

Towards resilient cities: A maturity model for operationalizing resilience

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ABSTRACT

A growing majority of the world's population lives in cities. This rapid urbanization increases the concentration of people and critical services in cities, which also upscale their exposure to acute shocks and long-term stresses such as floods, earthquakes, climate change or social dynamics. While all of these challenges are complex in themselves, in most cases, cities must face a combination of them.

Resilience thinking demands cities plan holistically so that they are prepared for whatever shocks and stresses may arise. Although there is a set of frameworks aimed at building city resilience, frameworks specifically aimed at operationalizing the resilience-building process within cities remain undeveloped. This research begins to fill this gap by developing a Resilience Maturity Model (RMM) that provides cities with a roadmap for operationalizing the resilience-building process. For that purpose, the RMM defines a sequence of maturity stages and a set of policies that help cities to assess their current maturity stage and identify the policies that need to be implemented to improve their resilience level.

1. Introduction

Nowadays, over half of the world's population lives in cities, and according to United Nations, 66% of the total world's population is expected to live in cities by the year 2050 (UN, 2014). Due to rapid population growth and urbanization, cities are becoming more exposed and vulnerable to the effects of a wide spectrum of disasters, ranging from acute shocks such as floods and earthquakes to chronic stresses such as the ones caused by climate change or social dynamics (Rockefeller Foundation & ARUP, 2014). Moreover, the impact of a disaster could extend the city's boundaries affecting regions and nations (Malalagoda, Amaratunga, & Haigh, 2014).

In order to reduce the risk of and impact from disasters and increase the safety and wellbeing of citizens, cities must be more resilient and prepared to address shocks and stresses. In this context, improving cities' level of resilience to expected and unexpected disasters is of utmost importance and requires a holistic approach (Collier et al., 2013; Jabareen, 2013). This work defines city resilience as the capacity to resist, absorb, adapt to and recover from shocks and stresses, to keep critical services functioning, to monitor and learn from on-going processes through city and cross-regional collaboration, and to increase adaptive abilities and strengthen preparedness by anticipating and appropriately responding to future challenges (Smart Mature Resilience, 2016a).

Due to the complexity and broad nature of the concept of resilience, operationalizing the city resilience-building process is still a challenge (Cavallo & Ireland, 2014; Meerow, Newell, & Stults, 2016). Currently there are limited examples of the effective sequential steps that cities should follow for developing cities' resilience (Jabareen, 2013; Weichselgartner & Kelman, 2014). Frameworks in the literature still do not provide a roadmap with a detailed sequence of policies that cities can implement to operationalize the resilience-building process (Collier et al., 2013; Cavallo & Ireland, 2014). Furthermore, cities can exhibit a great variation in their level of resilience, and existing frameworks do not help to identify which policies should be implemented considering the current situation of a city (Jabareen, 2013).

To deal with these challenges, governments and practitioners, who have the responsibility for building city resilience, need support and guidance to operationalize the resilience-building process (Weichselgartner & Kelman, 2014). This paper presents a resilience maturity model (RMM) for local, regional, national, and international authorities, policy-makers, and critical infrastructure (CI) operators to help them operationalizing the city resilience-building process. In this regard, the RMM provides end users with five sequential maturity stages (starting, moderate, advanced, robust, and vertebrate) that serve as a roadmap for effectively building city resilience.

Each of the model's maturity stages contains a description of the objectives and a list of policies that should be implemented in order to

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move to a more advanced stage. Additionally, each stage considers the engagement of different city stakeholders, since they are the key drivers that contribute to the effectiveness of the process. The RMM presented in this research was developed within the context of the Smart Mature Resilience (SMR) European project funded by the H2020 program. The SMR project takes the perspective that European resilience should rest on a resilience backbone in which cities act as the vertebrae and the collaboration among them would lead to creating this backbone.

This paper is organized as follows: [Section 2](#) presents a literature review of the existing research on improving city resilience. [Section 3](#) outlines the research methodology used to develop and validate the RMM, which is described in [Section 4](#). [Section 5](#) provides a discussion of the characteristics of the maturity model. Finally, [Section 6](#) highlights the main conclusions achieved in this research.

2. State of the art

In the last years, the concept of city resilience has become the most prominent term for dealing with shocks and stresses that affect cities (Lu & Stead, 2013). Resilience covers the ability of a city to understand and prevent the disaster risks, to mitigate those risks, and to respond in such a way as to minimize loss of or damage to life, livelihoods, property, infrastructure, economic activity and the environment (Spaans & Waterhout, 2017). This research considers resilience as a transversal capacity to deal with expected and unexpected threats. Resilience goes beyond traditional risk management approach. Apart from considering the threats the city is already preparing for, this approach also focuses on developing preventive and adaptive capacities to deal with unexpected threats (Park, Seager, Rao, Convertino, & Linkov, 2013).

Several frameworks and conceptual models have been developed to define the attributes and priority areas of resilient cities (Kontokosta & Malik, 2018; Weichselgartner & Kelman, 2014). The Rockefeller Foundation and Arup (2014) developed a City Resilience Framework that defines resilient systems as those that have the following qualities: being robust and redundant as well as flexible, resourceful, inclusive, and integrated. To be resilient, a city must have a combination of effective city leadership, good infrastructure, social cohesion, collective identity and relative prosperity (Rockefeller Foundation & ARUP, 2014). Furthermore, the Sendai Framework for Disaster Risk Reduction framework was developed by United Nations Office for Disaster Risk Reduction (UNISDR) in order to reduce disaster risks and losses and strengthen assets in cities over the next 15 years. To reach this objective, the Sendai Framework defines four priority actions that include understanding disaster risk, strengthening disaster risk governance, investing in resilience and enhancing disaster preparedness (UNISDR, 2015). As these frameworks demonstrate, building city resilience requires a holistic approach that includes understanding dependencies across city services, potential vulnerabilities and cascading effects, and cross-organizational resilience and collaborative efforts (Cavallo & Ireland, 2014; Collier et al., 2013). Existing city resilience frameworks emphasize the key role of stakeholders in the resilience-building process since they are on the front line when experiencing a disaster (Aldunce, Beilin, Handmer, & Howden, 2016). Stakeholders are individuals, groups or organizations who can affect or are affected by the resilience-building process; this includes the government, emergency services, volunteer organizations, CIs, citizens, the media, scientific entities and private and public companies (Malalgoda et al., 2014).

However, there is still a large gap in resilience operationalization when going from theory to practice and making resilience tangible and practical for cities (Collier et al., 2013; Serre, Barroca, Balsells, & Becue, 2018; Serre & Heinzlef, 2018). Currently, there are limited examples of the effective sequential steps that cities should follow to involve stakeholders in the resilience-building process and to improve the city resilience level (Weichselgartner & Kelman, 2014). Furthermore, cities can exhibit a great variation in their resilience level (Jabareen, 2013).

In this context, roadmaps that provide cities with the policies that should be implemented as a function of their current resilience level need to be developed (Cavallo & Ireland, 2014; Smart Mature Resilience, 2016a). Taking as a base the lack of roadmaps for operationalizing the resilience-building process, maturity models provide an ideal roadmap for evolving a process from an initial stage to a more advanced stage, passing through a number of intermediate stages. Maturity models define the goals to be met at each stage and the policies that need to be implemented to get from the beginning stage of maturity to the highest level of maturity (Wendler, 2012). In this context, maturity models may serve as reference frame for operationalizing the resilience-building process in cities in a systematic approach (Wendler, 2012).

The contribution of this research is the development of a resilience maturity model (RMM) that guides cities in the resilience operationalization process. The RMM provides cities with a roadmap with five maturity stages for building the city resilience in a systematic and incremental way. These stages establish the temporal sequence of implementation of the policies to increase their implementation effectiveness. Moreover, considering the importance of involving relevant stakeholders in the process to be successful, the RMM suggests the temporal order in which the different city stakeholders need to be engaged in the resilience building process.

3. Methodology

The complex and dynamic nature of city resilience requires adopting a holistic approach when planning to build resilience (Desouza & Flanery, 2013; Jabareen, 2013). For this reason, the participation of stakeholders with different perspectives and needs with regards to the resilience-building process is crucial, as it clarifies the interdependencies among services and sectors in order to develop more effective plans and policies (Cavallo & Ireland, 2014). For this purpose, co-creation processes are effective methods for integrating experts' fragmented knowledge and delivering insights into the resilience-building process. In addition, co-creation processes ensure that tools are developed specifically for the needs of end users (Voorberg, Bekkers, & Tummers, 2015).

The RMM presented in this paper was developed with the help of 40 multidisciplinary experts from different European countries (Germany, Denmark, Italy, Latvia, Norway, Spain, Sweden and UK) who had a strategic, operational or tactical background. Furthermore, participants had expertise in different areas of city resilience: 9 were experts in CI protection, 8 in climate change adaptation, 10 in social dynamics, 7 in local administration, and 6 in European governance and policy-making. These experts participated throughout the co-creation process to develop the RMM. The co-creation process consisted of three main steps: (1) workshops, (2) a Delphi process and (3) the pilot implementation of the RMM (see [Fig. 1](#)).

3.1. Workshops

For the first step, four workshops were organized with city representatives and local, regional and national stakeholders in order to gather their requirements regarding the resilience-building process. The workshops focused on exploring cities' current experiences, best practices and difficulties concerning resilience-operationalization. The Group Model Building (GMB) collaborative methodology was used to gather information and build consensus among the stakeholders involved in the workshops (Vennix, 1996). The GMB methodology consists of arranging exercises with experts divided into small groups, and afterwards, presenting the results in plenary sessions in order to encourage discussion between problem perspectives that enrich the process (Hernantes, Labaka, Laugé, Sarriegi, & Gonzalez, 2012). At the end of the workshops a list of policies for improving cities' resilience was generated. The workshops had the added benefit of creating a

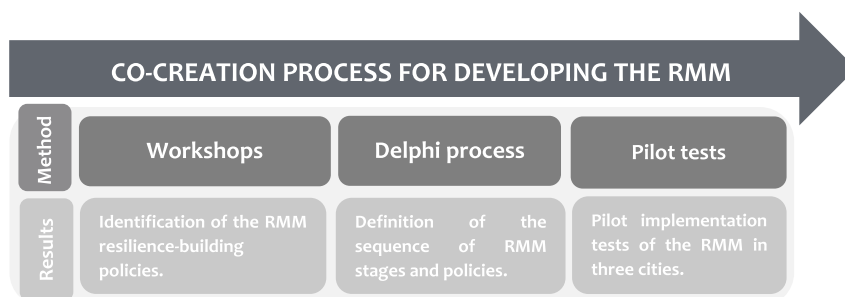


Fig. 1. Co-creation process for developing the RMM.

collaborative environment, building trust and increasing involvement and mutual learning among participants (Gonzalez et al., 2017).

3.2. Delphi process

After generating the resilience-building policies to be included in the RMM, the second step consisted of conducting a Delphi process to define the ideal and most effective sequence in which the resilience-building policies need to be implemented (Linstone & Turoff, 1975). The Delphi process involved two rounds: in the first round the description of the five maturity stages included in the RMM was validated and in the second round participants reached consensus in how to classify the resilience-building policies in terms of the maturity stage in which they should begin to be implemented (Smart Mature Resilience, 2016b).

3.3. Pilot tests

The RMM was developed through a process of pilot testing and feedback gathering with cities to ensure that the tool caters closely to the cities' needs. The cities of Kristiansand (Norway), Glasgow (UK) and Donostia (Spain) were the early adopters and constituted the operational environment in which the pilot implementation of the RMM took place. During the workshops organized to test the RMM, stakeholders from the municipality and regional and national networks including citizens, different local government departments, emergency services, and CI operators worked closely together on co-creating and testing the RMM. Participants were divided into four groups based on their background. Each group focused only on one dimension of the four defined in the RMM. The participants went through the five maturity stages finding evidence for each policy to assess the implementation level of each policy. The pilot tests helped these three cities to assess their current maturity stage. Based on the results, Donostia was classified in the moderate state, Kristiansand in the advanced stage while Glasgow is in the robust stage. Additionally, the RMM helped cities to identify the next policies that they need to implement in order to move forward in their resilience-building process. During these sessions, the RMM was a useful tool to facilitate the discussion among the city stakeholders.

4. The SMR resilience maturity model for cities

The RMM provides a tool for local, regional, national, and international authorities, policy-makers, and CI operators that allows them to reflect upon and make decisions about a city's resilience-building process. The RMM defines five sequential maturity stages (starting, moderate, advanced, robust, and vertebrate) that cities pass through, starting from their initial efforts in resilience-building process and ending with the achievement of resilience excellence. Based on the definition of these stages, the RMM enables cities to assess their current maturity stage and identify policies that allow them to advance to a more mature stage.

Each of the maturity stages includes a description of the objectives of that stage, the stakeholders that are actively involved in each

maturity stage and a list of policies that should be implemented in order to achieve the stage's objectives (see Table 1). The RMM includes the role of the relevant stakeholders that are involved in the resilience-building process, such as multi-level governance, CI providers, volunteers, emergency services, etc.

With regard to the policies included in the RMM, they have been classified according to four pillars or dimensions that combine effective leadership and governance (L), preparedness (P), infrastructures and resources (I) and cooperation (C) among the stakeholders. Each resilience dimension has been split into several sub-dimensions that group related policies (Smart Mature Resilience, 2016c).

The leadership and governance dimension entails the policy-making authority's commitment to promoting municipal, cross-sectorial and multi-governance collaboration (sub-dimension L1) as well as to crafting the appropriate legislation (sub-dimension L2). Furthermore, a learning culture (sub-dimension L3) and a resilience action plan (sub-dimension L4) need to be developed in order to empower stakeholders in the resilience-building process. The preparedness dimension refers to taking measures to improve the diagnosis and assessment of the city resilience level (sub-dimension P1). Furthermore, preparedness involves improving the training of stakeholders so they are able to deal with disasters (sub-dimension P2).

The infrastructure and resources dimension of resilience consists of the policies that improve the ability of CI services to achieve greater levels of robustness, redundancy, resourcefulness, and rapidity in the face of a disaster (sub-dimension I1). To that end, resources for building up the resilience and redundancies of infrastructures need to be deployed (sub-dimension I2). The cooperation dimension entails developing a holistic and participatory approach, meaning that partnerships between city stakeholders such as companies, volunteers, and citizens (sub-dimension C1) as well as alliances with other cities (sub-dimension C2) need to be established.

The following subsections describe the maturity stages.

4.1. Starting

The approach to emergency management adopted by the local government is based on the assessment of potential disasters without having an integrated approach towards multi-hazard and unexpected disaster risks. At this stage, different municipal departments and emergency services start to develop resilience-building policies. However, a common strategy among these policies is lacking.

Resilience also appears on the agenda of other stakeholders, such as CIs. However, CIs still work on increasing their individual resilience independently, without considering interdependencies with other services.

In view of these deficiencies, the local government endeavors to establish among stakeholders a common understanding of the resilience approach, where it is crucial that all involved row in the same direction. The local government identifies the relevant stakeholders that need to take part in the resilience-building process and leads the development of a resilience action plan with common practices and approaches, so that the resilience strategy is included in the city's agenda.

Table 1 Resilience maturity model. New stakeholders that start to participate at each maturity stage are marked in bold. Further information on the maturity model can be found in www.smr-project.eu/tools/maturity-model-guide/.

STAKEHOLDERS	STARTING	MODERATE	ADVANCED	ROBUST	VERTEBRATE
LEADERSHIP & GOVERNANCE	Local Government, Emergency services, CIs	Local Government, Emergency services, CIs Public and private companies, NGOs, Volunteers, Regional government	Local Government, Emergency services, CIs Public and private companies, NGOs, Volunteers, Regional government, Media Citizens, Academic and scientific entities, National government	Local Government, Emergency services, CIs Public and private companies, NGOs, Volunteers, Regional government, Media Citizens, Academic and scientific entities, National government, European policy-makers	Local Government, Emergency services, CIs Public and private companies, NGOs, Volunteers, Regional government, Media Citizens, Academic and scientific entities, National government, European policy-makers, International organizations
	(L1) Establish a working team responsible for resilience issues in the city	(L1M1) Establish a resilience department or committee and a cross departmental coordination board and procedures (L1M2) Align, integrate and connect there 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
	(L2) Integrate resilience into visions, policies and strategies for city development plans	(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 standard son resilience guidelines and policies
	(L3) 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
(L4) Resilience plan development	(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 resilience action plan development with other cities about to start the process

(continued on next page)

Table 1 (continued)

PREPAREDNESS		Reliability of infrastructures		INFRASTRUCTURE & RESOURCES	
<p>(P1) Diagnosis and Assessment</p>	<p>(P1S1) Assess and manage a wide range of risks (P1S2) List and prioritize critical service sand assets (P1S3) List existing plans and response mechanisms and guidelines for shocks and stresses</p>	<p>(P1M1) Take account of inter dependencies between risks when assessing and managing risk</p>	<p>(P1A1) Assess and prioritize risk scenarios and their implications through consideration of risk systemicity</p>	<p>(P1R1) Undertake regular and long-term risk assessment with a focus on risk systemicity</p>	<p>(P1T1) Assess the value added by CITY contributions to the resilience of other CITIES</p>
	<p>(P2) Education and Training</p>	<p>(P2S1) Conduct training and arrange emergency drills with the emergency teams and CI providers (P2S2) Inform citizens to volunteering opportunities in the local community (P2S3) Develop a common understanding of the resilience approach among stakeholders</p>	<p>(P2M1) Conduct training and arrange emergency drills including volunteers</p>	<p>(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</p>	<p>(P2R1) Establish a strong network of volunteers (P2R2) Conduct frequent joint training exercises between European cities</p>
	<p>(I1) Reliability of infrastructures</p>	<p>(I1M1) Identify inter dependencies of critical services at local level (I1M2) Develop periodical preventive maintenance procedures for CIs (I1M3) Develop measures to increase CI redundancy and reliability (I1M4) Implement monitoring systems for identifying risk shocks and long term stresses (I1M5) Carry out audits for CI providers</p>	<p>(I1A1) Develop flexibility measures</p>	<p>(I1R1) Identify interdependencies of critical services at international level</p>	<p>(I1T1) Encourage the continuous improvement of policies, to take advantage of any shock and stress to bounce forward and improveorre-design (I1T2) Apply big data approaches to analyze the information obtained</p>

(continued on next page)

Table 1 (continued)

INFRASTRUCTURE & RESOURCES		Resources to build up resilience (I2)	
(I2S1) Assess current initiatives and funding opportunities for the development of resilience	(I2M1) Allow for the resilience action plan in the local government budget	(I2A1) Promote and provide incentives for initiatives that contribute to build resilience	(I2R1) Promote and provide incentives to stakeholders for investment in R&D&I projects regarding Resilience.
(I2S2) Develop a list of the currently available response physical resources	(I2M2) Promote resources /tool sharing among CI providers with in a region during crises	(I2A2) Implement centralized control of coordination of critical resources and activities during shocks and stresses.	(I2R2) Monitor an effective use of resources to ensure the resilience-building process performance
(I2S3) Deploy a disaster relief fund for emergencies		(I2A3) Encourage stake holders to have appropriate insurance coverage	(I2T1) Assess the impact of innovation in the resilience-building process.
		(I2A4) Promote and provide incentives for the development of sustainable urban infrastructures	(I2T2) Monitor the insurance level of stakeholders
COOPERATION		Development of partnerships with city stakeholders (C1)	
	(C1M1) Develop a stakeholder engagement plan defining its roles and responsibilities	(C1A1) Align the objectives of different stakeholders and develop a common understanding of resilience	(C1R1) Widen collaborative networks with stakeholders to reflect on and make decisions about the progress of the city resilience
	(C1M2) Develop an internal communication platform for sharing information with different municipal departments and emergency services	(C1A2) Develop formal partnerships between academic and scientific entities to improve their silience building process	(C1R2) Arrange multi-stakeholder debriefing meetings
	(C1S1) Map relevant stakeholders to develop the resilience action plan	(C1A3) Undertake public consultations to receive feedback on the resilience action plan	(C1R3) Develop a public platform to enhance learning among city stakeholders
	(C1S2) Develop a public website with emergency information	(C1A4) Develop a public communication platform to interact with stakeholders	
Involvement in resilience networks of cities (C2)		(C2A1) Join a major Network of EU cities	(C2T1) Active involvement of local authority and stakeholders in networks (local, national, European & Global)
	(C2M1) Establish alliances with cities facing similar risks	(C2A2) Develop formal partnerships with regional stakeholders	(C2T2) Encourage stakeholders to present their experience concerning the resilience-building process as reference for other CITIES

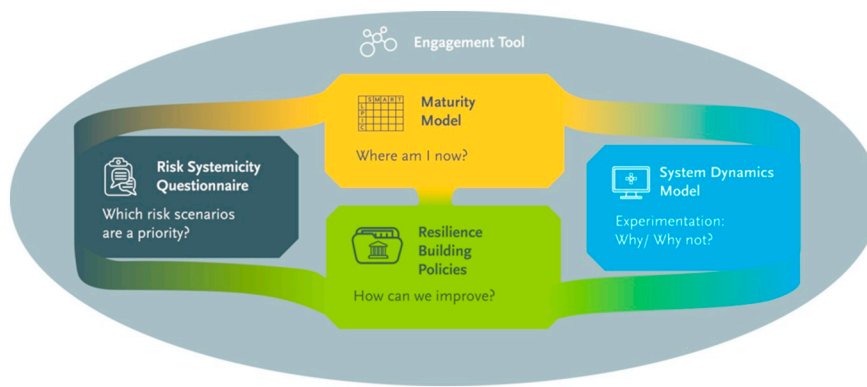


Fig. 2. SMR management guideline.

4.2. Moderate

The city resilience action plan includes policies that respond to expected and unexpected disaster risks from a holistic approach. The local government also sets up the organizational structure and the required resources to develop and manage the resilience action plan, monitoring the implementation of the policies.

In order to foster a resilience culture among stakeholders, the local government communicates the resilience strategy to public and private companies asking them for their commitment and active involvement. Furthermore, the local government carries out initiatives such as events and training activities to increase the awareness level of the different stakeholders. At this stage, the local government establishes partnerships with CIs, volunteer organizations, NGOs and emergency services to conduct joint training exercises. Furthermore, the interdependencies of the different CIs are integrated and included in the city resilience plan, which defines the strategy city needs to follow in the resilience-building process. Moreover, the local government joins networks and resilience projects with other cities and involves the regional government in the development of the city resilience action plan.

4.3. Advanced

The local government changes its role, becoming a facilitator instead of having a central guiding role. The role of the local government at this stage is to monitor the progress and effectiveness of the resilience action plan.

At this stage, the resilience action plan integrates all relevant stakeholders in the resilience-building process and is continuously improved based on lessons learned and best practices obtained through regular debriefing sessions with local and regional stakeholders.

Public and private companies are given incentives to achieve goals set in the city resilience action plan. The media is involved in the city resilience-building process so that the goals and actions of the resilience action plan are widely disseminated to citizens. Citizens are allowed to participate in platforms to provide input, suggestions and comments about the resilience-building process. Furthermore, academic and scientific entities work on methodologies for improving and evaluating the progress of the city's resilience. The national government is also involved in the city's resilience-building process. Finally, the multi-governance approach is included in the plans, but they are not yet fully operationalized.

4.4. Robust

All city stakeholders are actively involved in the development of the city resilience in full awareness that building resilience is a continuous improvement process and that it is part of daily thought and action. In addition, they make a significant effort to learn and improve resilience

by sharing lessons learned and providing feedback in multi-stakeholder discussions.

The resilience action plan is continuously improved and updated based on the feedback and suggestions received from the city stakeholders through consultation processes and participatory platforms. Furthermore, the multi-governance approach with a global dimension is well developed and operationalized. The city participates in networks with other cities, with a proactive posture and continuous learning, transferring knowledge and best practices in order to be prepared for unexpected disasters. This enables cities to have a common legislative framework with guidelines for collaboration among different countries and resource sharing in case of disasters.

4.5. Vertebrate

All the efforts by the city stakeholders are coordinated, integrated and aligned with the city resilience action plan. For this reason, at this stage, we refer to a city as a CITY (in capital letters), in which all stakeholders are committed and regularly engage in debriefing meetings.

The CITY excels in its resilience-building process and is an example for other cities to follow. Furthermore, the CITY is actively involved in networks with other cities and it collaborates with regional, national and international stakeholders in the implementation of resilience-building policies. The CITY is active, both nationally and globally, in spreading resilient initiatives. In fact, the CITY acts as a vertebra in the European resilience backbone and has an internalized resilience culture. The CITY is also proactive about supporting the development of resilience in other CITIES and regions as it understands that coexisting in a more resilient environment makes the CITY more resilient.

5. Discussion

Resilience operationalization entails making resilience concepts useful beyond their theoretical context. Indeed, this process of making resilience tangible and practical for cities has become an important challenge. The RMM presented here contributes to this issue by providing a roadmap that supports cities in the practical implementation of the concept of resilience.

Apart from using this RMM as a guide in the journey to building city resilience, this RMM can contribute to cities in additional aspects. The RMM can be used as a diagnosis tool that allows cities to assess their current resilience maturity stage and identify opportunities and challenges, supporting the development of resilience-strengthening strategies. The RMM also enables cities to prioritize policies based on the temporal order proposed through the five maturity stages. Furthermore, the RMM allows cities to monitor and track their progress in overcoming existing barriers, identifying lessons learned and learning from mistakes.

Involving relevant city stakeholders in the development of a city

resilience plan is of paramount importance to guarantee that the strategy addresses and integrates different points of view and interests. In this context, the RMM also helps increase understanding of resilience by using a common terminology to refer to the same concepts. It also allows stakeholders to understand resilience as a multidimensional objective, gaining a holistic understanding of each resilience dimension. Additionally, the use of the RMM facilitates a continuous process in which city stakeholders discuss and participate in the development of strategies to address city challenges, thus increasing their awareness of, engagement with and commitment to the resilience-building process.

The benefits of this tool have been tested in three pilot tests carried out in the cities of Kristiansand, Glasgow and Donostia. The pilot tests helped these three cities to assess their current maturity stage, identify the policies that have been implemented as well as the ones that need to be implemented in the short term. During these sessions, different stakeholders worked together, making it evident that each step of the resilience-building process requires communication and cooperation among all the relevant stakeholders.

Finally, it is worth mentioning that the RMM presented in this research is one of the pillars of the Smart Mature Resilience Management Guideline that provides cities with a set of five tools to enhance their level of resilience in a significant way (Fig. 2). The guideline integrates the following complementary tools: 1) the RMM that describes the ideal path to follow in the resilience-building process, 2) a Risk Systemicity Questionnaire that helps cities to analyze the current risks they are exposed to, 3) a Portfolio of Resilience Building Policies that provides examples of how to put in practice the policies identified in the RMM, 4) a System Dynamics model that enables cities to test different policies and understand the dynamics and the relationships among the policies defined in the RMM, and 5) a Community Engagement and Communication tool that provides a platform for stakeholder interaction. The use of the five tools developed within the SMR project will ultimately contribute to building city resilience from a holistic and multi-governance approach.

6. Conclusion

Cities are investing time and resources in developing strategies and policies to improve their resilience level. However, due to the complexity and wide scope of the concept of resilience, operationalizing the city resilience-building process is still a challenge. Existing frameworks in the literature still lack a roadmap that provides a detailed sequence of policies that cities can put into practice to operationalize the resilience-building process.

The RMM presented here is a roadmap that guides stakeholders along the resilience-building process, making the resilience development process tangible and practical for cities. In fact, this tool proposes a path forward, using the sequence of maturity stages and specific policies that need to be implemented to achieve the objectives defined in each maturity stage and move to a more advanced stage. The RMM contributes to the operationalization of resilience by: (1) facilitating a holistic understanding of the concept of resilience, using a common terminology and considering resilience as a multidimensional objective, (2) enhancing communication among stakeholders in order to facilitate a continuous process of discussion among the city stakeholders, which increases their awareness, engagement and commitment, and (3) identifying areas to be improved and supporting the development of resilience-building strategies.

The process of co-creation used for the development of this RMM, which involved multi-disciplinary stakeholders, guarantees the model is not confined to a theoretical approach but instead is practical for operationalizing the resilience-building process. Looking forward to future improvement of the RMM, indicators that cities can use to monitor the

implementation of the resilience building-process will be defined and included in the RMM.

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