affecting producing and transit countries,
- threats of climate change,
- slow progress in energy efficiency,
- integration and interconnection on energy markets.

According to the Treaty of Lisbon, the main aims of the EU's energy policy are to:

- ensure the functioning of the energy market;
- ensure the security of energy supply in the Union;
- promote energy efficiency and energy saving and the development of new and renewable forms of energy;
- promote the interconnection of energy networks.

One important aspect of the energy policy is to follow an integrated climate and energy policy, where EU has established the following targets by 2020:

- a reduction of 20% in greenhouse gas emissions compared to 1990 levels;
- an increase to 20% of the share of renewable energies in energy consumption;
- an improvement of 20% in energy efficiency.

For a general policy framework, two policy documents have been published in the energy sectors and discussing the post-2020 energy policy goals[12] and Energy roadmap 2050[13].

In this two general policy documents, only one document excplicitly mentions "resilience" in the context of climate resilient economy. climate change is a part of the focus because of the fact that the EU provides significant financial support linked to climate change and sustainable energy. Climate action objectives are represented in the 20% of EU spending (2014-2020) and are perceived as the appropriate

[12] http://www.europarl.europa.eu/RegistreWeb/search/simple.htm?reference=COM_COM(2013)0169
[13] http://www.europarl.europa.eu/RegistreWeb/search/simple.htm?reference=COM_COM(2011)0885

instruments to ensure that the objectives can contribute to strengthen energy security, building a low-carbon, resource efficient and climate resilient economy.

2.3.6 EU TRANS-EUROPEAN NETWORKS POLICY

The EU trans-European networks (TENs) policy focuses on three policy domains to connect all regions in the EU, i.e. transport, energy, and telecommunications. The goal of this policy is to contribute to the internal market development and employment, while pursuing environmental and sustainable development goals.

In the *transport area*, the policy goal is to build the Trans-European Transport Network (TENT-T)[14]. A recent 2013 EU transport infrastructure policy aims at transforming the existing patchwork of European roads, railways, inland waterways, airports, inland and maritime ports and rail/road terminals into an integrated network encompassing all EU member States. The infrastructure should be accessible for all citizens, safer, sustainable, low-carbon and energy-efficient system. The funding regarding the TENT-T in H2020 research projects are reflected through the support of the research in the field of smart, green and integrated transport.

The TEN-T was introduced in 1996, however only after 2013, the idea of resilience is incorporated into the policy document. In the Regulation (EU) No 1315/2013 of 11 December 2013 on Union guidelines for the development of the trans-European transport network, it is mentioned that during infrastructure planning, the risk assessments and adaptation measures adequately improving resilience to climate change and environmental disasters (or disaster resilience in general) should be taken into account.

In the *energy area*, a series of guidelines have been laid down in the area of trans-European energy networks (TEN-E). The Decision No 1364/2006/EC[15] aims at diversifying sources of supply, to increase security of supply by strengthening links with non-EU countries, to incorporate energy networks in the new Member States, and to ensure access to the TEN-Es for island, landlocked and peripheral regions. In the Annex of I the decision There are 32 projects of European interest for electricity and 10 for gas, while Annexes II and III list 164 projects for electricity and 122 for gas. However, no “resilience” concept have been mentioned in this policy document.

[14] See http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32013R1315 and http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L:2014:136:FULL&from=EN

[15] http://ec.europa.eu/ten/energy/legislation/doc/2006_09_22_ten_e_guidelines_2006_en.pdf

In the *telecommunication area*, the policy objective is to develop a future European broadband communications network. Decision No 1336/97/EC of 17 June 1997[16] laid down guidelines for the trans-European telecommunications networks (TEN-Telecom). It set out the objectives, priorities and broad lines of the policy. The priorities adopted included applications contributing to economic and social cohesion and the development of basic networks, particularly satellite networks. These guidelines were modified by Decision No 1376/2002/EC of 12 July 2002[17]. Likewise, in the main policy documents for TEN-Telecom, resilience is not introduced. Moreover, the "unit analysis" for this policy is the overall European region, and not a city.

2.3.7 EU INDUSTRIAL POLICY

The EU Industrial Policy touches upon 6 domains, encompassing the small and medium-sized enterprises, A digital agenda for Europe, the ubiquitous digital single market, defence industry, policy for research and technological development and innovation policy. Various strategies have been adopted and, the most recent being described in the communication 'For a European Industrial Renaissance', of January 2014[18]. Key priorities to attain under this communication strategy are.

- mainstreaming industrial competitiveness in other policy areas to sustain the competitiveness of the EU economy
- maximising the potential of the internal market
- implementing the instruments of regional development in support of innovation, skills, and entre-preneurship
- promoting access to critical inputs in order to encourage investment facilitating the integration of EU firms in global value chains.

The document mentions the needs for more coherent politics in the field of the internal market, including European infrastructures such as energy, transport and information networks, as well as for goods and services to attract new investments and create a better business environment. The document also stresses the importance of improved cooperation in the areas of good quality public administration, trade, research and raw materials. In this document, resilience is mentioned as a part of security level required for digitally enabled networks (e.g. ICT-enabled energy and logistics networks). In other word, it is closely related to the technical requirement of the ICT infrastructure.

[16] http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32002D1376&from=EN
[17] http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32002D1376&from=EN
[18] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52014DC0014

2.3.8 EU SOCIAL-EMPLOYMENT POLICY

The EU Social-Employment Policy consists of 6 domains, encompassing European Social Fund, employment policy, social security, health and safety at work, workers' right, social dialogue, gender equality, the fight against poverty, social exclusion and discrimination. In general, the social dimension of European integration has been greatly developed throughout the years. It is a key aspect of the Europe 2020 strategy, which aims at ensuring 'inclusive growth' with high levels of employment and a reduction in the number of people living in poverty or at risk of social exclusion.

The new EU strategic agenda mentions a clear target for its 'social' pillar i.e. 20 million people out of the risk of poverty by 2020, and commitment to a goal in the area of employment which means 75% employment for the 20-64 age group. The following initiatives are introduced to achieve this goal[19]:

- The agenda for new skills and jobs and making the labour market function better, helping people develop the skills of tomorrow and improving job quality and working conditions;
- Youth on the Move contributes to better education and training;
- The European Platform against Poverty and Social Exclusion helps to disseminate best practices and makes funding available to support social inclusion and fight against discrimination.

The public consultation on a preliminary outline for a European Social Pillar of Social Rights was issued in March 2016. The document strengthens the European social pillar[20] through three points: (1) equal opportunities and access to the labour market, (2) fair working conditions, and (3) access to adequate and sustainable social protection.

Resilience is mentioned in the document in term of social and employment performance when facing social issues such as high rising levels of inequality, increasing people with temporary job contracts, the growth of ageing, the high unemployment rate and other social issues. In addition to this, resilience is also specified in the context of social cohesion. Reducing social inequalities will increase social cohesion, and lead into more resilient society, and responded better in a crisis.

2.4 EU SECTORIAL APPROACH: BOTTOM-UP

This section will help shape a deeper understanding of the concept of resilience, how resilience has been applied and used in EU sectorial research projects with a focus on its application in an urban and

[19] http://ec.europa.eu/social/main.jsp?langId=en&catId=956
[20] http://www.europarl.europa.eu/thinktank/en/document.html?reference=EPRS_BRI(2016)586657

European context. The results from this review will contribute to the implementation of the Smart Maturity Resilience (SMR) Model and the SMR tools. To achieve our goal, the focus of the review comprises of:

(1) Resilience in a specific problem area or sector (including the definition, dimensions of resilience, resilience challenges or threats) and the link to the urban resilience and European dimension.
(2) Resilience approaches and challenges, including policies and best practices
(3) Metrics and Indicators for resilience.

2.5 REVIEW METHOD OF EU PROJECTS

In this section, we describe the method we use to conduct the literature review on the European Sectorial Approach to resilience. EU project reports and deliverables incorporating "resilience" are the main resources used in the literature review. This section presents the sources used to find relevant EU projects, the procedure for selecting the projects to review, and the number of relevant projects reviewed. The goal of the search is to find relevant projects related to Critical Infrastructure (CI), Climate Change (CC) and Social Dynamics (SD). The main method used for the literature review is a systematic mapping study encompassing relevant EU project reports and deliverables, policies and journal articles (Budgen, Turner, Brereton, & Kitchenham, 2008; Kitchenham, Budgen, & Pearl Brereton, 2011; Petersen, Feldt, Mujtaba, & Mattsson, 2008).

Information collected from literature:

- Resilience definition
- Resilience dimensions, and their specific definitions
- Resilience context, e.g. disaster risk reduction, adaptive governance
- Resilience threats/scenarios
- Type of CI and its specific definition
- Type of Social problems and explanation of the social problems
- Resilience challenges and solutions
- Identification of Best Practices, Guidelines and Standards
- Identification of existing relevant policies or policy improvements
- Resilience methods and approaches

ABBREVIATION: CI: Critical Infrastructure; CC: Climate Change; SD: Social Dynamics.

Wendler (2012) suggests a mapping study, as a specific form of literature review, aims at reviewing a relatively broad topic by identifying, analysing and structuring the goals, methods and contents of

previously conducted studies. For conducting the review, we developed a framework and the objective of gaining an understanding regarding resilience definitions, resilience methods and approaches, resilience dimensions, best practices and indicators we would like to extract, classify, analyse and synthesize from the literature. To document the extracted information, it is important to maintain the consistency of the type of information to extract, and ensure the future reusability of the materials. We defined a questionnaire in an online form covering all the necessary information to be obtained. The main information and concepts that were collected are as follows:

- Resilience definition (CI, CC, SD)
- Resilience dimensions, and their specific definitions (CI, CC, SD)
- Resilience context, e.g. disaster risk reduction, adaptive governance (CI, CC, SD)
- Resilience threats/scenarios (CI, CC, SD)
- Type of CI and its specific definition (CI)
- Type of Social problems and explanation of the social problems (SD)
- Resilience challenges and solutions (CI, CC, SD)
- Identification of Best Practices, Guidelines and Standards. Note, the standards will be discussed in D6.1 where an extensive standards analysis will be done (CI, CC)
- Identification of existing relevant policies or policy improvements (CI, CC, SD)
- Resilience methods and approaches (CI, CC, SD)
- Resilience metrics or indicators (CI, CC, SD)

2.5.1 SOURCES

To review the EU sectorial approaches, we examined different sources related to EU Projects, especially in the project catalogues of FP7 and H2020:

- Catalogue of EU funded projects in Environmental research 2007-2011 FP7 Theme 6– Environment (including climate change)[21].
- Catalogue of R&I Projects 2014 Climate action, environment, resource efficiency and raw materials Horizon 2020[22].

[21] The projects are under the Directorate General for Research and Innovation Environment directorate. See http://www.eurosfaire.prd.fr/7pc/doc/1306331658_environment_fp7_catalogue_05_2011.pdf.
[22] This is a catalogue for the EU Framework Programme for Research and Innovation. The projects are under Directorate-General for Research and Innovation Climate Action, Environment, Resource Efficiency and Raw materials. http://www.eip-water.eu/sites/default/files/h2020_sc5_projects-catalogue_a4.pdf

- Catalogue of Security Research Projects under the 7th Framework Programme for Research, EU Research for a Secure Society.[23]
- List of relevant EU projects identified in the SMR project proposal.
- EU policy documents, especially related to CI, EU CC policy, EU adaptation strategy to CC, and EU Integration policy.
- The OpenAIRE database[24]

In addition to this, as recommended by the EU commission, we looked at the H2020 projects under the same call as the SMR project. For FP7 projects in other sectors such as Food, Agriculture and Fisheries, and Biotechnology (FABS),resilience is discussed as solutions for problems such as feeding a growing world population (e.g. resilience of potato-based cropping, resilience of farming systems), which beyond the scope of our project. The documents under ENISA (European Union Agency for Network and Information Security)[25] are also subjects to investigation. As a unit in EU, ENISA is responsible for assisting national EU agencies, private sector and the EU Commission to develop sound preparedness, response and recovery strategies, policies and measures with respect to CI. Resilience of CI and European Public Private Partnership for Resilience (EP3R) are among the "interfaces" to our search in pursuing an understanding of the EU approach to resilience.

When searched in the OpenAIRE database the search strategy was "Resilience (All Fields, All Words) AND critical infrastructure (All Fields, All Words) AND European (All Fields, All Words)". However, the search returned only three documents. Although we used these three documents in the analysis, we believed that they were not enough to capture the overall picture of EU Sectorial approaches to resilience. Hence, our main efforts to find relevant projects were through the use of the catalogues have been mentioned above. We supplemented our EU sectorial approach by searching for scientific literature using SCOPUS and Science Direct digital libraries.

2.5.2 PROCEDURES FOR SELECTING LITERATURE

The procedures for selecting literature cover identification of EU-funded projects and scientific literature. We conducted the following procedure when searching for relevant EU sectorial projects:

- Step 1: identifying relevant EU calls where the resilience issues are very likely to be addressed, under FP 7 calls and Horizon 2020 calls listed in the "Sources" section earlier.

[23] This is a catalogue for FP7 research projects Directorate-General for Enterprise and Industry, Unit G4 Policy and Research in Security. The link to the catalogue can be found here: http://ec.europa.eu/dgs/home-affairs/financing/fundings/pdf/research-for-security/security_research_catalogue_2014_en.pdf
[24] https://www.openaire.eu/
[25] See https://www.enisa.europa.eu/activities/Resilience-and-CIIP

- Step 2: filtering the project list from project title and abstract using keyword “resilience”.
- Step 3: filtering the project list from project title and abstract using keywords “city” or “urban”.
- Step 4: filtering the project list from project title and abstract using “critical infrastructure”, “protection”, “social” or “social problems” or "urbanization/urbanisation", and “climate” or “climate change”.
- Step 5: upon inspection using criteria in step 4, keeping the projects that match best with those criteria.
- Step 6: filtering further by going through the project websites and manually checking if the identified projects were relevant, e.g. if the project actually about resilience, or only mentioned it as a part of other irrelevant context.
- Step 6: examining more closely the project reports and deliverables to be included in the review. Some EU projects have delivered scientific publications in addition to the project reports and deliverables.

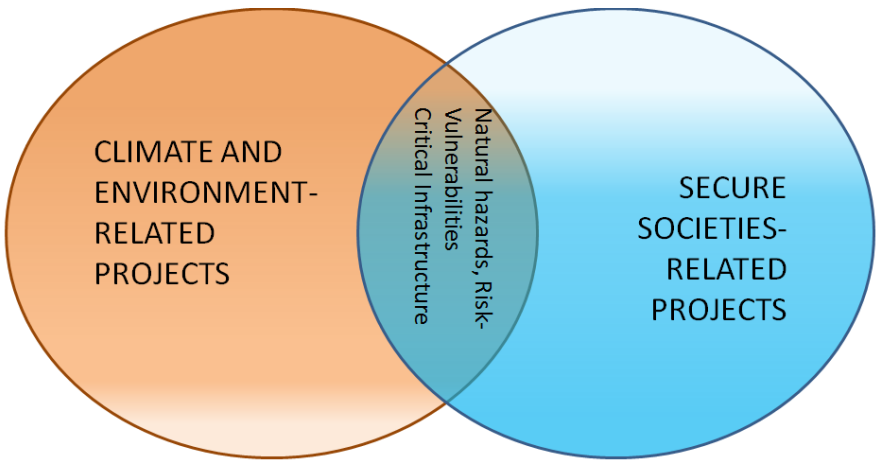

Figure 3 Common Interests of Security and Climate –related EU projects.

We found that the majority of selected projects that included a resilience perspective as a part of the solutions had common areas of interest as shown in Figure 3. The overlapping themes were natural hazards, risk and vulnerabilities, and critical infrastructure. The next section further elaborates our methodology for selecting the relevant projects to review.

2.5.3 OVERVIEW OF RELEVANT EU PROJECTS

As described earlier, we focused on two research programmes for EU projects: FP7 and H2020. FP7 classified its projects based on the following types of projects: *collaborative projects, networks of excellence, coordination and support action* and *individual projects*. *Collaborative research* FP7 projects

had to define scientific and technological objectives and specific expected results such as producing new knowledge or technology. *The networks of excellence* were intended for research institutions that integrated a substantial part of their activities and capacities in a specific field, through a "Joint Programme of Activities". Meanwhile, coordination and support actions (CSA) emphasized the coordination and networking of projects, programmes and policies.

H2020 Research programme is the current EU research and innovation programme. The most common types of actions are: Research and innovation actions (RIA), Innovation Actions (IA), and coordination and support actions (CSA). RIA is a funding for research projects tackling well-defined challenges, which can lead to the development of new knowledge or new technology while IA instrument is funding for “closer-to-the-market” activities, such as products for commercialization. As in FP7, CSA is a funding for the coordination and networking of research and innovation projects, programmes and policies.

For review purposes, we did not differentiate between the types of funding for research as long as“resilience” was part of the project. Beyond that, the EU research programme has other instruments for funding such as Frontier research grants – European Research Council (FRG-ERC), and Marie Skłodowska-Curie Actions (MSCA). But they are not part of instruments for funding two examined EU call themes. MSCA, for example, is to support researcher’s mobility. Table 1 to 4 show the number of projects in FP7 and H2020 calls (2007-2015) in Secure Societies and Climate Change themes, while the selected projects are shown in Table 5 and 6 (Section 2.1.4)

1 FP7 Environment (Including Climate Change) Projects

The main objective of environment research under FP7 is to manage both the man-made environments and natural environment, as well as their resources. It focuses on the interaction between the climate, biosphere, ecosystems and human activities and development of new environment-friendly technologies. The research priority is especially given to the areas of biodiversity and ecosystems, natural resources management, sustainable urban development, climate change adaptation and mitigation, and disaster risk reduction. Table 1 shows the number of projects identified under FP7for each main topic and the amount of selected projects using procedure in section 2.1.2, in our review. Despite a large number projects under FP7, only few projects that actually address “city” or “urban” and resilience, i.e. 11 of 407 projects.

Table 1 Selected Project from FP7 in the area of Environment (Climate Change)

Project Topic Area FP7	# Projects	Selected
Pressure on Environment and Climate	60	1
Environment and Health	35	0
Natural Hazard	22	7
Sustainable management of natural resources and biodiversity	46	1
Management and marine environment	26	0
Environmental Technology	90	2
Cultural Heritage	21	0
Technology Assessment, verification and Testing	10	0
Earth and Ocean Observation Systems and Monitoring methods	34	0
Forecasting methods and assessment tools for sustainable development	47	0
Dissemination and Horizontal activities	16	0
Total	**407**	**11**

2 Climate Action environment, resource efficiency and raw materials H2020

The recent research topics on climate action, environment and resource research topics stress how to achieve a resource efficiency and climate change resilient economy and society. The protection and sustainable management of natural resources and ecosystems, and a sustainable supply and use of raw materials, in order to meet the needs of a growing global population within the sustainable limits are highly crucial topics. Research and innovation H2020 cover the following broad lines of activities[26]:

- Climate Action: Informed decisions for a climate-resilient low-carbon society.
- Cultural Heritage: Engaging a new cultural heritage agenda for economic growth.
- Earth Observations: Crucial info on climate, energy, natural hazards and other societal challenges.
- Nature-Based Solutions: Providing viable solutions of natural ecosystems.
- Systemic Eco-Innovation: Generating and sharing economic and environmental benefits.

Table 2 shows the number of projects for each main call and the number of selected projects under H2020 (2015). Based on the catalogue 2015, there are 67 projects listed under “Climate Action, environment, resource efficiency and raw materials” theme, but again, only 3 projects that actually can fit for SMR review.

Table 2 Selected Project from H2020 in the area of Climate Action, environment, resource efficiency and raw materials

Project Areas H2020 (Climate Action)	#Projects	Selected

[26] See https://ec.europa.eu/programmes/horizon2020/en/h2020-section/climate-action-environment-resource-efficiency-and-raw-materials

Fighting and adapting to climate change	10	3
Protection of the environment, sustainable management of natural resources, water, biodiversity and ecosystems	6	0
Ensuring the sustainable supply of non-energy and non-agriculture raw materials	9	0
Enabling Transition toward a green economy and society through eco-innovation	36	0
Developing comprehensive and sustained global environmental observation and information systems	4	0
Cultural Heritage	1	0
Specific Implementation Aspects	1	0
Total	**67**	**3**

3 Secure Societies FP7

FP7 Secure Societies were calls to strengthen fundamental human rights, privacy, research into the preparedness and response of society to the potential or actual threats and crises. The projects under FP7's Security theme includes research on the societal dimension of security, protection of citizens against chemical, biological, radiological, nuclear and explosive (CBRNE) materials or man-made and natural events, critical infrastructure protection, crisis management capabilities, intelligent maritime and land border surveillance, pre-standardisation and the interoperability of systems. Table 3 shows the number of projects for each main call and the number of selected projects under FP7. We also notice in this table that a number projects under FP7 Secure Societies call are huge, i.e. 248. We found 18 projects address "city" or "urban" and resilience.

Table 3 Selected Project from FP7 in the area of Secure Societies

Project Areas FP7 (Secure Societies)	# Project	Selected
Security of the Citizens	52	0
Security of infrastructure and utilities	50	9
Intelligent surveillance and border Security	29	0
Restoring security and safety in case of crisis	51	5
Security system integration, interconnectivity and interoperability	20	3
Security and society	37	0
Security Research Coordination and Structuring	9	1
Total	**248**	**18**

4 Secure Societies H2020

The H2020 Secure Society calls aim at improving resilience, fighting against crime and terrorism, and enhancing the border security and cyber security. However, for H2020 Secure Societies project, to the knowledge of the authors, there is not yet a complete figure or systematic catalogue of how many projects are funded for each topic under the Secure Society call in 2014-2015 and 2015-2016. However, identified 87 H2020 projects were listed when searching the CORDIS website on February 15, 2016. Our review of these projects was limited because most of them only recently started in mid-2015 and thus there are only a limited a number of deliverables to review.

Table 4 Selected Project from H2020 in the area of Secure Societies

Project Areas H2020 (Secure Societies)	# Project	Selected
Disaster-resilience: safeguarding and securing society, including adapting to climate change	N/A	4
Fight against crime and terrorism	N/A	0
Border Security and External Security	N/A	0
Digital Security: Cybersecurity, Privacy and Trust	N/A	0
Total	87	4

Note on N/A: no complete figures for each topic are available

2.5.4 SELECTED RELEVANT EU-PROJECTS

In Table 5, we present the selected projects for climate change-related projects in FP 7 and H2020. The table summarizes the main concepts that are used in each project.

Table 5 Selected Environment (Climate Change) and Climate Action Projects in FP 7 and H2020

Framework	Project Title	Resilience	Protection	CI	CC	SD	Urban Context
FP7	CAPHAZ-NET	●			●	●	
	CORFU	●			●		
	EMBRACE *)	●			●		
	ENSURE	●			●		
	FLOODPROBE	●		●	●		
	MIAVITA	●			●		
	MOVE	●			●		
	SMARTEST	●			●		
	STAR-FLOOD	●			●		●
	TOPDAD	●		●	●		
	TURAS	●			●		●
H2020	RESIN	●			●		●
	EU-CIRCLE	●	●		●		●
	TRANSrisk	●			●		

**) is also in the list of identified project in SMR proposal*

Note that we review one completed project, CREW[27], which is not an EU-funded project, but a large project conducted in the UK on community resilience to natural hazard, and has initiated the discussion on resilience far before resilience discussed in EU projects. During the search process in the catalogue, we identified six climate change projects that were excluded from the review as they focussed on African or Latin American countries rather than EU context. The project challenges are related to the local problems, and do not address city or urban resilience. For example,

- WAHARA (Water Harvesting for Rainfed Africa).
- CLUVA (Climate Change and Urban Vulnerability in Africa).
- WHATER: Water Harvesting Technologies Revisited: Potentials for Innovations, Improvements and Upscaling in Sub-Saharan Africa.
- DEWFORA: Improved Drought Early Warning and FORecasting to strengthen preparedness and adaptation to droughts in Africa.
- COROADO: Technologies for Water Recycling and Reuse in Latin American Context
- COMBIOSERVE: community-based conservation in Mexico, Brazil and Bolivia.

In Table 6 we present selected projects from EU Secure Societies call in FP 7 and H2020. The table summarizes the main concepts that are used in each project.

Table 6 Selected Secure Societies FP 7 and H2020 Projects

Framework	Project Title	Resilience	Protection	Critical Infrastructure	Climate Changes	Social Problems	Urban/Cities Context
FP7	CAMINO	●	●	●			
	CAERUS	●				●	
	CASCEFF	●	●	●			
	CBRNEMAP	●	●			●	
	DESURBS	●		●			●
	DITAC ***)	●					
	DRIVER *)	●				●	
	EURACOM	●	●	●			
	FORTRESS	●					
	HARMONISE *)	●		●			●
	IMCOSEC	●		●			
	INFRARISK	●		●	●		
	INTACT	●		●			
	OPSIC	●				●	

[27] http://www.arcc-network.org.uk/project-summaries/crew/#.VuwLcOIrK00

	POP-ALERT*)	●				●	
	PEP *)	●				●	
	PRACTICE	●				●	
	RIBS	●	●	●			●
	SPARKS	●		●			
	STRUCTURES ***)	●	●	●		●	
	SECRICOM ***)	●					
	SLAM ***)	●					
	TACTIC	●			●	●	
	TACTICS	●	●				
	VITRUV	●		●		●	●
H2020	DARWIN **)	●					
	IMPROVER **)	●		●			
	RESILENS **)	●		●			
	RESOLUTE **)	●		●			●

**) is also in the list of identified project in SMR proposal*
***) recommended by the commission to be reviewed in the report*
****) Identified, reviewed but are not included in the analysis (not so relevant)*

Note that from both Table 5 and Table 6 some identified projects encompass social problems or social dynamics. This problem area will be discussed in Chapter 5. We reviewed these relevant projects again with respect to this problem area in addition to the scientific literature sources that were reviewed using the method explained in the next section 2.1.5.

2.5.5 SELECTING SCIENTIFIC LITERATURE

In addition to searching the EU project catalogues, to capture the European dimension of resilience in the three different problem areas, we used SCOPUS digital library. The keywords used in the SCOPUS are listed in Table 6. We only searched for journal articles excluding conference papers. We applied a three step filtering process to find the most relevant literature from our search.

- Filter 1: At this stage, the filtering was limited to Social Sciences and Decision Sciences, restricted to English articles.
- Filter 2: At this phase, the activity was mostly to detect duplication, especially for social problems (problem area 3) where we used five different keyword searches.
- Filter 3: At this final step, we conducted manual checking by reading the abstracts. At this point, even though we have applied two filters, we found a wide range of out-of-scope topics, such as child and art, archeology, marine life, politics, environmental humanities, biodiversity research, dermatology, and so on. During a deeper review from, reading the papers, further found topics were

excluded, such as flood in Jakarta, crisis in Afghanistan or urban history in Australia. The numbers listed under the Filter 3 column in table 7 are based on final articles that are included in the analysis.

Table 7 summarizes the overview of the keyword searches and the number of results obtained from the SCOPUS database.

Table 7 List of the Key-words Searches and the Results

Problem Area	Keywords	Results	Filter 1	Filter 2	Filter 3
CI	Resilien* AND critical infrastructure AND Europe Social science in ALL FIELDS	760	24	24	15
SD	Resilien* AND social problem AND Europe in Life Science and Social Science; Resilien* AND urbanization AND Europe in Social Science; Resilien* AND inclusion AND Europe in Social Science; Resilien* AND terrorist AND Europe in Social Science; Resilien* AND refugee AND Europe in Social Science	59	48	41	10

2.5.6 PROCEDURE FOR ANALYSIS

We used a qualitative approach to analyse the documents. In brief, the procedure for analysis is as follows:

- Developing of initial framework for analysis.
- Reading of articles (abstract, resilience definition, dimensions, threats …).
- Extracting the information in accordance to the outlined framework.
- Classifying the information into a systematic framework to analyse further the CI, CC and SD issues.
- Identifying metrics and relevant European dimension of resilience framework.
- Summarizing, grouping or re-grouping the information, and further detailed classification.
- Verifying the original sources for unclear information, looking at cited reference if necessary.
- Final analysis.

2.6 LITERATURE PROFILES

In this section, we present the profile of types of literature that have been analysed for the three problem areas, i.e. critical infrastructure, climate change and social dynamics.

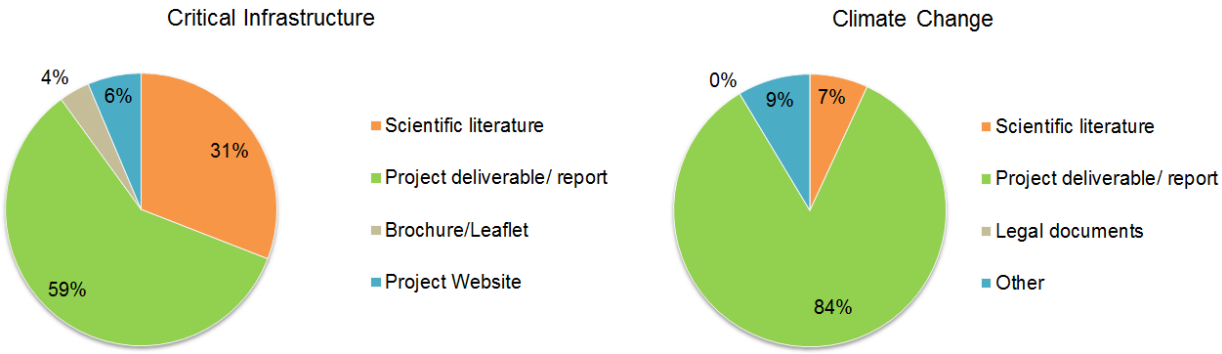

Figure 4 Overview of sources for literature review for CI and CC

Figure 4 shows the sources for literature review. Literature identified from EU CI projects are shown on the left diagram. The CI literature originates from project deliverables or reports (59%) followed by scientific literature (31%), project website (6%) and brochures or leaflets for the projects (4%). Brochures or leaflets were used if we were not able to find the report or deliverables due to access restriction applied in the project, or simply because the project was newly launched and therefore minimal documents had been produced. The right diagram in figure 4 shows the sources of CC literature. The CI literature originates from project deliverables or reports (84%) followed by scientific literature (7%), and others (9%). Others include leaflets, brochure or the website.

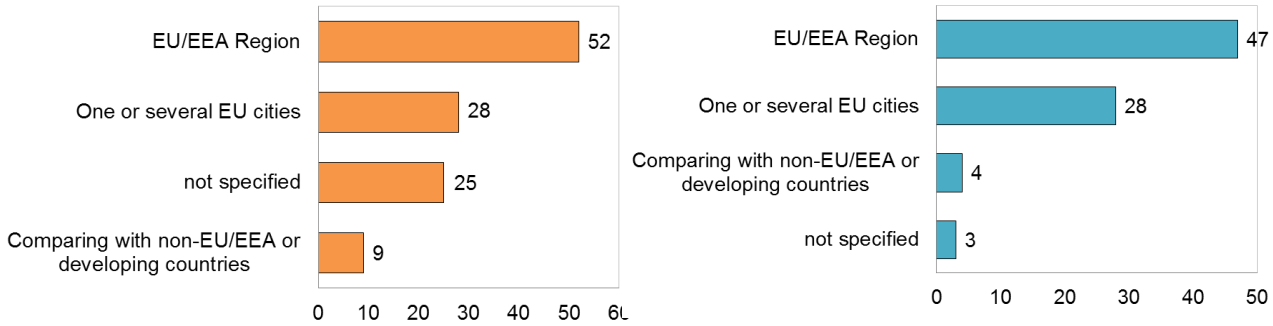

Figure 5 Coverage area as a unit analysis in the literature. In the left (orange chart) depicts CI literature while in the right (blue chart) is CC literature

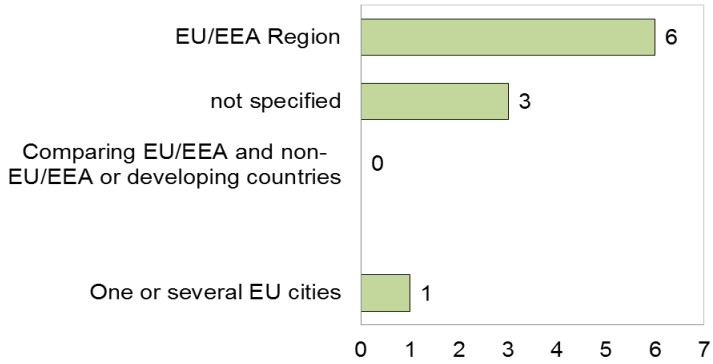

Figure 6 Coverage area as a unit analysis in SD literature

We also categorised the geographical coverage of the reports in the literature as seen in Figure 5 and 6. Most literature focused on EU/ EEA regions. That means the overall reports mention EU/EEA or European context as a general term without pointing to specific countries or specific cities. Some reports contained case studies in one or several EU cities, and thus we categorized them into the second type: "One or several EU Cities". For both CI and CC literature, these were the second most frequent types of reports. Some reports compared the resilience concepts and the application between EU/EEA and non EU-EEA countries (for example Israel) or developing countries such as cities in Asia, Africa or Latin America. The reports included in the "not specified" category were mostly literature review or state-of-the-art type reports.

With respect to the literature for SD discussion, as previously mentioned, we reused the identified project reports for CI & CC to address the SD issues. We also examined the SCOPUS literature, which added 10 articles to the analysis. The geographical coverages of SD literature from SCOPUS are shown in Figure 6. We also mapped issues addressed in the different CI and CC projects in Figure 7 and 8 respectively, to be able to grasp quickly, which project discussed what topic(s). Note that sometimes one project addressed multiple topics. In such cases, we used the same colour from a topic covered by a project

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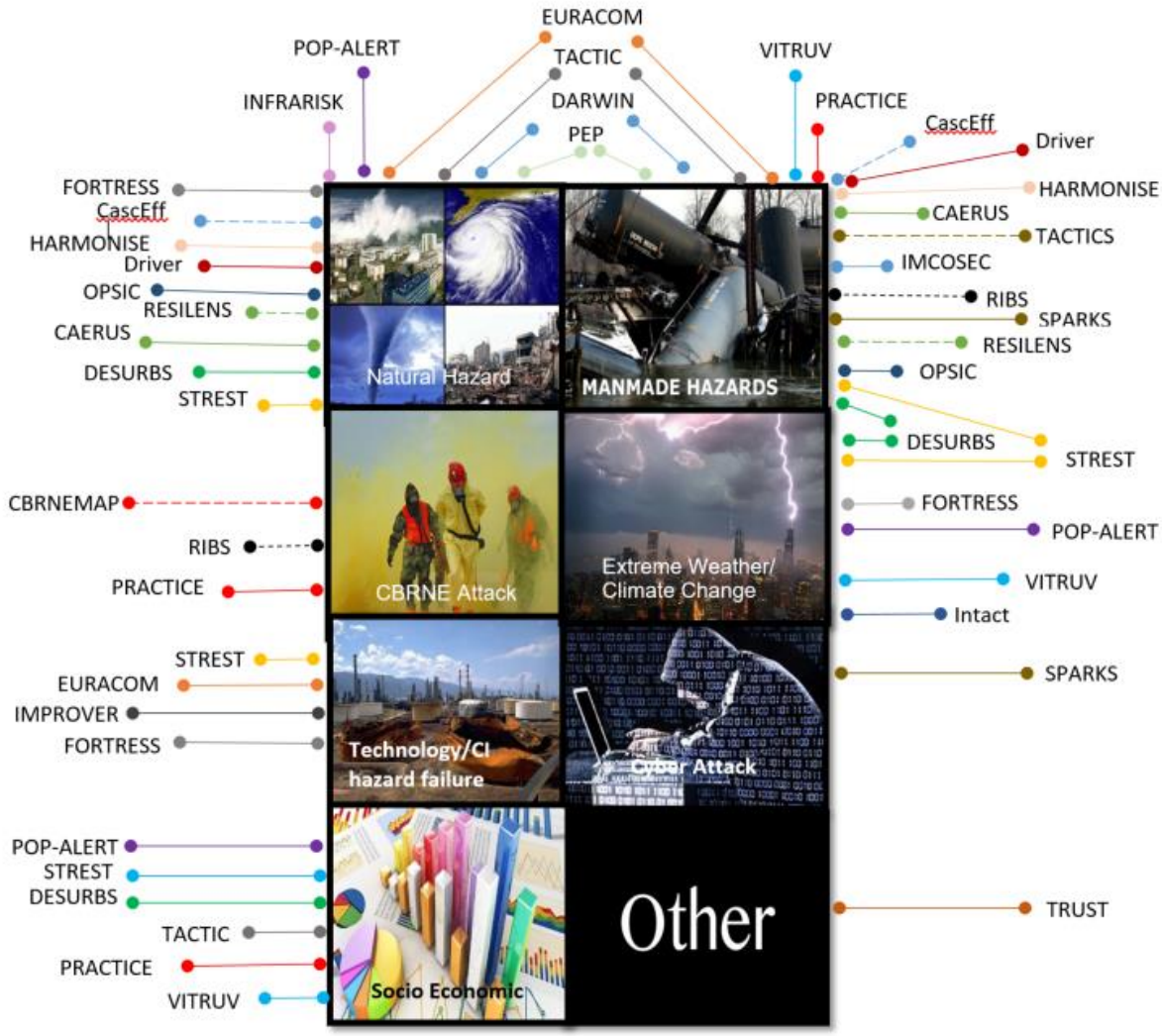

Figure 7 Map of CI projects and main resilience areas

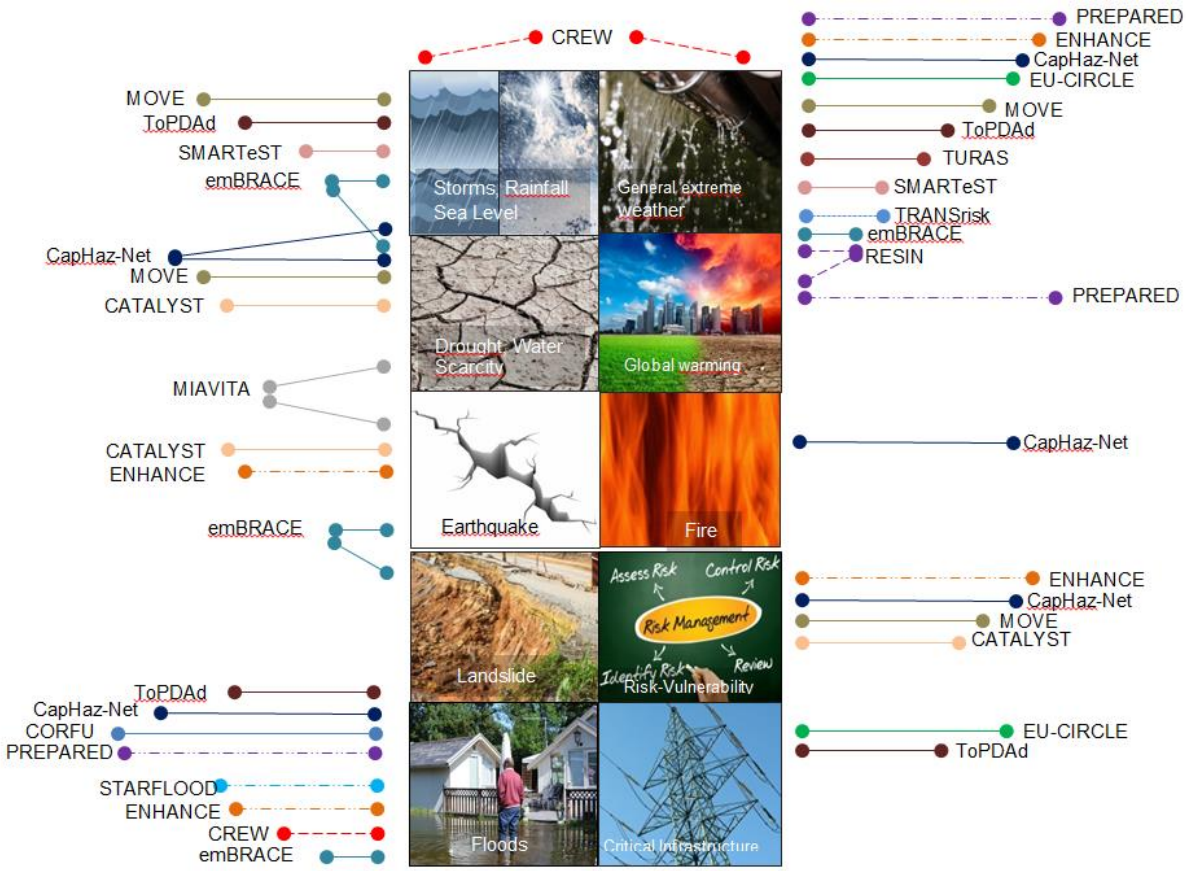

Figure 8 Mapping the focus of resilience concept in identified projects related to the Climate Change

Summary of EU Sectorial Approach

- **Reviewing 170 documents of EU-Funded Projects under FP7 and H2020:**
- Environment (Climate Change) FP7 (13 projects)
- Secure Societies FP 7 (18 projects)
- Climate Action environment, resource efficiency and raw materials H2020 (3 projects)
- Secure Societies H2020 (4 projects)
- **Reviewing European dimension of resilience from scientific articles identified in**
- SCOPUS Database (25 articles), OPENAire (3 documents) and ScienceDirect (10 documents)
- **Reviewing Relevant EU Policies in these following areas:**
- EU Policies on Critical Infrastructure Protection
- EU Policies on Climate Change
- EU Policies on Adaptation Strategy to Climate Change
- EU Policies on Integration

3 RESULTS: CRITICAL INFRASTRUCTURE

RESULTS: CI

- Definition of Critical Infrastructure
- Critical Infrastructure Resilience in EU Policy
- Resilience: definition, dimensions, challenge and threats CI resilience
- Approaches and Methods
- Metrics and Indicators
- Conclusions of CI Literature

3.1 INTRODUCTION

In this section, we elaborate the information about critical infrastructure (CI) resilience obtained from the literature identified in Chapter 2, Table 6. Out of 26 projects identified, 22 projects are included in the analysis. We reviewed 120 documents which include 25 articles identified from both SCOPUS and ScienceDirect digital library. Project websites/ leaflets were used if these particular projects are new and they have not yet produced any reports. If the reports or the project websites were no longer available for public access or restricted, reports in the CORDIS[28] website were used. Among the reasons for this restriction is that in some EU completed projects, prototypes for commercialization were developed, implying that the most basic information would not be made public. Likewise, for EU projects that had implications for EU security, the reports were often not publicly accessible at all, or only published as a summary of overall activities.

While D1.1 focuses on finding the worldwide approach to resilience and capturing the definition of resilience from the scientific literature, in order to assess the relevance, applicability and potential operationalisation of resilience implementation, this survey (D1.2) on EU-Secure society projects aims to answer the following questions:

- How have different EU projects on Secure Societies interpreted, defined, used and applied the resilience concepts in a specific CI sector or across sectors?
- What kinds of challenges and approaches exist in the area of CI?
- How is the resilience concept applied in different CI sectorial EU projects?

[28] CORDIS, Community Research and Development Information Service, http://cordis.europa.eu/projects/home_en.html

- What are the recommended policies to increase the city resilience with respect to the critical infrastructure?
- How can the sectorial application of resilience be linked to urban or city resilience, or even to be a backbone of EU city resilience?

It is worth to mention that during the EU project analysis in CI topic, there is always a trade-off between "urban" content and "CI content". When the project focuses on CI resilience, the details on how to build CI resilience is thoroughly examined, depending upon what perspective are used to achieve and explain CI resilience: dependency, interdependency, cascading effects, risk analysis, disaster risk reduction, resilience framework, or a mixture of them. However, the "urban" perspective is discussed in a limited way, or only treated as a context and background. When resilience or urban context are explored in-depth concerning the detailed mechanism, e.g. building organisational resilience, local government resilience, societal or community resilience, then the role of CI is only dealt with marginally.

The two charts in Figure 9 illustrate the topic coverages and approaches found in the identified CI

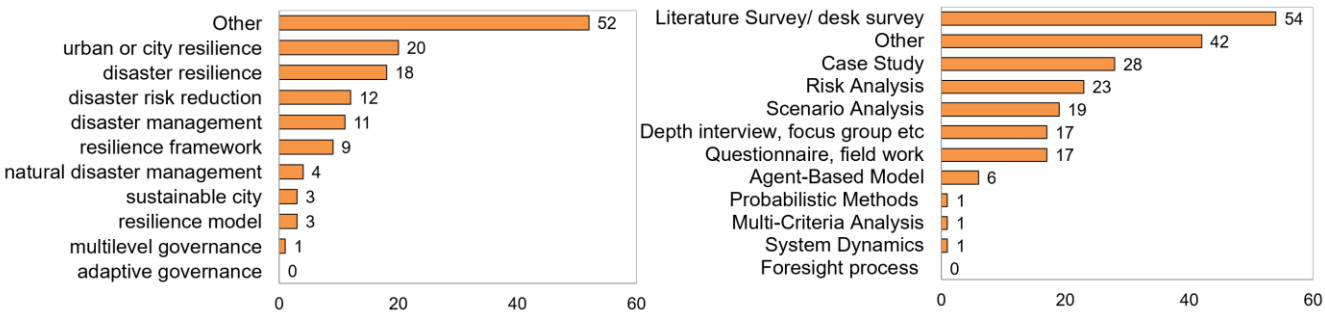

Figure 9 Left: Topics covered by EU CI projects; Right: Approaches used in the literature

literature. The left chart summarizes the topic coverages or contexts of resilience discussion in a report or an article. Disaster and urban or city resilience are the two most frequent contexts discussed in the literature. The list of "other" topic category in the top of the chart includes:

- Ability to respond CBE (Chemical, Biological, Explosive) events
- Adaptive management
- Adaptation of CI standard and design
- Cyber security governance
- Disaster preparedness
- Holistic resilience for greater urban areas
- Protection system of critical infrastructure
- Public-private partnership
- Resilience assessment and management
- Response capacity
- Resilience enhancement
- Threat identifications

- Improving response to crisis
- Vulnerability and risk analysis, vulnerability assessment

The chart on the right side of Figure 9 depicts the methods used in the reports on critical infrastructure and resilience. The five most frequently used methods are literature survey, case study, risk analysis, scenario analysis and depth interview / focus group discussion, respectively. Among methods used in CI literature that are not listed in the right chart of Figure 9 are the following: lab test, stakeholder engagement, statistical analysis, before-after change analysis, training, develop attack model, hazard assessment, mapping, multi-regional discussion, discrete event simulation, susceptibility analysis, comparative study, serious gaming and training, gap analysis expert/professional knowledge gathering, multi-regional discussion, and interdisciplinary approaches. Note that sometimes one report encompasses several themes or several approaches. Therefore, the numbers of topic and approach coverages do not correspond to the number of reports identified. This is valid as well for charts and diagrams shown either in the next sections or in the upcoming chapters.

3.1.1 WHAT IS CRITICAL INFRASTRUCTURE?

CI in European context is defined as "asset, system or part thereof located in Member States which is essential for the maintenance of vital societal functions, health, safety, security, economic or social well-being of people, and the disruption or destruction of which would have a significant impact in a Member State as a result of the failure to maintain those functions**". (EU Commission 2013)**

CIs are very important for a city and society in general because they provide services needed for daily human activities. And there is no doubt that today, people' and organisations' dependency on the availability of CIs is increasingly essential. Theoretically, CIs are described as "large-scale, spatially distributed systems with high degrees of complexity". These complexities largely stem from the vast functional and spatial dependencies and interdependencies that exist among the infrastructure systems, which enable failures to cascade from a system to other systems (Johansson & Hassel, 2010). According to the report to the US President's Commission on CI Protection, CI system is defined as "a network of independent, mostly privately-owned, man-made systems and processes that function collaboratively and synergistically to produce and distribute a continuous flow of essential goods and services" (Ouyang, 2014). Council Directive (2008) defines the Critical Infrastructures as "assets, systems or parts thereof, which are essential for the maintenance of vital societal functions, such as health, safety, security, economic or social well-being of people, and the disruption or destruction of

which would have a significant impact because of the failure to maintain those functions[29]".Thus, when CI is placed in European context, the definition is extended as follows: "**European critical infrastructure** includes those physical resources, services, and information technology facilities, networks and infrastructure assets, which, if disrupted or destroyed would have a serious impact on the health, safety, security, economic or social well-being of **two or more Member States"**. European Commission (2013)[30] defines CI in European context as "asset, system or part thereof located in **Member States** which is essential for the maintenance of vital societal functions, health, safety, security, economic or social well-being of people, and the disruption or destruction of which would have a significant impact in a Member State as a result of the failure to maintain those functions".

Seriousness of the impacts of CI failures on two or more Member States can be seen from:

- Extent of the geographic area which could be affected by the loss or unavailability of a CI element beyond three or more Member State's national territories;
- Effect of time (i.e. the fact that, for example, a radiological cloud might, with time, cross a border);
- The level of interdependency i.e. electricity network failure in one Member States affecting another

European Commission (2005)

Lange, Sjöström, and Honfi (2015) advocate the EU definition that what constitutes an EU critical infrastructure is determined by its cross-border effect that ascertains whether an incident could have a serious impact beyond **two or more Member States national territories**. This is defined as the loss of a critical infrastructure element and is rated by the:

- Extent of the geographic area which could be affected by the loss or unavailability of a CI element beyond three or more Member State's national territories;
- Effect of time (i.e. the fact that, for example, a radiological cloud might, with time, cross a border);
- The level of interdependency i.e. electricity network failure in one MS affecting another (European Commission (2005)[31].

Therefore, A CI is an asset or system, which is essential for European society and the environment. Because of the CI's high integration and modern Europe's dependencies, a failure of a superregional CI facility could cause large-scale effects. In the European Union (EU), measures are taken to increase the protection of society and environment (Billmaier & Reinders, 2014). Because of the CI's high integration and modern Europe's dependencies, a failure of a superregional CI facility could cause large-

[29] Council Directive 2008/114/EC of 8 December 2008 on the identification and designation of European critical infrastructures and the assessment of the need to improve their protection. Offical Journal of the European Union, 23 December 2008
[30] https://ec.europa.eu/energy/sites/ener/files/documents/20130828_epcip_commission_staff_working_document.pdf
[31] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A52005DC0576

scale effects. In the European Union (EU), measures are taken to increase the protection of society and environment.

In the INTACT project, McCord, Rodgers, Davis, Haran, and Berchtold (2015) have collected worldwide definitions of CI including the definition of various EU member states, and summarized the most important content covered by CI definition:

- A collective of several **attributes**: physical resources, services, information technology facilities, networks and infrastructure assets (physical or virtual);
- The **change of state**. If CIs are disrupted or destroyed, they must become so from having been in a steady state condition, or from operating at 'normal' operating capacity;
- The **nature** and **scale** of an event which causes the change of state – the **level of disruption** (minor to major) through to destruction (localised to widespread);
- The **impact** of an event – on people or infrastructure objectives;
- The potential geographical **area** that could be **affected**;
- The **time a CI may be affected** due to the occurrence of an event;
- The **interdependencies**, which may exist between CIs or elements of CIs.

In the European context, the CIs sectors are:

1. Energy

- Electricity (Infrastructures and facilities for generation and transmission of electricity in respect of supply electricity) such as
  - Oil (Oil production, refining, treatment, storage and transmission by pipelines)
  - Gas (Gas production, refining, treatment, storage and transmission by pipelines, LNG terminals)

2. Transport

- Road transport
- Rail transport
- Air transport
- Inland waterways transport
- Ocean and short-sea shipping and ports

Examples of CI include critical components of transportation, energy distribution and communication networks. There are differences from one author to another about whether sectors can be included or excluded from CIs. Below, the examples of the differences can be seen in compared to different authors:

Table 8 Example of CI Sectors

Source	CI Sectors	Source	CI Sectors

Katina, Ariel Pinto, Bradley, and Hester (2014)	• Telecommunications, • Electrical power systems, • Gas and oil storage and transportation, • Banking and finance, • Transportation, • Water supply systems, • Emergency services (including medical, police, fire, and rescue), • Continuity of government	RESILENS H2020 project[32]	• Energy • Transport • Agriculture • Water • Communications • Oil • Gas • Health • Security • Finance

In the European context, however, the CIs sectors[33] are:

1. Energy

- Electricity (Infrastructures and facilities for generation and transmission of electricity in respect of supply electricity) such as
- Oil (Oil production, refining, treatment, storage and transmission by pipelines)
- Gas (Gas production, refining, treatment, storage and transmission by pipelines, LNG terminals)

2) Transport

- Road transport
- Rail transport
- Air transport
- Inland waterways transport
- Ocean and short-sea shipping and ports

3.1.2 CI RESILIENCE IN EU POLICY

The need for introducing policies for CI protection in EU was triggered by two terrorist attacks, one in Madrid 2004, and the second one in London 2005 respectively, as stated in Green Paper on EPCIP (European Programme for Critical Infrastructure Protection)[34], where resilience was mentioned. The timeline of the development of CI protection and CI resilience, and the policy process are summarized in Figure 10.

[32] http://resilens.eu/
[33] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0114
[34] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A52005DC0576

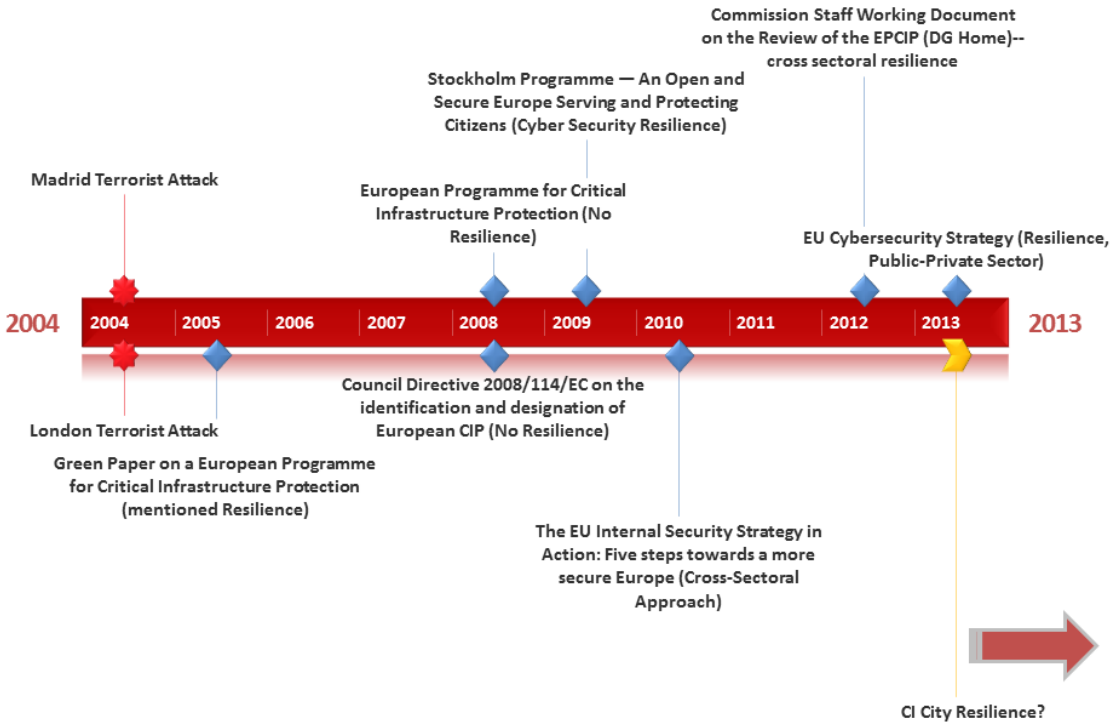

Figure 10 Resilience and EU Policy from timeline and development (Summary-SMR project)

The European Programme for Critical Infrastructure (EPCIP) was established in 2008. In the Green Paper (2005) that shaped EPCIP[35], protective measures for CI were dominant although the document admitted that protecting all CIs was not possible. However, at this stage, resilience was not a part of the policy. Council Directive issued in 2008,[36] highlighted the design of EU Critical Infrastructure and the need to improve its protection. Thus, the importance of "resilience" was not in the CI protection policies until 2012. It was the first time that the Commission Staff Working Document on Review of the EPCIP considered the concept of resilience as relevant.

Pursiainen and Gattinesi (2014) described that there was a debate regarding the deviation of the concept of resilience, which was perceived as a cross-sectorial approach as opposed to the original EPCIP treated resilience based on sectorial approach. Apparently a number of EU member States argued that security and resilience of a system may involve multiple sectors and made the sector focused approach less relevant, especially, for instance, the energy supply is not solely sectorial problem because when it comes to resilience it may affect other sectors such as transport and ICT.

[35] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A52005DC0576
[36] Council Directive 2008/114/EC of 8 December 2008

Between these 2008-2012 timelines, two important documents i.e. Stockholm Programme (2009)[37] and EU Internal Security Strategy (2010)[38] were adopted. The first document mentioned CI resilience in the context of cyberthreat. The second document included some objectives to increase the Europe's resilience to crisis and disasters, mentioning that "cross-sectorial threats" needed improvements to cope with crisis. The concept of resilience was included in The Staff Working Document that introduced CI protection and resilience. In 2012, the EU Cybersecurity strategy used the term "cyber resilience" highlighting that resilience is promoted when…" *the authorities and private sectors have more capabilities, capacities, resources and processes to prevent, detect and handle cyber security incidents*". In this case, the EU approach targeted national rather than EU legislation. Moreover, in this context, public-private partnership (PPP) was emphasized. In fact, there is still lack of effective incentives for private actors to provide reliable data on the existence or impact of incidents (Pursiainen & Gattinesi, 2014). From the brief overview of the CI regulations, apparently resilience was used in a very limited context at that time (2008-2012).

In the Commission Staff Working Document 2013[39], a new approach to EPCIP and making European Critical infrastructure more secure was introduced. This new approach to resilience is prominent. This document pointed out the lack of consideration about links between CI sectors and across national boundaries, and the need of a new approach to close this gap. A part of the new approach was also to look at the independencies between CIs, industry and state actors. In addition to interdependencies between sectors, there are also many interdependencies within the same sector, but spanning a number of European countries. One such example is the European high-voltage electricity grid, composed of the interconnected national high-voltage electricity grids. However, the document indicates the strong wish to involve in existing CI research and innovation activities notably in the "**Environment (including climate change) Theme**" research area.

In the meantime, the EU Adaptation Strategy to Climate -Change was launched in 2013. One of the eight actions for implementation proposed in this policy is as follows (Action 7): **Ensuring more resilient infrastructure: …"**to start mapping industry-relevant standards in the area of energy, transport and buildings and to identify standards that need to be revised to achieve better inclusion of adaptation considerations….". From the adaptation strategy and CI perspectives, the importance of including adaptation strategies to ensure resilient infrastructure is clear, and it reflects in the research themes we will discuss further in the next sections.

[37] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=URISERV%3Ajl0034
[38] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=URISERV%3Ajl0050
[39] http://ec.europa.eu/dgs/home-affairs/what-we-do/policies/crisis-and-terrorism/critical-infrastructure/docs/swd_2013_318_on_epcip_en.pdf

3.2 CI TOPICS

CI TOPICS

- CI Dependency and Interdependency
- CI Cascading Effects
- CI Risk and Vulnerability Analysis
- CI Resilience and CI Protection
- CI SmartGrid and Cyber Attack
- CI and Urban Resilience
- Other CI Themes

This part is organised thematically based on the most frequent perspectives or approaches used for analysing and discussing the CI and CI resilience. It is divided into six main topics. The seventh topic, “Other CI Themes”, is a section consisting of topics that do not belong to any of six main topics, or projects that were identified and seem little relevant for the SMR literature review. The first two subsections illustrate the overview of the literature, what kind of challenges, approaches, threats and scenarios are discussed in the CI literature. After that, we will start explaining the seven themes identified in the literature.

3.2.1 CI CHALLENGES AND APPROACHES

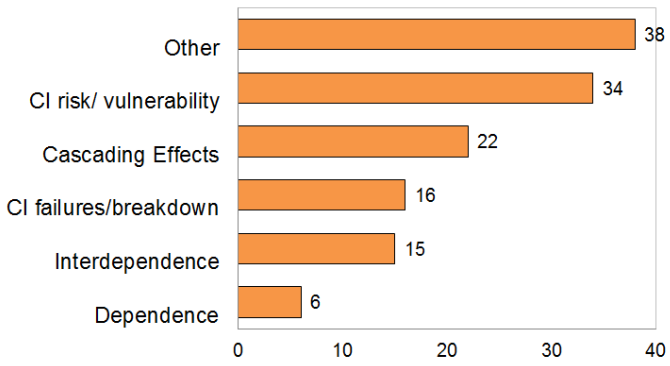

Figure 11 Overview of CI Context in the Literature

In this Section, we present the resilience challenges and approaches in the EU sectorial projects. Prior to elaborating the challenges, the overview of the CI resilience context described in the reports and the scientific literature found in the EU projects can be seen in Figure 11.

CI Risk and vulnerability are the most common themes discussed in the literature. Afterwards, cascading effects, CI failures and breakdown, interdependence and dependence come as the main perspective for looking at the CI. There is a category called “other” in Figure 11. The contexts under the “other” category are as follows:

CI CBRNE threat, CI protection, CI European resilience management guidelines, CI cyber-attacks, security attacks, CI service recovery/ CI stability, CI contingency planning and business continuity, CI preparedness. The remaining are topics where reports or articles do not fully address one of them, or are irrelevant because CI is used only as a case in the report, while the main context, for instance, is about improving crisis communication. The literature does not cover CI resilience, instead, it discusses cascading effects among a broad variety of societal sectors and CIs.

3.2.2 CI THREATS AND SCENARIOS

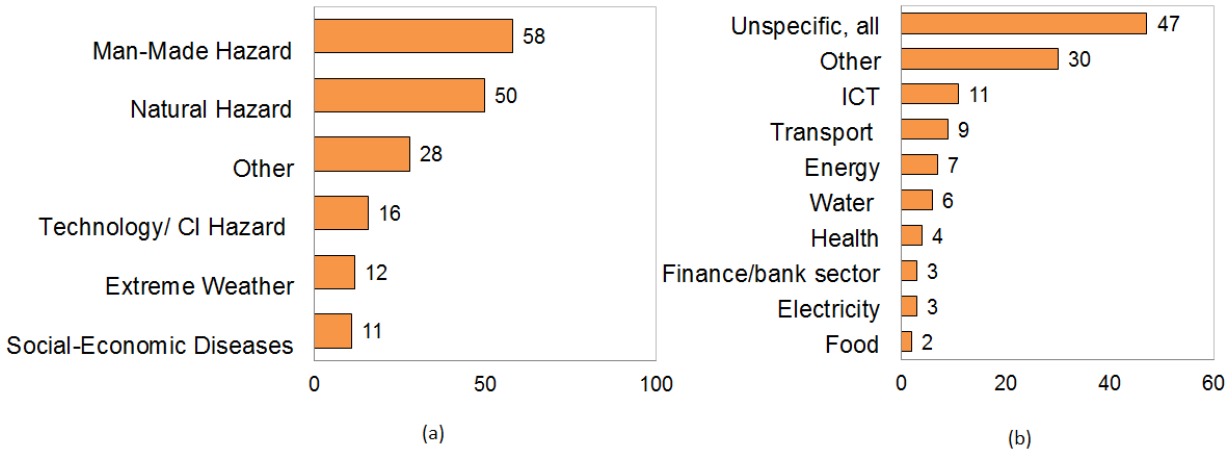

Figure 12 CI Threats/Scenarios and CI types.

Chart (a) on the left of Figure 12 shows a list of threats or scenarios discussed in the CI literature. Man-made hazard and natural hazard are the topics most frequently mentioned in the literature. While the rest are about technology or CI hazard itself, meaning the source of threats come from the technology itself, for instance, obsolete technology, malfunction and so on. Chart (b) shows the coverage of CI sectors that are addressed in the project.

3.2.3 CI DEPENDENCY AND INTERDEPENDENCY

An interdependency means there is two-bidirectional relationships between two infrastructures, the first one into the second one and the second one into the first one. **A dependency** is characterized by unidirectional relationship, i.e. one or several components in a system is dependent on the state of the components of another system (Rinaldi, Peerenboom, & Kelly, 2001).

The strong interdependencies between various infrastructures, such as those used in water and wastewater systems, transport systems (roads, bridges etc.), electricity and telecommunication systems

are seldom accounted for in the literature on current risk analyses. Recently, the importance of the concept has gained recognition as a discussion of CIP and CI resilience cannot be separated from interdependence, and dependence. There are also different interpretations concerning the CI interconnectedness, taking into account if they are dependent or independent. An interdependency means here is two-bidirectional relationships between two infrastructures, the first one into the second one and the second one into the first one. On the contrary, dependency is characterized by unidirectional relationship, i.e. one or several components in a system is dependent on the state of the components of another system. However, it must be stressed that some literature uses interdependency and dependency as interchangeable terms (Rinaldi et al., 2001).

The CascEff[40] and EURACOM[41] projects also discuss these dependency and interdependency issues. A dependency is a relationship between two products or services in which one product or service is required for generation of the other product or service. Interdependency is defined as the mutual dependency of CI Cascading effects and domino effects as discussed in section 3.2.1, and they can be caused by the failure within a single CI service (e.g. electric power transmission grid to electric power distribution grid) or across CI (e.g. failure of electric power generation due to loss of gas pressure). In the literature (Hassel, Johansson, Cedergren, Svegrup, & Arvidsson, 2014; Johansson et al., 2015), the impact of dependencies have different dimensions as shown in Table 9.

Table 9 Different Impacts of Dependency

Dimensions	Description
Dependency type	• Functional - the state of a system is dependent on the output(s) of another system. • Geographical - systems that are located in the same area and where changes in the local environment can create state changes in all of them • Logical - a state change in one system results in a state change in another, without any of the other dependencies occurring.
Location and spatial extent	• The geographical location (-s) and the size of the geographic area where the dependency impacts occur.
System extent	• Describes the proportion of specific impacted subsystem(s) within the system affected by the Dependency Impact. Categorized into: Single, Few, Majority, All
Starting and ending time	• Describes when Dependency Impacts initially occur and ends – described by Date and Time

[40] http://www.casceff.eu/
[41] http://www.eos-eu.com/Middle.aspx?Page=euracom

Figure 13 Energy Supply Chain (Source: EURACOM)

The EURACOM project is an example of a coordination action project that addresses the issue of protection and resilience of energy supply for European interconnected networks. The aim of this project is to identify a common holistic approach (end-to-end energy supply chain) and establishing coherent risk management procedures across energy sectors and EU countries. The project focuses on the dependency in the energy network, which is a very useful practical example of the importance of CI resilience, especially when dealing with dependency and interdependency in the electricity, natural gas and oil sectors.

The energy supply chain in these three sectors (electricity, natural gas and oil) can be shown in Figure 13 (EURACOM). In this chain, there are complex dependencies between organisations as players in energy sector such as producer, transmission system operators, distribution operators, consumer, shipper, trader, and supplier that interact between them. These organisations in the supply chain are subject to regulation both defined by national law and EU policies. This supply chain is also connected to the national regulators and EU regulators such as CEER (The Council of European Energy Regulators), and ERGEG (The European Regulators' Group for Electricity and Gas), and linked to different associations, and even interacting with other international supply chains that have similar dependency. While the dependencies and interdependencies in the energy sector are obvious, Figure 13 introduces a concept of intradependencies where within the organisation of supply chain, a kind of dependency occurs. Table 10 shows this intradependency happening in gas sector as an illustration, which also occurs in other energy sectors such as electricity and oil.

Table 10 Example of dependency and intradependency within supply chain of gas sector.

Categories	Description
Gas production dependencies	• Transport of condensate
Market operations	• Telecommunications (especially internet) • Financial services
Transport dependencies	• Electric power for compressors • Harbour main port operations / shipping (LNG transport) • Telecommunications for Gas transport service operator for coordination with other Gas transport service operators, with shippers and distribution operators • Telecommunication for SCADA teleoperations such as flow control and monitoring

Distribution dependencies	• Gas transport supply (pressure, calorie quality)
Customer services/interaction	• Telecommunications (especially internet) • Financial services
Non-normal mode of operations transport and distribution	• Emergency services • Police and military security services • Transportation for gas incident crews and materials (road)

The CI dependency in the energy sector will be even clearer as seen in Figure 14. This figure shows a cross-border, cross-sectorial electricity interdependency which has more complex relationships. Initially suggested by Rinaldi et. al. (2001), this figure has been adopted in EU Commission Staff Working Document (SWD) 2013 [42], indicating the CI dependency issue is extremely important and the commission is continuously paid attention to this issue.

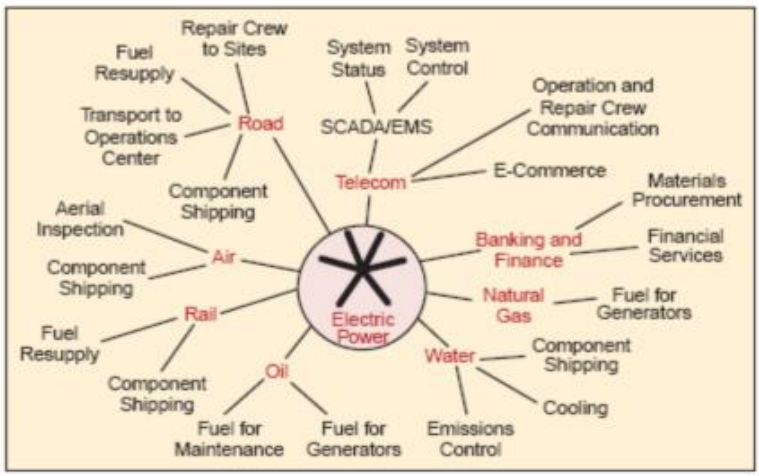

Figure 14 Example of electric power infrastructure dependencies.

Using a slightly different approach, INTACT[43] examines CI resilience with respect to extreme weather events (Bucchignani & Gutierrez, 2015; Eidsvig & Tagg, 2015; Mäki, Forssen, & Vangelsten, 2015; McCord et al., 2015; Vangelsten et al., 2015). The project with relevant task presents recent incidents of CI failures caused by extreme weather factors. These factors contribute to the vulnerability and resilience of CI to extreme weather. INTACT also identifies generic measures and gaps to protect CI. The CI dependency notion resembles the economic and societal aspects as described by Mäki et al. (2015) that infrastructure malfunctioning and outages can have far reaching consequences and impacts on economy and society. Owing to expensive long-term CI maintaining cost, future extreme weather

[42] https://ec.europa.eu/energy/sites/ener/files/documents/20130828_epcip_commission_staff_working_document.pdf
[43] http://www.intact-project.eu/

event must be taken into account when considering protection measures, mitigation measures and adaption measures to reflect actual and predicted instances of CI failures.

3.2.4 CI CASCADING EFFECTS

- **Cascading effects**: a disruption of one critical infrastructure leads to a series of disruptions in other CIs due to the dependencies between the critical sectors
- **Cascading effects** can be caused by the failure within a single CI service (e.g. electric power transmission grid to electric power distribution grid) or across CIs
- **Types of CI Failures**: cascading failures, escalating failures and common cause failures
- **Consequences of CI cascading effects** can be measured from different metrics and indicators:
  - Technical consequences (reduced quality, quantity, loss of components, damages)
  - Organisational consequences (affected units, reduced staffing)
  - Social consequences (political instability, unrest)
  - Human consequences (fatalities, injuries, homeless, mental health injuries)
  - Economic consequences (direct costs)
  - Environmental consequences (polluted land, forest, sea, animal)

Another emphasis in Critical Infrastructure Protection (CIP) is the risk of cascading effects, where a disruption of one critical infrastructure may lead to a series of disruptions in other CIs due to the dependencies between the critical sectors (Chmutina et al., 2014). Rinaldi et al. (2001) categorize cascading effects as the results of three types of CI failures:

- **Cascading failures**–where a failure in one infrastructure causes disturbances in another infrastructure. In this situation, there is a functional relationship between two or more infrastructures. For example, water supply is dependent on electricity for water treatment. These types of situations are categorized as functional interdependency.
- **Escalating failures**–where failure in one infrastructure worsens an independent disturbance in another infrastructure. For example, a breakdown in the metro is significantly worse if the main road is unavailable due to a fire in a tunnel. These situations are categorized as impact interdependency.
- **Common cause failures**–where two or more infrastructures are disrupted at the same time due to a common cause. For example, a fire in a culvert may cause interruption of electricity, water and telecommunication at the same time. Often the term geographic dependencies is used to categorize such failures because one or several elements of the infrastructures are in so close proximity that external threats may knock out several infrastructures at the same time.

One EU project addressing the issue of CI cascading effects is CascEff[44]. The challenges of this project are to improve the understanding of the cascading effects in crisis situations to reduce the consequences of escalating incidents in complex environments (Ekman & Lange, 2014; Lange et al., 2015). In CascEff project, technical definition for cascading effects is proposed as: The impacts of initiating event where 1) System dependencies lead to impacts propagating to other systems, and; 2) The combined impacts of the propagated events are of greater consequences than the root impacts, and; 3) Multiple stakeholders and/or responders are involved.

CascEff identifies hazards followed by risk assessment, critical infrastructures (e.g. blackout) or systems in which a failure likely triggers a cascading effect and a possible domino effect. The understanding of the domino effect is highly relevant especially when dealing with industries that have the potential for major accidents such as chemical or nuclear industry or transport of dangerous substances.

The project does not explicitly mention that CascEff's approach targets resilience enhancement. However, the proposed approach to deal with cascading effects before, during, and after an incident belongs definitely to capabilities required for resilience. Thus, increasing resilience is a result of better understanding of cascading effects, which should occur before and during the incidents. *Before an incident,* cascading effects can be identified through different means such as analysis, planning, and intuition. The roles of training, exercises and planning are crucial here. *During the incidents*, these effects may be identified through operational picture indications which require solid command and control, and collaboration (Ekman & Lange, 2014). Hassel et al. (2014) model the cascading effects as seen in the following Figure 15:

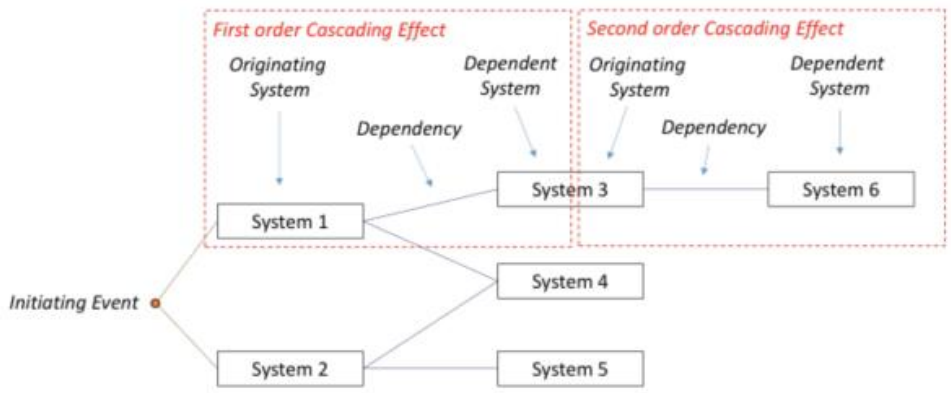

Figure 15 CascEff model shows the propagation of effects between systems in an incident. Source: Hassel et al. (2014)

[44] http://casceff.eu/

All cascading effects always start with an initiating event, which then can give direct impacts to other systems. The resulting effect is called a “first-order cascading effect”. If this line of propagation continues, second, third, etc. order cascading effects emerge. Cascading effects are also manifested in system impacts, which are multidimensional in nature. The cascading effects can be captured as consequences and indicators of consequences as shown in Table 11.

Table 11 Consequences and indicators

Consequences	Example Indicators	Consequences	Example Indicators
Technical consequences	• Reduced quality of a required input • Reduced quantity of a required input • Loss of components • Increased load • Damaged buildings • Loss of production	Human consequences	• Fatalities • Injuries • Homeless • Evacuated • Mental health injuries • People that has lost critical services.
Organisational consequences	• Affected organisational units • Reduced staffing	Economic consequences	• direct costs
Social consequences	• political instability • and civil unrest	Environmental consequences	• Polluted land • Polluted forest • Polluted sea • Dead animals

In addition, the CascEff project also offers metrics to measure the cascading effects. The metrics are total duration, total spatial extent, total cascade order, total consequences, cascade rapidity, relative duration, spatial proximity, relative spatial extent, duration, relative duration, avoided consequences, cascade order (Hassel et al., 2014). Interdependencies of infrastructure networks, cascading hazards and cascading effects are also discussed in the on-going INFRARISK[45] project (Adey, Hackl, Heitzler, & Iosifescu Enescu, 2014; Cheng & Taalab, 2014), but from the risk management process point of view. The cascading hazard and effect are captured from source events that will link to hazard event, infrastructure event, network event, and finally the societal event. Figure 16 shows how cascading hazards and cascading effects for risk assessment are captured in the example of the tree event.

Almost similar issues are tackled in the on-going STREST[46] project that addresses harmonized approach to stress tests for critical infrastructures against natural hazards. It discusses the impact of natural hazard events to the cascading failures of non-nuclear CI, multi-infrastructure collapse, and takes into account the consequences to the society and economy in general. The difference with

[45] http://www.infrarisk-fp7.eu/
[46] http://www.strest-eu.org/opencms/opencms/

INFRARISK is that STREST focuses on the stress-test method designed to evaluate the vulnerability and resilience of individual CIs and infrastructure systems.

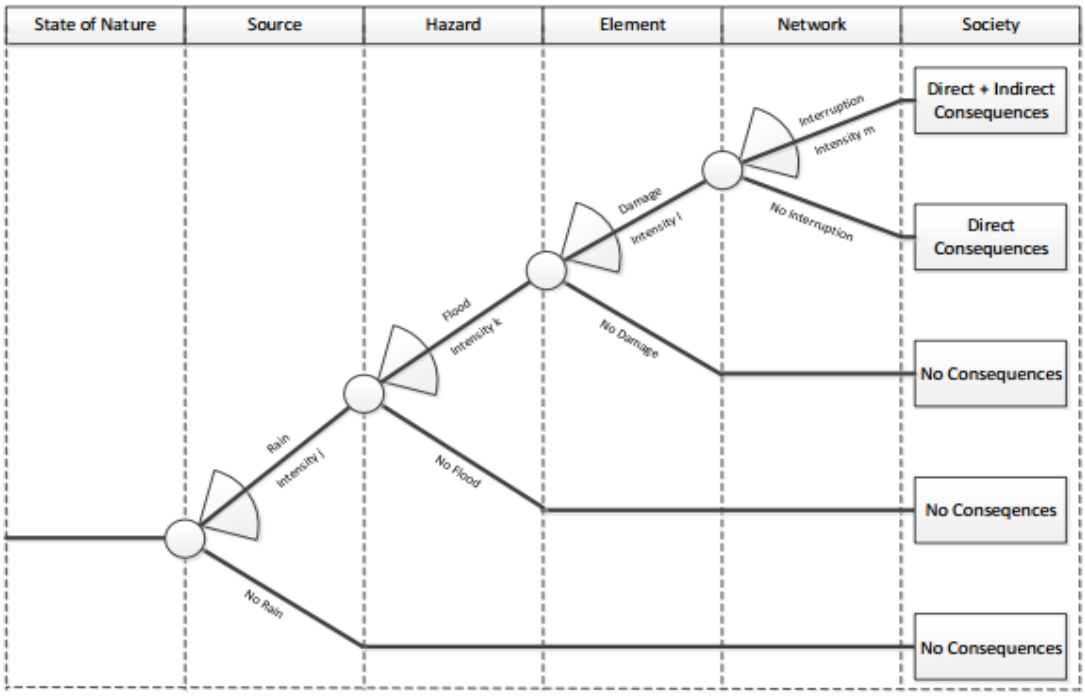

Figure 16 An event tree of infrastructure networks illustrate cascading effects. Source: (Adey et. al, 2014)

Using a slightly different approach, the FORTRESS[47] project focuses on the foresight tools for responding to cascading effects in a crisis. The project uses a wide range of scenarios such as a dam disruption, a European-wide blackout, a cross-border flooding, and mass-flooding. Hagen, Tzanetakis, and Watson (2015) revealed that the disruption of information relations and organisational relations were most commonly identified as triggers of cascading effects. These triggers concern relations that should have been functioning but failed to do so, leading to cascading effects. Disruptions of supply relations, concerning the dependency on the supply of materials or resources, and disturbance relations, unintended relations of interference, were less frequently identified but were still prominent triggers of cascading effects. Pre-disaster conditions and legal and regulatory relations were least frequently identified.

Furthermore, a comparative study is used to examine, which categorization of triggers in developed countries applies to a country such as the Solomon Islands. The study reveals that cascading effects in

[47] http://fortress-project.eu/

disasters in a country such as the Solomon Islands may have different causes from commonly identified triggers in developed countries. Additionally, it provides insight into ways in which disaster management in developing countries can result in unintended long-term social effects on the community level. Lack of coordination and cooperation of a functional disaster management plan potentially affected aid organisations response operations in a negative way (Hagen, 2015). One approach to study cascading effects in this project is GMA (General Morphological Analysis), which is used to obtain a comprehensive overview of the concepts and associated variables of historical case studies of cascading effects and to build relationships and a shared understanding of concepts among a multidisciplinary team (Watson, Hagen, & Ritchey, 2015). Unlike the CascEff project where cascading effects are to some extent related to CI resilience, in FORTRESS resilience, urban context or even CI context are not the foremost. Cascading effects in crises are portrayed through the mapping the interdependencies and relationships between different sectors and actors involved in crisis management, and map different aspects at play in cascading crises.

Finally, as a note, Luiijf, Nieuwenhuijs, Klaver, Van Eeten, and Cruz (2009) have conducted empirical studies based on 2375 serious incidents of different CI all over the world, and use the data to discover CI failures in Europe. There were 1749 CI failure incidents in 29 European nations where 95% of them occurred after the year 2000). The study concludes that cascades are frequent, highly asymmetric and focused. The majority of the incidents originate from the energy and telecom sectors. Interestingly, the article also points out that interdependencies occur less often than analysts have consistently modelled. In other words, despite dependencies and interdependencies exist everywhere, a reported serious cascading CI outages are rare. Only two cases of 770 CI failures were found. But we need to be cautious since this conclusion is drawn on news reports where more detailed damages may not be reported.

3.2.5 CI RISK AND VULNERABILITY ANALYSIS

The next theme that often appears in the literature is CI risk and vulnerability which are definitely important aspects in the crisis management and enhancing resilience (Johansson & Hassel, 2010). Risk is a combination of the probability and severity of adverse effects. The IPCC (2014) defines risk as “the potential for consequences where something of value is at stake and where the outcome is uncertain”. Johansson and Hassel (2010) add further saying that to conduct proper risk analysis one has to identify all relevant risk scenarios, assess them, and for each scenario estimate its likelihood of occurrence and adverse consequences. The following questions are frequent in the risk assessment procedures: What can go wrong? What is the likelihood of something will go wrong? What are the consequences?

The risk tolerance can be evaluated through different methods such as ALARP (As Low As Reasonably Practicable) and ALARA (As Low As Reasonably Achievable). According to ALARP principles, risks that are unacceptable must be reduced or eliminated under any circumstances, while risks that are clearly acceptable can be left without further action. ALARA relies on four principles: principle of **reasonableness** (economically and technically), **proportionality** (overall risk should not be larger than the benefits), **allocation** (allocation of risk in society should be fair) and **avoidance of disasters** (avoid risks with disastrous consequences) (Schwesig, Rochera, & Juan, 2015).

- Risk is the potential for consequences where something of value is at stake and where the outcome is uncertain.
- The common questions are: What can go wrong? What is the likelihood that if something will go wrong? What are the consequences?
- Risk analysis is conducted to develop strategies for mitigating hazard impacts
- Examples of risk evaluation methods:
    - ALARP (As Low As Reasonably Practicable)
    - ALARA (As Low As Reasonably Achievable)
- Risk assessment is also about contingency planning
- Risk is often linked to vulnerability
- The mean to achieve critical infrastructure resilience is reliable and effective risk and vulnerability management.

The risk is often also linked to the vulnerability which can be illustrated as “The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard” (UNISDR, 2009). Johansson and Hassel (2010) put forward three ways of discerning vulnerability in the interdependent context. It can be perceived as a global system property that describes the extent of adverse effects caused by the occurrence of a specific hazardous event. Normally, vulnerability is used to refer to a specific component of a system. Thus, a vulnerability in a system can refer to a situation where the failure of specific component can cause large damage. This type of component is called “*critical component*” and it is the first approach to interpret vulnerability. The second interpretation of vulnerability that is in the context of interdependent infrastructure is *critical geographical areas*. Thus, a hazardous event that occurs in the certain geographical area can have negative consequences to one or several CIs.

Risk and vulnerability analysis can help in shaping a good decision for risk reduction, control and management. Hazard and Operability Study (HAZOP), Failure Mode and Effects Analysis (FMEA), Fault-Tree Analysis (FTA), Event-Tree Analysis, and Risk Matrix are some of the most common methods identified in the projects highlighted risk and vulnerability analysis. ISO standards for risk management such as ISO 31000 are frequently referred to as a basis for conducting a risk assessment. In the

identified EU projects, many of them use the risk assessment and vulnerability assessment approaches to deal with resilience.

In addition to address interdependencies of infrastructure networks as discussed in Section 3.2.2, the INFRARISK[48] project (Adey et al., 2014; Avdeeva & van Gelder, 2015; Cheng & Taalab, 2014) targets a risk management process that includes different sub-processes to understand the risk to the critical infrastructure such as awareness of infrastructure elements (e.g. Roads, bridges) that may be prone to natural hazard, starting by understanding the events:

- Source events (initiating events), which occur regularly e.g. rainfall, tectonic plates movements, ground movement, etc.
- Hazard events (loading events) are events related to any earlier event or that may lead to consequences. e.g., earthquake triggers landslide.
- Infrastructure events include all the objects and the condition states of these objects to be considered, e.g. a bridge collapse.
- Network events include the states of use of the infrastructure network that might occur. For example, due to a tunnel collapse, the freight corridor between two cities is closed.
- Societal events include the actions of persons or group of persons. For example, due to the closing route, transporting goods are diverted over other routes or transport modes.

Understanding of the relationship between system elements will facilitate the risk identification process such as the need to ensure the identification of relevant scenarios such as events to which no value is to consider and events to which a value is to be incorporated. The risk analysis employs qualitative and quantitative approach. The calculation of the probability of occurrence of a scenario and the consequence of that scenario: **R = p (probability of that scenario) * C (Consequence).**

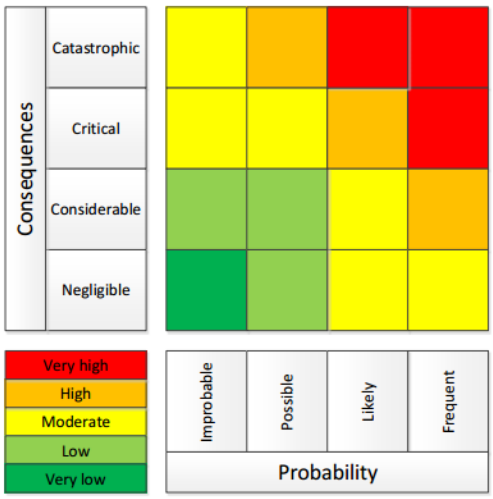

Figure 17 Risk Matrix

When it comes to qualitative approach, a risk matrix is used to assess the risk as seen in Figure 17. When it comes to quantitative approach, some of the instruments and methods such as statistical analysis, modelling and probabilistic methods are explored and used in the project. All these methods will help the project to do the risk evaluation process and risk treatment, i.e. what is

[48] http://www.infrarisk-fp7.eu/

the best way to modify the system. These interventions can include physical changes to the infrastructure, alteration of the natural environment or activities to alter the human behaviour during or following a hazard event. In addition, INFRARISK develops a stress test methodology that is applicable for the multi-risk scenario(Avdeeva & van Gelder, 2015). All these combined methods are to achieve an integrated approach to a hazard assessment. As mentioned earlier, the STREST project also addresses and discusses different probability techniques and risk assessment methods for developing integrated risk mitigation strategies of the hazard's impacts (Billmaier & Reinders, 2014; Mignan, 2014).

EURACOM, for example, uses risk assessment as a tool that cannot be separated from contingency planning. The link between these two is mainly preparation and lessons learnt through maintenance process. Apparently, risk assessment and contingency planning are important approaches in EURACOM to enhance the resilience level of the interconnected energy networks.

Likewise, the INTACT project Eidsvig and Tagg (2015) uses risk analysis to assess vulnerability and resilience of CI. Overall CI risk analysis framework of the INTACT project can be seen in Figure 18. The core of the figure depicts the probability, severity of CI Impacts, which are affected by the hazard, vulnerability and exposure on one hand, and by the environment, functions, human staff and technical structures, on the other hand. Central to this Figure 18 are the risk components i.e. probabilities and exposures. Risk assessment, risk communication and risk governance are three core risk concepts depicted in the rectangle frame. Risk governance affects two other risk pillars since the risk-related decision-making is lying here. Managing risk can be performed through adaptation (risk avoidance), coping (meeting short-term basic need and function of the system), mitigation (action to reduce hazard), and risk transfer (shifting financial consequences). Thus, in this project, resilience is treated as the desired state of CI to achieve but the mean to achieve resilience is reliable and effective risk and vulnerability management.

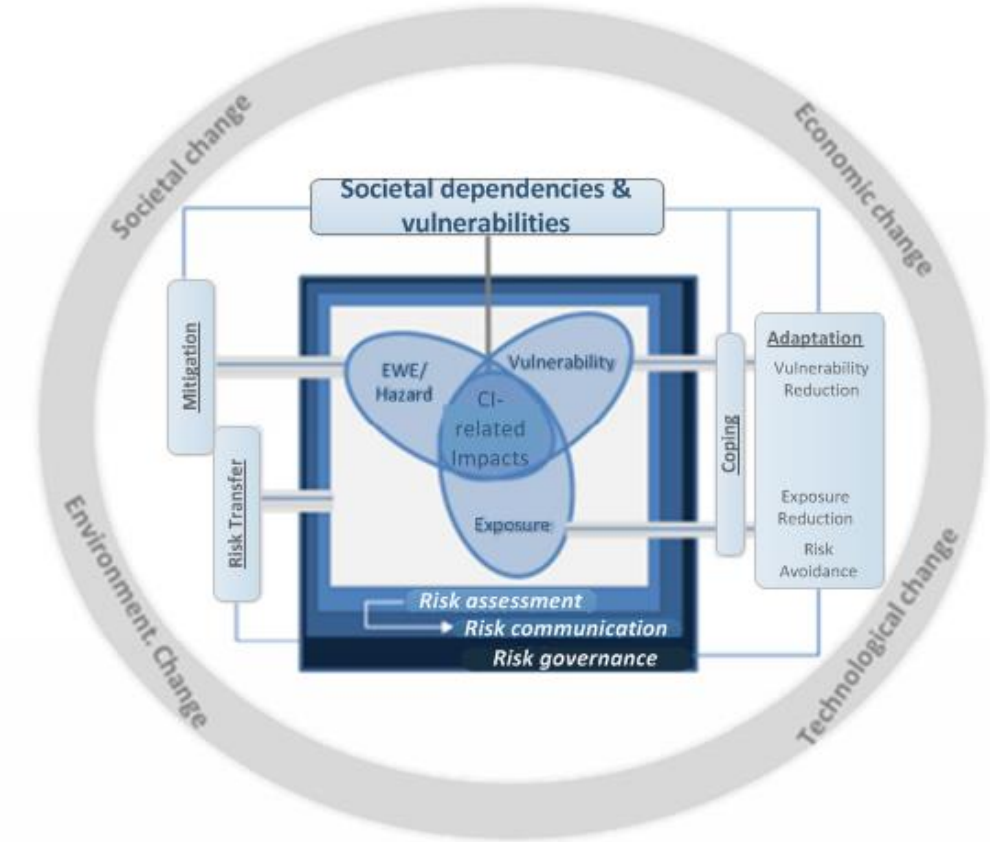

Figure 18 CI Impacts as a function of hazard, exposure and vulnerability and interrelations between risk, response mechanisms and impact, INTACT Framework

3.2.6 CI RESILIENCE AND CI PROTECTION

- CI resilience in EU-funded project reports is often used together with CI protection
- Sometimes both vulnerability and resilience concepts simultaneously to understand the concept of resilience.
- Critical Infrastructure cannot fully be protected, simply because it is too costly. The initiative toward resilience approach is acknowledged
- CI resilience as “the ability of critical infrastructures to mitigate hazards, contain the effects of disasters when they occur, and carry out recovery activities in ways that minimize disruption and potentially mitigate the effect of future disasters

The term of CI resilience in EU project reports is often used together with CI protection. In more recent projects, resilience has been a part of overall CI security goal and taken into consideration. The need for more resilient infrastructure is sometimes highlighted, but these portrayals are more in keeping with the concept of ‘engineering resilience’ –i.e. capacity for shock absorbance. TRUST document (Schwesig et al., 2015), e.g., reviews most cited resilience concept from the study of ecosystem identified as well in the SMR D1.1 report, i.e. the definition from Holling (1973; 2001), J. Walker and Cooper (2011), Brian Walker and Salt (2002) and Folke (2006). This report also quotes the literature on how to build resilience:

- incorporating uncertainty and surprise –i.e. more than simply trying to reduce uncertainty, this implies accepting that knowledge is never ‘complete’ and that unforeseen changes are inevitable;
- enhancing learning and supporting experimentation–i.e. allowing room for innovative management approaches, and learning from the outcomes of such approaches;
- facilitating participation and collective action –i.e. providing opportunities for interactions, and helping to build the skills for cooperation.

It is often argued, as also shown in the TRUST report, that resilience is closely tied to the concept of adaptive management (AM), making these two terms interchangeable. The central principle of AM is the acceptance of inevitable uncertainty around the behaviour of ecosystems. As complex adaptive systems, ecosystems inevitably shift and adjust to changing circumstances, in response to various drivers (e.g. climate change, human pressures), and those shifts cannot be predicted with certainty. Likewise, the outcomes of management measures are unpredictable. An AM perspective thus treats management measures as experimental, advocates the need to learn from the outcomes, and adjusts management practices to remain flexible.

There is scepticism about how AM and resilience 'work' as practical management concepts since there has long been uncertainty about how to evaluate their level of success. In the context of urban water services, some indications of such a shift in thinking –away from the conventional ideas of risk and stability towards more dynamic concepts of vulnerability, resilience and adaptability– are beginning to appear as indicated in the TRUST[49] project, although such shift is still premature. The project is concerned with urban water and it examines innovations and tools to create a more sustainable water future. The three concepts: risk, vulnerability and resilience are admittedly relevant for the urban water sector. Regardless of the increasingly prominence of the concept of resilience, the TRUST report (Schwesig et al., 2015) indicates that stakeholders in urban water sector seem much more comfortable with the concept of risk and risk management, and prefer an engineering-based resilience concept.

The indication to shift toward more resilience CIs is reflected as well in CascEff document (Lange et al., 2015) when discussing recent understanding, that to some extent, CI cannot fully be protected, simply because of too much cost, and acknowledge the initiative toward resilience approach. Lange et al. (2015) define CI resilience as "*the ability of critical infrastructures to mitigate hazards, contain the effects of disasters when they occur, and carry out recovery activities in ways that minimize disruption and potentially mitigate the effect of future disasters*". In this sense, CI resilience definition covers two main concepts i.e. the **interruption to or reduction of service** to infrastructure as well as the **recovery time**.

In the CascEff project, CI resilience is also discussed in terms of the **reduction in the ability** of infrastructure to provide the service it is intended to provide and **the duration of the period of recovery** to normal operation, since CascEff is interested in looking at the consequences of incidents that affect CI. Thus, the business continuity becomes an important concept to indicate the resilience of a system, as can be seen in the following figures 19 and 20[50]:

[49] http://www.trust-i.net/
[50] Source: ISO 22313:201, https://www.iso.org/obp/ui#iso:std:iso:22313:ed-1:v1:en

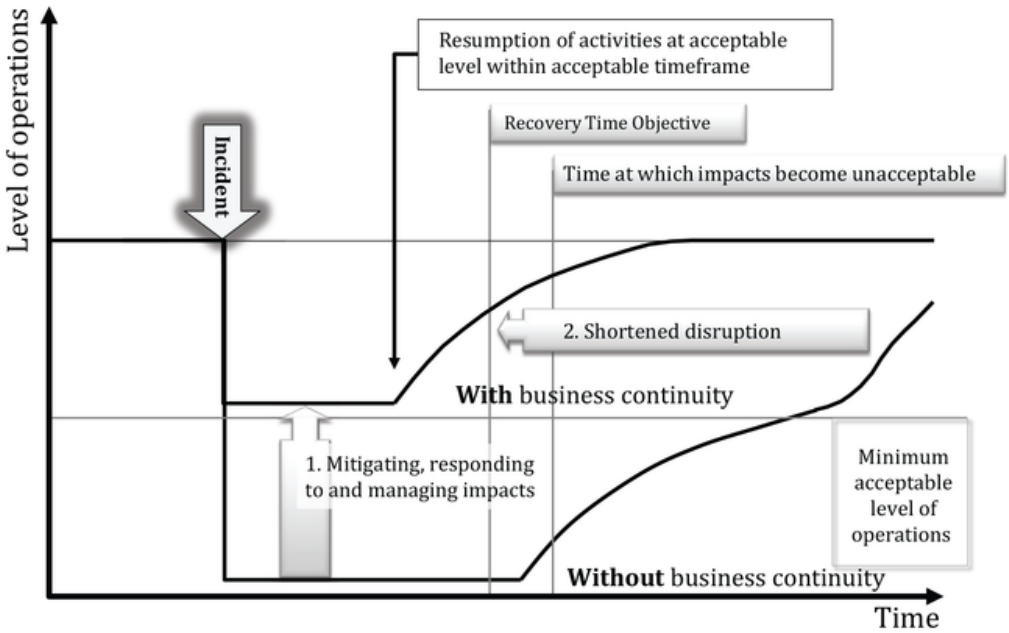

Figure 19 Business continuity being effective for sudden disruption (ISO 22313:2012)

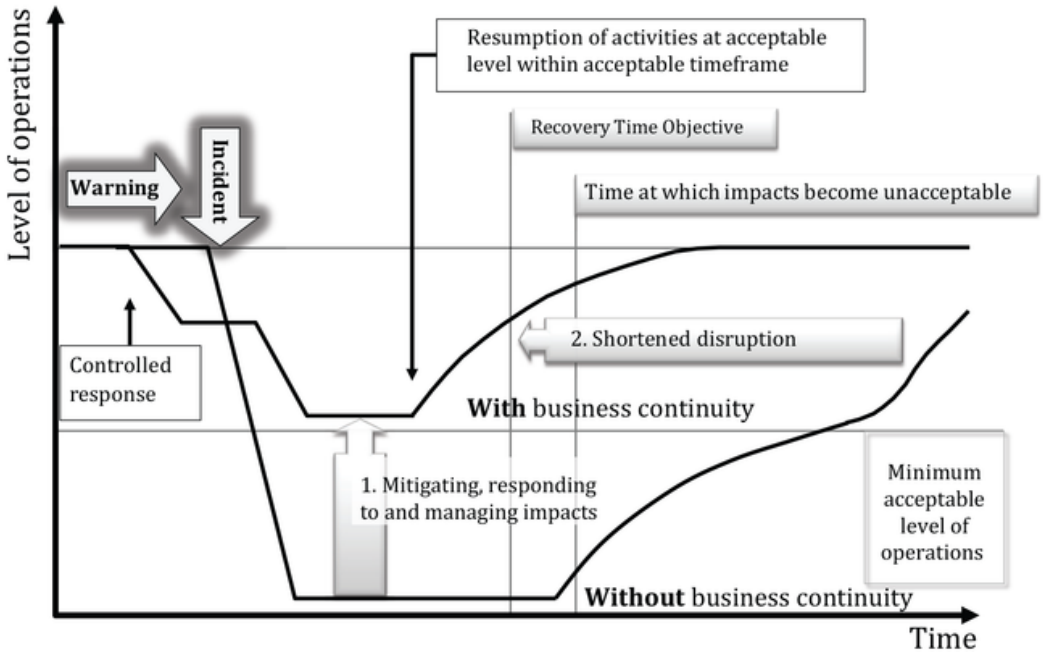

Figure 20 Business continuity being effective for gradual disruption (ISO 22313:2012)

As a practical example, EURACOM uses the contingency planning and business continuity as the main backbone of the resilience of energy supply in Europe (Tilsner & Arouca, 2009). The former is understood as an approach to prepare unpredicted adverse effect and circumstances, by defining particular strategies, counter-measures, planning of back-up actions and resources. The latter is seen in the context of the organisation as a whole that aims to ensure critical activities and services at an acceptable level in the case of disruptive events and emergency. Moreover, Lange et al. (2015) suggest that the CI resilience can be seen as performance and time for recovery when an event occurs using "4R" with following dimensions and indicators:

Table 12 "4R" dimensions and indicators

Dimension	Definition	Example of indicators
Robustness	the inherent ability of a system to withstand external demands without suffering degradation or loss of function	• damage avoidance • continued service provision of a physical asset.
Redundancy	the extent to which the system could be replaced by alternative solutions under stress	• backup/duplicate systems, • equipment and supplies,
Resourcefulness	the capacity to identify problems, establish priorities and mobilise resources in emergency situations including	• diagnostic and damage detection technologies, • availability of equipment and materials for restoration and repair

Rapidity	the speed to meet priorities and achieve goals in order to reduce losses, overcome disruption and restore services	• Optimization of the time to return to pre-event functional levels.

Thus, authors in these projects are aware of CI resilience, but the framework to derive the strategy to deal with CI hazards is formulated using the business continuity and contingency plan.

Slightly different from the two previous project examples, the INTACT project uses both **vulnerability** and **resilience** concepts simultaneously to understand the concept of resilience. Table 13 illustrates the vulnerability factors or challenges adapted from MOVE[51] in INTACT.

Table 13 Vulnerability and resilience framework

Factors	Description
Societal, economic and cultural	• Lack of adequate awareness of vulnerabilities • Dependency of CI on (the availability of) specialists • Level of trust and openness in society influences level of collaboration between stakeholders and knowledge sharing of possible vulnerability, interactions and cascading effects • Attitude towards development and technology can influence awareness of and interest in the management of risk to CI from extreme weather event. • Affluence in society is often correlated to risk acceptance. Less economically developed societies will accept higher risks and have less awareness of risk to CI. • Changes in economic, environmental, legal and regulatory settings including economic pressures under which systems operate which have reduced operating margins and a reduced number if redundancies • Level of criticality of a certain component or CI service with respect to time, quality and proportion (e.g. amount of customers supplied) (Casualties, Economic effects, Public effects in terms of the impact on public confidence or physical suffering)
Institutional	• Liberalization and privatization • Internationalization • Lack of adequate penalties • Institutional fragmented responsibilities • Level of institutional preparedness such as plans, trainings, measures in place.
Physical factor	• Dependency on infrastructure operation on circumstances and factors such as fresh water, fresh air, stable soil, wind or solar radiation, etc. • Impact of CC on stresses of electricity distribution network, and other CI (e.g. transportation). • Area planning and management influence the absorbing capacity of nature based systems to handle or reduce the effect of extreme weather • Inadequacy of back-up systems to continue operations when problems develop • Robustness (ability to physically withstand event) • Redundancy of components and services • Replaceability of component or service / Restoration (with respect to time and costs) • Level of infrastructure protection measures towards a certain hazard • Age/deterioration and level of maintenance

[51] MOVE project is also subject of review in this report. See further in chapter 4

Moreover, the INTACT project also gathered information from stakeholders concerning resilience factors that are important across CIs (energy, transportation, water, emergency service providers). The report revealed that the top-five most important factors considered by the stakeholders are technical solutions, improved maintenance, inspections, condition monitoring, improved preparedness planning, adjusting operation principles and processes, communication and warning systems (Mäki et al., 2015).

Currently, there are four ongoing EU projects under H2020 framework, i.e. IMPROVER, DARWIN, and RESILENS and RESOLUTE, where the objectives are closely related and very relevant for SMR. For a comparison, the following Table 14 summarizes the project coverages:

Table 14 EU sectorial policies covered in the project

	DARWIN	IMPROVER	RESILENS	RESOLUTE	SMR
EU Policies					
EU Civil Protection Mechanism -related international policies		X		X	X
CI Protection	X	X	X	X	X
CBRN - Explosive Action Plans		X			
Major accident hazards	X		X		X
Cross-border threat to health	X		X		
EU Adaptation Strategy to CC					X
Water and Marine Policies					
Control Export and Union of Custom Code	X				
Law Enforcement					
END-USERS					
Policy makers- stakeholders	X	X	X	X	X
Scientists	X	X	X		X
Industry including SME	X	X	X		
First Responders	X	X	X	X	X
General Public	X			X	X

IMPROVER[52] clearly plans to apply resilience concept to CI. Currently, IMPROVER uses engineering definition of resilience as a working definition, which resembles UNISDR resilience notion, i.e., "The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of essential basic structures and functions." Completely different from previous approaches to CI resilience, the community resilience is the central approach here. IMPROVER is concerned with the absence of a common European methodology for measuring or implementing

[52] http://improverproject.eu/

resilience, and a shared, well-developed system-of-systems approach, which would be able to test the effects of dependencies and interdependencies between individual critical infrastructures and sectors. IMPROVER's challenge is, therefore, to propose a method to evaluate the overall resilience of CI to threats and evaluate the performance and impact of the individual resilience concepts. At the time being, it is still a new project and limited sources are available to learn more about it.

The same approaches are reflected in the H2020 RESILENS[53] project that aims at realizing European Resilience for CI. The RESILENS goals are close to the SMR project goals, i.e. developing a European Resilience Management Guideline (ERMG) to support the practical application of resilience to all CI sectors. Moreover, RESILENS will develop resilience tools called a Resilience Management Matrix and Audit Toolkit that will enable a resilience score to be attached to an individual CI, organisation (e.g. CI provider) and at different spatial scales (urban, regional, national and trans-boundary). RESILENS in fact also addresses cascading effects and offers measures to handle them. A clear difference with the SMR project are the expected users of the resilience management guideline, where CI providers seem to have the central role, while in the SMR, the cities will be the core users of the SMR tools.

Similarly, DARWIN[54] focuses on improving responses to expected and unexpected crises affecting critical societal structures during natural and man-made disasters. To achieve this, DARWIN will develop European resilience management guidelines aimed at critical infrastructure managers, crisis and emergency response managers, service providers, first responders and policy makers. A highly adaptive response, is apparently the keyword for the definition of resilience used in the project. In addition, compared to the two other projects, DARWIN incorporates training and serious gaming to the project methods. DARWIN will also establish a Community of Crisis and Resilience Practitioners (CoCRP) to bring together infrastructure operators, members of the crisis and emergency response community, policy makers and other relevant stakeholders across Europe to exchange views and innovations around their responses to the crisis. The CoCRP will operate beyond the lifetime of the project.

RESOLUTE[55] proposes a systematic review and assessment of the state of the art of the resilience assessment and management concepts, as a basis for the deployment of a European Resilience Management Guide (ERMG), and perceive that resilience is about emerging behaviour associated with intra and inter-system interactions. The concepts will be adapted and adopted for addressing the Critical Infrastructure (CI) of the Urban Transport System (UTS). The project will establish the RESOLUTE

[53] http://resilens.eu/
[54] http://www.h2020darwin.eu/
[55] http://www.resolute-eu.org/

Collaborative Resilience Assessment and Management Support System (CRAMSS) that will support the next-generation of collaborative emergency services and decision-making process.

These five H2020 projects apparently aim at contributing in this lacking domain, i.e. resilience, and transforming resilience into management practice, and operationalise them. The projects give emphasis more on the resilience side and shift away from just “protecting” CIs, cities or other crucial societal infrastructures from threats.

3.2.7 CI SMARTGRID AND CYBER-ATTACK RESILIENCE

There are three projects address Smart Grid and Cyber-attack issues, i.e. SPARKS, CAMINO and TACTICS. The main idea behind these three projects is how to make CIs more resilience against cyber-attacks, due to terrorism motives, or other harmful actions. CAMINO suggests the regulations as part of the solutions, while SPARKS and CAMINO suggest technologies and improvement of technical security.

- How enable people to discover and to recover from attacks, losses and security failures.
- Well-organised simultaneous cyber-attacks to smart grid infrastructure can trigger a sequence of cascading events, leading to a system blackout. An effective measure to address this issue is to prevent, detect and mitigate malicious activities. In other words, the Smart Grid communications networks should be reliability and resilient.
- Resilient SmartGrid can be important CIs when city moves toward Smart City

SPARKS[56] is an example of an EU project aiming at building an acceptable level of resilience of the Smart Grid (SG) (Friedberg, McLaughlin, & Smith, 2015) that is destined to become a future important city infrastructure. In the SG context, many devices are deployed in the cities or households, enabling people and relevant entities to generate, collect, analyse and react to much more data. SPARKS defines SG as "an enhanced power grid that generates, transmits, and uses electricity with the support of information and communications technology (ICT) for advanced remote control and automation”. Hence, the flow of data will be exchanged and transferred, between devices, different entities and organisations in the cities, or even between systems, nationally and internationally.

Defensive mechanisms to thwart the intentional attack and inadvertent exposure or loss of data are becoming the greatest concern, especially to find mechanisms that enable people to discover and to recover from attacks, losses and security failures. The SPARKS project looks at a smart-meter as a part of the SG from the perspective of resilient hardware-based authentication mechanisms. The fear to the threats toward this equipment is clear. Recently, the malware *Havex* emerged. This malware has

[56] https://project-sparks.eu/

capability to attack control systems. Another example is crime-ware Trojan such as *BlackEnergy.* This Trojan was used to automate cybercriminal activity and has been adapted and extended to operate in industrial control systems (ICS).

Well-organised simultaneous cyber-attacks to smart grid infrastructure can trigger a sequence of cascading events, leading to a system blackout. An effective measure to address this issue is to prevent, detect and mitigate malicious activities. In other words, the Smart Grid communications networks should be reliability and resilient. When city moves toward Smart City, the disaster resilience and the effort to mitigate disaster may want to consider this aspect as an important part of the city's CI resilience.

In line with the effort to strengthen Smart Grid resilience against cybercrime and cyber-attacks, the CAMINO[57] project proposes the THOR concept (Technical, Human, Organisational, and Regulatory) to answer the challenges (Choras et al., 2015). Accordingly, CAMINO goes beyond just offering technical security aspect but also putting human awareness about cybercrime, cooperation public-private and public-public, as well as law provisioning, standardization and forensic as inseparable-intertwined dimensions to achieve resilience to cybercrime and cyber terrorism.

In contrast to these two projects that analyse potential intangible disturbances to CI, the TACTICS[58] project addresses countermeasures to tangible terrorist attacks. TACTICS suggests the importance of the need of the assessment indicating the types of activities and capacities required to deal with a terrorist attack at each stage of the disaster risk management cycle and an examination of the different elements that need to be considered by organisations and communities in preparing for and responding to terrorism (TACTICS, 2015). These emerging aspects of resilience potentially complement the discussion to the context of CI and urban resilience presented in the next section.

3.2.8 CI AND URBAN RESILIENCE

Today, approximately 50% of the world's population lives in cities and this trend is likely to continue into the future, with an estimated 70% of the world expected to be urban dwellers by 2050. This rapid expansion of cities occurs as well in Europe, exposing a larger number of people and economic assets to the threat of disasters and crisis events. In this section, we discuss a finished project RIBS and four on-going EU projects: HARMONISE, VITRUV, TRUST and DESURBS that are addressing these additional urban challenges, from a perspective of the design, planning and management of urban

[57] http://www.fp7-camino.eu/

[58] http://www.fp7-tactics.eu/. Note that we identified two projects with almost similar names: TACTICS and TACTIC. TACTIC project focuses more on the preparedness of cross-border disasters.

areas, and CI water. From a temporal perspective, there is a clear difference between older projects (which is more sectorial in nature), and the most recent ones where the need for a more "holistic", "comprehensive" or more "integrated" approach is obvious.

RIBS[59] resilient infrastructure and building security finished in 2013 concerned about the vulnerability of CIs in Europe against the terrorist attacks. RIBS have developed and applied novel spatial analysis techniques to better understand how people interact with the building. The project outlined a set of functional and non-functional requirements for an effective security system design process and assessment techniques to evaluate the proposal of the level of protection prior to implementation in buildings and infrastructures. This work aimed at securing buildings against hazardous attacks including chemical agents, biological agents, and explosives (CBE). The CBE protections offered by RIBS incorporate these domains:

Table 15 CBE and intruder protection measures developed in RIBS

Threat	Measures
Chemical	Monitoring, detection and identification of chemical agents should be performed to reduce the potential damage caused to the population in buildings of various types
Biological	Protection measures to defend against pathogens; Monitoring, detection and identification of biological agents should be performed to reduce the potential damage caused to the population in a building
Explosives	Explosion threat mitigation for buildings beyond the state of the art, by improving their effect against other types of threats; and reducing their costs; Considering the different areas of conflict or synergy between protection measures
Intruders	It will improve the understanding of the human threat and improve associated electronic access control systems. We will examine emerging threats in cryptology and in Persistent Authentication – sensor-based person tracking technologies and general machine learning techniques for hostile reconnaissance detection using a given set of sensors

The HARMONISE[60] project is concerned with the lack of comprehensive, holistic approach to improve the resilience and security of critical large-scale urban built infrastructure in Europe (Quarks, 2007). It highlights the characteristics of today's urban environment that are highly complex with multi-purpose and has interlinking and sometimes non-interlinking characteristics, involving multiple actors, interests and resources. Intertwined CI networks add an additional layer of complexity to urban developments. The HARMONISE project proposes resilience enhancement methods for large-scale urban built infrastructures, and the development of a comprehensive, multi-faceted, reinforcing concept to improve the security and resilience of this infrastructure. It encompasses the design and planning phases of infrastructures that lead to robustly built-infrastructure, invulnerable to natural/man-made disasters.

[59] http://cordis.europa.eu/result/rcn/140033_en.html. See also http://cordis.europa.eu/docs/results/242497/periodic1-ribs-leaflet-web-2012.pdf
[60] http://harmonise.eu/

Eventually, HARMONISE will improve the design and planning of urban areas that ensure enhanced security and resilience to new threats (HARMONISE, 2013; Kudlacek, Fiedrich, & Lukas, 2013).

VITRUV[61] addresses the urban planning needed to incorporate systematic comprehensive transparent and proactive approaches to identify potentially vulnerable areas, by developing software tools for the consideration of extraordinary threats in the range of urban planning. The qualitative or quantitative hazard and risk analysis of single buildings of infrastructure forms the basis. It consists of the analysis of events, scenarios, hazards, damage, frequency of event, exposure of personnel and risk including options for risk visualization and risk assessment. Based on an all hazard risk approach, the tools will enable planners, -to make well-considered systematic qualitative decisions (concept level) -to analyse the susceptibility of urban spaces with respect to new threats (plan level), and –to perform vulnerability analysis of urban spaces by computing the likely damage on humans, buildings and traffic infrastructure (detail level). In this project, the resilience is not about improving management or adaptive capacity of organisations, individuals, or community but how to adapt the physical infrastructure so that the security and resilience of citizens inside the city are ensured (Fischer et al., 2012).

- Enhancement methods in planning and design for large-scale urban built infrastructures, and the development of a comprehensive, multi-faceted, reinforcing concept to improve the security and resilience of this infrastructure
- Identification of vulnerable area in urban environment
- Resilience is achieved by establishing resilient infrastructure and building, understanding how people interact with buildings and built-in environment, allow them to respond and adapt to hazards.

DESURBS[62] proposes a solution to the nine main important urban planning issues or failures, ranging from the planning failures, architectural and industrial design issues, site management and monitoring, failures in structural issues (Chmutina & Bosher, 2013; Chmutina, Bosher, Ganor, Pinsly-Shach, & Turner, 2013; Chmutina et al., 2014; Clarke, Rowlands, & Coaffee, 2013; Coaffee, Rowlands, Clarke, & Rydock, 2013; DESURB, 2014; Felsenstein & Grinberger, 2013). It also addresses inadequate performance of the construction materials, inadequate maintenance of the built environment to the issues such as lacking of hazard mitigation, emergency response and stakeholder involvement in designing built environment. The DESURBS project provides different tools to enhance urban resilience, i.e. an urban space security event database. It will establish an integrated security and resilience (ISR) design framework that engages local stakeholders for identifying vulnerabilities and improving urban spaces with respect to security threats, comprehensive urban resilient design guidelines and

[61] http://www.vitruv-project.eu/
[62] http://desurbs.eu/

quantitative risk and vulnerability assessment models, tools and technologies, and includes Decision Support System Portal (DSSP) to help end users better understand the vulnerabilities and design possibilities.

The USDSS is based on standard risk assessment protocol. It uses a systematic process to establish ratings for the exposure to risk and the likelihood of that risk occurring, combining to provide an overall risk rating for each hazard or threat identified for a site. Outcomes are measured non-numerically, from very low to very high, reflecting the qualitative basis of the process.

3.2.9 OTHER CI TOPICS

PRACTICE points out to the fragmented technology, procedures, methods and organisation on a national and EU-level, in response to CBRN events. The PRACTICE project is the preparedness of the EU/EEA states in general to protect themselves from the potential non-conventional attacks such as Chemical, Biological, Radiological, and Nuclear (CBRN). The project aims to develop an integrated approach to CBRN crisis (Breivik et al., 2012; Endregard et al., 2012). The project involves the following activities:

- Identification, organisation and establishment of knowledge of critical elements in the event structure through studies of a wide selection of scenarios, real incidents and exercises.
- Analysis and identification of gaps in the current response situation, organisation and integration of the allocated response capabilities or functions in a toolbox of equipment, procedures and methods.
- An allocated system or public information kit for decision-support, first-responder training and exercise.

The innovative element developed during the project is an improved and integrated preparedness and response to CBRN events. The resilience in this project means the preparedness and the capability of the organisation to respond to CBRN events (Breivik et al., 2012).

IMCOSEC[63] opted for an approach that minimizes the impact of cost and time, thus making it practicable for commercial operators and enterprises, while creating a “win-win” solution between industry and regulatory authorities. Its concept reached for security that balances effectiveness with practicality within a regulatory framework. The project analysed security regulations, standards and trends, identified security gaps via a generic model of supply chains based on resilience and threat “trees” or charts, referenced security projects, technologies and industry needs and, finally, defined a roadmap for demonstration activities.

[63] http://cordis.europa.eu/result/rcn/55741_en.html

CBRNEMAP[64] evaluates multidimensional problem of CBRNE counterterrorism. Temporal events (before, during and after) were contrasted against societal targets and societal sectors directly involved by such events. The main contributions of CBRNEMAP in terms of building capacity needed for resilience are the effort to develop three demonstrators. First, a demonstrator with more than 50 different scenarios with desired high-level effects such as present and save lives. The detailed desired effects were then transferred to technological and procedural needs, i.e. capabilities. Those needs were then matched with available or unavailable capabilities. The second demonstrator object was confined to threatened societal functions (mass transport nodes, mass gatherings and political infrastructure). The need for the third demonstrator object is a cluster of activities (a system of systems) needed to optimize the processes developing European CBRNE counterterrorism capabilities.

The DRIVER[65] project deeply discussed different dimensions of resilience that are very useful and highly relevant to the SMR project. DRIVER covers individual, community, local government resilience in addition to communication in crisis. However, the nature of the discussion fits better to the subsequent chapters. We discuss the DRIVER project in Chapter 4 (Results: Climate Change) and Chapter 6 (Results: Social Problem), depending upon the topics that may fit one of these two chapters.

The OPSIC[66] project creates an operational guidance system (OGS) which could be used by psychosocial crisis managers and mental health professionals in order to provide high quality mental health and psychosocial support programming and interventions in the context of disasters. Likewise; due to the nature of the discussion that address most the individual psychosocial problems that could be interpreted as post disaster social dynamics and societal and individual resilience, we discuss the project in Chapter 6 (Results: Social Problem).

The [67] project was captured through our search criteria but apparently CI issues are mentioned just as a background and not a project focus. PEP developed a conceptual framework for investigating communication that supports community resilience. Such comprehensive framework is deemed as lacking, despite the high attention currently paid to community engagement in crisis management. Similarly, we consider the topic fits better in the Social dynamic discussion in Chapter 6.

[64] http://www.cbrnecenter.eu/project/cbrnemap/
[65] http://driver-project.eu/
[66] http://opsic.eu/
[67] https://agoracenter.jyu.fi/projects/pep

TACTIC[68] is the last project identified under the Secure Societies call that is dedicated to the preparedness stage of the large-scale and cross-border disasters. This project underlines the role of education, training and practice within the long-term learning framework.

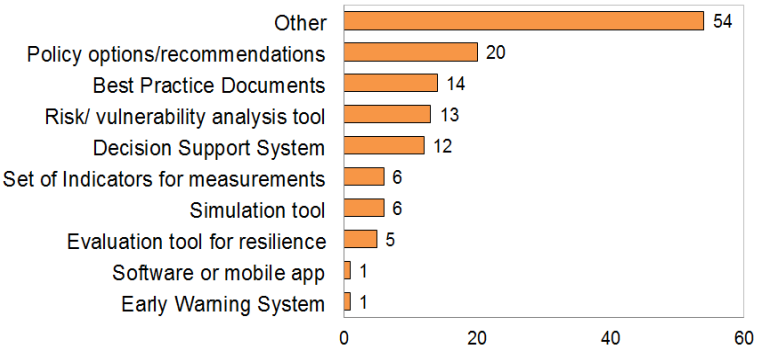

Figure 21 Overview of expected outputs to the project challenges

Finally, to sum up the review on EU approach, we also identified that the expected outputs of different projects identified in the CI literature can be categorized as shown in Figure 21. The outputs under "other" category are: establishing community of resilience practitioners, strategic roadmap, set of new security rules, CI cyber security protections, online decision support portals, management guidelines, resilience enhancement tools, sets of threat scenarios, set of requirements, trainings, crisis communication practice, and local resilient forums.

3.2.10 RESILIENCE DIMENSIONS

In fact, resilience has multiple dimensions even though the reviewed reports put resilience in the urban or city context. These "dimensions" of resilience are often treated as (a) unit(s) of analysis of the city, for example flood resilience. Some projects or articles only focus on a single dimension, but many of them discuss them as multiple units of analysis. Dimension approach to resilience has also been used in different scientific literature. Hence, the way to analyse the resilience from this approach is not a new method but is very useful to capture, what different authors mean by "urban resilience" that links to the "climate change".

The overview of resilience dimensions captured from our literature review activities can be seen in Figure 22. Community or societal resilience and urban or city resilience are the two most frequently discussed dimensions in the literature. The summary of the explanation of the resilience definition in each dimension is given below. From the definitions of resilience identified in each dimension, we extract the main concepts covered by the definitions.

[68] https://www.tacticproject.eu/

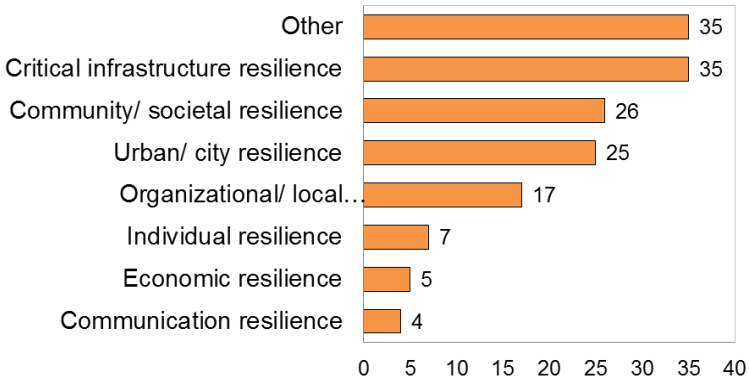

Figure 22 Resilience Dimensions in CI Literature

Then, we summarize and propose the synthesized version of resilience definition of each dimension:

1 CI Resilience

Table 16 Summary of CI Resilience

Project	Definition or Context of CI Resilience	Important Concepts
CascEff	The technological dimension … the ability to resist damage and loss of function and to fail in a safe way; …includes the physical components that add redundancy.	Ability to resist damage Ability to resist loss of function
IMPROVER	…the resilience concepts applied to the infrastructure …, principally the **technological and organisational** resilience. In order to assess resilience, it is necessary not only to evaluate the **overall resilience** of critical infrastructure to threats but also to evaluate the performance and **impact** of the individual resilience concepts.	Technological Organisational Overall and individual CI resilience
EU-JRC	… is a component, system or facility that is able to withstand damage or disruption, but if affected, can be readily and cost-effectively restored." …There are two key concepts in CI resilience i.e. resistance and restoration capability.	Facility that can withstand damage
RESILENS	…A transformative, cyclical process, **building capacities** in technical, social and organisational resources, so as to mitigate as far as possible impacts of disruptive events, and based upon new forms of risk management, **adaptability and the assessment** of potential **trade-offs** between parts of a system	Building capacity Mitigate impacts Adaptability
TRUST	NIAC, 2009[69]: … a resilient infrastructure or enterprise can **anticipate, absorb, adapt** to, and/or rapidly **recover** from a potentially disruptive event. In other words, CIs are generally about 'delivering the goods' regardless of disruptive events that may occur.	Anticipate Absorb Adapt Recover

From the definitions discussed in the different projects above, we propose a tentative definition of CI resilience as follows:

[69] https://www.dhs.gov/xlibrary/assets/niac/niac_critical_infrastructure_resilience.pdf

TENTATIVE DEFINITION OF CI RESILIENCE

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

2 Community/Societal Resilience Dimension

Table 17 Summary of Community/Societal Resilience Dimension

Project	Definition or Context of Community/Societal Resilience	Important Concepts
DRIVER	A resilient society is a society in which individuals, groups and communities are **able to cope with threats and disturbances** caused by social, economic, and physical changes (W.N. Adger, 2000). … **ability** of this complex, adaptive system **to cope with** threats and disruptions. …resilience of an individual, community or system is the capacity to offer **resistance, recover from or adapt** to disruptions and changes from the state of functioning that is perceived as 'normal'. …**ability** of communities exposed to disasters, crises and underlying vulnerabilities to **anticipate, prepare for, reduce** the impact of, cope with and recover from the effects of shock and stresses without compromising their long term prospects".	Cope with threats, disturbances, disruptions resistance recover adapt anticipate prepare reduce cope with recover
CascEff	…The social dimension encompasses population and community characteristics that render social groups either more vulnerable or more adaptable to hazards and disasters. Social vulnerability indicators include poverty, low levels of education, linguistic isolation, and a lack of access to resources for protective action, such as evacuation.	Vulnerable social group are more adaptable to hazards
EU-JRC	…procedural enablers of community resilience provide the information and ideas needed to **plan, prepare for, respond to, and recover** from a major disruptive event. Social enablers of community resilience are the **community cohesion** and motivation **to withstand** the emergencies.	Plan Prepare for Respond to Recover Community cohesion
PEP	Community resilience is seen as linking **a network of adaptive capacities** for successful adaptation in the face of disturbance A resilient community is able to **recognize unusual conditions**, **mobilise** resources and **self-organise** in response to a crisis ….in a **timely and efficient** manner, including through the preservation and restoration of its essential basic structures and functions" before, during, and after the crisis	Network of adaptive capacity Recognize events Mobilise resource Self-organise Timely –efficient Preservation Restoration
	Collaborative resilience… using social media, i.e. the ability to be resilient and **cope with** crises through **collaboration** between organisations and citizens	Ability to cope with collaboration
	Every individual has his or her **own resilience capabilities** that need to be enforced and deployed in a crisis situation …European **policy** on enhancing **public resilience** thus informs the visions of and actions taken by civic organisations focusing on risk- and crisis management on the **local level**	Own resilience capability Inform the local level

	Everybody in society should be mentally and practically **prepared** for unexpected situations that may arise" (Swedish Civil Defense League 2004:5).	Everyone's preparedness

From the definitions discussed in the different projects above, we propose a tentative definition of community and social resilience as follows:

TENTATIVE DEFINITION OF COMMUNITY AND SOCIAL RESILIENCE

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

3 Urban/city Resilience

Table 18 Summary of Urban Resilience Dimension

Project	Definition or Context of Urban Resilience	Important Concepts
DESURB	Resilience design, built-in, space: …a resilient built environment that: should be designed, located, built, operated and maintained in a way that maximizes **the ability of built assets**, associated support systems (physical and institutional) and the **people that reside or work within the built assets**, to **withstand, recover from, and mitigate** for, the impacts of extreme natural hazards and human-induced threats. Bosher's (2008) ... built-in resilience is a **quality** of a built environment's capability (in physical, institutional, environmental, economic and social terms) to keep **adapting** to existing and emergent threats.	Withstand Recover Mitigate Quality Adapting
HARMONISE	Urban resilience : …is the ability of citizens in an urban area to **handle unexpected** situations with **malfunctions** in the infrastructure (like failure in water supply, blackouts or traffic breakdowns). … **ability** of a city to **respond** positively to the effects of **changes** (environmental, social or economic). … **ability** of a community to **secure** its territory, the functionality of infrastructure and the ability of citizens to help themselves in front of a hazardous event (natural or manmade). …This **ability** is about a **variety of activities** (which can be classified in the design, implementation and control), aimed at achieving a better resilience to adverse events that may affect an urban community … **ability** of citizens and of the city (community and institutions) to deal with critical situations in a **proactive** manner, to come out stronger through a process of events	Handle unexpected Ability to respond Ability to secure Ability in variety of activities Ability of citizen to be proactive

	Resilience is the **sustainability** of all urban systems and / or the wider community. That is the **capacity** at managerial level, functional, organisational and technological **to support** all the transformations induced by the rapid changes taking place in key areas of the building, energy, mobility, safety, environment and emergency management Urban resilience' … towns and cities are **prepared** for **threats** that are perhaps unique in the urban context…including the **impacts** of a changing climate, water management and flood risk and counter terrorism measures. … **capacity** of a system to **absorb** a threat (natural or man-made) and to come back to **normal functionally** in time and under effective concepts. …. urban resilience is the **attitude** of inhabitants not only to wait for the administration to solve their problems in case of a disaster but the intention and the **ability to recover by themselves.**	Sustainability Capacity to support Prepared for threat and impacts Capacity to absorb Back to normal Ability to recover by themselves
Scientific Literature	A flood resilient city is one with the **ability to "resist, absorb, accommodate to and recover** from the effects of a flood hazard in a **timely and efficient** manner, including through the **preservation and restoration** of its essential basic structures and functions"	Ability to resist Ability to absorb Ability to accommodate Ability to recover Ability to preserve Ability to restore

From the definitions discussed in the different projects above, we propose a tentative definition of urban or city resilience as follows:

TENTATIVE DEFINITION OF URBAN OR CITY RESILIENCE

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

The citizen in the city can handle and respond to the unexpected situations from malfunction of CIs, changing of social, economic and environmental stress, and proactive in a crisis and ability to recover by themselves. The organisations at the city level have capacity to support all rapid transformation taking place in urban key areas.

4 Organisational/ local government resilience

Table 19 Summary of Organisational Resilience Dimension

Project	Definition or Context of Organisational or Local Government Resilience	Important Concepts
CascEff	**Organisational resilience** relates to the organisations and institutions that manage the physical components of the systems. This domain encompasses measures of organisational capacity, planning, training, leadership, experience, and information management that improve disaster-related organisational performance and problem solving.	Capacity planning Training Leadership Experience Information management
EU-JRC	… Issues such as emergency operations planning, alternate sites for managing disaster operations, **capacity to improvise, innovate and expand operations**, as well as the time between impact and early recovery …. The organisational resilience … a **proper risk management** system embedded in the organisation rather than technological solutions, and it includes such elements as training, risk assessment, prevention, mitigation.	Capacity to improvise Capacity to innovate Capacity to expand Proper risk management
PEP	Co-production of safety by organisations and citizens is especially needed to cope with large crises. Such collaboration is particularly feasible, when it focuses on crises which have a high probability of recurrence in the region	Cope with the crisis

From the definitions discussed in the different projects above, we propose a tentative definition of organisational or local government resilience as follows:

TENTATIVE DEFINITION OF ORGANISATIONAL/LOCAL GOVERNMENT RESILIENCE

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

5 Individual Resilience

Table 20 Summary of Individual Resilience Dimension

Project	Definition or Context of Individual Resilience	Important Concepts
Driver	Resilience is the adaptive capacity of individuals **to react or adapt** positively to a difficult and challenging event or experience	Capacity to react Capacity to adapt
PEP	Every individual has his or her **own resilience capabilities** that need to be enforced and deployed in a crisis situation	Own resilience capabilities

From the definitions discussed in the different projects above, we propose a tentative definition of individual resilience as follow:

TENTATIVE DEFINITION OF INDIVIDUAL RESILIENCE

Individual resilience is the adaptive capacity of individuals to react or adapt positively to hazards event.

6 Economic Resilience

Table 21 Summary of Economic Resilience dimension

Project	Definition or Context of Economic Resilience	Important Concepts
CascEff	Economic resilience …the **capacity to reduce** both direct and indirect **economic losses** resulting from disasters	Capacity to reduce economic loss
EU-JRC	Economic resilience: Rose defines economic resilience by differentiating between two types of resilience: static economic resilience is "the ability of an entity or system to maintain function (e.g., continue producing) when shocked" whereas dynamic economic resilience "is the speed at which an entity or system recovers from a severe shock to achieve a desired state	Ability to maintain function The speed to recover

From the definitions discussed in the different projects above, we propose a tentative definition of economic resilience as follows:

TENTATIVE DEFINITION OF ECONOMIC RESILIENCE

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

7 Communication Resilience

Table 22 Summary of Communication Resilience

Project	Definition or Context of Economic Resilience	Important Concepts
POP-ALERT	the population's **capacity to absorb** and **preparedness** to **make use** of different Crisis Management strategies and technologies developed at the EU level	Capacity to absorb Capacity to prepare
Scientific	Communication resilience dimension in the literature is in the form of network resilience or Internet resilience. Network resilience refers to a **steady state** of the Internet, maintaining an acceptable level of service in the face of faults (ENISA, 2009) Unlike a protection model, which seeks to avert disruption, resilient systems seek to enhance multiplicity and diversity in order to	Capacity to provide Communication infrastructure in a steady state enhance multiplicity and diversity

	absorb and respond to disruption after it appears and before it can cascade.	

From the definitions discussed in the different projects above, we propose a tentative definition of communication resilience as follows:

TENTATIVE DEFINITION OF COMMUNICATION RESILIENCE

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

5 CBRNE Resilience Dimension

Table 23 Summary of CBRNE dimension

Project	Definition or Context of CBRNE Resilience	Important Concepts
PRACTICE	Preparedness and Resilience Against CBRN Terrorism …. to improve the **ability** to **respond** to and **recover** from a Chemical (C), Biological (B), Radiological (R)or Nuclear (N) incident	Ability to respond and recover

From the definitions discussed in the different projects above, we propose a tentative definition of communication resilience as follows:

TENTATIVE DEFINITION OF CBRNE RESILIENCE

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

3.3 POLICIES AND BEST PRACTICES

In this section we describe the policies and best practices derived, mentioned or identified from the EU CI literature.

3.3.1 POLICIES

Table 24 Overview of Identified Best Practices

Project	Context	Policies
CAMINO	Individual level	• Development of Training and Awareness tools • Utilising Privacy Enhancing Technologies • Appropriate use and re-use of Data
	Organisation/local government level	• Adapting organisations to the cross-border nature of the Internet and Cybercrime/Terrorism • Introducing Cyber security as a society culture need • Promoting EU Institutional support to Generic Challenges and Obstacles at the Enterprise/ Company/SME Level
	National level and national law	• Investigatory Powers in intra-jurisdictional & trans-border cases • Interoperability of Common and Roman Law

		• Civil and Criminal Courts forensics/ admissibility/ evidential standards • Identity/Authentication Standards for Data Protection across borders
CasCeff	Community level	Policy support in planning for large scale incidents
CBRNEMAP	Organisation/local government level	Respond capabilities of the responders
DARWIN	Organisation/local government level	Policy to improve responsiveness of the first responders and service providers and guidance for policy advisors and senior EM managers
DESURB	Organisation/local government level National level and national law	• Revision of building code, tightening of planning policy, encouraging a socio-technical system approach, improvements to professional training • Land use policy, sheltering policy , service replacement policy • Suggest different measures for key operational issues (legacy of inappropriate urbanization, the impacts of climate change, legislation only goes part way), increasing awareness of who should do what, improving when the decision should be made, understanding who pays and business cases
EURACOM	Organisation/local government level, National level and national law	• European Forum for Energy Infrastructures – Security and Resilience, European methodologies of risk management and contingency planning, • Supporting European policies for the protection of critical energy infrastructures • Business continuity
RESILENS	Organisation/local government level	Resilience Management Matrix and Audit Toolkit, which will enable CI systems (encompassing assets and organisations) to quantitatively and qualitatively index their level of resilience. The proposed toolkit allows the quantitative analysis of the resilience of the systems at different spatial scales (urban, regional, national and trans-boundary)
SPARKS	National level and national law	Draft legal recommendations that can be used by national and EU policy makers in order to maintain the cybersecurity of smart grids. The juridical team will analyse the proposed measures regarding their capability under currently legislation – data protection issues, interference with privacy, data sovereignty, and so on.
	Organisation/local government level	toward building good response team that can quickly mitigate the risk of vulnerability
STREST	Organisation/local government level	Water policy, Environment control policy
TACTIC	Community level	Knowledge of legal responsibilities for flood protection
TACTICS	National level and national law Organisation/local government level	• Deploy appropriate counterterrorism technologies that enhance decision-making, but be prepared for ongoing changes in the technology landscape • Apply a structured approach to deployment of counterterrorism technology • Carefully consider data collection and data sharing • Deal early with considerations around privacy • Establish relevant partnerships and networks • Carry out regular audits and evaluations on the system use
TRUST	Organisation/local government level	Risk-based approach (Risk management, risk-vulnerability approach) and Resilience thinking and adaptive approach (Asset resilience and adaptive initiative)

Scientific Literature	Community level	• Such as how often failures cascade between infrastructures and patterns related to the extent the society is affected by infrastructure failures caused by interdependencies • European critical infrastructures
	National level and national law	• A program to assure the “safety and security” of the population ; sustainable vulnerability reduction
	Organisation/local government level	• CI safety design and construction, CI maintenance, CI data acquisition and monitoring system, CI crisis response equipment, CI organisational procedures for crisis management, CI top management commitment, CI crisis manager preparation, CI operator preparation, CI crisis response budget, External crisis response equipment, First responder preparation, Government preparation, Trusted network community, Crisis regulation and legislation, Public crisis response budget, Societal situation awareness • Safety and security policy, the agencies and officials responsible for natural disasters must be prepared for terrorism also. This approach is more likely to permit an affordable and politically sustainable effort at dealing with all disasters. There is so much interdependence of all the elements of the city’s functions that the consequences may be much the same, regardless of the nature of the triggering event.
	National level and national law	• Conducting exercises under the name “Cyber Europe", • Devising global code of conduct, supporting strategic cooperation, establishing a common language and standardizing the definition of gaps.

It is apparent that there is a huge variety of policy suggestions across the numerous EU projects targeting resilience. Lacking empirical evaluations of the long-term impact of those policies it is currently not possible to highlight particular policies as “best practice”, i.e., being superior to others. Given this limitation, SMR uses expert opinion via a Delphi process (T1.4) to identify policies that in the experts’ eyes seem most promising.

3.3.2 BEST PRACTICES

This part summarizes the best practice identified or listed in each identified project. These best practices in Table 25 may originate from other documents cited in our literature, or planned outputs of a specific project (i.e. to produce best practice document).

Table 25 Overview of Identified Best Practices

Project	Best Practice
CAERUS	• The Hyogo Framework for Action (2005) Other good practice identified: • Good practice of Humanitarian Donorship (GHD) • The European Consensus on Humanitarian Aid(2007 • Communication on the EU approach to Resilience (2012) • EU’s comprehensive approach to external conflicts and crises(2013)

CAMINO	• Realistic Roadmap for improving resilience against cybercrime and terrorism covered Technical, Human, Organisational, and Regulatory
DESURB	Suggest top down and bottom up approach to build-in resilience • Identify, characterize, and assess hazards • Assess the vulnerability of urban spaces to specific hazards • Determine the risk (i.e. The expected consequences of specific hazards/threats) • Identify ways to reduce those risks inherent safety • Prevention (reduce the likelihood of hazards/threats). • Detection (measures for early warning of hazards/threats) • Control (limiting the size of the hazards/threats) • Mitigation and adaptation (protection from the effects of hazards/threats). • Emergency response (planning for evacuation and access for emergency services) Identifying (and prioritising) a course of action to address and treat the hazard/threat and its associated risks. Risk Treatment can involve: • avoiding the risk by deciding not to start or continue with the activity that gives rise to the risk • removing the hazard/threat source • changing the likelihood or magnitude • changing the consequences;• protecting assets/spaces from the effects of the risk • preparedness planning for the impacts of risks (events) • sharing the risk with another party or parties [including contracts and risk financing • retaining the risk by informed decision making5prioritise risk reduction measures
EURACOM	• Baseline protection concept for CI[70], counteract[71], dhm[72], es-ISAC[73], Ramcap+[74], RMG-DOE[75],RVA[76],PAS55[77]. EURAM is a the proposed best practices will be produced by EURACOM. Among the methods compared, EURAM is considered the best because it is holistic, all-hazard and generically applicable to all CI sectors. • FSA BCM Practice Guide: synthesises best practices obtained from more than 60 firms in the scope of the Resilience Benchmarking Project designed to assess the resilience and recovery capability of the UK financial services sector in the event of major operational disruption such as a terrorist attack or natural disaster
INTACT	Best practices in engineering, materials, construction, planning and designing protective measures as well as crisis response and recovery capabilities.
RESOLUTE	100 resilient cities London resilience partnership, London resilience strategy The US National Infrastructure Protection Plan (NIPP, 2009)
TACTIC	Collects existing vulnerability, capacity, and resilience assessments or audits in order to gain an overview of the types of audits or assessments that already exist and use these tools to help develop and inform TACTIC's participatory community preparedness audit. The project also identifies key components of preparedness, and potential obstacles to preparedness.
TACTICS	Recommendation 1: deploy appropriate counterterrorism technologies that enhance decision-making, but be prepared for ongoing changes in the technology landscape

[70] http://www.kritis.bund.de/SubSites/Kritis/EN/publications/Baseline%20_Protection_Concept.html
[71] http://www.transport-research.info/sites/default/files/project/documents/20120719_144819_68320_Report%20_Deliverable%203_EN3.pdf
[72] http://www.dhm.nl
[73] https://www.esisac.com/
[74] http://files.asme.org/ASMEITI/RAMCAP/17978.pdf
[75] https://www.directives.doe.gov/directives-documents/400-series/0413.3-EGuide-07a
[76] http://brs.dk/eng/inspection/contingency_planning/Documents/RVA-model_user_%20guide.pdf
[77] http://www.mop.ir/portal/File/ShowFile.aspx?ID=3a0eb209-6710-4c3f-8d26-d7b9c1c5f150

	Recommendation 2: apply a structured approach to deployment of Counterterrorism technology Recommendation 3: carefully consider data collection and data sharing Recommendation 4: deal early with considerations around privacy Recommendation 5: establish relevant partnerships and networks Recommendation 6: carry out regular audits and evaluations on the system use
TRUST	Building resilience involves: • incorporating uncertainty and surprise – (accepting that knowledge will never be perfect, and that unforeseen changes are inevitable) • enhancing learning and supporting experimentation – i.e. Allowing room for innovative management approaches, and learning from the outcomes of such approaches; and • Facilitating participation and collective action – i.e. providing opportunities for interactions, and helping to build the skills for cooperation.

It is apparent that there is a huge variety of practices across the numerous EU projects targeting resilience. Lacking empirical evaluations of the long-term impact of those practices it is currently not possible to highlight particular ones as “best practice”, i.e., being superior to others. Given this limitation, SMR uses expert opinion via a Delphi process (T1.4) to identify practices that in the experts’ eyes seem most promising.

3.4 METRICS AND INDICATORS

In this section, we investigate the metrics and indicators that have been proposed, discussed and identified in different projects in our CI literature. Since the coverage of the indicators listed in different projects are very different, for example, DRIVER project (Rigaud, Clemenceau, Engelbach, Wendt, & Dubner, 2015) lists very extensive and detailed indicators in different dimensions of resilience while some other projects cover very limited indicators. Therefore, we organise this part based on different projects, instead of e.g. presenting tables and comparing different indicators have been used in different projects.

CascEff Project

Critical infrastructure resilience comprises of four interrelated dimensions; technical, organisational, social, and economic resilience (Lange et al., 2015). The indicators of each dimension are as follows:

- The technological dimension refers primarily to the physical properties of systems, including the ability to resist damage and loss of function and to fail in a safe way. The technical domain also includes the physical components that add redundancy.
- Organisational resilience relates to the organisations and institutions that manage the physical components of the systems. This domain encompasses measures of organisational capacity, planning, training, leadership, experience, and information management that improve disaster-related organisational performance and problem solving.

- The social dimension encompasses population and community characteristics that render social groups either more vulnerable or more adaptable to hazards and disasters. Social vulnerability indicators include poverty, low levels of education, linguistic isolation, and a lack of access to resources for protective action, such as evacuation.
- Economic resilience refers to the capacity to reduce both direct and indirect economic losses resulting from disasters

STREST Project

STREST project is about building the harmonized approach to stress tests for CIs against natural hazards. In this review, we examine "Report on Lessons Learned from on-going and completed EU projects" (Mignan, 2014). This report reviews nine EU FP 7 projects, among other things are GEISER, MATRIX, NERA, REAKT, SHARE, SYNER-G, ASTARTE, INFRARISK and INTACT. The approach for review is the "Knowledge Transfer" for practical reasons, i.e. to facilitate (i) knowledge transfer from one project to another one as well as (ii) interactions between parallel on-going projects. Thus, the review does not specifically target identification of indicators. Nevertheless, some projects cited in this report listed indicators as seen in the following Table 25:

Table 26 Resilience Indicators mentioned in STREST

Project	Context	Indicators
SYNER-G	Socio economic fragility	Coping capacity, i.e. • shelter, • emergency health, • transportation and • energy distribution;
INFRARISK		Flood hazard (intensity) indicators: • inundation depth, • flow velocity • water contamination • probabilistic flood hazard maps (percentile maps)

However, no indicators so far mentioned in the report based on the STREST project itself.

INTACT Project

We found two INTACT reports, i.e. Catalogue of Extreme Weather Events Damaging CI Report, Database (Vangelsten et al., 2015) and SOTA gaps, Taxonomy and Guidance Parameters for all WP's (McCord et al., 2015). The summary of identified indicators is as follows:

Table 27 Indicators identified in INTACT Project

Report	Indicators
SOTA gaps; Taxonomy and Guidance Parameters for all WP's	• Spatial extent (scale) Size of the affected area • Magnitude (intensity) The strength of the disturbing force (e.g., temperature, wind speed) • Magnitude (severity) The effects of the extreme event on ecological or social region • Frequency The number of disturbances per spatio-temporal area • Predictability The variance in the mean time between disturbances • Timing (Duration) The duration of the event • Timing (rate of onset) Rate at which the event occurs (gradual to sudden)
Catalogue of EWE Damaging CI Report, Database	• Disruption consequences and impact, the recovery duration, damages, and indicators signalling whether the incident could be relevant for identification of good and bad practices, use in scenarios, or analysis for SCADA or EWE effects. • Spatial extent (scale) Size of the affected area • Magnitude (intensity) The strength of the disturbing force (e.g., temperature, wind speed) • Magnitude (severity) The effects of the extreme event on ecological or social region • Frequency The number of disturbances per spatio-temporal area • Predictability The variance in the mean time between disturbances • Timing (Duration) The duration of the event • Timing (rate of onset) Rate at which the event occurs (gradual to sudden)"

RESILENS Project

The indicators identified from the RESILENS project are in the "Stakeholder Consultation Report" (Kudlacek et al., 2013) and "Resilience Evaluation and SOTA Summary Report" (Clarke et al., 2015):

Table 28 RESILENS indicators

Report	Indicators
Stakeholder Consultation Report	Indicator Transport: • On time performance. • Avoidable delays. • Passengers carried. • Back to normal" carrying load. • Resumption to normal airport flight schedule. • Recovery times. • Degree of availability of CI system. • Energy: Extent of damage incurred. Emergency Services: • Extent of assets, infrastructures or systems damage. • Number of assets back online (in operation). Government bodies: • Service provision (coverage).
Resilience Evaluation and SOTA Summary Report	Resilience qualities: • robustness, • redundancy, • resourcefulness, • rapidity

PRACTICE Project

As described in Section 3.3, the focus of resilience in the PRACTICE project is the preparedness of the EU/EEA states in general to protect themselves from the potential non-conventional attacks such as Chemical, Biological, Radiological, and Nuclear (CBRN). The project aims at creating an integrated approach to CBRN crisis. To elaborate what are needed for the CBRN preparedness, the project has defined set of scenarios and compiles CBRN preparedness parameters (Breivik et al., 2012). The critical event parameters are defined in the report as "the observables triggering or determining the performance of a function". The parameters (when people observe something) interact with function (when people perform an action). Therefore, in this project, the report divides the parameters into two categories: Key parameters triggering operational function and parameters that influence the performance of the function. Note that aspects that are more specific have security values and therefore they are not made available for public. The summary of the CBRN preparedness indicators presented in the Table 29 are the general parameters:

Table 29 CBRN preparedness indicators

Report	Indicators		
	Threat assessment	*Prevention*	*Preparedness*
General Parameters Key (parameters triggering an operational function)	• Incidents in other countries • Upcoming events • Suspicious communication/ contact • Threats, specific or non-specific • Trade with suspicious components or quantities • Information from the public • Quality of vector control	• Quality of inventory of CBR threat compounds (industrial sites, storages, …) • Quality of physical security measures, including containment and access control • Quality of cyber security • Quality of surveillance systems (cameras, patrols, …) • Quality of detection systems • Implementation of health surveillance	• Threat level based on agent characteristics • Threat assessment, gap analysis, output and conclusions • Measures implemented based on a threat assessment • Level of awareness and knowledge of the general public • Level of security of the site and physical protection of the threat agent • Level of knowledge of general infrastructure importance, vulnerability and conclusions on measures needed and implemented • Availability of personnel, vaccines, equipment, … • Equipment performance characteristics and number
Parameters influencing the performance of functions	• Weather characteristics (temperature, wind, precipitation, …) • Atmospheric pollution • Level of training of the responders • Level of public awareness		

	• Quality of the communication to the public • Availability of equipment • Capacity in the medical services • Speed of reference laboratory results • Capacities of laboratories and sampling team • Human behaviour in the situation (Auto-evacuation, confusion, …) • Location characteristics • Timing of incident (time of day, season) • Population at risk • Population affected (fatalities, injured, contaminated) • Accidental release or intentional attack
Key parameters triggering a response	• Announcement • Warning and reporting • Health and medical surveillance • Detection, sampling and identification of a threat agent • Threat agent properties • Performance degradation • Symptoms • Time for onset of symptoms • Path of intake • Release method • Mechanism of dispersal • Fate of agent

In addition to the indicators above, this report listed specific parameters that describe the threat agent properties for each C, B, R, and N threats. Although these are not directly indicate the city resilience, but knowledge on CBRN events that should trigger response is very important e.g. when pandemic spreads for unknown reason, and the responders can detect whether or not this event may link to CBRN attacks. At the preparedness stage, the capability to know the CRBN events will give higher value to city's resilience capability in general. The suggested capabilities are as follows:

Table 30 CBRN preparedness indicators

Report	Indicators
PRACTICE	Capability indicators to CBRNE **Chemical:** • ability of the first responders to rapidly detect and identify the cause of the incident the response times and inter-agency cooperation and coordination • the capacity of the health system to deal with a mass casualty event the availability and effectiveness of personal protective equipment and detection and identification systems communication and information strategy towards the public , human and social effects The ability of emergency services to • handle a mass casualty event • plans for registration and tracking of possible victims • inform the public and possible victims • Inter-agency collaboration, including also non-governmental organisations • The health system's ability, capacity and robustness to treat numerous casualties and deal with possible contamination

- Availability and effectiveness of individual protective equipment and detection and identification equipment
- Human and social impact
- The ability to identify the terrorist(s)and prevent further action

Toxic waste release to river system to evaluate Transnational response coordination and responsibilities and The alert routines, both at a national and international level

- Capability bio-security procedures at biological resource centres
- the early warning systems aiming at blocking the spread of the pandemics, including track and trace of potentially infected persons and population warning systems
- The excellence in international coordination, the harmonization of microbial diagnostic capacity in the EU and partner countries, the harmonization of communication strategies at the international level, in particular media handling and communication of public procedures, the mobilisation of resources and policies for medical treatment and prophylaxis the human and social issues

Biological attack on food supply

- Develop and maintain an early warning system for detection of food-borne epidemics
- Develop and maintain networks of microbiology laboratories able to quickly detect and identify pathogens and scale up their capacity
- Develop and maintain public health inspection teams able to quickly assess source of contamination
- Improve cross-sector collaboration for joint risk assessment and “one voice” communication to the citizens
- Rapidly identify the terrorist and prevent further action
- Ensure optimal European collaboration at a nearly stage, in particular regarding the crisis communication

Radiological dispersal in city

- The effectiveness of emergency authorities to detect and identify radioactive release
- The first responders’ competence, training and equipment to deal with a radioactive release event
- The evacuation of patients
- The communication to the public regarding the nature of the threat and what to do
- The management of possibly contaminated people
- Collaboration between the Police, the radiation protection authorities and the hospital staff
- Human and social impacts

RESOLUTE Project

The RESOLUTE project aims at creating the resilience management guidelines and operationalisation applied to urban transport environment, which is clearly one of the city’s CIs. The development of the metrics to measure resilience is found in this project (Ferreira & Simões, 2015). Based on the literature, RESOLUTE underlines that the resilience parameters should be able to capture a great diversity of system feature. In the RESOLUTE project, the metrics to evaluate the resilience is perceived from the internal organisational process point of view. It also summarizes the parameters for non-resilience systems, which can be treated as indicators when the resilience weakens. A summary of resilient and non-resilient system characteristics as suggested in RESOLUTE can be seen in Table 31.

Table 31 RESOLUTE's proposal on resilient and non-resilient system

Report	Indicators	
	Resilient system	**Non-Resilient system**
State of the art review and assessment report	***Top level commitment***: Management recognizes **human performance** concerns and tries to continuously and extensively address them	Defences erode under production pressures
	Just culture: support on **reporting of issues** upwards through the organisation yet not adopting blame attribution behaviours	Safety is not built as inherently as possible into the system and the way it operates by default
	Learning culture: willingness to respond to events not with denial but through repair and reform	There is not a high enough devotion to safety above or alongside other system goals
	Awareness: **Data gathering** that provides management with **insights** about various aspects of performance	There is a failure to revise risk assessments appropriately as new evidence accumulates
	Preparedness: The organisation actively anticipates problems and prepares for them (constant sense of unease)	Past good performance is taken as a reason for future confidence about risk control (**complacency**)
	Opacity: The organisation is aware of the boundaries and knows how close it is to the edge in terms of degraded defences and barriers	Fragmented problem solving clouds the big picture
	Buffering capacity: Ability to adapt to new or complex problems without disrupting overall functionality. It requires that people are able to make decisions without having to wait on management instructions	The organisation responds stiffly and slowly to changing demands and is not able to cope with unexpected situations
	Flexibility: Ability of the system to restructure itself in response to external changes or pressures	
	Tolerance: how the system behaves near a boundary – slowly degrades or quickly collapses when pressure pushes performance towards depletion of adaptive capacities	Breakdown at boundaries impedes communication and coordination, which do not have sufficient richness and redundancy

In brief, in this report it is argued that resilience should be measured in direct relation to how a system performs. Therefore, in build capability for system resilience, the following questions are very important: What capabilities are needed? How much of such capabilities? Where and when are such capabilities needed? Capabilities of sustained adaptability towards what?

Indicators Identified from Journal Articles

The indicators elaborated in this section are derived from scientific articles. There is a wide range of topics covered in these identified literature where the resilience of the critical infrastructure is explored and described. Reggiani, Nijkamp, and Lanzi (2015), for example, highlight the transport resilience and

the importance of the connectivity in urban areas, as the transport system is one of critical infrastructures. However, the resilience indicators are intended for a simulation context, which is not aligned with our goal to find indicators that can be used to measure resilience. Hammond, Chen, Djordjević, Butler, and Mark (2015) look at urban resilience from the perspective of its capacity to deal with the impact of flood. The authors of this paper mention some example of literatures and models that use several indicators to measure the characteristics of system, which may lead to the system being resilient. One of the examples that are relevant for flood resilience indicators, de Bruijn (2004), basically suggests three main parameters:

- the amplitude of the reaction to flood waves, using the expected annual damage and the expected average annual number of casualties;
- the gradualism of the increase of the impacts with increasingly severe flood waves, using a function of the slope of the discharge-damage relationship;
- the recovery rate, using a combined set of indicators related to physical, economic and social factors that speed up recovery

Furthermore, Labaka, Hernantes, and Sarriegi (2015), in a case study of a nuclear plant, propose an internal and external resilience framework for critical infrastructure, using the following dimensions: technical resilience and organisational resilience (internal), economic resilience and social resilience. However, based on these dimensions, no indicators to measure resilience are given, but some policies are identified from the proposed framework and are cited in the section 3.3.1 of this report.

Hernantes, Rich, Laugé, Labaka, and Sarriegi (2013) specify dynamic indicators, the Situational Awareness concept, a distinct form of vigilance that creates sensitivity to cues that indicate a change in the situation. The paper suggested mindfulness, communications, and common rewards as indicators. Ouyang (2014) proposes as CI Indicators, the types of CISs that more frequently damage other CISs, the ratio of being a cause of failure to be affected by failures, combinations of failures that are most frequent, and the number of people affected. Two literature works are identified with respect to the dependence and interdependence of the critical infrastructure. Luiijf et al. (2009) study empirically critical infrastructure in Europe from a dependency perspective. To this end, the authors use the following indicators to capture the dependencies, which cover quantitative and qualitative aspects:

- affected CI sector and service,
- initiating event,
- the concerned organisation(s),
- start and end times/dates,
- country,
- affected geographic area and its size,

- description of the cause,
- threat category and subcategory,
- consequences/damages and impact,
- recovery process

Bristow and Brumbelow (2013) introduce simulation to aid disaster planning and mitigation, and examine the tools and techniques for water distribution managers and emergency planners

- The effect of wind on the fire's rate of spread.
- historical earthquake-caused fires (prevailing wind direction)
- plan dimension of a (square) building, and separation distance between the buildings
- (the upgrading) incorporate areas with non-uniform building layout by directly calculating the burn distance through a building in the direction of the fire's advancement and the intervening distance to the next building for each new building the fire encounters
- available resources such as firefighters and fire engines
- the infrastructure damage profile

To sum up, in this section we have listed a wide range of indicators identified both from EU-sectorial projects and from literature review that link resilience to the Critical Infrastructure in a European context. The relevant indicators will be used further in other WPs to operationalise the concept of resilience.

3.5 CONCLUSIONS FROM CI LITERATURE

This chapter has presented the results of our review on EU sectorial and cross-sectorial projects under the Secure Societies theme focusing on Critical Infrastructure. The main findings of the review can be summarized as follows:

- The review has identified seven topics in the area of CI resilience, i.e. CI Dependency and Interdependency, CI Cascading Effects, CI Risk and Vulnerability Analysis, CI Resilience and CI Protection, CI SmartGrid and Cyber Attack, CI and Urban Resilience and Other CI Themes.
- When the project focuses on CI resilience, the details on how to build CI resilience is thoroughly examined, however, the "urban" perspective is discussed in a limited way, or only treated as a context and background. When resilience or urban context are explored in-depth concerning the detailed mechanism, e.g. building organisational resilience, local government resilience, societal or community resilience, then the role of CI is only dealt with marginally.
- From the policy CI sectorial perspective, resilience is associated with the technological meaning, for instance, interruption or reduction of CI service and CI recovery time. But to a certain degree, the social, economic and organisational aspects are a part of CI resilience, for

example dependency of CI on specialists, CI risk acceptance by societies, level of institutional preparedness on CI events. The resilience term is often used together with CI protection.

- Recent projects have applied CI resilience concept into wider context such as community resilience, city resilience, and European resilience.
- The review has identified eight resilience dimensions where CI is taken into consideration as a part of resilience framework. The summary of the definition of each dimension has been proposed.
- The review found several suggested policies, and best practice as well as indicators.
- It is apparent that there is a huge variety of policy suggestions across the numerous EU projects targeting resilience. Lacking empirical evaluations of the long-term impact of those policies it is currently not possible to highlight particular policies as “best practice”, i.e., being superior to others. Given this limitation, SMR uses expert opinion via a Delphi process (T1.4) to identify policies that in the experts’ eyes seem most promising.
- It is apparent that there is a huge variety of practices across the numerous EU projects targeting resilience. Lacking empirical evaluations of the long-term impact of those practices it is currently not possible to highlight particular ones as “best practice”, i.e., being superior to others. Given this limitation, SMR uses expert opinion via a Delphi process (T1.4) to identify practices that in the experts’ eyes seem most promising.

4 RESULTS: CLIMATE CHANGE

- Definition of Climate Change
- CC and CC Resilience in EU Policy
- CC Themes
- Policies and Best Practice
- Metrics and Indicators
- Conclusions

4.1 INTRODUCTION

In this section, we extract the information from 16 EU funded projects related to climate change (FP7 and H2020) as listed in Chapter 2, Table 5. It consists of 62 documents including analysis of nine scientific articles accessible from project websites, and two European Environment Agency (EEA) reports. The focus of the survey in the Climate Change (CC) sector is to answer the following questions:

- How have different projects on EU-environment and climate change interpreted, defined, used and applied the resilience concepts in a particular climate change sector?
- What kinds of climate change themes have been discussed in the CC projects and how do they link to city or urban resilience?
- How do the EU projects apply the resilience concept in the particular area?
- What are the recommended policies to increase the city resilience against the climate change?

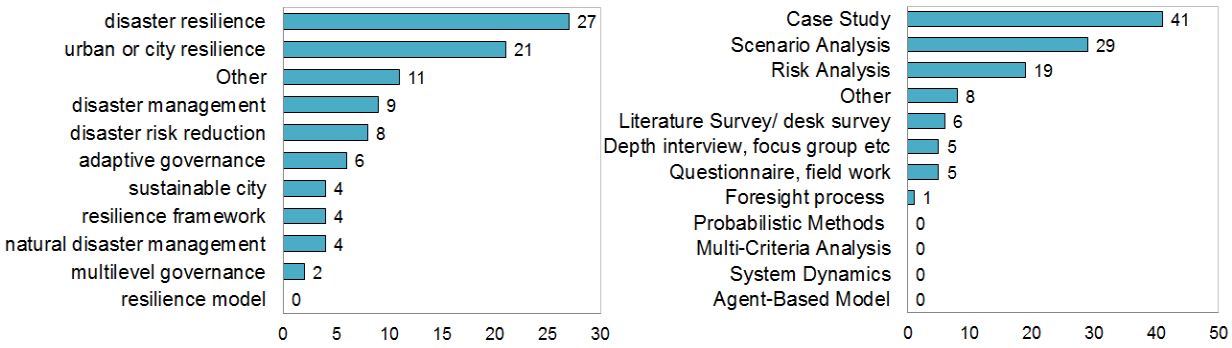

Figure 23 Left: Topics covered by EU climate change projects; Right: Approaches used in the literature

Figure 23 illustrates the topic coverage and approaches found in the identified literature. The left chart shows the topic coverage or contexts of a report or an article when discussing resilience. Disaster and

urban or city resilience are the two most frequent topics discussed in the literature. Under the third category, i.e. “other”, the following resilience contexts are covered:

- adaptive capacity,
- resilience technology,
- standardize approach for climate adaptation,
- strategy for strengthening Europe’s resilience to the impacts of climate change,
- ecosystem resilience and flood management.

Note from the left chart in Figure 23, we found only a couple documents covered the multilevel governance which is an essential framework for urban resilience and CC adaptation strategy in general. However, these two documents covered quite deep the multilevel governance topic. This topic is not only discussed deeply as multilevel governance, but also embraces multi-actor governance, multi-sector governance and multi-level risk governance ideas (Costa et al., 2013; Renn, 2008). The chart on the right in Figure 23 captures the methods used in our selected literature for examining resilience in different natural hazard sectors. Case study, scenario analysis, and risk analysis are the three most usual methods used in our literature. The examples of methods that are not listed in the chart on the right side, but are employed in some of the reports are:

- The expert/ professional knowledge gathering,
- The multi-regional discussion,
- The interdisciplinary approaches,
- The requirement specification analysis,
- The knowledge-based approach,
- The combination of qualitative and quantitative methods.

Note that sometimes one report encompasses several themes or several approaches. Therefore, the numbers of topics do not correspond to the number of reports identified.

4.1.1 WHAT IS “CLIMATE CHANGE”?

Many studies define climate change in a very generic way, but often it is interpreted and defined as a part of specific natural hazard threats, risks, and vulnerability. Climate change in literature refers to an identified change in the mean and the variability of its properties, and that persists for an extended period, typically decades or longer (Hallett, 2013). Climate change occurs due the natural internal processes or external forces, or to persistent changes in the composition of the atmosphere or land use. It can lead to the changes in precipitation and temperature.

Climate change is happening, projected to continue, and it poses considerable challenges for cities, and is considered as the most prominent threat to sustaining and enhancing the quality of life and economic competitiveness in European cities (EEA, 2012, 2013). How this impacts on a particular city depends on the exposure and vulnerability of a city, for example in terms of urban form, settlement pattern and socio-economic and environmental context (IPCC, 2012). Extreme weather events result in hazards such as heatwaves, floods, and drought are expected to happen more frequently in many parts of Europe. Climate change challenge in Europe appears as gradual changes in the environment such as increases in temperature, loss of biodiversity, and rising of sea levels, sudden and extreme weather such as storms and flooding (EEA, 2012, 2013). Thus, there are obvious links or influences between certain types of natural hazards (e.g. floods) and climate change. In a flood example, climate change is projected to affect the frequency, intensity and spatial patterns of river flooding. Furthermore, it will affect future city spatial patterns, growth, and development.

- **Climate change**: an identified change in the mean and the variability of its properties, and that persists for an extended period, typically decades or longer (Hallett, 2013).
- Climate change challenge **in Europe** appears as **gradual changes in the environment** such as increases in temperature, loss of biodiversity, and rising of sea levels, sudden and extreme weather such as storms and flooding (EEA, 2012, 2013).
- **Adaptation** in the context of **climate change** is the adjustment in natural or human systems in response to actual or expected climate stimuli or their effects, which moderates harm or exploits opportunities (IPCC 2014).
- **Adaptive capacity** is “the capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganising in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation.” (IPCC 2014).

It is important not to mix the definition of climate change with the “climate change scenario” concept, which is also often used in this research area. This concept is defined as “a plausible and often simplified representation of the future climate, based on an internally consistent set of climatological relationships and assumptions of radiative forcing, typically constructed for explicit use as input to climate change impact models. A 'climate change scenario' is the difference between a climate scenario and the current climate” (EEA, 2012).

Scientists have linked CC with vulnerability, particularly in relation to adaptation and adaptive capacity. “Ability to adapt” has been interpreted as similar to coping capacity and resiliency that is seen to be an important element of vulnerability. However, although the climate change research has a stronger emphasis on gradual and creeping changes, such as sea-level rise, the disaster risk community focuses primarily on crises and disasters linked to sudden-onset hazards (Birkmann et al., 2009). The link

between resilience, vulnerability and adaptation is based on the opinion of W.N. Adger et al. (2007) who refer adaptation practices as adjustments, or changes in decision environments, which might ultimately enhance resilience or reduce vulnerability to observed or expected changes in climate. A frequently cited definition as a basis for deriving adaptation strategy is offered by the Intergovernmental Panel on Climate Change (IPCC): "Adaptation in the context of climate change is the adjustment in natural or human systems in response to actual or expected climate stimuli or their effects, which moderates harm or exploits opportunities". Furthermore, IPCC (2014) suggests a definition that links resilience to the climate change and adaptive capacity. Adaptive capacity is interpreted as "*the capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganising in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation*."

The adaptation to climate change also contains a risk dimension. From a temporal perspective, adaptation to climate risks can be viewed at three levels, including responses to current variability (which also reflect learning from past adaptations to historical climates); observed medium and long-term trends in climate, and anticipatory planning in response to model-based scenarios of long-term climate change (W.N. Adger et al., 2007).

Thus, implementing a programme to reduce vulnerability due to climate change and to integrate adaptation into all sectors in a way that takes into consideration the wider context of social change in Europe is considered highly crucial for a resilient society building. It takes into account general issues such as global warming, global climate, general extreme weather, comprehensive overview of all potential threats in different parts of Europe, and climate impacts. There are also wide ranges of discussions in EU CC projects about resilience to CC, the adaptive capacity to CC, resilience risk and vulnerability and other themes as will be elaborated in Section 4.2.

4.1.2 CLIMATE CHANGE RESILIENCE AND EU POLICY

EU policy toward climate change was firstly triggered by the IPCC report in 1990 and UNFCCC negotiation about stabilizing the GHG (greenhouse gas emissions) of EU at 1990 level by 2000[78]. EU agreed on softer instruments in the fields of energy efficiency and renewable energies. With the help of a monitoring mechanism established by Decision 93/389/EEC[79], the Community could assess the

[78] European Council, Presidency Conclusions — Dublin 25/26 June 1990, Annex II: The Environmental Imperative, Council of the European Union, SN 60/1/90, 1990.

[79] 93/389/EEC: Council Decision of 24 June 1993 for a monitoring mechanism of Community CO2 and other greenhouse gas emissions. OJ L 167

development of national policy programmes on the reduction of GHG (there were no Member State targets) and monitor progress on the 2000 target. A set of policies were set/up between 1991-1993 to save energy in a more concrete way through standards for household electric equipment power consumption, GHG emission, building certification and thermal insulation, and renewable energy, such as SAVE programme (Specific Actions for Vigorous Energy Efficiency)[80]. From 1993 on the SAVE Directive[81] was in place, which required EU Member States to limit GHG emissions by further measures such as energy audits for energy intensive companies, building certification or thermal insulation of new buildings. The ALTENER programme[82] was introduced further in 1993 to encourage renewable energy supply followed by policy on GHG reduction

The next milestone is the implementation of Kyoto I where EU highlights the European emissions trading scheme introduces emission caps or limits and further detailed policies on GHG, renewable energies and energy efficiency. In Kyoto II, the climate and energy package were continued to pursue including the threefold policy approach mentioned in Kyoto I. In this policy thread above, climate change policy tends to focus on the energy saving, GHG reduction and the use of renewable energy. Apparently, these three strategies will be continuously pursued in the future with a clear timeline.

In the meantime, another direction as a response to CC problems was the development of the EU adaptation strategy, which started in 2009, when the European Commission's 2009 White Paper, Adapting to climate change strategy was issued[83]. In April 2013, the European Commission adopted an EU strategy for adaptation to climate change[84]. The strategy aims to make Europe more climate-resilient. The strategy is to enhance the preparedness and capacity of all governance levels to respond to the impacts of climate change. The EU Adaptation Strategy focuses on the three key objectives:

- Promoting action by Member States by encouraging all EU member states to adopt adaptation strategies and build up adaptation capacities
- Climate proofing action at EU level by promoting adaptation in the vulnerable sectors
- Better informed decision-making by addressing gap knowledge about adaptation

The implementation of the EU Adaptation Strategy is based on eight actions:

1) Encourage all Member States to adopt comprehensive adaptation strategies

[80] 91/565/EEC: Council Decision of 29 October 1991 concerning the promotion of energy efficiency in the Community (SAVE programme). OJ L 307, 8.11.1991

[81] Council Directive 93/76/EEC of 13 September 1993 to limit carbon dioxide emissions by improving energy efficiency (SAVE) OJ L 237 , 22/09/1993

[82] 93/500/EEC: Council Decision of 13 September 1993 concerning the promotion of renewable energy sources in the Community (Altener programme). OJ L 235 , 18/09/1993

[83] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2009:0147:FIN:EN:PDF

[84] http://ec.europa.eu/clima/publications/docs/eu_strategy_en.pdf

2) Provide LIFE funding to support capacity building and step up adaptation action in Europe (2014-2020)
3) Introduce adaptation in the Covenant of Mayors framework (2013/2014)
4) Bridge the knowledge gap
5) Further develop Climate-ADAPT as the 'one-stop shop' for adaptation information in Europe
6) Facilitate the climate-proofing of the Common Agricultural Policy (CAP), the Cohesion Policy and the Common Fisheries Policy (CFP)
7) Ensuring more resilient infrastructure
8) Promote insurance and other financial products for resilient investment and business decisions

It is worth to mention that resilient cities are only one of EU strategies to make Europe more resilience to climate change. The actions proposed above are obviously cross-sectorial, where most affected EU sectors are covered under these eight actions outlined in the EU Strategy on adaptation to climate change 2013.

4.2 CC TOPICS

- CC Risk and Vulnerability
- CC Urban/ City Resilience and Strategies
- CC and Technology Support
- CC Adaptive and Multilevel Governance
- CC-CI Dependency/ Interdependency and Impacts

This part is organised thematically based on the most frequent perspectives or approaches used for analysing and discussing the CC and CC resilience. This subchapter will be divided into five main topics. The two next sub-sections illustrate the overview of the documentations, what kind of challenges, approaches, threats and scenarios are discussed in the CC literature. Note that when discussing each topic, our goal is to identify as much as possible resilience aspects to the problem being investigated.

4.2.1 CC CHALLENGES AND APPROACHES

The EEA document (2013) reports results from a workshop where city planners and key target groups were gathered and learned about the CC challenges and risks. The document reports the wish of the city stakeholders to link to broader policy issues including sustainable urban development and improvements to the quality of life. Also, the report concludes that the common knowledge gap on the CC is in the following areas:

- climate hazards, impacts
- vulnerabilities
- adaptation management,
- knowledge management
- financing mechanisms
- cost and benefit analyses.

In this Section 4.2.1, we present the overview of resilience challenges and approaches in the EU sectorial projects identified from the literature. In fact some resilience challenges identified in literature is in line with the gaps identified in the EEA document listed earlier. Prior to elaborating the resilience challenges found in EU CC projects, the overview of the CC resilience context described in the reports and scientific literature reviewed for this report can be seen in Figure 24.

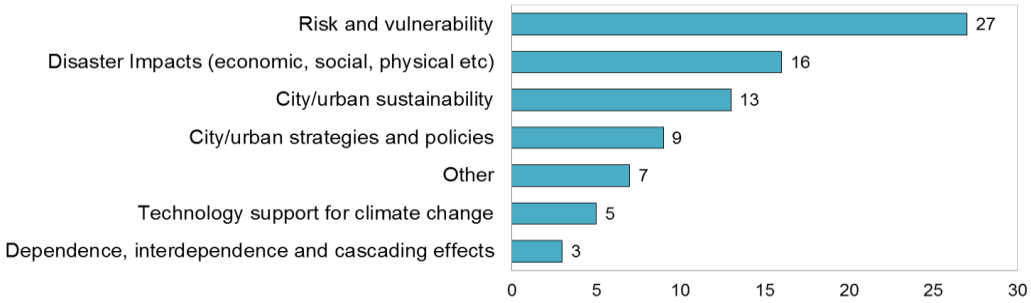

Figure 24 CC Challenges and Approaches

CC Risk and vulnerability are the most common themes discussed in the literature since risk and vulnerability are always the main starting point for discussing resilience. Policies, strategies, and actions are difficult to formulate without the knowledge of what is vulnerable in the system components, infrastructures or geographical areas, and what kind of risks that follow the detected vulnerabilities. Next, disaster impacts, city or urban sustainabilities and city or urban strategies and policies are the next themes found in the literature. Technology support for climate change and dependencies are two the least discussed topics, but equally important to know. There is a category called “other” in Figure 24.

4.2.2 THREATS AND SCENARIOS

The most visible approaches taken through sectorial approaches in climate-change related to EU projects are looking on different threats and designing how to handle the threats and build the resilience. Figure 25 summarizes the overview of the reports collected so far.

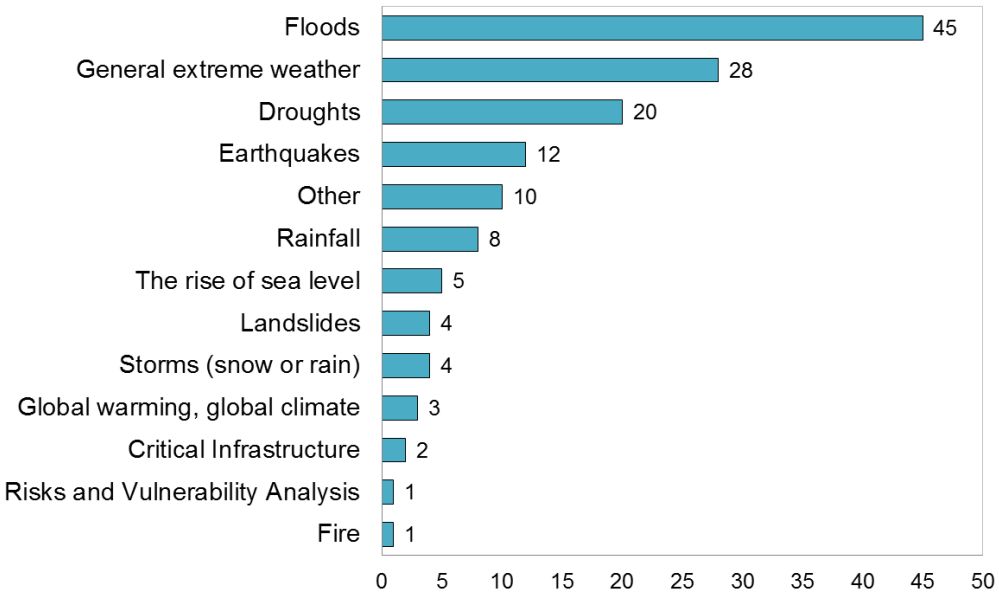

Figure 25 Overview of the most frequent threats discussed in EU Climate Change projects

From Figure 25 we notice that floods, general extreme weather, and droughts are the most frequent threats that have been linking to the resilience in our climate change literature. The contexts under the "other" category are as follow:

- Water supply, water scarcity
- General impacts of climate change such as fish stock, glacier, species
- Volcanic hazard
- Short term hazard

Nevertheless, many of them are intertwined and have been discussed as a part of a cause of or an impact to the hazards. For example, the rise of sea level or global warming and floods, or extreme weather and drought.

4.2.3 CC RISK AND VULNERABILITY

- A comprehensive **risk and vulnerability assessment** framework was defined, and tested in different EU cities through the MOVE project. The framework has flexibility in the implementation. Each city can decide what **indicators** are relevant to assess its own risks and vulnerabilities.
- A comprehensive handbook was produced by the MIAVITA project focusing **on risks and risk mitigation** in a specific threat, i.e. volcano hazard. But some contents are relevant for some other threats too. The approach covers prevention tools based on risk assessment, risk mapping and possible damage scenarios, reduction of people's vulnerability and improvement of crisis management capabilities, based on monitoring and early warning systems, secure communications and preparedness of the stakeholders.
- Risk topic is discussed in the ENHANCE project as the intertwined relationship with resilience approaches, and foundation for building risk assessment and risk management.

The definition of risk and vulnerability has been discussed in Chapter 3, and thus we will not repeat here since some of the basic methods, approaches and definitions in this area are closely related. We will focus more on how different CC projects address the issue of risk and vulnerability.

One of these projects that are completely dedicated to vulnerability analysis is the finished project MOVE[85], where methods for the improvement of vulnerability assessment in Europe are defined. This was motivated by the need to develop methods and indicators for improving vulnerability assessments to natural hazards in Europe and establishing a consistent framework. The project has produced a handbook (Alexander et al., 2011), a manual or vulnerability assessment (Vinchon et al.) and the MOVE web-based indicators metadata database (the MOVE wb-db)[86]. The database allows users to search indicators for vulnerability assessment that can include risk, risk governance, and adaptation. The MOVE wb-db consists of 260 indicators. Note that concepts such as "resilience" and "adaptation" dealt with in this project, but the former was captured as "*lack-of resilience*" while the latter was portrayed through *hazard and vulnerability interventions*. Further dimensions defined for measuring "*lack-of resilience*" are in fact "capacity to anticipate", "capacity to cope with" and "capacity to recover"—which are actually concepts that have been used for defining resilience. From a temporal perspective, MOVE was implemented between 2008-2011, which means that the EU policy on climate adaptations are not entirely in place. However, this project had laid a strong foundation toward an understanding of resilience to natural hazards. The overall picture and links between vulnerability, risk, risk governance, and adaptation were modelled as shown in Figure 26[87]:

[85] See: http://www.move-fp7.eu/

[86] http://www.gi4drr.org/move/move_query/#

[87] Source: http://www.gi4drr.org/move/move_query/#

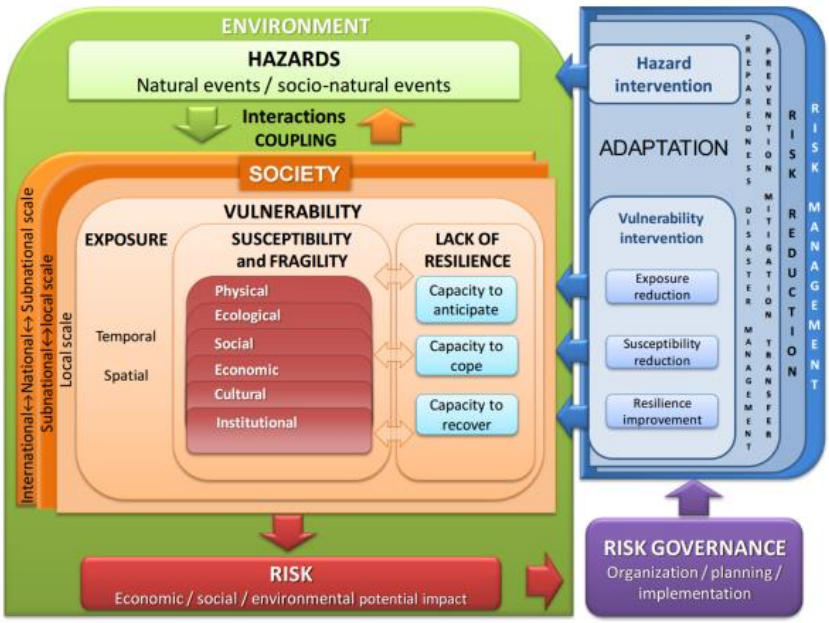

Figure 26 Framework for Assessing Risk and Vulnerability in MOVE

Another FP7 project discussing risk and resilience started around at the same time as the MOVE project was the MIAVITA[88] project that was completed in 2012. Although the project focused on risks and risk mitigation, the case was quite specific, i.e. Volcano hazard, but the considered aspects were quite broad, ranging from land use and urban planning, human vulnerabilities to emergency planning, CIs, communications. MIAVITA produced a handbook (Costantini & Thierry, 2012) that proposes the methodological framework and information flow needed for managing volcanic threats which are also evident in Europe (e.g. Iceland, Italy). The approach covers prevention tools based on risk assessment, risk mapping and possible damage scenarios, reduction of people's vulnerability and improvement of crisis management capabilities, based on monitoring and early warning systems, secure communications and preparedness of the stakeholders.

The mapping of hazard using GIS (Geographical Information System) is quite central to the risk assessment, and many best practices proposed in MIAVITA, have to do with GIS mapping. Good practices for monitoring are also listed, but they are dealt with monitoring volcanoes' symptoms, the use of sensors and measurement devices, as well as remote sensing and communications for real-time monitoring. However, good practice examples in the preparedness level formulated in this MIAVITA handbook are quite comprehensive and cover different stakeholders' preparedness, including students and pupils. In this respect, even though the best practice is specifically defined for volcano threat for

[88] Source: http://miavita.brgm.fr/default.aspx

preparedness, raising public awareness and community-based disaster risk reduction process, many aspects are actually relevant for other types of hazards too. Overall, parts of the best practices dealing with community and organisation preparedness for reducing risks in this MIAVITA handbook, with some adaptation to the context, are relevant and can contribute to further operationalising resilience.

The CapHaz-Net is an FP7 project that develops a framework to enhance the capacities of European societies to prepare for, cope with and recover from the negative impacts of a natural hazard. Social resilience is very central to the project and therefore, most of the risks discussed in the project cover risk perception, social vulnerability, risk communication and risk education. Two main backbones are defined, i.e. Social Capacity Building and Risk Governance (See also section 4.2.8) which both will lead into Social Resilience (Tapsell et al., 2010). Risk perception is seen by the CapHaz-Net as people's view of risks; the term refers to "people's judgments and evaluations of hazards they (or their facilities or environment) are or might be exposed to". The framework proposed in the CapHaz-Net project can be seen in Figure 27.

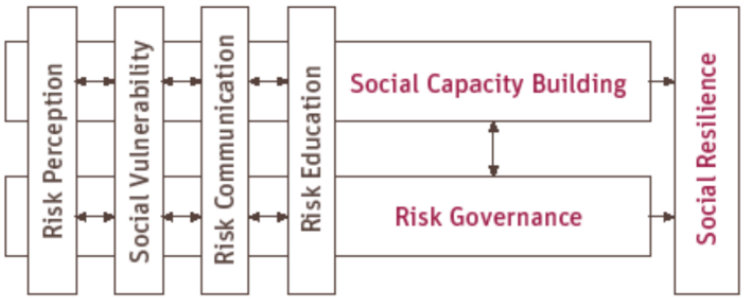

Figure 27 CapHaz-Net Thematic Structure

Social vulnerability is supposedly apparent after a hazard event, and different patterns of suffering and recovery are observed among particular groups in the population. The social impacts of the hazard are worse among the most vulnerable people in the society, i.e. the poor, minorities, children, elderly and disabled people since they are less prepared for emergencies. Some of them live in the highest risk location in substandard housing and lack of knowledge to take advantage of resources that would speed up the recovery process.

The CapHaz-Net report has introduced how the vulnerability' has emerged as a central concept for understanding the people's condition with respect to the ability to cope with a disaster (Höppner, Buchecker, & Bründl, 2010; Kuhlicke & Steinführer, 2010; Kuhlicke, Steinführer, Begg, & Luther, 2012; Kuhlicke et al., 2010; Tapsell et al., 2010; Wachinger & Renn, 2010; G. Walker, Whittle, Medd, & Watson, 2010). Traditionally research literature treats vulnerability as composed of two components and

is explained with the following relationship: **Vulnerability = function (s, v),** where s is susceptibility while v is value. The vulnerability is defined by the susceptibility of the system in question to adverse consequences following hazard impact; thus incorporating the inherent characteristics of the composite elements of this system and the value **(v)** placed on the system by society. Susceptibility can be viewed as both dependent and independent of the hazard scenario. In this project, the link between vulnerability and resilience and capacity is closely related, especially when referring resilience as a "flip-side" of vulnerability. This implies that high level of vulnerability means low level of resilience, vice versa. The project lists working definitions of resilience and social resilience as seen in Table 32:

Table 32 Definition of resilience, social resilience, and adaptive capacity

Concept	Definition
Resilience	The capacity for renewal, reorganisation, and development (Folke, 2006)
	An intrinsic ability of a system, an element, or a community to resist the impact of a natural or social event (Villagrán de León, 2006)
	The ability of a system, community, society, defense to react to and recover from the damaging effect of realized hazards (Gouldby & Samuels, 2005)
Social Resilience	The capacity of a community or society potentially exposed to hazards to adapt, by resisting or changing to reach and maintain an acceptable level of functioning and structure. This is determined by the degree to which the social system is capable of organising itself to increase its capacity for learning from past disasters for better future protection and to improve risk reduction measures (Gouldby & Samuels, 2005)
Adaptive Capacity	The ability or capacity of a system to modify or change its characteristics or behaviour to cope better with existing or anticipated external stresses. Adaptive capacity represents potential rather than actual adaptation (W Neil Adger, Brooks, Bentham, Agnew, & Eriksen, 2004)

The project introduces three approaches proposed by researchers in the area of vulnerability and natural hazards:

1) Exposure/ Biophysical model: the identification of condition that make people or place vulnerable to extreme natural events; 2) Vulnerability is a social condition, a measure of societal resistance or resilience to hazards 3) integration of potential exposures and societal resilience focusing on special places. The main questions for social vulnerability analysis are as follows:

- Who is at risk –who is most vulnerable?
- What kind of consequences can be expected for vulnerable populations?
- How can risks to vulnerable populations be mitigated or managed?

The project explored several methods to capture social vulnerability, qualitatively and quantitatively. In quantitative approaches, the efforts are put on finding indicators and measures to be able to assess vulnerability. The main issue with this approach is about data availability that often is unavailable nationally. In addition, data quality is sometimes difficult to guarantee due to the challenges to verify them, or the data sensitive to the changes. These challenges are coupled with the issues such as data

validation, data accuracy, method to weight the indicators and method to evaluate the indicators. The qualitative bottom-up approaches are considered promising and can bridge the gap. The examples of these bottom-up approaches are the Participatory Action Research (PAR) model, the Participatory Rural Appraisal (PRA), the Sustainable Livelihoods (SL) approach, and the Community-Based Participatory Research (CBPR) method.

- Risk topic is discussed in the CapHaz-Net project in terms of risk perception, social vulnerability, risk communication and risk education. Understanding of these risks are pillars to build social resilience, through risk governance and social resilience building.
- Vulnerability in the CapHaz-Net is introduced as "social vulnerability" for understanding the people's condition with respect to the ability to cope with a disaster.
- Risk topic in the CREW project is discussed in terms of community resilience and vulnerability. Community consists of interacting policy makers, SMEs, and householders. Each stakeholder group has its internal vulnerability, resilience, and adaptive capacity structure. Community resilience is interpreted as the interrelation between these groups.

From this overview, we understood that the CapHaz-Net project put a strong emphasis on the human dimension of the natural hazard and CC. Moreover, it is worth to mention that the understanding or exploration of risk in this project is quite comprehensive, where all aspects of risk perception at the individual level (Wachinger & Renn, 2010) and risk communication to risk governance are integrated into the project. Therefore, we also include these topics such as social vulnerability and individual risk perception as an important theme relevant for "Social Dynamics" in Chapter 6, and risk governance in Section 4.2.7. The findings of the CapHaz-Net on Risk and Resilience can be summarized in the following points:

- **Social capacity building** concerns the effective involvement of population at risk, organisations involved in disaster management and communities to contribute at various levels in managing their own and other actors' vulnerabilities to natural hazards.
- **Risk governance** indicates a shift of how societies are governed. Some characteristics of this transition are a 'rolling-back' of the state, privatisation and the entry of new forms of actors into the political decision-making process.
- **Risk perception** study underlines that the awareness of a hazard does not automatically translate into preparedness or concrete actions; they rather underline the relevance of the experience of hazardous events, the trust in authorities and measures as factors influencing risk perception (Wachinger & Renn, 2010).
- **Social vulnerability** concept is reaching the policy level. The question of how to define vulnerability and how to measure it remain contested.

- **Risk communication** gains increasing relevance in practice; a means to learn from practices and to adapt them (Höppner et al., 2010).
- **Risk education** is a social capacity building effort, highlights on a motivational and procedural basis, and covers the notion of 'learning to learn' e.g. curriculum based, standardised education on natural hazards.

In CapHaz-Net, all these points are inseparable, intertwined pillars for social resilience building (Kuhlicke & Steinführer, 2010). This project guides building social capacities of **organisations and local communities** (Kuhlicke, Steinführer, Begg, & Luther, 2012). This topic is summarized in Section 4.3.

The idea of IPCC's increased resilience within disaster risk framework is a starting point of the ENHANCE project. It sets to develop and analyse new ways to enhance society's resilience to catastrophic natural hazard impacts, among others by contributing to the development of new multi-sector partnerships (MSPs) to reduce or redistribute risk. Resilience in the ENHANCE's reports is perceived as the intertwined relationship between risk and resilience approaches, and foundation for building risk assessment and risk management (McLean & Guha-Sapir, 2013). As the Governance and Risk Governance is very central in this project to build resilience, further risk-related governance description in ENHANCE project is found in section 4.2.7.

The CREW project address the specific topic of flood hazards. The CREW project was funded by the EPSRC (Engineering and Physical Sciences Research Council) in the UK between 2008-2011. Although it is a non-EU project, the CREW is reviewed since the project started early with the concept of community resilience to extreme weather and included risk and vulnerability and adaptation as a part of the project goals. CREW integrated social and physical research to develop an improved understanding of risks and vulnerability from extreme weather events at the community level, as well as offered adaptive coping measures for reducing vulnerabilities, and strengthening resilience (Hallett, 2013). To illustrate the link between risk and vulnerability linking to community resilience, CREW developed the model depicted in Figure 28.

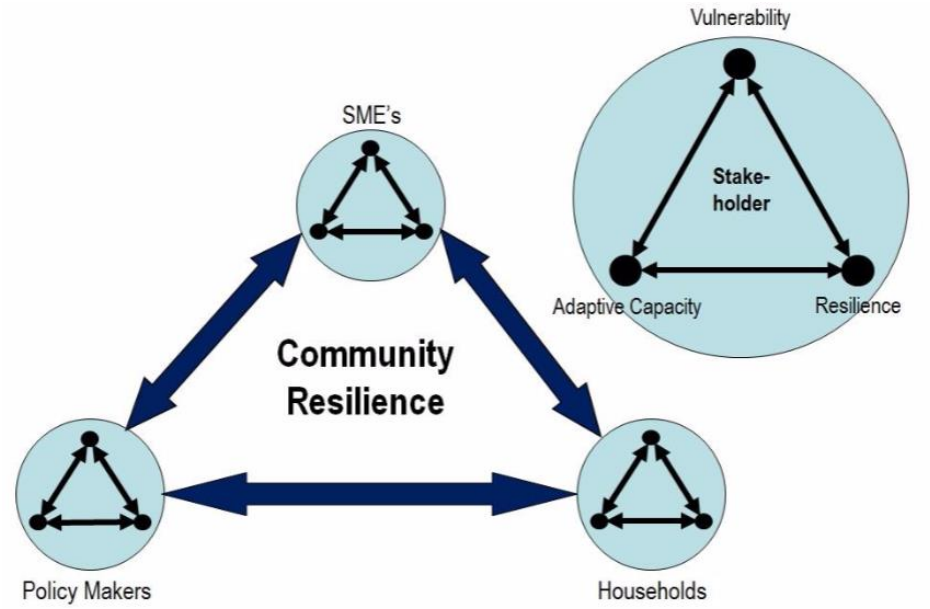

Figure 28 Community stakeholder model in CREW project (Hallett, 2013)

The idea is that stakeholders in the community ideally consist of interacting policy makers, SMEs, and householders. Each stakeholder group has its internal vulnerability, resilience, and adaptive capacity structure. Thus, community resilience is interpreted as the interrelation between these groups. The project suggests different phases to assess community resilience. It covers establishing boundaries of organisational systems and assesses its current vulnerability and resilience to extreme weather events. Such vulnerability information could be obtained from the local newspaper or relevant policy documentation. The next phase is to compare the climate impacts between current conditions and future scenarios, identify the gaps, which allow stakeholders to assess the risks and impact of the risks. The subsequent level of refinement is to detect particular system components that are highly vulnerable to extreme weather events having low coping capacity, and develop interventions that reduce vulnerability and increase coping capacity. These interventions, their costs, and expected impacts are assessed and plotted on an Impact-Priority Matrix. Once each resilience measure is established, high priority interventions within the adaptive capacity of the organisation can be incorporated into a short-or long-term adaptation plan, and their performance monitored with time and risk reappraisal. However, the risk and vulnerability methodologies are not elaborated in detail, and, in fact; the above steps are the common risk-vulnerability assessment steps. The strength of the CREW project is in the hazard impact part.

Note that our literature classification procedures have categorized the emBRACE [89] project to encompass risk and vulnerability (Karanci, Ikizer, & Doğulu, 2015; Kruse et al., 2012; Matin et al., 2015; Pelling et al., 2015). However, closer look at the unit analysis reveals that it covers individual's perception of resilience, mapping community resilience, assessing policies and social learning, as well as perceived measures for increasing resilience and health/ social services. The climate change is not a focus, and therefore, we will analyse the project in Chapter 5 (Social Dynamics).

4.2.4 CC URBAN/ CITY RESILIENCE AND STRATEGIES

The project that discusses resilience in urban unit of analysis is TURAS[90]. The goal is to enable adaptive governance, collaborative decision-making and behavioural change to facilitate local authorities and communities in the transition process. The project demonstrates and disseminates transition strategies and scenarios to enable European cities and their rural interfaces to build resilience.

Among the activities in TURAS are to embrace the concept of social-ecological resilience into urban planning (Crowe & Foley, 2013). The summary of definitions identified from the TURAS report is shown in Table 33. Several important concepts are used for establishing a set of adaptive co-management and urban governance as discussed further in Section 4.2.8.

Table 33 Definition of Resilience in TURAS project

Source	Elements
(Carl Folke, 2006)	A capacity to absorb shock, embracing a potential for 'renewal, re-organisation and development
(B. Walker et al., 2006); (Rees, 2010)	**Sustainability** can be understood as a related but distinctly different concept to resilience. The enhancement of resilience in social-ecological systems is about embracing change rather than constancy, presenting a dynamic form of sustainability. **Resilience** can be understood to reconfigure the basic principles of sustainability in response to a particular temporal or spatial context, accepting that the only constant is change
(Carpenter, Walker, Anderies, & Abel, 2001)	Resilience can be desirable or undesirable while sustainability infers maintaining system states that are preferable
(Redman, 2014)	Resilience is the ability of a system to act and has uncertain results, whereas sustainability is a desirable outcome specified in advance
(Ahern, 2011)	The 'safe-to-fail' approach of resilience thinking accepts change and uncertainty, building adaptive capacity for reorganising and recovering without changing state.

This project argues that social-ecology concepts are relevant to move toward urban resilience and sustainability. Among socio-ecological concepts that are relevant are diversity, complexity, and spontaneity; decentralization, alternative technologies; public participation and a vision of the future.

[89] www.embrace-project.eu
[90] http://www.turas-cities.org/

TURAS project also relates urban resilience to sustainability (Collier et al., 2013) where the following points should be taken into account:

- ….. as the ability to adopt and change …. to enable flexible governance, collaborative decision-making and behavioural change towards resilient and sustainable cities….
- …..as a driver of (new) urban policy towards a more integrated, multi-disciplinary and open planning system with community stakeholders as central to the planning process and planners as innovative, creative and holistic actors working within a multidisciplinary and multi-functional framework….
- ……as urban green policy is increasingly being used as a tool to enhance urban resilience and sustainability supporting biodiversity and ecosystem services ….. the unused sites and buildings could make cities and urban communities more resilient that will probably enable them to improve planning efforts with regeneration projects and innovative, creative design…..
- …….as mobilising social capital, (scarce) economic and environmental resources while seeking to work with planning stakeholders on the egalitarian way …. with de facto inclusion of cultural and other forms of knowledge….

4.2.5 CC AND TECHNOLOGY SUPPORT

There are two projects in our CC literature linking in specific the CC issue and technology support, i.e. SMARTeST[91], and ToPDAd[92]. The SMARTeST project concerns the flood events in Europe and worldwide and points out that the existing flood defense structures do not guarantee a sufficient protection level for people and properties. There is no sufficient strategy to cope with the future flood. On the other hand, the flood resilience technology has emerged but requires the adaptation or construction of the buildings themselves such as anti-flood air brick, sump and pump system, tanking basement. The resilient flood technology can be used to protect the building, including barriers, protection walls and flood products (Iain White, O'Hare, Lawson, & Garvin, 2013; Iain White, O'Hare, Lawson, Garvin, & Connelly, 2012; I. White, O'Hare, Lawson, Garvin, & Connelly, 2013). Hence, in this project, the use of resilience technology term specifically refers to flood resilience, flood technology, and flood risk management encompassing measures to keep water out of a building and to reduce the time for repair if the flood does occur, limiting the effect of flooding upon both places and people. The recent trend towards shifting responsibilities for governance and public administration makes flood risk management necessary.

When it comes to the technology for resilience, the challenges come from different dimensions. For example, from a regulatory perspective, there are no coherent regulatory frameworks or standards for

[91] The project has finished and the website was not maintained. We use the CORDIS website as a reference http://cordis.europa.eu/result/rcn/155563_en.html and the website that maintained the SMARTeST product http://www.smartfloodprotection.com/
[92] http://www.topdad.eu/

flood resilience. From institutional and policy perspective, the responsibility for flood risk management and flood resilience are often fragmented, coupled with limited funding for tackling this issue. Socially, certain sectors of society have less capacity or knowledge to respond to flood risk than others, and culturally there is resistance to flood resilience technologies; many are unaware of flood risk and do not believe that these technologies protect them.

- The use of resilience technology term specifically refers to **flood resilience, flood technology, and flood risk management**
- Typical discussions of urban floods: measures to keep water out of a building and to reduce the time for repair if the flood does occur, limiting the effect of flooding upon both places and people, shifting responsibilities for governance and public administration.
- Two project guidelines are available from the SMARTest project for household and authorities how to uptake the flood resilience technologies.
- Four technologies to support adaptation to CC impact in energy sector are proposed in TopDAd: energy efficiency buildings, smart meters for energy use and costs, smart appliances and smart grids.

In this SMARTeST project, a set of guidelines (Iain White, O'Hare, Lawson, & Garvin, 2013; I. White, O'Hare, Lawson, Garvin, & Connelly, 2013) was produced both at the household level and the authorities level to cope with the challenges mentioned earlier. In essence, the guideline for decision makers proposes ways for how to uptake the flood resilience technologies which have properties that are likely to benefit communities. While the guideline for being resilient against flood at the household level suggests what is the best to do /knowing the risk to make a decision on whether or not the owner of the properties needs these technologies for flood for protection. In brief, city resilience in this context has been interpreted as resilience against flood and the need for “grey measures”, i.e. physical interventions or construction measures to make buildings and infrastructures are more capable of withstanding extreme events.

The ToPDAd projects listed relevant changes through technology support that will benefit the energy sector (Aaheim et al., 2013)such as:

- Energy efficiency of buildings
- Smart meters that will provide consumers more information on their energy use and associated costs.
- Smart appliances and buildings that will allow for greater control of grids, improving the efficiency of energy generation, transmission, and distribution
- Smart grids will also allow for increased load levelling and hence reduced carbon intensity, as well as greater reliance on renewables many of which are more intermittent than would be acceptable in ensuring energy quality under the current energy transmission and distribution system.

4.2.6 CC ADAPTIVE AND MULTILEVEL GOVERNANCE

The concept of resilience within governance especially institutions and organisation is relatively new, and HFA 2005-2015 has pushed resilience agenda forward in governance circles. The governance structure can be public, private or community-based. Governance resilience has evolved and is interpreted in different directions as we found in EU-CC project reports. At least four main themes are linking to governance: CC Adaptation, adaptive capacity, adaptive governance and multilevel governance. One project specifically discusses the resilience of a local government instead of governance. Organisations operating within governance structures are rational systems that have clearly delineated and well-defined rules and objectives. They are projected as agents with resource, knowledge, technical skills to increase resilience and managing hazard risk (McLean & Guha-Sapir, 2013).

- **Governance, adaptive governance, risk governance and multilevel governance** are newly embraced concepts linking to resilience.
- Governance can be private, public or community-based.
- Capacity and capability are emphasized as a part of governance to achieve disaster resilience.
- CapHAz-Net uses **Social capacity** term i.e. all the resources available at various levels (e.g. individuals, organisations, communities) that can be used to anticipate, respond to, cope with, recover from and adapt to external stressors (e.g. a hazardous event). These resources include skills, knowledge, social networks as well as institutions, structures, and knowledge of how to elicit and use them.

There is a main concept linking to CC that is important in this section, i.e. about capacity building. HFA, frequently referred framework as a basis for building resilience, mentions capacity building elsewhere in the document. Capacity building is one of two pillars in CapHaz-Net to build resilience, although, in this project, social resilience is the focus. There are three reasons argued by the project as to why social capacity building for natural hazards in Europe is significant:

1) An observed increase in the occurrence of natural disasters as well as rising monetary damages questioning established protection and management strategies.
2) A changing distribution of responsibility between different state and non-state actors, that is, between the public, private and voluntary sectors.
3) A possible lack of capacities on the side of formal organisations involved in disaster and risk management (Kuhlicke et al., 2010)

A definition proposed by UNISDR (2009) of capacity is that it *covers the combination of all the strengths, attributes, and resources available within a community, society or organisation that can be used to achieve agreed goals. [...] Capacity may include* ***infrastructure*** *and* ***physical means***, ***institutions***, ***societal coping abilities***, *as well as* ***human knowledge***, *skills and collective attributes such as social relationships, leadership, and management. Capacity may also be described as* ***capability***. *Capacity assessment is a term for the process by which the capacity of a group is reviewed against desired goals, and the capacity gaps are identified for further action.*"

CapHazNet suggests a definition of capacity as "*a context-related ability of an individual, a social group, an organisation or institutional actors to decide and to behave successfully in a certain situation or to overcome the negative impacts of some event as well as to employ the necessary resources"*. This definition has been expanded as a working definition for "social capacity", i.e. "…all the resources available at various levels (e.g. individuals, organisations, communities) that can be used to anticipate, respond to, cope with, recover from and adapt to external stressors (e.g. a hazardous event). These resources include skills, knowledge, social networks as well as institutions, structures, and knowledge of how to elicit and use them". The project clearly wants to separate this concept with resilience although to a certain degree these two concepts are related.

Figure 29 Building social capacity

CapHaz-Net considers three elements involved in capacity building: **a status quo** (lack of capacity), **means and process** (how to improve the situations) and **expected outcome** (more capacities). CapHaz-Net argues that risk perception and social vulnerability were crucial to understand the status quo while risk communication and risk education are regarded as the means to achieve more social resilience as an outcome. The process can be seen in figure 29. Social capacity building is *a multi-level effort* and *an iterative mutual learning process*. The former incorporate efforts from individual, organisational, community and institutional levels. The latter is a concept of social capacity building as an iterative and mutual process that recognizes and takes into account mismatch expectations and actual results.

Another document produced from CATALYST [93] presents capacity development for hazard risk reduction and adaptation. The document appears as a best practice notebook for Disaster Risk

[93] http://catalyst-fp7.eu/

Reduction (DRR) and Climate Change Adaptation (CCA). The report refers to HFA, highlighting the considerable progress worldwide toward more proactive and holistic approach to DRR, but this progress is uneven among the five priorities increased capacity and strengthening preparedness and response. The progress is still limited in the area of integrating DRR with sustainable development and the framework for a local event with a special focus on the most vulnerable sectors of society.

For capacity building, CATALYST refers to HFA on the importance of education in promoting and enabling DRR. This document discusses CCA, DRR and capacity building at the higher level than practical level so that the validity quite flexible both in European and non-European context. For instance to support DRR/CCA problem, CATALYST suggests institutional and cultural analysis of DRR/CCA, hazard mapping, capacity analysis (adaptive capacity of locals) and some other methods. One important thing in this project is to provide knowledge and reduce the knowledge and institutional gap that affect human capacity to undertake effective DRR and CCA. Note that, in fact, most of the cases raised in this best practice document are outside Europe but several findings and framework have relevance for European context.

One of the themes covered by CapHazNet is the issue of Risk Governance and Multi-Level Governance. Governance of Risk is perceived as a way to handle natural hazard in the society (G. Walker et al., 2010). Adapting from Commission of Global Governance (CGG, 1995), CapHazNet incorporates the definition of Governance as…"the sum of the many ways individuals and institutions, public and private, manage their common affairs. It is a continuing process through which conflicting or diverse interests may be accommodated and co-operative action may be taken. It includes formal institutions and regimes empowered to enforce compliance, as well as informal arrangements that people and institutions either have agreed to or perceive to be in their interest". The main characteristics of governance are:

- Multiple actors, networks and partnerships (no longer single sovereign authority)
- New forms of authority and control (based on diplomacy and management)
- Multilevel governance and issues of scale (how much it is possible to talk on a widespread cross-national shift and trend?)

GOVERNANCE

- **Governance** is a continuing process through which conflicting or diverse interests may be accommodated and co-operative action may be taken. It includes **formal institutions and regimes empowered** to enforce compliance, as well as **informal arrangements** that people and institutions either have **agreed** to or perceive to be in their interest (CGC).
- **Risk governance** looks at the complex web of actors, rules, conventions, processes and mechanisms concerned with how relevant risk information is collected, analysed and communicated, and how management decisions are taken.
- Three **levels of governance** should be considered: local, national and global level
- **Multilevel governance** refers to a creating process in which both authority and policy making influences are shared across multiple levels of government.

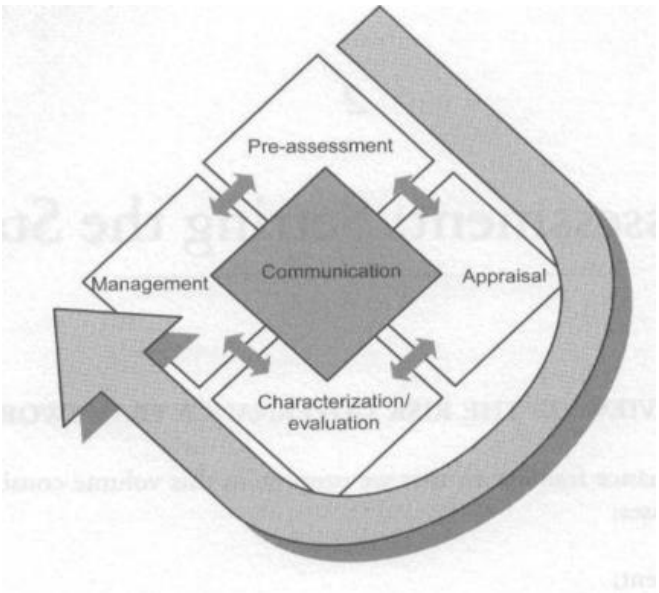

Figure 30 Five elements of Risk Governance (Renn, 2008)

Based on Renn's work (2008), CapHazNet adopts **risk governance** as a wide-ranging and multidisciplinary activity that…" *requires consideration of the legal, institutional, social and economic contexts in which a risk is evaluated, and involvement of the actors and stakeholders who represent them. Risk governance looks at the complex web of actors, rules, conventions, processes and mechanisms concerned with how relevant risk information is collected, analysed and communicated, and how management decisions are taken*." Risk governance is depicted as four consecutive phases of pre-assessment, appraisal, characterization/ evaluation and management, and an additional core linking all four other elements, i.e. communication. In brief, risk governance is described as **open, cyclical, iterative** and **interlinked**.

When bringing the issue of resilience cities in European context, apparently the principles of risk governance are highly relevant where different social and political contexts should be taken into account:

Table 34 Placing risk governance in wider social and political context

Context	Elements
Core risk governance process	• Pre-risk assessment • Risk appraisal • Evaluation (tolerability/ acceptability judgement) • Risk management • Communication
Organisational capacity	• Assets • Skills • Capabilities
Actor-network	• Politicians, Regulators • Industry/business • NGOs • Media • Public at large
Social climate	• Trust in regulatory institutions • Perceived authority of science • Degree of civil society involvement
Political and regulatory culture	• Different regulatory styles

Concerning the natural hazards issue, the relationship between levels of governance has also become increasingly important, as shown through several international cooperations in the area of disasters such as Global Disaster Information Network. The HFA (2005) points out the importance of 'good governance' and 'international and regional cooperation' to support actions at local levels. CapHazNet summarizes the implication of shifts to governance for the governance for natural hazard as seen in Table 35. Apparently, for the case of city resilience to CC and European dimension, this model is extremely relevant, and captures elements that are related:

Table 35 Shift to governance for the governance of natural hazards

New forms of governance	Governance of Natural Hazards
Core risk governance process	Government agencies, private sector utilities, businesses, community groups, householders
Organisational capacity	International agreements, cooperation between nations, Regional, and local networks
Actor-network	Communication and persuasion; use of market mechanisms; regulation of private companies
Social climate	Sharing of responsibilities with private sector, NGOs, and individuals

However, adopting multilevel governance on a common issue should be followed by an understanding of the positive and negative implication of this concept such as unclear responsibility or accountability and many other consequences that may follow.

PARTNERSHIP

- **Public-private partnership (PPP) and Public-public Partnership** are keys for implementing multilevel governance.
- **Partnership** is voluntary but enforceable commitments between public authorities, private enterprises, and civil society organisations. They can be temporary or long-lasting. They will be founded on the principle of sharing the same goal in order to reduce risk and gain mutual benefit.
- **Good partnership** comprises integration of activities, shared vision, consensus, negotiation, participation, collective action, representation, inclusion, accountability, volunteerism and trust.

Governance, Multilevel governance, Public-private partnership (PPP) and Public-public Partnership are extensively discussed in the ENHANCE[94] as a way to deal with risk. Governance is central as well to the project. According to ENHANCE project, governance is *the control of the process of collective action where actors and organisations are linked to one another and coordinated in their action in such way that commonly aims, and objectives can be pursued* (Costa et al., 2013). Three levels of governance should be considered: local, national and global level. In short, governance can be interpreted as "intergovernmental relationships."

In this context, the need for multi-actor processes, **multilevel governance** and **partnerships** are necessary structures for governance. Costa et al. (2013) point out that at a European level, **multilevel governance** refers to a creating process in which both authority and policy making influences are shared across multiple levels of government. In ENHANCE, the partnership is defined as "*voluntary but enforceable commitments between public authorities, private enterprises, and civil society organisations. They can be temporary or long-lasting. They will be founded on the principle of sharing the same goal in order to reduce risk and gain mutual benefit*…"

Partnership is necessary when the government cannot react alone on specific changes. Shifting from government to governance allows society to act effectively, and partnership can bring together ideas and resources for better results. Risk perception is the fundamental basis for solid risk management framework and multi-sector partnerships. It is influenced by risk culture (Carmona et al., 2014). Then, the issue of understanding the culture of risk management and stakeholder involvement is important here to shape capability for partnership in the society. On the other hand, effective partnership as suggested in ENHANCE should include the following characteristics: *integration of activities, shared vision, consensus, negotiation, participation, collective action, representation, inclusion, accountability, volunteerism* and *trust* (McLean & Guha-Sapir, 2013). In short, the partnership should be well-designed,

[94] http://www.enhanceproject.eu/

targeted at market failures that are uninsurable losses and affordable, a socially-fair risk transfer mechanism (Carmona et al., 2014).

There are insights from ENHANCE concerning risk governance, stressing the role of participations, trust between all actors and communication is the key to the successful practice of risk governance. Note that the risk management approaches are very central in ENHANCE project as a way to achieve resilience and a way to adapt social systems (organisations and institutions) who are engaged in hazard risk management to the changes in the environment.

Multilevel Governance can be pursued through the public-private partnership (PPP) which is characterized by a shared input of resources e.g. financial, staff, expertise. The project outlines the capitals required for a sustainable partnership, i.e. social capital, human capital, political capital, financial capital and environmental capital. The good governance indicators derived from this project for this sustainable partnership are described in Section 4.4.5.

Figure 31 Risk Governance Model toward Community Resilience in emBRACE project

We also compare the framework for Risk Governance proposed in the emBRACE project as shown in Figure 31. An earlier model of risk governance puts the natural hazard as central, while in emBRACE, community resilience is central to the risk governance model. The framework illustrates the dynamic interactions of community resilience where resources and capacities, action and learning are central to the framework. It shows the external factors that may affect community resilience, i.e. content, disturbance and change over time. Disaster Risk Governance focuses on external context encompassing laws, policies, and responsibilities, which enable and support civil protection practices. The development of community resilience is affected by this risk governance factor: in preparedness, response, recovery and mitigation.

ADAPTIVE GOVERNANCE

- **Adaptive Governance: flexible** and **learning-based collaborations** and **decision-making** processes involving both state and non-state actors, often at multiple levels, with the aim to adaptively negotiate and coordinate management of social–ecological systems and ecosystem services
- Summary of **aspects of governance** to build urban resilience**:**
    - Identification of Driver for Changes
    - Information and Feedbacks
    - Collaborative interdisciplinary governance
    - Social Capital
    - Whole system approach

The TURAS project (Crowe & Foley, 2013) examined aspects of governance to build socio-ecological resilience in urban area originating from literature. The points can be summarized as follow:

- the self-organised network system
- diverse policy actors brought together to focus on shared problems
- working in collaborative networks
- visionary and transformational leadership
- social capital (as the glue for adaptive capacity and collaboration)
- bridging organisations; building trust, identify common interests, resolve conflict
- a continuous process of learning, adapting and adjusting
- policies hypotheses and experiments to test them
- governance of natural resources through 'safe fail' experiments
- feedback of technical information
- redundancy, adaptability, and less hierarchical approaches
- a whole systems approach
- the precautionary principle
- collaboration in a polycentric governance system
- public participation
- an experimental approach to resource management
- management at a bioregional scale
- respect for local knowledge
- local communities that are not reliant on government to solve every problem can evolve their own response strategies, have access to relevant information and system

These governance principles has been used by TURAS in combination with the term adaptive co-management and urban governance. TURAS suggests the Adaptive Governance refers to *"…flexible and learning-based collaborations and decision-making processes involving both state and non-state*

actors, often at multiple levels, with the aim to adaptively negotiate and coordinate management of social–ecological systems and ecosystem services …"

McLean and Guha-Sapir (2013) add another concept on the governance issue that is important in the context of threat, i.e. sensemaking. In essence, good sense making is the ability to a build a pre-action capacity to enhance processes the selection of choices that produce good decision-making with increased awareness of risk. It is the capacity of social agents to adjust to risks and disaster events through mechanisms of learning, interpretation and action.

The DRIVER project proposes multiple resilient dimensions as project focus: individual resilience, community resilience, and the local government resilience (Scott Davis & Karikas, 2015; Scott Davis et al., 2015; Hofer, Dinesen, & Vinther-Larsen, 2014; MacDonagh et al., 2015; Rigaud et al., 2015). One of the DRIVER reports presents the methodology of resilience for the local government toward disasters and develops the assessment tool (Rigaud et al., 2015). The work suggests combining both top down and bottom up approaches to improve the disaster resilience of a city. The goal is to build a framework for city resilience framework and to develop resilience guidelines. Resilience is explained from two closely related perspectives: local government and city resilience. DRIVER also discusses the two concepts: local government and governance. The local government is an internal organisation; it could be about legislation, financial and political process. In short, the local government is about activities of the local authority. On the contrary, governance has external dimensions since it can cover partnership, interaction, dialogue, conflict among citizens and organisations.

Rigaud et al. (2015) introduce sets of definition such as Disaster Resilience, Disaster Resilience Management, Disaster resilience management framework, Disaster resilience management policy, plan, and process. In the table 36 below, we cited the resilience used by DRIVER in the context of local government resilience.

Table 36 Key concepts of resilience relevant for local government

Key concept	Definition
Disaster resilience	The capability to prepare for, prevent, protect against, respond to or mitigate any anticipated or unexpected significant threat or event, to adapt to changing conditions and rapidly bounce back to a normal or a "new normal" state, and reconstitute critical assets, operations, and services with minimum damage and disruption to public health and safety, the economy, environment, and national security
Disaster resilience management	Coordinated activities to direct and control an organisation with regard to disaster resilience
Disaster resilience management framework	Set of components that provide the foundations and organisational arrangements for designing, implementing, monitoring, reviewing and continually improving Disaster Resilience management throughout the local government organisation

Rigaud et al. (2015) using guidelines from UNISDR (2010) as a basis to formulate the role of local governments in disaster risk reduction, as seen in the box below.

THE ROLE OF LOCAL GOVERNMENTS IN DRR (DRIVER PROJECT)

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

The suggested model for local government resilience is proposed as we seen in the Figure 32. The main components are mandate and commitment, design and framework, implementation, monitoring and review, and continual improvement framework. The components of resilient framework for managing disaster are adapted from ISO 31000. Rigaud et al. (2015) in this DRIVER report, elaborate in details all the components in the framework in Figure 32.

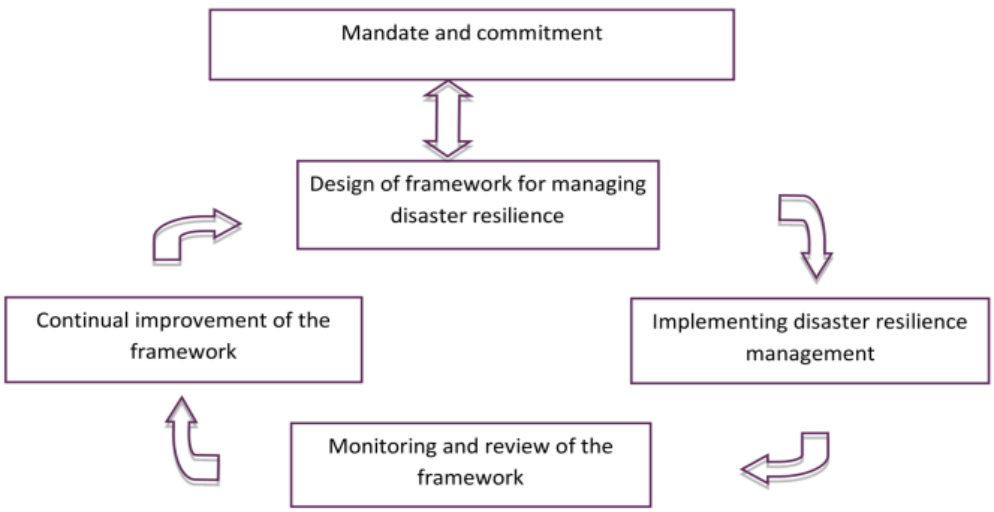

Figure 32 DRIVER's model of Relationship between the components of the framework for managing disaster resilience

In principle, all components of the disaster resilience management should be embedded in all local government organisations, practice and process as efficient as possible, and all four elements of the resilience management framework work as a continuous process. In the city context, this DRIVER report treated the city as an external and internal environment of the local government organisations that

should be involved in the disaster management process. In addition, this DRIVER report adds the risk and vulnerability assessment as an additional aspect of the resilience of the cities to understand the threats they face. In short, this report provides comprehensive and exhaustive lists of advice and actions to do, to strengthen local government resilience, ranging from warning system, preparedness, emergency response services, training and drills, monitoring, to plan and hazard recovery. This document put a strong emphasize on increased local government capability as a key for resilience building. The resilient organisation of the local government will eventually form resilient cities. Note that this DRIVER report document is intended to enhance understanding of local government resilience from theoretical perspective, which will be validated through a questionnaire, which is included in the report. The questionnaire explores the needs of the local government in disaster resilience context, during all phases of the disaster. Implicitly the document has included the adaptive capacity notions while the climate change adaptation is only a small part of bigger picture a local organisation needs to improve.

4.2.7 CC, CI INTERDEPENDENCIES AND IMPACTS

- In CC context, the interdependencies of networks and systems should also be connected to the adaptation planning.
- In urban setting, CIs are energy, water, transport, green infrastructure, ICT.
- Two recent H2020 projects i.e. EU-CIRCLE and RESIN tried to link climate change, climate adaptation with a comprehensive view of interconnected infrastructure in the cities and how to make resilient infrastructures in the cities.

Unlike the CI interdependencies discussion as we had in Chapter 3, in climate change context, the interdependencies of networks and systems (energy, water, transport, green infrastructure, information and communications technology) should also be connected to the adaptation planning so as to build resilience within European society (EEA, 2012). Two recent projects under H2020, i.e. EU-CIRCLE and RESIN tried to link climate change, climate adaptation with a comprehensive view of interconnected infrastructure in the cities and how to make resilient infrastructures in the cities. We also look at the ToPDAd[95] project that examines seven case studies from the tourism, transport and energy sector in particular, and PREPARE project that scrutinizes the CI water sector.

EU-CIRCLE [96] is a project under H2020 aiming at developing a Pan-European Framework for strengthening CI resilience to CC. This project was relatively newly launched, but one of the CI related projects clearly incorporating Adaptation Strategy to CC as outlined in EU Policy, and not only targets CI resilience. EU-CIRCLE targets improving resilience of infrastructure networks to natural hazard,

[95] Link to the project: http://www.topdad.eu/
[96] http://www.eu-circle.eu/

preparing for the future climate change, and avoiding cascading failures of interconnected CI systems. An innovative framework for supporting CI resilience to climate pressure, a validated Climate Infrastructure Resilience Platform (CIPR) for assessing potential impacts due to climate hazards, monitoring platform through resilience indicators and supporting cost-efficient adaptation measures will be part of EU-CIRCLE's goals to pursue. The "spatial" perspective is implicitly considered but is not completely treated as a unit analysis. The project's kick-off meeting emphasizes the spatial dimension:

- Supports the establishment of climate resilient infrastructure by ensuring that an asset is located, designed, built and operated with both the current and future climate in mind and incorporates resilience to the impacts of climate change over the lifetime of that asset
- Provide a coherent baseline for moving from sector-based climate resilience infrastructure frameworks, into *holistic resilience plans for entire regions*, introducing the interdependencies of heterogeneous infrastructures in the implementation process.

Likewise, dependency, interdependency, and cascading failures are not the main focus of analysis in this project. The resilience framework itself that is crucial in the EU-CIRCLE project. However, there are still limited results can be learnt from this project because it is newly deployed.

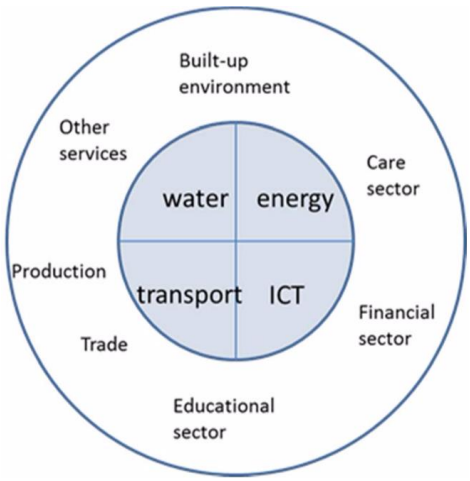

Figure 33 City and infrastructures in RESIN

The RESIN [97] project addresses challenges of poor integration of different domains, and between CIs and other city systems and urban adaptation strategies. The absence of a standardized approach concerning the methods for undertaking key tasks such as assessing climate risks and vulnerability, and prioritizing between adaptation responses, limits urban adaptation planning. RESIN will link the existing approaches for climate change adaptation of cities to disaster risk management of critical infrastructures to build an overall approach for all sectors and elements of the urban system. These will be a comprehensive framework for dealing with all components of the urban system: critical infrastructures, built-up spaces and public spaces, and will cover impact-and-vulnerability assessment and selection of adaptation options. Similarly to EU-CIRCLE, RESIN is a newly implemented project under H2020, and we have not yet found reports and deliverables of this project. From available information on RESIN, we learn that the project empasizes

[97] European CIIP Newsletter, October 15-February 16, Vol 9. No. 3, Special Issue CRITIS 2015. http://media.improverproject.eu/2015/10/ECN-22-v1.02b.pdf

comprehensive adaptation strategy in the area of critical infrastructure and resilience at the city as a unit of analysis. RESIN is the only project we found so far that combines the notion of resilient city and critical infrastructure.

- Climate resilient infrastructure can be achieved by ensuring that **an asset is located, designed, built and operated** with both the current and future **climate in mind** and incorporates resilience to the impacts of climate change over the lifetime of that asset.
- **EU-CIRCLE is working on** holistic resilience plans for entire regions, introducing the interdependencies of heterogeneous infrastructures in the implementation process.
- **RESIN is working on** improvement of poor integration of different domains, and between CIs and other city systems and urban adaptation strategies, introducing a standardized approach concerning the methods for undertaking key tasks such as assessing climate risks and vulnerability, and prioritizing between adaptation responses and limits urban adaptation planning.

The CORFU[98] project examines urban resilience in terms of its capacity to deal with flood. A methodology for flood resilience index has been developed in this project (J. Batica, Gourbesville, & Hu, 2013; Jelena Batica, Gourbesville, & Tessier, 2013). The vulnerability is seen as a result of the pressures of urban development, and the risk in fact refers to the risk culture that needs to be altered and resilience, that needs to be developed to accept a certain level of flooding. The ability to accept and be able to reorganise introduces a new concept, resilience. Level of acceptance of flooding with certain damage is expressed through carrying capacity. The project introduces three concepts to assess the flood risk in urban system: **carrying capacity, vulnerability and resilience**. Carrying capacity is the maximum tolerable damage that a community or a city could bear. The concepts of vulnerability and resilience serve to measure and to assess the carrying capacity of a community or a city. J. Batica et al. (2013) prefer the use of specified resilience "of what to what" rather than the general resilience definitions that often proposed elsewhere in the literature. In the context of urban flooding, resilience is defined as "*The capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure. This is determined by the degree to which the social system is capable of organising itself to increase this capacity for learning from past disasters for better future protection and to improve risk reduction measures*".

The idea is that the resilient urban systems and urban communities will improve by incorporating in the flood risk management cycle that consists of relief, resist, response, recovery and reflect. This so-called "5R" in essence is a flood resilience framework.

[98] http://www.corfu-fp7.eu/

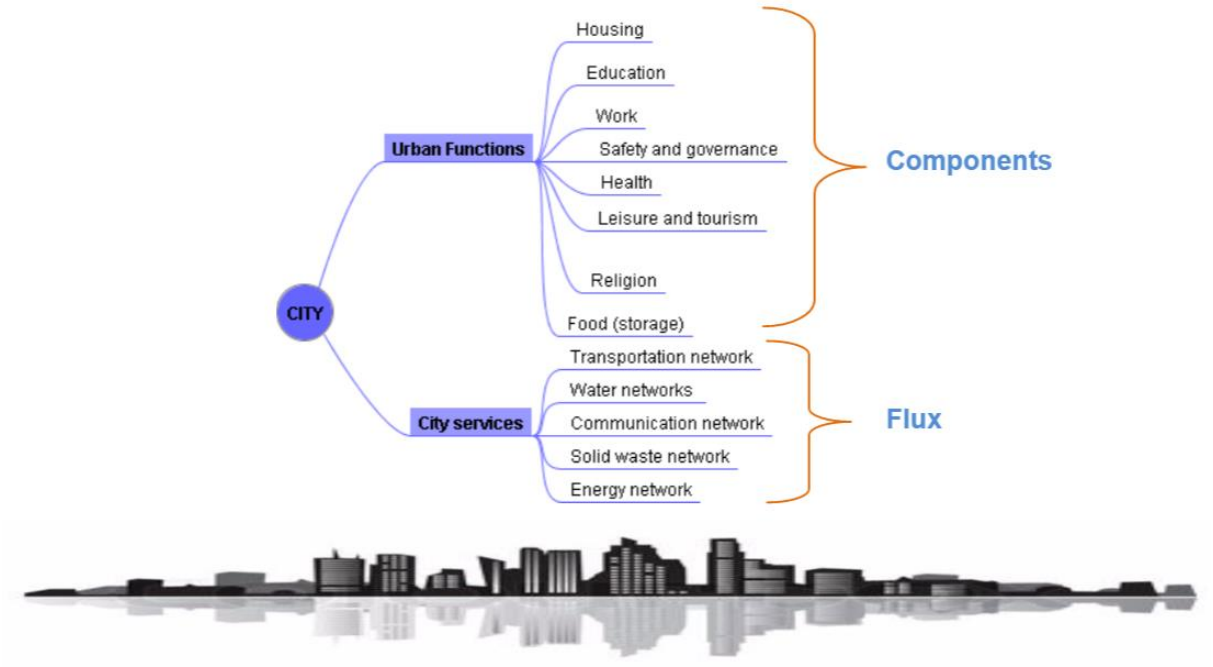

Figure 34 Urban functions and services in a city

Many urban systems are vital elements for urban resilience with respect to the flood during the event. Urban functions of a city are defined as components that the urban system must provide as fundamental needs to residents. Eight main urban functions that are required by the residents are: housing, education, food supply in terms of area for food storing and providing), working area, covering areas industry and areas for non-industrial activities, safety (police, fire brigade and rescue services at local level) and governance, health, leisure and tourism and areas for religious activities. “Services” will link all these physical components, gives functionality and interconnectivity to urban functions (e.g. the function of a house is to provide space for living). J. Batica et al. (2013) emphasizing the importance of understanding the ‘strategic’ urban functions that are vital for society. The authors listed power stations, water treatment plants, the control center of public transport, waste water treatment plants, firefighting stations and hospitals as the services that have a strategic value. In other words, the services in “urban” term are actually CI elements. And these strategic urban function experience fail it will trigger major damages for society and the economy. However, important solutions to these cascading damages mention by the authors are the “protection technologies”.

ToPDAd[99] project examines the climate change or extreme weather impacts on tourism, the effects of extreme events on traffic in cities; new potential arising for shipping as a result of Arctic ice melting; effects of climate change on energy production (renewable energy and nuclear energy); and macro-economic impact of extreme rainfall in cities. For example, flooding and heavy rain will reduce or disable completely the function of transformers, circuit breakers. Extreme prolonged temperature may affect the resources, communications, lines, cables, and so on. However, the main point in the project is not the risk itself, but the impacts and the interdependency or cascading effects caused by extreme weather events. We summarize two cases in the projects that encompassing CIs, i.e. about securing energy future and adaptation and resilience of the transport sector, which are also relevant in the context of city.

In the case of energy sector, ToPDAd poses some questions such as: What are the vulnerabilities of the energy system in a changing climate? How will these changes vary by different energy and climate regions across Europe? What will an increase in the frequency and/or severity of natural hazard events have on the energy system? Are there any pinch-points in Europe's energy system where effective adaptation strategies can effectively be implemented to reduce risks and vulnerabilities? (Aaheim et al., 2013). ToPDAd provides an illustration of the complexity due to the climate change that affects the power sector. Increasing temperature in summer leads to higher demand on power for activating air conditioning and simultaneously decreases the ability of network lines to carry power (which is a function of ambient air temperature due to the need for shedding of heat by wires). Changes in weather patterns are uncertain, while the implications for all renewable energy sources are yet unknown, which are weather dependent for continuity and level of supply. In gas sector, increased coastal and river erosion, with the potential for gas leaking will result in reduction in local supply security. In short, on the climate hazard vulnerable sectors likely to have most impact on the energy sector as described in ToPDAd (Aaheim et al., 2013), the main problems can be summarized as:

- **Transmission infrastructure** both above and below ground is very vulnerable to many types of extreme weather events which can disrupt supply affecting several connected regions.
- **Lack of water** for cooling fossil fuel and nuclear power stations reduces their capacity, especially during the increased demand such as heatwaves and extra power is required for cooling.
- Renewable energy sources vary in their availability and capacity to generate power under different weather conditions so a variety of sources is required to energy demand under different weather conditions.

[99] See: http://www.topdad.eu/

In the case of transport as a part of CI sector, ToPDAd provides some illustrations of disruptions due to extreme weather in different transport sectors especially road, rail, aviation. Cities in Northern Europe experience heavy snowfall that sometimes can increase the cost of maintenance although warmer winter can reduce this type of cost. In the rail sector, wetter climate increases precipitation, can lead to more flooding of railway tracks. In addition, strong wind can cut trees and blow leaves and sticks on rails. The trees can fall on electricity cables especially in wooden areas. The clearing will cause delays in the train service. Several studies cited in ToPDAd (Aaheim et al., 2013) suggest resilient measures in transport sector. However, the report points out the most important challenge for building resilience in transport sector, i.e. the cost factor. The reason is that most resilient measures to be taken are costly.

To a certain degree, looking at climate change impact on CIs is also covered in the INTACT project. The project illustrates different consequences that may happen for different kinds of CIs (Bucchignani & Gutierrez, 2015) as follows:

- The consequences for **transport infrastructure** such as rail, roads, shipping and aviation will differ from region to region. Increase in the frequency and intensity of extreme weather event such as heavy rain, snowfall, extreme heat and cold, drought and reduced visibility can cause damages and economic losses, transport disruptions and delays (European Commission, 2013).
- **Climate changes** will have effects on **energy transmission, distribution, generation and demand**. In fact, the generation of electrical energy is affected by efficiency reduction due to climate change (e.g. decreasing availability of cooling water for electricity generators). However, in some parts of Europe, increased precipitation or more wind may also lead to better opportunities for hydropower or wind energy generation. Furthermore, extreme weather periods, such as heat waves or cold spells, will cause higher energy demand peaks, causing overstress of energy infrastructure (European Commission, 2013).
- **Buildings and infrastructures** can be **vulnerable** because of their **design** (e.g. low resistance to storms) or **location** (e.g. in flood-prone areas, landslides, avalanches). Many European cities have been built along a river, and these rivers will respond to extreme rainfall or snowmelt events with extreme discharges, threatening the cities with floods (European Commission, 2013).

The last project we reviewed that discussed CI in relation to CC is PREPARED (Ashley & Tait, 2012; J. Raat, Menaia, & Sivertsen, 2014; Staub & Moreau-Le Golvan, 2012). As mentioned in Chapter 3, water is one of CI services that will affect the city life. PREPARED produces a catalogue of European adaptive initiatives in water sectors, (Staub & Moreau-Le Golvan, 2012), and partly summarized in the Section 4.3. This project reveals for major categories of initiatives in the water adaptation measures, i.e. in terms of (1) risk assessment and management, (2) supply-side measures, (3) demand-side measures and (4) global planning tools. To complete the adaptation measures, the project has offered database of adaptation initiatives, i.e. PREPARED Adaptation Initiatives Matrix and Prepared-AIM Tool. Supplied with pilot projects on testing different measures and technologies and techniques in different cities across Europe, the PREPARED project is the one that have shown how the adaptation measures and

the PREPARED project results is put into practice is also demonstrated in the city partners to ensure resilient water supply.

4.2.8 RESILIENCE DIMENSIONS IN CC LITERATURE

Similarly to the resilient dimensions identified in Chapter 3, CC literature can be analysed from the resilience dimension perspective (See section 3.2.10). The overview of resilience dimensions captured from our literature review activities can be seen in Figure 37. Community or societal resilience and urban or city resilience are the two most frequently discussed dimensions in the literature. In one of the projects we examined in our CC literature, a holistic resilience is proposed but the concrete operationalisation of this concept is not yet fully elaborated. And the resilience application is mostly to flood resilience. The efforts for looking the detailed dimension of resilience as also conducted in this section which will be synthesized further and used for proposing European resilient cities.

Figure 35 Resilience Dimensions captured in the EU Projects

1 Community, Societal or Society Resilience

Table 37 Summary of Community, societal or Society Resilience with respect to climate change

Project	Definition or Context of Community Resilience	Important Concepts
CapHaz-Net	…the capacity of a community or society potentially exposed to hazards to adapt, by **resisting** or **changing** in order to reach and **maintain** an acceptable level of functioning and structure (Tapsell et al., 2010).	Capacity Resist Changing Maintaining
	…capacities of individuals, communities and societies to deal with disasters, crises and stress.	Capacity to deal with disasters
	Social resilience is social capacity building efforts target to lessen two sides of **social vulnerability**: 1) **the external side** (i.e. exposure) through influencing more over-arching risk governance, emergency response or even social inequality. 2) **the internal side**, to combat social vulnerability from within: e.g. focused on educating, **improving** the level of	Capacity to combat social vulnerability Improving perceived risk and sense of responsibility

	perceived risk, building motivation and **a sense of responsibility** within individuals and communities to manage and mitigate their own risk (e.g. flood hazard). These efforts aim at **improving** the whole range of **social capacities** (knowledge, motivational, network, economic, institutional and procedural capacities).	Improving social capacities
CREW	… the ability of a community to **prevent, withstand, recover** from and **learn** from the impacts of EW hazards. … the ability of a community: to continuously **exist** and **function** during an EWE; to **bounce-back** from the impacts of EW hazards; to build a capacity for **learning** and **adaptation** for similar kind of extreme weather in the future (Hallett, 2013).	Prevent, Withstand, Recover Learn Exist Function Bounce-back Adapt
CATALYST	… highlights the importance of the **bottom-up** disaster **preparedness**, enhanced resilience at the community level which is considered as the front line of disaster risk management. … highlights the importance of **education** and **training** in DRR and how to institutionalize it.	Bottom-up preparedness DRR Education DRR Training
emBRACE	community resilience (from the perspective of disaster risk management) is influenced by the **processes and outcomes** of disaster risk management activities (preparedness, prevention, response, recovery and reconstruction).	Process and outcome of DRR
ENHANCE	… resilience of a community in respect to potential hazard event is determined by the degree to which the community has the necessary resources and is **capable of organising itself** both prior to and during times of need (UNISDR, 2009).	Capable of organising itself
MOVE	The socio-economic **fragility** and the **lack of resilience** are described by a set of indicators that aggravate the physical risk...	Fragility Lack of Resilience
PREPARED	… the ability of society to **adapt**, e.g. take-up innovations; **change** behaviours etc., which depend as much on social mores, cultures, norms, practices and attitudes as on wealth	Adapt Change
SMARTeST	… flexible and adaptable in circumstances such as flash flooding and surface water flooding…	Flexible Adaptable

From the definitions discussed in the different projects above, we propose a tentative definition of Community, Societal or Society resilience as follows:

Tentative Definition of Community, Societal or Society resilience

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

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

2 Urban Resilience Dimension

In the projects reports or literature we surveyed, the urban resilience dimension apparently is not the main focus or treated as a main unit analysis. Other dimensions are important to strengthen the urban or city resilience. In other words, city only a context or end result, and not the main backbone.

Table 38 Summary of Urban Resilience Dimension

Project	Definition or Context of Urban Resilience	Important Concepts
Climate-ADAPT	…In terms of adaptation, Europe's resilience to climate change depends largely on **local action**… An associated umbrella concept that could **promote adaptation** to climate change and keep it high on the political agenda was identified as community resilience	Local Action Promote adaptation
TURAS	Urban resilience prioritises the **identification** of the unpredictable, non-deterministic processes and **disturbances** that a **landscape or city** may be vulnerable to, **learning** about the past and possible future scenarios in terms of direct and indirect **consequences**, frequency and scale (Ahern, 2011) ….**continuous** process of **learning, adapting and adjusting** as 'active adaptive management'…(C. Folke, Hahn, Olsson, & Norberg, 2005) In spatial meaning… how different **area**s have varied **responses to a disturbance**	Identification disturbances Learning Consequences
RESIN	… increased urbanisation and the increasing consequences of global climate change place an **imperative on cities** to be proactive in **strengthening their resilience** to disasters in order to **secure** their economic competitiveness and to enhance the quality of life for their residents…. the importance of resilience…. and to **withstand** with hazard.	Strengthening resilience Withstand with hazard
CORFU	… overall **flood resilience** for different scales of urban systems.	Flood resilience
STAR-FLOOD	The context is a flood resilience ...the **capacity** of the European regions to **cope with** the flood risks: water management, disaster management, spatial planning.	Capacity Cope with the risk

From the definitions discussed in the different projects above, we propose a tentative definition of urban resilience as follows:

Tentative Definition of Urban resilience

Urban resilience covers the identification of the unpredictable, non-deterministic processes and disturbances that a landscape or city may be vulnerable to, understanding of how different areas have varied responses to a disturbance, and learning about the past and

possible future scenarios in terms of direct and indirect consequences, frequency and scale. It covers the capacity of European cities to cope with CC impacts such as the flood risks by improving water management, disaster management, and spatial planning.

3 Socio-ecological resilience

Table 39 Summary of Socio-ecological dimension

Project	Definition or Context of Socio-ecological Resilience	Important Concepts
EEA	… resilience describes the **stability of a system**. In an ecosystem context, this has primarily been interpreted in two ways, reflecting **different aspects of ecosystem stability**.	Stability
	…resilience describes the time it takes for an ecosystem **to recover to a quasi-equilibrium** state following disturbance ('engineering resilience' or 'elasticity').	To recover to quasi equilibrium
	…resilience denotes the **capacity** of ecosystems **to absorb disturbance** without collapsing into a qualitatively different state that is controlled by a different set of ecological processes	Capacity to absorb disturbance
TURAS	Social-ecological resilience can be understood as inherently political, **challenging the status quo** by highlighting **alternatives to the hegemony of unlimited growth** (Shaw, 2012).	Challenging status quo
	Two components …. social-ecological resilience: • **Adaptive cycles** that influence change at different scales; 'fore' loop (rapid growth, conservation) and 'back' loop (release, re-organisation) with change occurring mainly in the back loop …which can be seen as a time for new ideas and transformation	Adaptive cycles
	• **Thresholds** separating **multiple stable states** …occur in a back loop, and may precipitate a new '**quasi-stable regime'**, generally marking the start of a new **adaptive cycle**…the change is not random, but follows this recurrent pattern	Threshold multiple stable states
	resilience thinking as 'a framework for viewing a socioecological system as **one system operating over many linked scales** of time and space'. Resilience thinking is considered to offer 'a key insight for those planning our future' … and should have an **impact** on **decision making** …	One system operating over many linked scales
	An understanding of the adaptive cycle allows management of a system's resilience, identifying **optimal times for interventions**	Optimal times for intervention
	Resilience… the **ability to learn** from catastrophic events and **to adapt reactively and proactively** to changing environmental conditions	Ability to learn Ability to adapt
	...what disturbance can be **tolerated** and the system still functionally persist	Tolerate
	… the ability of a system **to adapt and adjust** to disturbance	To adapt To adjust
	Social-ecological resilience goes beyond a capacity to absorb shock, embracing a potential for 'renewal, reorganisation and development'.	Renewal Reorganisation

	Social-ecological resilience accepts the **inherent discontinuities, uncertainties and interdependencies** in the social-ecological systems within which we live…	Inherent discontinuities Uncertainties interdependencies

Note that most definitions related to the socio-ecological systems found in CC literature are tend to theoretical than practical-oriented. From the definitions discussed in the different projects above, we propose a tentative definition of socio-ecological system resilience, as follows:

Tentative Definition of Socio-Ecological System Resilience

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

4 Economic Resilience

Likewise, as in urban resilience, economic dimensions are placed in the context of wider concern, i.e. CC. Thus, it is about cost when facing the risk of hazards and economic vitality when CC targets come at the expense of economic sector.

Table 40 Context of Economic Resilience Dimension

Project	Context of Economic	Important Concepts
TRANSrisk	The cost of resilience	Cost
PREPARED	… the ability of society to **adapt**, e.g. take-up innovations; **change** behaviours etc., which depend as much upon social, cultures, norms, practices and attitudes as on wealth	Adapt Change
ToPDAd	… the energy system must **increase its resilience** to potential damage from climate change ... the policy challenge is to provide energy security, while maintaining **economic vitality** and meeting climate targets."	Economic vitality

From the definitions discussed in the different projects above, we propose a tentative definition of economic resilience, as follows:

Tentative Definition of Economic Resilience

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

5 Critical Infrastructure Resilience Dimension

Table 41 Context of Critical Infrastructure Dimension

Project	Context of Critical Infrastructure	Important Concept
CORFU	"Improve flood resilience of buildings. Resilience improved by the careful positioning of buildings in relation to the topography and the defined flood pathways, and by the sympathetic design of landscaping features."	Topography and positioning of building Landscape design
ToPDAd	… the energy system must increase its resilience to potential damage from climate change. Both gradual change and extreme weather events will influence the **reliability** of the system and the variability in the available resources (including wind, water and sun). The policy challenge is to provide **energy security**, while maintaining economic vitality and meeting climate targets."	Reliability Energy security

From the definitions discussed in the different projects above, we propose a tentative definition of critical infrastructure resilience, as follows:

Tentative Definition of Critical Infrastructure Resilience

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

6 Technology Resilience

Table 42 Context of Technology Dimension

Project	Context of Technology resilience	Important Concept
SMARTeST	This is about being resilient against flood at the household level by suggesting the importance **knowing the risk** in order to make a decision on whether or not necessary to protect property.	Knowing the risk Protection

From the definitions discussed in the different projects above, we propose a tentative definition of technology resilience, as follows:

Tentative Definition of Technology Resilience

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

7 Organisational/ Local Government Resilience

Table 43 A Local Government Resilience Dimension

Project	Context or definition	Important Concept
DRIVER	… four roles of the local government level at reducing disaster risk and contribute to the disaster resilience, i.e. to play central role in **coordinating and sustaining** multi-level, multi-stakeholders platform to promote disaster risk reduction; (2) to **engage** local communities and citizens within disaster risk reduction activities; (3) **to strengthen** institution**, capacities** and implement practical disaster risk reduction actions; and (4) to devise and **implement tools and techniques** for disaster risk reduction which can be replicated and scaled-up. ….the resilience capabilities should entail **capabilities** in the prevention, preparedness, response and recovery.	Coordinating Engaging Strengthening capacities Implementation of tools and techniques Capabilities

From the definitions discussed in the different projects above, we propose a tentative definition of local government/ organisational resilience, as follows:

Tentative Definition of Local Government Resilience

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

8 Individual Resilience

Table 44 A summary of Individual Resilience

Project Name	Context or definition	Important Concept
emBRACE	Psychological resilience … **one** of **the main constructs of societal** resilience, but it has never been targeted in the development of policy-actionable indicators (Cutter et al., 2010).	A construct of societal resilience
ENHANCE	An individual psychological resilience can also be shaped by management processes…there is a correlation between the degree of **social support** experienced during a shock phase, and the level of **psychological resilience** …after an event was observed	Shape by management process Social support

From the definitions discussed in the different projects above, we do not propose a definition of individual resilience.

9 Others

Table 45 A summary of "other" resilience concepts

Project Name	Context or Definition	Important Concept
CORFU	Flood Resilience the capacity of the European regions **to cope with the flood risks**: water management, disaster management, spatial planning	To cope with risk
FloodProBE	… greater flood resilience into critical buildings can be achieved through: …**Anticipatory** or pro-active interventions (into new buildings or existing buildings through retrofitting); this type of intervention is often referred to as planned adaptation. …**Opportunistic** interventions in conjunction with **autonomous** renewal or **upgrading** of existing buildings; this type of intervention is often referred to as mainstream adaptation. ….**Reactive** interventions during repairing activities of damaged buildings after the flooding….	Anticipatory Opportunistic Autonomous upgrading

From the definitions discussed in the different projects above is mostly about flood resilience. Therefore, we only focus on defining flood resilience in this category, as follows:

Tentative Definition of Flood Resilience

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

Finally, to sum up the review on EU approach, we also identified that the expected outputs of different projects identified in the CC literature can be categorize as seen the Figure 36. If we exclude "other" in the chart in Figure 36, the risk and vulnerability analysis and tools, recommendation, decision support system and set of indicators, and best practice documents are the five most popular outputs of the CC projects.

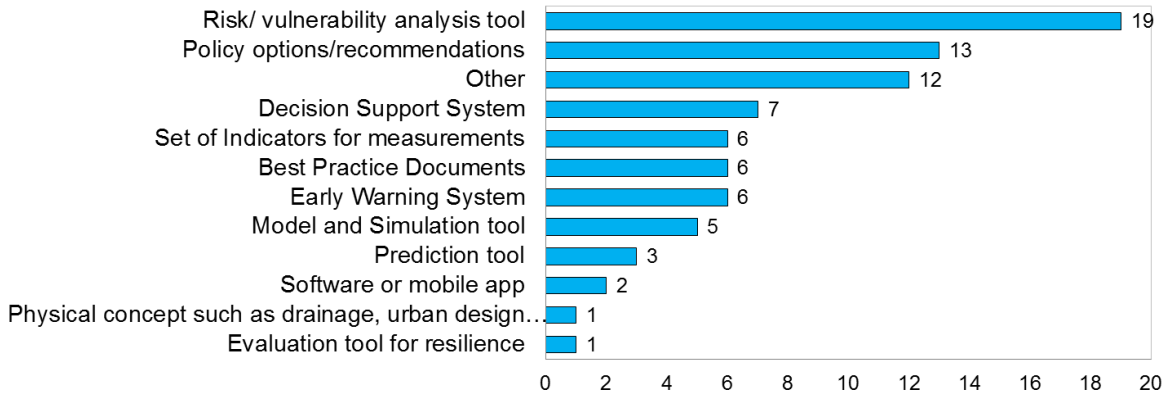

Figure 36 Expected outputs in Reviewed EU CC Projects

"Other" expected outputs of the projects are as follows:

- Geospatial ICT support infrastructure for urban resilience
- Physical concept such as drainage
- Urban design and other physical or space solutions
- Climate Risk insurance
- Prediction tool
- Interactive communication tool
- Early warning system
- Inventory adaptation measure
- Creating circle of sharing
- Standardized method for assessing climate change impacts

4.3 POLICIES AND BEST PRACTICE

In this section, we present the policies that are mentioned, suggested or subject of investigation in the literature review or CC projects, for future recommendation. Thus, it is not to mix with Section 4.1.2 where we traced the origin of EU Climate Policy and how it is developing now and looking at the plan for the future. In addition we also describe the best practices: best practice that are identified or mentioned in the literature, and best practice that is supposedly proposed or produced by the projects.

4.3.1 POLICIES

A big policy umbrella has been proposed in the area of climate adaptation, such as presented in the White Paper on adapting to CC[100]. To cope with the CC, the policy implementation should be able to address three different areas: *green measures, grey measures and soft measures*. **'Grey' infrastructure approaches** correspond to 'physical interventions or construction measures and using engineering services to make buildings and infrastructure essential for the social and economic well-being of society more capable of withstanding extreme events.' **'Green' infrastructure approaches** contribute to the increase of ecosystems resilience and can halt biodiversity loss, degradation of ecosystem and restore water cycles. At the same time, green infrastructure uses the functions and services provided by the ecosystems to achieve a more cost effective and sometimes more feasible adaptation solution than grey infrastructure. **'Soft' approaches** correspond to 'design and application of policies and procedures and employing, inter-alia, land-use controls, information dissemination and economic incentives to reduce vulnerability, encourage adaptive behaviour or avoid mal-adaptations. (UNECE, 2009). **Measures** in general can be of a **preventive** character and improve resilience yet they can also offer **preparative support** when dealing with the anticipated effects of climate change and extreme events. They can also **provide responses** to direct effects or aim to assist in the recovery of economic, societal and natural systems following an extreme event (UNECE, 2009).

[100] http://ec.europa.eu/health/ph_threats/climate/docs/com_2009_147_en.pdf

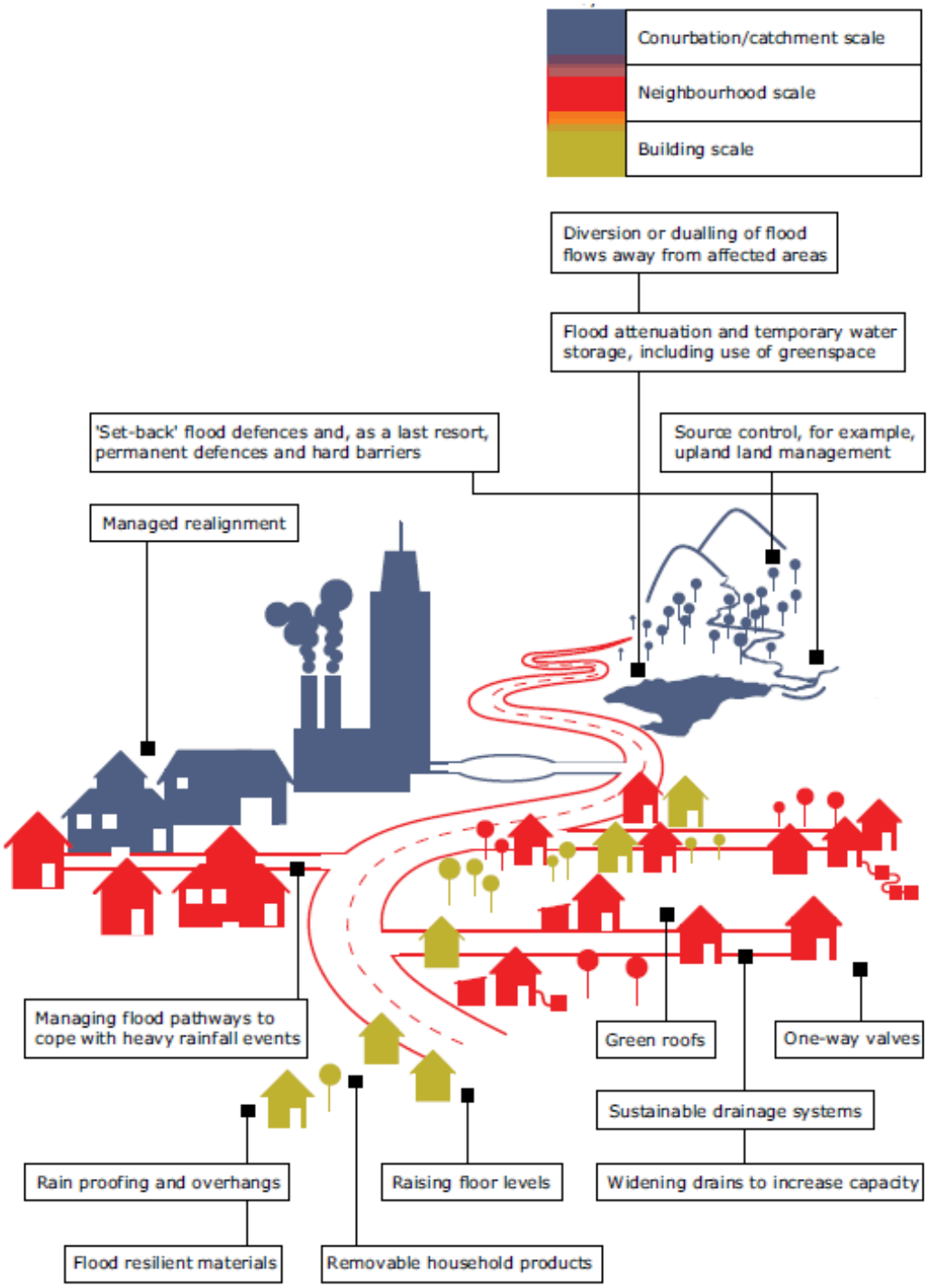

Figure 37 Green and Grey measures for adaptation to CC (UNECE 2009)

More concrete policy or suggestions from CC literature can be summarized in Table 46 below:

Table 46 Summary of Policies identified in CC literature

Project	Context	Policies
CapHaz-Net	National level and national law Community level	• European white paper on governance 2001 (transparency in decision-making processes) • An integrated communication framework in the context of flooding at the community level • Flood protection policy
EEA Report	Organisation/local government level	• Planning and implementation of local adaptation strategies • Mainstreaming of adaptation concerns into other policy areas • Spatial integration of adaptation needs through urban planning • Local emergency plans • Allocation of municipal resources and raising of other funds • Upgrading local infrastructure to make it resilient to climate change • Engaging civil society and private actors. At Regional level: Providing incentives, funding and authorization to enable local action • Addressing inter-municipal and urban-rural relations of climate change impacts and vulnerabilities • Developing and implementing with cities regional approaches • Ensuring regional coherence of local plans and measures
emBRACE	Organisation/local government level	• Policy, planning, priorities & political commitment. • Political consensus on importance of DRR (At all political levels and with local-level support for community vision)
PREPARED	Organisation/local government level	**What to adapts:** • technical equipment and other assets related to urban supply water • thinking and handling behaviour of stakeholders, communities and individuals **The adaptation strategies** may focus on: • water utilities assets and infrastructure, such as pipes (leakage control) and production sites (adaptation to changed water quality, alternative sources, altered groundwater recharge etc.), • the management of water demand and supply (quantity, quality), including the balancing of environmental and human needs; the differentiation between the destinations of water (irrigation, household use, etc.), as well as their evolution (e.g. due to longer growing season for agriculture, heat waves and concomitant urban demand); • the management of pollution risks, due to changes in water quality or due to changes in frequency and severity of rainfall events (sewer overflows); • the enhancement of the natural assimilative capacity of water bodies receiving treated wastewater discharges. **Soft measures:** • governance (laws, processes, arrangements) – mono or multi-level; • planning -- studies of possible impact of climate change; • water management; • insurance and financial capacity of systems for resourcing change; emergency and warning systems; • support to impacted population

		Hard measures • water storage (increased reservoir capacity); • alternative water sources; • water and wastewater reuse, rainwater harvesting; • water transportation; • dikes, seawalls, reinforced buildings, etc. **Supply side water adaptation measures** • Supply side: finding new sources of water (reservoirs, groundwater development, transfers...); • enhancing existing water sources (aquifer recharge and indirect potable reuse); • Improving the efficiency of resource utilization. **Demand side water adaptation measures:** • Reductions of leakages in water supply mains; • Use of water-efficient equipment and fittings; • Water reuse, rainwater or storm-water harvesting; • Promotion of water-sensitive behaviours. **Twin approach (supply and demand side)**
SMARTeST	Organisation/local government level Community level Organisation/local government level	• Procurement of Flood Resilience (FR) technologies • Inform household on how to protect their property from flood using flood resilience technologies • The role such as building adaptive capacity in communities, supporting ecosystem services, bioregional planning of resources and assimilation of wastes, and acting as bridging organisations that resolve conflict, facilitate co-operative initiatives and build trust.

4.3.2 BEST PRACTICE

Best practices identified in CC literature are can be seen in Table 47.

Table 47 Summary of Policies identified in CC literature

Project	Context	Best Practice
CapHaz-Net	Flood resilience	No single best practice for flood resilience, and thus, good elements of different practices should be combined. Some good practice identified: • Severe weather warnings, various countries • Peak discharge information system, Austria • Flood forecasting system, Czech Republic • Coordinated emergency training, Pays d'Aix, France • Public Announcement System, Sweden • Evacuation and warning simulation, Iceland • Åknes rock slope, Norway • IMGW forecast and warning system, Poland • Flood warning and evacuation Raciborz, Poland • IFKIS Hydro and GIN, Switzerland • Felsberg, Switzerland • Ensemble flood forecasting, UK
		Identify best practice and share knowledge.

Climate-ADAPT		Best practices (What has the city done well?) included: Early identification and engagement of key stakeholders within the city administration and outside (for example, other regional and national governmental departments and private sector organisations, and the establishment of a stakeholder working group). Some cities had been able to gather strong evidence bases of relevant data and future trends concerning the likely impacts of climate change, justifying the need for adaptation strategies.
		The EU has a role to play in demonstrating leadership to European cities (including those in the Outermost Regions). One aspect of this is in facilitating coordination, good practice exchange and knowledge transfer between cities in different European Member States.
CORFU	Flood resilience	Best practice of flood risk management – fully integrated.
EEA Report	Climate change	• Reducing heatwave impacts through urban renewal projects and urban planning • Transport management to reduce air pollutants Soft measures • Awareness and behaviour changes • Health warning systems and heat action plans • Stakeholder involvement • Mainstreaming into existing programmes, plans and policies
RESIN	Climate Adaptation	Best practice identification for climate adaptation
SMARTeST		• The Ecocities project good practice • UKCIP
STAR-FLOOD	Flood Resilience	**I. Flood Risk management** 1. Risk Prevention: proactive spatial planning allocation politics 2. Flood Defence: Dikes, dams, embankments, sand suppletion 3. Urban Green Infrastructure, flood retention and urban management 4. Warning Systems, Disaster Planning and Evacuation Plan 5. Rebuilding Areas, Insurance systems **II. Flood Governance Arrangements** 1. the relevant actors, such as spatial planners, water managers, emergency services and insurance companies, take responsibility and collaborate to implement the strategy, 2. the strategy is embedded in the actors' discourses, e.g., in thinking, discussions and policies, 3. the implementation is backed up by formal and informal rules and 4. the actors have the necessary power and resources (finances, knowledge, political and interaction skills)

4.4 METRICS AND INDICATORS

MOVE Project

In the MOVE project, a set of indicators is collected for measuring vulnerability, risk, risk governance and adaptation as shown in Table 48. Note that the application of these indicators varies from city to city depending upon what kinds of hazard scenarios taken into account.

Table 48 Proposed Indicators in MOVE project

Source	Indicators
MOVE	**Vulnerability** Causal factor of vulnerability • Exposure (temporal, spatial) • Susceptibility and fragility (physical, ecological, social, economic, cultural and institutional) • Lack of resilience (capacities to anticipate, cope and recover) **Risk** • Potential impact on economy • Potential impact on social • Potential impact on environmental **Risk Governance** • Organisation **Adaptation** • Hazard intervention • Vulnerability intervention

CapHazNet Project

Recall that we have discussed several aspects of CapHazNet which among other things tries to develop a way to evaluate social vulnerability quantitatively through a set of indicators. These include indicators of elements at risk, exposure indicators as well as susceptibility and resilience indicators (Messner & Meyer, 2006). The symbols indicate whether the variable may be an indicator of increased or decreased social vulnerability (+ = increases vulnerability, - = decreases vulnerability).

Table 49 Indicators for Community Resilience

Source	
CapHaz-Net	**Economic Development:** • Employment/population ratio • Median household income • Number of medical doctors per 10,000 • Corporate tax revenues per 1,000 • Percent creative class occupations • Income equity • Percent population with less than a high school education • Net business gain/loss rate • Occupational diversity • Urban influence **Social capital:** • Percent of two parent families • Number of arts/sports organisations • Number of civic organisations per 10,000 • Percent voter participation in 2004 presidential election • Number of religious adherents per 1000 population • Net migration per 1000 population • Property crime rate

	Common indicators • Age - children and very elderly (+) • Gender - women (+) • Employment (-) • Unemployment (+) • Occupation (depending upon whether skilled (-) or unskilled (+), also linked to income and financial status) • Education level (higher educational level -, low educational level +) • Family/household composition (large families +, single parents +, single person households +, home owner -, renter + etc.) • Nationality/ethnicity (minorities +, new migrants +) • Type of housing (single storey accommodation +, mobile housing +) • Number of rooms (low number indicates overcrowding +) • Rural/urban (low income rural +, high density urban +) • Levels of risk awareness and preparedness (high awareness -, low awareness +) • Previous flood experience (no experience +, high experience -) • Access to decision-making (increased access -, little access +) • Trust in authorities (no +, yes -) • Long-term-illness or disability (+) • Length of residence (linked to prior experience, short residence +) • Serviced by flood warning system (yes -, no +) • Type of flood (indicates potential damage levels) • Flood return period (indicates potential damage levels)

Source: the indicators of economic development and social capital for the community resilience model (Sherrieb, Norris, & Galea, 2010).

Table 50 Disaster Resilience Indicators for Benchmarking Baseline Conditions

Source	Indicators
(Susan L. Cutter, Burton, & Emrich, 2010)	From an indicator based perspective, (1) individual socio-demography, (2) individual resources, (3) community resources, (4) preparedness and mitigation, (5) social support, (6) personality, (7) spirituality, (8) disaster impact severity, (9) disaster experiences, (10) coping appraisals, (11) positive adjustment, and (12) positive emotions may be addressed for the assessment of individual psychological resilience.

DRIVER Project

The DRIVER project deliverables with respect to the resilience of local government cover several reports. We reviewed two of them (Scott Davis & Karikas, 2015; Rigaud et al., 2015). The first report,

"Conceptual Approach to resilience of local government", is a theoretical work as a process toward defining the resilience of local government in the DRIVER project. Local government resilience indicators identified in the DRIVER project are based on different selected frameworks, which have been classified according to the processes of the resilience of city to disaster, and was built based on ISO 31000 (See Section 4.2.6). The disaster capability at the local government dimension is evaluated or measured based on the organisational/managerial performance. DRIVER refers to several tools: Local Government Self-Assesment Tool (LG-SAT), Torrents Community Disaster Resilience Scorecard (TCDRC), Regional Disaster Resilience (RDR), Resilient Organisations Benchmark Tool (ROBT), City Resilient Framework (CFR) and GRT. The indicators are organised based on four disaster resilience capabilities: prevention, preparation, response and recovery:

Table 51 Capacity of Performance Indicators of Local Government Resilience (DRIVER)

Capability	Tool	Capacity of Performance Indicators
PREVENTION	LG-SAT	• participation of citizen groups and civil society • budget for disaster risk reduction. • assess the safety of schools and health facilities (upgrade as necessary) • maintain up to date data on hazards and vulnerabilities. • prepare risk assessments. • use risk assessment results as the basis for urban development plans • identify safe land for low-income citizens and upgrade (when feasible) • invest in and maintain critical infrastructure that reduces risk, such as flood drainage. • 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. • ensure that risks assessment results and the plans to support your city's resilience are readily available to the public and fully discussed with them. • apply and enforce realistic, risk compliant building regulations and land use planning principles. • provide incentives for homeowners, low-income families, communities, businesses and the public sector to invest in reducing the risks they face. • ensure that education programmes and training on disaster risk reduction are in place in schools. • ensure that education programmes and training on disaster risk reduction are in local communities
	M: CI	• Integrated Risk Management • Flood protection / Coastal protection strategies • Resilience-by-design approaches in critical infrastructure protection
	TCDRC	• Level of risk and vulnerability in the community
		• Characterization of the Regional All-Hazards Threat Environment • Infrastructure dependencies and interdependencies identification and associated significant vulnerabilities and consequences for regional resilience • Risk assessment and management • Specialized sector-specific regional disaster resilience needs cybersecurity, process control, and it systems, transportation, energy, water and wastewater systems, dams and levees, hospitals and healthcare, and air and seaport resilience

	CRF	• Reduced physical exposure and vulnerability • Minimal human vulnerability • Diverse livelihoods and employment • Collective identity and mutual support • Adequate safeguards to human life and health • Availability of financial resources and contingency funds • Social stability and security
	GRT	• Governance • Risk appreciation • Risk treatment, prevention, protection and review
PREPARATION	LG-SAT	• Install early warning systems
	TCDRC	• Level of risk and vulnerability in the community • Emergency planning, response and recovery resources available in the community • Procedures supporting community disaster planning, response and recovery
	RDR	• Resilience roles, responsibilities, authorities, and decision-making • Exercises, education, & training • Alert and warning, two-way information sharing, and situational awareness • Public information/risk communications, including media • Legal & liability issues
	ROBT	• Unity of Purpose: An organisation wide awareness of what the organisation's priorities would be following a crisis, clearly defined at the organisation level, as well as an understanding of the organisation's minimum operating requirements. • Planning Strategies: The development and evaluation of plans and strategies to manage vulnerabilities in relation to the business environment and its stakeholders. • Stress Testing Plans: The participation of staff in simulations or scenarios designed to practice response arrangements and validate plans. • A strategic and behavioural readiness to respond to early warning signals of change in the organisation's internal and external environment before they escalate into crisis.
	CRF	• Integrated development planning • Empowered stakeholders
	GRT	• Integrated development planning • Empowered stakeholders
RESPONSE	RORBT	• Leadership (Strong crisis leadership to provide good management and decision-making during times of crisis) • Staff engagement • Situation Awareness (to be vigilant about the organisation, its performance and potential problems) • Decision Making (having appropriate authority to make decisions) • Innovation and Creativity (staff is encouraged to solve problems in a novel way) • Effective Partnerships (access to relevant organisations during the crisis) • Breaking Silos (minimize divisive social, cultural and behavioural barriers) • Internal Resources (mobilisation of organisation's resources)
	CRF	• Effective leadership and management
RECOVERY	LG-SAT	• After any disaster, ensure that the needs of the affected population are placed at the centre of reconstruction, with support for them and their community organisations to design and help implement responses, including rebuilding homes and livelihoods.
	M: CI	• Existing Economic Recovery and Business Continuity Management (BCM)
	RDR	• Public information/risk communications, including Media • Recovery and long-term restoration challenges • Continuity of operations and business

RORBT	• Roles are shared and staff is trained so that someone will always be able to fill key roles. • Leveraging Knowledge: Critical information is stored in a number of formats and locations and staff has access to expert opinions when needed.
CRF	Continuity of critical services

In addition to the resilience concept for local government level listed here, DRIVER deliverables include a final report with title “Final concept for the resilience of local government”. However, this report is not accessible due to the nature of the deliverable which is restricted (only accessible for specific defined project).

EMBRACE Project

Table 52 Governance Indicators (emBRACE)

Source	Indicators	Indicators
	Governance • Accountability • Adjustment • Appraisals • Advocacy • Coordination, • Degeneracy • Flexibility • Participation • Functional • Heterogeneity • Plasticity/redundancy • Support • Relationship • Responsibilities • Voluntarism • Autonomous and interdependent	• Organisational capacities • Independent • Organised • Structural measures • Motivation/Incentive • Partnerships • Policies and Planning • Legal and regulatory systems • Policy and planning • Priorities and political commitment • Regulated • Involved • Insurance • Structures/ • Network and Connected • Management • Integration with development

ENHANCE Project

Table 53 Governance Indicators (emBRACE)

Source	Indicators
ENHANCE	**Governance (actors, institutional arrangements and organisations)** • Education, Research, Awareness and Knowledge • Information and communication • Culture and Diversity • Preparedness • Response • Protection • Exposure, Experience and Impact Severity. • Resources • Health and well-being/Livelihood • Economic • Adaptive capacity • Coping Capacity

	• Innovation and Capital • Infrastructure and Technical

Table 54 Indicators of Good Governance as proposed in ENHANCE project

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

Table 55 Indicator of public private natural disaster insurance system (ENHANCE)

Source	Indicators	Description

General Characteristics	Programme name/year establishment	The official name of an insurance scheme/year of establishment
	Programme duration	Duration, temporary or permanent
	Standard disaster return period	Reoccurence probability
	Damage intensity	Estimated damage % of GDP
	Compulsory coverage	Participation in insurance: Mandatory or voluntary
	Market penetration	% of homeowners in a given region or in a country who purchased insurance products
	Official trigger	Official disaster declaration
	Responsibility public sector	The main responsibilities of the public sector in the insurance system
	Responsibility private sector	The main responsibilities of the private sector in the insurance system
Funding	Hazard covered	The covered hazard: e.g. earthquake, flood etc.
	Damage covered	Type of damage covered e.g. properties, business interruption damage etc.
	Limit of indemnity	Overall and per policy limit of coverage in monetary value
	Individual policy deductibles	Amount of floss that policyholder pays before the insurance starts paying
	Premium setting	Who determine the premium (risk-based or flat)
	Premium level	The level of insurance premium for a specific risk for a specific period
	Reinsurance	Whether a PP system uses reinsurance for hedging risk (public/ private, with/without a state of guarantee)
	Reserves and special tax treatment	How PP insurance system builds up financial reserves (with/without a tax exemption)
Mitigation	Integration of risk mitigation and preventive measures	How damage mitigation and prevention measures are integrated into insurance programme
	Risk zoning and risk maps	Availability of risk map of hazard-prone area
	Incentives based on premiums	Risk-based premium provides policyholders with incentive to undertake mitigation measures
	Incentives based on deductibles	Risk-based deductibles provide policyholders with incentive to undertake mitigation measures

4.5 CONCLUSIONS FROM CC LITERATURE

From the projects we reviewed, there is a clear transition before and after the EU policy on Adaptation Strategy to Climate Change was launched in 2013:

Before 2013:

- Resilience is one of the dimensions of vulnerability, captured as “lack of resilience”
- Governance is new concept that has been embraced by resilience concept
- Risk governance, PuP, and PPP are important part of resilience

- City as a resilience unit analysis does not yet appear, as we found in the CI literature, city is only a background
- Metrics and indicators developed are intended for assessing risks and vulnerabilities against climate change or natural disaster or extreme weather events.
- Sectorial approach in EU CC Projects means different types of hazards due to climate change and different risks and vulnerability assessment techniques to increase resilience.
- Some efforts have been made to include adaptation concept in the projects.

After 2013:

- Climate Change Adaptation strategy has affected resilience definition, and applications. For example in the development of idea that climate resilient infrastructure can be achieved by ensuring that an asset is located, designed, built and operated with both the current and future climate in mind and incorporates resilience to the impacts of climate change over the lifetime of that asset.
- Many projects applied the resilience concept in connection with the adaptation strategy
- Reducing the GHG emission and energy saving is an example of adaptation strategy that has a link to earlier EU CC policies
- City resilience appears as a unit analysis for building resilience but apparently it is discussed as a “desired state” in a very general way. EU-CIRCLE is working on holistic resilience plans for entire regions, introducing the interdependencies of heterogeneous infrastructures in the implementation process. RESIN is working on improvement of poor integration of different domains, and between CIs and other city systems and urban adaptation strategies, introducing a standardised approach concerning the methods for undertaking key tasks such as assessing climate risks and vulnerability, and prioritising between adaptation responses and limits urban adaptation planning.
- How to measure resilience of a city is still missing in the literature. The resilience is seen from each component of a city such as individuals

There are different degrees of adaptations that possible to implement. It covers green, grey and soft measure. In some sectors, adaptation measures are very clear but very expensive to implement such as in the transport sector, which road and rail infrastructures, e.g., are spread all over a country and is difficult to control.

5 RESULTS: SOCIAL DYNAMICS

- Definition of Social Dynamics
- Social Dynamics in EU Policies and EU Urban Agenda
- Social Dynamics Themes
- Policies and Best Practices
- Metrics and Indicators
- Conclusion

5.1 INTRODUCTION

In this section, we extract the information on social dynamics based on scientific literature identified in Chapter 2. We reviewed ten journal papers on social dynamics, in addition to reused several projects containing social dynamics dimension and policy documents. The focus of the survey is to answer the following questions:

- What kinds of social dynamics issues have been considered important and affected the city resilience in Europe?
- How are these issues addressed in EU policies?
- What kinds of challenges exist, and what kinds of approaches are proposed in the area of social dynamics?
- What kinds of policies and best practices have been proposed to increase city resilience with respect to social dynamics problems?

5.1.1 WHAT IS SOCIAL DYNAMICS?

The social dynamics issue is mentioned in the SMR proposal, which is illustrated in the proposal as a trend that affects the potential hazards (SMR proposal, 2014, p. 1). On the other hand, social dynamics issue is mentioned as a part of project activities where SMR will integrate and address human and social dynamics in crises and disaster situations (SMR proposal, 2014, p. 8). The term is interchangeably used with social disruption (p.16), and social problems (p.16, 26, 28). In this report the social dynamics term is applied and discussed in the **three areas**: **First,** we highlight the most frequently discussed social issues in the literature that triggers social disruption and social unrest in the cities such as urbanization, poverty, unemployment, asylum seekers and integration, and social vulnerability. **Second**, we treat the

social dynamics in term of problems that affect human due to climate change such as disease, health, and human adaptive capacity. **Third**, the human and social dynamics in crisis and disaster situations how the resilience play a role in this context. It is seen from the perspective of individual and community resilience.

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

- **First**, social issues that triggers ***social disruption and social unrest*** in the cities such as urbanization, poverty, unemployment, asylum seekers and integration, and social vulnerability.
- **Second**, problems that affect human due to climate change such as ***disease, health, and human adaptive capacity***.
- **Third**, the ***human and social dynamics in crisis and disaster situations*** how the individual and community resilience play a role in this context.

Many literature points out that cities can be the risky places on earth for those who live in an urban environment where basic social services, authorities, food and water security, sewerage and building regulations are lacking – as centers of risk, exploitation, disease, unemployment, or poverty. This issue is also strengthened by our understanding of "The urban dimension of EU policies – key features of an EU urban agenda[101]" where for example, some related social issues are identified:

- Increasing population at risk of poverty (due to unemployment)
- Many cities experience de-skilling of the workforce, and an increase of low-skilled service sector job and working poor.
- Social and Spatial segregation (social exclusion, segregation, and polarization)
- The decline of economic and demographic aspects can induce a negative spiral of declining local tax revenues, and lower demand for good and service.

Furthermore, two EEA documents (EEA, 2012, 2013) addresses the social dynamics issues triggered by climate change are identified such as the challenges to adapt to the effect of water shortages, floods, heat waves, etc. that definitely will affect population and human adaptive capacity to withstand these change effects.

Human and SD during and after the crisis in term of resilience are mostly addressed in the EU projects identified in this report. Overall themes we captured from the EU project reports and scientific literature are explained further in Section 5.2.

[101] DRAFT REPORT on the urban dimension of EU policies (2014/2213(INI)) Committee on Regional Development

5.1.2 SD RESILIENCE IN EU POLICIES

There is no EU policy directly pointing to the Social Dynamics since problems related the human dynamics and conditions are spread in different EU sectorial policies. The most related EU regulations relevant for social dynamics are EU Social and Employment Policy, EU integration policy, to some extent, EU Humanitarian Aid and Civil Protection, and EU Climate Change Adaptation Strategy. The focus of EU integration policy is entirely about the immigration issues, and how to integrate and accommodate immigrants within European framework (e.g. values, cultures, employment) such as expressed in eleven points of Common Basic Principles 2004[102]. In European Agenda 2011 for integration[103], some actions to increase economic, social, cultural and political participation by migrants were proposed. Moreover, in 2014, EU Member States reaffirmed their commitment to implement the Common Basic Principles[104] and should work developed on the following issues:

- A more balanced non-discrimination approach to safeguard basic values.
- Voluntary pre-departure cooperation between countries of origin and destination
- More targeted reception policies responding to the specific needs of vulnerable individuals and groups at greater risk of social exclusion, including beneficiaries of international protection;
- Greater involvement of the private sector, social partners, and civil society to enhance diversity and non-discrimination at the workplace.

On the other hand, the EU humanitarian aid and civil protection have a strong global dimension, where the focus is to save and assist people who are affected by both natural disaster and man-made disasters. Therefore, the policies outlined in this area are more practical and action-oriented in various humanitarian aid sectors[105]. We will not discuss further these policies since assisting people affected by disaster goes beyond geographical or administrative boundaries, although it can be valid for city and urban resilience context if a disaster event occurs in one or more EU cities.

Furthermore, in the document mentioned earlier, The Urban Dimension of EU policies – Key Features of an EU Urban Agenda[106], the needs for "*strengthening cities' engagement and ownership of EU policies*" and "*better understanding of urban development processes*" are emphasized. In addition,

[102] http://www.eesc.europa.eu/resources/docs/common-basic-principles_en.pdf
[103] http://europa.eu/rapid/press-release_IP-11-911_en.htm?locale=en
[104] See document on Council conclusions of the Council and the Representatives of the Governments of the Member States on the integration of third-country nationals legally residing in the EU. http://www.consilium.europa.eu/
[105] http://ec.europa.eu/echo/what/humanitarian-aid/policy-guidelines_en
[106] DRAFT REPORT on the urban dimension of EU policies (2014/2213(INI)) Committee on Regional Development

measures on a limited set of major European societal challenges such as climate protection and demographic change are stressed. However, they are not explained further.

In the context of climate change adaptation, again, the Adaptation to Climate Change Strategy 2013[107] provides the relevant document to examine. In this strategy, the social problems or social dynamics refer to the health issues. The ground for this health issue is the SWD document 2013[108]. This SWD document underlines the following CC matters that can affect the human health: food- and vector-borne diseases, food safety, air quality, allergies, ultraviolet radiation, and so on. Such effects are distributed unequally among social groups and influence more the vulnerable group in the society such as children, elderly people or people with pre-existing illness or disabilities. This will be part of the thematic discussion in Section 5.2.6.

5.2 SD TOPICS

- Challenges and Approaches
- Refugee and Integration Problems
- Terrorism and Social Unrest
- Health and Human Adaptability to CC
- Social Vulnerability
- Individual and Community Resilience

This part is organised in more pragmatic way compared to two other problem areas. The reason is that we reused and relied on whether or not SD topics were included in the selections of our CC and CI literature reviewed earlier. Indeed, we supplied the analysis with information from policy documents and journal articles, but the organisation of this section is simpler than themes in the previous two chapters. This sub-section is divided into six topics. The first subsection illustrates the overview of the literature, what kind of challenges is discussed in the SD literature. After that, we start explaining the five themes identified in the literature.

5.2.1 SD CHALLENGES AND APPROACHES

Adding the dimension of social dynamics and social problems into the framework of city resilience is inevitably crucial but uneasy at the same time. The challenge lays on the incorporation of the social

[107] http://ec.europa.eu/clima/publications/docs/factsheet_adaptation_2014_en.pdf and http://ec.europa.eu/clima/publications/docs/eu_strategy_en.pdf
[108] http://ec.europa.eu/clima/policies/adaptation/what/docs/swd_2013_136_en.pdf

dimensions to city resilience concept, and how to operationalise them. In this section, we focus on EU projects related to resilience that raise the human dimension and social dynamics. It will be strengthened by the discussion derived from scientific literature.

The CapHazNet project summarize the main themes or problems as intertwinned between human and 'space' (city, urban, towns), as follows:

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

In sum, CapHazNet points put the increasing relevance of, and shift towards, responsibilization, resilience, and social capacity building. The CapHazNet[109] project mentions further three major societal processes which interact with societies' ability to build social capacities to prepare for, cope with and recover from the negative impacts of hazard in the European setting: (1) *Social and demographic changes*- increasing social polarization and international migration and mobility. (2) *Globalization*-- it includes the negative impacts of natural hazards that sometimes has a transnational dimension. (3) *Increasing fragmentation* at different spatial scales. These issues are apparently in line with the urban agenda that we have identified in the previous section (5.1).

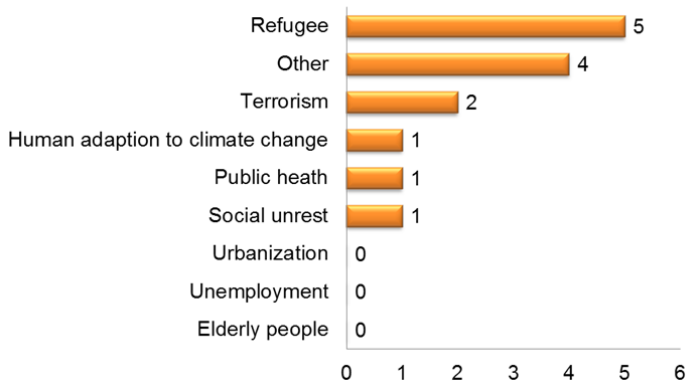

Figure 38 The main themes identified from literature

[109] www.caphaz-net.org

We also examined the scientific literature that linked resilience, social problems or social dynamics with European context. The summary of themes that are identified can be seen in Figure 38. Thus, the topics presented in the next sections are a combination of issues identified from EU policy documents and EU projects, especially the CapHazNet, OPSIC, PEP, POPALERT, DRIVER, and emBRACE projects.

5.2.2 REFUGEE AND INTEGRATION PROBLEMS

Apart from EU policies mentioned in Section 5.1.2, EU projects identified in our literature rarely touches the refugee or asylum seeker issues. To a certain degree, the projects discussing the vulnerable social group often cover the refugee/asylum seeker group. However, in the “social vulnerability” context, the integration in the society Vulnerability this group is not so much discussed. The refugee issue is found in the scientific literature (Björnberg, 2011; Geddes, 2001; Georgiades, 2009; Overland & Yenn, 2007; Skeie, 2014).

Skeie (2014) discusses young people, migration, and European dimension in a Norwegian context. Skeie outlines Norwegian discourse on refugee and education. The education is dominated by a focus on human capital and thinking related to the work-life situation, with a strong emphasis on improving the subject area for achievements and, in particular, certain basic skills, like reading, writing and arithmetic. As a result, the citizenship perspectives are becoming less invisible. In other words, citizenship education tends to be seen as a subcategory of subject learning, focusing on formal knowledge. Among key finding is that Norwegian society risks unwanted change by not being able to connect events to broader trends. Pupils are not being taught enough social sciences and are therefore unable to see bigger patterns of political influences. The public discourse (i.e. the media) shows this lack of a wider perspective.

Björnberg (2011) addresses the integration challenges of the asylum seeker group primarily in the area of interpersonal relationship and limitations in social networking. Resilience is mostly built within one’s own family because interaction with others is uncertain and subject to change. This article mentions communication as one of the problems commonly found among asylum-seeking families and individuals. Björnberg (2011) also suggests the adjustment in the approach to this group so that individuals feel more certain in the integration process and learn to trust others.

Resilience in this context concerns the individual's and his/her family's capacity to resist adversities that they experience as harmful to their psychological well-being. It includes the availability of resources that increase their operational capacity in the environment. Among these resources, social relationships are the most important. A supportive environment contributes to greater resilience in the individual, which

in turn contributes to improved capacity for coping or mastering of stresses. We notice that this article is very specific, talks about individual resilience on small-scale networks.

- EU integration policies accommodate immigrant issues.
- The citizenship and social science education for asylum seeker is as important as introducing them the work-life and other formal knowledge, but it is lacking.
- Limited interpersonal relationship and social networking are the main asylum seeker's challenges among asylum seeker groups
- Resilience in this group is mostly built within one's own family because interaction with others is uncertain and subject to change.
- Resilience in this context concerns the individual's and his/her family's capacity to resist adversities that they experience as harmful to their psychological well-being.
- Deeply rooted religious belief contributes for generosity or altruistic behaviour of refugee. In turn it increases the psychological resilience of individuals in this group. Resilience is interpreted from the perspective of "the ability to "bounce back" or regain form after great strain".

Through depth interview and field survey, Overland and Yenn (2007) discuss deeply rooted religious reasons as a possibility for generosity or altruistic behaviour, which in turn may increase the psychological resilience of these individuals. Resilience is interpreted from the perspective of "the ability to "bounce back" or regain form after great strain", or "the ability to adapt well to unexpected changes and events."

We are also aware of the existence of the European Council on Refugees & Exiles (ECRE)[110], a pan-European alliance of 85 NGOs. The aim is to protect and advance the rights of refugees, asylum seekers, and displaced persons. ECRE promotes the establishment of fair and humane European asylum policies and practices in accordance with international human rights law. ECRE provides various good practice guides on integration and education. However, we will not discuss further in this report, since the good practice is specialized on these two issues and not for elaborating the resilience building.

5.2.3 TERRORISM AND SOCIAL UNREST

In most of the documents, we found for writing this report, terrorism and social unrest were mostly discussed as a scenario, e.g., as a part of man-made hazard scenarios where the latter are quite a wide domain and can cover unintentional harmful actions such as a human error when operating CI, fatigue and so on. Sometimes they are treated as or a background for proposing a solution. Projects such as

[110] http://www.ecre.org/

the CBRNEMAP, RIBS, PRACTICE, TACTICS and SPARKS[111] projects highlight the capability of the responders or the robustness of infrastructures or technologies instead of how terrorisms or social unrest affect the social dynamics and how to build resilience to this particular threats.

In some projects, terrorism is used as a background scenario, and not a focus. The main suggestion is more to the development of individual and social resilience such as we can find in the DRIVER, CapHazNet, OPSIC and emBRACE[112] projects especially at addressing how to build resilience at individual and community level. However, we will discuss this project further in section 5.2.6 and 5.2.7.

In the scientific literature, terrorism is mentioned by Bruyelle et al. (2014) and Skeie (2014), however only Bruyelle et al. (2014) that discussed it in details, while Skeie (2014) uses it as a background information. The paper analyses the case of 07/07/2005 London bombing in the trains and considers the human behaviour in crisis, and found the following facts are relevant:

- Victims have been consistently found to *keep a social behaviour*, help themselves and others, sometimes to the point of self-sacrifice
- Panic is rare and does not spread
- Cooperation and support far outweigh selfishness
- The role of social identity
- The role of natural leaders
- The role of information: what is happening, where is happening, what to do
- The role of communications: to inform the authorities of the situation and speed the organisation of the rescue, but also to provide the passengers and on-board staff with reassurance and the information they need to react to the situation, acknowledging the fact that they can help themselves

Bruyelle et al. (2014) also suggest what to prioritize after the attack, which has some critical functions to recover from shock:

- Alleviate the risk of panic
- Allow the survivors to assess their situation and provide the authority in charge of the crisis management with information
- Allow the authorities to provide information and instructions to the survivors
- Allow the survivors to help themselves while waiting for rescue.

[111] For the CBRNEMAP, see this link: http://www.cbrnecenter.eu/project/cbrnemap/. The link to the RIBS project is http://cordis.europa.eu/project/rcn/96576_en.html. The official site http://ribs-project.eu/ has been closed as the project terminated. The link to the PRACTICE project is http://www.practice-fp7-security.eu/#&panel1-2. The link to the TACTICS project is http://www.fp7-tactics.eu/ and finally the link to SPARKS project is https://project-sparks.eu/.

[112] The link to the DRIVER project is http://driver-project.eu/. The link to the OPSIC project is http://opsic.eu/ and the link to the emBRACE project is http://www.embrace-eu.org/ .

- Allow the evacuation

- Terrorism and social unrest were mostly discussed as a scenario
- Suggestion for action after terrorist attack:
    - Alleviate the risk of panic
    - Allow the survivors to assess their situation and provide the authority in charge of the crisis management with information
    - Allow the authorities to provide information and instructions to the survivors
    - Allow the survivors to help themselves while waiting for rescue.
    - Allow the evacuation
- With respect to terrorism, resilience building also means increased preparedness of individual and society

The article suggests the policies correspond to individuals as well as to local government and national government such as:

- Equipment that needs to be survivable: lighting, passengers to driver communications, train to ground communications, door operating systems, first aid equipment, smoke relief systems
- Equipment to be improved in the case of emergency: rescue kits, evacuation guidance signs, instruction posters, and labels; people would make better decisions if they are directed or they are provided with real information about the situation.
- The absence of panic and the continuity of social identity
- Help as opposed to selfishness: social behaviour of helping each other, trying to know what happen.
- Training and the consequences of its absence: knowing what to do facilitates the evacuation process.
- Improving information flows: the information to the authorities and information to the victims.

Apparently, most of the projects and articles on the terrorism issue are intended to increase preparedness the individual and society in general as a part of resilience building.

5.2.4 HEALTH AND HUMAN ADAPTATION TO CLIMATE CHANGE

- The human health issues due to CC: Food- and vector-borne diseases, Feed and food safety issues, Water-related issues, Air quality, Allergies, Ultraviolet radiation, Increase of health inequalities, Vulnerable groups, Environmentally induced migration.
- The impact of CC such as heat waves, are unevenly distributed across the regions of Europe and can be additional burdens for lower income groups and certain vulnerable groups.
- One of the projected CC impacts is the higher demand for health services than the capacities. Adaptive capacity is necessary to cope with this situation.
- Resilience to human health is "…the ability to maintain healthy levels of function over time despite adversity or to return to normal function after adversity."

Human health is an issue that concern Europeans as the effects of the climate change. EEA document, for example, mentions about sensitivity to the heat that varies among the population. Some groups are

more sensitive to heat than others. Of special importance in terms of sensitivity to heat are senior citizens aged 65 years and over. Nevertheless, the human health issues due to climate change are not merely about heat waves. The Commission Staff Working Document (SWD) 2013 summarized a comprehensive overview of the CC impacts directly and indirectly to the human health such as:

- Food- and vector-borne diseases (i.e. temperature-sensitive infectious diseases, such as food-borne infections (Salmonella sp., and others), mosquito-borne diseases).
- Feed and food safety issues (e.g. the present of mycotoxin in the food, contamination).
- Water-related issues (due to the mobilising of pathogens or extensive water contamination from overflowing sewage pipes and bacteria contamination is also likely to affect drinking water quality).
- Air quality (negative health effects occur mainly on respiratory and, to a lesser extent, cardiovascular diseases).
- Allergies (increase the seasonability and duration of allergic disorders like hay fever or asthma).
- Ultraviolet radiation (CC causes “ozone mini-holes” that generates higher UV radiation levels. Excessive UV exposure causes skin cancers and cataracts).
- Increase of health inequalities (CC may increase health inequalities within and between countries and put additional stress on poorer groups).
- Vulnerable groups (the impact of CC such as heat waves, are unevenly distributed across the regions of Europe and can be additional burdens for lower income groups and certain vulnerable groups, such as children, those working outdoors, the elderly, people with disability).
- Environmentally induced migration (health protection of vulnerable groups migrating within the EU territory could require an enhanced capacity of Member States' health systems).

This policy document points out that nature and final impacts of CC will depend on the adaptive capacity and action of the health system and baseline access of different populations to this service (SWD 2013). It is projected that the demand for health services may increase beyond the capacities, and, therefore, adaptive capacity is important in the sense of emergency preparedness and response. The policy document does not specify the definition or link of human healt and resilience. However, we found a scientific literature that conducting a systematic review on the human health (Johnston et al., 2015). One definition that may be relevant to link with the human health is “…the ability to maintain healthy levels of function over time despite adversity or to return to normal function after adversity”. However, of course, the adaptive capacity and human health resilience are not only about individual health resilience, but it is also about organisation capabilities.

5.2.5 SOCIAL VULNERABILITY

- **Social vulnerability** is "The characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recovery from the impact of a hazard".
- **Social resilience** is social capacity building efforts target **external and internal** sides of social vulnerability to lessen: **1)** The external side (i.e. exposure) through: influencing more over-arching risk governance **and** influencing emergency response or even targeting those areas of social inequality**. 2)** The internal side combat social vulnerability from within **by** focus**ing** on improving the level of perceived risk, building motivation and a sense of responsibility within individuals and communities to manage and mitigate their own risk.
- There are different ways to calculate the social vulnerability with respect to the natural hazard. For example:
    - Social and Infrastructure Flood Vulnerability Index (SIFVI)
    - Spatial Multi-Criteria Analysis (SMCA)
- The social capacity is an important part of building resilience, especially by empowering the vulnerable groups due to economic reasons, ages, and disabilities.

As indicated in the EEA document on Urban Adaption to Climate Change in Europe (EEA, 2012), the following issues are mentioned, and reflecting the existence of the social fragility and the need to shape individual resilience:

- The conditions related to social fragility and lack of resilience conditions can favor the second order effects (indirect impact) when a hazard event strikes an urban center
- The social sensitivity, i.e. differences among the population with low incomes, the disabled and sick, young children and ethnic minorities can affect social resilience.
- The concentration of economic power and households in cities and their growing demand for products and resources from outside their borders have caused most of the greenhouse gas emissions and much of the pressure on the ecosystems surrounding these cities.

The one of the most comprehensive overviews of social vulnerability can be found in the CapHazNet project (Kuhlicke, 2013; Kuhlicke et al., 2012; Kuhlicke et al., 2010; Tapsell et al., 2010). The project collected the working definitions of Social Vulnerability.

A term used to define the susceptibility of social groups to potential losses from hazard events or society's resistance and resilience to hazard as proposed by Blaikie, Cannon, Davis, and Wisner (2007). Wisner et.al (2004) define social vulnerability as "The characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recovery from the impact of a natural hazard. It involves a combination of factors that determine the degree to which someone's life, livelihood, property and other assets a put at risk by a discrete and identifiable event. Among the

products of social inequalities are as the susceptibility of social groups to the impacts of hazards, as well as their resiliency or ability to adequately recover from them. Hence, ...susceptibility is not only a function of demographic characteristics ... but also more complex constructs such as health care provision, social capital and access to lifelines' (Susan L Cutter & Emrich, 2006; Susan L Cutter, Emrich, Webb, & Morath, 2009).

Social resilience is social capacity building efforts target both sides of social vulnerability to lessen:

- The *external* side (i.e. exposure) through:
    - influencing more over-arching risk governance
    - influencing emergency response or even targeting those areas of social inequality
- The *internal* side, to combat social vulnerability from **within**:
    - focused on educating, improving the level of perceived risk,
    - building motivation and a sense of responsibility within individuals and communities to manage and mitigate their own risk (particularly a requirement for flood hazard).

These efforts aim at improving the whole range of social capacities (knowledge, motivational, network, economic capacities as well as institutional and procedural capacities).

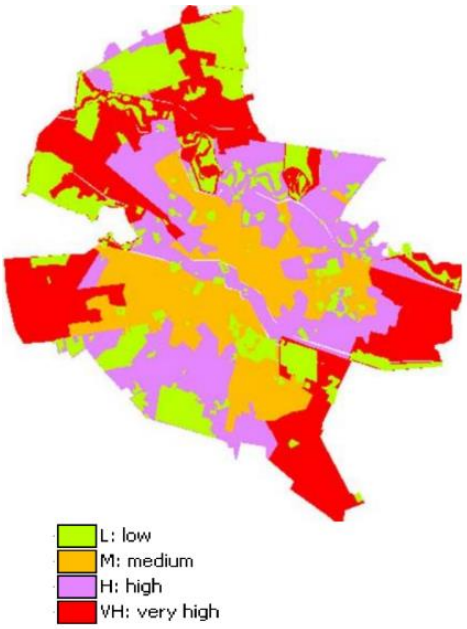

Figure 39 Total vulnerability with respect to capacity in Bucharest City. Source: Armaş (2008)

One of the CapHaz-Net project reports provides a different case where human vulnerability or social vulnerability play role (Tapsell et al., 2010). In this report, different ways to calculate the social vulnerability with respect to the natural hazard are mentioned such as Social and Infrastructure Flood Vulnerability Index (SIFVI), or Spatial Multi-Criteria Analysis (SMCA). An example of the perception of the seismic risk in Bucharest (Romania) using SMCA is described in the report, based on the study of Armaş (2008) to illustrate the social vulnerability. The total vulnerability of analysed urban space was calculated by dividing the total human vulnerability values by a composite "capacity" factor. Two indicators are used to measure "capacity", i.e.,:

- Preparedness level (expressed through distance to the hospitals, fire stations, and police stations)
- Awareness level (based on literacy rate).

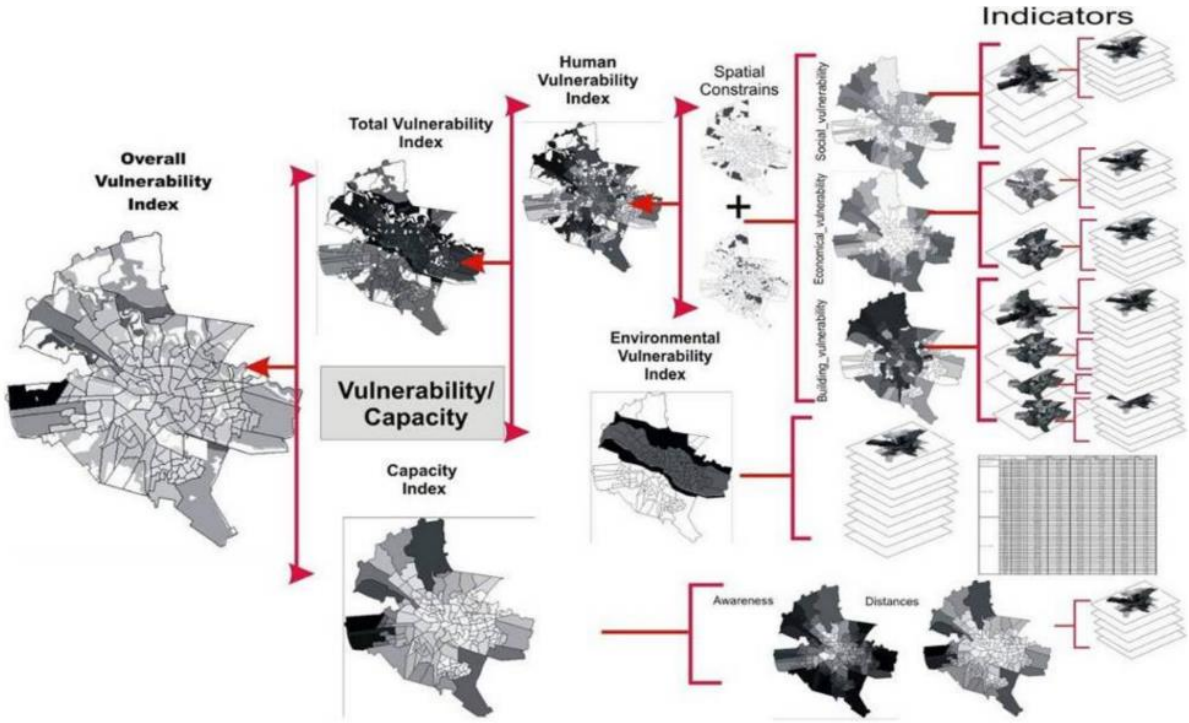

Figure 40 The spatial multicriteria analysis to capture social vulnerability (Tapsell et. Al., 2010)

This technique (as also shown in Figure 40) has revealed the configuration of the total vulnerability where the vulnerability is increasing in the marginal area (see Figure 39, marked with red). The approaches to represent the total vulnerability index map considers several spatial composite indicators: Social, Economic, Building stock vulnerability for capturing human vulnerability and adding the environmental vulnerability into the spatial multi-criteria analysis as shown in Figure 40 (Tapsell et al., 2010).

In short, from this social vulnerability perspective, the social capacity is an important part of building resilience, and the groups in the society that need empowerment are those who are vulnerable due to economic reasons, ages, and disabilities. The social vulnerability mapping as seen in Figure 39 and Figure 40 is a way to locate them quickly in a particular geographical area.

5.2.6 INDIVIDUAL AND COMMUNITY RESILIENCE

Recall in Section 5.1.1 we also include the SD themes in terms of community and individual resilience. Individual and community resilience are both often discussed together, although some projects tried to separate them as a different level of resilience, but, in the end, they are connected to some extent, for

example, which has been discussed in the emBRACE, ENHANCE and DRIVER projects. These three projects discuss individual resilience with different depth. OPSIC is a project that is fully dedicated for exploring individual resilience in the psychosocial context.

- Recently, the concept of individual resilience has shifted from physiological meaning toward the dynamic processes that occur within the social and ecological environment.
- Enhancing the resilience of populations at risk at the mitigation stage, and monitoring individual and community resilience during the recovery stage is a part of individual psychosocial resilience building.
- In the psychosocial context, **individual resilience** is "a person's capacity for adapting psychologically, emotionally and physically reasonably well and without lasting detriment to self, relationships or personal development in the face of adversity, threat or challenge"
- **Community resilience** should covers community access to a diversity of resources and capacities (e.g. socio-political, financial, physical, human); the capability to act effectively in the mitigation of risks and impacts; mutual learning from experience; collaboration; and the need to understand local contexts (emBRACE)
- From the **empowerment and crisis communication** perspective, individual citizen is important, so that they are prepared and more resilience in the disaster situation

In one of the ENHANCE project reports, McLean and Guha-Sapir (2013) discuss the importance of an individual psychological resilience. Management processes can shape this resilience since there is a correlation between the degrees of social support experienced during a shock phase, and the level of psychological resilience measured after an event was observed. This concept of resilience has shifted from merely about physiological meaning toward more about the dynamic processes that occur within the social and ecological environment at multi-interdependent scales. The emBRACE project also examines resilience in the various context (Birkman et al., 2012; Kruse et al., 2012; Pelling et al., 2015). On individual resilience, both projects apparently agree that focusing on the disasters-psychology perspective of resilience can contribute and give valuable insights into governance structures, institutions, on shaping post- ante management actions (on recovery and rehabilitation). However, both ENHANCE and emBRACE does not go further at the individual resilience level, since the project focus is mostly on governance aspect as we have discussed in Chapter 4.

The OPSIC project quotes European policy paper (Seynaeve, 2001) stating the importance of providing psychosocial support to all affected groups in crisis. Since then, many European projects and programs, taking this perspective into account. Following the Tsunami Disaster in 2004/5, many European countries sent out mobile psychosocial teams to support their citizens abroad and many developed psychosocial support programs for relatives and survivors in the aftermath of this event. The Madrid bombings in March 2004 and London bombings in July 2005 also influenced the development of psychosocial support programs all over Europe based on important lessons learned in the process (Wilson, Murray, & Kettle, 2009).

The finished project that purely scrutinizes resilience at the individual level and especially in the recovery stage is the OPSIC project. OPSIC create an operational guidance system (OGS) which could be used by psychosocial crisis managers and mental health professionals in order to provide high-quality mental health and psychosocial support programming and interventions in the context of disasters. The indicators of best practice based on recent psychosocial programming carried out in Europe are collected in a comprehensive way (Juen et al., 2015). The OPSIC project, in fact, collected 190 European guidelines and policy documents relevant to psychosocial support in a crisis. Nowadays psychosocial support is a highly recommended and often used intervention form in the European context of disasters. In this psychosocial support, there is a rather high degree of harmonization in Europe. However, the quality and types of support are not fully developed in the different European countries, due to lack of resources, knowledge or awareness about the state of the art in psychosocial support. The project output, i.e. MHPSS (Mental Health and Psychosocial Support) comprehensive guideline is intended to be a basis for best practice enabling the EU countries to develop national guidelines and disaster plans on psychosocial support. The MHSSP guideline includes planning tools handbook in addition to 51 action sheets. The MHSSP guideline identified the gaps in the European psychosocial guidelines on how individuals recover from the following issue:

- Ethnic gender and culture
- Older people, disabled persons and children
- Terrorist attacks and flooding
- Communication and social media use
- Psychosocial support in shelters and evacuation centres
- Recovery and long-term effects
- Best Practice criteria for psychosocial programming
- Definition of terms such as disaster, crisis, and emergency
- Recommendation for tools

The MHSSP guideline is intended to improve and close these gaps. On resilience, the MHPSS guideline is intended for enhancing the resilience of populations at risk at the mitigation stage, and monitoring individual and community resilience during the recovery stage. Since the psychosocial is the main focus of this OPSIC project, the resilience has been interpreted here as *"a person's capacity for adapting psychologically, emotionally and physically reasonably well and without lasting detriment to self, relationships or personal development in the face of adversity, threat or challenge" (Juen et al., 2015).* In MHPSS, it is also mentioned resilience approach as "*Individuals and groups can be supported in accessing psychological, social, cultural and other resources in order to return to normal functioning*".

In short, resilience in the OPSIC project is considered as resilience at the individual level, in terms of the psychology and psychosocial.

Furthermore, we found the following projects: emBRACE, DRIVER, POPALERT and PEP[113] deal with **community resilience**. In general, the emBRACE project goal is to build resilience to disasters amongst communities in Europe. The objectives of emBRACE are to:

- Identify the key dimensions of resilience across a range of disciplines and domains
- Develop indicators and indicator systems to measure resilience concerning natural disaster events
- Model societal resilience through simulation experiments
- Provide a general conceptual framework of resilience, 'tested' and grounded in cross-cultural contexts
- Build networks and share knowledge across a range of stakeholders
- Tailor communication products and project outputs and outcomes to multiple collaborators, stakeholders and user groups.

The project was recently completed in September 2015. The emBRACE project produces a handbook that covers all main concepts, methods, and case studies used during the project implementation. The project defines resilience as "the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions". In the initial gap analysis of current resilience concept, emBRACE (Birkman et al., 2012) summarizes various conceptualizations of resilience and its entities as follows:

[113] https://agoracenter.jyu.fi/projects/pep

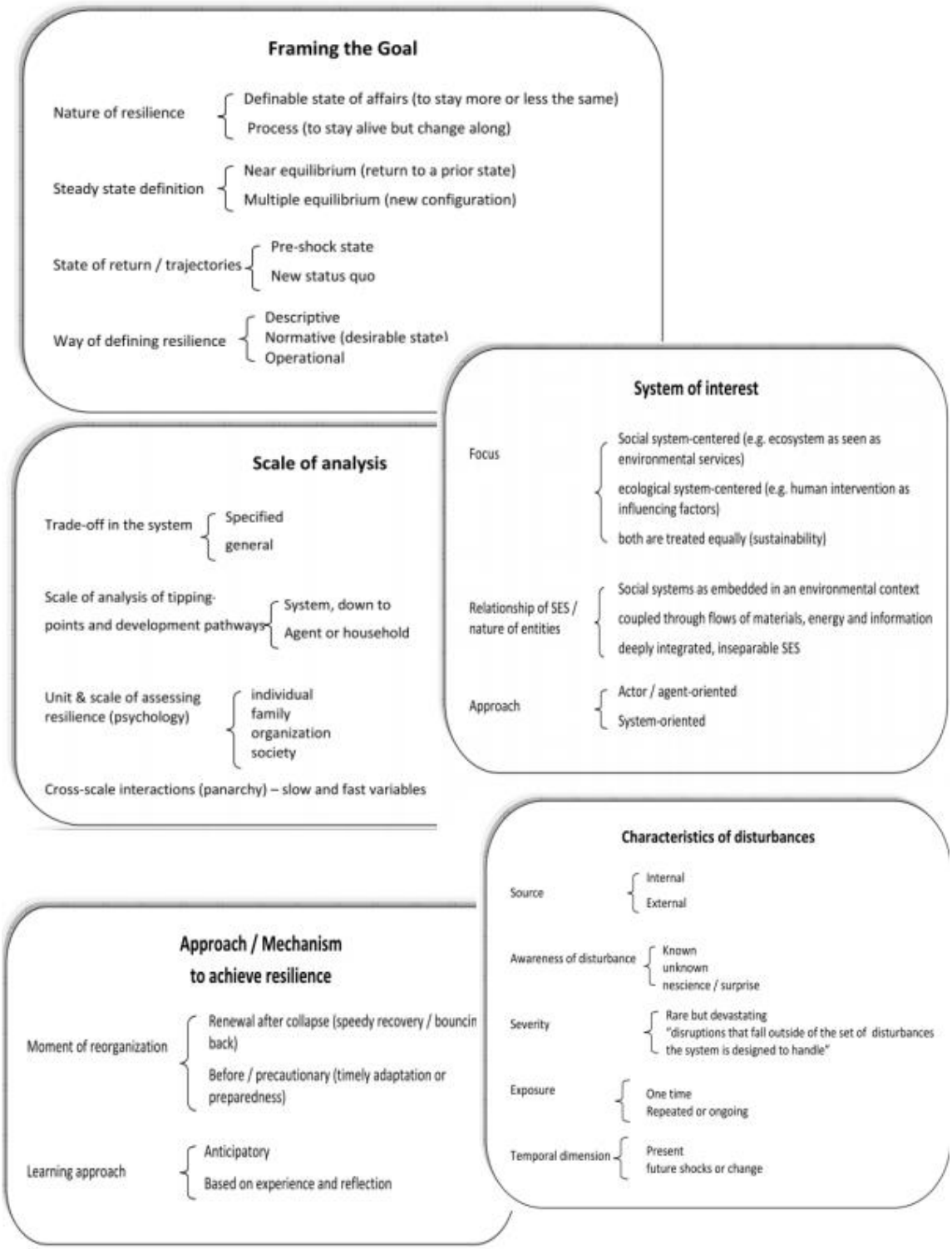

Figure 41 Summary of Resilience Concept form literature in emBRACE project (Birkman et al., 2012)

Figure 42 final framework of community resilience in emBRACE project (Deeming, 2015)

As a final framework for community resilience, emBRACE project suggests the following framework as seen in Figure 42. Note that we also present the emBRACE framework in Chapter 4. However, the emBRACE's resilience community framework is put inside a box indicating wider context i.e. Disaster Risk Governance. Figure 42 illustrates the dynamic interaction across three component domains (Resources, Actions and Learning). There are sub-components of each component, indicating important aspects required for building community resilience.

For reaching out purposes, emBRACE issues policy brief series for community resilience:

- *Policy Brief Series, Policy Brief 8.2: An evidence-informed approach to supporting EU policy-making and international engagement in building capabilities and capacities for Community Disaster Resilience*[114].
- *Policy Brief Series, Policy Brief 8.3: A focus on the role of National Government in building capabilities and capacities for Community Disaster Resilience*[115].
- *Policy Brief Series, Policy Brief 8.6: A focus on the role of Local and Municipal Authorities in building capabilities and capacities for Community Disaster Resilience* [116]
- *Policy Brief Series, Policy Brief 8.4-5: A focus on understanding Community and Non-Governmental Organisations' Capabilities in Building Community Disaster Resilience* [117]
- *Local Stakeholder Group (LSG) Briefing Note – Cumbria, Understanding Community Capabilities in Building Community Disaster Resilience – Findings from the emBRACE North of England case study*[118].

In general, these documents suggest the components found to underpin community resilience. They consist of a range of factors, for example, community access to a diversity of resources and capacities (e.g. socio-political, financial, physical, human); the capability to act effectively in the mitigation of risks and impacts; mutual learning from experience; collaboration; and the need to understand local contexts.

[114] https://drive.google.com/file/d/0B9RBeBGSyVgFby12aGc0M1dIZTg/view
[115] https://drive.google.com/file/d/0B9RBeBGSyVgFcFhuTU9WenJhSmc/view
[116] https://drive.google.com/file/d/0B9RBeBGSyVgFSWd0ckRtMk1JWG8/view
[117] https://drive.google.com/file/d/0B9RBeBGSyVgFUnRMajFWa0R3UUU/view
[118] https://drive.google.com/file/d/0B9RBeBGSyVgFc3hEb3A2blJUOU0/view

In terms of disaster risk management, these components should be understood not simply as factors that can be associated with and resourced through straightforward civil-protection mechanisms, but as much broader based resources, capacities and capabilities more normally associated with the concept of social protection.

PEP (Haataja, Rantanen, & Sullivan, 2014; Vos et al., 2014)analyses individual citizen from the empowerment perspective, especially in the crisis communication, so that they are prepared and more resilience in the disaster situation. It covers the role of local communities in crisis preparedness and response, and (b) how to involve the citizens in this task. In sum, PEP project proposes solutions for enhancing public resilience. Among issues that are considered need further investigation for improving resilience is social media, since there are barriers regarding the adoption of this mode of organisations, and the willingness and motivation to participate as well as the process to participate are equally important.

POPALERT also links crisis communication and individual or community resilience project identifies specific target success stories within existing and past community preparedness programmers and put together a portfolio of case studies on social networking and community self-reliance initiatives, which could be replicated to the crisis with a European dimension and to crossborder disasters. The project studies the best ways to blend contemporary tools with the existing to create flexible and easily deployable toolkits for preparing and alarming the European population in case of crisis. The project approach for improving the current practices revolves around the use of messaging and cultural sharing technologies to create awareness using technologies and approaches that offer the best form of accessibility and penetration by citizens and authorities. A set of case studies from fifteen countries are identified and are drawn from across the world but with a concentration in Europe. It tries to achieve a better understanding of the drivers, constraints and complexities of population preparedness and to create a state-of-the-art framework for assessing and understanding the level of community preparedness at the EU level. The individual behaviour is analysed in terms of preparedness, such as reaction, awareness of risks and willingness to engage in preparedness actions.

5.3 POLICIES AND BEST PRACTICES

This section presents different policies and best practices proposed and identified from various EU projects. The policies and the best practices identified here can be the recommendations from the projects, or identified in the project from other documents.

5.3.1 POLICIES

Table 56 Policies identified from SD-related Projects and Literature

Project	Focus	Policy
DRIVER	Community level	Social media policy
	Organisation/ local government level	• Statement of the overall intentions and direction of an organisation re-lated to disaster resilience management. • The organisation's rationale for managing risk • Links between the organisation's objectives and policies and the risk management policy • Accountabilities and responsibilities for managing risk • The way in which conflicting interests are dealt with • Commitment to make the necessary resources available to assist those accountable and responsible for managing risk • The way in which risk management performance will be measured and reported • Commitment to review and improve the risk management policy and framework periodically and in response to an event or change
	National level and national law	There is at present an eagerness within national and international bodies responsible for communications during the full cycle of preparedness, response and recovery to learn from others and adopt a policy of ongoing improvement.
PEP	Individual level	Potential voluntary engagement; organised volunteers, semiorganised individuals, and “non-organised” individuals
	Organisation/local government level	Awareness and preparedness
	Community level	• Recommendations are specifically developed for involv-ing the public in societal crisis management and thus en-hance community resilience 4 In's • Community empowerment • Potential voluntary engagement; organised volunteers, semiorganised individuals, and “non-organised” individuals
POP-ALERT	Individual level	A need to target information, and particularly the development of emergency planning, to key in to these identified personal priorities and challenge the perceptions of risk directly.
	Organisation/local government, Community level Individual level	• communications to communities are clear and well formed, but do not take responsibility away from communities. • effective communication between authority groups (governmental and public institutions)

5.3.2 BEST PRACTICE

The best practices presented in this section are identified from three different projects, i.e. PEP, DRIVER and POP ALERT. Many of them are existing best practices or guidelines in different countries where EU can learn from, while few of them are project recommendations. Most of the projects identified these best practices are to compare, how different countries built resilience in the early warning and preparedness phases.

Table 57 Best Practice in Community and Crisis Communication

Project	Focus	Best Practice
PEP	Community Resilience	Examples of best practices in **preparedness phase** • Cold Weather Plan for England • Www.gov.uk/government/publications/cold-weather-plan-for-england-2013 • Emergency 2.0 Wiki Http://emergency20wiki.org/wiki/index.php/Main_Page • Before the storm, an educational game to get them thinking about storm preparation and disaster resilience/ Australian Emergency Management Institute, Http://www.em.gov.au/Resources/Pages/Before-the-Storm-phone-game.aspx • American Red Cross smart phone applications: get ready, get notified, find help: http://www.redcross.org/prepare/mobile-apps Examples of best practices in **early warning phase** • Fire Ready app, Australia http://www.cfa.vic.gov.au/ • Flood warning system, Germany www.hochwasserzentralen.de/ • A community based Facebook group for flood update in Australia: https://www.facebook.com/#!/ • Pages/SEQ-Flood-Update/191689447509987?Fref=ts • The Federal Emergency Management Agency (United States) provides FEMA mission-related information on Twitter: @fema
POP-ALERT	Crisis communication resilience	**Principles** • Selfhelp and creating awareness when attempting to convey critical safety messages. • To prepare societies to cope with crisis in an efficient way by blending traditional preparedness and first action strategies with the use of innovative contemporary tools. • Resilience is multi-faceted and requires the shared efforts of the various authorities and the public. Best practice of alert system in **different countries**: • The Integrated Public Alert and Warning System (IPAWS) program of the U.S. Federal Emergency Management Agency • UK National Mobile Alerting Trials • Extended Floodline Warning Direct Trial • National Steering Committee on Warning & Informing the Public UK • (RM112) Emergency Centre Murcia, Spain • National Centre for Mountain Slide Surveillance Norway

		• floodex the Netherlands • NL Alert • Greece: Variable Message System and Hercules Shield • France: Population Alert • Israel: evigilo – SMART: Scalable Messaging Application in Real Time • Australia: A Standard Emergency Warning Signal (SEWS) • Japan: J-Alert • Canada: CANALERT • Mozambique: The Famine Early Warning System Network (FEWS NET)

5.4 METRICS AND INDICATORS

The PEP project targets the enhancement of the citizen response especially in the use of social media and mobile service. Thus the proposed indicators is based on this project focuses on public resilience (Vos et al., 2014). The paper explores the role of local communities in crisis preparedness and response, and investigates a way to involve the citizens in crisis situations. The framework used to identify or measure the enhancement of community resilience are as follows:

Table 58 Community Resilience Framework

Report	Indicators
Enhancing Public Resilience: A Community Approach (PEP)	• Individual responsibility (engage, to act, and to be prepared), • Preparedness (education, training and exercises), • Collaboration (between the general public, voluntary organisations,and public authorities/ local councils), • Communication (voluntary organisations-public authorities/local councils), • The role of civil society (e.g. should we expect civil society to be more involved, or involved in alternative ways?) • Real-life experiences (good and bad examples of collaboration, communication).

One of the PEP project deliverables discusses community approaches that include the public in crisis management. PEP suggests a way to foster community resilience through coproduction by response organisations and citizens. There are wide ranges of themes that are important for achieving community resilience, but they are not so specific discussed as metrics or indicators for resilience, and thus, are not incorporated here.

emBRACE surveys different categories of resilience and their of indicators (Birkman et al., 2012). The summary of the indicators is as follows:

Table 59 Indicators related to the community resilience, identified in emBRACE project

Context of Resilience	Indicators
Socio-ecological resilience	• learning, • sharing, • re-organisation, • preservation of knowledge and re-sources, • diversity, human capacity, • and information and networking.
Psychological resilience	• (1) individual socio-demography, (2) individual resources, (3) community resources, (4) preparedness and mitigation, (5) social support, (6) personality, (7) spirituality, (8) disaster impact severity, (9) disaster experiences, (10) coping appraisals, (11) positive adjustment, and (12) positive emotions.
Critical Infrastructure	• robustness, • rapidity, • redundancy, and • resourcefulness Note that emBRACE put notes that how exactly the CI relates to resilience of the communities need further examination
Community resilience (Cutter, 2010)	• social (e.g. age, transportation access, telephone access, language competency) • economic (e.g. housing capital, employment, income and equality, health access) • institutional (e.g. mitigation, insurance, experience), • infrastructural (housing type, shelter capacity, medical capacity, evacuation potential'), • ecological, and community (place attachment, political engagement, social capital, religion, civic involvement, advocacy)
Community Resilience (Norris et.al (2008)	• Adaptive Capacity • (1) economic development, (2) social capital, (3) information and communication, and (4) community competence. • The key indicators for community resilience include: (1) resource volume and diversity, (2) resource equity and social vulnerability, (3) network structures and linkages, (4) social support, (5) community bonds, roots, and commitments, (6) systems and infrastructure for informing the public, (7) communication and narratives, (8) collective action and decision-making, and (9) collective efficacy and empowerment.
emBRACE (summary and synthesized of 81 componets of resilience identified in the project)	1. Governance (Actors, Institutional Arrangements, Organisations) 2. Education, Research, Awareness and Knowledge 3. Information and Communication 4. Culture and Diversity 5. Preparedness 6. Response 7. Protection 8. Exposure, Experience and Impact Severity 9. Resources 10. Infrastructure and Technical 11. Health and Well Being/ Livelihood 12. Economic 13. Adaptive Capacity 14. Coping Capacity 15. Innovation and Capital

DRIVER project also explore the Community Resilience (Scott Davis et al., 2015). As discussed in Section 5.2.7, the report views community resilience from a systems perspective, and assumes that community resilience comprises a multi-dimensional, complex concept. It encompasses capacities allowing practitioners to address and strengthen component parts of community resilience through quantitative measurement tools, scorecards and qualitative methods. The project examines seven frameworks/tools for community resilience as follow:

- Community Disaster Resilience ScoreCard (CDRS) from Torrents Institute,
- The Community Resilience Manual (CRM) from Canadian Centre of Community Renewal,
- Queensland Resilient Profile Framework (CRPF),
- DROP Model and Disaster Resilience Indicators (DMDRI),
- Communities Advancing Resilience Toolkit, (CART),
- Community Engagement Theory (CET) and
- Community Resilience Performance Measurement Methodology and Standard Indicators (CRPMMSI).

Community resilience indicators identified in DRIVER project based on the aforementioned frameworks are as follow:

Table 60 Indicators of Community Resilience

Frameworks	Indicators
CDRS (Torrens Institute 2012)	Covers 22 indicators and four domains of resilience: • Community connectedness • Risk and vulnerability • Planning and procedures • Available resources
CRM (Canadian Centre of Community Renewal 2000)	Covers 23 indicators and four characteristics of resilience: • People in the community; • Organisations in the community; • Resources in the community; • Community process.
QRPF (Malcolm 2012)	Approximately 70 resilience indicators under six domains: • Healthy, safe and inclusive communities, • Dynamic, resilient local communities, • Sustainable built and natural environments, • Culturally rich and vibrant communities, • Democratic and engaged communities, • Demography
DMDRI	• Social resilience; • Economic resilience, • Institutional resilience; • Infrastructure resilience; • Community capital
CART	No of indicators > 50 divided/ categorized into: • Connection and caring;

(Pfefferbaum et al. 2013)	• Resources; • Transformative potential Disaster management Data fields for the community profile amongst others include: demography, household, housing, education & libraries, business & economy, transportation, health & human services, interest based, organisations, media & internet, voluntarism, criminality, recreation
CET (Paton 2013)	No of indicators not known; they are divided into multi-level areas as follows: • Individual factors (beliefs, place attachment, responsibility, skills, knowledge, etc.); • Social / Community factors (sense of community, leadership, social support, participation, etc.); • Institutional/Environmental Factors (legislation, trust, resources, government)
CRPMMSI (IFRC 2014)	Seven dimensions of resilience identified: • Human; • Physical; • Economic; • Environmental; • Social; Institution/ Governance; • External Resources

The project decided to choose Community Engagement Theory (CET) and The Community Advancing Resilience Toolkit (CART) as the participatory method toolkit to inform the design of resilience awareness-raising model, which is tailored with Red Cross resilience thinking.

5.5 CONCLUSIONS OF SD LITERATURE

The social dynamics term is applied and discussed in the three areas: First, social issues that triggers social disruption and social unrest in the cities such as urbanization, poverty, unemployment, asylum seekers and integration, and social vulnerability. Second, we treat the social dynamics in term of problems that affect human due to climate change such as disease, health, and human adaptive capacity. Third, we discuss the human and social dynamics in crisis and disaster situations in terms of how the resilience plays a role in this context. It is seen from the perspective of individual and community resilience.

We also identify the common topics and approach to resilience in Social dynamics literature and typical problems in each problem: urbanization, poverty and unemployment, refugee and integration, terrorism and social unrest, health and human adaptability to CC, social vulnerability, and individual and community resilience. Typical urban problems identified are the increasing economic and financial cost of disasters. In addition, the density of infrastructure and number of people living in at-risk areas, disparities in wealth and socio-economic status, and intensified land use and increasing conflicts between socio-economic land use and hazard mitigation policy. There is a clear need for better understanding of interrelations and social dynamics of risk perception, preparedness, and impacts. In addition, there is a realization of the importance of the intangible impacts of natural hazards and disasters and the need for increased post-disaster support and recovery.

6 TOWARDS EUROPEAN DIMENSION OF URBAN RESILIENCE

6.1 INTRODUCTION

In chapter 2-5, we presented the overview of different EU sectorial approaches and scientific literature where resilience is referring to the following three problem areas: Critical Infrastructure (CI), Climate Change (CC) and Social Dynamics (SD). In this Chapter 6 we examine, how "urban" has been considered in the European context so far, and how the Smart Mature Resilience project can contribute and create a "resilience backbone" for Europe. The focus of this section is as follows:

- "Urban Concept": in particular how cities have been represented and projected within EU policies
- Proposal to strengthen the EU dimension of city resilience, derived from resilience's elements and dimensions that have been captured in chapter 2-5.
- Summary of "keywords" collected from general definitions of resilience, filtered through EU project literature; additional proposal on working definition of different resilience dimensions.
- Summarize the Key Findings and Implications for the Project

6.2 EXISITING URBAN ELEMENTS IN EU POLICIES

As mentioned in Chapter 2, there is no direct EU urban policies, but historically, there have been implemented various programs, initiatives and policies to provide a vision, picture and shape of the"urban" elements in Europe. We identified that urban aspect occurs in the context of Green cities, as Open cities, as Resilient cities, as Innovative cities and Creative cities. In addition, cooperation and exchange of experience between cities has been laid down as part of the EU Urban Agenda. By recognizing this we ensure that the SMR contribution is highly relevant and fills the gap between existing policies and approaches to the cities in Europe. In the next section, we summarize the perspective on Green Cities, Open Cities, Innovative-Creative Cities, Cooperation between Cities and Resilient Cities.

Green Cities represent ideas, policies, initiatives and projects within sustainable urban mobility environmentally friendly cities, and cities that targeting zero CO2 emissions. Thus, the focus lies upon measures and policies on: controlling urban pollution, improving the air quality, promoting urban sustainability and intelligent mobility, and increasing the amount of green spaces in cities. The use of

environmentally friendly transport and sustainable products is highly emphasized. The establishment of targets and limits for different pollutants can be used as a tool to control air quality, as well as waste management and urban wastewater treatment. Initiatives at city level have been initiated; for example, the Covenant of Mayors aims among other issues to significantly limit CO2 emissions. Energy efficiency for mobility, and also in the building sector and other areas that consume significant amounts of energy have been introduced.

Open cities focus on how to make buildings, cities and environments more age-friendly (to all age group). In addition, they focus on the implementation of EU integration policies, since cities are responsible for a wide range of services provided to migrants and they play an important role in shaping the interaction between migrants and the society that welcomes them. **Innovative and creative cities** highlight the richness and diversity of European cultures as a part of EU's aim for smart, sustainable and inclusive cities and stimulus for dynamism, creativity, and social inclusion.

Cooperations between Cities focus on platforms and initiatives aimed at improved cooperation between cities and at encouraging further exchanges of experience at the European and International levels. The examples of these initiatives include URBACT, Urban Development Network (UND), and International Urban Cooperation (IUC). URBACT is an European exchange and learning programme which promotes sustainable urban development, and it integrates the economic, social and environmental dimensions. The URBACT programme facilitates cities to collaborate in developing new, and sustainable solutions to major urban challenges. Currently, there are 7 000 people from 500 cities, in 29 countries, who have participated in the URBACT programme. Furthermore, the UDN consists of more than 500 cities/urban areas across the EU responsible for implementing integrated actions based on Sustainable Urban Development strategies 2014-2020 period; while IUC is intended to promote international urban cooperation. In brief, Europe's cities want to link up, build and share knowledge and solutions with other cities and regions.

Resilient cities, thus also the SMR's project focus is to extend city resilience toward overall European resilience. As mentioned earlier, in April 2013, the EU strategy on adaptation to climate change committed also to make Europe more climate resilient. The effects of climate change will have far-reaching consequences across Europe, and climate adaptation is needed to protect people, buildings, infrastructure, businesses and ecosystems. We have seen that policy, strategy and actions have been proposed or formulated. However, there is still lack of clarity regarding how city resilience is operationalised, implemented and measured, as now the SMR project wants to achieve.

6.3 TOWARDS EUROPEAN CITY RESILIENCE

We have already reviewed extensively in the existing European Policies and projects in the previously mentioned CI, CC and SD areas. In this section, we have synthesized some findings from the literature and try to propose them as a model of resilient dimensions.

6.3.1 SUMMARY OF DEFINITIONS AND DIMENSIONS OF RESILIENCE

Below there is a summary of resilience definitions of each dimension within the city context that have been extracted in Chapter 4 and 5. The summary of these tentative definitions will be used to illustrate the three models of resilience.

TENTATIVE DEFINITION OF EACH RESILIENCE DIMENSION

- **CI RESILIENCE from CI Literature**

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

- **CI RESILIENCE from CC Literature**

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

- **COMMUNITY AND SOCIAL RESILIENCE from CI Literature**

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

- **COMMUNITY AND SOCIAL RESILIENCE from CC Literature**

The capacity of individuals, communities or societies potentially exposed to hazards to adapt, be flexible, and bounce-back by resisting or changing behaviours, taking-up innovations, organising itself in order to continuously exist, reach and maintain an acceptable level of functioning and structure. This capacity also covers the capability to combat social vulnerability, enhance perceived risk, sense of responsibility, and learn from the previous hazards which can be improved through education and training.

- **URBAN OR CITY RESILIENCE from CI Literature**

The urban or city resilience consists of a mixture of resilient built-in environment, resilient design, resilient citizens, and resilient organisations. Resilient built environment should be designed, located, built, operated and maintained in a way that maximizes the ability of built assets, associated support

systems (physical and institutional) and the people that reside or work within these built assets, to withstand, recover from, and mitigate the impacts of extreme natural hazards and human-induced threats.

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

- **URBAN OR CITY RESILIENCE from CC Literature**

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

- **SOCIO-ECOLOGICAL SYSTEM RESILIENCE from CC Literature**

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

- **ORGANISATIONAL/LOCAL GOVERNMENT RESILIENCE from CI Literature**

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

- **ORGANISATIONAL/LOCAL GOVERNMENT RESILIENCE from CC Literature**

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

- **INDIVIDUAL RESILIENCE from CI Literature**

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

- **ECONOMIC RESILIENCE from CI Literature**

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

- **ECONOMIC RESILIENCE from CC Literature**

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

- **CBRNE RESILIENCE from CI Literature**

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

- **COMMUNICATION RESILIENCE from CI Literature**

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

- **FLOOD RESILIENCE from CC Literature**

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

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

The following terms have been used in our literature as a unit for building resilience

- Pan European resilience
- Urban/ city resilience. The terms such as space or spatial resilience are found to refer to city or urban area
- Urban built infrastructure resilience
- Flood resilience, ecological, socio ecological resilience
- Critical infrastructure, smartgrid, technical, communication resilience
- Cybersecurity resilience
- Chemical, Biological, Radiological, Nuclear and Explosive (CBRNE) resilience
- Economic resilience
- Organisational/ local government resilience
- Community/ societal resilience/ public/ neighbourhood resilience
- Individual resilience, psychosocial, psychological resilience
- Holistic resilience

Note that there are two terms i.e. “Holistic resilience” and “Pan-European” resilience in this list of dimensions. However, the notions of these two terms are not fully well defined as units of analysis.

6.3.2 SUMMARY OF KEYWORDS IN THE DEFINITIONS OF RESILIENCE

In Task 1.2 we have collected and filtered different definitions of resilience from different authors that have been cited in the selections of EU project deliverables. There are many definitions, with many coming from the same sources, and some try to adapt in accordance to the context (i.e. resilience to what? for example, the resilience to flooding). The definitions compiled in this section are presented as the collection of main keywords that are frequently used and become the main essence of resilience understanding. The reason is that many of these definitions are discussed already in T1.1, and analysed thoroughly. Therefore, we extract the main concepts from the definitions and try to find the occurrence of these set of keywords on all identified definitions from literature, to understand the common words describing resilience. We present two collections of keywords summarized in two charts: the first (Figure 46) is the keywords that were derived from CI literature (Section 6.4.1) and that the other (Figure 47) was derived from CC literature (Section 6.4.2).

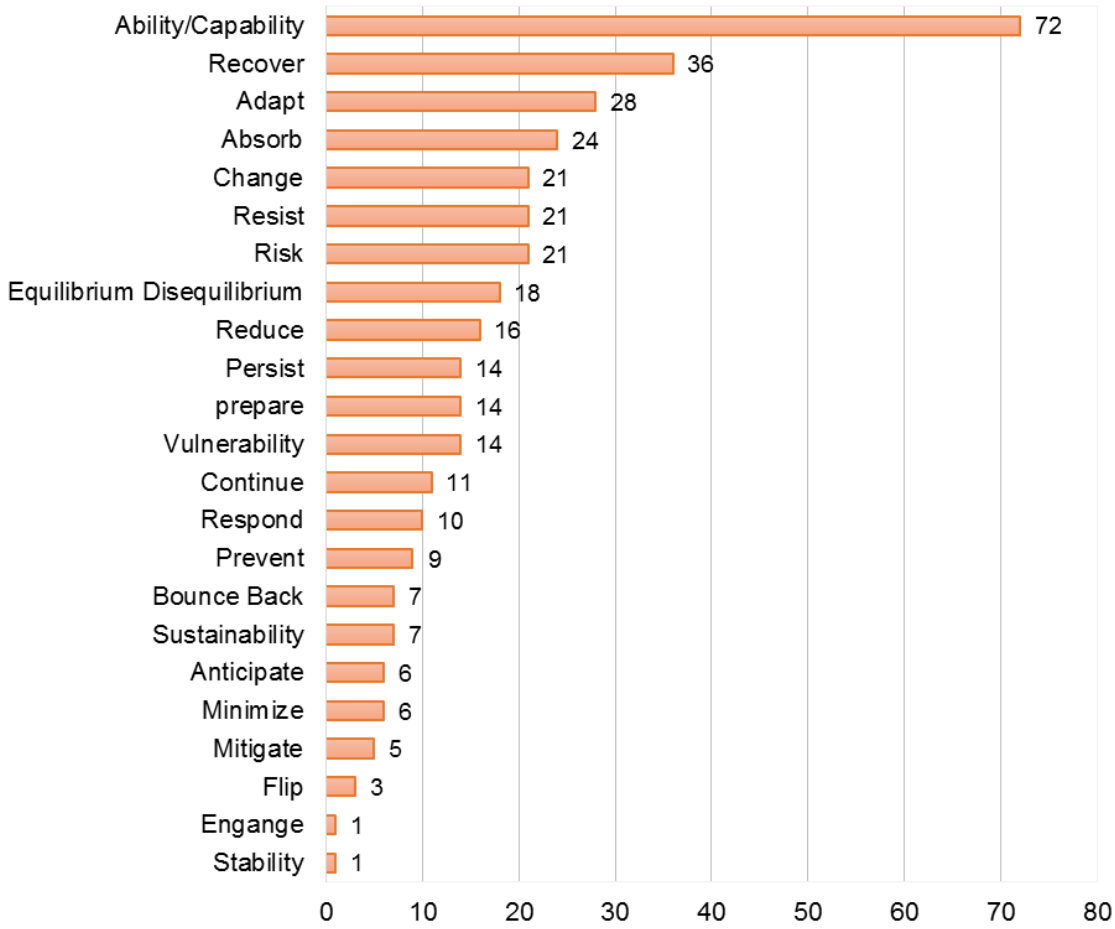

Figure 43 Common Keywords of Resilience Definitions cited in CI EU Project Reports / CI Literature

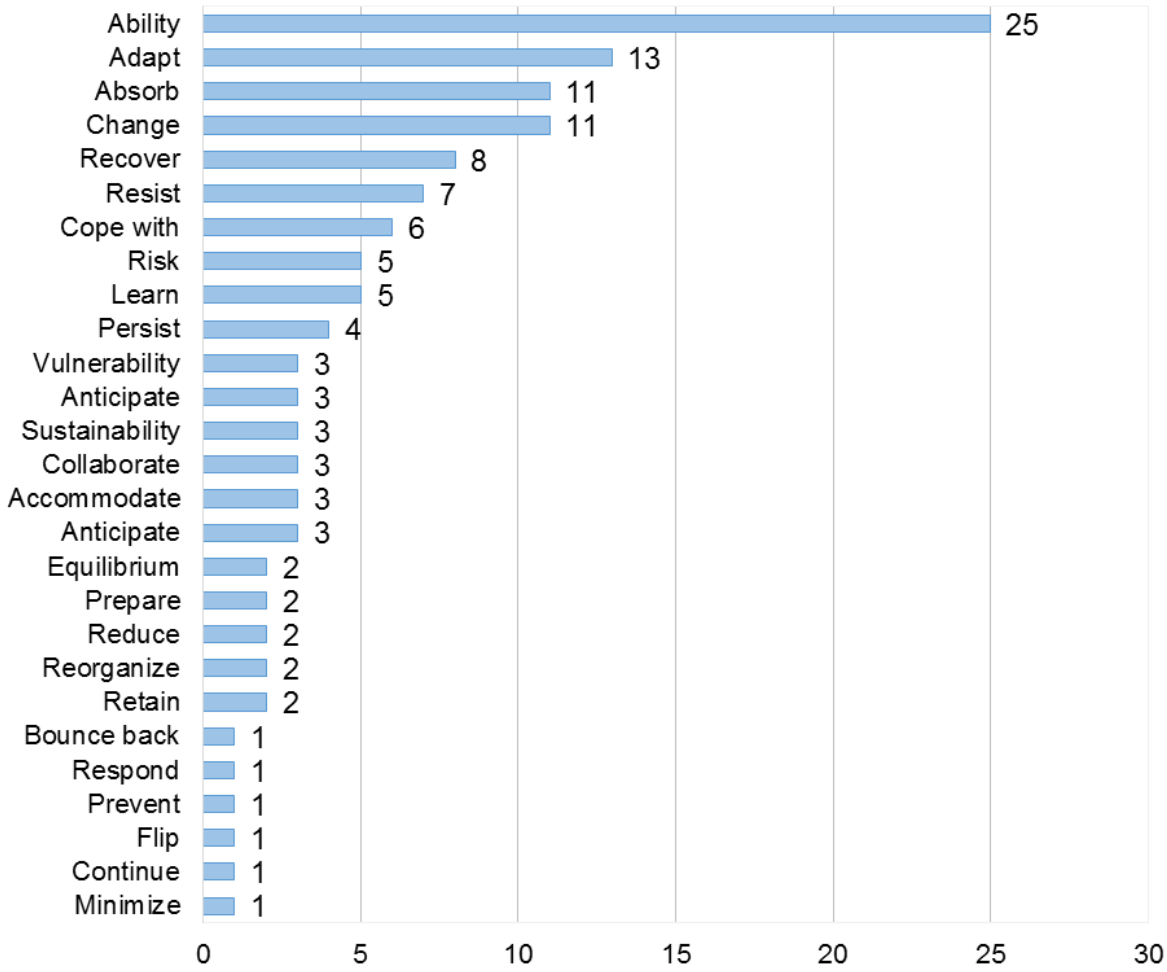

Figure 44 Common Keywords of Resilience Definitions cited in CI EU Project Reports / CI Literature

6.4 MODEL OF THE DIMENSIONS OF RESILIENCE

The basic idea of which dimensions should be included in the proposed resilient dimension model is based on the dimensions that have been identified in the CI, CC and SD literature. Frequently used concepts and definitions to describe resilience are reused for proposing three different models. Each model contains suggested elements to achieve European City Resilience:

1. **Model of Capacity:** ensuring all elements in a city, country, and Europe (actors, entities, environment, physical buildings, and infrastructures) are resilient. In this model, the crucial issue is **capacity** needed in different resilience dimensions.

2. **Model of Adaptive and Risk Governance:** Ensuring that risks, institutional arrangement, tasks, and responsibilities are distributed across sectors, actors, entities, and in different resilience dimensions, and geographical boundaries.

3. **Model of Networking and Learning**: ensuring that spread of resilience across dimensions, entities, actors and geographical boundaries are granted through networking, learning, and sharing circles.

The dimensions incorporated in these three proposed resilient models are based on the lists of elements included in the resilience definitions in different dimensions that have been identified in Section 6.3.1 and 6.3.2 below, and based on components and indicators that have been extracted in Chapter 2-5. These components and elements are mapped within these three models. Since there are enormous amount of resilience elements have been identified, the mapping cannot be implemented in one model, and therefore it is splitted into three models. These models are high level, comprehensive aggregation of big themes of resilience in the literature. Subsequently, identified elements of resilience are categorized into relevant, corresponding model, i.e. by analyzing if particular elements belong to “capacity”, “risk and governance” or “networking and learning”. In other words, the models complement to each other, and are not intended for comparison.

The models are shown in Figures 42-44. It is essentially an interaction of resilience of different components of the city’s system that eventually will be reflected as overall city resilience. In this model, the local government organisations are central as transition hubs towards resilience within the different dimensions of a city. All three models encompass the same elements. In the left side, there is an arrow depicting the efforts for establishing holistic resilience as we have described earlier. The three blocks in the middle represent different levels of governance: city level, national level, and international level. They also represent different stages of resilience: in the preparedness, response, recovery, and mitigation, as these emergency management stages are highly related to resilience. The ellipse above each block represents the continuous process of designing frameworks for managing, implementing, monitoring and improving resilience in each emergency management stage.

During the desk survey, various themes linked to resilience has been explored such as public-private partnerships, socio-ecological environments, and vulnerabilities, multilevel governance, adaptive

governance, social capacity, risk governance, risk communication and education, collaboration, mutual learning from experience, interdependencies between critical infrastructures, mobilization of social capitals, collaborative decision making, and more. In our models, we map necessary elements and their interactions found in the literature above and locate them in these three frameworks. These elements are represented by small arrows, which link different blocks of governance levels.

6.4.1 MODEL OF CAPACITY

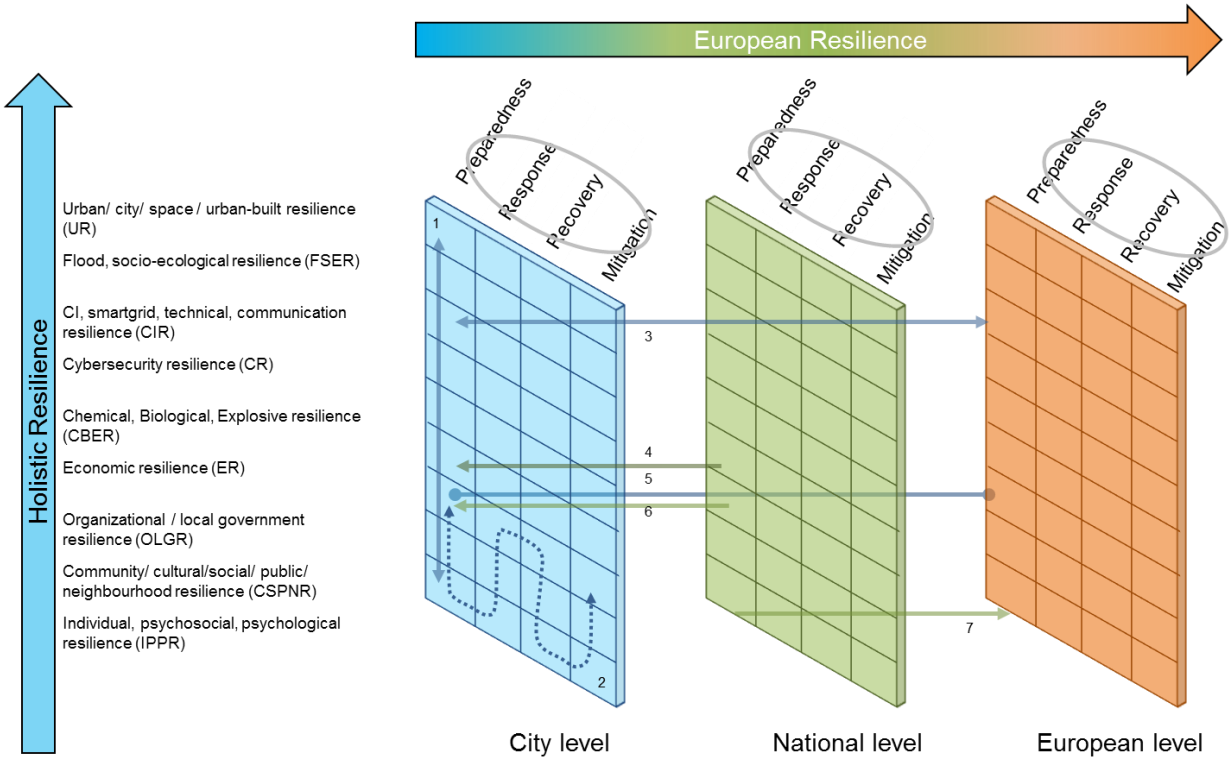

Figure 45 Model 1: Resilience Dimensions and Capacity

Model of Capacity describes *capacity* as a prerequisite for transforming resilience from the citiy-level to the European level. In this model, capacity refers to ability to receive, hold or absorb unexpected events in all elements of resilience (individuals, private and public entities, physical environments, buildings, and infrastructures) in a city, country, and Europe. Capacity is an important notion which, to a certain degree, captures the essence of resilience, as also seen in the charts in Fig 1. In model 1, the capabilities to withstand hazards should be developed in each unit listed on the left side of Fig. 43. The role of local government in the city level is very central and functions as glue for the resilience of other

units. The numbered arrows in Fig. 45 show the resilience elements linking cities, nations, and Europe. The number of each arrow represents the following aspects of capacity:

1 Representing the capacities that should be built and nurtured in each dimension. arrow 1 is located in the “preparedness” column as these capacities are instituted in the cities, which can be unique from place to place depending upon each city’s risk pictures. Examples of capacities found in the literature are summarized in the **capacity matrix** (see Table 61).

2 Representing the continuous interaction process between a local government with the community and the individual in all disaster phases: preparedness, response, recovery, and mitigation. The local government educates community and individuals about disaster preparedness and risk perception. Individuals develop self-resilience, ability to collaborate with neighbours and community, or even provide support during crisis to the local government. Community can help mobilizing resources and communicate among important entities in crisis.

3 Capability to understand CI dependencies, interdependencies and cascading effects within and across the sectors. arrow 3 is linked through the national and European level, as CI services such as power supply and energy production, transportation, and water are often linked closely to the national government and so they can encompass several European cities. failures at providing CI services can result in cascading disasters across other services that rely on this specific service, which can spread geographically beyond the national border, e.g. between cities nearby the national border. Alternatively, water pollution in a city, for instance, with time will probably cross the national border. Accordingly, arrow 3 also depicts the capacity to deal with these three governance levels with respect to CIs.

4 The capability of the national government to support economic resilience through various robust, supportive regulations where cities may be affected, especially the business entities.

5 Training and personnel exchanges across geographical boundaries as part of a preparedness plans to increase the capability of local government in emergency management and resilience building. It can enhance the capability to coordinate with national government as well as other European cities especially when respect to dealing with larger scale or cross-boundary disasters.

6 The capability of the national government to support the local government with necessary regulations, and to convey the EU strategies and guidelines such as “EU Domestic action on resilience” into action at the city level. This element will support further the city’s preparedness, as represented by the arrow 6.

7 The capability of national government to follow the development at the EU level and to bring local initiative and interest into EU policies; capacity to make international agreement in the area of resilient cities; capability to harmonise resilience policy with other EU member states.

In this model, the capabilities to deal with hazards should be developed in every dimension listed on the left side of the figure. The role of local government at the city level is very central and plays a connecting role for different parts of the resilience dimension. A way to develop city resilience that links to the national and European level where the numbers below refer to the numbered lines in Figure 43, is as follows.

1. Representing **capability matrix** (see Table 61) that shows the link between each dimension and what kind of capability should be developed.
2. Representing the continuous interaction process between local government with the community and the individual. The local government educates community and individuals about disaster preparedness and risk perception. Individuals develop self-resilience, ability to collaborate with neighbours and community. Community can help to mobilise resources and communicate in crisis.
3. Capability to understand CI dependency, interdependency and cascading effects
4. Capability of national government to support economic resilience through regulations
5. Training and exchange across geographical boundaries to increase capability of local government in emergency management and resilience building
6. Capability of national government to support local government with necessary regulations, to convey the EU spirit into action at city level
7. Capability of national government to follow the development in the EU level and to bring local initiative and interest into EU policies; capacity to make international agreement in the area of resilient cities; capability to harmonise resilience policy with other EU member states

The capability matrix mentioned in point 1 (Table 61) shows the required capabilities in different dimensions, (from, to or within the dimension itself).

Table 61 Capability matrix

FROM DIMENSION \ TO DIMENSION	UR	FSER	CIR	CR	CBRNE	ER	OLGR	CSPNR	IPPR
UR	Adapting built-environment	Adaptive to extreme weather	Less hazard prone CI location	Secured by design Urban CIs	minimizes CBRNE events	Urban economy keep adapt to threats	Built assets support institutional	Built assets support Community	Built assets support safe environment
FSER	Robust to flood and to other natural and ecological threats	Adaptive to ecological threats and dependencies	Resilient CIs to ecological threats		Recover from CBRNE events that affect environment				
CIR	Robust ICT support		dependency			Robust ICT support	Robust ICT support	Robust ICT support	Robust ICT support
CR	Robustness to cyber-attacks on ICT based CIs		Robustness to cyber-attacks on ICT based CIs	Minimize dependency, cascading effects		Robustness to cyber-attacks on ICT based CIs	Robustness to cyber-attacks on ICT based CIs		
CBRNE	Capacity to detect event						Robust tech to provide alerts		
ER	Adaptive to economic stress					Cost and losses	Adaptive to economic stress	Adaptive to economic stress	Adaptive to economic stress
OLGR	Regulations, resilience budget, technology	Technology support, robust spatial design, Advice for resilient technology usage	Minimize interdependency risk and impacts, Sustainable CIs, Securing CIs	CR events or know resource to contact	Detect and respond CBRNE event or Know resources to respond CBRNE	Regulations	Support relevant entities Capability for PuP, collaborate, share, learn, network, leadership	DRR education PPP Awareness education	Risk education Support counselling Advice for resilient technology usage
CSPNR	Proactive to urban events	Adaptive to ecological threats	Securing CIs	Prevent, respond and recover from CR events	Detect and inform abnormality	Adapt and recover from economic events	Mobilise resource To inform local authorities	Risk and resilient culture, learn, share, self-organise	Cooperate, support indviduals
IPPR	Risk perception, self-resilience	Risk perception, self-resilience	Risk perception, self-resilience	Inform abnormality	Inform abnormality		Support, engage, volunteering	Build cohesion, In-form abnormality	Self-resilience

UR: Urban Resilience; **FSER**: Flood, Socio-Ecological Resilience; **CIR**: Critical Infrastructure Resilience; **CR**: Cyber Security Resilience; CBER: Chemical, Biological, Explosive Resilience; ER: Economic Resilience; **OLGR**: Organisational/ Local Government Resilience; **CSPNR**: Community, Cultural, Public, Neighbourhood Resilience; **IPPR**: Individual, Psychosocial; Psychological Resilience

We notice mutuality or reciprocal relations between each dimension in terms of capacity; and therefore, a matrix of resilience capacity is introduced here, which is again derived from the elements extracted from literature identified in Chapters 3-5. The capacity matrix mentioned in point 1 (Table 61) shows the required capabilities with respect to different dimensions of capacity (from, to or within the same dimension). The heading “Capacity from Dimension” in the left part of the Table illustrates the capacities needed in different resilience dimensions included in model 1. The heading “To Dimension” in the upper part of the table represents the intended focus or application area of the resilience capacity building. For example, the box linking OLGR (Organizational/ Local Government Resilience) dimension column and UR (Urban Resilience) dimension row, contains “Regulations, resilience budget, technology”. It is read as the capacity of organization or local government to provide regulations, resilience budget and technology that will strengthen the resilience of the urban environment.

6.4.2 MODEL OF ADAPTIVE AND RISK GOVERNANCE FOR RESILIENCE

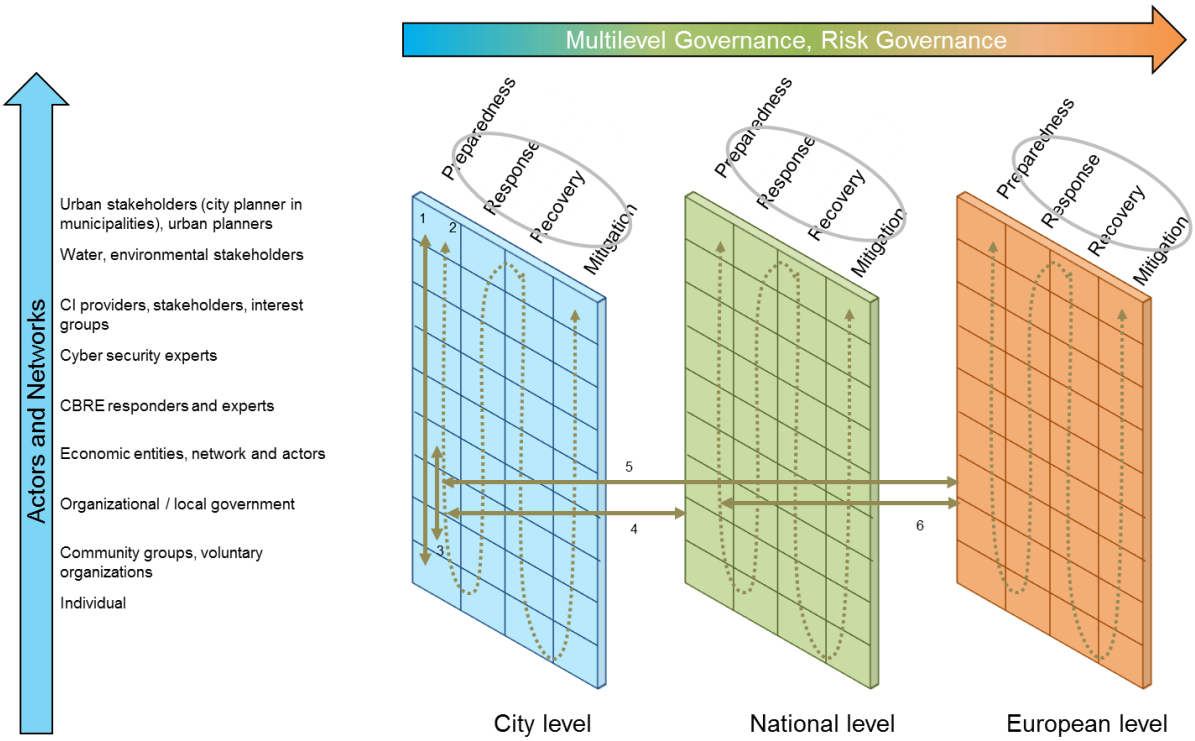

Figure 46 Resilience dimensions and governance (Model 2)

This second model in Fig. 46 captures the adaptive governance, risk governance, and multilevel governance. The upwards arrow on the left side represents the actors and networks in each

corresponding resilience, while the right arrow dimension captures the notion of risk governance, and multilevel governance at different levels. Firstly, Governance is a continuing process through which conflicting or diverse interests may be accommodated, and co-operative action may be taken. It includes formal institutions and regimes empowered to enforce compliance, as well as informal arrangements that people and institutions either have agreed to or perceive to be in their interest (CGC). Secondly, Risk governance looks at the complex networks of actors, rules, conventions, processes and mechanisms concerned with how relevant risk information is collected, analysed and communicated, and how management decisions are taken. And thirdly, Multilevel governance refers to a creative process in which both authority and policy making influences are shared across multiple levels of government. Similarly to the Fig. 45, the numbered arrows (Fig. 46) depict relevant elements found in the literature with respect to governance. The number of each arrow represents the following ideas:

1. The arrangement of risk and responsibility sharing among various local stakeholders at different dimensions. arrow 1 is located in the “preparedness” column as an arrangement in a city can be established in and between different actors in different dimensions of resilience. The common interest could be the basis for this, with the common goal to increase preparedness.
2. Participations among actors in different groups (city, national, European levels) and communication between them on the arrangement as represented by each arrow in each governance level covers all different identified stakeholders, in various stages of emergency management.
3. Risk perception, and sharing of responsibilities among local actors and stakeholders to minimize the potential negative impacts of the risks.
4. Trust of the regulatory framework for governance.
5. Risk perception, communication and sharing of responsibilities with national stakeholders and international stakeholders to minimize the potential negative impacts of the risks. Governance, Multilevel governance, Public-private partnership (PPP) and Public-public Partnership are ways to deal with the risk, which will be further discussed in the third model.
6. Representing facilitation for international agreement with respect to governance and shared responsibilities, particularly if the risks will involve international networks. International agreements, cooperation between nations, Regional, and local networks.

6.4.3 MODEL OF NETWORKING AND LEARNING FOR RESILIENCE

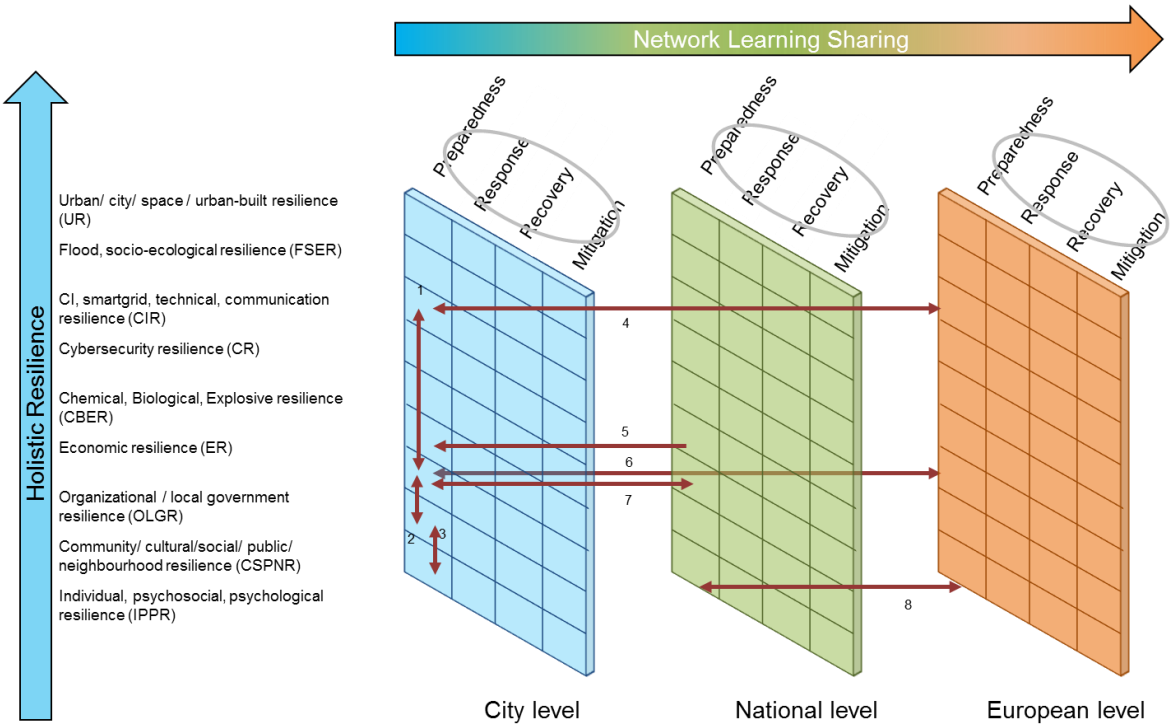

Figure 47 Resilience Dimension and Learning-Sharing Network (Model 3)

This model captures the networks of actors establishing the learning and sharing links in different parts of the dimensions of resilience. One of the networking models discussed in the literature is public-private partnerships (PPP) where the aim is to establish a kind of cooperation with respect to financing, constructing, renovating, managing and maintaining important infrastructures for society. The partnerships play an important role in implementing multilevel governance, and the numbers below refer to the numbered lines in Fig. 47:

1. Networking between local government and CI stakeholders-providers as well as economic entities through PPP. The partnership is voluntary but enforceable commitments between public authorities and private enterprises, which can be short-term or long-term. The partnerships are essentially founded on the principle of sharing the same goal in order to reduce risk and gain mutual benefit. Good partnerships comprise the integration of activities, shared vision,

consensus, negotiation, participation, collective action, representation, inclusion, accountability, volunteerism, and trust.

2. Public-public Partnership (PuP), where the focus is the partnership between public authorities and citizens in general, aiming at strengthening resilience through community engagements. It is represented by arrow 2. The form could be the community helping the local government through resource mobilization, or the local government updating and educating the community with respect to the resilience practices and actions.
3. Local community networks for emergency preparedness. These refer to self-organized communities, neighbourhoods, special interest groups and other local organizations initiated by and for the community. It is represented by arrow 3 that links the CSPNR and IPPR columns.
4. PPP in CI areas at European level, as represented by arrow 4. In this case, in the literature, CIs often are connected by interdependencies with other CIs, which are sometimes located geographically outside a country. Failure in one component or one CI can result in cascading failures in all other CI components or other CI sectors in other countries. Therefore, PPP does occur not only locally, but also nationally and internationally within the European region.
5. Facilitation from the national government to the local administration for networking with national actors. It connects economic sectors at local and national levels. The networking is intended for strengthening economic entities and businesses in various levels of government.
6. International and European resilient city networks, best practice sharing, as so far have been promoted through e.g. Durban Adaptation Charter, Mayor Adapt, world mayors council, Compact of Mayors.
7. Networking with national actors for emergency preparedness to increase resilience especially in facing of an escalated unexpected event, which is too big to be handled by local resources.

Overall, we argue that in order to integrate cities with the future European resilience backbone, resilience elements in all vertical dimensions should be accomplished, which then can be considered as holistic resilience. When a holistic city resilience is transmitted, replicated and referred as a role model across regions and nations, then the Pan-European resilience will gradually be attained.

6.5 KEY FINDINGS AND IMPLICATIONS FOR SMR

Key Finding 1

At a high-level, EU-Sectoral approaches have been defined as (relevant) ***EU Sectoral policies***. At this level, in fact, EU has no formal authority over urban policy, although some efforts have been initiated to foster the development of EU cities such as the regulation of improvements, creating workable financial instruments and creating a European platform for urban knowledge exchange, although it has been placed under the Regional and Cohesion policy. Some efforts have been initiated to put the Urban Dimension in EU policies. EU Urban "one stop shop" is launched and an overview of achievements in urban and city area are collected in a single page, but apparently none of them relate to city resilience. "Climate adaptation in cities" is the closest point found in this urban one stop shop that could be related to resilience.

Implications: To consider a policy or strategy that brings and promotes further the operationalisation of resilience concept as a management practice in a city setting, covering various services, stakeholders, and entities in the city. It is important that resilience is not perceived as just one aspect of climate change, but also a part of the discourse in Urban Dimension of EU policies.

Key Finding 2

Currently the European Urban Agenda is more about a joint effort of the EU Commission, Member States and European Cities Networks to strengthen the recognition of the urban dimension by European and national policy actors.

Implications: To consider policies or strategies that can promote resilient cities among European Cities Network, and EU Urban Agenda.

Key Finding 3

There are some active networks already for knowledge and experience sharing between cities regarding sustainable urban development, involving a significant number of city participants (approximately 500 cities) from different countries in Europe such as URBACT, UDN, and IUC.

Implication: The network of learning and sharing of resilience "best practice" is also an important finding from the literature review. In addition to considering existing networks dealing with resilience, the sustainable urban development networks can also be taken into the account when promoting the idea of the resilient city.

Key Finding 4

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

Implications: At the higher level of EU sectorial policies, resilience concept is known but fragmented across different sectors, and is not always connected to the unexpected events and disaster preparedness, neither is it a part of managerial practice. EU resilience management guidelines can be a way to integrate different EU sectorial policies and to build a comprehensive disaster resilience framework that is applicable for different EU sectors with a city at a core.

Key Finding 5

EU sectorial policies are very general, and therefore the complementary bottom-up approaches are needed to help us operationalize the concept of resilience and disaster resilience. In this report, we defined it as the review on research products that explored the-state-of-the-arts, implementations, and applications of resilience in different EU joint research projects that will eventually contribute to meet the goals of relevant EU policy sectors. The review focuses on Critical Infrastructure, Climate Change, and Social Dynamics. A set of resilience definitions, resilience dimensions, best practices, indicators has been identified.

Implications: The indicators identified in this review can be transferred further for defining indicators of Resilience Maturity Model and System Dynamics modelling tool. The set of resilience definitions will strengthen and confirm the resilience definition proposed in this SMR project. The collection of best practices referred in the literature can be used further to help in the operationalization of EU resilience management guidelines. The standards referred in the literature will help to identify further relevant standards in the standardization activities. The identified resilience dimensions and their detailed components can be used for building a comprehensive framework as how to build “resilience backbone”.

Key Finding 6

The majority of resilience dimensions derived from the top down approach is in line with the results obtained from the bottom-up approach. From the top down approach, we found the following dimensions: city (climate change), individual, ICT and transport infrastructure and societal resilience. From the bottom up approach we found: Pan European resilience, urban/ city resilience, urban built infrastructure resilience, flood resilience, ecological, socio ecological resilience, Critical infrastructure, smartgrid, technical, communication resilience, cybersecurity resilience, CBRNE resilience, economic resilience, Organisational/ local government resilience, community/ societal resilience/ public/ neighbourhood resilience, Individual resilience, psychosocial, psychological resilience and holistic resilience. Thus, we identified the resilience dimension vertically (from individuals to urban or city level), and horizontally (the link between cities, national government and European environment).

Implications: Most of the resilience dimensions identified from the top down approach are also covered in the findings as part of the bottom-up approach, and thus they are complimentary. Having a good understanding of different dimensions of resilience and each component will help further at defining the "Resilience Backbone".

Key Finding 7

To bring resilience from the city level towards the future European resilience backbone, resilience elements in all vertical dimensions should be accomplished, which then can be considered as holistic resilience. When a holistic city resilience is transmitted, replicated and referred as a role model across regions and nations, then Pan-European resilience will gradually be attained.

Implications: To ensure most important elements of each dimension identified in this literature activities are reflected in the SMR products and tools.

6.6 INFORMATION USAGE

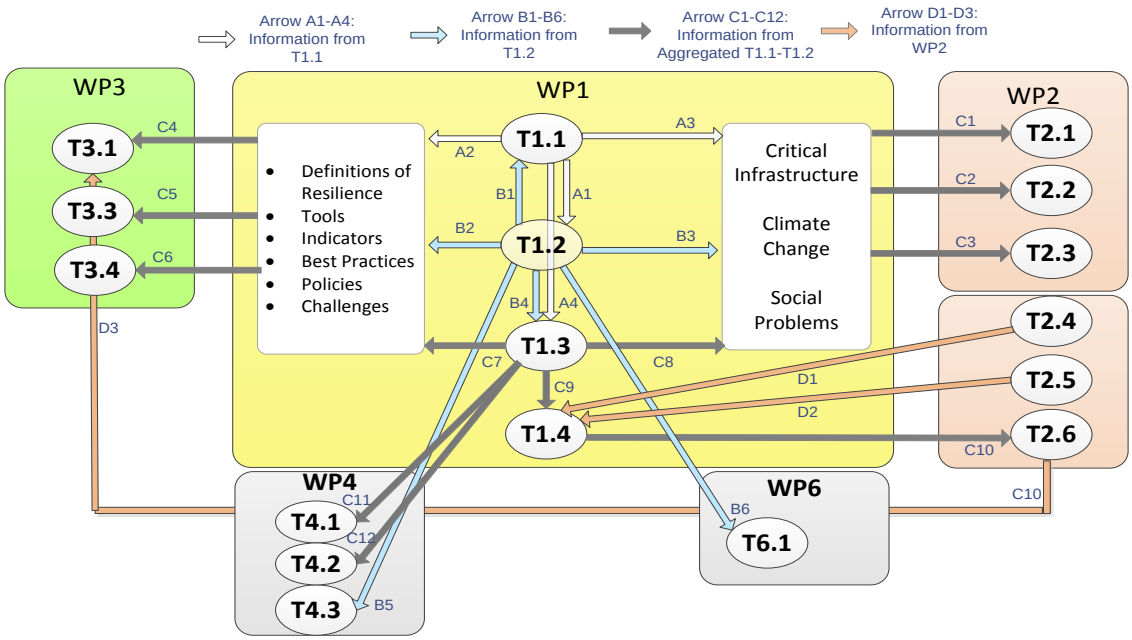

Figure 48 Information flow

This section explains the information flows between interrelated WorkPackages and Tasks that link directly with the Tasks as part of WP1. The diagram in Fig. 48 illustrates the results of WP1 that can be used in other WPs, especially WP2, WP3, WP4, and WP6. Each WP is depicted as a box consisting of corresponding tasks. The information usage is portrayed through a number of arrows linking different tasks:

- The white arrows (A1-A4) represent the information from T1.1 to other tasks,
- The blue arrows (B1-B6) represent the information from T1.2 to other tasks,
- The gray arrows (C1-C10) represent the information, after the findings in T1.1 and T1.2 were aggregated.
- The light orange arrows (D1-D3) represent the information from WP2 to other WPs including WP1.

The white boxes inside the WP1 show the main content of T1.1, T1.2, and T1.3. The A1-A4 relationship is explained in the D1.1 report. In this section, we will focus on the arrows B, C, and D.

- Arrow B1 connecting T1.2 and T1.1 indicates T2-1 cooperation and contribution for T1.1, especially in terms of tools, indicators, best practices, and policies.
- Arrow B2 to the white box in the left side: information extractions using top-down (i.e. by looking at EU sectorial policies) and bottom-up approach (by examining EU-funded projects). The aim is to gather information with respect to the definitions of resilience, indicators, best practices and policies and challenges.

- Arrow B3 to the white box in the right side: information extractions that focus on three problem areas: Critical Infrastructure, Climate Change, and Social Dynamics.
- Arrow B4 connecting T1.2 and T1.3 indicates the information summary flows from T1.2 to T1.3 to be used for report synthesize and further analysis.
- Arrow B5 connecting T1.2 and T4.3 indicates the information flow from EU project examination relevant for T4.3, especially EU projects that have included social media and community engagement as a part of the resilience strategies.
- Arrow B6 connecting T1.2 to T6.1 the information flow from EU project examination relevant for T6.1, especially EU projects that refer to specific standards that have been referred in the reviewed projects and deemed as relevant in the resilience context.
- Arrows C1, C2, and C3 represent the inputs and preliminary information from literature in the three problem areas: CI, CC and SD provided by T1.1, T1.2 and T1.3 in advance of each workshop preparation, i.e. T2.1 (CI), T2.2 (CC) and T2.3 (SD).
- Arrows C4, C5 and C6 represent the information consumptions from aggregated results obtained from WP1, for example, by aggregating the indicators from WP1 to the revised version of Maturity Model (T3.1), indicators needed for System Dynamics model (T3.4), and policies to be included in the Resilience building policies (T3.3).
- Arrows C7 and C8 represent aggregated, synthesized information in T1.3 that covers main findings from T1.1 and T1.2 (arrow C7), including the CI, CC, and SD problem areas (arrow C8).
- Arrow C9 connecting T1.3 and T1.4 indicates the information summary flows from T1.3 to T1.4 to be used for Delphi process and design.
- Arrow C10 connecting T1.4 and T2.6 indicates the information from Delphi process (T1.4) to be taken into account in the development of the maturity model (T2.6).
- Arrows C11 and 12 point to T4.1 and 4.2 specify the use of some findings such as resilience definition in WP4. In addition, since there are some overlapping with respect to the literature review in WP1 and WP4, the information exchange occurred here especially on feedback and share library resources and information extracting methods.
- Arrows D1 and D2 to T1.4 represent additional information and support for the Delphi Design (T1.4) especially from the results of the holistic resilience report (T2.4) and resilience requirements from the cities (T2.5).
- Arrow D3 connecting T2.6 to T3.1 represents the improvement of the maturity model in T2.6, which is not only based on Delphi process and other workshop activities in WP2, but also from the worldwide survey, EU sectorial surveys and synthesise reports.

6.7 CONCLUSIONS OF CHAPTER 6

In this Chapter 6 we summarize the “urban” dimensions in the European context such as Green Cities, Open Cities, Innovative Cities, and suggest and how the Smart Mature Resilience project can contribute further in the area of Resilient Cities and suggest a “resilience backbone” for Europe. We also summarize and synthesise the definition of resilience in different dimensions found in the CI and CC literature to ensure that current approaches to resilience are properly captured in our EU sectorial approach review.

We have proposed three different models of European City Resilience as a synthesis that can be used to operationalise further the resilience concept, i.e. model of capacity for resilience, Model of Adaptive and Risk Governance for Resilience, and Model of Networking and Learning for Resilience. These three models and each component are intertwined and will contribute spread to the city resilience building and to the state, and European level. Eventually, the European backbones for resilience are fully established, and resilience of city can be measured. At the end of the chapter 6, we provide a summary of “keywords” collected from general definitions of resilience, filtered through EU project literature; additional proposal on working definition of different resilience dimensions.

7 SUMMARY AND CONCLUSIONS

In this section we summaries the main findings from the three studies (1) systematic literature review of EU sectoral policies, European Projects and EU-Approach, (2) review of problem areas related to critical infrastructure, climate change and social problems (3) literature survey of the European approaches in the corresponding three problem areas.

Deliverable 1.2 (D1.2) is a report containing an analysis of European Sectorial approaches to resilience using the top down and bottom up approaches. At a higher level, the term “sector” is clearly applied and directly used by EU to refer to policies, and therefore, in the top down approach, we gathered overview of relevant EU sectoral policies and see how the resilience is referred in each sectoral policy. At the higher level of EU sectorial policies, resilience concept is spreaded across different sectors, and is not always connected to the unexpected events and disaster preparedness, neither is it a part of managerial practice. In addition, urban and city is not directly covered in EU sectoral policies as it is a part of EU Regional and Cohesion policy. Cities and resilience are central in the EU environmental policy, but the focus is climate change. A clearer agenda on EU cities is formulated in EU Urban Strategies. EU resilience management guidelines can be a way to integrate different EU sectorial policies and to build a comprehensive disaster resilience framework that is applicable for different EU sectors with a city at a core.

From the bottom-up approach, the report includes (1) a systematic literature review of three problem areas covered in SMR project: resilience in critical infrastructure (CC), climate change (CI) and social dynamics (CD), (2) a review of EU project reports both FP7 and H2020 in the area of Secure Societies and Climate Change related to resilience in these three problem areas and the city resilience is a part of the focus, and (3) repository of policies and best practices as well as metric and indicators identified from this review. The work in this deliverable has been aimed at a deepening our understanding of European dimension of. The report will provide a basis for the SMR project when operationalising the concept of resilience to a practical level and city context as a backbone for resilience of European cities.

Results from the work in this task show the different applications of resilience concepts in EU funded research projects in each problem area. The analysis in CI area shows the resilience is only used interchangeably or together with protection concepts, although there are more growing attention on the intertwined across CI sectors where the interdependencies and cascading effects play role. Most recent projects have started to include the concept of adaptive capacity to CC link to CI by, e.g. taking into consideration whether or not the CI facilities located in the hazard-prone areas. The analysis in CC

linking with resilience has started to include the governance and financing dimension into the resilience definition at the city level. In fact, operationalisation and measuring the resilience of the city is still lacking.

The social dynamics and resilience is also an elusive one when comes to implementation and operationalisation. The problems point into several directions: it is about adaptive capacity to CC and human health; it is about social vulnerability and how to increase social resilience of these vulnerable groups in the society, including how to integrate the asylum seekers into the European society, and it is about the individual ability to cope with and recover from hazards. In the end of this document we try to link all the most important dimensions and indicators that have been identified from the EU projects and policies with respect to these three problem areas, as a repository to build further the European Resilience Management Guidelines.

8 REFERENCES

Aaheim, A., Brown, D. C., Axhausen, K. W., Ciari, F., Stahel, A., Perrels, A., . . . Nokkala, M. (2013). Sector-level adaptation challenges in the literature.

Adey, B., Hackl, J., Heitzler, M., & Iosifescu Enescu, I. (2014). Preliminary Model, Methodology and Information Exchange: INFRARISK FP7 Project.

Adger, W. N. (2000). Social and ecological resilience: are they related? Progress in Human Geography, 24, 347-364. doi: 10.1191/030913200701540465

Adger, W. N., Agrawala, S., Mirza, M. M. Q., Conde, C., O'Brien, K., Pulhin, J., . . . Takahashi, K. (2007). Assessment of adaptation practices, options, constraints and capacity. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. In M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden & C. E. Hanson (Eds.), (pp. 717-743). Cambridge, UK: Cambridge University Press.

Adger, W. N., Brooks, N., Bentham, G., Agnew, M., & Eriksen, S. (2004). New indicators of vulnerability and adaptive capacity (Vol. 122). Norwich: Tyndall Centre for Climate Change Research.

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

Alexander, D., Barbat, A., Carreño, M. L., Kienberger, S., Miniati, R., Welle, T., . . . Glade, T. (2011). Handbook of Vulnerability Assessment in Europe.

Armaş, I. (2008). Social vulnerability and seismic risk perception. Case study: the historic center of the Bucharest Municipality/Romania. Natural Hazards, 47(3), 397-410.

Ashley, R., & Tait, S. (2012). Use of scenarios in PREPARED (pp. 33-33): PREPARED FP7 Project.

Avdeeva, Y., & van Gelder, P. (2015). Stress Test Methodologies: Infrarisk FP7 Project Report.

Batica, J., Gourbesville, P., & Hu, F. Y. (2013). Methodology for flood resilience index. Paper presented at the International Conference on Flood Resilience: Experiences in Asia and Europe, Exeter, United Kingdom.

Batica, J., Gourbesville, P., & Tessier, F. (2013). Methodology for Maturity of Flood Risk Management Frameworks Assesment – Application To Asian and European Cities. Paper presented at the International Conference on Flood Resilience Experiences in Asia and Europe – ICFR, Exeter, United Kingdom.

Billmaier, M., & Reinders, J. (2014). State-of-the-art in hazard and risk assessment of nonnuclear critical infrastructures: STREST FP7 Project.

Birkman, J., Changseng, D., Wolfertz, J., Setiadi, N., Karancı, N., İkizer, G. K., . . . Fordham, M. (2012). Early Discussion and Gap Analysis on Resilience: emBRACE FP7 project.

Birkmann, J., Buckle, P., Jäger, J., Pelling, M., Setiadi, N., Garschagen, M., . . . Kropp, J. (2009). Extreme Events and Disasters: A Window of Opportunity for Change? – Analysis of Changes, Formal and Informal Responses After Mega Disasters. Natural Hazards. doi: DOI 10.1007/s11069-008-9319-2

Björnberg, U. (2011). Social Relationships and Trust in Asylum Seeking Families in Sweden. Sociological Research Online. doi: 10.5153/sro.2286

Blaikie, P., Cannon, T., Davis, I., & Wisner, B. (2007). At Risk: Natural Hazards, People's Vulnerability, and Disasters. BMC Medical Research Methodology, 7.

Breivik, H., Endregard, M., Hege Schultz, H., Bastings, I., Peters, C., & Wevers, J. (2012). D2.3 Critical Event Parameters. from https://dl.dropboxusercontent.com/content_link/5KQRbOFwWdeq36npkfrM46SbptUxK9yYhJbk4kd1Bo0TIdGq1YbElvc3HsVjQ3nn/file

Bristow, E. C., & Brumbelow, K. (2013). Simulation to Aid Disaster Planning and Mitigation: Tools and Techniques for Water Distribution Managers and Emergency Planners. Journal of Water Resources Planning and Management. doi: 10.1061/(ASCE)WR.1943-5452.0000283

Bruyelle, J.-L., O'Neill, C., El-Koursi, E.-M., Hamelin, F., Sartori, N., & Khoudour, L. (2014). Improving the resilience of metro vehicle and passengers for an effective emergency response to terrorist attacks. Safety Science. doi: 10.1016/j.ssci.2013.07.022

Bucchignani, E., & Gutierrez, J. M. (2015). Definition of different EWIs, to support the management of European CI.

Budgen, D., Turner, M., Brereton, P., & Kitchenham, B. (2008). Using mapping studies in software engineering. Paper presented at the Proceedings of PPIG Lancaster University.

Carmona, M., Mañez, M., González, P., Calzada, R., Surminsky, S., Bayer, J., . . . Andreu, J. (2014). Deliverable 4.1: Working paper: Risk perception and risk cultures in Europe.

Carpenter, S., Walker, B., Anderies, J. M., & Abel, N. (2001). From Metaphor to Measurement: Resilience of What to What? Ecosystems, 4, 765-781. doi: 10.1007/s10021-001-0045-9

CGG. (1995). Our Global Neighbourhood: Oxford University Press.

Cheng, T., & Taalab, K. (2014). Deliverable D5.1 Integrated Spatio-Temporal Database: INFRARISK FP7 Project.

Chmutina, K., & Bosher, L. (2013). D2.2: tools for the assessment of the security threats: Desurbs FP7 Project.

Chmutina, K., Bosher, L., Ganor, T., Pinsly-Shach, D., & Turner, M. (2013). D2.1: Roles of Key Stakeholders: Desurbs FP7 Project.

Chmutina, K., Bosher, L., Rowlands, R., Clarke, J., Coaffee, J., Melas, P., . . . Sabeur, Z. (2014). D2.3: Generic Integrated Security and Resiliencedecision support framework: DESURB FP7 Project.

Choras, M., Kozik, R., Bruna, M. P. T., Yautsiukhin, A., Churchill, A., Maciejewska, I., . . . Jomni, A. (2015, 2015/08//). Comprehensive Approach to Increase Cyber Security and Resilience. Paper presented at the 2015 10th International Conference on Availability, Reliability and Security (ARES), Toulouse.

Clarke, J., Coaffee, J., Rowlands, R., Finger, J., Hasenstein, S., & Siebold, U. (2015). Resilience Evaluation and SOTA Summary Report.

Clarke, J., Rowlands, R., & Coaffee, J. (2013). D1.5: Urban Space Design Safety Scale: Desurbs FP7 Project.

Coaffee, J., Rowlands, R., Clarke, J., & Rydock, J. (2013). D1.1: Security incidents analysis: Desurbs FP7 Project.

Collier, M. J., Nedović-Budić, Z., Aerts, J., Connop, S., Foley, D., Foley, K., . . . Verburg, P. (2013). Transitioning to resilience and sustainability in urban communities. Cities, 32, Supplement 1, S21-S28. doi: http://dx.doi.org/10.1016/j.cities.2013.03.010

Costa, M. M., Carmona, M., Gee, K., Gerkensmeier, B., Ratter, B. M. W., Botzen, W., . . . Paudel, Y. (2013). Governance Indicators for (Un)succesful MSPs.

Costantini, L., & Thierry, P. (2012). Handbook for Volcanic Risk Management - Prevention, Crisis Management, Resilience (pp. 1-198): MIAVITA FP7 project.

Crowe, P., & Foley, K. (2013). The Turas Project: Integrating Social-Ecological Resilience and Urban Planning (pp. 1-15): TURAS FP7 Project.

Cutter, S. L., Burton, C., G., & Emrich, C., T. (2010). Disaster Resilience Indicators for Benchmarking Baseline Conditions Journal of Homeland Security and Emergency Management (Vol. 7).

Cutter, S. L., & Emrich, C. T. (2006). Moral hazard, social catastrophe: The changing face of vulnerability along the hurricane coasts. The Annals of the American Academy of Political and Social Science, 604(1), 102-112.

Cutter, S. L., Emrich, C. T., Webb, J. J., & Morath, D. (2009). Social Vulnerability to Climate Variability Hazards: A Review of the Literature: Hazards and Vulnerability Research Institute, Department of Geography, University of South Carolina, Columbia.

Davis, S., & Karikas, D. (2015). D.33.1. Community resilience model | Driver Project: Driver FP7 project.

Davis, S., Karikas, D., Kerstholt, J., Lindt, M. V. D., Duijnhoven, H., & Dinesen, C. (2015). Community Resilience Model (pp. 1-36).

de Bruijn, K. M. (2004). Resilience indicators for flood risk management systems of lowland rivers. International Journal of River Basin Management, 2(3), 199-210. doi: 10.1080/15715124.2004.9635232

Deeming, H. (2015). 2nd emBRACE EAG/ECG Session Brief: emBRACE FP7 Project.

DESURB. (2014). Urban Resilient Design Guidelines (pp. 62-62): Desurb FP7 Project.

EEA. (2012). Urban adaptation to climate change in Europe (pp. 1-146).

EEA. (2013). Adaptation in Europe - Addressing risks and opportunities from climate change in the context of socio-economic developments — European Environment Agency (pp. 1-136).

Eidsvig, U., & Tagg, A. (2015). SOTA of Modelling and Simulation Approaches, used currently to assess CI vulnerability, INTACT Deliverable D4.1 project co-funded by the European Commission under the 7th Frame-work Programme. Wallingford

Ekman, O., & Lange, D. (2014). Report of Incident Management in Crisis (pp. 1-34): CascEff FP7 ptoject.

Endregard, M., Breivik, H., Hege Schultz, H., Sandrup, T., Fonteyne, P.-A., & Eriksson, H. (2012). D2.2 Reference Set of CBRN Scenarios.

Felsenstein, D., & Grinberger, Y. (2013). D4.2 Urban Simulation Modeling, 4.3 Probability Estimation, 4.4 Optimization: Desurbs FP7 Project.

Ferreira, P., & Simões, A. (2015). State of the Art review and assessment report (pp. 1-87): Resolute H2020 Project.

Fischer, K., Riedel, W., Häring, I., Nieuwenhuijs, A., Crabbe, S., Trojaborg, S. S., . . . Müllers, I. (2012). Vulnerability Identification and Resilience Enhancements of Urban Environments. In N. Aschenbruck, P. Martini, M. Meier & J. Tölle (Eds.), Future Security: 7th Security Research Conference, Future Security 2012, Bonn, Germany, September 4-6, 2012. Proceedings (pp. 176-179). Berlin, Heidelberg: Springer Berlin Heidelberg.

Folke, C. (2006). Resilience: The emergence of a perspective for social–ecological systems analyses. Global Environmental Change, 16, 253-267. doi: 10.1016/j.gloenvcha.2006.04.002

Friedberg, I., McLaughlin, K., & Smith, P. (2015). Towards a Cyber-Physical Resilience Framework for Smart Grids Intelligent Mechanisms for Network Configuration and Security (pp. 140-144): Springer.

Geddes, A. (2001). Asylum in Europe: States, the European Union and the international system. Refugee Survey Quarterly. doi: 10.1093/rsq/20.2.59

Georgiades, S. (2009). Greek-Cypriot Refugees' Welfare a Third of a Century Following their Expatriation: Implications for Local and International Policy. Journal of Immigrant & Refugee Studies. doi: 10.1080/15562940802687256

Gouldby, B., & Samuels, P. (2005). Language of Risk: Project Definitions.

Haataja, M., Rantanen, H., & Sullivan, H. (2014). [Enhancing public resilience technology : a desk study].

Hagen, K., Tzanetakis, M., & Watson, H. (2015). Cascading effects in crises : categorisation and analysis of triggers. Proceedings of the 12th International ISCRAM Conference. Kristiansand, Norway.

Hallett, S. (2013). Community Resilience to Extreme Weather - the CREW Project. Final Report (pp. 110-110): CREW FP7 project.

Hammond, M. J., Chen, A. S., Djordjević, S., Butler, D., & Mark, O. (2015). Urban flood impact assessment: A state-of-the-art review. Urban Water Journal, 12, 14-29. doi: 10.1080/1573062X.2013.857421

HARMONISE. (2013). Action Plan of Report on Strategies and Actions Beyond the State of the Art: HARMONISE FP7 Project.

Hassel, H., Johansson, J., Cedergren, A., Svegrup, L., & Arvidsson, B. (2014). Method to Study Cascading Effects.

Hernantes, J., Rich, E., Laugé, A., Labaka, L., & Sarriegi, J. M. (2013). Learning before the storm: Modeling multiple stakeholder activities in support of crisis management, a practical case. Technological Forecasting and Social Change, 80, 1742-1755. doi: 10.1016/j.techfore.2013.01.002

Hofer, J., Dinesen, C., & Vinther-Larsen, L. (2014). Report on Risk Perception.

Holling, C. S. (1973). Resilience and Stability of Ecological Systems. Annual Review of Ecology and Systematics, 4, 1-23. doi: 10.1146/annurev.es.04.110173.000245

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

Höppner, C., Buchecker, M., & Bründl, M. (2010). Risk Communication and Natural Hazards.

IPCC. (2012). Managing Risks of Extreme Events and Disasters to Advance Climate Change Adaptation Special Report of the Intergovernmental Panel on Climate Change: Intergovernmental Panel on Climate Change

IPCC. (2014). Climate Change 2014: Synthesis Report: Intergovernmental Panel on Climate Change.

J. Raat, K., Menaia, J., & Sivertsen, E. (2014). Resilient Water Supply Resilient Water Supply Feedback from validation and: PREPARED FP7 Project.

Johansson, J., & Hassel, H. (2010). An Approach for Modelling Interdependent Infrastructures. Fire Safety Engineering, 95, 1335-1344.

Johansson, J., Svegrup, L., Arvidsson, B., Jangefelt, J., Hassel, H., & Cedergren, A. (2015). Review of previous incidents with cascading effects.

Johnston, M. C., Porteous, T., Crilly, M. A., Burton, C. D., Elliott, A., Iversen, L., . . . Black, C. (2015). Physical disease and resilient outcomes: a systematic review of resilience definitions and study methods. Psychosomatics. doi: 10.1016/j.psym.2014.10.005

Juen, B., Warger, R., Nindl, S., Siller, H., Lindenthal, M. J., Huttner, E., . . . Thormar, S. (2015). The Comprehensive Guideline on Mental Health and Psychosocial Support (MHPSS) in Disaster Settings.

Karanci, A. N., Ikizer, G., & Doğulu, C. (2015). Work Package 4 Archetypes of personal attributes & cognition for psycho-social resilience from narratives Deliverable 4.1: emBRACE FP7 project.

Katina, P. F., Ariel Pinto, C., Bradley, J. M., & Hester, P. T. (2014). Interdependency-induced risk with applications to healthcare. International Journal of Critical Infrastructure Protection, 7, 12-26. doi: 10.1016/j.ijcip.2014.01.005

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, 638-651. doi: 10.1016/j.infsof.2010.12.011

Kruse, S., Pelling, M., Espeland, T., Huq, N., Abeling, T., & Kuhlicke, C. (2012). Work Package 6 Report on the systematization of the emBRACE framework to the consortium emBRACE FP7 Project.

Kudlacek, D., Fiedrich, F., & Lukas, T. (2013). Deliverable D1.2 / Stakeholder Consultation Report Multi-disciplinary Engagement: Harmonise FP7 Project.

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

Kuhlicke, C., & Steinführer, A. (2010). Knowledge Inventory.

Kuhlicke, C., Steinführer, A., Begg, C., & Luther, J. (2012). Toward More Resilient Societies in the Field of Natural Hazards: CapHaz-Net's Lessons Learnt (pp. 1-76).

Kuhlicke, C., Steinführer, A., Tapsell, S., Faulkner, H., McCarthy, S., & Alexan, M. (2010). Social capacity building for natural hazards : A conceptual frame (pp. 1-50): CapHaz-Net FP7 Project.

Labaka, L., Hernantes, J., & Sarriegi, J. M. (2015). Resilience framework for critical infrastructures: An empirical study in a nuclear plant. Reliability Engineering & System Safety, 141, 92-105. doi: 10.1016/j.ress.2015.03.009

Lange, D., Sjöström, J., & Honfi, D. (2015). Losses and consequences of large scale incidents with cascading effects (pp. 1-43).

Luiijf, E., Nieuwenhuijs, A., Klaver, M., Van Eeten, M., & Cruz, E. (2009). Empirical findings on critical infrastructure dependencies in Europe. Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 5508 LNCS, 302-310. doi: 10.1007/978-3-642-03552-4_28

MacDonagh, P., Comer, M., Mackin, M., O'Byrnes, R., Elliot, A., McCarthy, S., . . . Christian, K. (2015). D35.1 – Analysis and review of existing crisis communication plans and strategies (pp. 1-98): Driver FP7 project.

Mäki, K., Forssen, K., & Vangelsten, B. V. (2015). Factors Contributing to CI Vulnerability and Resilience , INTACT Deliverable D3.2 project co-funded by the European Commission under the 7th Frame-work Programme, . Tampere, Finland. .

Matin, N., Taylor, R., Forrester, J., Pedoth, L., Davis, B., & Deeming, H. (2015). Mapping of social networks as a measure of social resilience of agents: emBRACE FP7 project.

McCord, M., Rodgers, J., Davis, P., Haran, M., & Berchtold, C. (2015). Deliverable D1.1 SOTA gaps, Taxonomy and Guidance Parameters for all WP's: INTAC FP7 Project.

McLean, L., & Guha-Sapir, D. (2013). Developing A Resilience Framework (Vol. 2015): ENHANCE FP7 Project.

Messner, F., & Meyer, V. (2006). Flood damage, vulnerability and risk perception–challenges for flood damage research: Springer.

Mignan, A. (2014). Report on lessons learned from on-going and completed EU projects: STREST FP7 Project.

Ouyang, M. (2014). Review on modeling and simulation of interdependent critical infrastructure systems. Reliability Engineering and System Safety, 121, 43-60. doi: 10.1016/j.ress.2013.06.040

Overland, G. J., & Yenn, V. (2007). Generosity and resilience: Transnational activity among the Khmer of Norway. Refuge.

Pelling, M., Sharpe, J., Pearson, L., Abeling, T., Gerger-Swartling, A., Forrester, J., & Deeming, H. (2015). Social Learning and Resilience Building in the emBRACE: emBRACE FP7 Project.

Petersen, K., Feldt, R., Mujtaba, S., & Mattsson, M. (2008). Systematic mapping studies in software engineering. Paper presented at the 12th international conference on evaluation and assessment in software engineering.

Pursiainen, C., & Gattinesi, P. (2014). Towards Testing Critical Infrastructure Resilience (pp. 1-39). Luxembourg.

Quarks, C. (2007). Project Summary: Harmonise FP7 Project.

Redman, C. L. (2014). Should sustainability and resilience be combined or remain distinct pursuits? Ecology and Society, 19(2). doi: 10.5751/ES-06390-190237

Rees, W. (2010). Whats blocking sustainability? Human nature, cognition, and denial. Sustainability: Science, Practice, & Policy, 6(2).

Reggiani, A., Nijkamp, P., & Lanzi, D. (2015). Transport resilience and vulnerability: The role of connectivity. Transportation Research Part A: Policy and Practice. doi: 10.1016/j.tra.2014.12.012

Renn, O. (2008). Risk Governance: Coping with Uncertainty in a Complex World. Natural Hazards, 48(2), 313.

Rigaud, E., Clemenceau, A., Engelbach, W., Wendt, W., & Dubner, S. (2015). Conceptual approach to resilience of local governments (pp. 1-117).

Rinaldi, S. M., Peerenboom, J. P., & Kelly, T. K. (2001). Identifying, understanding, and analyzing critical infrastructure interdependencies. Control Systems, IEEE, 21(6), 11-25.

Schwesig, D., Rochera, E. C., & Juan, E. E. (2015). Cities of the Future Conference Transitions to the Urban Water Services of Tomorrow (TRUST). MÜLHEIM AN DER RUHR, GERMANY. 28 - 30 APRIL 2015.

Seynaeve, G. (2001). Pycho-Social Support in situations of Mass Emergency: A European policy paper concerning different aspects of psycho-social support for people involved in major accidents and disasters.

Sherrieb, K., Norris, F. H., & Galea, S. (2010). Measuring Capacities for Community Resilience. Social Indicators Research, 99, 227-247. doi: 10.1007/s11205-010-9576-9

Skeie, G. (2014). Young people and the european dimension in a norwegian context. Migration and national critical events as challenges to citizenship education. Journal of Social Science Education. doi: 10.2390/jsse-v13-i3-1310

Staub, M., & Moreau-Le Golvan, Y. (2012). Catalogue of European adaptive initiatives of the water sector to face climate change impacts (pp. 98-98): PREPARED FP7 Project.

Swedish Civil Defence League (2004): The best knowledge of how to cope in vulnerable situations, Civilförsvarsförbundet (Civil Defence League), Solna, Sweden.

TACTICS. (2015). TACTICS: Tactical Approah to Counter Terrorists in Cities: TACTICS FP7 Project.

Tapsell, S., McCarthy, S., Faulkner, H., Alexander, M., Kuhlicke, C., Brown, S., . . . Bianchizza, C. (2010). Social vulnerability to natural hazards (pp. 524-524): CapHaz-Net FP7 Project.

Tilsner, D., & Arouca, D. (2009). Deliverable: D2.2: Desktop Study – Contingency Planning Methodologies and Business Continuity: EURACOM FP7 Project.

UNECE. (2009). Guidance on Water and Adaptation to Climate Change. Geneve, Switzerland: United Nations Economic Commission for Europe.

UNISDR. (2009). UNISDR Terminoology on Disaster Risk Reduction International Stratergy for Disaster Reduction (ISDR) (pp. 1-30).

Vangelsten, B. V., Mäki, K., Räikkönen, M., Schwab, M., Berchtold, C., Koops, O., . . . Eidsvig, U. (2015). Deliverable D3.1 Catalogue of EWE damaging CI. Report, database. from http://www.intact-project.eu/intact/assets/File/wp/D3_1_Catalogue_of_EWE.pdf

Villagrán de León, J. C. (2006). Vulnerability: a conceptional and methodological review: UNU-EHS, Institute for Environment and Human Security.

Vinchon, C., Carreño, M. L., Contreras-Mojica, D. M., Kienberger, S., Schneidebauer, S., Alexander, D., . . . Decker, B. Assessing vulnerability to natural hazards in Europe: From Principles to Practice A manual on concept, methodology and tools.

Vos, M., van het Erve, A., de Gouw, N., M, H., Hokkanen, L., Johansson, C., . . . Wall, E. (2014). Public Empowerment: Guidelines for engaging the public in crisis management (pp. 44-44): PEP FP7 Project.

Wachinger, G., & Renn, O. (2010). Risk Perception and Natural Hazard.

Walker, B., Gunderson, L., Kinzig, A., Folke, C., Carpenter, S., & Schultz, L. (2006). A handful of heuristics and some propositions for understanding resilience in social-ecological systems. Ecology and Society, 11(1).

Walker, B., & Salt, D. (2002). Resilience thinking.

Walker, G., Whittle, R., Medd, W., & Watson, N. (2010). Risk governance and natural hazards: CapHaZ-Net FP7 Project.

Walker, J., & Cooper, M. (2011). Genealogies of resilience: From systems ecology to the political economy of crisis adaptation. Security Dialogue, 42, 143-160. doi: 10.1177/0967010611399616

Wendler, R. (2012). The maturity of maturity model research: A systematic mapping study. Information and Software Technology, 54, 1317-1339. doi: 10.1016/j.infsof.2012.07.007

White, I., O'Hare, P., Lawson, N., & Garvin, S. (2013). Six Steps To Property Level Flood Resilience - Guidance for Property Owners (pp. 20-20): SMARTEST FP7 Project.

White, I., O'Hare, P., Lawson, N., Garvin, S., & Connelly, A. (2012). Barriers to Flood Resilience: Findings from the SMARTEST Project (pp. 11-11): SMARTEST FP7 Project.

White, I., O'Hare, P., Lawson, N., Garvin, S., & Connelly, A. (2013). Six steps to flood resilience - Guidance for local authorities and professionals (Vol. 414, pp. 1-46): SMARTEST FP7 Project.

Wilson, J., Murray, V., & Kettle, J. N. (2009). The July 2005 London bombings: environmental monitoring, health risk assessment and lessons identified for major incident response. Occupational and environmental medicine, 66(10), 642-643.

Wisner B, Blaikie P, Cannon T, Davis I. 2004. At Risk: Natural Hazards, People's Vulnerability, and Disasters, (2nd edn). Routledge: London.

ANNEX

LIST OF ACRONYM

SELECTED SECURE SOCIETY PROJECTS

Below in the list of project acronym and the explanation. Click the project abbreviation to reach the link to the project website. For completed projects where the original websites are not maintained anymore, the link will connect to the CORDIS website.

Table 62 List of Abbreviation in Secure Society Projects

Abbreviation	Project Title	Funding/Year
CAERUS	Evidence based policy for post-crisis stability: bridging the gap	FP7 2014-2017
CAMINO	Comprehensive Approach to cyber roadMap coordINation and develOpment	FP7 2014-2016
CascEff	Modelling of dependencies and cascading effects for emergency management in crisis situations	FP7 2014-2017
CBRNEMAP	Road-mapping Study of CBRNE Demonstrator	FP7 2010-2011
DESURBS	Desaining Safer Urban Spaces	FP7 2010-2014
DITAC	Disaster Training Curriculum	FP7 2012-2014
DRIVER	Driving Innovation in Crisis Management for European Resilience	FP7 2014-2018
EURACOM	EUropean Risk Assessment and COntingency planning Methodologies for interconnected energy networks	FP7 2009-2012
FORTRESS	Foresight Tools for Responding to cascading effects	FP7 2014-2017
HARMONISE	A Holistic Approach to Resilience and SysteMatic ActiOns to Make Large Scale UrbaN Built Infrastructure SEcure	FP7 2013-2016
IMCOSEC	IMprove the supply chain for COntainer transport and integrated SECurity simultaneously	FP7 2010-2011
OPSIC	Operationalising Psychosocial Support in Crisis	FP7 2013-2016
PEP	Public Empowerment Policies for Crisis Management	FP7 2012-2015
POP-ALERT	Population Alerting: Linking Emergencies, Resilience and Training	FP7 2014-2016
PRACTICE	Preparedness and Resilience against CBRN Terrorism using Integrated Concepts and Equipment PRACTICE	FP7 2011-2015
RIBS	Resilient infrastructure and building security	FP7 2010-2013
SECRICOM	Seamless communication for crisis	FP7 2008-2012
SLAM	Standardisation of Laboratory analytical methods	FP7 2012-2014
SPARKS	Smart Grid Protection Against Cyber Attacks	FP7 2014-2017
TACTIC	Tools, methods And training for CommuniTIes and society to better prepare for a Crisis	FP7

TACTICS	Tactical Approach to Counter Terrorists in Cities	FP7 2013-2015
VITRUV	Vulnerability Identification Tools for Resilience Enhancements of Urban Environments	FP7 2011-2014
DARWIN		H2020 2015-2018
IMPROVER	Improved risk evaluation and application of resilience concepts to critical infrastructure	H2020 2015-2018
RESILENS	Realising European Resilience for Critical Infrastructure	H2020 2015-2018
RESOLUTE	RESilience management guidelines and Operationalisation appLied to Urban Transport Environment	H2020 2015-2018

SELECTED CLIMATE CHANGE PROJECTS

Table 63 Climate change projects

Abbreviation	Project Title	Framework
CapHaz-Net	Social capacity building for natural hazards toward more resilience societies	FP7 2009-2012
CATALYST	Capacity Development for HAzard Risk Reduction and Adaptation	FP7 2013-2015
CORFU	Collaborative research on flood resilience in urban areas	FP7 2010-2014
CREW	Community Resilience to Extreme Weather	EPSRC 2008-2011
EU-CIRCLE	A Pan-European Framework for Strengthening Critical Infrastructure Resilience to Climate Change	H2020 2015-2018
emBRACE	Building Resilience Amongst Communities in Europe	FP7 2012-2015
ENHANCE	Enhancing risk management partnerships for catastrophic natural hazards in Europe	FP7 2012-2014
EU-CIRCLE	A Pan-European Framework for Strengthening Critical Infrastructure Resilience to Climate Change	H2020 2015-2018
FloodProBE	Technologies for the cost-effective Flood Protection of the Built Environment	FP7 2009-2013
MIAVITA	MItigate and Assess risk from Volcanic Impact on Terrain and human Activities	FP7 2008-2012
MOVE	Methods for the improvement of vulnerability assessment in Europe	FP7 2008-2011
PREPARED	Prepared Enabling Change	FP7 2010-2014
RESIN	Climate Resilient Cities And Infrastructures	H2020 2015-2018
SMARTeST	Smart Resilience: Technologies, Tools and Systems	FP7 2010-2013
STAR-FLOOD	Strengthening and Redesigning European Flood Risk PracticesTowards Appropriate and Resilient Flood Risk Governance Arrangements	FP7 2007-2013
ToPDAd	The Tool-supported policy development for regional adaptation	FP7 2012-2015
TRANSrisk	Transitions Pathways and Risk Analysis for Climate Change Mitigation and Adaption Strategies	H2020 2015-2018
TURAS	Transitioning toward Urban Resilience and Sustainability	FP7 2011-2015

OTHER ACRONYM IN THE TEXT

Abbreviation	Description
CC	Climate Change
CBO	Community-based Organisation
CBE	Chemical, Biological and Explosive
CBPR	Community-Based Participatory Research
CBRNE	Chemical, Biological, Radiological, Nuclear and Explosive
CBRN	Chemical, Biological, Radiological and Nuclear
CCA	Climate Change Adaptation
CDM	Clean Development Mechanism
CI	Critical Infrastructure
CoCRP	Community of Crisis and Resilience Practitioners
CRAMSS	Collaborative Resilience Assessment and Management Support System
CRF	City Resilient Framework
CSA	Coordination and Support Actions
CSO	Civil Society Organisation
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
DSS	Decision Support System
ECCP	European Climate Change Programme
ENISA	European Union Agency for Network and Information Security
ERMG	European Resilience Management Guideline
EWS	Early Warning System
ETS	European Emissions Trading Scheme
FABS	Food, Agriculture and Fisheries, and Biotechnology
GCM	Global climate model
GEC	global environmental change
GFDRR	Global Facility for Disaster Reduction and Recovery
GHG	Greenhouse gas
GIS	Geographic Information System
GRT	Gestion des Risques Territoriau (Territorial Risks Management Method)
HFA	Hyogo Framework for Action
IA	Innovation Actions
ICS	Industrial Control Systems
IPCC	Intergovernmental Panel on Climate Change
LG SAT	Local Government Self-Assessment Tool
M:CI	Morgenstadt: City Insights
MHPSS	Mental Health Psychosocial Support
MSPs	Multi-Sector Partnerships
OSG	Operational Guidance System
PAR	Participatory Action Research
PPP	Public Private Partnership

PuP	Public Public Partnership
PRA	Participatory Rural Appraisal
RDR	Regional Disaster Resilience
RIA	Research and Innovation Actions
SAVE	Specific Actions for Vigorous Energy Efficiency
RORBT	Resilient Organisations Benchmark Tool
SD	Social Dynamics
SIFVI	Social and Infrastructure Flood Vulnerability Index
SL	Sustainable livelihoods
SMCA	Spatial Multi Criteria Analysis
SWD	Staff Working Document
TCDRC	Torrents Community Disaster Resilience Scorecard
THOR	Technical, Human, Organisation and Regulatory
UNFCCC	United Nation Framework Convention on Climate Change
UTS	Urban Transport System