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**Building an effective collaboration
between civil protection
decision-makers and scientists for DRR:
the Italian experience**

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Building an effective collaboration between civil protection decision-makers and scientists for DRR: the Italian experience

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Keywords: disaster risk reduction, scientific advice, policy making, Italy

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Introduction

Disaster Risk Reduction (DRR) is a task that our society is increasingly urged to address at all scales, from global to local (SFDRR, 2015). It is typically knowledge-based, knowledge having the role of enabling policy and practice to carry out informed decision-making and coordinated action (Weichselgartner and Pigeon, 2015).

The need to promote a more vigorous and continuous action of DRR raises from the observation that, in the last decades, despite the considerable amount of available scientific information and of actions already undertaken, disaster related losses are increasing almost all over the world, as brilliantly depicted by the title of the paper by White et al. (2001): “*knowing better and losing even more*”. This increase is due to many interlaced reasons. They include the increase of both the hazard, due for instance to climate change and to the multiplication of “Seveso” plants, and the vulnerability and exposure, e.g., related to a widespread and in some cases poorly governed urbanisation (see, among many others, GFDRR, 2016).

In particular, DRR related to risks that are managed by civil protection organizations relies on two fundamental pillars: technical decision-makers and scientists. Above them there are the political decision-makers, i.e., those who represent the political willingness and who support risk reduction activities according to choices that are in harmony with the electoral mandate (Dolce and Di Bucci, 2014).

The community of technical decision-makers manages the entire risk cycle, including prevention and preparedness, forecast, emergency and emergency overcoming, whereas the scientific community provides data, products, models, scientific information and advice as a qualified support for sound decision-making. Although their importance and role are well known and reciprocally acknowledged, how to effectively implement the interplay between them to achieve effective DRR is another matter (see, among many others, Cramer et al., 2018; DG-R&I, 2019; SAPEA, 2019).

Recent literature underlines how this interplay is becoming more and more important (e.g., Ranchod and Vas, 2019; Heikkila et al., 2020). For instance, according to Ismail-Zadeh et al. (2017), disaster science is progressively moving from single disciplinary research sectors, through a multidisciplinary approach, towards an interdisciplinary research. This path, however, still remains entirely within the scientific community. The envisaged final step envisaged, however, would be the implementation of a transdisciplinary, co-designed and co-produced research involving public bodies, business and civil society in the process.

This action-oriented research, co-produced with technical decision-makers, allows to move through the levels of understanding, i.e., from the facts and data, to the information, up to the knowledge, meant as an organized information that, once applied, becomes a shared wisdom (also see the so-called DIKW pyramid; Ackoff, 1989; Weichselgartner and Pigeon, 2015, among others).

In this perspective, the knowledge process requires intense collaboration between scientists and society, the latter including both politicians and the public, especially when scientists move from their research framework to the “*disaster advisory science*” (Donovan and Oppenheimer, 2016). However, when dealing with the interplay between science and policy-making for DRR, relevant gaps - epistemological, strategic, institutional - have been pointed out (Albris et al., 2020, with references), along with some proposals to bridge them (e.g., Gaillard and Mercer, 2012, among others). In many cases, these proposals focus on the need to complement the

top-down institutional approach with a bottom-up one (Amaratunga et al., 2018) and to use them together to pursue DRR, starting with risk assessment and establishing actions to be implemented based on a dialogue phase.

Within this general and theoretical framework, a concrete question remains in the need of an answer: how to build, in practice, an effective collaboration between civil protection decision-makers and scientists, in order to obtain an incisive and timely DRR? The aim of this paper is to provide this answer based on the experience at national scale made by the Italian system of civil protection, which has a long-lasting experience of relationships between science and decision making.

The relationship between science and civil protection decision-making characterises civil protection organizations, as well as risk and emergency management agencies, in many Countries.

For instance, in many European Countries these relationships may develop within committees and expert groups appointed by the national authorities responsible for civil protection. Some examples are provided by De Groeve and Casajus Valles (2015). A role is also often played by the National Platforms for DRR, which were issued after the Hyogo Framework and still operate under the Sendai Framework (HFA, 2005; SFDRR, 2015); often these National Platforms include representatives from public administrations and scientific institutions (<https://www.preventionweb.net/english/hyogo/national/list/?pid:23&pih:2>).

An overview on an international scale of some national systems of scientific advice can be found in a survey made by the European Commission (2015), where the presence of advisory councils, advisory committees, national academies and chief scientific advisors is mapped. In some cases, such as the United States, there is a formal agreement for cooperation and coordination of activities and programmes of mutual interest between the agency and the scientific institution dealing with DRR, namely FEMA and USGS (FEMA-USGS, 2016).

The relationship may be openly acknowledged, as in the case of New Zealand, where a section of the Guide to the National Civil Defense Emergency Management Plan is dedicated to science and research organizations (New Zealand Government, 2015), or may remain behind the writing of governmental documents, as with Spain's National Civil Protection Strategy (Spain Government, 2019), for which collaboration with university centres is simply mentioned in the document's preface.

In addition, the relationship can also provide support for the training of civil protection operators, as happens for example in Chile (<https://www.onemi.gov.cl/historia/>), where a Civil Protection Academy created by ONEMI (Oficina Nacional de Emergencia del Ministerio del Interior y Seguridad Pública) also uses courses organized by various universities.

Based on this brief overview, it is clear that the relationship between the scientific community and civil protection exists in many Countries and on a supranational scale, in different parts of the world. Nevertheless, it is not an easy collaboration, and criticalities may come to light (OECD, 2015).

In Italy, how to build an effective collaboration between civil protection decision-makers and scientists has been addressed and 'digested' for years, in particular referring to those risks that the law assigns to civil protection liability (Table 1).

Table 1. Risks of civil protection in Italy (Legislative Decree 1/2018, art. 16).

Body in charge	Risk
Types of risks for which the Italian civil protection system takes action.	seismic volcanic from tsunamis hydraulic hydrogeological from adverse weather phenomena from water deficit forest fires
Types of risks for which the responsible bodies are identified by specific laws. However, the action of the civil protection system can also be carried out for these ones.	chemical nuclear radiological technological industrial transport environmental health uncontrolled re-entry of objects and space debris

DRR for these risks falls within the civil protection function. This function is not limited to emergency management, but includes also risk forecasting and prevention activities. The latter continually need to be further developed and updated, also due to technological evolution and advances of scientific knowledge. Finally, the civil protection function also includes the phase of emergency overcoming, understood as the restoration of normal living conditions for the populations and territories affected by a disaster (for a general overview, see Dolce et al., 2020).

The civil protection system is multilevel and has responsibilities in a wide range of fields. The system is coordinated by the Civil Protection Department, which is part of the Prime Minister's Office. Legislative Decree 1/2018 - Civil Protection Code, which is the law that currently regulates the Italian civil protection system (namely, the National Civil Protection Service, NCPS), clearly identifies the subjects that make up the system. It distinguishes them into Components – i.e., State, Regions and Autonomous Provinces, local Authorities –, Operational Structures – i.e., Firefighters, National Health Service, civil protection Volunteers, etc. – and Contributing Subjects – professional orders, public and private companies, etc. The scientific community is explicitly mentioned among the Operational Structures.

This paper aims at showing how an effective collaboration between the two communities of civil protection decision-makers and scientists has been built in this context, maintained and updated over the years and decades in Italy, having the DRR as a common goal. As will be shown in section 2 and discussed in section 4, this collaboration has benefited from the presence of so-called hybrid experts, civil servants operating at the interface between the two communities.

The experience here discussed or parts of it, providing ideas and food for thoughts, may be useful as a good practice to share with or be of inspiration to academics, policy makers and practitioners in other Countries and international Institutions who are working to address similar challenges to achieve the same goal in the coming years (section 3).

Science-Civil Protection Relationship in Italy

In Italy, the relationship between Science and Civil Protection is a long lasting one. It formally dates back to 1992 (subsection 2.1), when the first civil protection law was issued, assigning a role to scientific institutions. It continues today under a new law, which came into force in 2018. The complex and multifaceted interaction currently taking place has developed within this regulatory framework (subsection 2.2), facilitated by the interface role played by hybrid experts (subsection 2.3).

Science-Civil Protection, a relationship issued by law

The collaboration between science and civil protection in Italy dates back to 1976, in the aftermath of the Friuli earthquake. The formal relationship between the scientific community and the Italian NCPS, a system of which scientists are de facto part, was then enshrined in the Law 225/1992. In that law, technical-scientific bodies and research institutions were included among the national operational structures of the NCPS, and the "*Commission for the forecasting and prevention of major risks*" (in short, the so-called Major Risks Commission) was established for the first time. It was considered, and still is, the technical-scientific advisory body of the Civil Protection Department for all the civil protection activities aimed at forecasting and preventing the various risk hypotheses (Legislative Decree 1/2018, art. 20).

In the current Civil Protection Code, several articles are dedicated to the scientific community. On the one hand, this focus of the law represents the recognition of the important role the scientific community plays in civil protection activities. On the other hand, it expresses the need to better regulate this role in a context that has seen the question of responsibilities and their correct attribution to the various actors of the civil protection system increasingly emerge, over the years and at both international and national level.

It should be noted that the role played by the law is not only formal. The law shapes the collaboration between scientists and civil protection decision-makers in a very practical way, because all the contributions described in the boxes from (i) to (vi) in Figure 1 are managed according to the Civil Protection Code. A few examples below may help to go into more detail.

Among the contents of the Code, some excerpts deserve some comments. In defining the role of the scientific community, it is specified that it "*participates in the National Service through the integration in the activities of civil protection [...] of knowledge and products resulting from research and innovation, also already available, which have reached a level of maturity and consensus recognised by the scientific community according to the practices in use, also as a result of initiatives promoted by the European Union and International Organisations also in the field of research for protection against natural disasters*" (Legislative Decree 1/2018, art. 19; all the excerpts from the Italian laws quoted in the text have been translated by the authors).

This part of the law takes into account the fact that in the dialectic of scientific research the development of different hypotheses is intrinsic. The development of a hypothesis, according to the scientific method (or Galilean method), is part of a series of steps that include observing a phenomenon and/or formulating a research question, developing a hypothesis to explain it, predicting some consequences of this hypothesis, constructing an experiment or collecting information in a natural laboratory about the predicted consequences, analysing the results to test the hypothesis and, finally (it may take many iterations), falsifying it. Therefore, according to the Code, a scientific product must undergo a complete verification process by various

scholars and research groups, before becoming a consolidated scientific asset (which, however, over the years will be destined to show its limits and possibly be abandoned). The underlying concept is to base civil protection activities on this type of knowledge and products. In this way, one does not have to deal with the results of a single researcher, because it would be easy to find contrary or different results produced by other researchers.

An example of a consensus reached within a broad scientific community on a product of interest for civil protection is the Italian national seismic risk model, included in the National Risk Assessment submitted to the European Commission in 2018 (ICPD, 2018). The model, which is based on the seismic hazard model adopted in the National Building Code (NTC, 2018), was developed by a large community of engineers, involving most universities and research institutes with expertise in seismic risk (Dolce et al., 2020). Based on different sets of fragility curves, it puts together four risk models for residential masonry building stock and two models for residential reinforced concrete building stock. These six models were produced by different research groups and were integrated in the final model following an ensemble approach.

It should be noted that the Code does not intervene in an area that does not fall within its remit, namely that of defining who and how to determine whether or not the knowledge and products of research and innovation have reached the necessary maturity and consensus. This task is left to the scientific community, which has the competence and the right to do so. Finally, with a view to the efficiency and effectiveness of public administration action and the optimization of resources, it is also suggested that qualified knowledge already developed, and therefore funded, at European and international level be drawn on.

The Code defines the activities through which the participation of the scientific community in the NCPS is achieved. Four types of activities are identified:

“(a) routine and operational activities [...] which include, inter alia, monitoring and surveillance of events, development of databases and any other activity useful for emergency management and risk forecast and prevention which provides products of immediate use;

(b) experimental activities preparatory to the activities referred to in point a), as well as the production of scientific contributions and the synthesis of existing research useful to this end;

(c) targeted research preparatory to the development of products useful for risk management [...] and the study of the related scenarios;

d) collaboration in the preparation of technical regulations of interest”
(Legislative Decree 1/2018, art. 19).

This organisation implements a practice already in use in civil protection for more than a decade, which aims to channel scientific activities of interest to civil protection into a path that leads to concrete results and products. This path starts with targeted research (point c) and, through a phase of experimentation, testing and procedural refinement (point b), arrives at full operation (point a).

One example of this path is the national seismic tsunami warning system for the Italian coasts (SiAM—Sistema di Allertamento da Maremoti), which has been operating since January 2017 (<http://www.protezionecivile.gov.it/en/risk-activities/tsunami-risk/activities>). The system consists of two Competence Centres (see subsection 2.2), namely the National Institute of

Geophysics and Volcanology and the Italian Institute for Environmental Protection and Research, and the Civil Protection Department. Currently, this activity is part of those described in point a above, but it started as applied research (i.e., point c), and then underwent a long period of test and refinement (i.e., point b), before becoming fully operational (Dolce and Di Bucci, 2015; Selva et al., in press).

In addition, the technical-scientific contribution to the drafting of regulatory acts (point d), which has often been provided by the scientific community within a broader framework of loyal cooperation between public administrations, is made explicit. One example of this type of support can be found in the definition of the so-called red and yellow zones on which the national civil protection plans for the volcanoes of Vesuvius and Flegrean Fields are based. The identification of these zones was based on documents drawn up by specially established scientific working groups (http://www.protezionecivile.gov.it/media-comunicazione/dossier/dettaglio/-/asset_publisher/default/content/aggiornamento-del-piano-nazionale-di-emergenza-per-il-vesuvio; http://www.protezionecivile.gov.it/media-comunicazione/dossier/dettaglio/-/asset_publisher/default/content/aggiornamento-del-piano-nazionale-di-emergenza-per-i-campi-flegrei).

In this general context, the regulatory framework represented by the Code also defines the characteristics of the Competence Centres, which have gradually joined the civil protection system since 2004.

Competence Centres and other kinds of collaboration

The Italian Prime Minister's Directive of 27/02/2004 (art. 3) defined for the first time the "*Competence Centres as those entities that provide services, information, data, processing and technical-scientific contributions in specific fields*". In 2012 (Prime Minister's Decree of 14/09/2012), the principles for their identification were better established, focusing in particular on those bodies that have specific or exclusive technical and scientific knowledge, including Universities and Research Centres.

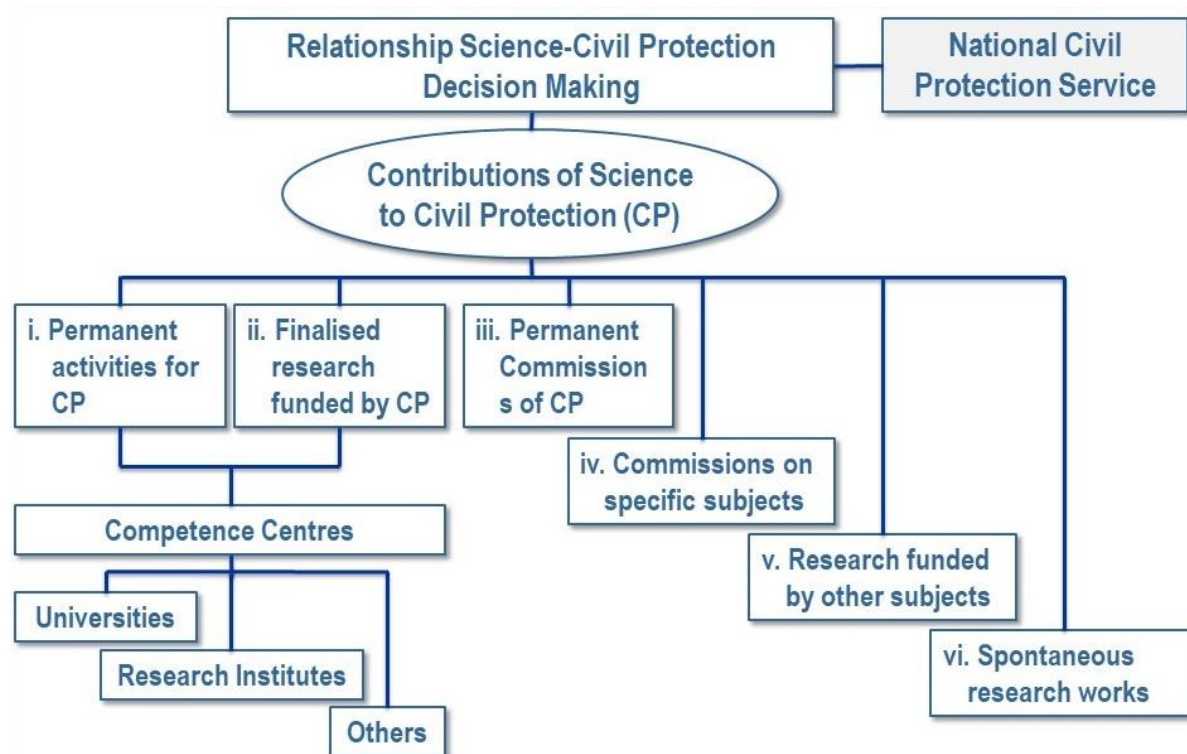
In the Code currently in force, the definition of Competence Centres is proposed in a way that is less focused on the exclusivity of the know-how of the entities and more directed towards the type of knowledge and products they are able to provide. In particular, it is established that "*research bodies and institutes, consortia and university structures that own and make available knowledge and provide products resulting from research and innovation activities, which can be integrated in civil protection activities, can be identified as Competence Centres*" (Legislative Decree 1/2018, art. 21). In this context, emphasis is placed on the possibility of establishing '*networks of Competence Centres for the development of specific topics on integrated themes and in a multi-risk perspective*' (Legislative Decree 1/2018, art. 21).

One example of these networks is the Italian Center for Research on Risk Reduction (CI3R; <https://www.ci3r.it/en/home-english/>). It is a stable consortium established under the aegis of the Civil Protection Department and formed by research institutes and centers, all of which are Competence Centres. It aims to create a network of multidisciplinary competences to carry out prevention and preparedness activities for civil protection and, more generally, towards disaster risk reduction with a multi-risk, multi-sectoral and systemic approach.

To complete the analysis of the relationship between science and civil protection, it is worth remembering that interactions do not only take place between civil protection decision-makers and the Competence Centres and Major Risks Commission. The possible interactions are

much more articulated (Fig. 1), also including contexts that may be differently formalised, or even completely non-formalised. *Ad hoc* national and international commissions (e.g., Jordan et al., 2011) can be set up to address specific civil protection issues. In addition, there are frequent exchanges with groups of scholars engaged in research on topics of interest that have, however, been funded in areas other than the civil protection system, such as international and European projects (e.g., TSUMAPS - Basili et al., 2020; SERA - <http://www.sera-eu.org/en/home/>; BuildERS - <https://buildersproject.eu/>; EFLIP - <https://www.eflip-project.org/>), ministerial research funding (e.g., Antoncecchi et al., 2020), private foundations (e.g., Global Earthquake Model - <https://www.globalquakemodel.org/>). Exchanges may also take place with individual researchers who, benefiting from ordinary research funds, are independently engaged in studies with potential civil protection implications. As we will see in section 2.3, in many cases the Civil Protection Department has its own representatives in stakeholder and end-user groups or in advisory boards of research projects funded by the European Commission, or alongside public administrations dealing with scientific topics where the competence on risks is partly shared with the civil protection system.

Figure 1. Chart of ways in which scientific communities can contribute to DRR civil protection activities (modified from Dolce and Di Bucci, 2015).



Lively dialectics and dynamic relationship, with the related difficulties, are intrinsic in the interaction between science and civil protection decision-making and have already been widely analysed (Dolce and Di Bucci, 2014). In short, these two points of view, while looking at shared issues, require continuous adjustments towards a common balance point, as well as an agreement on the responsibility of each of the two parties, which implies respect for roles.

Given the complexity of the subject, there is no doubt that, in many cases, it is difficult to keep the contribution of scientists totally separate from that of decision-makers, both technical and political, because the decision-making process is necessarily fuelled by interactions and feedback between the two parties. These interactions concern, on the one hand, the needs of the decision-makers and, on the other hand, limitations in the possibility of scientists to realise their demands, including the correct assessment of uncertainties related to the scientific information provided. Distortions may occur in the interpretation of individual roles, and thus in the assumption of responsibility; this is particularly the case if scientists or decision-makers do not or cannot perform their task, or if, for various reasons, they exceed the limits of their role (Dolce and Di Bucci, 2015). By way of example, scientists may provide non-quantitative assessments, or fail to provide the necessary scientific support in cost-benefit analyses, or advise on civil protection actions for which they do not have the full information framework and expertise. On the other hand, political decision-makers often neglect to establish or make explicit the level of risk acceptable for the community they represent. For instance, during the COVID-19 pandemic, what was the accepted balance between casualties and economic losses was not publicly explained by the relevant Authorities. Sometimes political decision-makers prefer to state the need for a zero-risk solution (which is effectively a non-decision), while avoiding allocating an adequate budget for effective risk mitigation. Finally, technical decision-makers may tend (or be forced, under emergency conditions) to make and implement decisions that are not their responsibility. This may be the case, for example, if there is a lack of quantitative scientific assessments, a lack of definition of acceptable risk, or a lack of budget to carry out a given action.

Including hybrid experts in a public administration

One ‘tool’ that has proved to be effective for the interaction between the civil protection decision-making level and the scientific community is the so-called ‘hybrid expert’. Hybrid experts are civil servants who have a solid expertise in both research and public administration and are able to understand and use the language of the two fields. Their expertise is recognised by both the scientific and the decision-making communities, and they are therefore called upon to play an interface role, being able to link the demands, expectations and (often short) timescales of decision-makers and the data, information, uncertainties and (longer) timescales of scientists. Therefore, their activity can significantly contribute to increasing the overall knowledge of scientists and decision makers towards a better DRR strategy.

In Italian civil protection, there is a long tradition of hybrid experts who facilitate the interaction between decision-makers (political and technical) and national and international scientific institutions (Competence Centres, Major Risks Commission, etc., and EU Joint Research Centre, participants in European projects, etc., respectively) for the definition of civil protection policies and decisions.

An overview of the roles played by various hybrid experts in the Italian Civil Protection over the last three decades is summarised in Table 2. Over the years, these roles have included top positions in the civil protection system, participation in scientific groups and projects, definition and management of scientific activities financed by the Civil Protection Department and carried out by its Competence Centres. Among the hybrid experts, there are qualified scientists whose research activities have been carried out in close contact with civil protection and who, at some point, have taken on a managerial role in a civil protection organisation.

Table 2. Presence and role of hybrid experts in the Italian Civil Protection Department over the last three decades.

Hybrid experts in the Italian Civil Protection Department	Role
Governmental level	Full Professor (with scientific expertise) serving as Minister or Undersecretary for the Coordination of Civil Protection <hr/> Full Professor (with scientific expertise) serving as Head of the Civil Protection Department <hr/> Full Professor (with scientific expertise) serving as Deputy Head of the Civil Protection Department <hr/> Full Professor (with scientific expertise) serving as Director General of the Civil Protection Department <hr/> Research Manager (with scientific expertise) serving as Director General of the Civil Protection Department <hr/> Civil Protection Department Civil Servant (with scientific expertise) representing the Department in the relationships with Competence Centres
Major Risks Commission	High level Decision-Maker (with Public Administration expertise) serving as Deputy Head of the Major Risks Commission
Technical scientific committees	High level Decision-Maker (with technical and public administration expertise) serving as Coordinator of Technical Scientific Committee
At international level	Civil Protection Department Directors and Civil Servants (with scientific expertise) representing the Department in the relationships with EU (working groups, etc.) <hr/> Civil Protection Department Directors and Civil Servants (with scientific expertise) representing the Department in the relationships with International bodies, such as UN, WMO, etc. (working groups, etc.) <hr/> Civil Protection Department Directors and Civil Servants (with scientific expertise) representing the Department in EU research projects (Horizon 2020, etc.) <hr/> Civil Protection Department Directors and Civil Servants (with scientific expertise) managing research units in EU projects

As always, there are pros and cons, for an administration, in having its own hybrid experts. On the one hand, this allows a primary result to be achieved, i.e., an effective orientation of the activities of research institutions' towards topics of interest for civil protection and the full exploitation of the latest and most consolidated scientific advances. On the other hand, this might imply a certain amount of interference in scientific matters by a non-scientific public administration, albeit without undermining the independence of scientific advice. This latter aspect might induce a public administration to give up the interface action carried out by hybrid experts in order to keep scientific advice and decision-making separate and, consequently, also to achieve a clear separation of responsibilities. One solution sometimes adopted in these cases is to delegate the interface role to specially established scientific committees. Unfortunately, the scientists who form these committees do not usually have civil protection or public administration skills. Moreover, in this way, the public administration with civil protection tasks completely loses its role of guidance and coordination (which in Italy is assigned to it by law), all the more so in the case of activities that are within its competence and interest, and which it finances.

Challenges posed by disaster risks and DRR in the coming years

One can take 2030 as a target date, in line with the Sendai Framework and the Sustainable Development Goals (SFDRR, 2015; A/RES/70/1, 2015). From a civil protection point of view, there are many challenges related to DRR in this timeframe, and they need to be addressed in the global perspective of climate change, green deal and urbanisation.

While it is quite undisputed that scientific community and civil protection decision-makers will move from single risk to multi-hazard risk assessments and evolutionary scenarios, it is less clear how this approach can scale from local to global while providing at all scales results that are useful, usable and used (Aitsi-Selmi et al., 2016).

As an example, the integration of social vulnerability and social exposure in the classical risk analysis can be considered, where vulnerability is generally referred to the physical vulnerability of buildings and infrastructures, while population exposure is limited to census information on people living in the analysed area. How to measure social vulnerability, how to include it in quantitative risk models, how to assess related uncertainties? Some good examples of possible indicators, for instance related to earthquakes, are already available (e.g., see the Global Earthquake Model: <https://storage.globalquakemodel.org/what/physical-integrated-risk/socio-economic-vulnerability/>), but widespread implementation of quantitative assessments of social vulnerability in models of other risks is still limited.

The characterisation of social vulnerability is also relevant to support emergency management, especially in the definition of civil protection plans. Knowing the presence and distribution of vulnerable individuals and groups allows civil protection authorities and the groups themselves to be prepared in advance and, in the event of a disaster, to strongly mitigate its consequences.

In turn, social vulnerability is deeply intertwined with the problem of how to communicate information on civil protection risks to vulnerable groups, both in ordinary time and during emergencies, i.e., with the question of how to make the best use of the innovative technologies that are already in place and will be increasingly powerful and available in the coming years.

Scientific data and papers, civil protection documents, emergency plans and risk models in a GIS environment, as well as real-time information via short messages, all this will be at everyone's fingertips via our smartphones and tablets. But will scientists and civil protection decision-makers be able to communicate properly with the lay people? And will the lay people understand correctly what the scientists and authorities mean and want to say?

About this, a field of research that is gaining ground in the world of civil protection is that of behavioural science, which have been progressively developed by scholars (Allais, Edwards, Fischhoff, Kahneman, Slovic and Tversky, among many others) on the borderline between economics, psychology and sociology. Their aim has been to investigate and explain certain observed 'anomalies' concerning human choices, in other words the decision-making process, compared to the behavior expected according to the classical economic models. These models assume a rational theoretical agent (Kahneman 2011), later called "homo economicus" (Thaler and Sunstein 2008, and references therein), whose behaviour is, however, very different from that observed in humans. The latter is, in fact, affected by heuristic principles that transform the complexity that characterises the estimation of probabilities and the prediction of numerical values into an easier evaluation of judgement.

Usually these heuristics work well, but there are some cases in which they can lead to serious and systematic errors, called biases (e.g., Tversky and Kahneman, 1974). These predominantly unconscious mechanisms affect the decision process, and knowing them is important in civil protection decision-making, both in ordinary and in emergency conditions (Di Bucci and Savadori, 2018).

Scientists with this expertise are already making a valuable scientific contribution to risk communication for civil protection purposes, and are expected to do so even more in the coming years. For example, over several years, some officials in the Italian Civil Protection Department, with expertise in subjects such as communication sciences but also with more technical profiles (architects, engineers, geologists), have specialised in this discipline.

This mix of expertise has gradually brought the culture of behavioural sciences into civil protection practice in relation to the whole risk cycle management. It also enabled a better understanding of the critical issues between civil protection, science and society, such as what happened in the so-called L'Aquila Trial (Di Bucci et al., 2019 and references therein).

Collaborations and activities that have benefited from behavioural sciences have developed under the umbrella of a memorandum of understanding between the Presidency of the Council of Ministers (of which the Civil Protection Department is part) and the National School of Administration. In this framework, experimental analyses are being carried out, e.g. for the correct communication of hazard and risk models through websites managed by Competence Centres (concerning, for example, seismic hazard and risk, respectively: new CPS-INGV website about to open; SICURO+ website <https://www.sicuropiu.it/index.xhtml>, Dolce et al. 2019).

From a broader perspective, the contribution of science and the interaction with civil protection are also foreseen in the European regulation. Art. 13 of the DECISION 1313/2013/EU provided that *"The Commission shall, within the Union Mechanism [...], set up and manage a training network open to training centres for civil protection and emergency management personnel as well as other relevant actors and institutions on prevention of, preparedness for and response to disasters. [...]."*

The training network shall aim to: [...], create synergies among its members through exchange of experience and best practices, relevant research, lessons learnt, courses and workshops, exercises and pilot projects". Few years later, DECISION (EU) 420/2019 amended art. 13 above by introducing the Union Civil Protection Knowledge Network, which is *"a network of relevant civil protection and disaster management actors and institutions, including centres of excellence, universities and researchers [...], together with the Commission"*.

The European Commission with its Directorates is making huge efforts to build this Knowledge Network, involving all the different stakeholders. The challenge, from the point of view of this paper, is how the Member States of Europe can face the challenge of contributing to this community by balancing their needs with those of a common civil protection house. And this is even more challenging if one considers European civil protection as being involved not only in supranational emergencies, but also and above all in all phases of the risk cycle, in particular prevention and preparedness.

What is Italian civil protection doing about this? Two new initiatives deserve to be mentioned. The first is an attempt to establish a mixed community of scientists and risk management experts and to make a European 'Doctrine on disaster risk and crisis management', also leveraging on the cooperation occurring within the above said mixed community. This activity

is taking place within the framework of a European project called “ROADMAP” (EuRoPeAn ObservAtory on Disaster risk and crisis MAnagement best Practices; <https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/how-to-participate/org-details/999999999/project/101017776/program/31082527/details>), funded by DG-ECHO. The term doctrine is understood as ‘a shared understanding of disaster management among decision-makers and scientific actors’.

The second initiative is now taking its first steps, and concerns the desire to build a high-profile academic course in Italy to train professionals with skills in disaster risk reduction and management and civil protection. To achieve this goal, the Italian Civil Protection Department is working with the Conference of Italian University Rectors on how to introduce and enhance civil protection disciplines and degree courses into Italian university curricula.

Discussion

In light of the challenges that the future holds for DRR, one may wonder whether the approach described above will still be valid and applicable in Italy (4.1) and, in general terms of ideas and input, in other Countries as well (4.2), for a more fertile relationship between science and decision making in DRR.

Applicability of the current model in Italy in the coming years

The way in which the joint activity of scientists and decision-makers in the Italian civil protection has been built shows strengths and weaknesses. The major strength, in the authors’ opinion, is the full and daily involvement of the scientific community in every phase of disaster risk management, side by side with civil protection decision-makers, helped by the hinge role played by hybrid experts. This allows civil protection decision-makers to make decisions based on the best available science over the entire risk cycle and, when necessary, quickly. In short, the system works.

There are however also some weaknesses, which need to be managed. Two, in particular, are worth commenting on.

The first one is related to the increasing complexity of risk management and its multi-hazard risk dimension, including Na-Tech and cascading effects. This complexity needs specific skills developed in advance, before an emergency occurs. From the scientists point of view, specialists in different hazards and risks, disciplines and sectors, have to share and adapt their deep knowledge in their own scientific field and collaborate for a common goal that goes beyond their usual interest. They are, however, more used to and feel more comfortable working within their own scientific silos, where their research or academic careers have developed or are progressing. In order to obtain this multi-hazard risk knowledge and have it available for civil protection purposes in a transdisciplinary approach, a solution envisaged in Italy is based on the establishment of a consortium of several Competence Centres (CI3R, described in the previous section) with different expertise and knowledge of the risks, and on a close and continuous collaboration between the consortium and the Civil Protection Department. This collaboration is in its infancy, but is also benefiting from partnerships within the framework of European projects focusing on civil protection, such as the aforementioned ROADMAP Project.

The second weakness stems from the very nature of civil protection coordination in Italy, which is in the hands of the Prime Minister, who performs it through the Civil Protection Department.

Therefore, as far as the scientific aspects are concerned, coordination has often developed according to a top-down approach. As seen in the Introduction, according to the most recent vision on the topic (e.g., SFDRR, 2015), this approach could be improved with a greater use of the bottom-up approach, including local knowledge in DRR (e.g., Mercer et al., 2009; UN-DRR, 2009; Hiwasaki et al., 2014), and making decisions shared with -and therefore accepted by- the population. European and Italian laws, which are based on the principle of subsidiarity, support this development. However, its practical implementation is not an easy task. Scientific institutions are contributing to this structural change by supporting the Civil Protection Department in specific initiatives. For instance, some examples of participated civil protection planning on a municipality scale are already available (https://www.lifefranca.eu/wp-content/uploads/2019/10/15_Participatory-process-for-Civil-Protection-planning.pdf). In addition, during emergencies, scientists from Competence Centres are regularly on site in the crisis area to explain what happened and is happening and to provide scientific information that forms the basis for emergency decisions made by local and national authorities (e.g., Camassi et al., 2014; <http://www.protezionecivile.gov.it/-/attivita-di-informazione-alla-popolazione>; <https://ingvterremoti.com/2014/01/20/terremoto-parliamone-insieme-attivita-di-informazione-alla-popolazione-dellumbria/>).

Finally, in this bottom-up approach a fundamental role is played, and will be much more so in the future, by voluntary organizations, which are an important reality in the Italian civil protection scene. Volunteers can effectively participate in the activities carried out by scientists and decision-makers, being able to establish an effective two-way interaction with citizens. On the one hand, they can support the development of risk awareness and civil protection culture through direct contact with the population. An example of this activity is represented, in Italy, by the communication campaign “I don’t take risks” (<http://iononrischio.protezionecivile.it/en/dont-take-risks/>). Through a storytelling-oriented mode, civil protection volunteers, suitably trained in a virtuous cascading process, have the task of meeting citizens, informing them about the risks to which they are potentially exposed and sensitising them to a self-protection approach. Moreover, the campaign contents are conceived and elaborated with the help of the scientific community, involving the Competence Centers. On the other hand, volunteers can also foster a bottom-up approach in the scientific field by supporting local data collection. An example of this so-called citizen science concerns the involvement of civil protection volunteers for rapid assessment of earthquake impacts (e.g., Sandron et al., 2021).

Applicability of the Italian model in other Countries

Every Country has its own uniqueness in the field of civil protection, made up of specific institutional organization and regulatory framework, socio-cultural environment, and types of risk to be managed. For instance, as can be seen from Table 1, in Italy civil protection does not deal with cyber-risk or terrorism. In addition, there are some risks that are ordinarily managed by institutions other than civil protection (for example, the health risk, which is dealt with by the Ministry of Health), but on which the civil protection system can intervene in the event of an emergency of national importance, such as the COVID-19 pandemic. Finally, in Italy it is the Prime Minister who is in charge of the civil protection function, and coordinates the whole system (the NCPS) through the Civil Protection Department and with regard to the whole risk management cycle.

In other Countries civil protection is often organized differently, risks and priorities of interest may vary and, in some cases, the emergency is under the responsibility of a different administration from the one in charge of prevention.

Being aware of this, in the authors' opinion, there is no civil protection model that is valid for all Countries. However, some ideas and solutions adopted in Italy could represent a good input for other Countries to make their relationship between science and decision-making in DRR more effective and fruitful. Moreover, some of the solutions described, suitably adapted, could also provide food for thought for European and international bodies working on DRR.

First of all, it can be considered good practice that scientific participation and the contribution of the scientific community to the civil protection system and activities are regulated by law. This makes roles and responsibilities clear, and defines the scope and manner of collaboration.

Secondly, another solution that can be considered effective is for the scientific community to be formally part of the civil protection system. In the case of Italy, this inclusion is achieved mainly through collaboration with the Civil Protection Department, which fosters daily interaction with the scientific community on issues related to the entire risk cycle. Moreover, also some Regions have developed fruitful collaborations with universities and research institutes. The relationship has evolved over time thanks to an ever close connection and cooperation, which eventually leads to a co-production of knowledge. On the one hand, this allows the scientific community to better understand the needs and demands of civil protection. On the other, the civil protection world can better understand what answers the scientific community can actually provide to the complex demand for interpretation, modelling and simulation of reality and forecasting of events (Di Bucci and Dolce, 2019).

Thirdly, the cross-fertilization between STEM (Science, Technology, Engineering and Mathematics) disciplines and social sciences, in particular behavioural sciences, can be an important step forward for civil protection systems.

Finally, good practice can be recognized in the presence of hybrid experts in the civil protection system and the role they play in the interface between the scientific community and decision-makers for the purposes of DRR.

In this collaboration between scientists and civil protection decision makers, however, there may be some pitfalls that deserve to be pointed out.

A first pitfall could lie in the way scientists are selected. Having few individual scientific advisors, even if they are renowned and have high-profile expertise, could provide the civil

protection system with specific points of view that are perhaps different from those that other high-profile scientists could provide. How, then, should scientific advisors be selected? The adopted solution is two-folded. One option is day-to-day collaboration with research institutes, i.e., the aforementioned Competence Centres, rather than with individual researchers. The other option is the establishment of permanent or ad hoc scientific commissions and working groups, as seen in the previous sections. In practice, the choice has been made to use a plurality of experts working together and thus providing a concise and shared view of the problem at hand from the outset.

A second pitfall could be the level of scientific acceptance of the research products on which civil protection relies to make decisions. How should these products be selected? As seen in section 2.1, in Italy the solution is provided by the Civil Protection Code, which indicates the quality required for scientific results and products to be usable by civil protection. Proper compliance with the law, however, is quite difficult if one is not sufficiently familiar with the scientific world, which is why hybrid experts can be effective for this purpose. In this perspective, the background of these experts is relevant. They could be either civil protection officers with a scientific profile, or researchers working in scientific institutions (universities or research institutes) temporarily employed in civil protection bodies. In the latter case, it is important that these hybrid experts coming from the scientific world are able to fully identify themselves with the role of the civil servant, in order to adopt an objective attitude towards the scientific knowledge and products on the basis of which decisions have to be made.

Conclusion

The complexity of nature and of natural phenomena that can produce catastrophic consequences, together with the growing complexity of the anthropized world and of human behaviour, make civil protection actions and the decision-making processes underlying them increasingly difficult. For this reason, for about forty years the world of civil protection in Italy has been trying to operate using the best science for its decisions and actions, thanks to a close collaboration with the world of research. This collaboration is also very effective in building mutual trust between the scientific and decision-making communities, an achievement that is important to emphasise.

It is clear that, faced with the need to carry out prevention and preparedness actions, as well as to manage emergencies and their overcoming, the request of the civil protection world is to have answers from the scientific world that are as certain as possible about what could happen, in order to make the best possible decisions. Unfortunately, all the necessary information is characterised by a great deal of uncertainty, which is increased by imperfect knowledge of the real world and awareness of all those aspects that may affect adequate modelling for forecasting purposes. For this reason, civil protection decisions and actions must necessarily take into account the ineradicable uncertainties that are part of the models and their results.

On the one hand, the scientific world is working to reduce the uncertainties of scientific evaluation, which is a difficult task to achieve. On the other hand, the inevitable uncertainty of scientific evaluations must be included in a decision-making process whose outcome does not admit of 'probabilistic nuances', because it must lead to a choice between two, or at most a few, completely different alternatives.

In this process, it is essential that scientific community and civil protection decision-makers together can refer to general principles of a purely political nature, such as the definition of acceptable risk, which can be translated into specific operational criteria for each situation under consideration.

These criteria, together with civil protection procedures, must be shared with the political level and the whole community in a participatory process that also takes account of uncertainties, recognising that they must combine choices that should be predefined in peacetime. At the same time, they must be flexible enough to adapt to unforeseen developments of events during crisis management. Unfortunately, this is difficult to achieve and often impossible, due to the variety of sometimes unpredictable or even unimaginable situations that may arise. It is in these cases, which are unfortunately more frequent than one might think, that the necessary close cooperation between science and civil protection can prove most difficult, and it is precisely these cases in which, however, such collaboration is essential.

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Cited references

- A/RES/70/1 (2015) - Transforming our world: the 2030 Agenda for Sustainable Development. Resolution adopted by the General Assembly on 25 September 2015. https://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E
- Ackoff R. (1989) - From Data to Wisdom. *Journal of Applied Systems Analysis*, 16, 3–9.
- Aitsi-Selmi A., Blanchard K., Murray V. (2016) - Ensuring science is useful, usable and used in global disaster risk reduction and sustainable development: a view through the Sendai framework lens. *PALGRAVE COMMUNICATIONS* | 2:16016 | DOI:10.1057/palcomms.2016.16
- Albris K., Cedervall Lauta K., Raju E. (2020) - Disaster Knowledge Gaps: Exploring the Interface Between Science and Policy for Disaster Risk Reduction in Europe. *Int J Disaster Risk Sci*, 11, 1–12. www.ijdrs.com, <https://doi.org/10.1007/s13753-020-00250-5>
- Amaratunga D., Malalgoda C., Haigh R., Panda A., Rahayu H. (2018) - Sound Practices of Disaster Risk Reduction at Local Level. *Procedia Engineering*, 212, 1163–1170.
- Antoncecchi I., Ciccone F., Dialuce G., Grandi S., Terlizzone F., Di Bucci D., Dolce M., Argnani A., Mercorella A., Pellegrini C., Rovere M., Armigliato A., Pagnoni, G., Paparo M.A., Tinti, S., Zaniboni F., Basili R., Cavallaro D., Coltelli M., Firetto Carlino M., Lipparini L., Lorito S., Maesano F.E., Romano F., Scarfi L., Tiberti M.M., Volpe M., Fedorik J., Toscani G., Borzi B., Faravelli M., Bozzoni F., Pascale V., Quaroni D., Germagnoli F., Belliazzi S., Del Zoppo M., Di Ludovico M., Lignola G.P., Protà A. (2020) - Progetto SPOT - Sismicità Potenzialmente inescapabile Offshore e Tsunami. Report integrato di fine progetto. 44 p. DOI: 10.5281/zenodo.3732887 - ISBN: 9788894366945
- Basili R., Brizuela B., Herrero A., Iqbal S., Lorito S., Maesano F.E., Murphy S., Perfetti P., Romano F., Scala A., Selva J., Taroni M., Tiberti M.M., Thio H.K., Tonini R., Volpe M., Glimsdal S., Harbitz C.B., Løvholt F., Baptista M.A., Carrilho F., Matias L.M., Omira R., Babeyko A., Hoechner A., Gürbüz M., Pekcan O., Yalçiner A., Canals M., Lastras G., Agalos A., Papadopoulos G., Triantafyllou I., Benchechroun S., Agrebi Jaouadi H., Ben Abdallah S., Bouallegue A., Hamdi H., Oueslati F., Amato A., Armigliato A., Behrens J., Davies G., Di Bucci D., Dolce M., Geist E., Gonzalez Vida J.M., González M., Macías Sánchez J., Meletti C., Ozer Sozdinler C., Pagani M., Parsons T., Polet J., Power W., Sørensen M., Zaytsev A. (2020) - The making of the NEAM Tsunami Hazard Model 2018 (NEAMTHM18). *Frontiers in Earth Science. Section Geohazards and Georisks. Research Topic: From Tsunami Science to Hazard and Risk Assessment: Methods and Models.* doi: 10.3389/feart.2020.616594
- Camassi R., Nostro C., Bernardini F., Crescimbene M., Ercolani E., La Longa F., Meletti C., Pessina V., Pignone M. (2014) - Le attività informative dell'INGV in emergenza sismica: motivazioni e ipotesi di sviluppo futuro. *Proceedings GNGTS National Meeting.* <http://www3.ogs.trieste.it/gngts/files/2014/S23/Riassunti/Camassi.pdf>
- Cramer L., Thornton P., Dinesh D., Jat M.L., Khatri Chhetri A., Laderach P., Martinez Barón D., Ouedraogo M., Partey S., Totin E., Vasileiou I., Veeger M. (2018) - Lessons on bridging the science-policy divide for climate change action in developing countries. *CCAFS Working Paper no. 250.* Wageningen, the Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Available online at: www.ccafs.cgiar.org
- DECISION 1313/2013/EU - Decision No 1313/2013/EU of the European Parliament and of the Council of 17 December 2013 on a Union Civil Protection Mechanism. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32013D1313>
- DECISION (EU) 2019/420 - Decision (Eu) 2019/420 of the European Parliament and of the Council of 13 March 2019 amending Decision No 1313/2013/EU on a Union Civil Protection Mechanism. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32019D0420>
- De Groeve T., Casajus Valles A. (2015) - Science Policy Interfaces in Disaster Risk Management in the EU. Mapping the support provided . 47 pp. JRC97968, EUR 27520 EN, ISBN 978-92-79-52740-1, ISSN 1831-9424, doi:10.2788/023384, LB-NA-27520-EN-N
- DG-R&I (2019) - Directorate-General for Research and Innovation, Group of Chief Scientific Advisors (European Commission): Scientific opinion - Scientific Advice to European Policy in a Complex World. Luxembourg: Publications Office of the European Union, 2019. ISBN: 978-92-76-12557-0; doi:10.2777/80320; Catalogue number: KI-02-19-872-EN-N. 84 pp.

- Di Bucci D., Dolce M. (2019) – La scienza nel processo decisionale di protezione civile per la gestione dei rischi. In: Amato A., Flora G., Valbonesi C. (Eds.), *Scienza, diritto e processo penale nell'era del rischio*. Chapter X, 201-218. G. Giappichelli Editore, Torino. ISBN: 9788892129580
- Di Bucci D., Dolce M., Savadori L. (2019) - Deciding (or not) on the acceptable level of seismic risk: first behavioral considerations on the L'Aquila trial. *BGTA, An International Journal of Earth Sciences*, 60 (2), 337-358. Doi: DOI 10.4430/bgta0247
- Di Bucci D., Savadori L. (2018) - Defining the acceptable level of risk for civil protection purposes: a behavioral perspective on the decision process. *Natural Hazards*, 90 (1), 293-324. Doi: <https://doi.org/10.1007/s11069-017-3046-5>
- Dolce M., Di Bucci D. (2014) - Risk management: roles and responsibilities in the decision-making process. In: Peppoloni S., Wyss M. (Eds.), *Geoethics: Ethical Challenges and Case Studies in Earth Science*. Section IV: Communication with the Public, Officials and the Media. Chapter 18, 211-221. Elsevier. Publication Date: November 18, 2014 | ISBN-10: 0127999353 | ISBN-13: 978-0127999357 | Edition: 1
- Dolce M., Di Bucci D. (2015) – Civil Protection Achievements and Critical Issues in Seismology and Earthquake Engineering Research. In: Ansal A. (Ed.), *Perspectives on European Earthquake Engineering and Seismology*, Volume 2. Springer series "Geotechnical, Geological and Earthquake Engineering", 39, Chapter 2. 21-58. doi: 10.1007/978-3-319-16964-4_2
- Dolce M., Garro G., Griner F., Sicoli R., Speranza E., Bocchi F., Borzi B., Di Meo A., Faravelli M., Savadori L., Sillari G., Dolce A. (2019) - Più sai e meno rischi: SICURO+, per sensibilizzare i cittadini sul tema del Rischio Sismico. *Proceedings XVIII Italian National Conference on Earthquake Engineering - ANIDIS "Ingegneria Sismica in Italia"*, Ascoli Piceno, 15-19 Settembre 2019, SG03- 26-38.
- Dolce M., Miozzo A., Di Bucci D., Alessandrini L., Bastia S., Bertuccioli P., Bilotta D., Ciolli S., De Siervo G., Fabi D., Madeo L., Panunzi E., Silvestri V. (2020) - La protezione civile in Italia. Testo istituzionale di riferimento per i docenti scolastici. Dipartimento della Protezione Civile-Presidenza del Consiglio dei Ministri. Edition 1: July 2020, 236 pp.
- Dolce M., Prota A., Borzi B., da Porto F., Lagomarsino S., Magenes G., Moroni C., Penna A., Polese M., Speranza E., Verderame G.M., Zuccaro G. (2020) - Seismic risk assessment of residential buildings in Italy. *Bulletin of Earthquake Engineering*, S.I.: Seismic Risk Assessment in Italy. <https://doi.org/10.1007/s10518-020-01009-5>
- Donovan A., Oppenheimer C. (2016) - Resilient science: The civic epistemology of disaster risk reduction. *Science and Public Policy*, 43 (3), 363–374. doi: 10.1093/scipol/scv039
- DPCM 27/02/2004 - Direttiva del Presidente del Consiglio dei Ministri del 27 febbraio 2004, recante «Indirizzi operativi per la gestione organizzativa e funzionale del sistema di allertamento nazionale e regionale per il rischio idrogeologico ed idraulico ai fini di protezione civile». (*Gazzetta Ufficiale*, Serie Generale n. 59 del 11-03-2004 - Suppl. Ordinario n. 39). <http://www.gazzettaufficiale.it/eli/id/2004/03/11/04A02391/sg>
- European Commission (2015) - Strengthening Evidence Based Policy Making through Scientific Advice. Reviewing existing practice and setting up a European Science Advice Mechanism. *Research and Innovation*, 28 pp. <https://vdocument.in/strengthening-evidence-based-policy-making-strengthening-evidence-based-policy.html>
- FEMA-USGS (2016) - Memorandum of Understanding between the Federal Emergency Management Agency of the Department of Homeland Security and the U.S. Geological Survey of the Department of the Interior. 16 pp. <https://www.usgs.gov/about/organization/science-support/mou/mou-between-usgs-and-fema>
- Gaillard J.C., Mercer J. (2012) - From knowledge to action: Bridging gaps in disaster risk reduction. *Progress in Human Geography*, 37 (1), 93–114. doi: 10.1177/0309132512446717
- GFDRR (2016) - The making of a riskier future: How our decisions are shaping future disaster risk. © 2016 Global Facility for Disaster Reduction and Recovery, 143 pp. <https://www.gfdr.org/en/publication/making-riskier-future-how-our-decisions-are-shaping-future-disaster-risk>
- HFA (2005) - Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters. Extract from the final report of the World Conference on Disaster Reduction (A/CONF.206/6), UN-ISDR, 22 pp. <https://www.unisdr.org/2005/wcdr/intergover/official-doc/L-docs/Hyogo-framework-for-action-english.pdf>

- Hiwasaki L., Luna E., Syamsidik, Shawd R. (2014) – Process for integrating local and indigenous knowledge with science for hydro-meteorological disaster risk reduction and climate change adaptation in coastal and small island communities. *International Journal of Disaster Risk Reduction*, 10, 15-27. <http://dx.doi.org/10.1016/j.ijdr.2014.07.007>
- ICPD (2018) - National Risk Assessment 2018. Overview of the potential major disasters in Italy. Italian Civil Protection Department, Updated December 2018. <http://www.protezionecivile.gov.it/documents/20182/823803/Documento+sulla+Valutazione+nazionale+dei+rischi/57f337fd-a421-4cb0-b04c-234b61997a2f>
- Ismail-Zadeh A.T., S.L. Cutter, K. Takeuchi, D. Paton (2017) - Forging a paradigm shift in disaster science. *Nat. Hazards*, 86, 969–988. doi: 10.1007/s11069-016-2726-x
- Jordan T., Chen Y., Gasparini P., Madariaga R., Main I., Marzocchi W., Papadopoulos G., Sobolev G., Yamaoka K., Zschau J. (2011) - Operational earthquake forecasting. State of knowledge and guidelines for utilization. *Annals of Geophysics*, 54 (4). doi: 10.4401/ag-5350
- Kahneman D. (2011) - Thinking, fast and slow. Macmillan, Basingstoke, 499 pp. ISBN 978-1-4299-6935-2
- Law 225/1992 - Istituzione del Servizio Nazionale della Protezione Civile [Establishment of the National Civil Protection Service]. <https://www.gazzettaufficiale.it/eli/id/1992/03/17/092G0253/sg>
- Legislative Decree 1/2018 – Codice della Protezione Civile [Civil Protection Code]. https://www.gazzettaufficiale.it/atto/serie_generale/caricaDettaglioAtto/originario?atto.dataPubblicazioneGazzetta=2018-01-22&atto.codiceRedazionale=18G00011&elenco30giorni=true
- Mercer J., Kelman I., Taranis L., Suchet-Pearson S. (2009) - Framework for integrating indigenous and scientific knowledge for disaster risk reduction. *Disasters*, 34 (1), 214–239. doi: 10.1111/j.1467-7717.2009.01126
- New Zealand Government (2015) – The Guide to the National Civil Defense Emergency Management Plan 2015. Published by the Department of the Prime Minister and Cabinet, updated in 2020. 321 pp., ISBN 0-478-25470-0. <https://www.civildefence.govt.nz/assets/guide-to-the-national-cdem-plan/Guide-to-the-National-CDEM-Plan-2015.pdf>
- NTC (2018) - DECRETO 17 gennaio 2018. Aggiornamento delle «Norme tecniche per le costruzioni». 372 pp. <https://www.gazzettaufficiale.it/eli/gu/2018/02/20/42/so/8/sg/pdf>
- OECD (2015) - Scientific Advice for Policy Making: The Role and Responsibility of Expert Bodies and Individual Scientists. OECD Science, Technology and Industry Policy Papers, No. 21, OECD Publishing, Paris. <http://dx.doi.org/10.1787/5js3311jcpwb-en>
- Prime Minister's Directive of 27/02/2004 - Indirizzi operativi per la gestione del sistema di allertamento nazionale per il rischio idrogeologico e idraulico [Operational guidelines for the management of the national warning system for hydrogeological and hydraulic risk]. http://www.protezionecivile.gov.it/transparent-administration/legal-measures/detail/-/asset_publisher/default/content/direttiva-27-febbraio-2004-indirizzi-operativi-per-la-gestione-del-sistema-di-allertamento-nazionale-per-il-rischio-idrogeologico-e-idraulico
- Prime Minister's Decree of 14/09/2012 - Definizione dei principi per l'individuazione e il funzionamento dei Centri Competenza [Definition of principles for the identification and operation of Competence Centres]. http://www.protezionecivile.gov.it/amministrazione-trasparente/provvedimenti/dettaglio/-/asset_publisher/default/content/dpcm-del-14-settembre-2012-definizione-dei-principi-per-l-individuazione-e-il-funzionamento-dei-centri-competenza
- Ranchod R., Vas C. (2019) - Policy networks revisited: creating a researcher-policy maker community. *Evidence & Policy*, 15 (1), 31-47. <https://doi.org/10.1332/174426417X15139342679329>
- SAPEA (2019) - Science Advice for Policy by European Academies: Making sense of science for policy under conditions of complexity and uncertainty. Berlin: SAPEA. ISBN: 978-3-9820301-3-5; <https://doi.org/10.26356/MASOS>. 182 pp.
- Sandron D., Tufaro T., Scolobig A., Di Bernardo F., Parolai S., Rebez A. (2021) - A citizen science approach for supporting rapid earthquake impact assessments, *International Journal of Disaster Risk Reduction*, 52, 101969, <https://doi.org/10.1016/j.ijdr.2020.101969>
- Selva J., Amato A., Armigliato A., Basili R., Bernardi F., Brizuela B., Cerminara M., de' Micheli Vitturi M., Di Bucci D., Di Manna P., Esposti Ongaro T., Lacanna G., Lorito S., Løvholt F., Mangione D., Panunzi E., Piatanesi A., Ricciardi A., Ripepe M., Romano F., Santini M., Scalzo A., Tonini R., Volpe M., Zaniboni F. (in press) - Tsunami risk management for crustal earthquakes and non-seismic sources in Italy. *La Rivista del Nuovo Cimento*. doi: 10.1007/s40766-021-00016-9

- SFDRR (2015) - The Sendai framework for disaster risk reduction 2015-2030. 32 pp. UNISDR/GE/2015 - ICLUX EN5000 1st edition. <https://www.undrr.org/publication/sendai-framework-disaster-risk-reduction-2015-2030>
- Spain Government (2019) – National Civil Protection Strategy. Published by Gobierno de Espana, 61 pp. NIPO (on-line): 042-19-060-2, <https://www.dsn.gob.es/ca/file/3277/download?token=40Daelk3>
- Thaler R.H., Sunstein C.R. (2008) - Nudge: improving decisions about health, wealth, and happiness. Yale University Press, New Haven, 293 pp.
- Tversky A., Kahneman D. (1974) - Judgment under uncertainty: heuristics and biases. *Sci New Ser* 185 (4157), 1124-1131.
- UN-ISDR (2009) – Indigenous Knowledge Disaster Risk Reduction | Policy Note. 16 pp. https://www.unisdr.org/files/8853_IKPolicyNote.pdf
- Weichselgartner J., Pigeon P. (2015) - The Role of Knowledge in Disaster Risk Reduction. *Int. J. Disaster Risk Sci.*, 6, 107–116. doi: 10.1007/s13753-015-0052-7
- White G.F., Kates R.W., Burton I. (2001) - Knowing better and losing even more: the use of knowledge in hazards management. *Global Environmental Change Part B. Environmental Hazards*, 3 (3), 81-92. <https://doi.org/10.3763/ehaz.2001.0308>