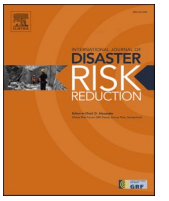
International Journal of Disaster Risk Reduction 115 (2024) 105069

Contents lists available at ScienceDirect

International Journal of Disaster Risk Reduction

journal homepage: www.elsevier.com/locate/ijdrr



A methodological approach to classify good practices for urban and metropolitan risk management

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ARTICLE INFO

Keywords:
Disaster risk reduction
Stakeholder engagement
Good practices
Indicator-based assessment
Risk management
Urban and metropolitan settlements

ABSTRACT

The proposed methodology is based on the development of criteria and indicators of Good Practices for Disaster Risk Reduction (DRR) in multi-risk scenarios, derived from a comprehensive review of established practices in scientific literature, carried out with the direct involvement of Stakeholders. The latter, understood as interest bearers but also as actors who receive benefits from the actions in which they are engaged, are usually only involved in some phases of DRR, mainly in those that concern the implementation of decisions that have already been taken. Considering that the meaning of "Good Practice" is highly debated in the literature, and starting from the definition proposed by Olivier Serrat, referred to as "*anything that has been tried and shown to work in some way*", the objective of this work is to engage a variety of societal Stakeholders (experts, local administrators, civil society) in all the phases of DRR, as bearers of knowledge, expertise and competences fundamental to assess the effectiveness of both existing and new DRR practices.

1. Introduction

The proposed study is part of the national project RETURN - multi-Risk sciEnce for resilienT commUnities undeR a changiNg climate, funded by the Extended Partnership composed of Italian Universities, Research Centres, and companies with funds from the National Recovery and Resilience Plan [1] from the European Union – NextGenerationEU, under Mission 4 "Education and Research" – Component 2 "From Research to Business" – Investment 1.3.

Considering the potential increase in the frequency of natural catastrophic events related to climate change, and the severity of their impacts on urban and metropolitan settlements, the partnership aims to achieve a better understanding of complex natural multi-risk dynamics and to develop predictive models applicable at multiple scales, in both the short and long term [2–6].

In detail, this paper presents the first results of research conducted within Spoke TS1: Urban and metropolitan settlements, Work

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https://doi.org/10.1016/j.ijdrr.2024.105069
Received 7 July 2024; Received in revised form 23 November 2024; Accepted 6 December 2024
Available online 7 December 2024

Package (WP) 2 – Multi-risk-oriented modelling of urban systems, Task 2.4 - Best practices for urban and metropolitan risk management.

The criterion that distinguishes urban and metropolitan settlements from rural ones is essentially related to population density and the presence of physical facilities and infrastructures. Urban settlements are characterised by significant population density (ratio of inhabitants per square kilometre) and the provision of infrastructure and utilities. Metropolitan settlements present the same characteristics but, from a geographical and administrative point of view, they refer to territories linked to one or more central cities by relations of functional interdependence, measured directly or through the identification of homogeneity or proximity areas. Contiguous municipalities that meet an average density in more than 1500 Ihab/km^2 and the total of the area must be more than 250,000 inhabitants tend to be aggregated. These areas are also characterised by a significant flow of economic and social relations.

Suburban areas identify areas on the extreme outskirts of a city, usually residential, or industrial, but in some cases also rural. In rural areas, more than 50 per cent of the population resides in municipalities with a predominantly agricultural economy and a population density of less than 150 inhabitants per km^2. These areas are generally less endowed with physical infrastructure and utilities.

The interest in focusing on urban and metropolitan settlements comes from the evaluation of the high-level of complexity about the risk management in these areas, especially linked to their extension and population density. Damages produced by environmental, natural and anthropogenic events on the physical, functional and social systems are considerable on all the national territory.

Moreover, the safety evaluation and management of the historical and residential heritage, the functionality of the infrastructural network and strategic buildings are a priority of the NRP [1] and it has also been recognised by the 2030 Agenda with five Sustainable Development Goals, specifically on the resilience of infrastructures and communities.

The task aims to build a national and international Repository of Good Practices for multi-risk management in urban and metropolitan settlements, investigating the effectiveness and criticality of practices implemented during a natural catastrophic event and the potential effectiveness of practices that have been designed but not yet applied. The results of the cataloguing work provide fundamental support for identifying Good Practices applicable in multiple contexts and risk scenarios.

To achieve the intended result, the research conducted so far starts from the definition of what is meant by “practice” in multi-risk management in urban and metropolitan settlements, based on bibliographic references. Subsequently, to define criteria for identifying and cataloguing Good Practices, an inductive methodology for the elaboration of indicators of Good Practices, derived from the analysis of international programmes, is designed. The development of this methodology involve several internal Stakeholders in the project who, based on their specific expertise and the semantic analysis of data collected from international programmes, selected, standardised, and clustered a large set of indicators.

One of the main expected outcomes of this work is to develop a participatory, flexible and dynamic methodology aimed at involving different types of Stakeholders. This inclusive approach strengthens the relationship between the academic expertise, represented by the internal knowledge Stakeholders involved in the first elaboration of the Good Practice Indicators, and the technical and political knowledge operating on the territory through the public decision-makers, who represent the external Stakeholders. Even in the first phase of the indicators’ elaboration, the research considers external Stakeholders, anticipating the needs that may be expressed by any context characterised by a multi-risk scenario and identifying the parameters useful to support and improve the Disaster Risk Management (DRM). This aspect can be seen in the methodology for the elaboration of the indicators and relevant variables which, expressed in a question form, will guide the public decision-makers in both a self-assessment and implementation of the practices applied in their context.

Future research developments include validating the Good Practice indicators, which will involve internal and external Stakeholders pertaining to specific application contexts identified in the project.

1.1. State of the art

Introduced in the organisational context of private enterprises, the term “Stakeholder” refers to the necessity for a company to be accountable not only to its Shareholders but also to groups outside the company (Stakeholders), who may nonetheless be affected by its decisions: suppliers and customers, consumers and environmental associations, residents near production facilities, etc. [7]. In this sense, a Stakeholder is defined as any group or individual who can influence or can be influenced by the achievement of the organisation’s objectives [8], who can affect the organisation’s focus, results, and resources, or who is influenced by such results [9]. When applied to the perspective of Public Administrations, the figure of the Stakeholder assumes a broader significance, referring not so much as for companies to the goal of profit-making, but rather to the goal of generating public goods and services for the community [7]. Identifying and involving Stakeholders in decision-making processes enables decision-makers to consider the possible impacts (social, economic, urban, environmental, etc.) of an action, and to identify the actors who can assist in the definition and implementation phases of the process. In this perspective, *Stakeholder engagement* takes on full significance in Disaster Risk Reduction (DRR) and Disaster Risk Management (DRM) practices. The complexity and deep uncertainty that characterise natural disasters, exacerbated by climate change, which generates multi-risk events with increasing frequency, necessitate broadening the decision-making framework to foster active processes of risk governance. Knowledge, skills, values, experiences, memories, and usual practices—whether good or not—are all elements that can be translated into resilience resources in the co-construction of policy actions aimed at reducing disaster damage.

In recent years, scientific literature on best practices for the governance of environmental and anthropogenic risks has grown. The available literature highlights the importance of the role of the *Stakeholders*. A rich empirical literature reports the results of research on specific issues, favouring the case-study approach, and highlighting methodological, conceptual, and applicative implications of

Stakeholders' involvement in DRR practices. Maurizi and Fontana [10] present the case of the risk communication plan development in the Argentine city of Santa Fe, which is particularly exposed to flood risk due to its orographic characteristics and, in recent decades, due to the increased frequency of intense rainfall due to climate change. The Communication Program implemented various strategies and actions with the participation of teachers, students, neighbourhood organizations, the Red Cross, and other local actors. These efforts aimed at increasing the awareness and understanding of flood risk in the city, thereby strengthening the preparedness of each sector to respond effectively.

Boersma et al. [11], present the case of the so-called "Amsterdam Crisis Resilience Living Lab" set up in the financial district of Zuidas, and the one of the Indische Buurt neighbourhoods, with about 55 per cent of immigrant residents. This initiative enables the co-creation of knowledge produced by both formal organizations and local Stakeholders in close collaboration with researchers from the Vrije Universiteit Amsterdam and the Institute for Societal Resilience. The research demonstrates the potential of collaboration among institutional responses, traditional organizations (e.g., firefighters, police), and other local Stakeholders (such as community organizations, citizen groups, and private businesses) to foster a more inclusive and resilient approach to crisis management [12,13]. The Living Lab experience emerges as an effective form of Stakeholder engagement [14].

In this regard, the concept of community engagement in mitigating the consequences of disasters is well-documented in the empirical literature, especially with the recent emphasis on Community-Based Disaster Risk Management (CBDRM) approaches [15,16]. These approaches typically stem from community participation and a mindset of shared responsibility [17]. However, especially in areas with low-income and immigrant populations, the literature highlights the necessity for targeted communication programmes and direct community involvement, such as physically holding meetings in affected neighbourhoods. These strategies, implemented in Living Lab forms as seen in the Amsterdam case and more recently in Huston [17] using a grounded theory methodological approach, have yielded appreciable results.

A novel approach to studying DRR processes adopts the social capital perspective [18–20]. The social capital is understood as the endowment of relational network available within a community [21], that drive information, expertise, emotional sources, economic sources, etc. It constitutes an endowment to which all the community can access to achieve collective objectives. The use of social capital implies the capability of different actors to work in network [22,23].

This approach, empirically applied in our research, allows for identifying the most relevant forms of social capital for enhancing resilience against natural disasters [24]. This perspective holds significant promise for analysing particularly fluid, uncertain, and context-specific dynamics such as those related to crisis management. These studies (and others alike) share two crucial considerations: i) despite their global nature, current crises primarily impact at the local scale, with severe damage on local communities; ii) crisis management is the "*process of how we prepare for, respond to, and learn from the effects of a wide range of major failures that impact upon groups of people, from organizations to local, national and international communities*" [25]. Therefore, it is strategic to create opportunities for local actors to participate actively in the crisis management process, promoting their collaboration. Their grasp of the local context and their integration into local networks have emerged as crucial elements in fostering more inclusive crisis responses. Incorporating a diverse array of perspectives and perceptions regarding risk and vulnerability from multiple Stakeholders is a crucial starting point for developing effective DRR strategies. This approach also re-establishes the relationship of trust between institutions, experts, and citizens, laying the groundwork for consensus that facilitates more effective risk communication by the government.

In general, there is growing evidence that field studies and empirical applications are moving towards a participatory approach that goes beyond traditional stakeholder consultation [26]. This approach is more inclusive, incorporating Stakeholders with factual knowledge and experience at both local and national levels, actively involving them in DRM and proposing operational actions and replicable workflows. For example, in the case study of Santa Fe [10] a set of actions aimed at implementing risk communication for the population is identified; in the case study of Amsterdam [11] a model of actions that develops a set of organisational interactions, to be activated in emergency situations, is proposed; in the case study on Cameron [26] a socio-ecological cut modelling, that prefigures the interactions between populations and hazards, is produced. These analytical approaches are predominantly qualitative, while the aim of our research is to develop a qualitative-quantitative analytical one. The goal is to achieve a holistic understanding of the multi-hazard risk system, which is now inevitable given the increasing challenges posed by climate change and natural disasters. This approach requires a well-articulated methodological framework concerning steps, techniques, and tools to be deployed, particularly focusing on Stakeholder identification and engagement. The literature provides numerous contributions in this direction, developing conceptual models and well-established frameworks that are dynamic and adaptable to different contexts and hazards [27–29]. However, aligning the actions of Stakeholders with formal response structures remains a pressing question that can be best addressed only through collaboration with local actors.

1.2. Tools and indicators for DRM and resilience

To reduce communities' vulnerability to adverse events, DRM strategies aim to provide them with tools to withstand, recover, and "build back better" after disasters [4]. These approaches involve practices, procedures and protocols designed to foster long-term resilience. However, while tools for managing extreme events are increasingly available at national and international levels, detailed information on specific risk scenarios and vulnerabilities are often accessible only at local scales. The gaps between risk governance levels often results in information dispersion, highlighting the need for new tools to align decision-making, enhance understanding of disaster risk and vulnerabilities, evaluate policy effectiveness, and ultimately support the identification of Good management Practices [30]. Cardona [30] and Bretch et al. [31] highlighted indicators' effectiveness in identifying vulnerabilities, enhancing information accessibility, enabling risk scenarios comparisons across space and time, and setting benchmarks to improve effective disaster risk management. In complex multi-risk scenarios, indicators serve as an essential tool in supporting Stakeholders in

defining policies to be implemented and/or monitoring those already in place [32]. The European project Myriad-EU [32] adopts the following definition of an indicator: "*observable and measurable characteristics that can be used to simplify information and facilitate understanding of the state of a concept or phenomenon and/or to monitor it over time to show changes or progress toward achieving a specific change*" [33]. Tracking this progress requires observable and measurable characteristics, which are not always aligned in the literature, as in evolving concepts like "resilient community" [34–36] or resilience more broadly [37–39].

In this context, developing an adaptable set of indicators to monitor the effectiveness of DRM practices, both new and existing, can serve as a Good Practice itself: unlike observable clues that emerge only post-event, indicators allow for proactive assessment of vulnerabilities, identification of exposed elements and potential risk factors [40]. By providing measurable and observable characteristics that simplify complex data, indicators also enable Stakeholders to track progress, guide decision-makings, and support the development and monitoring of DRM practices.

Building on the above consideration, an inductive approach focused on "inescapable practice" has been adopted. Those that consistently emerge across multiple frameworks, programmes, practices etc., presumably bear essential indicators in effective DRM and resilience. To this end, a review of relevant documents regarding these topics was conducted. An initial set of 18 documents was selected by the RETURN project's knowledge Stakeholders, either based on their expertise or chosen from established practices within the relevant scientific literature. Additional documents were subsequently sourced from the Solution Explorer database, an open-access repository of existing Good Practices developed within the ROADMAP project [41]. The inclusion criteria, chosen as filters for querying the database, were aligned with key points of the RETURN project: *practices* implemented in *urban or metropolitan settlements* and applying *multi-risk approaches* to address a wide spectrum of natural and anthropogenic risks, both intensive and extensive [42]. The query yielded 22 results, obtaining a final set of 40 documents, listed in Annex A of the Supplemental Material.

These documents were then analysed in detail considering the following criteria: Stakeholder engagement; participation and cooperation across different sectors and societal levels, both public and private; adoption of a multi-criteria approach (social, economic, cultural, structural etc.). These enabled the selection of practices based on their relevance, replicability, and suitability for deriving DRM and resilience indicators aligned with the overall aims of the proposed study. The review led to the exclusion of 35 documents, mainly due to their lack in generalised approaches with narrow or single-dimension scope; limited or not cross-sectoral stakeholder engagement; and context-related approaches.

In the end, the following 5 core documents were selected: the Sendai Framework for Disaster Risk Reduction 2015–2030 [4], the Disaster Resilience Scorecard for Cities [43], the Australian Disaster Resilience Index [44], the City Resilience Index [45], and the emBRACE framework for Community Disaster Resilience [46].

A description of all five documents is provided in Annex B of the Supplemental Material.

Each document was chosen based on its alignment with the inclusion criteria and was also selected to represent a diversity of viewpoints, ensuring varied perspectives for deriving the indicators. Specifically, the Sendai Framework for Disaster Risk Reduction [4] was chosen as the most recognised framework and, along with its operational tool, the Disaster Resilience Scorecard for Cities [43], were selected as international programmes led by public entities, with a common understanding of resilience. The Australian Disaster Resilience Index [44], also developed by a public entity and generally aligned with Sendai priorities, was chosen for its national focus on the Australian context and its distinct definition of resilience. The emBRACE project [46], an international public-funded initiative, provides a comprehensive and enhanced view of resilience, consistent with the Sendai Framework. Selected from the documents proposed by the knowledge Stakeholders, it was chosen to provide an academic perspective, adding depth to the analysis, and enriching the study's methodology. The City Resilience Index [45], developed by an international private entity, diverge from the Sendai Framework, providing its own operational definition of resilience.

1.3. Operational definition of Good Practice

To develop a methodology for designing Good Practice indicators for multi-risk management in urban and metropolitan settlements, the research began with defining what is meant by "practice". Based on the topics covered and the research team's established expertise, a "practice" was assumed as any action or system of actions implemented by Stakeholders in a given territorial context to cope with a disaster, including actions taken during each phase of both risk assessment (establishing context, risk identification, risk analysis, and risk evaluation [47]) and risk management (mitigation, preparedness, response and recovery [48,49]). The specific application context, therefore, identifies the multiscale of the practice, which may correspond to spatial government instruments, emergency plans, local policies related to one or more phases of risk management, national or international programmes, etc. or the combination of these elements.

Depending on the context and scale of application of the practice, different Stakeholders are identified, including scholars who are experts in the field, technical and political actors within the analysed context, local associations, Third Sector entities, etc. Having established and shared the definition of practice within the relevant scientific community, the study focused on identifying bibliographic references related to the definition of "Good Practice", which was preferred over "best practice" as a conceptual framework [50].

In this article, the definition proposed by Olivier Serrat [51] is accepted: "*A Good Practice is defined as anything that has been tried and shown to work in some way (whether fully or in part but with at least some evidence of effectiveness) and that may have implications for practice at any level elsewhere*". The limitation of this definition lies in the need to first apply a Good Practice to verify its effectiveness, which requires waiting for a catastrophic event to occur. In addition, to benchmark multiple practices, there would have to be a recurrence of the same catastrophic event, which by definition is understood as an event of high intensity and low frequency, in the same reference context. This second assumption is also unlikely since any urban or metropolitan settlement subjected to a catastrophic event would be

altered by it, either through increased vulnerability in the short term due to the damage sustained from the impacts of the external hazard, or increased resilience in the long term because of the restoration and consolidation efforts carried out on the physical, social, and cultural system.

The exemplification of what constitutes Good Practices manifold and documented in technical reports and case study commentaries. Some of the most well-known include the Sendai framework [52], the two Baltimore reports from 2013 to 2018 [53,54], the Santa Fe case study [55], and other recent studies related to climate changes [56,57]. The approach followed to identify Good Practice in these examples can be defined as direct, as these procedures are directly recognised to be those that would have mitigated the damage effects induced by observed disaster events. Departing from this approach, to develop a methodology that can be generalised to any risk situation, it is first necessary to establish an exigency framework that concerns individual Stakeholders and the community. This requires observing how various actors may be involved in a disaster event, identifying detectable criticalities on which the damage to people or property depends, defining the strategies to overcome these critical conditions, and outlining actions that lead to the protection of individuals and urban contexts involved, following a chain of action that depends on the specific urban contexts in which the events occur, and the types of risks and multi-hazard conditions examined. The reference to individual Stakeholders and the community influences whether Good Practice can have implications beyond merely structural aspects, extending to cultural, social, political, and economic dimensions as well.

In light of these considerations, this article proposes an inductive approach to the definition of Good Practices, which begins with the identification of cultural, social, political and economic indicators, generally defined considering various disaster situations, and that can be easily adapted to different urban contexts, as well as specified as optimal requirements for minimising damages related to a given event. Such an approach allows for the development of a flexible and dynamic methodology for the identification and cataloguing of potential Good Practices that, even if not tested in the occurrence of an actual catastrophic event, can be considered "promising" as they meet established criteria and indicators in DDR practices, as well as in the accredited industry literature. In this sense, the proposed methodology also overcomes the limitation of Serrat's [53] definition of Good Practice.

2. Methodology

2.1. Research phases

To identify useful indicators to determine which are the "Good Practices" for urban and metropolitan multi-risk management, an inductive methodology based on bibliographical references is proposed.

The Working Group (WG) engaged in this phase is multidisciplinary and brings together young researchers and scholars who are also professionally involved in concertation with Civil Defence and local authorities in risk management, assuming roles as Knowledge Stakeholders. In the first steps of the methodological approach, a group of 17 Knowledge Stakeholders, pertaining to different scientific fields, was selected from the RETURN project: 1 sociologist expert in Security, risk and vulnerability; 1 sociologist expert in Sociology of the environment and territory; 1 sociologist expert in Urban and rural sociology; 1 sociologist expert in Social vulnerability in urban and metropolitan risk management; 1 construction and civil engineer expert in Engineering for building renovation and technological innovation; 1 construction engineer-architect expert in Diagnosis and recovery of Cultural Heritage; 1 construction engineer-architect

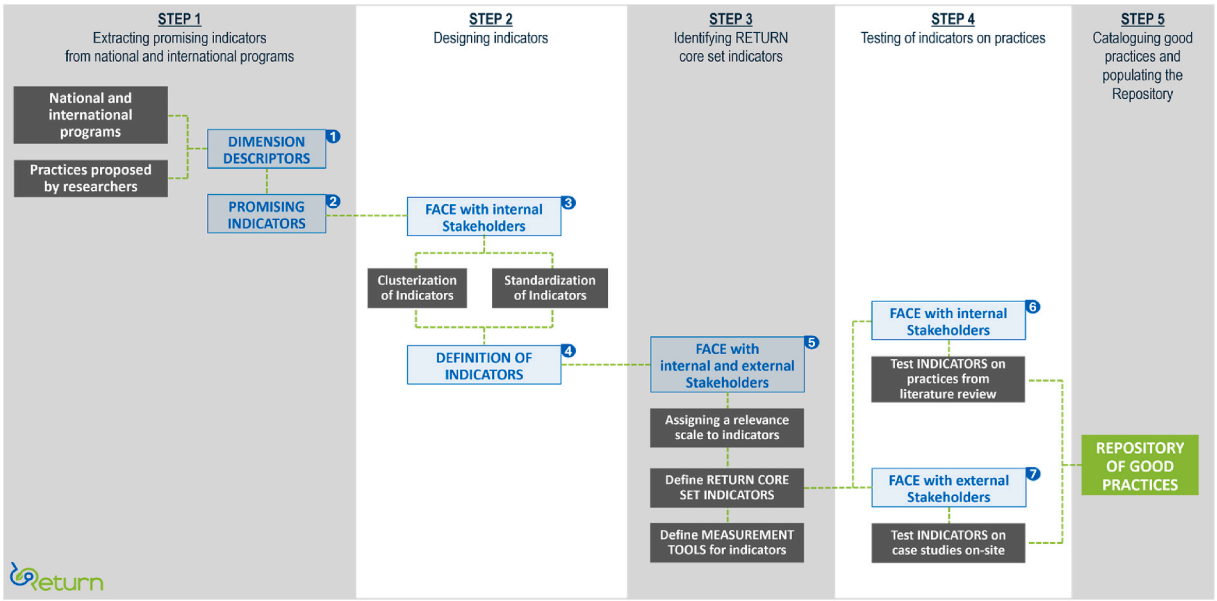

Fig. 1. Workflow for creating the repository of Good Practices for multi-risk management in urban and metropolitan settlements.

experienced in Assessing the impacts of natural and anthropogenic hazards on building envelopes; 1 civil engineer expert in Best management practices in urban drainage systems; 1 civil engineer expert in Structural engineering; 1 construction engineer expert in Diagnosis and treatment of structural instability; 1 civil engineer expert in Structural engineering, geotechnics and seismic risk; 1 civil engineer expert in Advanced seismic protection technologies for new and existing structures; 1 architect expert in Urban, building and public space regeneration to contrast climate impacts; 1 mathematician and medical statistician expert in Epidemiology and biostatistics; 1 physicist expert in Risk and natural hazard assessment, impact forecasting, data mining and processing; 1 physicist expert in Statistical seismology, capacity building and technology transfer; 1 environmental engineer expert in Exposure modelling for multi-hazard analysis.

The methodological approach followed the workflow shown in Fig. 1.

In Step 1, a set of national and international programmes and frameworks addressing the issue of multi-risk management at the urban and metropolitan scale, were analysed.

The analysed programmes were chosen following the approach described in section 1.2. To select the documents, the following inclusion criteria were agreed by all the experts:

- *Practice:* actions, systems of actions, plans, methodological approaches, and regulatory prescriptions implemented to manage multi-risk scenarios in urban and metropolitan settlements.
- *Multi-risk scenario*: a specific scenario typical of a physical and anthropogenic context on which a system of risks simultaneously impacts.
- *Urban and metropolitan settlements*: physical systems in which housing, production and industrial functions take place in a complex characterised by a high level of anthropisation in terms of both population and building density.

To ensure the applicability of the research results to the Italian national context, which the RETURN project addresses, programmes and frameworks developed in high-income countries were chosen.

For each programme, dimension descriptors were extracted, corresponding to the objectives, targets, and priorities outlined in the analysed documents.

For each dimension descriptor, the knowledge Stakeholders developed one or more promising indicators, both qualitative and quantitative. The proposed promising indicators aim at assessing the extent to which the objectives, targets, and priorities of each programme are achieved, indicating the effectiveness of the programme itself.

Following the principle of redundancy of information given by each programme, the extrapolation of promising indicators was focused on the five frameworks described in the introduction.

In Step 2, the promising indicators were examined through a co-occurrence analysis, which resulted in the identification of three different hierarchical clusters for indicator classification.

At this stage, through a comparison between experts composing the WG, the promising indicators were merged, rewritten and standardised in form of variables, expressed as questions that must guide the end user to understand if the specific information is contained in the practice. Variables were classified into clusters resulted from the co-occurrence analysis and grouped into 9 criteria, characterized by homogeneous topics aiming at including all features of risk assessment and management. The considered variables were also classified according to the stages of the Sendai Framework.

The variables were paired with quantitative or qualitative measurable indicators, aimed at collecting the data recorded by the specific analysed practice.

For each cluster, a list of suggestions was included in drop-down menus by the WG. However, in order to maintain the flexibility of the tool, in each drop-down menu there is always also the choice “other”, which allow the compiler to edit a new value in open form. Additionally, for each variable, the suggestion of sources containing necessary information and methods to measure or evaluate them, were identified.

Fig. 2 shows the cataloguing scheme of the 9 criteria and their relevant indicators.

Steps 1 and 2 complete the first part of the methodology, resulting in a set of indicators useful to identify practices for multi-risk management in urban and metropolitan settlements, that is one of the expected outcomes.

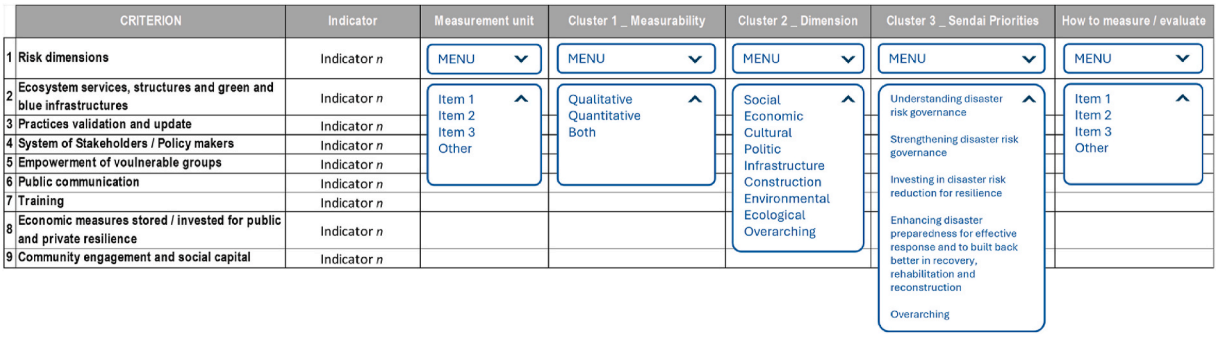

Fig. 2. Methodological scheme for indicators collection.

Next steps aim at determining the *RETURN core-set indicators*, i.e. indicators that a practice must absolutely comply with in order to be defined as "Good".

In these phases internal knowledge Stakeholders and external Stakeholders, representing the social actors of some territories chosen as applicative case studies, will be called upon to assign each indicator a weight, according to their expertise, expressing how relevant the individual indicator is to define an action, or system of actions, as "Good Practice for multi-risk management in urban and metropolitan settlements".

2.2. Methodology for identifying external Stakeholders

The classification proposed by Bobbio [7] distinguishes Stakeholders in three main areas: public institutions (i.e. local territorial authorities, functional agencies, etc.); organised groups (i.e. pressure groups, territorial associations, citizens' committees); and unorganised groups (citizens and collectives, i.e. the totality of citizens comprising the local community). At this stage of the proposed work, external Stakeholders will be identified within public institutions, particularly among the heads of local territorial authorities, and within organised groups, specifically referencing the territorial associations most directly involved in crises management. This exclusive choice is motivated by: a) the need to contain the time required to elaborate the core set of indicators; b) the opportunity to refer to "political" actors who are more directly and consistently involved in decision-making; c) the opportunity to consider at least the associations that are more rooted in the territories and have experience in crisis intervention. Consistent with these motivations, Stakeholders will be identified through a positional approach (actors who occupy top positions in local institutions and organizations) and then, when necessary, through a snowballing and reputational method (accepting indications of subjects reputed to be significant Stakeholders with respect to the analysed practices) [58].

This methodological approach will be applied by identifying external Stakeholders through case studies in specific urban contexts, based on two main criteria: relevance concerning experience/exposure to multi-risk, and a minimum level of familiarity with the WG

Table 1
Dimension descriptors extracted from analysed programmes.

Programmes	Dimension descriptors target/goals/priorities
Sendai Framework for Disaster Risk Reduction 2015–2030 [4]	(Priority 1) – Understanding disaster risk (Priority 2) – Strengthening disaster risk governance to manage disaster risk (Priority 3) – Investing in disaster risk reduction for resilience (Priority 4) – Enhancing disaster preparedness for effective response, and to « Build Back Better» in recovery, rehabilitation and reconstruction
Disaster Resilience Scorecard for Cities, 2021 [43]	(Essential 1) – Organize for Resilience (Essential 5) – Safeguard Natural Buffers to Enhance the Protective Functions Offered by Natural Ecosystems (Essential 7) – Understand and Strengthen Societal Capacity for Resilience (Essential 3) – Strengthen Financial Capacity for Resilience (Essential 2) – Identify, Understand and Use Current and Future Risk Scenarios (Essential 4) – Pursue Resilient Urban Development (Essential 6) – Strengthen Institutional Capacity for Resilience (Essential 8) – Increase Infrastructure Resilience (Essential 9) – Ensure Effective Disaster Response (Essential 10) – Expedite Recovery and Build Back Better
Australian Disaster Resilience Index (ADRI), 2020 [44]	1. Social Character 2. Economic capital 3. Emergency services 4. Planning and the built environment 5. Community Capital 6. Information Access 7. Social and community engagement 8. Governance and leadership
City Resilience Index (CRI), 2018 [45]	Infrastructure and Ecosystem 7. Reduced exposure and fragility 8. Effective provision of critical services 9. Reliable Mobility and Communications Leadership and Strategy 10. Effective leadership and management 11. Empowered Stakeholders 12. Integrated development planning
Indicators for a Resilient Community, 2011–2015 [46]	Preparedness Response Recovery Mitigation Social support Resource and Capacities Learning

researchers, which may facilitate accessibility. Contact with Stakeholders will be direct, with flexible involvement methods. Additionally, the possibility of involving members of the city community, when necessary and possible, is not excluded.

3. Results

At present, the research has completed the first two steps.

In Step 1, a total of five international programmes addressing the broad spectrum of DRR [4,43–46] were analysed, extrapolating the relevant dimension descriptors from the programmes' targets and priorities. One or more promising indicators were developed for each dimension descriptor. At this stage, the indicators (or variables) are considered promising, with the understanding that only after the process of clustering and standardisation consistent with the objectives of the RETURN project (Step 2), they will be confirmed or not as Good Practice indicators for multi-risk management in urban and metropolitan settlements.

Table 1 shows the dimension descriptors analysed for each programme, while Table 2 details an example of extrapolation of promising indicators from one of the analysed programmes.

The complete catalogue of the 236 promising indicators is provided in Annex C.

From the co-occurrence analysis performed on the 236 promising indicators, three different hierarchical clusters were derived to classify them:

- Cluster 1 (*measurability*): identifies the degree of measurability of the promising indicators, dividing them into qualitative and quantitative indicators (type, number, percentage, etc.).
- Cluster 2 (*dimension*): identifies the dimension to which the promising indicators refer, broken down into different variables, including social, economic, cultural, political, infrastructure, construction, environmental, and ecological. More than one dimension may be indicated.
- Cluster 3 (*Sendai Framework phases*): identifies the risk management phase to which the indicator refers, concerning those identified in the Sendai framework [4]. This classification aligns with the one already adopted in the ROADMAP project [41], distinguishing the stages of Understanding Disaster Risk; Strengthening Disaster Risk Governance; Investing in Disaster Risk Reduction for Resilience; and Improving Disaster Preparedness for Effective Response and Better Rebuilding in Recovery, Rehabilitation and Reconstruction. More than one phase may be indicated.

Overall, the indicators were organised into 9 criteria according to the methodology described in section 2.1:

- Criterion 1 - *Risk dimensions*: identifies the dimensions and types of risk considered by a practice, taking into account that the RETURN Good Practice Catalogue will apply to the management of multi-risk scenarios in urban and metropolitan settlements.
- Criterion 2 - *Ecosystem services, structures, and green and blue infrastructures*: assesses if the external Stakeholders, who apply the practices, have an in-depth knowledge of the city's infrastructure, including protection infrastructure against prevailing hazards, and if its state of maintenance and operation is regularly monitored and maintained.

Table 2
Elaboration of promising indicators for dimension descriptors extracted from analysed programmes – methodological examples of promising indicators extracted from priorities of Sendai Framework for Disaster Risk Reduction 2015–2030 [4].

Programmes	Dimension descriptor target/goals/priorities	Promising indicators
Sendai Framework for Disaster Risk Reduction 2015–2030 [4]	**(Priority 1) – Understanding disaster risk**	
	Ability to analyse all dimensions of risk	Number and type of risk dimensions analysed
	Ability to assess a pre-disaster condition	Number and type of models or tools used for pre-disaster assessment
	Ability to demonstrate the effectiveness of actions	Actions that the project aims to carry out and capable of being demonstrated by models
	(Priority 2) – Strengthening disaster risk governance to manage disaster risk	
	Ability to involve relevant Stakeholders and partners	Number and type of Stakeholders and Partner involved
	(Priority 3) – Investing in disaster risk reduction for resilience	
	Ability to attract public and private investments	Number and type of Sponsor or Partnership involved
	Ability to create innovation, growth, and job	Number of instruments and tools validated
	(Priority 4) – Enhancing disaster preparedness for effective response, and to « Build Back Better» in recovery, rehabilitation, and reconstruction	
	Ability to strengthen disaster preparedness	Results by qualitative measurement tools
	Ability to empower women and persons with disabilities to publicly lead	Number of women and persons with disabilities empowered
	Ability to promote gender equitable and universally accessible response approaches	Number of public events that involve actors of equal gender representation in the event's organization and planning.
	Ability to strengthen resilient Built Back Better strategies	Results by quantitative measurement tools

- Criterion 3 - *Practices validation and update*: understands if external Stakeholders adopt tools to verify the effectiveness of practices before the occurrence of a catastrophic event and if they periodically update maps and standards describing the most severe risk scenarios.
- Criterion 4 - *System of Stakeholders/Policymakers*: comprehends which and how many Stakeholders and policymakers are involved in the design and implementation of the practices, and if there are structured relationships between the different actors.
- Criterion 5 - *Empowerment of vulnerable groups*: addresses if Stakeholders implementing practices are aware of the presence of vulnerable groups, as well as how these groups are involved in the design of risk management policies.
- Criterion 6 - *Public communication*: determines risk communication strategies practised by Stakeholders, and if tools to evaluate their effectiveness have been developed.
- Criterion 7 - *Training*: understands what training actions are implemented by Stakeholders, and if strategies have been developed to assess their effectiveness.
- Criterion 8 - *Economic measures stored/invested for public and private resilience*: evaluates what economic resources have been dedicated in cities for risk management, if these resources are considered sufficient, and how much they weigh against the overall public budget.
- Criterion 9 - *Community engagement and social capital*: examines whether and to what extent the community is involved in the design and implementation of applied risk management practices.

Fig. 3 shows the synoptic picture of the number of indicators developed for each criterion.

As an example, Table 3 presents all the indicators constructed for Criterion 1 - *Risk dimensions*, following the specified methodology, deferring to Annex D for the comprehensive collection of 132 indicators developed across all 9 criteria.

4. Discussion

On the basis of identified frameworks aimed at proposing or supporting the elaboration of indicators of Good Practices 132 promising indicators have been identified, systematised standardised and then organised into 9 homogeneous criteria. These indicators have also been categorised on the basis of their measurability, dimension and pertinence to the Sendai priorities, providing suggestions on possible ways to measure or evaluate them. The study was conducted focusing on indicators of Good Practices for the multi-risk management in urban and metropolitan settlements in high income countries. Thus, this work provides an innovative and flexible tool that may serve both scholars and public decision-makers to evaluate existing practices and to develop new-ones as well as to create and update a Repository of Good Practices.

Given the diverse sources from which these frameworks derived, and the large number of indicators proposed, an innovative aspect of this approach lies in their selection and combination to avoid redundancies and overlaps, while considering the multidimensional aspects of DRR.

A further innovative aspect is the organisation of variables into homogeneous criteria, that allows to better evaluate each indicator in its specific context, as well as their classification according to different clusters.

Although the focus of the study was on the specific context of multi-risk scenario in urban and metropolitan settlements in high-income countries, the proposed open-ended methodology can be reproduced in other contexts to identify and categorise new indicators following the provided structure.

An important aspect that characterises the proposed methodology for indicators' selection is the restriction to variables that can be measured either quantitatively or qualitatively, resulting in indicators that can be assessed objectively by different experts. The issue of reproducibility has been at the basis of all the developed steps.

The most innovative aspect of this work consists in the involvement of Stakeholders with multidisciplinary backgrounds fostering a

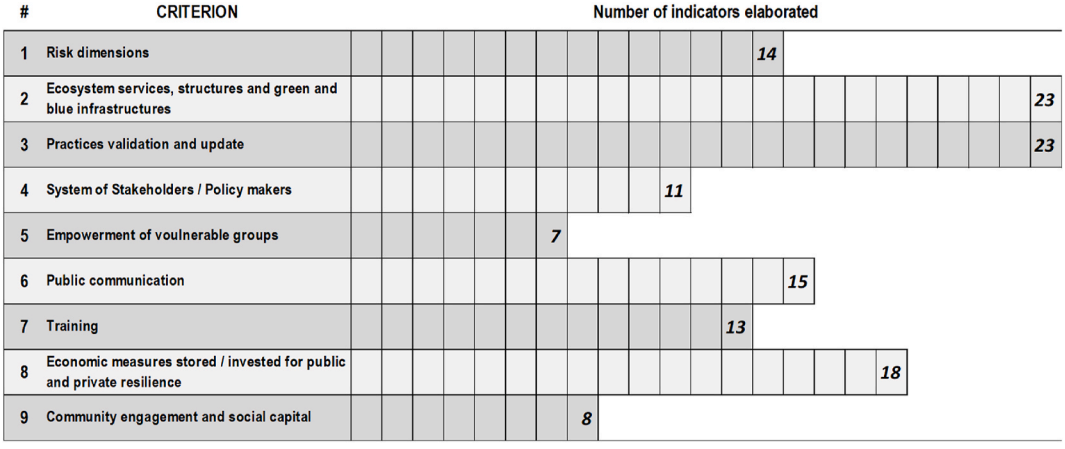

Fig. 3. Synthesis of the number of indicators elaborated for each criterion.

Table 3
Standardisation and clustering of indicators for criterion 1 – Risk dimensions.

CRITERION 1 - RISK DIMENSIONS						
Variables	Indicators	Measurement unit	Cluster 1 Measurability	Cluster 2 Dimension	Cluster 3 Sendai Priorities	How to measure/ evaluate
How many risk dimensions are analysed?	Number of risk dimensions analysed	no.	Quantitative	Overarching	Understanding disaster risk governance	Analysis of the plan
Which types of risk dimensions are analysed?	Types of Risk Dimensions	select one	Qualitative	Overarching	Understanding disaster risk governance	Analysis of the plan
Do the city governance measures include and implement disaster risk reduction (DRR) approaches in multi-risk scenarios due to climate change?	Presence of DRR approaches due to climate change in governance measures	y/n	Qualitative	Overarching	Overarching	Number and type of approaches
Does the city have maps to evaluate the consistency of built heritage, updated within the last 5 years?	Presence of maps to evaluate the consistency of built heritage, updated within the last 5 years	y/n	Qualitative	Overarching	Understanding disaster risk governance	Analysis of the plan
Does the city have maps to evaluate the consistency of informal settlements, updated within the last 5 years?	Presence of maps to evaluate the consistency of informal settlements, updated within the last 5 years	y/n	Qualitative	Overarching	Understanding disaster risk governance	Analysis of the plan
If yes, which types of informal settlements have been recorded?	Types of informal settlements recorded	select one	Qualitative	Overarching	Understanding disaster risk governance	Analysis of the plan
What percentage of informal settlements has been recorded?	Percentage of informal settlements recorded	%	Quantitative	Overarching	Understanding disaster risk governance	Analysis of the plan
Does the city have maps to evaluate the consistency of green spaces, updated within the last 5 years?	Presence of maps to evaluate the consistency of green spaces, updated within the last 5 years	y/n	Qualitative	Overarching	Understanding disaster risk governance	Analysis of the plan
Does the city have maps to evaluate the consistency of open spaces, updated within the last 5 years?	Presence of maps to evaluate the consistency of open spaces, updated within the last 5 years	y/n	Qualitative	Overarching	Understanding disaster risk governance	Analysis of the plan
Does the city have lists of skills needed to face the identified risk scenarios?	Presence of lists of skills needed to face the identified risk scenarios	y/n	Qualitative	Overarching	Understanding disaster risk governance	Analysis of the plan and policies
If yes, which types of skills have been identified?	Types of skills identified	select one	Qualitative	Overarching	Understanding disaster risk governance	Analysis of the plan and policies
Does the city have maps to evaluate the percentage of high-risk urban areas where development is restricted or prohibited under planning guidelines?	Presence of maps to evaluate the percentage of high-risk urban areas where development is restricted or prohibited under planning guidelines	y/n	Qualitative	Overarching	Understanding disaster risk governance	Analysis of the plan and policies
Does the city have a catalogue of past hazard events?	Catalogue of past hazard events	y/n	Qualitative	Overarching	Understanding disaster risk governance	Analysis of the plan and policies
If yes, does the catalogue include the impact assessment for the past hazard events?	Presence of impact assessment for past hazard events	y/n	Qualitative	Overarching	Understanding disaster risk governance	Analysis of the plan and policies

comprehensive debate among experts from the start and during the entire process of the proposed methodology.

The number of programmes analysed to derive Good Practice indicators could be considered a potential limitation. However, the five frameworks considered cover different application scales and origins, including technical, political and research dimensions. The detailed analysis of these programmes early on revealed a considerable redundancy among the promising indicators, verifying the comprehensiveness of the collected information.

Experts involved as internal Stakeholders belong to the Italian context. This feature could represent a criticality. However, the Italian territory includes many different risks (volcanic, seismic, bradyseismic, land-slides, floodings, heat-waves, etc.) providing thus

expertise in a variety of multi-risk scenarios. Moreover, many Stakeholders involved in the WG have international experiences in DRR and DRM.

The diversity of internal Stakeholders constitutes an element of strength, providing varied perspectives including semantic gaps, based on which different scholars, in relation to their expertise, evaluate and interpret indicators differently. On the positive side, this fosters opportunities such as the shared understanding of fundamental semantic codes related to risk management issues and the mutual exchange of knowledge and skills.

So far, a useable tool for evaluating Practices in high-income countries has been produced, as well as a methodology that could allow to develop similar tools for other contexts.

The next step will envisage the "validation" phase involving internal and external Stakeholders in the project. This phase aims to achieve two main objectives: i) determine the relative importance of the identified promising indicators, and ii) specify the context in which each indicator is most relevant. Additionally, the aim will be to identify a subset of cross-cutting indicators standing as indicators of Good Practises independent of specific contexts, while acknowledging that others may be more relevant in specific contexts.

At this stage, it will be considered important to involve knowledge Stakeholders to assign a weight of relevance to each indicator. These weights will inherently reflect the role of the Stakeholders and their specific scientific expertise, as well as the types of hazard(s) they primarily study. To address the criticality of varying relevance attributed by knowledge Stakeholders to indicators, due their multidisciplinary perspectives, Multi-Criteria Analysis (MCA) methods may be employed.

5. Conclusions

This paper provides an innovative and flexible tool that will serve both scholars and public decision-makers to assess and eventually improve existing Practices, or design new ones, for multi-risk management in urban and metropolitan settlements.

This work also led to the proposal of an open and dynamic methodology, designed to implement indicators of Good Practices congruent with specific situations and application contexts. Possible future research advancements may focus on developing a Repository of Good Practices through open-science and open-access digital platforms, making it accessible and implementable in real time. This approach sets the stage for developing dynamic Guidelines for drafting Good Practices for multi-risk management, capable of evolving and adapting over time to respond to changing external conditions, potential increase of the impacts of hazards deriving from climate change, and the possible adjustment in land management policies across different context and scales of reference.

CRediT authorship contribution statement

Veronica Vitiello: Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Investigation, Formal analysis, Conceptualization. **Roberto Castelluccio:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Funding acquisition, Conceptualization. **Anna Maria Zaccaria:** Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Investigation, Funding acquisition, Conceptualization. **Antonino Rapicano:** Writing – original draft, Investigation, Formal analysis, Data curation. **Mariacarla Fraiese:** Writing – original draft, Investigation, Formal analysis, Data curation. **Eva Negri:** Writing – review & editing, Writing – original draft, Investigation, Funding acquisition. **Gloria Terenzi:** Writing – original draft, Investigation, Funding acquisition.

Funding

This study was carried out within the RETURN Extended Partnership and received funding from the European Union Next-GenerationEU (National Recovery and Resilience Plan – NRRP, Mission 4, Component 2, Investment 1.3 – D.D. 1243 2/8/2022, PE0000005).

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Roberto Castelluccio, Anna Maria Zaccaria, Eva Negri, Gloria Terenzi reports financial support was provided by European Union Next-GenerationEU. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

Data presented in this contribution represent the first results obtained by researchers of the Extended Partnership of the RETURN project, Spoke 5, WP2, Task 2.4. The work developed so far required constant comparison with the other scholars participating in the Task, whom the authors wish to thank here. Developing the set of indicators has already involved an important collaboration with the scholars of the same partnership working in Spoke 3. Based on the first methodological approach developed together, in future research development, both groups will jointly proceed with the field validation of the indicators and the application of MCA methods for the identification of the core set of Good Practice indicators for multi-risk management in urban and metropolitan settlements.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijdrr.2024.105069.

Data availability

Data will be made available on request.

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