European Commission

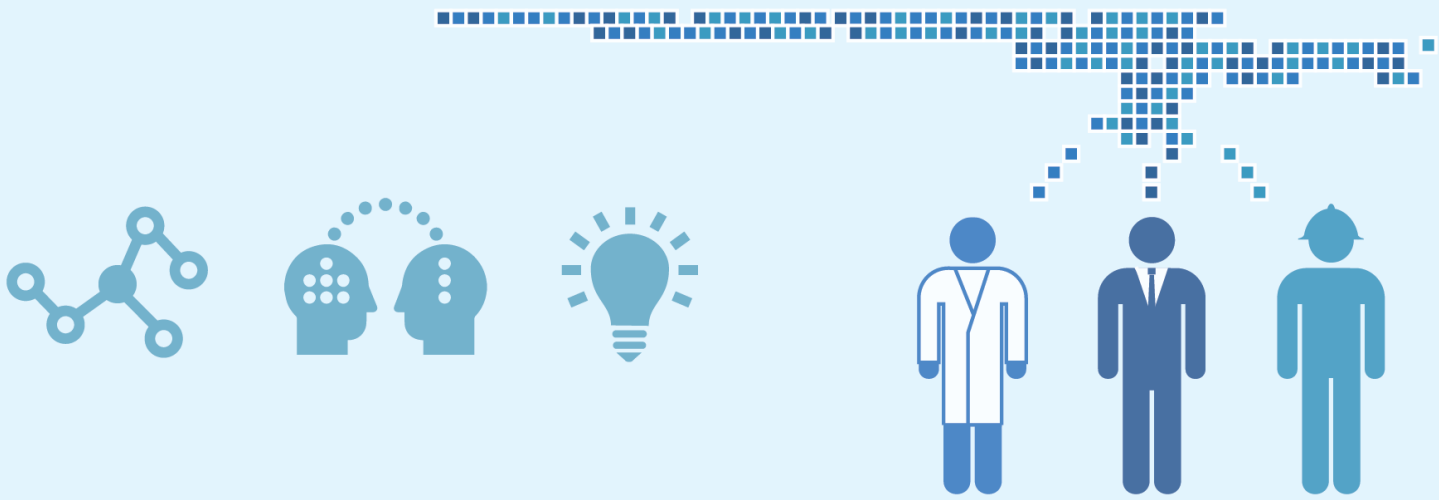
JRC SCIENCE FOR POLICY REPORT

Science policy interfaces in disaster risk management in the EU

Requirements and conditions for efficient SPIs in practice

Montserrat Marin Ferrer
Ainara Casajus Valles
Gaia Civiletti

2016



Joint Research Centre

EUR 28280 EN

Contact information
Name: Montserrat Marin Ferrer
Address: European Commission, Joint Research Centre, Directorate for Space, Security and Migration
Disaster Risk Management Unit
Via E. Fermi 2749, I-21027 Ispra (VA) – Italy
Email: Montserrat.marin-ferrer@ec.europa.eu
Tel.: *+39 0332 785810*

JRC Science Hub
https://ec.europa.eu/jrc

JRC104362
EUR 28280 EN

PDF	ISBN 978-92-79-64398-9	ISSN 1831-9424	doi:10.2788/196166	LB-NA-28280-EN-N
Print	ISBN 978-92-79-64399-6	ISSN 1018-5593	doi:10.2788/944382	LB-NA-28280-EN-C

Abstract

Science Policy Interface No 3. Requirements and conditions for efficient science policy interfaces in disaster risk management
EU countries use science policy interfaces (SPIs) in different stages of disaster risk management although some challenges and gaps remain in practice. The current study reveals the requirements for SPIs to create knowledge ready for 'action' and the conditions for these at institutional and social level. From these, three practices emerge as critical for success. The framework built serves to monitor and boost SPIs in practice and a source of knowledge to share and strategically work at the Disaster Risk Management Knowledge Centre.

Contents

Acknowledgements

We would like to express our deepest appreciation to the people that participated in the interviews, for their time and input, and to the colleagues that provided their help to complete this analysis.

Mr Sergio Delgado — General Directorate of Civil Protection, Department of the Interior, Generalitat de Catalunya.

Ms Maude Devés — Association française pour la prévention des catastrophes naturelles (AFPCN)

Ms Daniela di Bucci — Dipartimento della Protezione Civile

Mr Luca Ferraris — CIMA Research Foundation

Mr Vicente Gracia — International Centre for Coastal Resources Research (CIIRC)

Mr François Gérard — Association française pour la prévention des catastrophes naturelles (AFPCN)

Mr Eugenio Gil Lopez — Formerly in charge of the Programme for Management and Knowledge of the Consejo de Seguridad Nacional (CSN) and former officer of the International Atomic Energy Agency (IAEA)

Ms Catherine Guenon — Direction générale de la sécurité civile et de la gestion des crises, Ministère de l'Intérieur

Ms Maria Jose Jimenez Santos — Consejo Superior de Investigaciones Científicas (CSIC)

Mr Stefano Lorito– Istituto Nazionale di Geofisica e Vulcanologia (INGV)

Mr Carlo Meletti — Istituto Nazionale di Geofisica e Vulcanologia (INGV)

Ms Christine Mengus — Direction générale de la sécurité civile et de la gestion des crises, Ministère de l'Intérieur

Mr Alberto Michelini — Istituto Nazionale di Geofisica e Vulcanologia (INGV)

Ms Virginia Murray — Public Health England

Ms Elsa Rothschild — Association française pour la prévention des catastrophes naturelles (AFPCN)

Mr Roberto Rudari — CIMA Research Foundation

Mr Kees van Ruiten — Deltares

Ms Maureen Wood — Joint Research Centre of the European Commission

Executive summary

Policy context

Taking into account the importance and current use of science and technology in disaster risk reduction (DRR), there is a need to address some gaps and challenges when scientists and decision-makers work together. Based on two previous JRC studies that showed the role of science in disaster risk prevention, preparedness and response, the current study highlights the requirements and conditions for using evidence in disaster risk management (DRM) policymaking and investments, considering the project level but also the institutional and social context. The results are useful for acting upon certain practices strategically to enhance efficient science policy interfaces (SPIs).

Key conclusions

- Policymakers, practitioners and scientists value the use of SPIs for DRM. Trust and learning are common outputs of collaborative work and dialogue.
- In early warning systems SPIs are common and strong. In response, accountability and uncertainty are sometimes problematic in practice and in disaster risk prevention multidisciplinary participation and, in general, scientists' engagement in policy implementation and review needs to be promoted.
- SPIs require a minimum set of requirements at project level, such as resources and transparency, but this is strongly affected by the institutional and social practices.
- SPIs are dynamic, and the features and requirements interact with each other constantly. Depending on the context, some factors may gain importance and some can even hinder others. Minimum levels, however, are usually vital for SPIs to be efficient, to create knowledge for 'action'.
- Working through the features listed would provide models and technologies for dealing with disaster risk and facilitate trust and learning and, in the long term, SPIs would promote horizon scanning.
- Three factors emerge as crucial for SPIs to exist and work: end-users' needs are communicated and collected, there are procedures and responsibilities for monitoring and evaluation, and there is a continuous development of models and technologies.
- 'Brokers', which can be individuals or groups, are useful to link different actors and networks, facilitating dialogue and discussion within the SPI and dissemination out of it.
- It is necessary to balance three processes at any level: top-down vs bottom-up processes, formal vs informal interactions and complexity vs oversimplification of information. Here, the role of brokers can be profitable to balance these processes.
- Communication from the SPI to other stakeholders needs to be well addressed in future actions so minimum resources need to be in place to boost societal learning.

Main findings

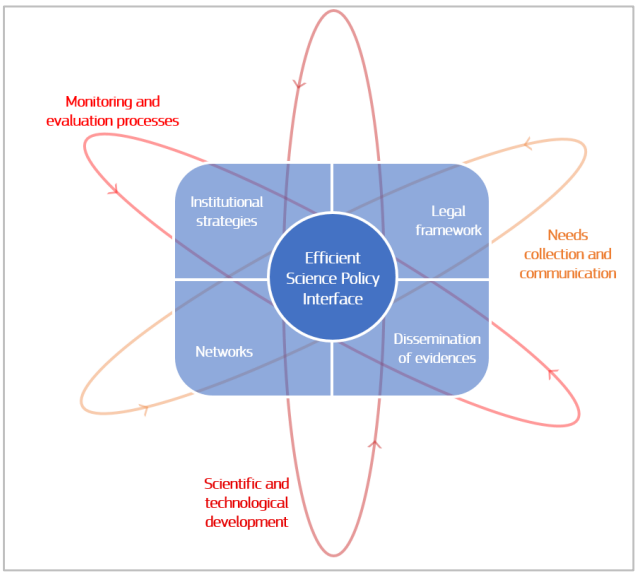
The interviews and public material indicate that six features are required for the co-production of knowledge between the three communities: shared vision and mission, multidisciplinary participation, resources, transparency, adaptability and continuity.

At the same time, there are four conditions at the institutional and social context that facilitate the establishment and work of SPIs.

1. There is a legal framework incentivising the use of evidence in DRM, with a special focus on multidisciplinary and multisectoral outputs.
2. Institutional strategies are in place, defining the role of the organisation in SPIs.
3. Each community is networked within itself and with others.
4. The evidence of the benefits of SPIs and multidisciplinary research are correctly disseminated.

Three factors need to happen continuously at any level and are critical for success.

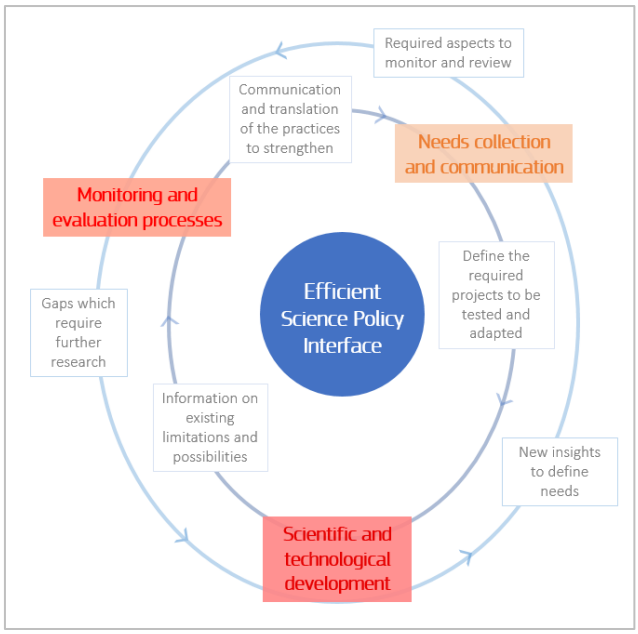
1. Needs are communicated and collected for applied research and the establishment of partnerships.
2. There are clear procedures and responsibilities for monitoring and evaluation of the actions and products resulting from research, SPIs and institutional activities together with the processes.
3. Scientific models and technologies are developed, based on loss data and new needs, and the results are made available.



Related and future JRC work

In general, it is necessary to enlarge the existing knowledge of the role of 'brokers' in reality and the SPIs to deal with multi-hazard and multi-risk policies and activities.

Specifically regarding the Disaster Risk Management Knowledge Centre (DRMKC), the practices presented in the report serve as basis for knowledge sharing. Based on the three critical factors for success, the DRMKC together with its partners should work for promoting them at EU and country level.



Quick guide

Based on existing research, efficient SPIs are understood as the interactions of scientists and decision-makers that create knowledge that is 'ready for use'. In practice this means that information is produced in line with end-users' needs and the most robust available science is used for DRM policies and activities.

1. Introduction

The international recognition of the role of science and technology in DRR calls for the gaps in scientific capacities and information among countries to be addressed in order to use them effectively (Dickinson et al., 2016). Two previous JRC studies highlighted the important role of science in DRM in EU Member States and mapped where and who are the main actors providing scientific input (de Groeve et al., 2015; de Groeve and Casajus Valles, 2015).

Different factors hinder a good integration of science results into DRM actions. Most research on disaster risk remains academic and is carried out with a low level of collaboration between disciplines, remaining fragmented and out of policymakers' sight (Gall et al., 2015). Moreover, researchers and policymakers use different languages and have different aspirations and interests, so finding common paths of action is difficult. Politicians usually prefer relevant products with a high impact and results that are visible in the short term, while scientists are sometimes not able to respond to end-users' needs in time, as traditional scientific models require a whole process of analysis, testing and repetition (Nowotny et al.,2001). In fact, the results given by some researchers are too technical, which impedes their application. At the same time, some scientists fear a loss of independence and objectivity when working with decision-makers. It has actually been proved that scientists also have their own agendas for research. Moreover, when scientific evidence is disputed and decisions are at stake, scientist will be also influenced by their financial, social, political and personal interests (van den Hove, 2007; Elliot and Resnik, 2014). In addition, many governmental groups have competences in DRM; responsibilities and actions are scattered and even overlap between different governance levels and institutions. In reality, although working groups are composed with a view to addressing some DRM issues, science and policymakers are not fully integrated in a dialogue for learning and co-production of knowledge which is actually 'used' for DRM policymaking and investments (Norton et al., 2014; Spiekermann et al., 2015).

SPIs arise as the spaces where both scientists and policymakers can interact and produce knowledge together — a knowledge that is 'ready for use' to apply in policies and activities. There is no definitive structure for SPI; it may include boundary organisations or knowledge brokers ([1]), inside or besides the 'scientists' and the 'decision-makers' engaged (Cvitanovic et al., 2015), working either informally or in structured processes or both. Anyway, it is clear that processes need to be adaptive (Cash and Moser, 2000) so learning and trust need to be in place in the SPI to secure information and values are shared for timely and legitimate outputs. Policies and actions based on evidence would also facilitate coordination of strategies and resources in DRM, expand innovative programmes and strengthen accountability.

Knowing what is needed and could work, it is necessary to highlight **which actions need to be prioritised strategically**.

([1]) Knowledge brokers' main roles are (Turnhout et al., 2013):
- engaging in and facilitating interaction between knowledge producers and users;
- linking knowledge supply and demand acting as intermediary; or
- a combination of the two.

2. Scope and objectives

Considering that knowledge is more than just 'providing information' (Weichselgartner and Pigeon, 2015), there is a need to understand which are the mechanisms that would serve to structure and organise information that is 'actionable' and 'ready for use' in DRM policies and programmes. In particular, the current study analyses how information should be produced in order to (1) be in line with the end-users' needs and (2) ensure that the most robust science available is used and available for policymaking and investments in DRR. The mechanisms described are divided into two levels, as the barriers may be found at project or programme level, which is called the 'micro level', but also in higher spheres, considering the institutional and social context, labelled in the report as 'macro level' (Figure 1).

In the present study the interaction between three communities is considered:

- policymakers, who are responsible for or involved in formulating public policies, working in governmental agencies, departments or ministries engaged in any phase of DRM;
- practitioners, understood as the people working in the agencies and bodies that have a designated responsibility for DRM, such as civil protection groups;
- scientists, who are experts in natural or social science or humanities and who work producing and disseminating research; they can be found in research organisations (placed within governmental agencies, universities, institutes, etc.), funded or not by governments.

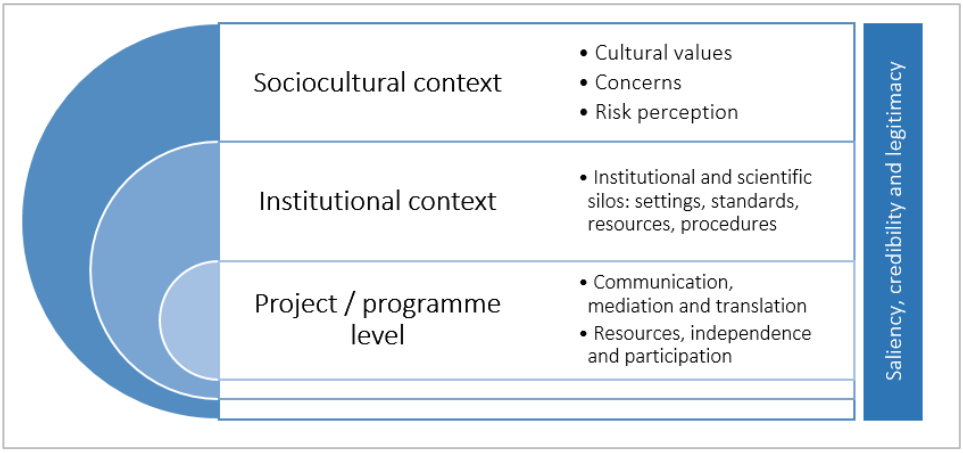


Figure 1. Framework of action for science policy interface (De Groeve and Casajus Valles, 2015)

Depending on the specific cultural and institutional predisposition, DRR groups and practices may change, building an interesting pool within the EU where the mechanisms that promote partnerships synthesising scientific knowledge and integrating it into policy and investments can be identified. The results may be useful to (1) formulate a robust framework of DRM issues to be surveyed and monitored in the EU to highlight effective actions, tools and legislative and technical mechanisms and (2) share expertise and capacities and, when possible, transfer knowledge, tools and methodologies within the Disaster Risk Knowledge Centre (DRMKC).

The DRMKC was established in 2015 in order to improve and deepen the relationship between policymakers and scientists in the field of DRM. It mainly covers three topics (Figure 2):

1. enhancing partnerships to facilitate science input through networks and alliances;
2. knowledge production, transfer and use;
3. securing advances in innovative technologies and capacities for disaster risk and crisis management.

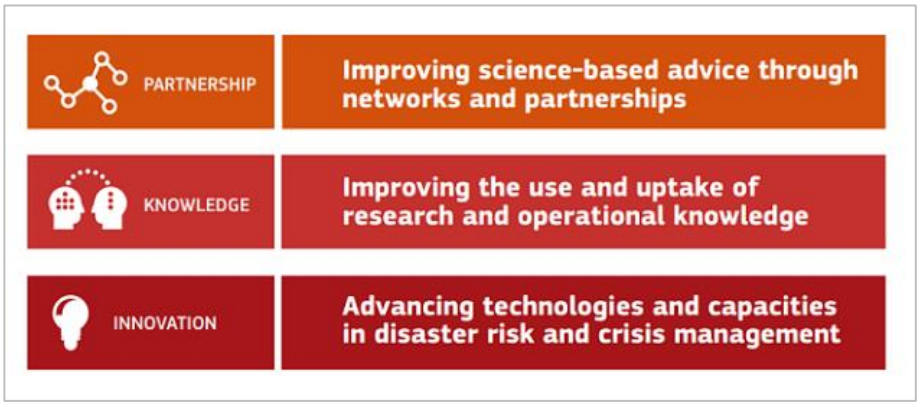


Figure 2. Pillars of the Disaster Risk Management Knowledge Centre

3. Methodology

Four attributes need to be secured in the SPI to facilitate a space for participants to communicate, translate and mediate for new knowledge: **credibility, relevance, legitimacy and iterativity** (Cash et al., 2002; Cash et al., 2003; Sarkki et al., 2015).

The four attributes, which may change with the context and the needs of stakeholders (Sarkki et al., 2014), are described as follows:

- Credibility: the quality, validity and scientific adequacy of the people, processes and knowledge exchanged in the interface. Considering that the interrelations between science and policy are complex that would mean that the SPIs deal and negotiate with multiple types of expertise that are appropriate, representative and relevant.
- Relevance: how pertinent and impartial are the people, processes, knowledge and products to policy and societal needs. So, besides reinforcing scientific objectivity, it is necessary to adequately represent the plurality of perspectives from which the problem can be viewed, not forgetting its interactions with interests and power relations.
- Legitimacy: the perceived fairness and balance of the SPI processes. In the present study, this means that the represented views and actors are pertinent for the issue to discuss and relevant, and that the final output(s) contain(s) all these perspectives properly.
- Iterativity: the continuous interaction of participants, aiming to build constructive relationships and knowledge among all of them at the interface and between the SPIs and external audiences. Here iterativity would facilitate the outputs of the SPI being refined incrementally, up to a satisfactory level (Jones, 2002; Koetz, Farrell and Bridgewater, 2011; Sarkki et al., 2015).

A smart practice is something that works and that has been proven to be good and to have led to good results (Veselý, 2011). In the current study, a smart practice would be a representation of a mechanism or tool that fulfils one or both of the following objectives: (1) it is in line with the end-users' needs and (2) it ensures that the most robust science available is used and available. The examples presented would be classified based on the DRMKC pillars. A practice defined as smart should be a better way to do things, with the definition of 'better' being based on the four abovementioned attributes — credibility, relevance, legitimacy and iterativity — and the structure, processes and outputs created in the SPI providing a real case of efficient SPI in practice. Several 'smart practices' were pinpointed as the basis for analysis and some of these are presented as examples of efficient SPIs in reality.

The present report is based on both publicly available materials from EU countries and European institutions and interviews with scientists, policymakers and practitioners from Spain, France, Italy, the Netherlands and the United Kingdom.

The interviews (Annex I) were carried out between January and April 2016 and consisted of open questions, covering the following topics:

- the role of science in policymaking, early warning systems (EWS) or emergency response;
- the funds available for research into DRM;
- the features and resources available in the interfaces between science and politics and their difficulties;
- how uncertainty is managed;
- who is accountable;
- the role of science in communication to the broad public.

The interviews are vital for studying the interactions of all communities within different SPIs in different stages of policymaking and different disaster risk phases, together with existing research. This way it is possible to pinpoint the conditions for SPIs to be efficient

at the 'micro' level. The interviews, together with publicly available material from Member States, are used to study the 'macro' level. In order to design best-case scenarios, simple trees of cause and effect are built (Annex II), depicting what would be necessary for SPIs to be efficient, promoting the four attributes of credibility, relevance, legitimacy and iterativity. The trees become a kind of 'spider web' covering the main relations of cause and effect for the objectives of the study, displaying the requirements for efficient SPIs in DRM to exist and operate at the 'macro' level.

4. Findings

4.1 Micro level

According to the research, a set of characteristics proposed by Young et al. (2013) needs to be particularly enhanced when establishing a space for scientists, practitioners and policymakers to work together, bearing in mind the close links that exist between them.

1. **Shared vision and mission**. People engaged in the interface must not only understand the objectives and scope of the interaction, but also understand the importance of it. Scientists and policymakers sometimes only work with their own colleagues, gaining important knowledge in their specific tasks and the topics they usually deal with, so some participants may not understand their role and responsibilities, their added value in the interface. Having a clear picture of what the collaboration aspires to be not only secures good results, but also makes it easier to share values that motivate and engage the entire DRM community in achieving the goals. Moreover, this feature is fed by and strengthens two others: continuity and transparency. Accountability issues should be tackled in order to secure pertinent participation.

Association française pour la prévention des catastrophes naturelles (AFPCN) Platform (France)

This association was created in 2001 as a space for exchange and learning for the different stakeholders engaged in natural disaster prevention in France: scientists, state representatives, private companies, NGOs, etc. The platform, supported by the Ministry of the Interior and the Ministry of the Environment, Energy and the Sea, aims to be a **network of networks**, bringing people together to improve public policies and to promote effective and coherent DRR actions. Membership is open to any individual working in and interested in DRR.

Different kind of activities are carried out, from organising meetings and debates between public authorities and members of civil society to participating in R & D projects, funded by national research agencies or the European Commission.

Source: *Vie de l'association* (17 October 2016) (in French). Retrieved from https://afpcn.org/animation-et-reseau-dacteurs/vie-de-lassociation/

2. **Multidisciplinary participation**. Generally speaking, natural and engineering disciplines have long experience of collecting data and analysing disaster risk events and impacts. Nonetheless, the interviewees highlight the importance of working with social sciences, especially to understand community perception and to make the population aware and more participative in DRR initiatives. Moreover, social science and humanities may have the expertise to facilitate a smooth and easy interaction between some scientists, policymakers and practitioners in front of complex situations. This aspect is boosted by enough resources and adaptability in the SPI.

Atomic Reporters

This non-profit organisation, composed of professionals with different backgrounds, acts as an information broker, improving journalistic understanding and coverage of nuclear science and technology. Besides disseminating news from all over the world, Atomic Reporters prepares fact sheets for the media and organises workshops and conferences to enhance the capacity of journalists to report on nuclear and radiation issues.

Source: Atomic Reporters (25 October 2016). Retrieved from http://www.atomicreporters.com/

3. **Resources**. Financial resources seem to be vital for all communities to work together, as these strongly affect the human resources and time available for the work. This factor is crucial for research organisations that are not under an institutional umbrella for funding and in countries where innovation and research funds are limited and private companies have few incentives to participate in research. In fact, the interviews have shown the need to further explore the role of the private sector as a funder and collaborator in research. Resources are enhanced if there is a sense of continuity and if the SPI is adaptive.

Centres of Competence (Italy)

A decree in 2002 established a network of different centres that provide services, information, data and other types of technical-scientific contribution to the areas of need of Italian civil protection. The network is composed of public agencies and academic and other research organisations listed in a decree of 2013 covering different disciplines. The Civil Protection Directorate (DPC) directly requests and provides funds for specific 'products' or activities, signing agreements covering these. Other types of research activities may be possible through European projects or regional funds.

The partnerships have different assignments such as updating databases related to landslides and floods, giving support to meteorological forecasts or defining and evaluating possible volcanic scenarios. All agreements, together with their costs and time lines, are published on the website of the DPC.

Sources:

Molce, M. and 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*, Geotechnical, Geological and Earthquake Engineering. Switzerland: Springer International Publish. Retrieved from: http://www.springer.com/cda/content/document/cda_downloaddocument/9783319169637-c2.pdf?SGWID=0-0-45-1523471-p177310377

Centri di competenza (17 October 2016) (in Italian). Retrieved from http://www.protezionecivile.gov.it/jcms/it/centri_competenza.wp?pagtab=3 - pag-content

4. **Transparency**. This is not only necessary at the beginning, to explain the needs and the possible expected risks of a process, but throughout the whole process of collaboration. For this reason, this aspect should be carefully reviewed as part of internal monitoring processes. If participants are transparent, they more easily understand each other to and can together overcome the possible barriers of language and assumptions, fitting the product within their agendas and obtaining a product of quality. Transparency means that practitioners and policymakers are clear about their agendas, limitations and requirements, collaborating with their experience and knowledge. Equally, scientists must highlight the constraints and limitations of the outputs, particularly regarding 'uncertainty', and the problems of lack of data or the existing gaps of knowledge. In order to secure transparency, van den Hove (2007) proposes the creation of room for participatory processes. The sense of continuity also has a positive effect on this feature.

Scientific advisers (United Kingdom)

Most government departments in the United Kingdom have a chief scientific adviser (CSA) who guides ministries in including technology in policies, identifying and discussing emerging issues and facilitating the use of science and technology in policymaking and communication. This person mainly works through the Chief Scientific Advisers' Network, under the leadership of the government's chief scientific adviser. With this structure, departments ensure that they have sufficient in-house research capability to use and advise on policies and decisions with evidence, while linking with external experts when necessary.

Communication and transparency over the processes and assumptions is stressed in the guidelines for offering scientific and engineering advice. The use of an open and transparent approach in dialogue with policymakers and the general public is recommended, so that they have all the information regarding evidence, uncertainty and assumptions as soon as possible. Equally, it is recommended that scientists, advisers and policymakers have a clear understanding regarding their roles and boundaries.

Sources:

Chief Scientific Advisers (25 October 2016). Retrieved from https://www.gov.uk/government/groups/chief-scientific-advisers

Government Office for Science (2010), 'The government chief scientific adviser's guidelines on the use of scientific and engineering advice in policy making'. Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/293037/10-669-gcsa-guidelines-scientific-engineering-advice-policy-making.pdf

5. **Adaptability**. In line with transparency, it may sometimes be necessary to assess output, explore new possibilities or spend time translating and analysing information and data, considering the high degree of complexity and uncertainty around DRM. In these cases, the group needs to be sufficiently open to new participants and ideas to enter timely. In practice, monitoring mechanisms that measure the effectiveness of the interaction and the points for improvement need to be in place. Likewise, sufficient and timely resources need to be secured for new inputs.

National Strategy (Netherlands)

The National Security and Safety Strategy establishes a multi-sectoral process based on government-wide cooperation to identify risks at national level and work over the capabilities of the whole system. The process starts picturing the possible threats and analysing scenarios, to draft a Risk Assessment, which is the basis for the capability assessment. Different groups and institutions are engaged with different roles in the stages of the process, based on the threats and the context to analyse.

The Network of Analysts for National Security (ANV) is the group appointed to carry out the risk assessment. The ANV is composed by a permanent core of six organizations, named as the NRA Task Group, and a set of institutions, civil services, and research organizations, which participate as contributors, reviewers or assessors depending on the expertise required. Besides these, the ANV has a parallel working group in charge of methodological questions and improvements.

The Capability analysis is done by a working group of experts, which comes up with a findings report that is handled to the Cabinet for decision-making and implementation.

Sources:

Dutch Ministry of Security and Justice/ Ministry of Interior and Kingdom Relations (2009), Working with scenarios, risk assessment and capabilities in the National Safety and Security Strategy of the Netherlands. The Hague, Netherlands: Directorate-general for Public Safety and Security.

Rademaker, M. (2009). National Security Strategy of the Netherlands: an innovative approach. Information & Security, 23(1): 51-61.

6. **Continuity**. In order to have enough time and space for participants to discuss and learn, the creation of relations of trust and collaborative work needs to be understood as ongoing. The interviews showed that all communities are willing to collaborate and that their experience has been positive overall, considering continuity a cornerstone for (1) the implementation of results (policies or technologies) and for (2) horizon scanning, looking in the long term regarding impact and anticipating emerging challenges. Continuity seems to facilitate that, with time, the relationships of trust and learning move from the individual level to the institutional one, making relevant the present outputs but also preparing the ground for timely and adequate future outputs. It is noteworthy mentioning that the rest of features can facilitate or underpin the continuity of future collaboration, especially the lack of (a minimum level of) resources or transparency. Here it is necessary to mention that a kind of continuity among participants is positive to constructively contribute to the process, as terms, objectives and processes may have been jointly defined in previous stages.

The Major Accidents Hazards Bureau (MAHB)

This initiative, located at the JRC, is a special unit dedicated to scientific and technical support for actions regarding the control of major industrial hazards, mainly those related to the implementation, monitoring and review of the Seveso directives. For that reason, it fulfils a number of key services requirements for the European Commission, and particularly for DG Environment.

For example, in order to inform the Commission about major accidents within national territories and to prevent future events, the group operates the Major Accident Reporting System (eMARS). Likewise, the MAHB provides scientific and administrative support to the Seveso Plants Information Retrieval System (SPRIS). This is the forum for the exchange of information between the Commission and Member States and acts as a regulatory committee, adapting and harmonising criteria and practices among countries. In addition, the MAHB organises technical meetings and seminars and provides support to technical working groups while being involved in different research activities.

The different SPIs that have been created and evolved around the MAHB for more than 30 years are an example of long-term continuity. The ongoing investment of resources and commitment has turned in trustful partnerships. Nowadays the European Commission is supported by Member States in leading the support of chemical accident prevention and preparedness.

Sources:

Duffield, S. (2003), 'Major accident prevention policy in the European Union: The Major Accident Hazards Bureau (MAHB) and the Seveso II Directive', *Institution of Chemical Engineers Symposium Series,* No 149. Retrieved from https://www.icheme.org/communities/subject_groups/safety_and_loss_prevention/resources

/hazards_archive/~/media/Documents/Subject_Groups/Safety_Loss_Prevention/Hazards_Archive/XVII/XVII-Paper-01.pdf

Wood, M. (2003), '*The Major Accidents Hazards Bureau of the EC Joint Research Centre Mission, Services, cooperation with countries in implementing the Seveso II Directive*'" (Power Point Slides).

The features listed below are the basis for networking, as they define the SPIs' structure. Knowledge production and transfer are fundamental characteristics of an efficient SPI. In turn, an efficient SPI would have the required spaces for innovation.

It is worth mentioning that, depending on the final product — that is partially related to the disaster phase — and the context, there are some trade-off between these aspects. For example, in the case of emergency response, the decision-maker would give far more importance to timely and relevant outputs than to legitimacy among the participants. In line with this, it would, for example, prefer multidisciplinary participation to promoting continuity.

4.2 Macro level

In order to enhance effective processes at the project/programme level, it helps to understand the barriers above this level, within the institutional and social context. A number of diagrams constructed based on the study suggest a new set of aspects (Annex II) as conditions for efficient SPIs.

The specific actions are described below, following the three pillars of the DRMKC.

4.2.1. Partnerships

1. **National and sub-national DRM legal framework**. A legal framework and a clear political mandate that promotes the interaction of the three communities (scientist, policymaker and practitioners), establishes the incentives and resources for applied research in DRM and facilitates the SPIs' 'micro features'. A legal framework for DRM should be complemented and coherently linked to other laws and policies from various sectors (such as natural resource management, housing, planning, climate change or health) and throughout all administrative levels. Equally, it is necessary that the framework(s) in place recognise the role of multi-stakeholder platforms, undergo periodic reassessments as risk and knowledge are continuously evolving, engage 'non-traditional' stakeholders, encourage organisational and social learning and support institutional memory (Djalante, Holley and Thomalla, 2012; Djalante, 2012). The interfaces that would be created to put in place DRM legal regulations at country and European level would be a space of interaction and an opportunity for all three communities to learn and build trust. In particular, it has been proved that it is necessary to have a clear strategy to link priorities and funds because specifying the priorities and funding applied research independently may not automatically result in real societal progress.

2. **Institutional strategies**. Every community, within its institution or organisation, should have a strategy to work collaboratively with the other communities for the best results, both in designing policies and specific products and also in implementing and reviewing them. Nowadays, many government agencies or research institutes that are part of ministries or embedded in governmental structures have in their mandates the requirement to participate in SPIs for DRM. This type of collaborative work is in practice more common for EWS or surveillance, especially for hazards of natural origin, than for response or prevention. The approach needs to give importance to networks for collaboration and coordination and focus on experimentation, where development is designed, implemented and tested (Koetz et al., 2009).

These strategies would determine the necessary actions to carry out in order to facilitate their teams to work in SPIs, providing a sense of mission for the institution and its workers to operate in SPIs for DRM. In practice, the institutions should define:

a) their role(s) in DRM and the benefits to be gained from applied research; in the case of research organisations, besides a strategy for applied research, it should consider the mechanisms to promote and facilitate collaboration with other scientific disciplines;
b) the role(s) of its workers in DRM SPIs, based on the resources that would be provided to the interface (funds, human resources, networks, etc.) and the internal capacity building actions;
c) mechanisms to mobilise human resources for the interaction with other communities;
d) mechanisms to mobilise financial resources for the interaction with other communities;
e) mechanisms to promote horizon scanning, transparency, adaptability and independence, (the latter is of paramount importance for scientists);
f) mechanisms to disseminate their products/needs/requirements; these will need to be published in different forms and forums, including networks, and using the required 'language'.

These strategies would prepare the ground for capacity-building actions, changes in organisation and the adoption of specific practices. Capacity-building activities would cover internal processes, such as spaces to learn from other colleagues' experiences, or to better interact with other communities. For scientists it would be interesting to get training in communication skills and understanding of policy processes, while for policymakers it would be more necessary to explore why science is valued and even designate a group for R & D that manages and promotes the use of science in their activities (Choi et al., 2005; Young et al., 2013). In any case, the strategy should identify individuals that are willing to work in SPIs and encourage them to promote their roles as 'mediators' playing a bridging role and as 'opinion leaders', to steer science policy processes, through the government system or their networks.

MSB Research planning (Sweden)

Research and development is vital for the work of the Swedish Civil Contingencies Agency (MSB), which is responsible for issues concerning civil protection and emergency management. The institution supports applied and needs-oriented research to solve societal problems. MSB itself allocates an annual budget for different research activities and cooperates with other groups in order to ensure research grants through joint calls.

The current strategy (2014-2018) covers five research areas:

- individual and public safety;
- protection from fire, accidents and hazardous substances;
- business continuity and resilience of society;
- strengthened emergency management;
- civil defence and security information.

It also covers six cross-cutting issues that run transversely through the research areas:

- EU, international relations and security policy;
- gender and diversity;
- information and communication;
- management and collaboration;
- methods and technology;

- risks, threats and vulnerabilities.

Complementing the strategy, MSB adopts yearly research plans that identify the concrete direction and focus of the research in the coming years.

Sources:

MSB (2013), *Forskning för ett säkrare samhälle. Ny kunskap för framtidens utmaningar MSB:s forskningsstrategi 2014–2018* (in Swedish). Retrieved from: https://www.msb.se/RibData/Filer/pdf/27246.pdf

MSB:s forskningsplan 2016 (25 October 2016) (in Swedish). Retrieved from https://www.msb.se/sv/Om-MSB/Forskning/MSBs-forskningsplan-2016/

3. **Network(s) of research organisations.** If research organisations are well connected with each other, over time, they will facilitate collaborative work, producing and disseminating multidisciplinary insights. If they are grouped, they can better disseminate their work, identify gaps in research, find funders, detect barriers to overcome when they talk to each other, mobilise relevant actors, assess their impact, promote their strengths, etc. All of these actions will support multidisciplinary research and impact and research organisations will increase their capacities to work with decision-makers. This is required above all by the research groups dealing with new or emerging risks, which are not institutionalised or remain unknown by most stakeholders, included politicians. At the same time, if research organisations are grouped, existing SPIs can easily select the suitable experts to take part in the work. Better coordination in research and innovation will ensure an efficient use of resources and development.
   One of the objectives of these networks should be to produce knowledge for action, and disseminate it among the participants in the network and other relevant stakeholders, adapting the message and the channel to the audience.

Disaster Research Alliance (United Kingdom)

The UK Alliance for Disaster Research (UK-ADR) is an open network of research organisations that aims to help the government to implement initiatives to reduce the impact of disasters. There are three lines of action:

1. building a research community to interact with other initiatives and coordinate its work with other associations for science advice;
2. engaging with the government and being the contact point for those in the UK Government seeking science input;
3. strengthening DRR knowledge, identifying gaps and sharing information and opportunities, promoting multidisciplinary research.

The alliance will sit on the UK Disaster Research Group (UK-DRG), a committee of research funders and users that has been hosted by the UK Collaborative on Development Sciences since 2009.

Sources:

About UKADR (25 October 2016). Retrieved from http://ukadr.org/about.html

UK Alliance for Disaster Research (2016), *Draft Constitution*. Retrieved from http://ukadr.org/docs/UKADR_Constitution.pdf

4. **Network(s) of policymakers and practitioners.** Equally, a network of government officials engaged in DRM would facilitate their work as stakeholders in applied research and as participants in SPIs. It is preferable that networks are multisectoral, taking into account the individuals or groups of government officials that are involved in issues such as health and social security, economics, housing, industry and energy. At the same, some networks should encompass different phases of the DRM cycle.
   The networks would facilitate coordination among groups, organising initiatives and resources. Equally, in the spaces of interaction their concerns and needs should be discussed and well disseminated so the scientific community can apply them in research.

National Commission for Civil Protection (Portugal)

This coordinating body in the field of civil protection is presided over by the Ministry of Internal Administration and is composed of representatives of different ministries (Forestry, Economy, Justice, Health, etc.), the president of the National Authority of Civil Protection (ANPC) and representatives of the Association of Municipalities and of fire fighters. The main mandate of the group is to guarantee that the policies and technical norms in civil protection are implemented, as well as the permanent function of the services that carry out actions in emergency management. It also adopts mechanisms for institutional collaboration between all agencies and departments with responsibilities in the topic at national level, mobilising the required organisations and staff so that actions can be implemented in a coordinated way.

Source:

Comissão Nacional de Protecão Civil (25 October 2016) (in Portuguese). Retrieved from http://www.prociv.pt/pt-pt/PROTECAOCIVIL/SISTEMAPROTECAOCIVIL/COMISSAONACIONALPROTECAOCIVIL/Paginas/default.aspx - /collapse-0

5. **Spaces for interaction and discussion between the three communities.** These spaces for interaction and discussion between policymakers, practitioners and scientists are useful to share their knowledge, experiences, needs and constraints. In this way, each community can understand the possibilities and limitations of working with each other, and take suitable actions within their institutions and working groups to build capacities and establish mechanisms to ease SPIs. These kinds of spaces also facilitate the building of relations of trust among participants and organisations that is necessary for long-term and transparent partnerships, while preparing the field for future actions in research and policymaking. In this way, these type of 'arenas' would be profitable in the short term but also in the medium and long term by translating the knowledge and trust into strategic plans at all levels and for the different organisations. These spaces could be face-to-face events or workshops, with target participants, or web platforms or webinars.

National DRR platforms

Because disaster risk reduction is a complex issue that requires political and legal commitment, public understanding, scientific knowledge and the development of multisectoral policies and activities, the UN has been promoting the implementation of multi-stakeholder platforms for DRR at national level for almost 20 years. One of the objectives is to provide a space for coordinated dialogue and partnership between the different actors. The construction of these platforms depends on the legal and

social context of each country, although the leading ministry or agency is in position and has the capacity to coordinate the participation of all relevant partners.

Source:

UNISDR (2007), *Guidelines on national platforms for disaster risk reduction*. Retrieved from http://www.unisdr.org/files/601_engguidelinesnpdrr.pdf

Identifying and including individual or groups that can work as brokers to the networks, would facilitate the actions within the networks and the connection of different groups and networks with each other. The networks would hopefully promote dialogue and trust among participants, preparing the ground for 'action': identifying and communicating needs, generating a synthesis of existing research, identifying gaps and opportunities or incorporating resources (financial, expertise, networks) into existing partnerships, aiming to stimulate new research and SPIs.

4.2.2. Knowledge

1. **Needs are communicated and collected**. End-users' needs trigger applied research and efficient SPIs. The communication of needs is quite common for the design of EWS and for well-known hazards of natural origin. It is important that the communication of the needs of all communities and their collection is done continuously, which can be done from the spaces of interaction and networks mentioned above.
   It is noteworthy the close link between end-users' needs and outputs from loss data collected and analysed. The task of collecting loss data gives valuable information about the existing weaknesses of risk management practices and the areas to be reformed as well as the factors and activities that act as loss drivers (de Groeve et al., 2014).
2. **Ongoing monitoring and evaluation**. The assessment of processes, products and impacts of SPIs would provide evidence of the benefits of SPIs and smart practices on which stakeholders should interact and how. Nowadays several government agencies assess the products of SPI products but is it important to stress the need to monitor and assess prevention plans and activities, due to the complexity and interests at stake. Additionally, in the interviews it was claimed that scientists need to be more involved in these processes.
   The assessments should be transdisciplinary and multisectoral. This would promote the need for quality procedures among stakeholders, which would increase the relevance of the products generated by the SPIs, and would identify which areas to need to be improved and/or better studied. Besides promoting research and SPI projects and programmes, the results would be useful for drafting policies and norms as well as improving the performance of networks.
   It is necessary to assess, on the one hand, the outputs and impacts of applied and multidisciplinary research and, on the other, the products and results of SPIs.

Copernicus User Uptake (EU)

The European Earth observation programme Copernicus collects, processes and provides environmental data from satellites and sensors to end-users, who employ it for policymaking or operational actions. Regarding emergency management, Copernicus can provide data to use in preparedness; it also supports EWS and provides products, like maps and levels of damage, to respond to an event.

In order to ensure that the data, services and information are attractive for users, a comprehensive user engagement strategy is in place, which is driving the implementation and future development of the system. The starting point of the strategy was listing the activities for uptake carried out in every country. Later, all of these were assessed to identify best practices in existing structures and tools as well as areas for improvement. From these, key recommendations and a set of concrete actions were drafted for its future implementation.

Sources:

'Civil protection and humanitarian aid' (27 October 2016). Retrieved from http://www.copernicus.eu/main/civil-protection-and-humanitarian-aid

SpaceTec Partners (2016), *'Copernicus user uptake: engaging with public authorities, the private sector and civil society'.* Retrieved from http://www.copernicus.eu/sites/default/files/library/Copernicus_User_Uptake_Engaging_with_Users_0.pdf

3. **Dissemination of the benefits of SPIs**. The dissemination to different audiences of the benefits of SPIs, which could come from lessons learnt drafted from emergency recovery processes or observed smart practices in the interaction between the three communities, may emerge from evaluations and assessments. These representative practices will increase the awareness of all three communities, which is very important for having a shared vision and mission within the SPI, and constitute a basis for drafting (or improving) the strategies of institutions and organisations. This point is crucial for prevention actions, as they provide results that are not always evident to all stakeholders or visible in the short term.

Lessons learnt from 2002 floods (Austria)

In August 2002 record-breaking amounts and intensities of rainfall were observed in central Europe, which produced flash floods in small rivers in the area, followed by floods in the rivers Vltava, Elbe and Danube. There were 100 fatalities connected with the floods and the economic loss in the Czech Republic, Germany and Austria was estimated at EUR 14.5 billion.

In the aftermath, the countries collected details of losses and analysed the response actions carried out. In Austria, the Institute for the Environment, in cooperation with the University for Rural Development, reported on the damages, estimating the direct and indirect damages, and draw lessons from the flood. The report convinced the Austrian government to fund and establish an applied research and development programme to study flood causes and effects and test existing capabilities. All of this served to draw conclusions for further actions. The final report, which engaged 62 organisations from federal governments, federal provinces, municipalities, universities and private companies, provided recommendations for policy, governance and research and became the road map for future actions, which envisaged an enhancement of applied research and collaborative work between several stakeholders.

Sources:

Habersack H. and A. Moser (2003), *Ereignisdokumentation Hochwasser August 2002* (in German), Zentrum für Naturgefahren und Risikomanagement (ZENAR), Universität für Bodenkultur Wien, Universität für Bodenkultur. Available at: http://zenar.boku.ac.at

Habersack H., Petraschek A. and Bürgel J. (2004), *Analyse der Hochwasserereignisse vom August 2002 — Flood Risk* (in German), BMLFUW, Vienna, Austria. Retrieved from: http://www.umweltbundesamt.at/fileadmin/site/umweltthemen/klima/FloodRisk/FloodRisk_deutsch_Endversion.pdf

Plate E. J., 'Consequences of the central European flood of August 2002 with emphasis on the Elbe River in Germany', in Chvoshian, A. and Kuniyoshi, T. (eds), *Large scale floods report* (pp. 53-88). Retrieved from http://www.ifi-home.info/icfm-icharm/Large_Scale_Flood_Report_Web.pdf

Ulbrich, U., Brücher, T. Fink, A. H., Leckebusch, G. C., Krüger, A. and Pinto, J. G (2003), 'The central European floods of August 2002: Part 1 — Rainfall periods and flood development', *Weather*, No 58, pp. 371-376.

It is important to take into account some points in order to better disseminate information and knowledge to the target audience(s) identified: choosing the correct channel(s), targeting the message and using the most suitable technique for the specific audience (Norton et al., 2015). In line with the previous point, it would be profitable to monitor the result of the communication.

Science Report (EU)

This ongoing initiative of the DRMKC aims to understand the role and integration of scientific evidence in DRM. The report, which will be launched in May 2017, covers the current status of DRM actions and knowledge, especially regarding communication, to point out the challenges and list a set of recommendations for future actions. The main target audience is policymakers and practitioners, who will find its way into legislative form and practice. At the same time, the knowledge gaps detected could serve as valuable reference input for Horizon2020 call.

4. **Dissemination of the benefits of multidisciplinary collaboration**. In order to connect the different disciplines in DRM research and application, it is necessary to disseminate the outputs, and especially the impact on the research groups and the policies drafted/implemented, to both research organisations and policymakers.

Science in policy design and implementation for landslides (Italy)

Science has been engaged in the policies and norms around landslide risk for a long time. At the beginning of the 20th century, science mainly studied the physical trigger factors of landslides and past events for structural engineering works.

After the 1966 landslide in Florence, an interministerial commission was set up, known as the Marchi Commission. The multidisciplinary group, which included hydrologists, engineers, geologists and planners, acted as a boundary organisation and as a catalyst using new science to shape the institutional framework. Their idea was to manage water and soil resources in an integrated way, through hazard and risk assessment, using the river basin as the main unit of planning and management. In 1984, the National Group for Hydrogeologic Disasters' Defence (GNDCI) was created, composed of universities, research institutes and local administrations and, some years later, in 1989, river basin authorities (RBAs) were created for the planning and regulatory activities. Since that year, in addition to the national river basin authorities, several interregional, regional and provincial river basin authorities have been appointed for landslide management; a multi-scale governance approach recognised the contribution of a large number of stakeholders.

Similarly, in 1992, a new law reformed the national civil protection and integrated scientific research and technological expertise for disaster management within a structured system. The network of centres covers academic and research groups from different disciplines.

Sources:

Pelling, M., Bye, L., Zehra Zaidi, R., Scolobig A, Sharma, U., Mafttei, R., Tudor, E., Mihai, V., Porumbescu, C. and Angignard M. (2011), *The cultures of landslide risk management in Europe and India*, SafeLand FP7, Deliverable D5.5.

Scolobig, A., Linnerooth-Bayer, J. and Pelling, M. (2014), 'Drivers of transformative change in the Italian landslide risk policy', *International Journal of Disaster Risk Reduction*, Vol. 9, pp. 124-136

Scolobig A. and Pelling, M. (2015), 'The co-production of risk from a natural hazards perspective: science and policy interaction for landslide risk management in Italy', *Natural Hazards*, Vol. 81, No 1, pp. 7-25.

5. **Dissemination of the scientific and technological advances and results**. The possibilities and results obtained by technologies, models and tools need to be disseminated, taking into account the language and channels that each community would use. Making the advances accessible would promote their further development and use in practice, by making them more visible to funders, existing SPIs or future collaborative works. Nonetheless, communication should not be oversimplified, especially if the audience is scientists, as this may have negative consequences for innovation and raising awareness.

DRMKC Project Explorer (EU)

As part of the DRMKC, a web platform has been developed containing a common repository of relevant research and operational projects related to DRM together with their results, in form of reports, publications or datasets. Nowadays, there are more than 300 projects stored, funded by the seventh framework programme for research and development (FP7). The programme ran between 2007-2013 as the main instrument for funding research in Europe. In the future, it is expected that projects involving Member States and directorates-generals engaged in the DRMKC will be included in the repository.

The platform aspires to also be a 'space' for interaction, where registered users, could comment on and discuss the project, promoting the direct use of the results both in further research and by decision-makers, and raising awareness among stakeholders. Lastly, having effectively identified users, organisations, research topics, communication channels and results, it would be easier to find partners for research or for SPIs, as well as defining trends in the use and communication of research.

As Young et al. (2013) point out, SPIs play a role in changing the behaviour of different stakeholders, directly through raising awareness or indirectly through the policies implemented or the results of research. Knowledge brokers or intermediaries not only smooth the communication within the interface, but also with other audiences. As stated, the communication activities would be designed for specific audiences and contexts, and minimum resources for communication would need to be in place.

4.2.3. Innovation

1. **Scientific models and technologies are tested**. If loss data is collected and the practice of assessment is common, scientific models would be tested in order to improve them, responding at the same time to the needs of policy-makers and/or the practitioner community. Testing and improving science provides the basis for new activities and legal frameworks and also raises the awareness and commitment of stakeholders to SPI. The result of these tests needs to be well disseminated.
2. **Scientific models and technologies are adapted to new needs**. As needs change over time, based in part on policy and research advances, science needs to continuously evolve, improving its outputs. These outputs, which may represent an increase in capacity, need to be disseminated, as mentioned above.

ARGOS Consortium

In 1992, Prolog Development Centre (PDC) and the Danish Emergency Management Agency (DEMA) developed the ARGOS software system to support the emergency organisation in case of incidents involving atmospheric dispersion, such as chemical and radiological releases, smoke from fires and biological agents. ARGOS warns about the situation and provides an overview of its evolution, indicating the consequences of the dispersion and the proper evacuation zones. Besides facilitating decision support and information in the response phase, the system can also be used in recovery and preparedness, for planning, dimensioning and training.

The product has been developed over more than 15 years with the involvement of end-users and today ARGOS supports emergency response in 13 countries. The group of end-users that exchange knowledge and ideas, which actually make up the ARGOS Consortium, is a strong network of research institutes, emergency organisations and the private company.

Sources:

The ARGOS Consortium (27 October 2016). Retrieved from http://www.argosconsortium.org/

PDC-ARGOS (27 October 2016). Retrieved from http://www.pdc-argos.com/

Equally, as regarding partnerships and knowledge transfer, brokers and intermediaries can be an interesting input for innovation, not only connecting the different actors in the system and bridging ties, but also promoting the idea of creating new possibilities and dynamism within a system (Howells, 2006).

It is important to highlight that besides the output or products (policies, technologies, models, etc.) of the SPI, the interaction of these communities will generate trust, horizon scanning and learning, which would facilitate future SPIs. These three products could also come from other actions carried at the institutional and social levels. The relationship between the causes and effects are dynamic and nonlinear, so many different interactions will be generated with each other and new ones will be triggered with time.

5. Results

Based on the existing limitations and barriers for DRM, and always considering that SPIs are dynamic partnerships, six features seem to be required for the co-production of knowledge:

1. Shared vision and mission
2. Multidisciplinary participation
3. Resources
4. Transparency
5. Adaptability
6. Continuity.

These factors are closely interlinked at project level but also with other actions that happen in their surroundings as the participants in the SPIs are part of groups and institutions and they are embedded in a social context. For that reason and to boost efficient SPIs related to DRM, it is recommended that they act more strategically at the 'macro level'. This, in turn would feed from SPIs that are formed continuously. The conditions that facilitate DRM SPIs in practice are as follows:

- There is a legal framework incentivising the use of evidence in DRM, with a special focus on multidisciplinary and multisectoral outputs. In particular, a joint strategy for DRM and research leverages funding projects and programmes that actually respond to societal needs.
- Institutional strategies are in place, fulfilling the legal requirements and the mandate of the organisation, among both governmental bodies and research organisations. These strategies should define their role in SPIs for DRM policymaking and investments together with guidelines for encouraging their workers to interact with others and to be engaged in SPIs.
- The groups in each community are networked, with a special focus on the disaster impact of events, promoting integrative approaches, and there are spaces for interaction between the three communities, in form of workshops, conferences or meetings.
- The evidence of the benefits of SPIs and multidisciplinary research is correctly disseminated, which would increase the awareness of each community and push for regulations, plans and funds to be in place to promote the use of evidence in DRM policymaking.

In turn, three factors are critical for success for the abovementioned conditions in the social and institutional context.

All the features of the project are interlinked with each other and with other levels (Figure 3), changing with time. Furthermore, all features and conditions require a kind of balance, which may change based on the context and needs. For example, a correct integration of needed scientific disciplines and other types of knowledge is required for common understanding. So diversity and representation should be well balanced, based on the needs. Similarly, although continuity is vital for SPIs to be established and for horizon scanning, partnerships that are too strict may hinder adaptability and, with time, innovation. Actually, formal and well-structured SPIs need to be complemented by others that are more informal and ad hoc, out of governmental dictates, and more open to innovative processes and solutions. Equally, two processes need to co-exist at both 'micro' and 'macro' levels: bottom-up versus top-down approaches, which would ensure leadership and relevant information and participation, and complexity versus simplification mechanisms, taking into account the different actors engaged in SPIs at different levels and the complexity around DRM.

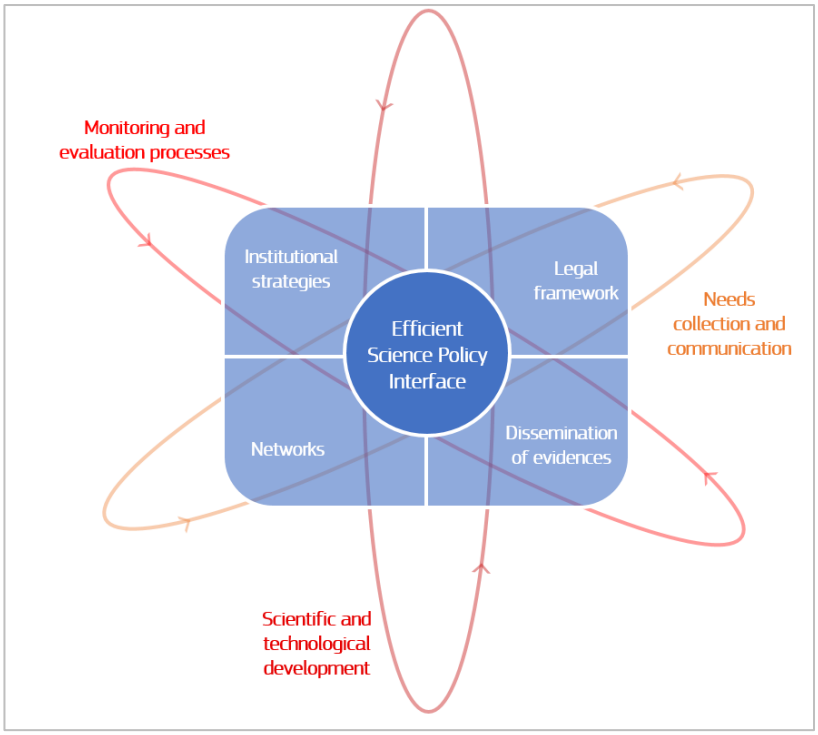


Figure 3. Representation of the micro and macro level elements essential for efficient science policy interfaces

For the different processes to balance, the role of 'broker' or 'intermediate' group or individual seems to be profitable for reaching consensus and disseminating 'actionable' information, while paying special attention to the critical factors for success. Some aspects, especially regarding governance, and in particular the integration of sustainability-disaster risk-climate change spheres (Gall, Cutter and Nguyen, 2014), remain a challenge. For that reason, the actions to implement at the 'micro' and 'macro' levels demand an incremental approach, where small changes are assessed and from which new changes are introduced.

6. Conclusions

From the interviews with the three communities (policymakers, practitioners and scientists) and publicly available material, it is concluded that SPIs and collaborative work are valued by all communities and that trust and learning processes are usually achieved, besides the outputs needed. From their experiences, six core features are identified within the SPIs in order for them to be efficient: shared vision and mission, multidisciplinary participation, resources, transparency, adaptability and continuity. This low level, labelled as the 'micro' level, is influenced by actions happening in the institutional and social contexts, named the 'macro level'. For SPIs to be efficient four conditions need to be in place: a legal framework which promotes the use of evidence for policymaking, institutional strategies that facilitate the collaborative work between the three communities, well-established networks within and across the communities and good dissemination of information and knowledge. There are three required practices that are critical for the success of the abovementioned conditions: needs are communicated and collected systematically, there are procedures and responsibilities for monitoring and evaluation, and there is a continuous development of models and technologies. These three practices need to be established and happening continuously within the SPIs, at the 'micro' and 'macro' levels, in a two-way interaction and dialogue.

The practices and features that enhance effective SPIs are interrelated and feedback from each other at all levels continuously (Figure 3). Some of these are difficult to secure, such as transparency, and some may even 'hinder' others with time. Because of this, the features mentioned need to be monitored effectively, to maintain the required balance. Likewise, it is necessary to bear in mind the balance between different processes at the two levels: formal vs informal and bottom up vs top down, and complexity vs oversimplification. For the management of them it is recommended to strengthen 'brokers' between groups and adaptive governance processes, based on experimentation and monitoring. It is noteworthy that the balance of features and processes would depend on the context and the SPIs.

SPIs seem to work particularly well for EWS, where the micro features are generally well secured from all communities. In emergency response, uncertainty and accountability are sometimes problematic, affecting some of the features of an efficient SPI. In those cases, it would be positive to have a clear legal framework and carry out capacity-building activities for each community. Regarding policymaking, SPIs are common for prevention and preparedness although scientists are sometimes not engaged in policy implementation or review. Here, there seem to be important differences in agreement between science and the values of decision-makers. Thus, it is proposed to boost more and stronger SPIs for prevention and more cross-sectoral networks including research, linking different sectors and administrative levels. Equally, within the groups and organisations, mediators or individuals willing to work in SPIs need to be trained and boosted.

As a result of the considered institutional and social practices, it is expected that learning and trust between the communities will be enhanced, facilitating SPIs. In turn, these two elements are also products of an efficient SPI. With time, by implementing and securing the abovementioned practices, it is expected that a sense of 'over the horizon' would be generated, and agendas from all communities would be coordinated. This would promote more relevant applied research, facilitate innovation and ease the establishment of SPIs in DRM. Governments can push for the establishment of SPIs, as observed in many of the examples, but the influence of scientists and other groups could come from the networks. Furthermore, it is expected the construction of a culture of assessment and evaluation, where monitoring and review processes are carried out by decision-makers and scientists. Nowadays, 'monitoring' processes and applied research are not very attractive for some scientists, as the 'innovative' factor is low and these kinds of activities are poorly rewarded within its community. Equally, policymakers and practitioners should be engaged in assessing the impact of applied research, giving valuable feedback for future research projects and for the real use of results. This lacking step of review should be directly addressed by the institutional strategies and plans.

The features proposed at the 'micro level' and the practices at the 'macro level' envisage that scientists and decision-makers usually have (opposite) interests and values within the interfaces. For this reason, transparency must come from all communities and from the interface with other audiences. It is vital to clarify who is involved in the SPIs and when, as well as who is funding them, while the one-way and linear model of information and knowledge among the participants is being abandoned, promoting the interaction in early stages of policymaking. Scientists need to better explain their results and uncertainties while decision-makers need to learn to ask comprehensive and different questions regarding the same issues. Also, the outputs of the interface will need to be well disseminated to other stakeholders, which would raise awareness of critical issues and would make all actors change their behaviour, and the interface would have to also hear what others think.

It is obvious that communication becomes a vital activity for enhancing SPIs. The two-way dialogue needs to be reinforced within and outside of the SPIs, to the recipients of policymaking but also to other groups. Uncertainty and differences in values and norms between different stakeholders requires that communication is in place to promote societal learning ([2]) and trust. In fact, two stakeholders play an important role in DRM SPIs, although not considered in the present study. These are, first of all, the private sector, which represents an interesting partner in applied research while it encourages innovation in DRM, and, secondly, the citizens, as disaster risk is socially and culturally constructed. Their perception and priorities would push governments to act to a certain extent and notably determine the implementation of initiatives and actions.

Although the topic of SPIs has been well studied in the last decade, most of the studies are related to biodiversity, ecosystem services, climate change and the health sector. These topics share some characteristics and challenges with DRM that need to be further studied in practice, such as the existence of multiple scales and its interaction (from EU-national-regional to local and vice versa), the incentives for engagement and ownership in SPIs and the conditions and mechanisms for conflict management. Some others are more specific to the DRM field, like the multi-risk approach and the particularities and synergies existing between different phases of the DRM cycle. In the study, practitioners and policymakers have been considered to be in some aspects a unique community: decision-makers. It would be significant to better explore the role of practitioners as mediators between some stakeholders or even as bridges between scales, as they have strong expertise on the practical application of actions and the particularities of different areas of the territory. Actually, the role of knowledge brokers as mediators, translators and linkers needs to be researched due to its added value in SPIs, evident in the trees of cause-effect (Annex II).

([2]) Social learning can be single (incremental changes in routines and strategies), double (questioning the assumptions and mental models) and triple (when values and norms are questioned leading to a deeper understanding of the context, power dynamics and values), required depending on the problems faced (Argyris, 1999; Hulbert and Gupta, 2015).

7. The DRMKC and science policy interfaces

Identifying what would facilitate SPIs to become established and efficient from a strategic point of view highlights the points that could to be tackled from the DRMKC. In fact, the activities carried out under the umbrella of the DRMKC represent a good opportunity to increase the knowledge of SPIs in practice for DRM policymaking and investments.

Based on the results of the present study, it is evident that further contemplation of the three factors that are critical for success is urgent (Figure 4). In that sense, the DRMKC already contemplates the development and testing of technologies and models under the pillar of innovation. In that case, it is important to appropriately channel and disseminate results to different stakeholders. In order to make research results more accessible and usable we should move from the traditional reports and scientific research papers to more innovative packages such as games or interactive scenario planning tools (Schut et al., 2014). Here, it would be interesting to mainly deal with the topics identified in the previous chapter: modelling vulnerability and understanding the underlying causes and drivers of risk in Europe, multi-hazard and even multi-risk models and technologies, and linking DRM and climate change.

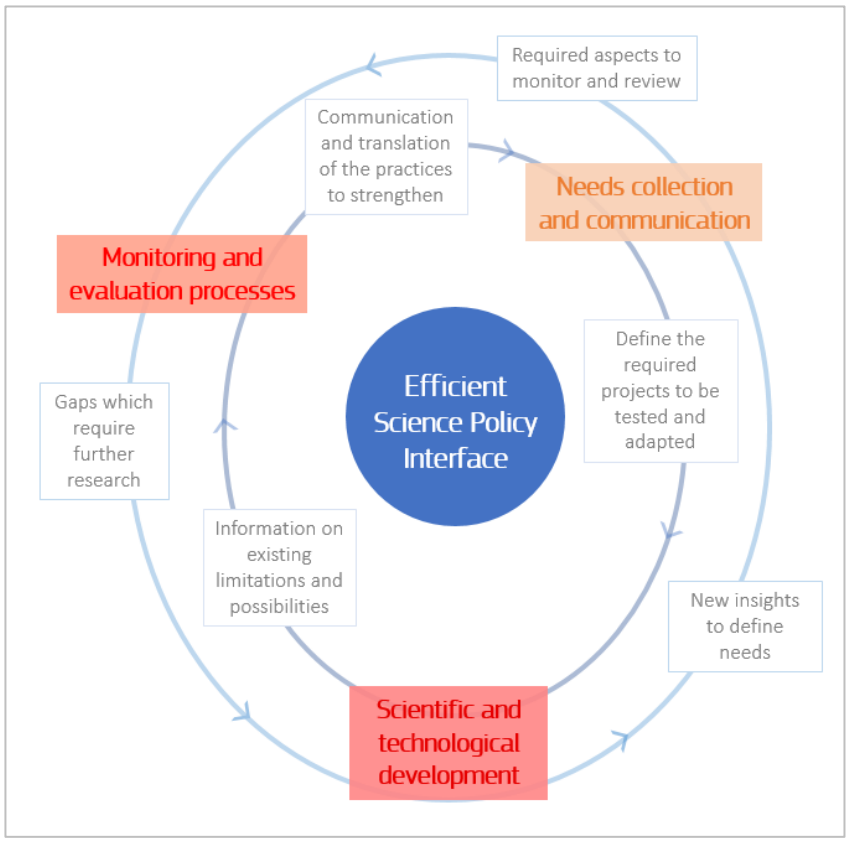


Figure 4. Representation of the micro and macro level elements essential for efficient science policy interfaces

Regarding the communication and collection of needs, it is necessary (1) to define smart practices to be shared and raise awareness at national and sub-national levels (for example, EWS design and monitoring seem to have large experience in working through SPIs so it could be an interesting source of inspiration to detect good practices and adapt them to other risks and DRM phases), and (2) to establishing systems to collect and analyse end-users' needs at EU level to later disseminate them to target audiences, like research groups, policymakers/practitioners and research funders.

Lastly, monitoring and evaluating demands needs to be addressed at all levels by different stakeholders. At EU level is necessary to provide better insight regarding the impact of multidisciplinary and applied research. Therefore, it is recommended to (1) review the

implementation of policies at EU level and (2) assess the impact of research with a European scope and/or funds in practice, revealing the challenges in practice and engaging all important stakeholders.

The DRMKC should work together with its partners, defining the activities to be carried out in order to promote the three factors for success at EU level, especially the actions that feed back into each other (Figure 4). All the mentioned actions at EU level and their promotion at national level will inform the agendas of research organisations, funders and decision-makers while matching science with evidence in policymaking and vice versa. Nonetheless, it is worth mentioning that the complexity of the systems involved poses a challenge for the assessments and that the results of these assessments need to be well communicated for institutional, organisational and social learning, in order to encourage 'action'.

It is especially important to devote efforts to the development and adoption of knowledge brokers in DRM. It is necessary to deepen its effectiveness and the problems that knowledge brokers find in reality in enhancing micro and macro features, considering the different phases of the disaster cycle. Here, a first attempt could be studying the role of practitioners and its links with other groups and agencies. Equally, the DRMKC should promote its role as 'broker', disseminating needs and sharing smart practices, while linking different projects, networks and disciplines within Europe. Here, the balance of processes (formal vs informal, bottom up vs top down, and complexity vs oversimplification) and features could guide its work, in order not to overlap with existing structures and provide relevant help. The DRMKC as broker would benefit the four conditions of the 'macro' level.

In the present study, three communities have been considered (policymakers, practitioners and scientists) yet other stakeholders also play a role in DRM, as in the SPIs that are formed. Their participation is profitable, balancing the power relations and providing valuable insights and resources. Further research might study the possibilities for further interaction and the existing barriers for suitable knowledge transfer.

Annex I. Interview templates

Questions for decision-makers

Use of science: Do you use scientific support in policymaking, EWS or disaster response?

- In which stage is science generally used:
  - In policymaking: to draft policies, to implement policies, to monitor them?
  - In EWS: to design EWS, to implement them or monitor them?
  - In disaster response: to support the response?
- Which should be the role of science?

Actors: who provides scientist advice?

- Are there research groups/institutes/agencies which commonly work with you (your institution) providing scientific input to policymaking/develop EWS/during operations? Which are these?
- Do you use different expertise used, from natural and social science, to support you?

Funds for research: Is your institution involved in research for DRM policymaking, EWS or emergency response?

- Does your institution fund research? If so, which type of research do you fund normally, applied or academic research?
- If not, is it possible for you to influence where research funds are allocated?
- Are there scientists with the required expertise available to work with your institution?
- Is the institution involved in bilateral agreements or partnerships with other institutions internationally?

Mechanisms for integration: How is scientific data or advice integrated in the policymaking process/in the development of EWS?

- Is it a structured process (for example, through agreements and partnerships) or experts are required for specific tasks? Is this structure convenient or could be improved?
- Do you have the sufficient resources (time and money) to properly integrate the scientific information into decision-making?
- Are the roles and procedures clearly defined and explained to the scientists?

Uncertainty: Do scientists communicate you the existing uncertainty of their advice and studies?

Accountability: Who has to respond for the decisions, policies, plans and other regulations made regarding risk prevention and mitigation?

- What actors are accountable in policymaking/monitoring events/warning the population/emergency response?
- Are scientists accountable? What are they accountable for?
- Is accountability defined by law?

Difficulties: Which are the problems that your institution commonly faces when working with scientists?

- Is the information given by experts understandable? Is information presented in an easy way?
- Are the products given by experts (like a map, a scenario, a risk assessment, new systems to warn population) on time and relevant?
- Is the input of science evaluated in order to know its relevance?

Workflow: Does your institution support regional and local level to integrate science?

- Do you facilitate regional and local levels to integrate science in their policymaking processes (for example for emergency planning or risk assessment)?
- Do the scientific group provide support to the local level directly or through the national authority?

Communication with the public: Are the outputs of policymaking (risk assessments, prevention plans, maps, mitigation actions, warnings, information regarding response, etc.) jointly divulgated to the general public?

Questions for scientists

Use of science: Do you participate in policymaking, EWS or disaster response?

- In which stage is science generally used:
  - In policymaking: to draft policies, to implement policies, to monitor them?
  - In EWS: to design EWS, to implement them or monitor them?
  - In disaster response: to support the response?
- Are decision-makers willing to use the data/information/outputs provided by you?
- Which should be the role of science?

Funds for research: Which institution fund research for DRM policymaking, EWS or emergency response?

- Who funds this research nationally? Which type of research is funded, operational or academic research?
- Have you participated in international research DRM? Who funded it?
- Is your institution involved in bilateral agreements or partnerships with other institutions or research groups for DRM activities and plans?

Mechanisms for integration: How is scientific data or advice integrated in the policymaking process/in the development of EWS?

- Is it a structured process (for example, through agreements and partnerships) or experts are required for specific tasks? Is this structure convenient or could be improved?
- Are the roles and procedures clearly defined and explained to scientists?

Uncertainty: Do you communicate decision-makers the uncertainty of your studies/products provided?

- How do you deal to communicate uncertainty to decision-makers?

Accountability: Who has to respond for the products/services/advice provided?

- Are scientists accountable? What are they accountable for?
- Is accountability defined by law?

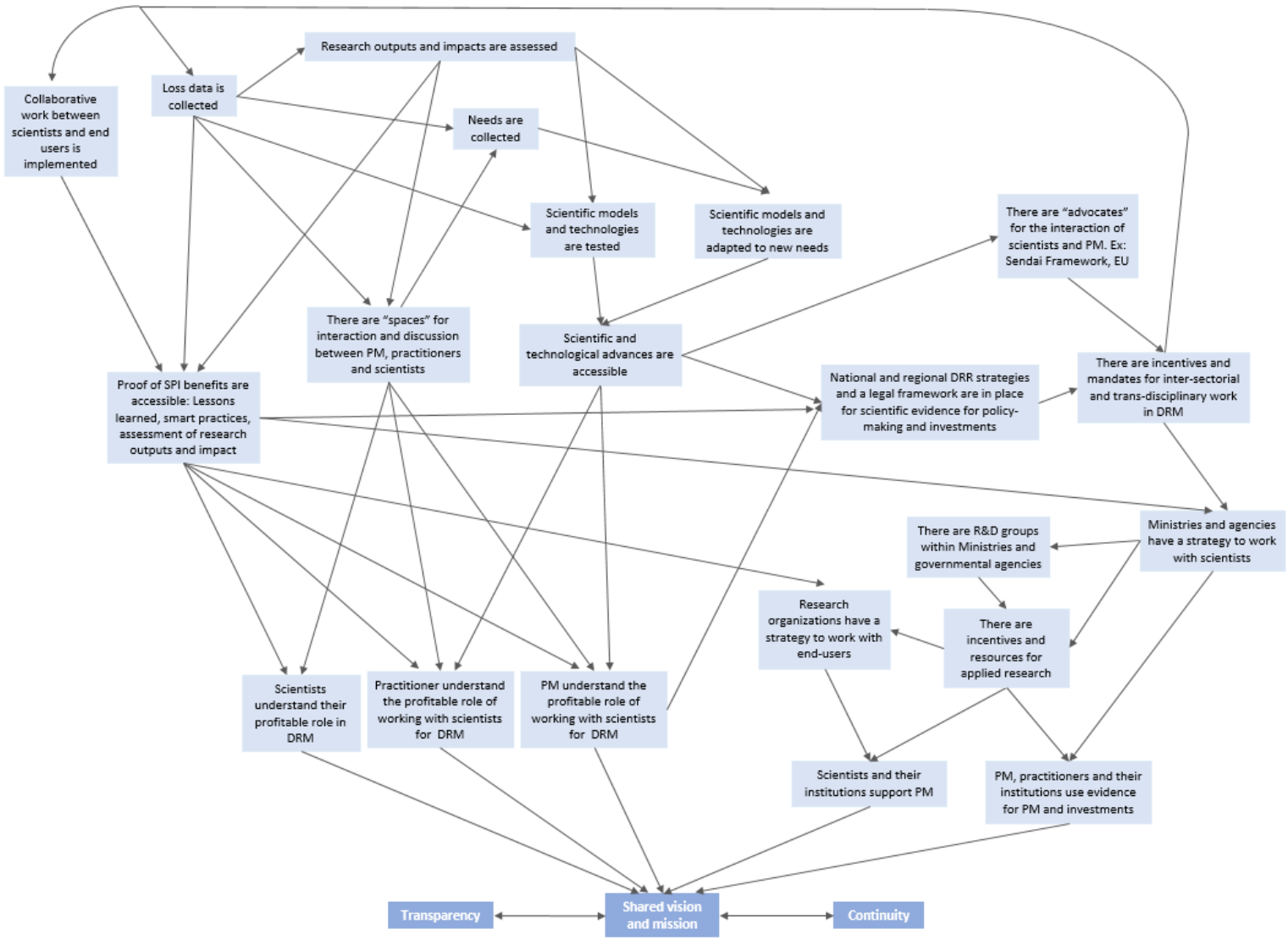
Difficulties: Which are the problems that your institution commonly faces when working with decision-makers?

- Do you have the sufficient resources (time and money) for providing the service/output required?
- Do you have all the information you need to work?
- Can you work and communicate with the necessary independence?
- Do you translate and present the information in an easy way for decision-makers?
- Is the input of science evaluated in order to ensure quality?

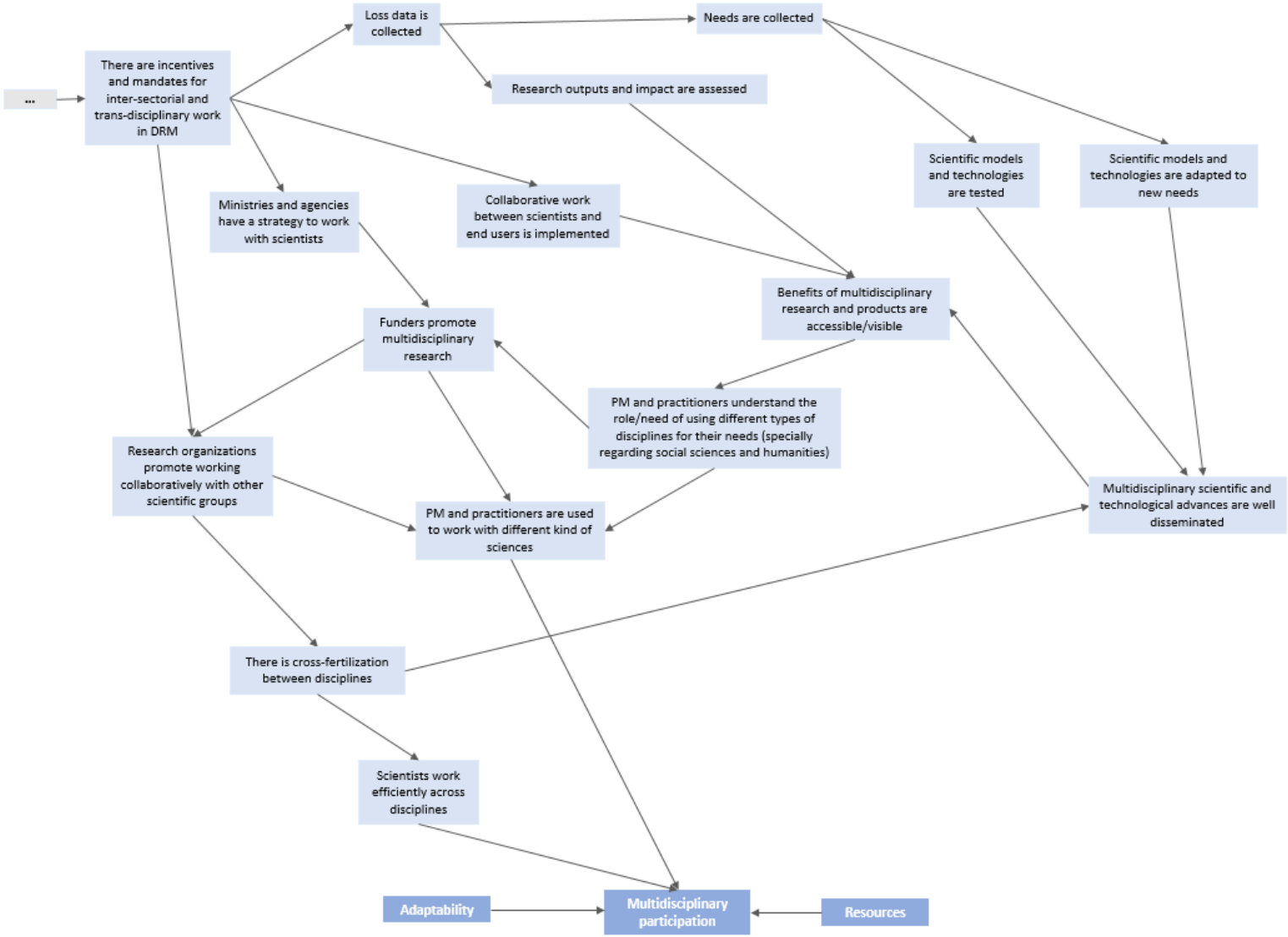
Communication with the public: Are the outputs of policymaking (risk assessments, prevention plans, maps, mitigation actions, warning, information regarding response, etc.) jointly divulgated to the general public?

Annex II. Cause-effect trees of best-case scenarios

Shared vision and mission



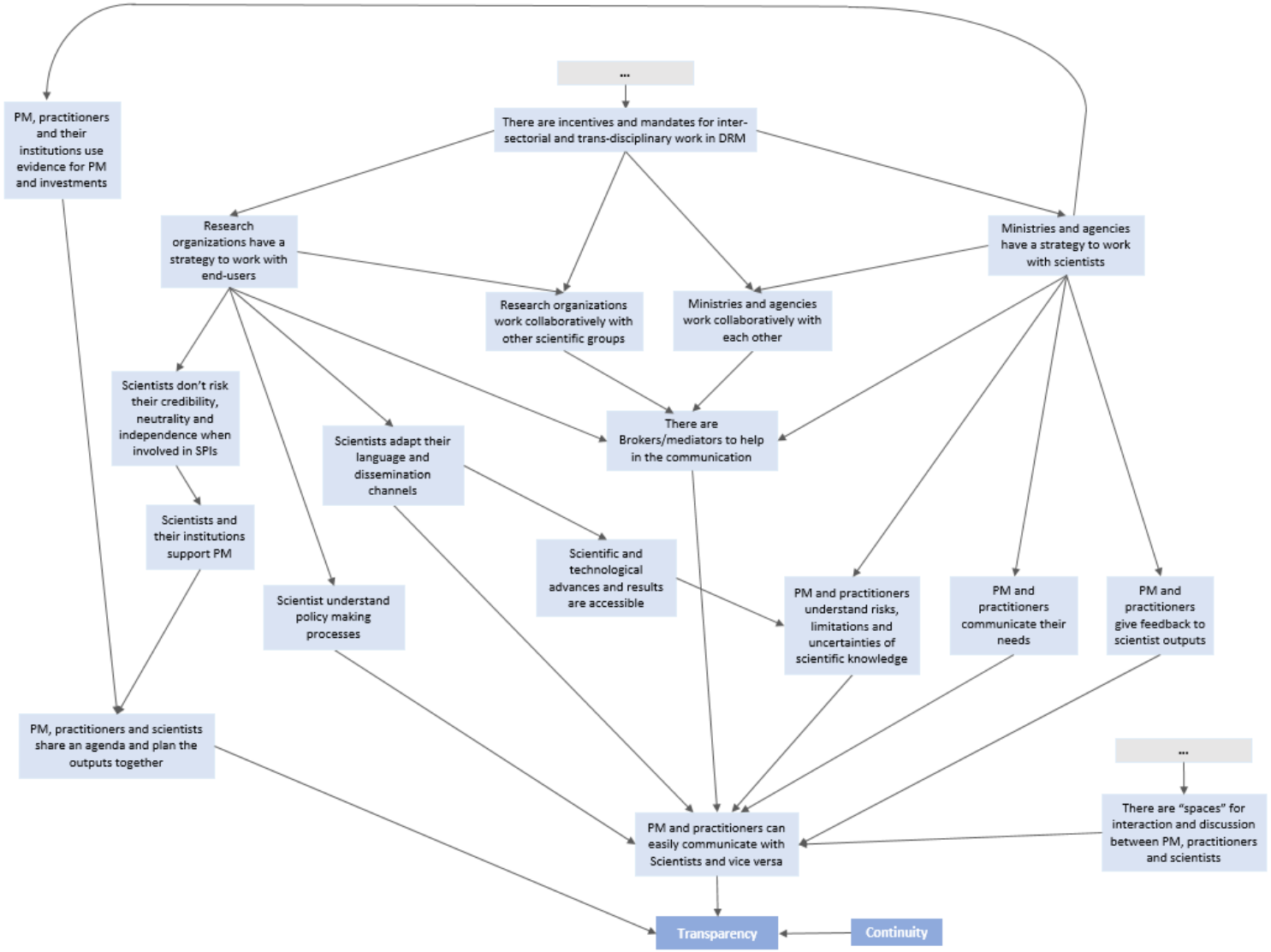
Multidisciplinary participation



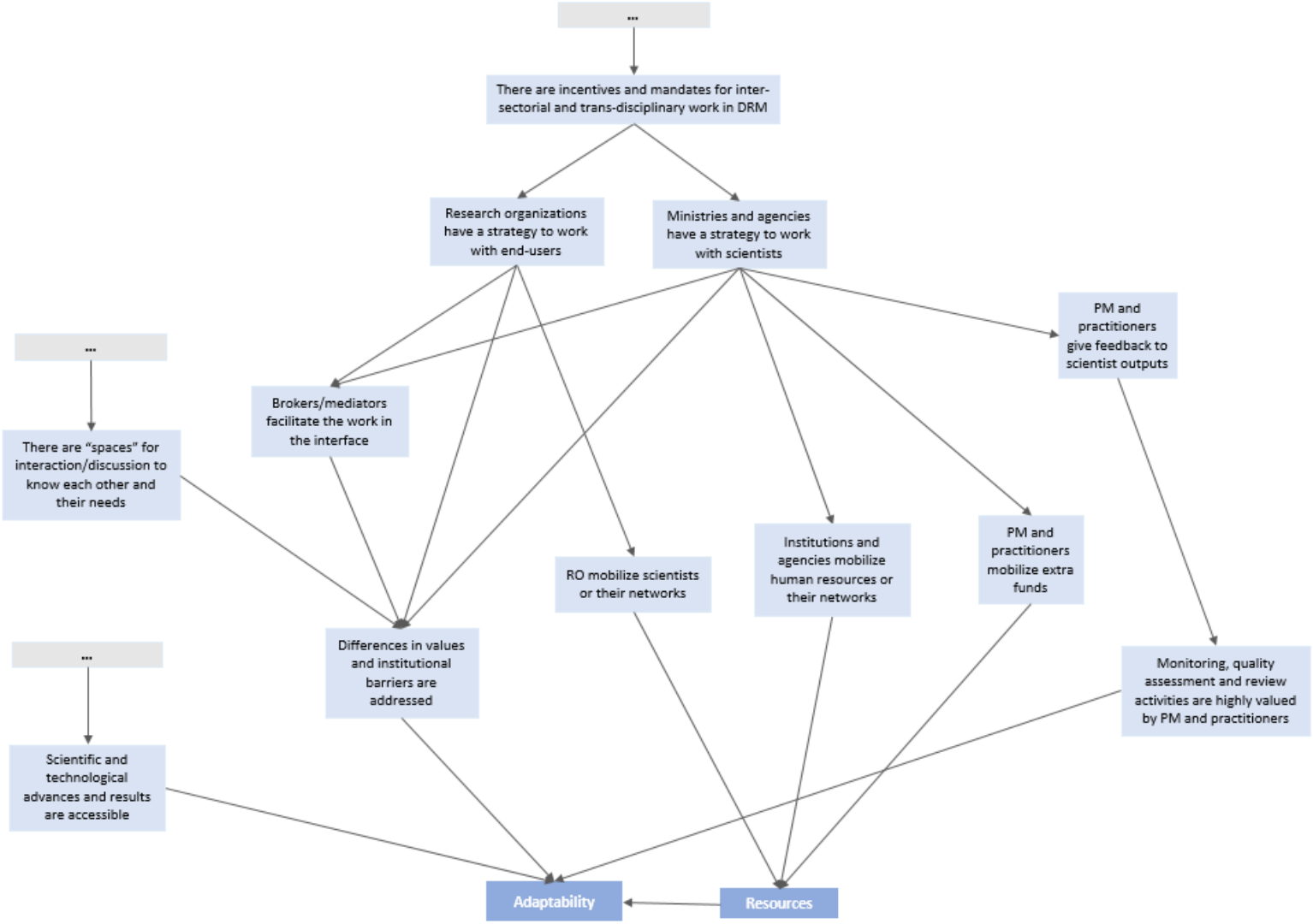
Resources


Ministries and agencies have a strategy to work with scientists
Ministries and agencies work collaboratively with each other
There are R&D groups within Ministries and governmental agencies
...
There are incentives and mandates for inter-sectorial and trans-disciplinary work in DRM
Funds are available for applied research
Research organizations have a strategy to work with end-users
There are incentives and resources for applied research
Institutions and agencies mobilize human resources or their networks
Research organizations promote working collaboratively with other scientific groups
RO mobilize human resources or their networks
Scientists and their institutions support PM
Research results are open
Adaptability
Resources
Continuity

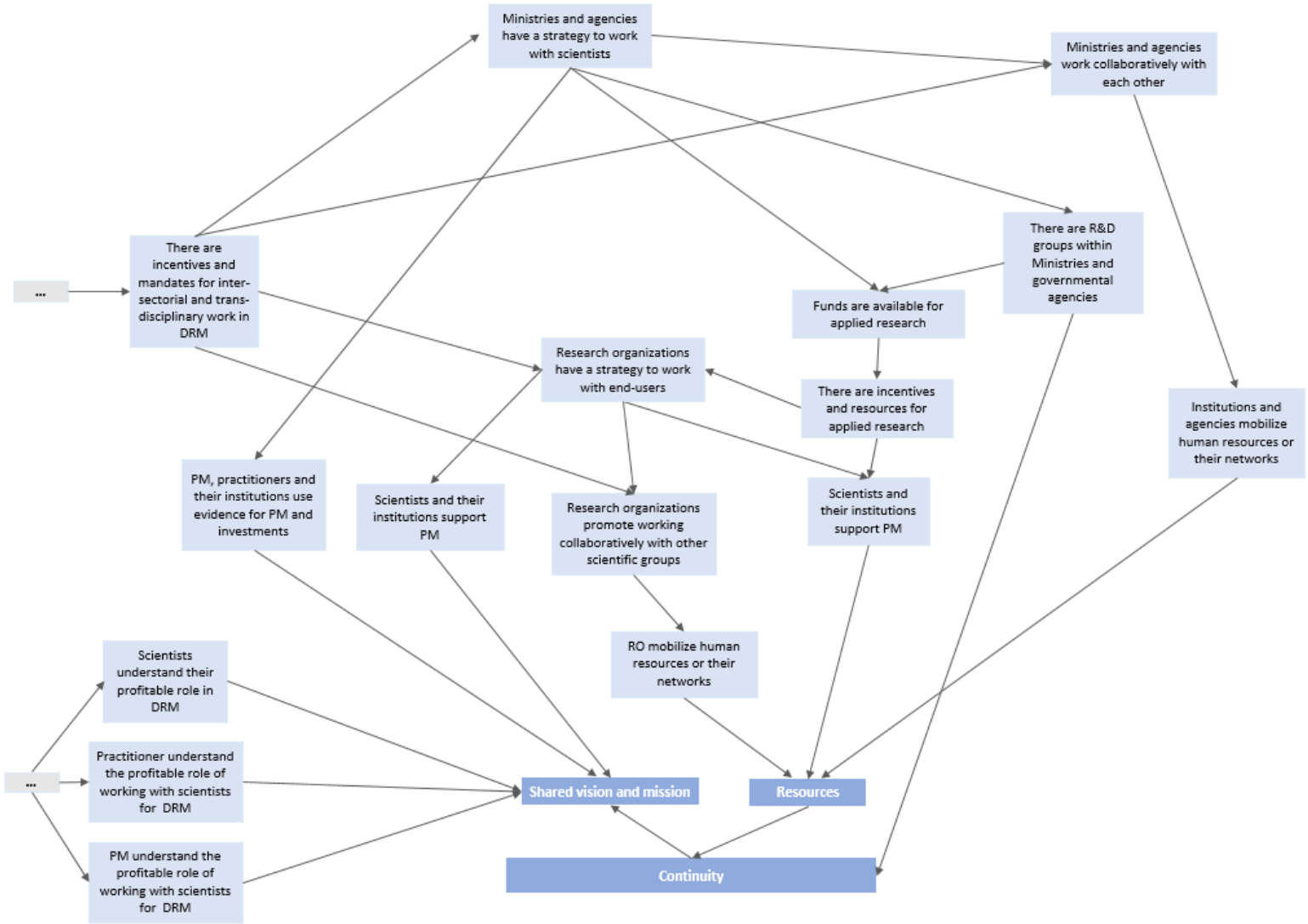
Transparency



Adaptability



Continuity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There are R&D groups within Ministries and governmental agencies
Funds are available for applied research
Research organizations have a strategy to work with end-users
There are incentives and resources for applied research
Institutions and agencies mobilize human resources or their networks
PM, practitioners and their institutions use evidence for PM and investments
Scientists and their institutions support PM
Research organizations promote working collaboratively with other scientific groups
Scientists and their institutions support PM
RO mobilize human resources or their networks
Scientists understand their profitable role in DRM
...
Practitioner understand the profitable role of working with scientists for DRM
PM understand the profitable role of working with scientists for DRM
Shared vision and mission
Resources
Continuity

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List of abbreviations and definitions

DRR:	disaster risk reduction
DRM:	disaster risk management
DRMKC:	Disaster Risk Management Knowledge Centre
EWS:	early warning system
SPI:	science policy interface
UNISDR:	United Nations Office for Disaster Risk Reduction

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LB-NA-28280-EN-N

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doi:*10.2788/196166*

ISBN *978-92-79-64398-9*