SMART MATURE RESILIENCE

DELIVERABLE 3.1: REVISED RESILIENCE MATURITY MODEL

TECNUN | 30/11/2016

REVIEWED VERSION | 31/10/2017

	Revised Resilience Maturity Model
Deliverable no.	D3.1
Work package	3
Dissemination Level	Public
Author (s)	Josune Hernantes (TECNUN), Leire Labaka (TECNUN), Raquel Gimenez (TECNUN), Patricia Maraña (TECNUN)
Co-author(s)	Jose Julio Gonzalez (CIEM), Vasileios Latinos (ICLEI), Amy Rankin (LiU), Igor Pyrko (Strath), Susan Howick (Strath), Colin Eden (Strath), Rene Linder (DIN)
Date	30/11/2016
File Name	Deliverable 3.1: Revised Resilience Maturity Model
Revision Authors	Raquel Gimenez (TECNUN), Maider Sainz (TECNUN
Ethics Revision	Maider Sainz (TECNUN)
Reviewed by (if applicable)	Lucy Vilarkin (Bristol), Pierluigi Potenza (Roma), Julie Robertson (Glasgow), Duncan Booker (Glasgow), Ib Jespersgaard (Vejle), Silje Solvang (Kristiansand), Judith Moreno (Donostia), Timurs Safiulin (Riga)

This document has been prepared in the framework of the European project SMR – SMART MATURE RESILIENCE. This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement no. 653569.

Funded by the Horizon 2020
programme of the European Union

EXECUTIVE SUMMARY

The main objective of the SMR project is to develop a Resilience Management Guideline that aims to help in the operationalisation of the resilience building process of European cities. This Guideline integrates five complementary tools that will enhance significantly the CITY[1] resilience defined as the ability **"to resist, absorb, adapt to and recover from acute shocks and chronic stressed to keep critical services functioning, and to monitor and learn from on-going processes through city and cross-regional collaboration, to increase adaptive abilities and strengthen preparedness by anticipating and appropriately responding to future challenges".**

These five tools are: 1) a Resilience Maturity Model, 2) a Risk Systemicity Questionnaire, 3) a Portfolio of Resilience Building Policies, 4) a System Dynamics Model and 5) a Community Engagement and Communication tool.

This report focuses on the first tool explaining the methodology used to develop it in addition to describe its maturity stages. Literature review was carried out in order to gather information about worldwide approaches regarding resilience. Furthermore, Group Model Building workshops have been arranged during the SMR Project first year to gather the needed requirements for the development of this Resilience Maturity Model from experts. A Delphi process and a validation workshop have also been carried out to further validate the Maturity Model and ensure its replicability and transferability to other CITIES in Europe.

The Resilience Maturity Model comprises five maturity stages to guide cities through the optimal path of building resilience from a strategic approach. Each maturity stage contains a description of the objectives of that maturity stage, the stakeholders that need to be engaged in each stage in addition to a list of policies that should be developed in order to achieve the objectives defined in that maturity stage. A set of indicators have also been identified for monitoring and assessing the performance of these policies and justify their investments on resilience. Finally, the steps to follow in order to implement successfully the Maturity Model are explained. These steps consist of: 1) Assessment, 2) Strategy development, 3) Strategy implementation and 4) Strategy monitorization.

[1] The SMR Project defines the concept of CITY as an environment that involves all the relevant stakeholders in the resilience building process. This concept is further explained in Section 4.2.

TABLE OF CONTENTS

1 INTRODUCTION

The severe consequences of the natural disasters that we have suffered in the last two decades such as the Indian Ocean tsunami in 2004, the Katrina and Sandy hurricanes in 2005 and 2012, the Haiti Earthquake in 2010, the East Japan Great Earthquake and Tsunami in 2011 and the most recent earthquake in Nepal in 2015, have overwhelmed the response capacity of cities. Moreover, the perspective for the next decades is not satisfactory, since it is expected that the number of disasters will continue increasing due to climate change and dense settlements in coastal and other disaster-prone areas. In addition, the dependency of current society on critical infrastructures may act as a stress multiplier for a whole range of social, environmental or economic challenges that a city may face.

Nowadays, the majority of the world's population live in cities, and according to forecasts, an increasing number of people will live in cities in the coming decades (100 Resilient Cities, 2016; Prior et al, 2013). As cities continue to grow, there is an urgent need to work toward building cities' resilience to the effects of a wide spectrum of disasters, ranging from acute shocks such as floods, droughts, and earthquakes to chronic shocks such as climate change, or environmental pollution (Godschalk, 2003; Prior et al, 2013; Weichselgartner and Kelman, 2014).

Resilience thinking supports the transition from disaster management to an all-hazards approach, placing the emphasis on the ability of a complex system to deal with shocks and long-term stresses (Singh-Peterson et al., 2015). Resilience management expands the scope of risk management, in addressing complexities that characterise the operation of large integrated systems, considering known as well as unforeseen threats (Linkov et al. 2014). In this respect, the creation of more resilient cities or communities allows them to withstand and recover from shocks and stresses, being able to adjust plans and procedures prior to, during and following new or unexpected disturbances, so that they can maintain their function as needed throughout the disruption (Hollnagel, 2009).

Current literature and international initiatives such as the Rockefeller Foundation through its 100 Resilient Cities program and the United Nations Office for Disaster Risk Reduction (UNISDR), through its Making Cities Resilient Campaign, provide a broad set of frameworks, which include characteristics and priorities for building resilient cities (Johnson et al. 2014; Shaw, 2012; UNISDR, 2005; UNISDR, 2015; 100 Resilient Cities, 2016). However, there is still the need to provide guidance for the operationalization of resilience for a practical application of resilience concepts in decision making and planning. Operationalization entails making resilience concepts useful and useable beyond their theoretical context to policy makers and managers. In order to find a way to address this need, the SMR

project is developing, testing and validating a Resilience Management Guideline. This Resilience Management Guideline builds on five complementary tools that will enhance the anticipation and the coordination across different stakeholders and will enable addressing risks and opportunities in order to facilitate planning and decision-making process. These five tools are: 1) a Resilience Maturity Model, 2) a Risk Systemicity Questionnaire, 3) a Portfolio of Resilience Building Policies, 4) a System Dynamics Model and 5) a Community Engagement and Communication tool.

This deliverable focuses on the first tool, the Resilience Maturity Model. The SMR project has developed a Maturity Model that defines incremental stages, which guide CITIES through the ideal path for building resilience taking into account the definition of City Resilience developed within the SMR project scope. City Resilience has been defined as "**is the ability of a CITY[2] or region to resist, absorb, adapt to and recover from acute shocks and chronic stressed to keep critical services functioning, and to monitor and learn from on-going processes through city and cross-regional collaboration, to increase adaptive abilities and strengthen preparedness by anticipating and appropriately responding to future challenges".**

1.1 Contribution of the Maturity Model

The aim of the Maturity Model is to provide a tool for reflection and guidance in the resilience building process, that enables cities to develop an analysis of its current status and providing a guideline about what the following steps should be from a strategic approach.

The Maturity Model is primarily designed to assist CITIES in assessing current maturity stage and identify future resilience demands and capacities in order to advance to a more mature level.

The SMR Maturity Model defines five maturity stages: Starting, Moderate, Advanced, Robust, and verTebrate[3]. Each of these maturity stages includes a description of the objectives of each stage, the stakeholders actively involved in each maturity stage, a list of policies that should be developed in order

2 The SMR Project defines the concept of CITY as an environment that involves all the relevant stakeholders in the resilience building process. This concept is further explained in Section 4.2.

3 The initials of the first fourth maturity stages with the 'T' of the last stage set up the SMART acronym, that is the first word of the name of this project: 'SMART Mature Resilience (SMR)'.

to achieve the objectives defined in the respective maturity stage and a set of indicators that can be used to monitor the progress of the policies.

From the SMR project perspective, the use of the Maturity Model can contribute to cities in the following areas:

- **Common and holistic understanding of resilience concept**: The Maturity Model provides a tool for increasing common understanding of resilience using a common terminology to refer to the same concepts. It allows end users to understand resilience as a multidimensional objective, gaining a holistic understanding of each dimension and their interrelationships.
- **Enhancing communication among stakeholders:** The Maturity Model provides a set of policies and indicators that help the exchange of experiences and information within and beyond cities. The use of the Maturity Model facilitates a continuous process of discussion and participation of the city stakeholders, that increases their awareness, engagement and commitment on the resilience building process. It may help to strengthen partnerships among various stakeholders.
- **Identifying and supporting development of resilience-strengthening strategies:** The Maturity Model is a strategic tool that provides a roadmap about how the resilience process may be through the policies defined in each stage. The Maturity Model enables, from a strategic level, the identification of areas that need to be improved in each city and reflect these in policymaking and planning. Once the city has identified its weaknesses, the city should identify its priorities and develop the resilience-strengthening policies, which implementation process using the proposed indicators.

The use of the Maturity Model as a tool for discussion also helps create consensus on what needs to be done to build or enhance resilience guiding the decisions making process.

1.2 Fulfillment of the city requirements through the Maturity Model

In D2.5, general requirements of the European Resilience Management guideline and specific requirements that each tool should fulfil were gathered from the cities based on four workshops conducted in WP2. Therefore, when developing the tools and the resilience management guideline it is important to verify that the general and specific requirements defined in D2.5 are effectively addressed and fulfilled.

The following tables explain the general and specific requirements that were defined for the Maturity Model and how these requirements have been accomplished.

1.2.1 GENERAL REQUIREMENTS APPLICABLE TO ALL THE EUROPEAN RESILIENCE MANAGEMENT GUIDELINE TOOLS

Requirement	Accomplishment explanation
Useful user friendly tools tailored to relevant stakeholders	Some of the major changes done to the preliminary version of the maturity model (deliverable 2.6) are related to the fulfilment of this requirement. Reducing the number of policies and dimensions, the creation of sub-dimensions, the reordering of the policies to show their evolution through the stages… all these changes make the maturity model more understandable and therefore more user friendly. Moreover, the refinement of the explanation of the roles of the different stakeholders in each of the maturity stages also provides input on how each stakeholder could take advantage of using this tool. The online version of the Maturity Model will be interactive and user friendly in order to facilitate the use of it to all the city stakeholders interested in having an overview of how the optimal path towards building resilience is.
Tools developed should complement the tools, indicators, policies, methods and procedures that are currently being used in cities	The final version of the maturity model has been developed not only revising the existing literature regarding city resilience but also analysing reports and strategies of different cities and worldwide projects and approaches. This way it is ensured that the policies included in the maturity model have already been applied in some cities and consequently are replicable to others.
Guideline to enable prioritisation of resilience building policies for CITY with respect to infrastructure	The Maturity Model provides an optimal path for building city resilience. Therefore, this tool will provide help determining the temporal order for the implementation of the resilience

resilience, climate adaptation and social issues	building policies in order to achieve the highest efficiency in the resilience building process.
Need to standardize the resilience building process	All the names of the stages, dimensions, sub-dimensions, policies and indicators included in the Maturity Model have been standardize as well as properly defined in order to ensure a common understanding.

1.2.2 SPECIFIC REQUIREMENTS APPLICABLE TO THE MATURITY MODEL

Requirement	Accomplishment explanation
Guideline to help in the allocation of efforts needed and steps to take over time, to develop and effectively implement the resilience action plan (or de facto resilience action plan)	The Maturity Model provides an optimal path for building resilience. Therefore, it could be defined as a guideline to help in the allocation of efforts and steps to take over time. The evolution of the policies within each sub-dimension and through the five different stages provides a quick overview of which is the optimal way of implementing the resilience action plan.
List of indicators to measure the effectiveness on the resilience action plan (or de facto plan)	The Maturity Model gives a list of indicators including inductor indicators as well as result indicators whose main aim is to monitor the resilience building process of a city.
Mapping of key stakeholder's roles and responsibilities with respect to the development and implementation of the resilience action plan (or de facto plan)	The Maturity Model lists and defines city stakeholders. It also explains the roles and the responsibilities of the different stakeholders in each of the maturity stages.
Guideline to involve all the relevant stakeholders in emergency preparedness and crisis management through plan preparation, regular	The 'Preparedness' and 'Infrastructure & Resources' have specific policies explaining how relevant stakeholders should gradually involve in all these activities.

training, emergency drills and exercises	

2 STATE OF THE ART

Worldwide there have been twice as many disasters and catastrophes in the first decade of this century as in the last decade of the 20th Century (Government and Disaster Resilience Minitrack, 2016). During the aftermath of these disasters, the need for improving our ability to manage and assess the cities' resilience emerges. However, how to best prepare for already known risks as well as the unexpected ones is an enormously complex activity that is still in a primal stage.

CITIES require mechanisms for evaluating policies designed to build resilience and more specifically, metrics for monitoring and assessing the performance of these policies and justify their investments on resilience. Additionally, the resilience measurement may contribute to raise awareness about the need for resilience and the needed resources (Prior et al., 2012). However, resilience can be difficult to measure precisely because it is a complex and multidimensional concept.

In this regard, progress is being making on finding suitable indicators and metrics that retain the resilience key attributes. There are several studies that define a methodology/tool and a list of indicators to be able to evaluate the resilience level of the cities and regions. A comprehensive overview of approaches and tools are provided in D1.1. A summary of main methods is provided below.

2.1 Frameworks to measure the resilience level of the cities

Cutter et al. (2014) define a methodology and a set of indicators to assess the resilience level of the communities. They define six main resilience categories (social, Housing/infrastructural, community capital, economic, institutional, and environmental) and for each of them they define a series of indicators (49 in total) in order to be able to estimate the value of each category and the resulting resilience score.

Similarly, Kusumastuti et al. (2014) develop a resilience index to estimate the resilience level of Indonesia against natural disasters. The proposed resilience index is defined as a ratio between the preparedness and vulnerability. Within these two components several dimensions (social, community capacity, economic, institutional, infrastructure, and hazards) and sub-dimensions have been defined.

In turn, for each sub-dimension several indicators have been defined to evaluate the resilience level of this country.

Based on economic development and social capital, a resilience index has been defined to evaluate the level of community resilience (Sherrieb et al., 2010). Ten indicators have been listed to measure the economic development grouped in three categories: resource level, resource equity, and resource diversity. In order to assess the social capital dimension, seven indicators have been defined classified by three categories: social support, social participation, and community bonds.

From a geographic approach, Zhou et al. (2010) define a model of Disaster Resilience of Loss-Response of Location that define disaster resilience based on three dimensions: (1) Time, (2) space and (3) attribute. The time dimension is basically divided into three periods: before (pre-), during (in-) and after (post-) disaster. The space dimension can be divided into several spatial scales according to the scope of disaster-influenced area: community, town, county, province, and country. Finally, the attribute dimension indicates the categories that can be affected in an area through a hazard such as economic, institutional, social and environmental characteristics.

More specifically, related to urban resilience, Bozza et al. (2015) define an integrated framework based on Hybrid Social-physical networks by merging both physical and social components and taking into account engineering measures to assess the resilience level of the urban area in order to face disasters. In the same vein, Araya-Muñoz et al. (2016) define an adaptive capacity index for urban areas to face climate change. This index is calculated based on 17 indicators that in turn they are aggregated in 6 determinants, and these six in three components (awareness, ability and action) that allow assessing the adaptive capacity index.

Regarding cities, there are two very well-known tools that allow evaluating the resilience level of the cities. The first one is the City Resilience Index (CRI) which is a tool developed Arup for the Rockefeller Foundation that gives the city a holistic ‘resilience profile’. It proposes 52 indicators that measures the following four dimensions: Health and well-being, economy and society, Infrastructure and environment and, Leadership and strategy (ARUP, 2016).

The second one is the Sendai Framework for Disaster Risk Reduction 2015-2030 which aims to achieve the substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries over the next 15 years. The Sendai Framework defines four priorities for reducing disaster risks: (1) Understanding disaster risk, (2) strengthening disaster risk governance to manage disaster risk, (3)

investing in disaster risk reduction for resilience and (4) enhancing disaster preparedness for effective response and to “build back better” in recovery, rehabilitation and reconstruction. In order to accelerate the implementation of the priorities set forth in the Sendai framework, the United Nations International Strategy for Disaster Reduction launched the U.N. Disaster Resilience Scorecard (UNISDR, 2014) which integrates all aspects of disaster resilience and identify shortfalls in cities’ resilience plans. It provides 85 criteria addressing the ten essentials of disaster management: organization, budget, preparation, infrastructure, safety of essential facilities, building regulations, training for disaster, ecosystem protection, warning systems, and restoration needs.

Finally, it is worth mentioning the OECD framework, which is a framework for city resilience that identify economic, social, environmental and institutional drivers that can aid cities improve resilience. In a comprehensive report, OECD examines and analyses approaches, policies and concrete city actions worldwide (OECD 2016). The resulting framework is part of their contribution to the implementation of the Sendai Framework and the New Urban Agenda of the UN (c.f. Habitat III conference in Quito, 2016). Specifically, OECD identifies four factors that affect resilience (economic, social, environmental and strong open-minded leadership). Moreover, the OECD report states that enhancing resilience requires new ways of designing and delivering policies, since the policies should support flexibility. Moreover, the report discusses the importance of collaboration with multi stakeholders (i.e., citizens and private sector).

As it has been mentioned, there are several studies that suggest indicators and tools that allow evaluating the resilience level of a city. However, most of them present static indicators that limit to estimate the resilience level of a city using a numeric value and focus on evaluating the internal resilience level of the cities without taking into account the external stakeholders and their relationships.

2.2 Maturity models for resilience building process

Despite the importance of improving the resilience of cities, currently there are limited examples of the sequential steps that cities should follow in developing resilience (Molin Valdés et al., 2013). Furthermore, cities can exhibit a great variation in resilience level, and there is a lack of guidance on which policies should be implemented as function of the current situation of a city (Oteng-Ababio et al., 2009). In addition, there is little understanding of how the different stakeholders of a city should work and collaborate to develop the city’s resilience (Singh-Peterson et al., 2015). In this context, the SMR project presents a Maturity Model that proposes an ideal sequence of maturity stages guiding the relevant stakeholders in a city in resilience building process.

Maturity models serve to identify the ideal path for the evolution of a process from an initial stage to a more advanced stage, passing through a number of intermediate stages (Becker et al., 2009; Wendler, 2012). Maturity models consist of a structured collection of elements describing the characteristics of effective processes at different stages, suggesting goals to be achieve at each stage and transition activities to get from the bottom stage of maturity to the highest level of maturity (Pullen, 2007). Furthermore, maturity models provide criteria and characteristics that need to be fulfilled by a community to reach a particular maturity level. During maturity appraisal, a snap-shot of the organization regarding the given criteria is made (Becker, Knackstedt et al. 2009).

The objective of Maturity Models is therefore, to describe the trajectory of an organization over time through stages of increasing maturity measured by capability to perform some process (Wendler 2012). The bottom stage stands for an initial stage that can be, for instance, characterized by an organization having little capabilities in the domain under consideration. As the stage increases, activities are performed more systematically and are better defined and managed (Fraser, Farrukh et al. 2003). Therefore, the highest stage represents a conception of total maturity and advancing on the evolution path between the two extremes involves a continuous progression regarding the organization's capabilities or process performance.

Although Maturity Models have their origin in quality management, a systematic mapping study, published in 2012, surveying the use of maturity models until 2010 identified articles in scientific journals and conferences on uses of maturity models in nearly two dozen application domains (Wendler 2012). Software development and software engineering were by far the most popular application areas with a total of 89 articles. Applications in public sector, project management, other business areas, engineering and knowledge management and process management appeared in more than ten papers each. Other applications included engineering, outsourcing, medical sector, supply chain management, business functions, business intelligence, collaboration processes, finance/controlling, IT functions, IT governance, IT alignment, leadership and sustainability (Wendler 2012, Figure 3, p. 1328). In recent years, maturity models have been developed and validated in new domains, including environmental management and information security (Rigon et al. 2014).

Despite their differing purpose, for example as a tool for continuous improvement or as a means for the assessment and benchmarking, maturity models classify and assess institutional, organizational and or technical capabilities of an organization or information system that provide certain beneficial effects according to the corresponding maturity level (Frick, Kuttner et al. 2013). The use of Maturity Models generates an awareness of the analyzed aspects: their state, importance, potentials, requirements,

complexity, and so on. Furthermore, the maturity models may serve as reference frame to implement a systematic and well-directed approach for improvements, ensure a certain quality, avoid errors, and assess one's own capabilities on a comparable basis (Wendler 2012). In line with this, maturity models are used as an evaluative and comparative basis for improvement and to derive an informed approach for increasing the capability of specific area within an organization (Bruin et al, 2005). Actually, maturity models should be sufficient to support organizations in the assessment of their maturity level and capabilities to conduct inter-organizational integration by the identification of beneficial effects corresponding to each maturity level and the enactment of necessary measures to overcome existing impediments of preventing inter-organizational activities (Frick, Kuttner et al. 2013).

Given the identified gaps on the resilience operationalization process and taking into account the characteristics of maturity models, the SMR project has developed a Resilience Maturity Model that comprises five well-defined maturity stages to guide cities through the ideal path of building resilience. This research includes the role of the external stakeholders since it understands CITY (in capital letters) as an environment that involves all the relevant stakeholders that are involved in the resilience building process such as multi-level governance, critical infrastructure providers, volunteers, emergency services etc. (see Section 4.2 for further detail). Cities will start from stage one, and from there move on to a more advanced stage, passing through a number of intermediate stages. Therefore, the SMR Resilience Maturity Model will provide guidance to cities on the specific resilience building policies that they have to implement in each of the maturity stages. The implementation of these policies will allow the cities to move forward from one stage onto the next and consequently improve their resilience level. Furthermore, in order to be able to diagnose the current situation, several indicators have been defined that permit to define the stage in which each CITY is in the four resilience dimensions at any time.

3 METHODOLOGY

The development of the Maturity Model has been carried out in an iterative way, improving the model continuously until reaching the version described in this deliverable.

Before starting with the development of the Maturity Model a conceptualization phase was carried out through a literature review. The objective of this conceptualization phase was to obtain an overview of current practice in urban resilience and EU sectoral resilience approaches, to identify, synthesise and assess the main challenges and best practice of today. As a result of this phase, deliverables D1.1, D1.2 and D1.3 were developed.

After the preliminary conceptualization phase, the development of the Maturity Model was accomplished through two phases. In the first phase, a preliminary version of the Maturity Model was presented in D2.6. Four Group Model Building (GMB) workshops were organized and conducted, and the main content of the maturity model was gradually developing with the input gathered during these workshops. Rotterdam, Vejle and Glasgow resilience strategies (part of the cities' involvement in the 100 Resilient Cities program) have been reviewed in order to gather additional information to develop the Resilience Maturity Model[4]. Additionally, a Delphi methodology with additional experts external to the project has been used to validate the Maturity Model.

In a second phase, this Maturity Model was enhanced thanks to the cities' feedback and the validation workshop held in Kristiansand (Figure 1). The next sub-sections elaborate further each method employed to formulate the Maturity Model.

[4] Vejle's Resilience Strategy (2016). www.100resilientcities.org/page/-/100rc/Vejles_resilience_strategy_webquality_160316.pdf

Rotterdam's Resilience Strategy (2016). http://www.resilientrotterdam.nl

Glasgow Resilience Strategy (2016). www.glasgow.gov.uk/index.aspx?articleid=17668

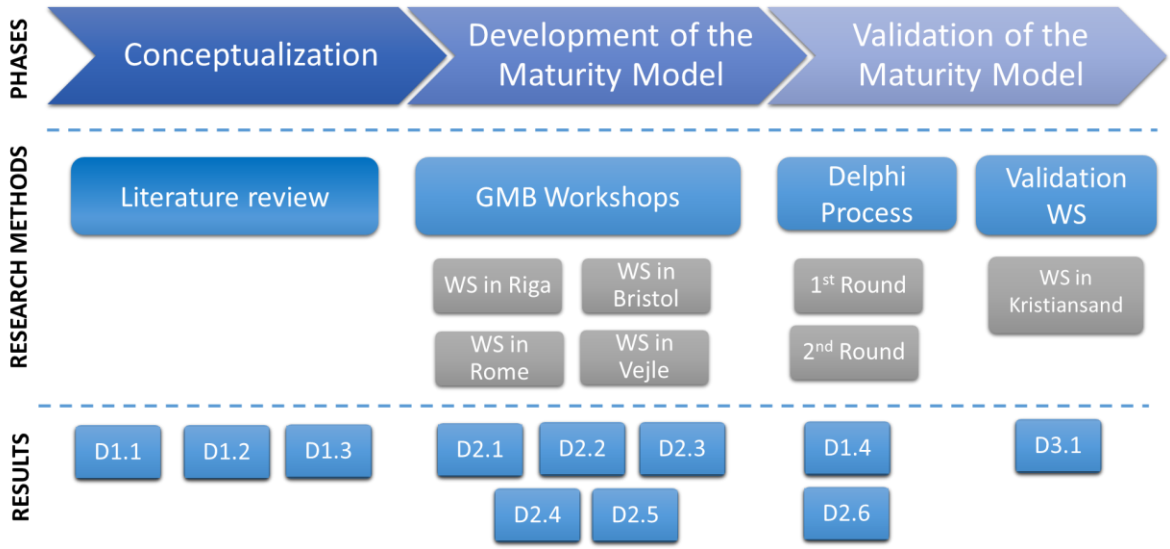

Figure 1: Methodology to develop and validate the SMR Maturity Model

3.1 Group Model Building

Group Model Building (GMB) is a collaborative methodology that enables integrating fragmented knowledge, initially residing on the minds of different experts, into aggregated models (Richardson and Andersen, 1995). Through different exercises such as stakeholders' analysis, policies and indicators identification, models are developed that integrate the experts' fragmented knowledge and deliver insights to the problem (Andersen et al., 1997; Andersen et al., 2007; Rich et al., 2009).

Four workshops were arranged between October 2015 to May 2016 in the city of Riga, Bristol, Rome and Vejle in the field of Critical Infrastructures (CIs), Climate Change and Social Issues. The SMR consortium employed the GMB methodology to gather knowledge from domain experts about the challenging areas. The workshops provided a wealth of information about different aspects of each problem area which was then used as an input for developing the maturity model. In the first workshop (Riga, 26th-29th October 2016), SMR acquired information about dependencies of cities on CIs defining the most relevant milestones occurred in the history related to CI dependency; the relevant indicators to assess the resilience level of the cities regarding their dependency towards CIs, and the Behaviour over Time (BOT) graphs. For further results, see Deliverable D2.1.

The second workshop (Bristol, 25th-28th January 2016) identified a wide range of policies, indicators and barriers about Climate Change and resilience. The workshop in Bristol also pinpointed the first indication on the dynamics of building resilience, and identified the evolution of the main policies and which policies need to be implemented first. Following steps regarding the development of the maturity model were to reaching consensus on which specific stage the different policies need to be implemented. Complete documentation of the results obtained in the workshop of Bristol can be found in Deliverable 2.2.

The third workshop (Rome, 22nd-25th February 2016) resulted in a better definition of the specific stages of the city-resilience preliminary maturity model and suggested relevant indicators to measure the resilience level in a particular stage and throughout the whole process. These results were valuable and contributed to comprehend better the dynamics of building resilience. Further results can be found in Deliverable 2.3.

Finally, the fourth workshop (Vejle, 9th -12th May 2016) focused on consolidating, integrating and validating the results obtained in the previous workshops on Critical Infrastructures, Climate Change, and Social Dynamics. The main focus of this workshop was to validate the identified policies in each stage of the maturity model, and provide feedback for the proposed definition of the city resilience. As a result, a better definition of the policies that need to be implemented in the specific stages of the city-resilience preliminary maturity model was developed. The results also served to understand better the dynamics of building resilience. Overall results are documented in the Deliverable 2.4.

3.2 The Delphi Method

Based on the results presented in the deliverables D1.1, D1.2 and D1.3 and the information gathered from experts during the four workshops conducted in WP2 using the Group Model Building methodology, the SMR project has developed its own definition of City Resilience in addition to a preliminary version of the Maturity Model. These results have been validated using a Delphi methodology involving multidisciplinary experts with experience in different areas of resilience (Critical Infrastructure, Climate Change, Social Issues) and different levels (city representatives/governance and the European Dimension of resilience).

The Delphi method is a systematic and iterative process for structuring a group communication process that aims at conducting detailed examinations and discussions of a specific issue for the purpose of goal setting, policy investigation, or predicting the occurrence of future events (Ulschak, 1983; Turoff & Hiltz, 1996; Ludwig, 1997). Delphi, in contrast to other data gathering and analysis, techniques, employs multiple iterations to obtain a consensus concerning a specific topic. Iterations refer to the feedback

process. The process has a series of rounds, and in each of these rounds every participant works through a questionnaire which is returned to the facilitator who collects, edits, and returns to every participant a summary of all the comments made by each participant to be aware of the range of opinions and the reasons underlying those opinions (Ludwig, 1994).

In the case of SMR project, the Delphi took place of two rounds. The purpose of the first round was to validate the City Resilience definition as well as the description of the five stages defined in the preliminary version of the Maturity Model. In addition to this, experts were asked to identify to what extent stakeholders should be involved in each of these five stages of the Maturity Model.

In the second round, the Delphi process participants were asked in the first place to re-evaluate the answers from the first questionnaire where the experts did not reach a consensus. Additionally, they were asked to classify a set of resilience building policies considering the maturity stage where they should start their development to guarantee their effectiveness in the resilience building process. After these two rounds, experts were provided with an anonymous summary of the opinions gathered in the first and second rounds so they could review this summary of results and see their own answers with regard to other participants' answers. Deliverable 1.4 provides further details about the process and the obtained results.

3.3 Validation workshop

The Preliminary Maturity Model presented in D2.6 has been improved to facilitate its comprehension and application. The feedback gathered from the representatives from the seven cities involved in the SMR project through the activities carried out in WP5 in addition to the workshop held in Kristiansand on September 2016 was included in this new version of the Maturity Model. The following are the most significant improvements:

- **City stakeholders**: The list of stakeholders has been updated including new stakeholders such as professional volunteers and sectoral regulators.
- **Resilience dimensions**: While the preliminary Maturity Model considered five resilience dimensions, the Maturity Model presented in this deliverable considers the following four ones: Leadership & Governance, Preparedness, Infrastructure & Resources and Cooperation. Learning is now considered as a continuous process developed in each of the four resilience dimensions used in the SMR Project.

- **Maturity stages descriptions**: The description of each maturity stage has been extended and classified according to the four resilience dimensions mentioned before. This way, it is easier to follow the evolution of these resilience dimensions over the maturity process.
- **Roles of stakeholders**: the role of stakeholders is described in each maturity stage, providing more details about their responsibilities at each stage.
- **Policies dimensions and sub-dimensions**: The policies included in the Maturity Model have been classified considering the four resilience dimensions: Leadership & Governance, Preparedness, Infrastructure& Resources and Cooperation. At the same time, each resilience dimension has been split into several sub-dimensions. These sub-dimensions will help cities to visualize their maturity levels in these predetermined sub-areas as well as overall, as cities can be at different maturity stages in different policy dimensions and sub-dimensions.
- **Standardization of policies syntax**: the policies have been numerated and named following the same standard: policy code, task and description. This facilitates how identify and refer to them. First, each policy has been given a code that consists of a letter, a number, a letter and a number: the first letter correspond to the four resilience dimensions ("L" for Leadership and Governance, "P" for Preparedness, "I" for Infrastructure and Resources, and "C" for Cooperation). The following number corresponds to the number of sub-dimension defined within each dimension. The following letter identifies the maturity stage (S-Starting, M-Moderate, A-Advance, R-Robust and V-vertebrate) and the following number the number of policy within this sub-dimension. For example, "L1S1 Establish a working team responsible for resilience issues in the city" policy has the following code: L1S1. L refers that this policy belongs to the Leadership and Governance dimension. 1 refers that this policy belongs to the first sub-dimension. The following letter, S, explains that this policy is in the first stage of the maturity model "Starting stage" and finally, the number 1 means that it is the first policy within this sub-dimension and within the starting stage. This code does not provide any information itself; it is just the name for the policy. Second, the name of the policy is provided. The task associated with the policy shall be written such as: "DO THAT" without a full stop at the end. The task is reduced to the essential and does not include any descriptions or examples. And finally, a description of each policy is provided including information and/or examples.
- **Reduce the number of policies**: the number of policies included in the Maturity Model has been reduced from 132 to 90, to facilitate its comprehension and use. The policies proposed in the Maturity Model are described from a strategic approach therefore, a process of particularization to each city context should be carried out when implementing this tool in practice.

4 STRUCTURE OF THE MATURITY MODEL

The SMR Maturity Model defines a sequence of five maturity stages cities pass through from their initial efforts in resilience building process towards the achievement of resilience excellence. The five maturity stages are: Starting, Moderate, Advanced, Robust, and verTebrate.

As it was explained in the Deliverable 2.5, the SMR Maturity Model is defined at a strategic level, where each stage represents a generic characterization of the resilience building process and could be applied to any city. The resilience building policies included in each maturity stage are also described using a high-level approach due to this tool's strategic approach and its target end-users. These resilience building policies included in the Maturity Model will be afterwards particularized for each city context and characteristics in the Portfolio of Resilience Building Policies tool[5], which aims to provide support at a tactic or operative level. Following some characteristics to consider during the particularization process to carry out in each city during the Maturity Mode implementation is explained (Figure 2):

- **Population:** different aspects must be considered related to population. Population density in an urban area makes cities especially vulnerable both to the impacts of shocks and stresses. For instance, the number of people and critical services affected due to a blackout is significantly bigger in cities than in rural areas.
  The average age of citizens, the percentage of economically active population, percentage of citizens with higher education, and percentage of immigrants are also relevant indicators to consider in order to particularize the Maturity Model since they provide information about the current and future challenges of the city.
- **Geographical location**: the location of a city can influence the probability of suffering certain type of shocks and stresses. For instance, Donostia-San Sebastian is a coastal city with propensity for huge waves and consequently wave damage and flooding. On the other hand, Rome is more likely to suffer the effect of an earthquake because of its location in a seismic active area.

[5] The Portfolio of Resilience Building Policies tool will provide insights to adequate the generalist policies presented in the Maturity Model into more specific policies designed for the context of each city. This tool is part of the Resilience Management Guideline proposed by SMR project.

- **Vulnerabilities:** It is of paramount importance for each city to assess its particular challenges in order to know the type of shocks and stresses that it can suffer from and to identify the correct actions to implement to avoid or at least minimize their effects.
- **Governance**: the government is a key element in the resilience building process. It must guarantee the delivery of services and resources, respond to shocks and long-term stresses and provide security. The government is in charge of implementing new legislation and regulation to promote the resilience building process.
- **Economic situation:** cities that invest in public infrastructure, planning systems, and support for employment growth can increase their resilience significantly, thus improving long-term investment prospects. On the other hand, cities in developing countries face high chances of suffering shocks and long-term stresses due to their relative lack of resources to guarantee the social welfare and increase the quality of infrastructures and adapt them to deal with these events. Indicators as unemployment rate, local GDP, business activity, investments in R&I and the budget the city council manages enable to analyze the economic situation of a city.
- **Quality of infrastructures:** guaranteeing a high level of performance of the facilities that are critical to the citizens' health and welfare is really crucial to deal with shocks and stresses. Energy, transport, communications and health are examples of these critical services. Concrete actions must be implemented towards the promotion of quality infrastructure investment to increase their redundancy, reliability and flexibility.

  Apart from the critical services, the overall city infrastructure needs to be able to withstand a shock or easily to be restored if it is damaged during a shock. The city's urban plan should define measures to adapt the infrastructures (houses, buildings…) located in particularly vulnerable areas and to build new infrastructures using technologies that can minimize the effect of shocks. This is the case of Japan, where the buildings must meet earthquake-safe building codes.
- **Quality of life- Social cohesion:** it is "the capacity of a society to ensure the welfare of all its members, minimising disparities and avoiding polarisation". The strength of relationship between neighbours is an indicator of how well communities will adapt when a shock occurs. In those situations, citizens cooperate to achieve shared well-being. It is important to build also social cohesion when living with communities from a variety of cultures, ethnicities, languages and abilities. Immigration's influence on social cohesion is one of the major challenges for Europe's future. Successful integration of immigrants is a prerequisite for social cohesion and economic progress.

Indicators such as crime rate, poverty and integration programs among others are also crucial measurements to assess the quality of life of a city.

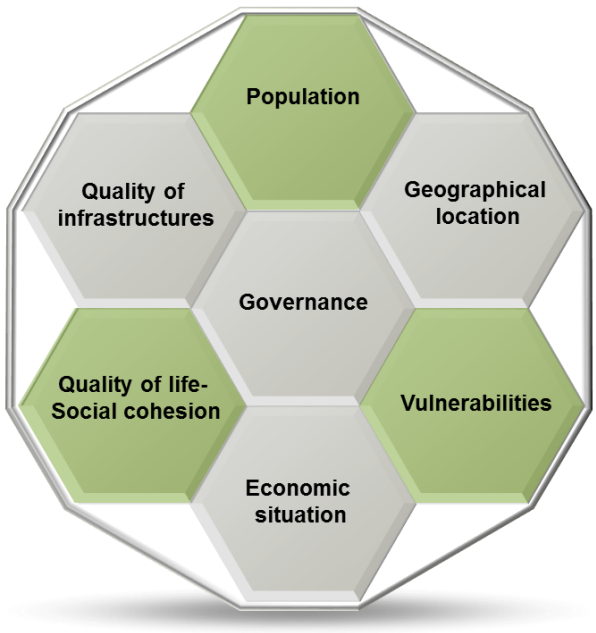

Figure 2: Context characteristics of a city

Each city has been performing specific actions towards resilience in different ways. Some of them have been working for several years on the concept of resilience while others have just started. Therefore, the requirements each of the cities are not the same. In fact, a city that has been developing resilience building activities for several years will require different activities than a city that has just started the path of developing this concept. Thus, the potential end users of the Maturity Model, basically all the CITY stakeholders, can use the SMR Maturity Model on the one hand, to identify areas that need to be improved and on the other hand, to assess their corresponding maturity stage considering the efforts made in the resilience building process. Once they identify their corresponding maturity stage, the cities should identify their priorities and the Maturity Model will help them through its policies to guide along their path in the resilience building process considering their future resilience demands and capacities. Following the suggested implementation order of the resilience building policies, cities will find the ideal way to advance in the resilience building process and improve their resilience level to deal with shocks and long-term stresses.

Each of the five maturity stages defined in the SMR Maturity Model presents the following components (see Figure 3):

- **Description**: The model presents a description of what the objective of each of the stages is, so the cities could know where to focus on.
- **Stakeholders involved**: The progression of the involvement of the agents in the resilience building process is fundamental. Consequently, we have given importance to present the agents that should be involved in each of the stages.
- **Policies**: The actions that cities should take to complete each of the stages have been exposed, so they could know exactly what steps they should take to reach the objective of the stage.
- **Indicators:** Having indicators that assess the resilience building process can help city stakeholders identify gaps and can support the continuous development that is made towards resilience building policies. Two types of indicators have been identified: effort indicators and result indicators. Effort indicators are indicators that reflect the amount of effort that has been invested in implementing policies, while result indicators are indicators that estimate the level of implementation of the policies.

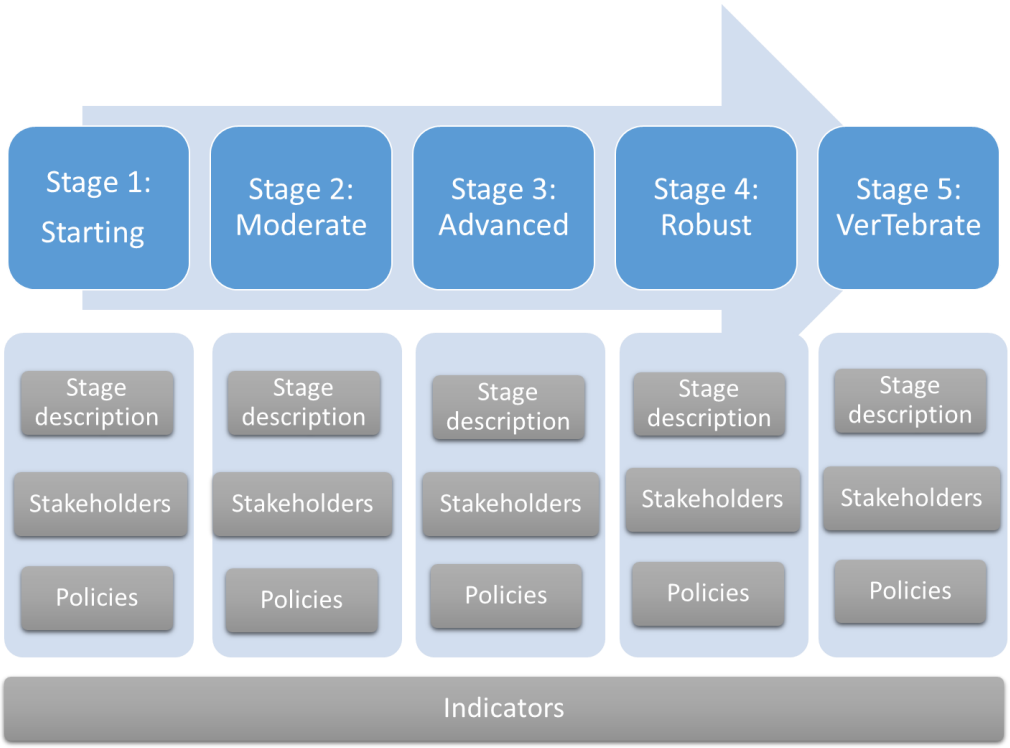

Figure 3: SMR Maturity Model elements

Following sections will describe these components of the Maturity Model with further detail.

4.1 Stage description

Each maturity stage in the model presents a description of its objective, so the cities could know clear where to focus on. As the cities progress through on the maturity stages, they will mature from lower resilience to higher resilience representing vertebrae of the backbone of European resilience.

As it was explained already in the proposal, the overall objective of the SMR project is to develop, test and demonstrate a pilot of European Resilience Management Guideline that will increase significantly the ability of the European region exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions.

The high level of interconnectedness and interdependencies among cities and their systems may lead to cascading effects and crisis escalation from local level to regional, national or even international level. This is the main reason that cities should not be considered as isolated entities in the resilience building process. Furthermore, it is evident that no city, any municipal or regional authority has complete jurisdiction, control or ownership over resilience; this is mainly due to the city's multifaceted nature and the complexity of its systems. In this context, the SMR project presents a holistic approach where cities are not considered as isolated entities, but rather as interconnected and interdependent units of a variety of structures, systems and communities. Within the SMR approach, cities are considered as vertebrae in a strong and solid European resilience backbone (see Figure 4).

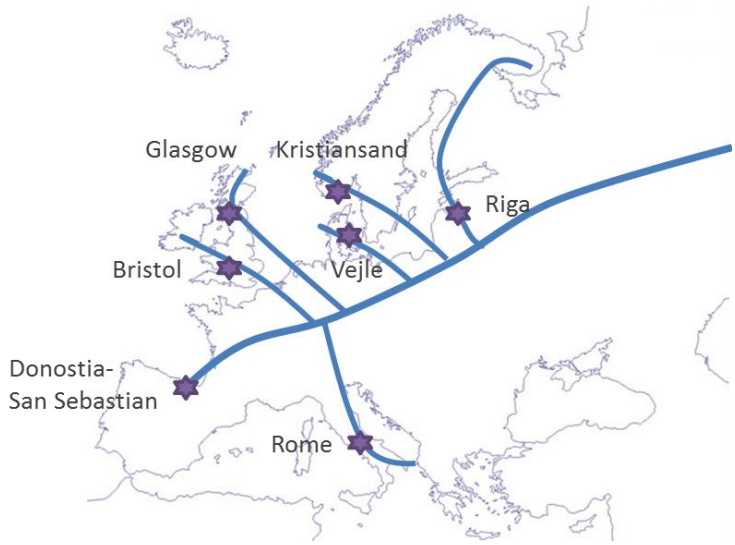

Figure 4: SMR European backbone concept

The aim of this 'Backbone' is to maximize the impact of the Resilience Management Guideline by involving as many cities in Europe as possible.

4.2 Involvement of stakeholders and improvement of city resilience

Building city resilience is a complex process that requires the commitment and engagement of numerous stakeholders progressively (Dieleman 2013; Malalgoda et al. 2013). Resilience literature emphasizes that the resilience of a city cannot be found on the level of the system (city) alone, but it depends on the capacity of the stakeholders to prevent, prepare, respond, and recover from disasters (UNISDR, 2007). City stakeholders are the individuals, groups or organizations from various disciplines and with different needs, responsibilities and resources that are involved in the resilience building process. City stakeholders include emergency services, critical infrastructure (CI) providers, academic and scientific entities, media, public and private companies, different tiers of governance (local, regional, national and international), volunteer organizations, and non-governmental organizations.

The success of building city resilience is determined by the extent to which city stakeholders are involved in the resilience-building process (Kapucu et al., 2010). Furthermore, the involvement of the stakeholders in the resilience-building process maximizes local capacities and available resources (Oxley, 2013). Building city resilience therefore, requires analyzing the needs of the different city stakeholders and empowering them to take actions. In this context, the SMR project defines the concept of CITY (in capital letters) as an environment that involves all the relevant city stakeholders in the resilience building process (Figure 5).

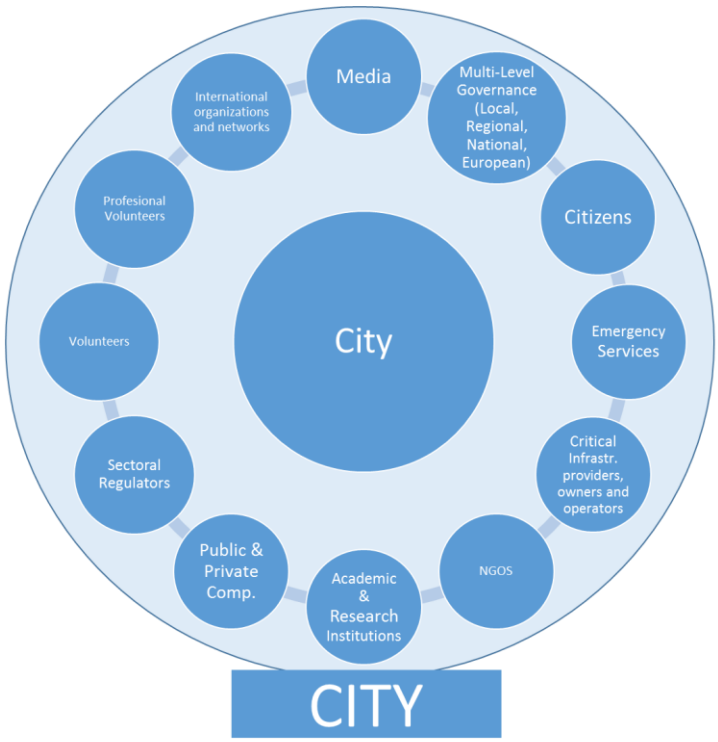

Figure 5: CITY concept – a city that involves all the relevant stakeholders in the resilience building process

The progressive involvement of the stakeholders is considered in the description of the maturity stages. Thus, city (in small letters) is used in the first three maturity stages since all the relevant stakeholders are not still involved in the resilience building process. The CITY (in capital letters) concept is used in the Robust and VerTebrate maturity stages, where all the stakeholders are already involved in the resilience building process.

Table 1 shows the description of the relevant stakeholders considered in the SMR Project.

Table 1: List of relevant stakeholders in SMR Project

Stakeholder	Roles in building city resilience
Local government	Local government includes the different departments of the city council and all the municipal agencies. It is considered as the institutional level closest to citizens. It provides a strategic planning vision to better prepare the city to

	respond to disaster risks and improves health, well-being and education. Furthermore, local government is responsible for ensuring the continuity of some services in the city, which may include highways, energy, water and telecoms infrastructure.
Regional government	A regional government is an entity that has a control on a specific area that may include different cities.
National government	A national government is the political authority that controls a nation. The national government is responsible for maintaining security and stability and for establishing national laws and enforcing them.
European policy makers	The European policy makers are made up of the governments of the EU Member States and it is the highest political authority in the EU. European policy makers are responsible for setting the overall EU policy.
Sectoral Regulators	Bodies that set and enforce regulations for the sector for which they are responsible– these bodies may include utilities, aviation, transport, finances, legal and healthcare.
Emergency services	The emergency services include entities that manage emergencies such as civil protection units and managers, as well as entities that are on the front line of emergencies such as police, firefighters, military forces and health care services. The role of these entities is to provide security and safety to citizens by reducing, preparing and responding to disaster risks.
Critical infrastructure providers, owners & operators	Critical infrastructures provide essential needs to the citizens and economy, including transportation, water, energy, communications, information technology, space, nuclear, defense, waste, health care, food, finance system, chemicals, and government. The adequate functioning of these assets, networks, and systems (including distributed networks) is crucial during emergencies as is their continued ability to deliver services in the longer-term.
Media	Media includes the local newspapers and radio and television channels. They play an important role disseminating hazard information and early warning measures in an easy to understand and accessible manner.

Academic and scientific entities	Academic and scientific entities include universities and research centers as well as other wider educational establishments such as schools. They contribute to increasing the knowledge and the development of methodologies and technologies to better mitigate and prepare for, respond to, and recover from emergencies.
Public and private companies	Public and private companies include consultancies, insurance companies, SMEs and businesses. Many services depend on city structures, and thus companies need to be engaged in awareness raising and training programs so that they are able to prepare and respond to emergencies. These companies are sometimes represented by professional networks and associations. These are membership organisations representing professionals in specific sectors influencing current best practice, policy development, industry standards, and responding to government consultations, sometimes with accredited membership.
Citizens	Citizens play a vital role in initiating action by advocating for change and influencing decisions from the local government. Citizens need to be empowered to act responsibly in emergencies. This stakeholder group could be subdivided into neighborhoods, communities of interest etc.
Professional Volunteers	Professional Volunteers are people that due to their professional background are well prepared to provide help in crises and emergencies. Professional Volunteers are doctors, nurses, fire fighters, police officers, and so on, that offer their help in a voluntary basis in case it is required.
Volunteers	Volunteers include people involved in organizations such as youth organizations, churches, day centers, community emergency response organizations that have not received professional training but have been trained to accomplish specific duties such as, cleaning, organizing, and so on. These organizations may be funded by governments, business or private persons.
NGOs	A Non-Governmental Organization (NGO) is an organization that is neither a part of a government nor a conventional for-profit business. Usually set up by ordinary citizens, NGOs can act as support or lobbying bodies, encouraging

	others to be prepared or plan ahead in case of emergencies. NGOs are usually related to special interest groups on the environment, equalities or civic heritage.
International organizations and networks	Apart from all levels of governances, nowadays there are international organizations committed to building resilience. These organizations lead and participate in research projects in order to achieve this objective. Examples of these organizations are the Rockefeller foundation and UNISDR, among others. There are also international city networks that support the sharing of best practices and lessons learnt.

4.3 Policies

Policies are defined as the actions or measures that cities should develop in order to achieve a maturity stage. Each maturity stage has defined a set of policies so that each CITY knows exactly what steps they should take to reach the objective of that stage. Actually, each maturity stage defines specific resilience building policies taking into consideration the descriptions and requirements of the maturity stages. Note that the implementation of these policies will allow the CITY to move forward from one stage onto the next, i.e. while the policies defined in one maturity stage are not completely developed CITIES cannot achieve that maturity stage. In addition, it should be highlighted that when the city progresses to the next stage, it does not mean that it has to leave behind all the knowledge accumulate within previous stages, but that it should at least maintain what it had already achieved.

These policies[6] have been classified considering four resilience dimensions already defined in D1.3 (see Figure 6). Each resilience dimension has been split into several sub-dimensions that group policies that are related. These sub-dimensions help CITIES to visualize their maturity level in these predetermined sub-areas, as CITIES can be at different maturity stages in different policy dimensions and sub-dimensions.

[6] In the Maturity Model, each policy has been given a code for reference that consists of: the name of subdimension (for example: L1, L2, P1), the letter that identifies the maturity stage (S-Starting, M-Moderate, A-Advance, R-Robust and V-vertebrate) and a number. This code does not provide any information itself; it is just the name for the policy.

1) **Leadership & Governance**: Leadership and Governance affect the decision-making process of the CITY. Commitment by the leaders to a resilience culture, values and vision is essential for promoting effective strategies, inclusive decision-making and the engagement of relevant city stakeholders. All government levels should develop an organizational culture of enthusiasm for challenge, agility, flexibility, adaptive capacity and innovation.

   This dimension involves also the concept of multi-level governance that requires understanding the dynamic inter-relationship within and between different levels of governance and government. The transfer of competencies upwards to supra-national organizations and downwards to sub-national authorities has arguably transformed both the structure and capacity of national governments. Within this dimension three subdimensions have been considered to classify the policies in the Maturity Model.

   - Municipality, cross-sectorial and multi-governance collaboration (L1): This sub dimension includes all the policies related to the activities the city conducts to establish collaboration in topics related to resilience within the different departments of the municipality, between different sectors and between different governmental bodies.
   - Legislation development and refinement (L2): This sub dimension includes all the policies related to the development of laws and procedures that help formalizing the city's resilience building process.
   - Learning culture (learning and dissemination) (L3): This sub dimension includes all the policies related to the fostering of resilience culture among different CITY stakeholders as well as improving the learning process within the city.
   - Resilience action plan development (L4): This sub-dimension includes all the actions regarding the development of the resilience action plan

2) **Preparedness**: It refers to anticipation of future needs and adapting the CITY functions accordingly. Preparedness can be developed at all levels of society, from individuals and communities to leaders and governments. It also includes being prepared for the unexpected, by increasing flexibility and the CITY's adaptive capacity and skills. The sub-dimensions included in Preparedness are the following:

   - Diagnosis and Assessment (P1): This sub-dimension includes the policies regarding the systems and methodologies that can be used to monitor and assess the implementation of the resilience action plan.

- Education and Training (P2): this includes all the activities that can be carried out to inform, educate and train the city stakeholders. Activities to refine and disseminate the training programmes are also considered.

3) **Infrastructure & Resources:** The CITY infrastructure requires robustness to resist and absorb hazards through the preservation and restoration of its essential functions. This requires redundancy, risk management and continues work on decreasing vulnerabilities apart from the deployment of resources. The resources include all assets, people, skills, information, technology (including plant and equipment), premises, and supplies and information (whether electronic or not) that an organization needs to have available to use, when needed, to operate and meet its objectives.

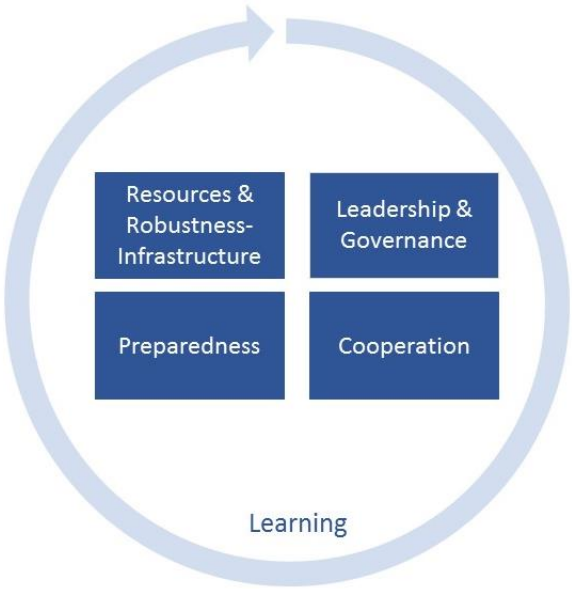

Figure 6: Dimensions used to classify the policies in the SMR Maturity Model

Within this dimension three sub-dimensions have been defined to classify the policies in the Maturity Model.

- Reliability of infrastructures (I1): This sub dimension includes all the policies that help increasing the overall reliability, redundancy and flexibility of Critical Infrastructures
- Resources to build up resilience (I2): This sub dimension includes all the policies related to the allocation of resources to build up city resilience and improve the quality of crisis response.

4) **Cooperation:** Cooperation refers to working or acting together for a common purpose or benefit. Cooperation is developed within the city and at a cross-regional level. The necessary stakeholders across city and regional sectors including European cities will be considered. Cooperation is also developed at community level involving different stakeholders such as volunteer groups and citizens that show the ability to self-organise. The sub-dimensions included in Cooperation are the following:

- Development of partnerships with city stakeholders (C1): The different stakeholders within a city (companies, volunteers, citizens…) need to take part in the city resilience building process. Therefore, the municipal authority needs to carry out policies to develop collaboration partnerships and agreements with the city stakeholders and involve them in participative, learning and decision-making processes
- Involvement in resilience networks of cities (C2): Cities need to be aware and collaborate with cities in order to contribute to its own as well as the overall resilience level. The municipal authority of a city needs to establish alliances and represent the city in networks of cities. This participation will allow the city to identify best practices, receive help and learn with other cities about the resilience building process.

As it is shown in Figure 5, resilience development is a continuous learning process. Learning is developed in each of the four resilience dimensions used in the SMR Project. The city stakeholders acquire knowledge, behaviour, skills, values, preferences or understanding of infrastructures, preparedness, leadership and cooperation that help improve the level of resilience, optimize the use of resources and avoid repeating previous mistakes. Learning is achieved through monitoring of past events and on-going processes to make predictions about future needs. The city needs to develop a set of best practices, which can help to guide new knowledge and learning and reflection activities. Learning is acquired in each of the four dimensions mentioned previously, being a cross-dimensional and a continuous process. Leadership & Governance fosters the culture of resilience, formalize the learning process and develop mechanisms to assess it. The reflection on past events, emergency drills and exercises allows to learn from previous mistakes improving the preparedness of city stakeholders to deal with future shocks and long-term stresses and the reliability of infrastructures. Resources need to be allocated to fund research projects to innovate. Finally, the cooperation and collaboration among the city stakeholders and their participation in national and international networks in which they collaborate with other cities and stakeholders can foster the learning processes through the mutual sharing of best practices and knowledge.

4.4 Indicators

Cities require mechanisms for evaluating policies designed to build resilience and more specifically, metrics for monitoring and assessing the performance of these policies and justify their investments on resilience. Additionally, the resilience measurement may contribute to raise awareness about the need for resilience and the needed resources (Prior et al., 2012). However, resilience can be difficult to measure

precisely because it is a complex and multidimensional concept. In this regard, progress is being making on finding suitable indicators and metrics that retain the resilience key attributes.

The Maturity Model identifies a rich set of qualitative and quantifiable indicators, since both types are considered important and complementary. A qualitative assessment provides a subjective diagnosis of a city's resilience identifying key strengths and weaknesses in policy, practice and behaviours; while a quantitative assessment enables cities to baseline their current status performance and monitor progress over time.

The indicators' aim is to provide cities with metrics for discussion and analysis of the different policies developed in the resilience building process, giving an indication of positive behaviours and supporting the continuous development that is made towards resilience building policies. The proposed indicators serve as a source of inspiration to measure the progress of the policies but until experience accrues the proposed indicators should be considered as promising candidates for resilience metrics rather than as being written in stone. Still, the periodical use of suitable indicators enables evaluation of progress towards objectives and identification of gaps and priority actions.

Two type of indicators have been identified: effort indicators and result indicators. Effort indicators are indicators that reflect the amount of effort that has been invested in implementing policies, while result indicators estimate the level of implementation of the policies. In turn, these indicators have been classified in the following nine categories based on their similarities.

- Learning: Within this group we have included all the indicators related to the learning process taking into account the systematization of the learning process and how far the learning process has been implemented.
- Stakeholder coordination: within this group we have included all the indicators related to measuring the level of coordination of the CITY stakeholders and the amount of agreements to ensure the effective coordination.
- Commitment: within this group we have included all the indicators related to the level of commitment and engagement of the different CITY stakeholders in the resilience building process.
- Capacity to respond: within this group we have included all the indicators related to assessing the capacity to face shocks and long-term stresses and the availability of resources and infrastructure during the response phase.
- Training: within this group we have included all the indicators related to the training activities carried out in the CITY and the level of training obtained.

- Resources: within this group we have included all the indicators related to measuring the resources used to set up resilience building approaches.
- Plans and procedures: within this group we have included all the indicators related to the implementation level of the resilience action plan and its coverage.
- Critical infrastructures network: within this group we have included all the indicators related to ensure the security and reliability level of the CIs and assessing the interdependences among the CI network.
- CI Maintenance: within this group we have included all the indicators related to the level of maintenance activities carried out in the CIs and the reliability level of them.

5 REVISED VERSION OF THE MATURITY MODEL

The SMR Resilience Maturity Model is essentially an integrated recommendation of identified best practices, including experts' views for defining the optimal evolution of the resilience building process from an initial stage to a more advanced stage, passing through a number of intermediate stages, where cities have different starting points. The fulfilment of the policies included in each maturity stage are expected to allow the city to move forward from one stage to the next one improving its resilience at a local level as well as enhancing the European resilience level.

The SMR Resilience Maturity Model classifies the policies into different maturity stages to increase the efficacy of the resilience building process. However, it does not mean that the policies will start to be implemented and will be fully developed in the same maturity stage. The policies developed in previous maturity stages must continue being considered as the CITY makes progress through the maturity stages. Therefore, the SMR Maturity Model includes the concept of a continuous improvement management process, allowing policies to adapt to new situations extending the well-known PDCA cycle[7] and the Integrated Management System developed in the CHAMP Project[8].

7 http://www.hse.gov.uk/managing/plan-do-check-act.htm

8 http://www.localmanagement.eu/index.php/cdp:home

The PDCA cycle (Figure 7) begins with the Plan step that involves identifying a goal or purpose and putting a plan into action. These activities are followed by the Do step, in which the components of the plan are implemented. Next comes the Check step, where outcomes are monitored to test the validity of the plan for signs of progress and success, or problems and areas for improvement. Finally, the Act step closes the cycle, integrating the knowledge and learning generated by the entire process, which can be used to adjust the goal. These four steps are part of a cycle of continuous improvement

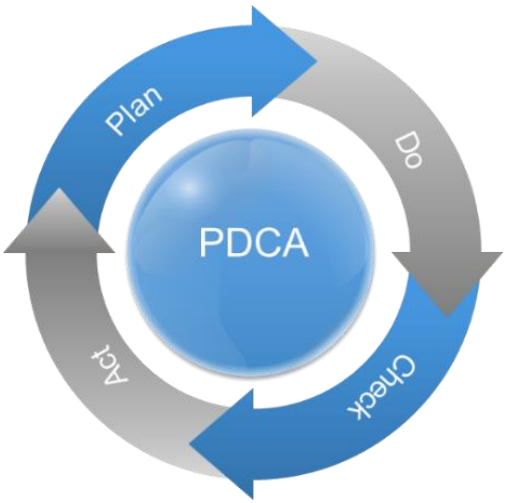

Figure 7: PCDA cycle

This management process is repeated in each of the maturity stages, keeping in mind two cross-cutting elements throughout the maturity path: the involvement of stakeholders and quality improvement. The number of the stakeholder (including external stakeholders outside the city) involved actively in the resilience building process increases as cities progress in the maturity stages. At the same time, the learning the cities are acquiring during the different maturity stages leads to raising the effectiveness and quality of the measures adopted in the more advanced maturity stages.

Figure 8 represents this iterative management process to build and improve the city resilience level throughout all maturity stages, where the X axis shows the increase in the number of the stakeholders involved in the resilience building process, while the Y axis shows the quality improvement over the maturity stages. The increase in the size of the PCDA cycles also shows an increase in the scope of the policies included in each maturity stage.

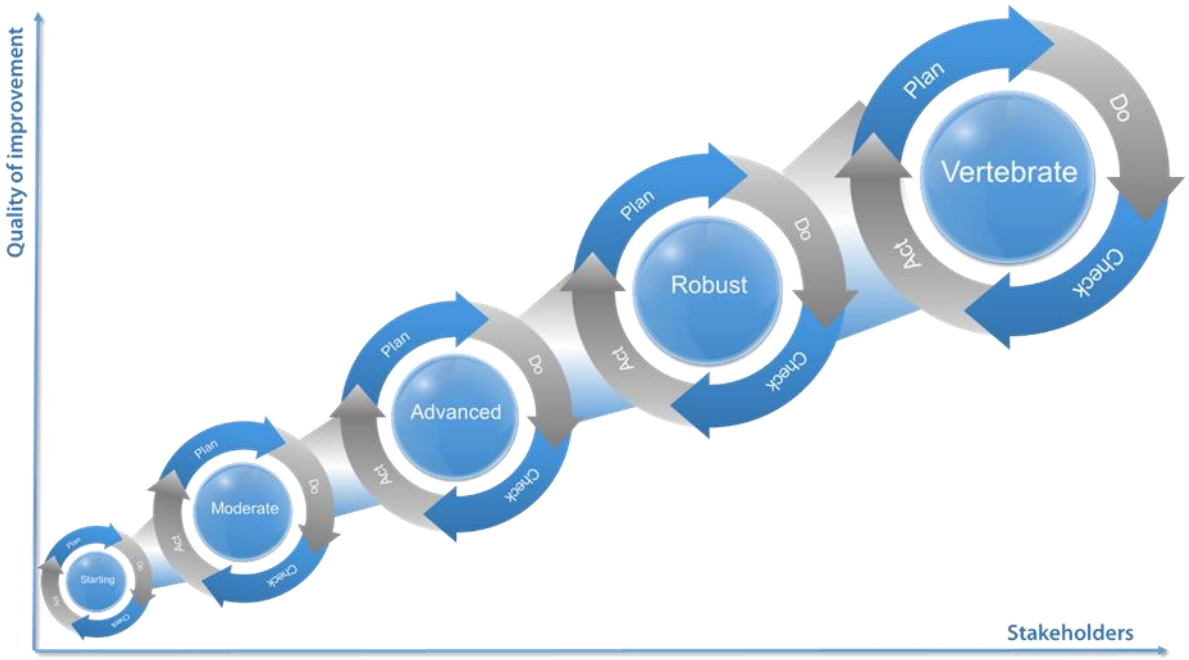

Figure 8: Iterative management process to build and improve the city resilience level throughout all maturity stages

The following sections describes each maturity stage, including the stakeholders involved and the policies included in each stage. The whole SMR Maturity Model is presented in Annex 1.

5.1 Stage 1: Starting

5.1.1 DESCRIPTION

STARTING	
Leadership & Governance	City departments have started developing resilience policies but a coordination between the different activities conducted by different departments is lacking. A common strategy among the municipal departments is still missing. However, a need to establish a working team responsible of resilience issues has been recognised. Resilience appears is in the agenda of other relevant stakeholders outside the municipality. However, they work independently focusing their efforts on

	increasing their own individual resilience without considering the existing links with other relevant stakeholders. As of now, the resilience policies have been limited to the city's borders. The local authority adopts a local governance approach, not recognizing yet the need for a multi-governance approach. As a consequence of this local governance approach, there is a lack of collaboration with sub urban or regional stakeholders. The local government recognizes the need to identify requirements regarding resilience, and they develop an integrated resilience action plan with common practices and approaches. This way, the resilience approach/strategy is included in the city's agenda at a strategic level. Moreover, the city starts to be aware of the importance of creating a resilience culture that enables learning from experience and connecting city departments and CITY stakeholders around topics related to resilience building.
Preparedness	So far, the emergency management is based on risk assessment without having an integrated approach towards multi-hazard nor a long-term perspective. A basic risk management has been conducted in an ad hoc manner being still fragmented and incomplete regarding different types of hazards. Having in mind the resilience approach, and as a preliminary step for defining the city resilience action plan, the municipality carries out an analysis of the city's vulnerabilities and strengths, listing the assets and prioritizing the critical services concerning their significance for the city in case of a shock occurs. A database with information about past shocks and current risks is used to evaluate impact and probability of individual risks, which helps to develop risk mitigation strategies for highest priority risks at city. This database is also used with learning purposes compiling information and best practices from past experiences. The local government endeavours to establish a common understanding of the resilience approach among stakeholders, which is crucial to row in the same direction.

	At this stage, training exercises and drills are conducted between emergency services and Critical Infrastructure providers to meet minimum mandatory requirements. The municipality is aware of the need to involve other stakeholders in this training programme, and so it offers to citizens volunteering opportunities within the local community.
Infrastructure	Critical Infrastructure providers operate independently of each other, therefore there is a need for improved organisation and cooperation among the Critical Infrastructure providers; and especially in times of emergency when a disruption to one Critical Infrastructure can lead to cascading effects across other infrastructures. Contingency plans required by the law are carried out. The basic resources are in place to achieve the organisation's emergency management objectives. Service agreements are established and maintained for managing and delivering services The entities of the cities have carried out an analysis of resilience resources that they need to manage shocks and long-term stresses (e.g. personnel, facilities, tools, technology, equipment and budget). The basic resources are in place to achieve the city's emergency management objectives. The local government carries out monitoring of the proper functioning of the CIs in order to ensure the service of critical services and their safety.
Cooperation	The municipal authority provides citizens with a public website that informs them about emergencies and potential risks, and it offers them the opportunity to join volunteer groups and be involved in emergency management. However, information about other resilience building activities carried out by different stakeholders at the municipality is limited. Relevant stakeholders and sectors outside the municipality work independently from others. Therefore, at this stage, the municipal authority maps and identifies the relevant stakeholders that need to be take part in the development of the city action plan.

	The city does not tend to collaborate with sub urban or regional stakeholders and its participation in resilience networks is incipient.

5.1.2 STAKEHOLDERS INVOLVED

At the starting stage, the commitment of the local government to the city resilience building process is required to include the resilience approach in the city's agenda. At this stage, the different departments of the local government take actions and implement policies that contribute to improving the city resilience. However, these measures and policies are not coordinated and integrated into a common strategy. At this point, the **local government** acts proactively leading the resilience building process. Its role is crucial since it integrates the actions developed independently by different municipal departments and stakeholders into a common strategy and communicate it so that everybody involved in the process has the same understanding about its objectives.

Furthermore, at this stage **emergency services and critical Infrastructure providers** have agreements to collaborate with the local government to guarantee the provision of basic services as well as an adequate response in case of emergencies. Nevertheless, collaboration among critical service providers and emergency services need to be improved as these services operate independently. At this point, the role of Critical Infrastructure providers is reactive to accomplish the local government and emergency services requests, conducting joint emergency drills to meet minimum mandatory requirements.

5.1.3 POLICIES

The different polices or actions that each city may consider in this stage are the following ones. Each CITY needs to prioritize them based on their current situation.

Dimension	Policy
Leadership & Governance	**(L1S1) Establish a working team responsible for resilience issues in the city** The city establishes the basis of an interdisciplinary team that will mainly focus on resilience building efforts, from initial assessment to specific interventions and projects that strengthen resilience.

	(L1S2) Integrate resilience into visions, policies and strategies for city development plans The city starts to include the term resilience as central part to its agenda, and takes the decision to involve resilience building activities in development and planning procedures. **(L3S1) Develop a strategy to create a resilience culture** The strategy should foster the resilience culture in a city among citizen's agencies. It should also focus on a culture of knowledge and respect of various stakeholders by learning from experience and integrating city departments and city stakeholders. **(L4S1) Identify the city requirements regarding the resilience process** The local government arranges cross-departmental meetings and workshops to identify the city resilience requirements from a holistic, rather than a silo, perspective as it has been until now. These meetings also involve other stakeholders such as Critical Infrastructure providers. The needs of a city to improve its resilience level regarding problems derived from critical infrastructures dependencies, climate change and social dynamics are identified. These requirements will be used afterwards to develop the resilience action plan.
Preparedness	**(P1S1) Assess and manage a wide range of risks:** Use a risk register to evaluate impact and probability of individual risks. Develop risk mitigation strategies for highest priority risks at city/regional level. The goal is to have an overview of the past shocks that the city has dealt with including facts and measured data and to generate assumptions on the risk of future incidents. This involves the generation of a list of risks mainly focused on sudden shocks and stresses, and the assessment of their impact and probability. Policies considered by a city will then be evaluated with respect to these risks on an individual basis. This database should be updated regularly based on shocks and stresses experienced by the city and region. **(P1S2) List and prioritize critical services and assets**

This policy is about prioritizing among conflictive goals to identify essential and non-essential services and assets and to assess the most important values/assets to protect. The shocks and risks identified in the database developed in P1S1 are prioritized with respect to their significance to the city. This is important because it helps the city understand better how to allocate its resources and how to organize its preparation for addressing those shocks and risks.

(P1S3) List existing plans and response mechanisms and guidelines for shocks and stresses

It is necessary to have an updated database that compiles the plans that are being developed independently by different municipal departments in order to have a complete picture of all the plans and response guidelines to deal with shock and stresses.

(P2S1) Conduct training and arrange emergency drills with the emergency teams and Critical Infrastructures providers

Resilience responsible staff at the city council need to carry out training activities with the emergency teams and Critical Infrastructure providers in order to be prepared and respond quickly when a shock occurs. A needs based training programme is established and the exercises with emergency services are conducted regularly according to the training programme.

(P2S2) Inform citizens about volunteering opportunities in the local community

The local government provides information about different initiatives and activities where they can be involved through the arrangement of workshops, conferences or the city council website. The role volunteering plays in strengthening citizen engagement, social inclusion and building resilient communities is of high importance. It is widely recognised that volunteering opportunities have a positive impact on individuals, organisations and the wider community.

Volunteering seeks to build community well-being, sustainability and respects the dignity of all people; helps tackle social, cultural, economic and environmental issues; and builds a more humane and just society. These initiatives of volunteering refer to activities undertaken independently as an

	individual to help others (e.g. checking on the wellbeing of an elderly neighbour), or as part of wider community activity in response to an identified issue or need (e.g. care and maintenance of the local environment). **(P2S3) Develop a common understanding of the resilience approach among stakeholders** The local government adopts a common terminology to be used by all departments in order to construct a shared understanding of resilience. This terminology is explained to the staff working in resilience building process through meetings and workshops.
Infrastructure & Robustness	**(I1S1) Develop cooperation/collaboration agreements with critical providers** The local government establishes collaboration agreements with critical infrastructure providers in the city to ensure continuity of critical services in case of crisis or emergency, and to help and collaborate with them in emergency situations in order to ensure the delivery of critical services in the city. It also makes agreements with potential supplier and external emergency services and update them periodically. **(I1S2) Develop plans to monitor CIs functionality** The local government establishes plans to monitor and control the proper functioning of the CIs. The plan establishes how often the monitoring is performed, and, as part of the monitoring process, they evaluate the degree of investment in safety and security of the infrastructure – for example, whether there is a contingency plan in place in case a crisis occurs or not, how often the service is interrupted, etc. **(I1S3) Develop contingency plans for critical infrastructures** local governments have emergency contingency plans to deliver critical services in case of emergency situations aimed at keeping CI functioning at minimal level in case of crisis or emergencies. **(I2S1) Assess current initiatives and funding opportunities for the development of resilience** Cities start to look for opportunities such as participation as partners in EU-Projects for funding or cooperation with other cities to enhance city resilience.

	(I2S2) Develop a list of currently available response physical resources At this stage, local government makes an exhaustive analysis of the critical infrastructures and services, resources, assets of the city, etc. in order to know the capacity of the city to improve resilience and face shocks and long-term stresses. Furthermore, it estimates the costs of response activities and assigns the efforts required. **(I2S3) Deploy a disaster relief fund for emergencies** local government allocates funding to provide resources and help city stakeholders in emergencies and increase the resilience of the city.
Cooperation	**(C1S1) Map relevant stakeholders to develop a resilience action plan** This policy is about mapping stakeholders who will play a role in the development of a resilience action plan. The city delineates relevant entities in different sectors of the city, as well as public and private companies that provide vital services for the city. This can include identifying stakeholders who are not a part of the existing structures, but who will be necessary in the future. The stakeholders can also be interest groups within the local communities, NGOs and media. **(C1S2) Develop a public website with emergency information** A public website is set up to provide up-to-date information one-way (local government to citizens). The public website should provide information for communicating advice and support to citizens during any shock event.

5.2 Stage 2: Moderate

5.2.1 DESCRIPTION

MODERATE	
Leadership & Governance	Local government works towards an adaptation of a resilience approach in order to be prepared for expected and unexpected events. The city develops a systematic and holistic approach to building resilience by supporting populations at risk to withstand, cope with, adapt and quickly recover from shocks and stresses.

	The resilience action plan includes: 1) the scope, 2) the policies to be developed that are focused on Critical Infrastructure interdependencies, climate change and social problems and 3) the roles and responsibilities of city stakeholders. The city is committed to the resilience building process and therefore, it sets up an organizational structure aimed at managing the resilience action plan, which includes deploying resources for its development. The city is aware of the future challenges related to climate change and social issues. Consequently, policies to help tackling those problems are developed. At this moment, resilience policies are not limited within the city's borders, they start to be aligned, integrated, and connected with the ones included in regional plans. The city is concerned about the need to develop a multi-level governance approach at a European level and therefore it develops a white paper in which the basis for future legislative frameworks are set up. The city is conscious of the importance of increasing resilience awareness among the stakeholders. Therefore, resilience awareness activities such as campaigns, events or training activities for all the stakeholders are conducted.
Preparedness	local government revises best practices to deal with shocks and stresses used in different sectors and other cities to elaborate the resilience action plan. Debrief meetings to identify and analyze lessons from past experiences are conducted with municipal departments, emergency services and Critical Infrastructure providers. Emergency services provide training to volunteer organizations, especially for those who live in risk prone areas. Early warning systems to alert society when a hazard is approaching are set up to prepare them to deal with shock events in a more effective way.

Infrastructure	Risk assessment with regard to hazards affecting Critical Infrastructures is operationalized in cooperation with Critical Infrastructure providers in order to deliver essential services in case of crisis or emergency, defining measures to rapidly bounce back maintaining the previous level of functioning. Measures to improve Critical Infrastructures' reliability and robustness are identified and implemented, such as implementation of redundant systems, development of preventive maintenance activities, compliance of audits. Furthermore, analysis of the interdependencies with other CIs is conducted in order to anticipate the cascading effects. Resilience action plan is integrated in the local government budget and they promote that CI providers share resources and tools in the resilience building process.
Cooperation	At this point, a platform to exchange information on the resilience building process is established. However, the platform is internal to the municipality and emergency services. In order to scale up resilience building efforts, the municipality develops a stakeholder engagement plan to define the roles and responsibilities of stakeholders that need to be involved in the development of a resilience action plan. Regarding collaboration, the city recognizes the importance of participating in networks with other cities and establishes alliances with cities that face similar risks.

5.2.2 STAKEHOLDERS INVOLVED

At moderate stage, **Critical Infrastructures and emergency services** collaborate on a regular basis with the local government The **local government's** commitment has fostered the achievement of partnerships between **Critical Infrastructure providers** and emergency services to conduct joint training exercises regularly. The interdependencies from the different critical services are integrated and included into a common long-term resilience plan of the city. Furthermore, at this stage, **volunteers and NGOs** are involved in training programs and emergency exercises with emergency services and Critical Infrastructures. Local government is a key driver in this process informing citizens about the volunteering

opportunities and supporting them. In addition, the **regional government** starts to be involved in the resilience building process and collaborates with the local government in the development of the city resilience action plan. Finally, initial efforts are undertaken by the local government to involve public and private companies in the resilience building efforts.

The **local government** is aware of the importance of creating public-private partnerships to help communities become more resilient in addition to increasing the efficiency and effectiveness of the resilience building process. Consequently, the local government communicates the resilience strategy to public and private companies asking them for their commitment and active involvement.

5.2.3 POLICIES

The different polices or actions that each city may consider in this stage are the following ones. Each CITY needs to prioritize them based on their current situation.

Dimension	Policy
Leadership & Governance	**(L1M1) Establish a resilience department or committee and a cross departmental coordination board and procedures** This department or committee will be formed by committed staff that will steer and coordinate the city's resilience action plan, thus: • Institutionalize the resilience action plan by developing a new organizational structure in the municipality, including the CRO position alongside other supporting roles • Monitor the implementation of the resilience building plan, coordinating the actions across the different stakeholders and raising any new challenges. • Moving away from just planning, the city allocates resources into a resilience action plan and a department that will deal specifically with resilience building efforts **(L1M2) Align, integrate and connect the resilience action plan with regional plans** The city has an overview of all existing local and regional plans and develops and aligns its resilience action plans taking them into consideration. For instance, the city will need to adopt urban planning and building design strategies that

allow them to increase their abilities to better respond and adapt to the economic, social, and physical challenges connecting each strategy to regional plans.

(L1M3) Adopt climate change preventive actions

The city is aware of climate change and its remaining challenges and therefore, it is committed to adopting preventive actions to tackle the consequences of climate change such as establishing a target for citywide emissions to help reduce them.

(L1M4) Promote equality of access to services and basic infrastructure to vulnerable sector of society

Improve the access to basic infrastructure and basic services such as potable water, sanitation, health services and education to vulnerable sectors of society.

(L2M1) Develop a white paper about multi-level governance approach

The city develops a white paper that will set up the basis of future laws and regulations regarding resilience, to integrate mechanisms developing long-term strategic plans and involving all levels of governance (regional, national and international), reinforcing its democratic dimension and following EU standards and regulations.

(L3M1) Promote a culture of resilience

The city is conscious of the importance of increasing resilience awareness among the stakeholders. To do so, the city should arrange different resilience awareness raising activities such as campaigns, events or training activities for all the stakeholders.

(L3M2) Review of best practices to deal with shocks and stresses used in different sectors and other cities

This policy has to do with learning from other cities' and sectors' experiences to assess own vulnerabilities and response capacity. Plans and strategies from national and international cities are revised.

(L4M1) Develop a resilience action plan to respond to shocks and long term stresses

The city develops a systematic and holistic approach to building resilience by supporting populations at risk to withstand, cope with, adapt and quickly recover from shocks and stresses with a focus on efficient interventions having a lasting

	impact. Local government wants to be prepared for expected and unexpected events. The resilience action plan includes: 1) the scope, 2) the objectives, which considers human lives and health, societal functionality, economic assets and environment and 3) the roles and responsibilities of the city stakeholders.
Preparedness	**(P1M1) Take account of interdependencies between risks when assessing and managing risk** Use a more holistic approach to risk assessment through using the risk register to reflect on interdependencies between risks. Identify 'potent' risk policies that can manage a number of risks in a risk area and focus on allowing the city to pay attention to 'bouncing back' from both shocks and stresses. **(P2M1) Conduct training and arrange emergency drills including volunteers** Training activities are conducted with volunteers in order that they respond quickly when a shock occurs. Training is provided by the emergency services to prepare them to deal with shock events in a more effective way. This training enables volunteers to act as a conduit for information between emergency responders and the local community to promote resilience, minimize the impact of disruptive events upon the community and reduce the need for external support.
Infrastructure & Robustness	**(I1M1) Identify interdependencies of critical services at local level** Critical infrastructures need to define the interdependencies that exist with other critical services and stakeholders in order to estimate how the impact can affect the other critical services of the city and the availability of the response resources. **(I1M2) Develop periodical preventive maintenance procedures for Critical Infrastructures** Critical infrastructure providers are required to carry out preventive maintenance actions with a regular periodicity. The objective of these preventive maintenance actions is to guarantee the correct level of performance of critical infrastructures and the systems within the CIs so that they are able to provide critical services in emergencies.

	(I1M3) Develop measures to increase Critical Infrastructure redundancy and reliability Critical Infrastructure providers are required to identify actions that ensure their redundancy and reliability in terms of providing critical services in case of emergencies. Back-up systems are necessary in order to ensure the functioning of the CIs. The implementation of these actions could start in this first stage or can be part of the following maturity stages, depending on the context of the city (resources deployed, commitment of the stakeholders…). **(I1M4) Implement monitoring systems for identifying shocks and long-term stresses** Systems for gathering data and anticipating any possible shock and long-term stress are implemented, such as sensors, weather forecasting systems. **(I1M5) Carry out audits for critical infrastructure providers** The local governments require that Critical Infrastructure providers conduct periodic audits to ensure that they have emergency plans and comply with rules and legislation to deliver essential services in case of crisis or emergency. **(I2M1) Allow for the resilience action plan in the local government budget** Costs and resources assigned to the implementation of the resilience action plan of the city are included in the local budget of the local government to increase the resilience level of the city. Furthermore, the distribution of the resources among the stakeholders is determined. **(I2M2) Promote resources/tool sharing among CI providers within a region during crises** The local government encourages CIs to share resources and tools so that they are able to obtain extra resources during a crisis and there is more coordination and cooperation during a crisis. Sharing the information systems allows for improvement in understanding among the CIs and sharing the same information among the different stakeholders.
Cooperation	**(C1M1) Develop a stakeholder engagement plan defining its roles and responsibilities** The city starts to develop a systematic plan on how to engage and interact between previously identified stakeholders. The city has a clear definition of their

	roles and responsibilities and a systematic plan such as awareness program for socializing and increasing awareness of the stakeholders of the city resilience action plan. **(C1M2) Develop an internal communication platform for sharing information with different municipal departments and emergency services** A website that facilitates the internal communication and information sharing via a secure online platform among the different departments of the municipality and emergency services is to set up. **(C2M1) Establish alliances with cities facing similar risks** The city starts to look for opportunities for further cooperation and learning with other cities to strengthen the collaboration and learn, and thus to enhance city resilience.

5.3 Stage 3: Advanced

5.3.1 DESCRIPTION

ADVANCED	
Leadership & Governance	At this point, city resilience policies start to be aligned, integrated and connected with the national-level plans. The city recognizes a need for a multi-governance approach towards resilience. The local authority starts to develop a plan for a multi-level governance approach involving the municipal, regional and national levels of governance. The city recognizes a need to develop legislative frameworks that includes the obligations and responsibilities of the different stakeholders in the resilience building process. Moreover, it also recognizes the need to conduct certification processes that demonstrate their commitment regarding city resilience. The city recognizes the need to formalize the learning process.

	The municipality changes its role in the resilience building process from being the central guide of the process to becoming a facilitator.
Preparedness	The city has developed an operational resilience action plan with an holistic approach that integrates all sectors and relevant stakeholders. The resilience action plan is recognised and followed within the municipality and by city stakeholders. The progress of the resilience action plan is monitored using leading and lagging indicators in order to assess the effectiveness and impact of the implemented policies. Training exercises are conducted regularly at a national level involving citizens and public and private companies. The training programme is regularly reviewed and updated in line with the analysis of requirements regarding city resilience.
Infrastructure	The resilience action plan contains measures to increase the flexibility of city infrastructures to deal with shocks and stresses and to adapt to on-going circumstances. Providing incentives for citizens and private sector to provide with solutions at local level helps strengthening social cohesion and supporting the goals of the resilience action plan. The government encourages local businesses to invest in appropriate insurance coverage and to develop a resilience plan to be able to face crises in an efficient manner. Finally, the management of critical resources is centralized so that they can be efficiently used in the occurrence of crisis.
Cooperation	The city recognizes that in order to increase the engagement and mobilization of relevant stakeholders there is a need for a shift from top-down city level to bottom-up initiatives. As a result, a public communication platform is set up and public consultations are conducted to allow stakeholders to provide input and suggestions with respect to the city resilience building process.

Furthermore, at this stage, the municipality meets on a regular basis with representatives from different city stakeholders in order to identify common goals and construct a shared understanding of the approach to building city resilience.

At this point, the city joins a major network of European cities (such as Smart Mature Resilience or Resin European projects) dedicated to resilience building, and it starts to collaborate with regional stakeholders concerning the resilience building process.

5.3.2 STAKEHOLDERS INVOLVED

At the advanced stage, **local and regional governments, emergency services, critical infrastructures and public and private partnerships** are engaged in learning networks to improve the city resilience action plan. Furthermore, the contribution of **academic and scientific entities** is recognized at this stage, where partnerships are developed to identify methodologies to improve and evaluate the progress of the city resilience. The research carried out by academic and scientific entities is of paramount importance in the development of new concepts and approaches and in the assessment of their relevance in the resilience-building process. The **local government** provides incentives for investments in R&D&I projects to test innovative ideas, methodologies and tools that address the challenges of the resilience building process.

In addition, to improve collaboration with **public and private companies**, these companies are provided with incentives if they contribute to the achievement of goals of the city resilience action plan. Also, the media is involved in the city resilience building process and information is shared with them so that the goals and actions of the resilience action plan are widely informed to citizens. Media is used by the local government as a channel to communicate and disseminate to citizens the municipality strategy towards building resilience, increasing citizens' awareness and commitment to contributing in the resilience building process.

At this stage, **citizens** are also provided with the opportunity to participate in platforms to provide input, suggestions and comments about the resilience building process. Moreover, direct citizen involvement is a strategic shift in resilience building process. Citizens contribute to increasing the preparedness, response, and recovery of shocks and stresses since they are usually the first responders, already at the scene of a disaster as it occurs demonstrating a capability to deal with the emergency situation.

Programs designed at any governance level to inform citizens about the specific risks in their local environment and providing tips on how to prepare for and react to these risks increase their awareness and preparation capacity to take appropriate actions if something occurs.

Finally, the **national government** is also involved in the resilience building process of the city to integrate and connect the city resilience action plan with national plans.

5.3.3 POLICIES

The different polices or actions that each city may consider in this stage are the following ones. Each CITY needs to prioritize them based on their current situation.

Dimension	Policy
Leadership & Governance	**(L1A1) Align, integrate and connect the resilience action plan with national plans** The city has in hand an overview of all existing local and regional plans and develops and aligns its resilience action plans taking them into consideration. For instance, the city will need to adopt urban planning and building design strategies that allow them to increase their abilities to better respond and adapt to the economic, social, and physical challenges connecting each strategy to regional and national plans. **(L1A2) Develop a plan for multi-level governance approach involving the municipal, regional and national levels of governance** The city develops a plan with mechanisms to involve and coordinate municipal, regional and national levels of governance in topics related to resilience. **(L2A1) Conduct certification processes to achieve the conformity with national standards** The city conducts certification processes for assessing the activities of a city with regard to the fulfillment of existing national standards related to resilience. A standard is a documented definition or rule approved and monitored from compliance by the local authority as a minimum acceptable benchmark of resilience. The achievement of these standards demonstrates the concern and formal commitment of the city with respect to building city resilience. **(L3A1) Formalize the learning process and institutionalize regular debriefing meetings**

	The learning process should be described and formalized by local authorities. Regular debriefing meetings between the CITY stakeholders should be initiated and their periodicity and format should be defined. The principal objective of these meetings is to analyze what was done in response to previous shocks and how the event was handled. The good and bad actions of management must be analyzed. This reflection will enable the identification of best practices and lessons learned. In addition, the resilience action plan is regularly evaluated and updated reflecting the lessons learned from past events. After the occurrence of a significant event, lessons learned are documented and the resilience action plan is updated according to them, their consequences and cascading effects. **(L4A1) Develop leading indicators for assessing the performance of the resilience action plan** A set of indicators are identified and used to monitor and assess the level of implementation of the resilience action plan. These indicators can be measured quantitatively or qualitatively, and provide useful information of the deployment of resources and the evolution of the policies included in the resilience action plan.
Preparedness	**(P1A1) Assess and prioritise risk scenarios and their implications through consideration of risk Systemicity (e.g. using Risk Systemicity Questionnaire)** Scenarios are used to analyze the cascading effects, long-term ramifications of shocks and unintended consequences of the implemented policies. These scenarios are evaluated regularly and the identified 'lessons learned' are documented and integrated within the resilience action plan. Use the risk systemicity tools for an increasingly advanced holistic approach through assessment of risk scenarios and their long-term impacts on a city/region. Use the RSQ for policy suggestions and help with prioritizing high risk areas through coordination with relevant stakeholders **(P2A1) Provide training for citizens and public and private companies** This policy is about carrying out training activities with local organisations and individuals to identify and utilise local resources for dealing with shocks and

	longer-term stresses. This training is focused on collaboration-training for different organizational bodies in the city with a focus on flexibility, authority, responsibilities, and communication and role-taking. **(P2A2) Conduct emergency drills at national level** This policy is about carrying out regular training activities at the national level involving relevant stakeholders such as citizens in order to ensure their efficient collaboration when a shock event occurs, thus supporting the preparation and response. **(P2A3) Develop education programs in schools about the resilience action plan** An effective collaboration with schools needs to be conducted in order to explain the goals and actions of the resilience action plan and thus to increase the citizens' awareness of resilience and their preparation to deal with future emergency situations. **(P2A4) Assess and refine the training programs** Exercises and drills are conducted regularly according to the training programme including the relevant city stakeholders. However, to guarantee their effectiveness this training programme is reviewed regularly and updated in line with the analysis of requirements. The exercises that are carried out are evaluated and extracted lessons learned documented to include them afterwards in the resilience action plan.
Infrastructure & Robustness	**(I1A1) Develop flexibility measures** Flexibility is an essential part of resilience that refers to the ability to change and adopt alternative strategies. By learning how to be more adaptable, infrastructures will be better prepared to respond to adversities. Resilient infrastructures and organizations often use difficult events as an opportunity to bounce forward to a higher resilience level and branch out in new directions. While some may be highly affected by abrupt changes, those which are highly resilient are able to adapt and thrive. **(I2A1) Promote and provide incentives for initiatives that contribute to build resilience**

	At this stage, the local government promotes the investments in resilience and gives rewards, grants or incentives to bottom-up initiatives that have been active in sectors related to resilience. At this point, the municipality changes its role, becoming a facilitator of initiatives and proposals from the citizens and private sectors. **(I2A2) Implement centralized control of coordination of critical resources and activities during shocks and stresses** The city needs to control in a centralized way the coordination of resources and activities during shocks and stresses to ensure the most efficient response to crises. Resources are updated, documented and tracked, and their availability is prepared for immediate deployment. **(I2A3) Encourage stakeholders to have appropriate insurance coverage** The city needs to alert stakeholders about the importance of having an appropriate insurance coverage and resilience business plans so that they are able to resist better to the shocks and long-term stresses and when something occurs, it is easier to get resources for the recovery. **(I2A4) Promote and provide incentives for the development of sustainable urban infrastructure** The regional government establishes incentives in order to make investments in sustainable urban infrastructures. These measures reduce the threats to the climate change and effectively make cities more sustainable.
Cooperation	**(C1A1) Align the objectives of different stakeholders and develop a common understanding of resilience** The city should find ways to build a common understanding and set common objectives, between stakeholders when it comes to resilience. Representatives from different stakeholders of the city are invited to participate in multi-stakeholder meetings and committees in order for these stakeholders to explain the concerns and challenges and be able to align efforts and objectives to build resilience. **(C1A2) Develop formal partnerships with academic and scientific entities to improve the resilience building process.**

	Academic and scientific entities contribute to the development and understanding of the resilience building process. Academic and scientific entities can provide methodologies and tools to improve and evaluate the resilience building process. **(C1A3) Undertake public consultations to receive feedback on the resilience action plan** Stakeholders need to be provided with the opportunity to provide their feedback on their resilience building process of the city. Therefore, the city carries out public consultations and surveys in which the priorities and necessities of the stakeholders are identified. **(C1A4) Develop a public communication platform to interact with stakeholders** A public communication platform is set up to allow stakeholders provide input, suggestions and comments about the resilience building process. **(C2A1) Join a major Network of EU cities** The city becomes a member of resilient cities network to collaborate and learn from other cities. However, the participation of the city in this network is incipient and helps the city to identify what other cities are doing to improve their resilience level. **(C2A2) Develop formal partnerships with regional stakeholders** The city develops alliances with the stakeholders at regional level in order to identify interdependencies, pool resources and collaborate to build the resilience of the region.

5.4 Stage 4: Robust

5.4.1 DESCRIPTION

ROBUST	
Leadership & Governance	The city has developed an operational resilience action plan which follows a holistic approach integrating all relevant sectors and stakeholders.

	Resources are allocated to support research and development activities and to improve the CITY's capacity to cope with current and future shocks and stresses. At this point, resilience policies of the city start to be aligned, integrated and connected with the international resilience management guidelines. The city starts to develop policies that enable them to work in partnership and to create and promote learning opportunities (all ages, all parts of city).
Preparedness	The resilience action plan is continuously revised and improved based on the non-compliances identified and improved including lessons learned obtained through institutionalizing regular debriefing sessions to facilitate a shared understanding, reflection and discussion. The resilience action plan is also continuously improved based on research and best practice. The emergency drills and exercises are evaluated and lessons learned are documented. The resilience action plan is updated reflecting the outcomes of training exercises and stress tests. Exercises and drills are carried out at a European level with the aim of improving the inter-organizational coordination, identifying gaps in resources and validating the policies, equipment and inter-organizational agreements. At this point, the involvement in these exercises of all stakeholders relevant to the cities is a fact, covering also the multi-governance approach.
Infrastructure	The government monitors the proper use of resources in order to verify the effective improvement of the resilience level. Furthermore, it provides incentives to stakeholders to invest in projects that aims at improving the resilience level of the CITY. It also encourages citizens to assess themselves in order to take the necessary actions, such as having a proper insurance coverage, to ensure they are well prepared to face shock and stresses.

Cooperation	All relevant stakeholders that need to be involved in the resilience action are engaged in the resilience building process, so in this stage we can talk about a CITY. Resilience is a part of daily thinking and acting of stakeholders and they regularly participate in collaborative networks and debriefing meetings where the progress of the city resilience building process is decided. Furthermore, the resilience action plan is continuously improved and updated based on the feedback and suggestions received from the city stakeholders through the feedback obtained in public debriefing meetings and participatory platforms. The CITY participates in a regional, national and international networks with regard to resilience, with a proactive posture and continuous learning and transferring knowledge.

5.4.2 STAKEHOLDERS INVOLVED

At the robust stage, the **European policy makers** are involved in the city resilience building process. This enables to have a common legislative framework with guidelines for the collaboration among different countries and the resource sharing in case of shocks and stresses. The European policy makers also provide guidelines to help infrastructure providers to incorporate resilience building programs towards climate change, shocks and stresses apart from the policies to overcome inequalities and promote well-being and cohesion.

Additionally, the city is engaged in a variety of **European networks** to collaborate with other European cities. Therefore, at this stage **all the city stakeholders (local, regional, national and European government, emergency services, critical infrastructures, public-private companies, NGOs, volunteers, regional government, media, citizens, academic and scientific entities)** are actively involved in the development of the city resilience. Furthermore, the feedback and opinion from these stakeholders are taken into account for the implementation of the resilience action plan and to make decisions about the progress of the city's resilience. At this stage, stakeholders recognize the importance of collaborating in the resilience building process and perceive the benefits. In addition, they make significant effort to learn and improve the resilience development by sharing lessons learned and engaging in multi-stakeholder discussions.

5.4.3 POLICIES

The different polices or actions that each city may consider in this stage are the following ones. Each CITY needs to prioritize them based on their current situation.

Dimension	Policy
Leadership & Governance	**(L1R1) Align, integrate and connect the city resilience plan with regional, national and international resilience management guidelines** The CITY follows a cohesive and integrated planning approach regarding resilience that involves all relevant stakeholders and aligns processes and actions with management guidelines from all governance levels. The city develops long-term strategic plans involving all levels of governance, reinforcing its democratic dimension and following EU standards and regulations. The city coordinates with national and international authorities to apply and adapt policies and legislation to municipality action plan. The city includes the EU dimension on its city resilience plan, what defines how the city needs to interact with other European cities to increase the European Resilience Backbone. **(L2R1) Conduct certification processes to achieve the conformity with international standards** The city conducts certification processes for assessing the activities of a city with regard to the fulfillment of existing international standards related to resilience. A standard is a documented definition or rule approved and monitored from compliance by the local authority as a minimum acceptable benchmark of resilience. The achievement of these standards demonstrates the concern and formal commitment of the city with respect to building city resilience. **(L3R1) Create a Learning city** The city works in partnership to create and promote learning opportunities (for all ages and all parts of the city). **(L4R1) Assess and monitor the efficiency of the resilience action plan periodically in order to improve it continuously** The resilience action plan is continuously monitored and reviewed to support continuous improvement. It is also updated reflecting the outcomes of training

	exercises that are conducted and general lessons learned. Results from research and best practice are also incorporated in the resilience action plan.
Preparedness	**(P1R1) Undertake regular and long-term risk assessments with a focus on risk systemicity** Identify long term risk for city/region/Europe. Regular evaluation of risk scenarios and policies, using risk sistemicity tools, informed by the European perspective. **(P1R2) Establish a strong network of volunteers** Volunteer groups have a crucial role in the city resilience building process. Therefore, the city should provide resources, help and support in order increase the capacity of volunteers to lead and coordinate resilience building activities. **(P2R2) Conduct frequent joint training exercises between European cities** The CITY leads the implementation of training exercises where all the relevant stakeholders from the European resilience backbone take part.
Infrastructure & Robustness	**(I1R1) Identify interdependencies of critical services at international level** Critical infrastructures need to define the interdependencies that exist with other critical services and stakeholders at international level in order to estimate how the impact can affect the other critical services of the city and the availability of the response resources. **(I2R1) Promote and provide incentives to stakeholders for investments in R&D&I projects regarding resilience** At this stage, the local government promotes investment in resilience and gives rewards, grants or incentives to companies and organizations both from the public and private sector that are committed to improve their resilience level. **(I2R2) Monitor an effective use of resources to ensure the resilience building process performance** The use and distribution of resources among the different stakeholders is monitored in order to ensure the proper use of them. The national government

	is responsible for controlling this and evaluating the required resources for the future.
Cooperation	**(C1R1) Widen collaborative networks with stakeholders to reflect on and make decisions about the progress of the city resilience** Stakeholders of the city (representatives from the emergency services, CI, public and private companies, academic entities, media, citizens, and volunteer organizations) need to collaborate beyond each organisational boundary to improve the city resilience building process. In order to improve collaboration, working groups related to resilience topics are established. **(C1R2) Arrange multi-stakeholder debriefing sessions** Regular multi-stakeholder public debriefing sessions provide the opportunity for to all relevant stakeholders to develop a shared understanding, reflect upon, and contribute to the resilience building process. **(C1R3) Develop a public platform to enhance learning among city stakeholders.** A public platform such as websites and databases needs to be set up in order for stakeholders to share experiences, lessons identified and best practices and learn from each other's experiences. **(C2R1) Participate proactively in regional, national and international networks of resilient cities to promote initiatives, exchange experiences and learn** It is important for a city to exchange experiences and participate in collaborative networks with other cities at a regional, national and international level in order to learn and increase its resilience level.

5.5 Stage 5: Vertebrate

5.5.1 DESCRIPTION

VERTEBRATE	
Leadership & Governance	The CITY acts as leader and supports the development of other city resilience plans based on their own experience.

	Relevant stakeholders, including citizens, provide feedback regularly to the city about the resilience building process, plans and policies. The city develops formal procedures to assess the effectiveness of the learning process.
Preparedness	The CITY helps to develop training activities for other CITIES training programmes in cooperation with other CITIES. At this point, there is a full integration of all relevant stakeholders within resilience action plan, with a high level of participation of these stakeholders in the decision-making and learning processes. Communities and stakeholders are able to self-organise in order to help in case a shock or stress occurs.
Infrastructure	The CITY has achieved a good redundancy level of all the critical services so the service of the critical resources is highly assured. It also encourages and develops a continuous control of the improvement of the policies to face any shock and stress and to bounce forward efficiently. The government evaluates the impact of the resilience building process in the ordinary lifestyle of the citizens and monitors the insurance level of the citizens and companies in order to ensure their continuity in case of a crisis.
Cooperation	The CITY recognizes the need to develop resilience in other CITIES and regions, as it understands the importance of coexisting in a more resilient environment, which makes the CITY more resilient. Therefore, the CITY and its stakeholders are active both nationally and globally to spread resilient initiatives and foster resilience awareness in other cities presenting actions and best practices implemented in the CITY.

5.5.2 STAKEHOLDERS INVOLVED

At vertebrate stage, all the efforts from the city stakeholders (**local, regional, national and European government, emergency services, critical infrastructures, public-private companies, NGOs, Volunteers, Regional government, media, citizens, academic and scientific entities)** are coordinated, integrated and aligned with the city resilience action plan. Furthermore, all these

stakeholders are regularly engaged in debriefing meetings and experiences and lessons learned from these stakeholders are a useful input for improving the city resilience action plan. The CITY acts as tutor for the resilience building process in other cities.

Partnerships with **international organizations** such as the Rockefeller foundation and UNISDR (The United Nations Office for Disaster Risk Reduction), which lead and participate in research projects related to the improvement of resilience in different topics, can provide the CITY with the opportunity of networking with other cities and share knowledge and experiences.

5.5.3 POLICIES

The different polices or actions that each city may consider in this stage are the following ones. Each CITY needs to prioritize them based on their current situation.

Dimension	Policy
Leadership & Governance	**(L1T1) Support the development of other city resilience plans aligned, integrated and connected with regional, national and international resilience management guidelines** The CITY provides support to other cities on how to develop city resilience plans that are properly aligned, integrated and connected with regional, national and international resilience management guidelines. **(L2T1) Contribute in the development of standards on resilience guidelines and policies** The CITY contributes with its expertise to the development of international standards of resilience guidelines and policies. **(L3T1) Develop formal procedures to assess the effectiveness of the learning process** The CITY implements formal procedures and indicators to manage the learning process **(L3T2) Promote leadership for knowledge and sharing among global cities, regions and nations.** The CITY acts as a leader concerning knowledge transfer and enables learning from best practices around the world.

	(L4T1) Share the CITY's expertise in resilience action plan development with other cities about to start the process. The CITY shares it knowledge about the process of developing a resilience action plan in order to help cities which are about to start the same process.
Preparedness	**(P1T1) Assess the value added by CITY contributions to the Resilience of other CITIES** The CITY develops assessment procedures and indicators that estimate which has been its contribution to the development of the resilience in other CITIES. **(P2T1) Develop training plans in cooperation with other CITIES** The training plans and activities are not developed taking only into account local agents; but also including other relevant agents from the European resilience backbone. **(P2T2) Develop training activities for other CITIES** The CITY leads the implementation of training activities for other CITIES which are interested in developing their resilience. The CITY also designs and develops materials that can be used by other CITIES for training purposes. **(P2T3) Support self-organisation of the involved agents to improve the Resilience of the CITY.** The agents involved in the resilience-building process including public and private agents, volunteer groups and citizens, are supported to carry out resilience activities that not necessarily need to be led by the local authority.
Infrastructure & Robustness	**(I1T1) Encourage the continuous improvement of policies to take advantage of any shock and stress to bounce forward and improve or re-design** The CITY understands that shocks and stresses can also be observed as opportunities for improvement and consequently the objective after a crisis is not simply to return to the previous state, but also to improve the design of the CITY so that it improves its city resilience further. **(I1T2) Apply big data approaches to analyse the information obtained** Take advantage of big data to analyse all the information gathered through sensors, applications, platforms… used by different CITY stakeholders

	(I2T1) Assess the impact of innovation in the resilience building process. The government evaluates the impact of the innovation activities carried out in the CITIES in the resilience building process and in the ordinary lifestyle of the citizens. Furthermore, the future actions regarding the innovation of the CITY are defined based on the analysis. **(I2T2) Monitor the insurance level of stakeholders.** The CITY analyses and monitors the status of the insurance level of stakeholders in order to ensure that they have an appropriate level to face crises.
Cooperation	**(C1T1) Support self-organization of the cooperation among all the stakeholders involved in the resilience development** The stakeholders involved in the resilience development have the capacities to self-organize and coordinate effectively action, plans and activities that deal with shocks and stresses in an efficient way. **(C1T2) Involve all stakeholders in the learning process** The CITY involves all local stakeholders such as citizens and companies in learning processes such as public debriefing meetings. In these meetings the resilience building process is evaluated and lessons learned and best practices to improve the resilience building process are identified by the local stakeholders. **(C2T1) Active involvement of local authority and stakeholders in networks (local, national, European & Global)** The local authority and local stakeholders take part proactively in networks with other cites (at local, regional, national and international level) to share and receive best practices on the resilience-building process. **(C2T2) Encourage stakeholders to present their experiences concerning the resilience building process as a reference for stakeholders from other CITIES** The CITY encourages local stakeholder to share their experiences and contribution in the development of the city resilience in order to foster resilience awareness to stakeholders from other CITIES, and even contributing to training in other CITIES.

5.6 Resilience indicators

The following table presents the indicators defined to assess the policies included in the Maturity Model. These indicators have been assigned to the resilience policies defined in the Maturity Model. For each policy, indicators that can be used to monitor them have been identified. In Annex II the policies that can be monitored with each indicator are presented.

In general, the defined indicators are still at a high level and therefore it is necessary to particularize and adjust them to the corresponding city during the pilot implementation of the Maturity Model in a CITY (to be done in WP5). Additionally, the SMR Project will collaborate with the Smart Resilience Project whose main objective is to identify suitable indicators for assessing resilience.

CATEGORY	NAME	INDICATORS OF EFFORT	NAME	INDICATORS OF RESULTS
LEARNING	**Number of debriefing meetings carried out**	Number of debriefing meetings that a city is carrying out with its stakeholders (e. g. CI providers, volunteer groups, academic and scientific entities) after having established resilience awareness campaigns. **Unit of measure:** number of debriefing meetings /per time	**Percentage of lessons learned implemented per lessons learned identified**	Percentage of lessons learned regarding policies, resilience-building activities, best practices implemented within a city compared to the lessons identified **Unit of measure:** Percentage of updates of the city's plans based on lessons identified
	Number of mechanisms (platforms, websites) to share lessons learned with CITY stakeholders	Number of available mechanisms, platforms or websites such as the SMR Information Portal or SMR Resilience Building Policy Tool in which CITY stakeholders can exchange lessons learned on resilience. **Unit of measure:** number of mechanisms available	**Number of best practices shared among stakeholders**	Number of analyzed and reviewed best practices that, through experience and research, have been proven to improve resilience. **Unit of measure:** number of best practices /per time
	Effort taken to learn from what other stakeholders do to increase resilience	Effort allocated by stakeholders to carry out debriefing meetings and review best practices and lessons learned with other stakeholders and cities **Unit of measure:** Resources such as time and effort	**Learning activities executed among stakeholders and with other cities**	Existence of procedures and activities to review and share best practices among stakeholders and among other cities **Unit of measure:** Existence of procedures and activities and frequency in which they take place

STAKEHOLDER COORDINATION	**Number of cooperation agreements with CITY stakeholders**	Number of cooperation agreements and partnerships established with city stakeholders (e. g. CI providers, volunteer groups, academic and scientific entities) **Unit of measure:** number of cooperation agreements/per time	**Number of stakeholder group involved in resilience-building activities about resilience**	Number of stakeholders representing different organisations which engage in multi-organisation activities about resilience. **Unit of measure**: number of stakeholder groups involved/per time
	Number of cooperation agreements with external governmental bodies and cities	Number of collaboration agreements that a city has with external governmental bodies (regional, national, international) and cities (i.e. involvement in EU projects, UNISDR or Rockefeller foundation networks). **Unit of measure:** Number of cooperation agreements/per time	**Number of policies aligned with regional, national and international input**	Number of local policies that are aligned with regional, national and international resilience management guidelines. **Unit of measure:** Number of policies/per time
			Existence of emergency plans that integrate stakeholders	Existence of emergency plans developed to address potential disaster risks and shared by all relevant stakeholders including volunteers and citizens **Unit of measure:** number of emergency plans that are shared

COMMITMENT	**Percentage of resources dedicated to lead EU projects or other joint initiatives**	Percentage of city's budget allocated to lead EU projects or other joint initiatives in the context of building city resilience. **Units of measure:** Percentage of city's budget to lead EU projects	**Funding received from EU projects and similar initiatives**	Amount of money granted towards resilience initiatives. **Units of measure:** Money received from EU projects
	Number of awareness-raising events targeting CITY stakeholders	Communication and dissemination activities scheduled, organized and conducted by the city, targeting different stakeholders and citizen groups that aim to increase awareness and knowledge on anticipated shocks, stresses, risks and vulnerabilities **Unit of measure:** Number of activities/per time	**Number of certifications**	Number of acknowledgements in the form of certifications acquired by a city in the field of resilience. **Unit of measure:** Number of certifications
	Percentage of local government budget spent on resilience-building activities	Percentage of the local resources (money, time) spent on developing resilience-building process **Unit of measure:** Resources dedicated by the local government to building resilience/per time		

CAPACITY TO RESPOND	**Resources allocated to adopt extraordinary infrastructures to face shocks**	Resources to adopt extraordinary infrastructures to face crisis situations, describing the flexibility of the CI to adapt to analyzed shocks. **Unit of measure:** Number (and type) of resources available/per time	**Average time for CIs to return to normality**	This indicator lists recent incidents and for each one, it indicates how long CIs and services have taken to recover. **Unit of measure:** Time such as minutes, hours or days.
	Resources allocated to improve the reliability of the CI	Resources invested in improvement of infrastructures in relation to identified needs. **Units of measure:** Resources invested in relation to identified needs (according to priorities of core infrastructure)	**Percentage of infrastructures and population with insurances**	Percentage of infrastructures and citizens insured per total amount of infrastructures and citizens. **Units of measure:** Percentage of infrastructure and population with insurances
	Resources allocated to incentivize CITY stakeholders to invest in resilience	Resources allocated to incentive stakeholders to invest in development/maintenance of resilience related activities. **Units of measure**: Resources of the local government budget spent in resilience development related activities		

TRAINING	**Resources deployed for training exercises**	Resources (human capital, materials, working hours etc.) spent for educational activities scheduled, organized and conducted by the city, targeting different stakeholders practitioners and groups **Unit of measure:** Resources spent for educational activities	**Effectiveness of training exercises**	Extent to which stakeholders participating in drills show strong evidence of having absorbed training. **Units of measure:** Level of effectiveness
	Frequency of training exercises	Number of training exercises that emergency services, CI providers, and stakeholders carry out in a period of time. **Unit of measure:** Number of training exercises /per time	**Number of trained volunteers**	Number of volunteers that have received training and are prepared to deal with emergencies **Units of measure:** Total number of volunteers that participate in training courses
PLANS AND PROCEDURES	**Resources dedicated to the development of the resilience action plan**	Resources provided by the local government to develop the city resilience action plan. **Units of measure**: Resources allocated by the city to develop the city resilience action plan	**Number of updates of the resilience action plan**	Number of updates and revisions made to the resilience action plan based on the feedback provided by the CITY stakeholders **Units of measure:** Number of updates of the resilience action plan per time
			Percentage of businesses/CIs with contingencies plans	Number of CI providers, companies and business with updated emergency contingency plans **Unit of measure:** number of companies out of the total number of CIs and companies.

CRITICAL INFRASTRUCTURES NETWORK SECURITY	**Number of analysis of CIs interdependencies**	Number of monitoring checks/ analyses of interdependencies between CIs are performed. **Units of measure:** Number of analyses per time	**Percentage of CIs that fulfil legal requirements**	Number of CI infrastructure or system that fulfil legal requirements to ensure the basic service of this sector **Units of measure:** Number of CI systems/infrastructures out of the total
	Number of revision of CI risk assessment	Frequency of revision of CI risk assessment. **Units of measure:** number of CIs/ number and type of risk variables measured/ number of risk assessments per CI/number of collaborative risk assessment between CIs	**Number of redundant systems/infrastructures per CI sector**	Number of redundancy systems/infrastructures per CI sector in order to ensure the basic service of this sector: **Units of measure:** Number of redundancy systems/infrastructures per CI
	Number of assessments to identify weaknesses	Frequency of updates to identifying potential weaknesses in CIs through risk assessment and anticipation of future challenges. **Units of measure:** Number and frequency of risk assessments/anticipation of future challenges		

CI MAINTENANCE	**Number of stress tests/audits**	Number of stress tests and audits that each CI carry out during a year. **Units of measure:** number of tests/audits / year	**Number of maintenance procedures in each CI sector**	Number and type of maintenance procedures in each CI sector. **Units of measure**: Number of maintenance procedures in each CI sector
	Resources invested in preventive maintenance activities	Resources invested in preventive maintenance activities in relation to analysis of required investment. **Units of measure**: % of required investments receiving funding		

5.7 Ranking of the indicators by maturity stage

The following table ranks the defined indicators according to the maturity stage in which they need to start to be monitored. Once an indicator starts to be monitored in one stage, it should continue to be monitored throughout the following maturity stages. Therefore, this raking allows to prioritize which indicators should start to be monitored at each maturity stage.

STARTING	MODERATE	ADVANCED	ROBUST	VERTEBRATE
Resources dedicated to the development of the resilience action plan	Number of cooperation agreements with external governmental bodies and cities	Number of certifications	Number of updates of the resilience action plan	Percentage of resources dedicated to lead EU projects or other join initiatives
Percentage of local government budget spent on resilience building activities	Number of stakeholder group involved in resilience-building activities about resilience	Number of debriefing meetings carried out		
Number of assessments to identify weaknesses	Number of policies aligned with regional, national and international input	Percentage of lessons learned implemented per lessons learned identified		
Number of revision of CI risk assessment	Number of analysis of CIs interdependencies	Learning performance assessment		
Percentage of businesses/CIs with contingency plan	Resources allocated to improve the reliability of the CI	Percentage of infrastructures and population with insurances		
Resources deployed for training exercises	Number of stress tests/audits			

Number of cooperation agreements with CITY stakeholders	Resources invested in preventive maintenance activities			
Number of awareness raising events targeting CITY stakeholders	Number of analysis of CIs interdependencies			
Number of trained volunteers	Number of redundant systems-infrastructures per CI sector			
Frequency of training exercises	Percentage of CIs that fulfil legal requirements			
Resources allocated to adopt extraordinary infrastructures to face shocks	Number of maintenance procedures in each CI sector			
Resources allocated to improve the reliability of the CI	Average time for CIs to return to normality			
Funding received from EU projects and similar initiative	Resources allocated to incentivize CITY stakeholders to invest in resilience			
Number of mechanisms (platforms, websites) to share lessons learned with CITY stakeholders	Number of best practices shared among stakeholders			
Existence of emergency plans that integrate stakeholders	Effort taken to learn from what other stakeholders do to increase resilience			
Effectiveness of training exercises				

6 IMPLEMENTATION OF THE MATURITY MODEL

At the outset one should have in mind that achieving full resilience maturity will be the outcome a long process. The duration of the process to fully achieve maturity in CITIES as vertebrae of the European resilience backbone will necessarily be much longer than the duration of this SMR project. The outcome of WP1 clearly indicates that, despite impressive gains in knowledge and accumulated experience, much more knowledge and experience must accrue so as to come close enough to the goal of full mature resilience against disasters, natural and man-made. In fact, even when a state of full mature resilience should be reached, in the sense of satisfying pre-defined criteria of such state, we will only know to what extent such resilience maturity matches required resilience when the CITIES, acting as a resilience backbone, pass the tests that future natural and man-made disasters will pose.

At the current stage of the SMR project, the Maturity Model for resilience should be viewed as a core element of a resilience management guideline grounded on insight from best practice and integrated expert views. The implementation and usage of the Maturity Model must address a fundamental challenge:

- On the one hand the Maturity Model targets necessarily the *totality* of aspects and actions to achieve complete resilience maturity levels S-M-A-R-T, whereby reaching such levels each would require several years of fully aligned governance principles and complete commitment in the city.

- On the other hand, our project tests, validates and demonstrates the Maturity Model on the basis of three pilot projects of six months' duration in selected partner cities

To provide convincing evidence each pilot projects focuses on a challenge that in a nutshell contains the methodology for the implementation of the maturity model in a city (see Figure 9). Such process proceeds basically in four steps:

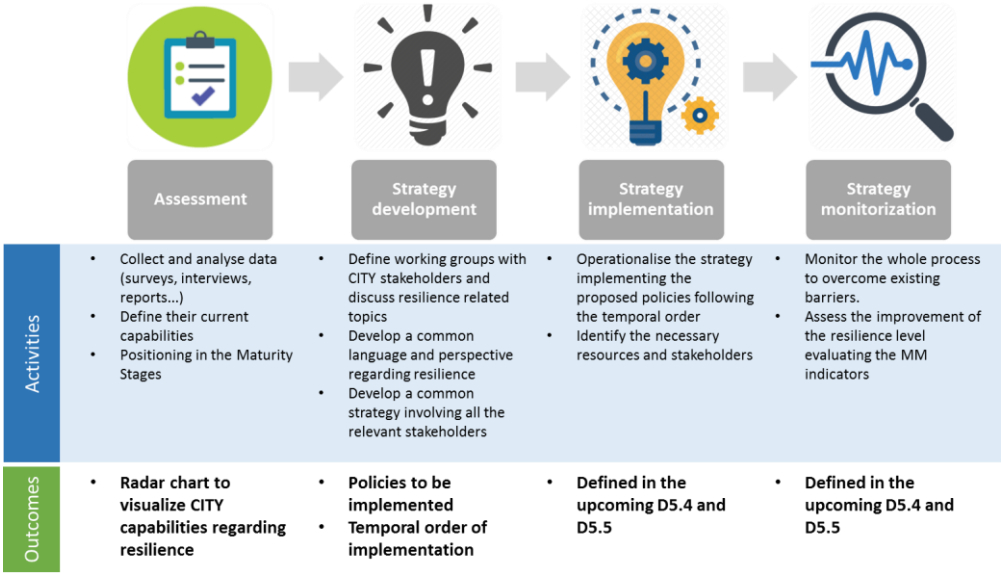

Figure 9: Implementation stages

1. *Assessment*: the assessment process consists of collecting and analysing data and evidence through surveys, interviews or reports for each of the goals and policies identified in the Maturity Model. Based on this information, cities can define their current status of capabilities, thereby positioning themselves within one of the maturity stage for each dimension described in the model. As an output a radar type chart will be obtained in which the evaluations achieved for each resilience dimensions and sub-dimensions will be obtained (see Figure 10).

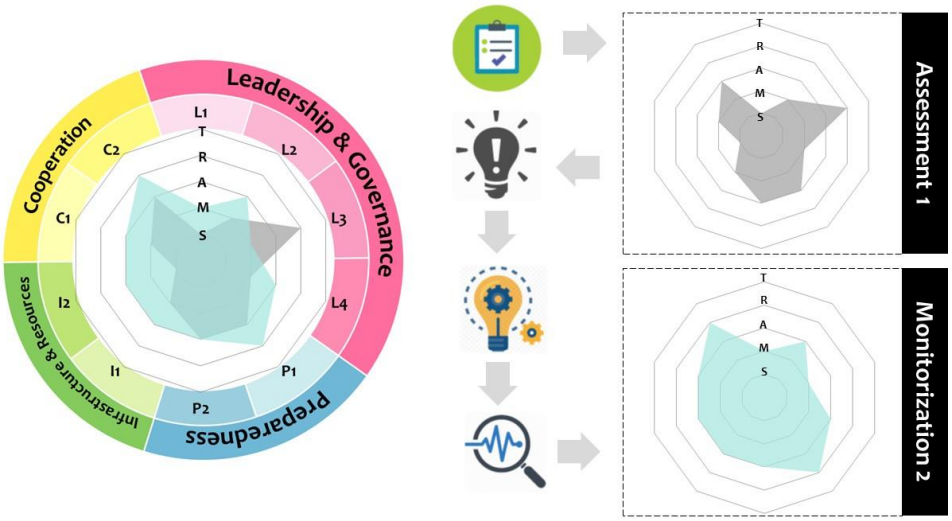

Figure 10: Radar chart obtained from the assessment

2. *Strategy development*: once a city has identified its current maturity stage, it can use the maturity model as a guide to define the strategy that they need to follow in the future and to define what resilience-related policies it may need to implement to improve resilience. In this process it is necessary to involve the stakeholders in the process to identify opportunities for collaboration and actions in the resilience strategy. In addition, the Maturity Model will also provide a common language to all the involved stakeholders, which can be particularly relevant in the context of stakeholders representing different areas of interest such as climate change, social issues or critical infrastructures.

3. *Strategy implementation*: in this step we operationalize the defined strategy. A planning will be carried out in order to prioritize the policies that need to be implemented and the temporal order of their implementation. Furthermore, the resources that are needed will be defined as well as the stakeholders that need to be involved. In D5.5, more detail explanation about how the implementation process of the Maturity Model should be carried out will be given based on pilot implementation of the MM in the three TIER 1 CITIES.

4. *Strategy monitorization*: once the strategy is implemented it is important to monitor the implementation process based on the assessment of the maturity model indicators to demonstrate increase of resilience towards the next maturity level. If the results are not the expected ones, it might be necessary to readjust the plan and make some changes in order to achieve the expected results and be able to improve the resilience level of the CITY.

The detailed description of how cities should implement and use the Maturity Model will be an outcome of project WP5, Task 5.4 and be fully documented in deliverable D5.5, as part of the Resilience Management Guideline.

After the final delivery of the Resilience Management Guideline and as part of this guideline the Maturity Model will support cities in the assessment process of developing city resilience as it can be used for benchmarking purposes and as a point of reference. The Maturity Model will help cities assess their current effectiveness, and support them in establishing which sets of capabilities they require in order to improve their performance with regards to the resilience building process.

7 CONCLUSIONS

Cities are investing time and resources in developing strategies and policies to improve their resilience level. However, sometimes they make progress in the strategic plan without an understanding of whether they are following the correct path or they are implementing policies that may hamper their progress. Moreover, building city resilience is a complex process that requires the commitment and engagement of numerous stakeholders progressively.

The Maturity Model developed within the SMR Project provides CITIES with a tool for reflection and guidance in the resilience building process, that enables them to develop an analysis of its current status and providing a guideline about what the following steps should be from a strategic approach. The Maturity Model enables the identification of areas that need to be improved in each city and reflect these in policymaking and planning.

The SMR Maturity Model defines five maturity stages: Starting, Moderate, Advanced, Robust, and verTebrate. Each of these maturity stages includes a description of the objectives of each stage, the stakeholders actively involved in each maturity stage, and a list of policies that should be developed in order to achieve the objectives defined in the respective maturity stage. Additionally, the Maturity Model proposes qualitative and quantitative indicators that can be used as measures of positive behaviours that support the continuous development that is made towards resilience building policies.

7.1 Limitations of the Maturity Model and future steps

Although the SMR Maturity Model provides a practical and useful tool for building the resilience level of cities, it also presents some limitations. The policies included in the Maturity Model have been defined from a highly strategic level, and therefore when putting them into practice, it is necessary to customize them to each city context. Furthermore, the Maturity Model does not define how much time each city will need to advance to a higher stage since this could vary from city to city as well as from stage to stage. It also depends on the amount of resources a city allocates to this resilience-building process as well as the city's commitment to resilience.

In order to improve the SMR Maturity Model and validate its usefulness in practice, the pilot implementation processes of the Maturity Model will enable to adapt and particularize the Maturity Model to each city context, obtaining a first assessment of its current stage. The pilot implementation will be carried out in Donostia, Glasgow, and Kristiansand, during the development of WP5. The implementation of the Maturity Model in three different cities will also help to refine the Maturity Model,

gathering feedback about the policies and alternative indicators CITIES consider useful to measure the resilience building process. Thus, the Maturity Model described in this document will be improved taking into account the valuable information gathered during the pilot implementation. These pilot tests will help to enhance the model and ascertain its value in supporting cities in the resilience-building process as well as define some guidelines when implementing it.

8 REFERENCES

100 RESILIENT CITIES (2016), http://www.100resilientcities.org/resilience#/-_/, 2016, (Last accessed May 2016).

Andersen, D. F., & Richardson, G. P. (1997). Scripts for group model building. *System Dynamics Review*, 13 (2), 107–129.

Andersen, D. F., Vennix, J. A. M., Richardson, G. P., & Rouwette, E. (2007). Group model building: problem structuring, policy simulation and decision support. *The Journal of the Operational Research Society*, 58 (5), 691–694.

Araya-Muñoz, D., Metzger, M. J., Stuart, N., Wilson, A. M. W., & Alvarez, L. (2016). Assessing urban adaptive capacity to climate change. Journal of Environmental Management, 183, 314-324.

ARUP (2016), City Resilience Index: Inside the CRI. Available at: http://www.arup.com/city_resilience_index

Becker, J., Knackstedt, R., & Pöppelbuß, D. W. I. J. (2009). Developing maturity models for IT management, *Business & Information Systems Engineering*, 1(3), 213-222.

Bozza, A., Asprone, D., & Manfredi, G. (2015). Developing an integrated framework to quantify resilience of urban systems against disasters. Natural Hazards, 78(3), 1729-1748.

Cutter, S. L., Ash, K. D., & Emrich, C. T. (2014). The geographies of community disaster resilience. Global environmental change, 29, 65-77.

de Bruin, T., Rosemann, M., Freeze, R. & Kulkarni, U. (2005), Understanding the main phases of developing a maturity assessment model. *Australasian Conference on Information Systems (ACIS).* Sydney, 8-19.

Dieleman, H. (2013). Organizational learning for resilient cities, through realizing eco-cultural innovations, *Journal of Cleaner Production*, 50, 171-180.

Fraser, P., Moultrie, J., & Gregory, M. (2002). The use of maturity models/grids as a tool in assessing product development capability*, Engineering Management Conference, 2002. IEEE International*, 244-249.

Frick, N., Kuttner, T. F., & Schubert, P. (2013). Assessment Methodology for a Maturity Model for Interorganizational Systems--The Search for an Assessment Procedure. *System Sciences (HICSS), 2013 46th Hawaii International Conference*, 274-283.

Godschalk, D. R. (2003). Urban hazard mitigation: creating resilient cities, *Natural Hazards Review,* 4(3), 136-143.

Government and Disaster Resilience Minitrack. 2016. Hawaii International Conference on System Sciences. [ONLINE] Available at: http://www.hicss.org/#!government-and-disaster-resilience/c1iyq. [Accessed 11 May 2016].

Hollnagel, E. (2009). The four cornerstones of resilience engineering, *Ashgate Studies in Resilience Engineering*,117-134.

Johnson, C. & Blackburn, S. (2014). Advocacy for urban resilience: UNISDR's Making Cities Resilient Campaign, Environment and Urbanization, 26(1), 29-52.

Kapucu, N., Arslan, T. & Demiroz, F. (2010), Collaborative emergency management and national emergency management network, *Disaster Prevention and Management: An International Journa*l, 19 (4), 452-468.

Kusumastuti, R. D., Husodo, Z. A., Suardi, L., & Danarsari, D. N. (2014). Developing a resilience index towards natural disasters in Indonesia. International journal of disaster risk reduction, 10, 327-340.

Linkov, I. et al. (2014). Changing the resilience paradigm, *Nature Climate Change*, 4(20), 407-409.

Ludwig, B. (1997). Predicting the future: Have you considered using the Delphi methodology? *Journal of Extension*, 35(5), 1-4.

Ludwig, B. G. (1994). Internationalizing Extension: An exploration of the characteristics evident in a state university Extension system that achieves internationalization. Unpublished doctoral dissertation, The Ohio State University, Columbus.

Malalgoda, C., Amaratunga, D., & Haigh, R. (2013). Creating a disaster resilient built environment in urban cities: The role of local governments in Sri Lanka, *International Journal of Disaster Resilt in the Built Environment*, 4(1), 72-94.

Molin Valdés, H., Amaratunga. D., & Haigh, R. (2013). Making cities resilient: From awareness to implementation, International Journal of Disaster Resilt in the Built Environment, 4(1), 5-8.

OECD (2016). Resilient Cities (preliminary). Available at: https://www.oecd.org/gov/regionalpolicy/resilient-cities-report-preliminary-version.pdf (Accessed 2016-11 -18)

Oteng-ababio, M., Sarfo, K.O., & Owusu-sekyere, E., (2015). Exploring the realities of resilience: Case study of Kantamanto Market fire in Accra, *Ghana. International Journal of Disaster Risk Reduction*, 12, 311-318.

Oxley, M. (2013). A "people-centred principles-based" Post-Hyogo Framework to strengthen the resilience of nations and communities, *International Journal of Disaster Risk Reduction*, 4, 1-9.

Prior, T. and Hagmann, J. (2012), Measuring Resilience: Benefits and Limitations of Resilience Indices, Eidgenössische Technische Hochschule Zürich, Center for Security Studies (CSS) http://dx.doi.org/10.3929/ethz-a-010044458

Prior, T., & Roth, F. (2013). Preparing for Disasters in Global Cities: An International Comparison, Zurich, Switzerland.

Pullen, W. (2007). A public sector HPT maturity model. Performance Improvement, 46(4), 9-15.

Rich, E., Sveen, F.O., Qian, Y., Hillen, S.A., Radianti, J. and Gonzalez, J.J. (2009) Emergent Vulnerability in Integrated Operations: A Proactive Simulation Study of Risk and Organizational Learning, International Journal of Critical Infrastructure Protection, Vol. 2, pp. 110.

Richardson, G. P., & Andersen, D. F. (1995). Teamwork in group model building. *System Dynamics Review*, 11 (2), 113–137.

Rigon, E. A., Westphall, C.M., Santos, D. R. D., & Westphall, C. B. (2014). A Cyclical Evaluation Model of Information Security Maturity, *Information Management & Computer Security,* 22(3), 265-278.

Shaw, K. (2012). The rise of the resilient local authority? *Local Government Studies,* 38 (3), 281-300.

Sherrieb, K., Norris, F. H., & Galea, S. (2010). Measuring capacities for community resilience. Social Indicators Research, 99(2), 227-247.

Singh-Peterson, L., Salmon, P., Baldwin, C., & Goode, N. (2015). Deconstructing the concept of shared responsibility for disaster resilience: a Sunshine Coast case study, Australia. *Natural Hazards*, 79(2), 755–774.

Turoff, M., & Hiltz, S. R. (1996). Computer based Delphi process. *Gazing into the oracle: The Delphi method and its application to social policy and public health*, 56-88.

Ulschak, F. L. (1983). Human resource development: The theory and practice of need assessment. *Reston Publishing Company, Inc.*

UNISDR (2005). Hyogo framework for action 2005-2015: building the resilience of nations and communities to disasters, In Extract from the final report of the World Conference on Disaster Reduction (2005).

UNISDR (2007). Terminology: basic terms of disaster risk reduction. Available at: http://www.unisdr.org/we/inform/terminology [2015, July].

UNISDR (United Nations Office for Disaster Risk Reduction). (2014). "Disaster Resilience Scorecard for Cities."

UNISDR (2015). Sendai framework for disaster risk reduction 2015-2030, Sendai, Miyagi, Japan.

Weichselgartner, J., & Kasperson, R. (2010). Barriers in the science-policy-practice interface: Toward a knowledge-action-system in global environmental change research. *Global Environmental Change,* 20(2), 266–277.http://doi.org/10.1016/j.gloenvcha.2009.11.006

Wendler, R. (2012), The Maturity of Maturity Model Research: A Systematic Mapping Study, *Information and Software Technology*, 54,1317-1339.

Zhou, H., Wan, J., & Jia, H. (2010). Resilience to natural hazards: a geographic perspective. Natural Hazards, 53(1), 21-41.

ANNEX I. OVERALL VIEW OF THE REVISED MATURITY MODEL

Annex I presents the whole Resilience Maturity Model. This Maturity Model defines five maturity stages: Starting, Moderate, Advanced, Robust, and verTebrate. Each of these maturity stages includes the following components: a description of the objectives of each stage, the agents involved in each maturity stage in addition to a set of resilience building policies to implement in order to reach de objective of each stage. The policies have been classified using four dimensions: Leadership & Governance, Preparedness, Infrastructure & Resources and Cooperation.

With this complete view of the Resilience Maturity Model, it can be seen in which maturity stage the policies should start their development, and how these policies evolve over different maturity stages. Additionally, it can be seen how he number of stakeholders engaged in the resilience building process increases as we make progress in the maturity stages.

	Subdimensions	STARTING	MODERATE	ADVANCED	ROBUST	VERTEBRATE
Stakeholders		**Local Government, Emergency services, CIs**	Local Government, Emergency services, CIs **Public-private companies, NGOs, Volunteers, Regional government**	Local Government, Emergency services, CIs Public-private companies, NGOs, Volunteers, Regional government, Media **Citizens, Academic and scientific entities, National government**	Local Government, Emergency services, CIs Public-private companies, NGOs, Volunteers, Regional government, Media Citizens, Academic and scientific entities, National government **European policy makers**	Local Government, Emergency services, CIs Public-private companies, NGOs, Volunteers, Regional government, Media Citizens, Academic and scientific entities, National government European policy makers **International organizations**
Leadership&Governance	**Municipality, cross-sectorial and multi-governance collaboration (L1)**	**(L1S1)** Establish a working team responsible for resilience issues in the city **(L1S2)** Integrate resilience into visions, policies and strategies for city development plans	**(L1M1)** Establish a resilience department or committee and a cross departmental coordination board and procedures **(L1M2)** Align, integrate and connect the resilience action plan with regional plans **(L1M3)** Adopt climate change preventive actions **(L1M4)** Promote equality of access to services and basic infrastructure to vulnerable sector of society	**(L1A1)** Align, integrate and connect the resilience action plan with national plans **(L1A2)** Develop a plan for multi-level governance approach involving the municipal, regional and national levels of governance	**(L1R1)** Align, integrate and connect the city resilience plan with regional, national and international resilience management guidelines	**(L1T1)** Support the development of other city resilience plans aligned, integrated and connected with regional, national and international resilience management guidelines
	Legislation development and refinement (L2)		**(L2M1)** Develop a white paper about multi-level governance approach	**(L2A1)** Conduct certification processes to achieve the conformity with national standards	**(L2R1)** Conduct certification processes to achieve the conformity with international standards	**(L2T1)** Contribute in the development of standards on resilience guidelines and policies
	Learning culture (learning and dissemination) (L3)	**(L3S1)** Develop a strategy to create a resilience culture	**(L3M1)** Promote a culture of resilience **(L3M2)** Review of best practices to deal with shocks and stresses used in different sectors and other cities	**(L3A1)** Formalize the learning process and institutionalize regular debriefing meetings	**(L3R1)** Create a Learning city	**(L3T1)** Develop formal procedures to assess the effectiveness of the learning process **(L3T2)** Promote leadership for knowledge transferring and sharing among global cities, regions and nations
	Resilience action plan development (L4)	**(L4S1)** Identify the city requirements regarding resilience process	**(L4M1)** Develop a resilience action plan to respond to shocks and long term stresses	**(L4A1)** Develop leading indicators for assessing the performance of the resilience action plan	**(L4R1)** Assess and monitor the efficiency of the resilience action plan periodically in order to improve it continuously	**(L4T1)** Share the CITY's expertise in resiience action plan development with other cities about to start the process
Preparedeness	**Diagnosis and Assessment (P1)**	**(P1S1)** Assess and manage a wide range of risks **(P1S2)** List and prioritize critical services and assets **(P1S3**) List existing plans and response mechanisms and guidelines for shocks and stresses	**(P1M1)** Take account of interdependencies between risks when assessing and managing risk	**(P1A1)** Assess and prioritise risk scenarios and their implications through consideration of risk systemicity (e.g. using Risk Systemicity Questionnaire)	**(P1R1)** Undertake regular and long-term risk assessment with a focus on risk systemicity	**(P1T1)** Assess the value added by CITY contributions to the resilience of other CITIES
	Education and Training (P2)	**(P2S1)** Conduct training and arrange emergency drills with the emergency teams and Critical Infrastructures providers **(P2S2)** Inform citizens to volunteering opportunities in the local community **(P2S3)** Develop a common understanding of the resilience approach among stakeholders	**(P2M1)** Conduct training and arrange emergency drills including volunteers	**(P2A1)** Provide training for citizens and public and private companies **(P2A2)** Conduct emergency drills at national level **(P2A3)** Develop education programs in schools about the resilience action plan **(P2A4)** Assess and refine the training programs	**(P2R1)** Establish a strong network of volunteers **(P2R2)** Conduct frequent joint training exercises between European cities	**(P2T1)** Develop training plans in cooperation with other CITIES. **(P2T2)** Develop training activities for other CITIES **(P2T3)** Support self-organisation of the involved agents to improve the Resilience of the CITY

Infrastructure & Resources	**Reliability of infrastructures (I1)**	**(I1S1)** Develop cooperation/collaboration agreements with critical providers **(I1S2)** Develop plans to monitor CIs functionality **(I1S3)** Develop contingency plans for critical infrastructures	**(I1M1)** Identify interdependencies of critical services at local level **(I1M2)** Develop periodical preventive maintenance procedures for Critical Infrastructures **(I1M3)** Develop measures to increase critical infrastructure redundancy and reliability **(I1M4)** Implement monitoring systems for identifying risk shocks and long term stresses **(I1M5)** Carry out audits for critical infrastructure providers	**(I1A1)** Develop flexibility measures	**(I1R1)** Identify interdependencies of critical services at international level	**(I1T1)** Encourage the continuous improvement of policies, to take advantage of any shock and stress to bounce forward and improve or re-design **(I1T2)** Apply big data approaches to analyse the information obtained
	Resources to build up resilience (I2)	**(I2S1)** Assess current initiatives and funding opportunities for the development of resilience **(I2S2)** Develop a list of the currently available response physical resources **(I2S3)** Deploy a disaster relief fund for emergencies	**(I2M1)** Allow for the resilience action plan in the local government budget **(I2M2)** Promote resources /tool sharing among CI providers within a region during crises	**(I2A1)** Promote and provide incentives for initiatives that contribute to build resilience **(I2A2)** Implement centralised control of coordination of critical resources and activities during shocks and stresses. **(I2A3)** Encourage stakeholders to have appropriate insurance coverage **(I2A4)** Promote and provide incentives for the development of sustainable urban infrastructures	**(I2R1)** Promote and provide incentives to stakeholders for investment in R&D&I projects regarding Resilience. **(I2R2)** Monitor an effective use of resources to ensure the resilience building process performance	**(I2T1)** Assess the impact of innovation in the resilience building process. **(I2T2)** Monitor the insurance level of stakeholders
Cooperation	**Development of partnerships with city stakeholders (C1)**	**(C1S1)** Map relevant stakeholders to develop the resilience action plan (**C1S2)** Develop a public website with emergency information	**(C1M1)** Develop a stakeholder engagement plan defining its roles and responsibilities (**C1M2)** Develop an internal communication platform for sharing information with different municipal departments and emergency services	**(C1A1)** Align the objectives of different stakeholders and develop a common understanding of resilience **(C1A2)** Develop formal partnerships between academic and scientific entities to improve the resilience building process (**C1A3)** Undertake public consultations to receive feedback on the resilience action plan **(C1A4)** Develop a public communication platform to interact with stakeholders	**(C1R1)** Widen collaborative networks with stakeholders to reflect on and make decisions about the progress of the city resilience **(C1R2)** Arrange multi-stakeholder debriefing meetings **(C1R3)** Develop a public platform to enhance learning among city stakeholders	**(C1T1)** Support self-organization of the cooperation among all the stakeholders involved in the resilience development (**C1T2)** Involve all stakeholders in the learning process
	Involvement in resilience networks of cities (C2)		**(C2M1)** Establish alliances with cities facing similar risks	**(C2A1)** Join a major Network of EU cities (**C2A2)** Develop formal partnerships with regional stakeholders	**(C2R1)** Participate proactively in regional, national and international networks to promote initiatives, exchange experiences and learn	**(C2T1)** Active involvement of local authority and stakeholders in networks (local, national, European & Global) **(C2T2)** Encourage stakeholders to present their experience concerning the resilience building process as reference for other CITIES

ANNEX II. RELATIONSHIPS BETWEEN POLICIES AND INDICATORS

The resilience indicators described in Section 5.6, have been related to the resilience policies defined in the Maturity Model. For each policy, indicators that can be used in order to measure this policy have been identified. In this Annex, the policies that can be assess with the proposed indicators have been defined, including this information in brackets near each indicator.

	Subdimensions	EFFORT INDICATORS	RESULTS INDICATORS
Leadership&Governance	**Municipality, cross-sectorial and multi-governance collaboration (L1)**	Number of cooperation agreements with CITY stakeholders (L1M2) Resources dedicated to the development of the resilience action plan (L1S1, L1S2,L1M1, L1M3, L1M4) Number of cooperation agreements with external governmental bodies and cities (L1M2, L1A1, L1A2, L1R1, L1T1)	Number of stakeholder group involved in resilience-building activies about resilience (L1M1, L1A2) Number of policies aligned with regional, national and international input (L1M2, L1A1, L1R1, L1T2)
	Legislation development and refinement (L2)	Number of cooperation agreements with external governmental bodies and cities (L2M1)	Number of certifications (L2A1, L2R1, L2T1)
	Learning culture (learning and dissemination) (L3)	Effort taken to learn from what other stakeholders do to increase resilience (L3M2, L3A1, L3R1, L3T1, L3T2) Number of cooperation agreements with external governmental bodies and cities (L3T2) Percentage of local government budget spent on resilience building activities (L3S1, L3M1) Number of debriefing meetings carried out (L3A1, L3T1, L3T2)	Learning activities executed among stakeholders and with other cities (L3M2, L3T2) Percentage of lessons learned implemented per lessons learned identified (L3A1, L3R1, L3T1) Number of best practices shared among stakeholders (L3A1, L3R1, L3T1, L3T2)
	Resilience action plan development (L4)	Resources dedicated to the development of the resilience action plan (L4S1, L4M1, L4A1, L4R1) Number of cooperation agreements with external governmental bodies and cities (L4T1)	Number of updates of the resilience action plan (L4R1)
Preparedeness	**Diagnosis and Assessment (P1)**	Number of analysis of CIs interdependencies (P1M1) Number of assessments to identify weaknesses (P1S1) Number of revision of CI risk assessment (PIS2, P1A1, P1R1)	Number of policies aligned with regional, national and international input (P1T1) Percentage of businesses/CIs with contingency plans (P1S3)
	Education and Training (P2)	Resources deployed for training exercises (P2S1, P2M1,P2A1, P2A2, P2A4, P2R2, P2T1, P2T2, P2T3) Number of cooperation agreements with external governmental bodies and cities (P2A2,P2R2,P2T1, P2T2) Number of cooperation agreements with CITY stakeholders (P2S1, P2M1, P2A3, P2R1) Number of awareness raising events targeting CITY stakeholders (P2S2, P2S3, P2A3) Frequency of training exercises (P2S1, P2M1,P2A1, P2A2, P2R2, P2T1, P2T2, P2T3)	Number of trained volunteers (P2S2, P2R1, P2T3) Effectiveness of training exercises (P2S1, P2S3, P2M1, P2A1, P2A2, P2A4, P2R2, P2T2)
Infrastructure & Resources	**Reliability of CIs and their interdependences (I1)**	Resources allocated to adopt extraordinary infrastructures to face shocks (I1S3, I1A1, I1T1) Resources allocated to improve the reliability of the CI (I1S2, I1M3) Number of stress tests/audits (I1M5) Resources invested in preventive maintenance activities (I1M2) Number of cooperation agreements with CITY stakeholders (I1S1) Number of revision of CI risk assessment (I1M4) Number of analysis of CIs interdependencies (I1M1, I1R1)	Number of maintenance procedures in each CI sector (I1M2) Number of redundant systems-infrastructures per CI sector (I1M3) Percentage of CIs that fullfil legal requirements (I1M5) Average time for CIs to return to normality (I1M3)
	Resources to build up resilience and to response (I2)	Resources dedicated to the development of the resilience action plan (I2M1) Resources allocated to incentivize CITY stakeholders to invest in resilience (I2M2, I2A1, I2A3, I2A4,I2R1,I2T2) Percentage of local government budget spent on resilience building activities (I2S2, I2S3,I2A2, I2R2) Percentage of resources dedicated to lead EU projects or other join initiatives (I2T1)	Percentage of infrastructures and population with insurances (I2A1, I2A3, I2A4,I2R1,I2T2) Funding received from EU projects and similar initiatives (I2S1)
Cooperation	**Development of partnerships with city stakeholders (C1)**	Number of cooperation agreements with CITY stakeholders (C1S1, C1M1, C1A1, C1A2, C1T1) Number of debriefing meetings carried out (C1R2, C1T2) Number of mechanisms (platforms, websites) to share lessons learned with CITY stakeholders (C1S2, C1M2, C1A4) Number of awareness raising events targeting CITY stakeholders (C1A3, C1R2)	Number of stakeholder group involved in resilience-building activies about resilience (C1A2, C1R1, C1T2) Number of best practices shared among stakeholders (C1M2, C1A3, C1R2, C1T2) Existence of emergency plans that integrate stakeholders (C1S1, C1M1)
	Involvement in resilience networks of cities (C2)	Number of cooperation agreements with external governmental bodies and cities (C2M1, C2A1, C2A2, C2R1, C2T1, C2T2) Number of mechanisms (platforms, websites) to share lessons learned with CITY stakeholders (C2T2)	Number of policies aligned with regional, national and international input (C2T1, C2T2)