



Image: Evgeny Dubinchuk – https://stock.adobe.com/be_en/images/large-flames-of-forest-fire/24003771?prev_url=detail
Icon in page corners: Fire icon by Nicolas Vicent, from the Noun Project (<https://thenounproject.com/search/?q=fire&i=91161>)

Knowledge-Based Crisis and Emergency Management

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Key takeaways:

- Science and knowledge enable a shift from reactive to proactive risk management.
- Scientists, policymakers and practitioners must work together. In particular, in the emergency management context, it is essential to create tight feedback loops between scientific developments and their application in the real world. Trust and transparency are crucial in this relationship.
- Scientists must learn what information to provide to whom at what time and in what format, so the information is directly relevant in the decision-making process of practitioners.
- In a disaster context, maps are essential communication tools. They can help build a narrative and can show evolution in time, historical background, thematic information and context information.
- No expert or single organisation can be sure to provide comprehensive science advice on everything alone. For a science for policy organisation, it is crucial to establish long-term partnerships with complementary organisations to leverage and exploit expertise and skills beyond the own organisation.

Please note that this chapter was drafted before the global COVID-19 outbreak. Some of the advice will inevitably benefit from further reflections from managing this crisis. Learning the lessons from COVID-19 response and the role of science in it is a crucial task to the wider science for policy community. The JRC is fully committed to it and will share the results in future publications.



Starting from a situation where knowledge was used on an ad hoc basis, uncoordinated across hazards or sectors, and where emergency management was mainly reactive, without links to prevention and forward looking reconstruction, we have come a long way (UNISDR, 2015). Knowledge is now considered as part of the crisis response, rather than supporting it (IFRC, 2005). Two or three decades ago, the typical situation during a crisis was one of lack of information. Any piece of science-based information – be it a map, a satellite image or an analysis of press coverage – was welcome and used, but there were few mechanisms to deliver this information systematically and timely. Fast forward 20 years and we are in a situation of information overflow with new challenges of making sense of contradictory and volatile information for decisions that affect a reality with ever-more complex sociotechnical interdependencies, including ethical and legal considerations (Comes et al., 2017).

Being active for over 20 years not only at European Union (EU) level but also at global level, national level and local level, we have built an insight into roles and needs for science advice at each government level. Some of our key conclusions are described below.

Knowledge Is Enabling the Shift From Reactive to Proactive Risk Management

Emergencies are situations where a natural hazard, a technological accident, a disease outbreak, a violent conflict or another event shocks society and may become a disaster if not managed well. They are typically fast-changing situations with many stakeholders where decisions must be made based on incomplete information and in chaotic circumstances. In this context, scientific data, such as early warnings, real-time sensor observations, monitoring systems or predictive models, have the potential to fill an information vacuum and allow emergency responders to make more informed decisions. However, getting science advice to the right person at the right time in the right format remains an enormous challenge.

Science is equally useful in reducing disaster or conflict risk, such as taking mitigation measures for known risks, plan preparedness actions ahead and prevent the creation of new risk. In this context, science can offer a detailed understanding of current risk, future risk (with scenarios of demographic change, climate change, land use change or socioeconomic volatility), the expected impacts of disasters in multiple economic and social sectors and cost-benefit analyses of preventive measures. Also here, it is a huge challenge to bring science advice into a political process where it competes with vested and special interests, other policy priorities and short-term thinking. In addition, science advice faces the difficulties of communicating complex multidisciplinary science to a nonscientific and multisectoral audience.

The science-policy interface in the EU is quite diverse, with some models centralising the function through Chief Science Advisors and others with networks, partnerships or boundary

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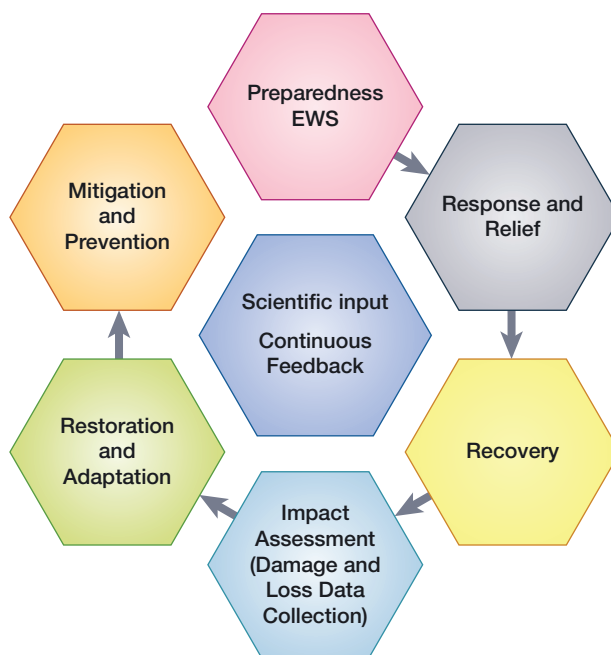
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organisations (Marin Ferrer et al., 2016). A golden rule in crisis and emergency management is to handle crises as local as possible and as global as necessary. Subsidiarity is essential not only as a principle of EU law but also as a crisis management principle. However, it makes the landscape of actors complex and multilayered, and, crucially, responsibilities for decision-making may escalate from one level to the next, involving coordination at EU level in extreme cases. Furthermore, as disaster risk reduction is a cross-sectoral policy, decisions on prevention involve many sectors of government simultaneously. It is therefore not surprising that the EU's Civil Protection legislation (Decision 1313/2013¹) requires the Commission to 'take action to improve the knowledge base on disaster risks and facilitate the sharing of knowledge, best practices and information, including among Member States that share common risks'. A shared knowledge base across policy levels and sectors is essential to have coherent crisis management and risk reduction.



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Crisis and emergency management are part of a disaster risk management cycle with six distinct phases. Sound risk assessment based on science and knowledge is essential for well-informed risk management.

¹<https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32013D1313>.



Five Lessons We Learnt

Create a Virtuous Feedback Loop Between Science, Policy and Practice

The most important lesson is that scientists, policymakers and practitioners must work together. In particular, in the emergency management context, it is essential to create tight feedback loops between scientific developments and their application in the real world. This allows scientists to see firsthand the strengths and weaknesses of their systems and focus further research and development where it is most needed. It allows practitioners to be involved in the design of systems from the beginning, understand possibilities and limitations, and therefore trust the information at time of crisis.

The codesign of our scientific work with policymakers and practitioners is now embedded in our corporate strategy. In practice, it requires an open and flexible approach from our scientists to work and deliver at the speed of crisis management practitioners or policy decision-makers. This is a mind shift that is well worth making as new research and solutions are continuously tested in the 'real world' (Box 1).

Our scientists frequently provide ad hoc scientific advice in crisis situations, including sectorial advice. For example, we sometimes provide rapid science-based response to requests from DG Agriculture and Rural Development concerning extreme agrometeorological conditions in specific regions of the EU. We can do this, thanks to a flexible organisation and expert staff that can be rapidly mobilised in addition to frequent communication with relevant policy stakeholders, anticipation and preparedness (e.g., prepare basic data on weather, agrometeorological indicators and crop model results readily available). This, in turn, is made possible because many of these elements are in place for regular non-crisis-related activities (for example, the **JRC MARS Bulletins Crop Monitoring in Europe** providing monthly yield forecasts, <https://ec.europa.eu/jrc/en/mars/bulletins>).

Furthermore, tight collaboration during the crisis management cycle led to a buildup of expertise in crisis rooms and crisis management support tools in the **European Crisis Management Laboratory**, which contributed to the launch of the Commission's Emergency Response

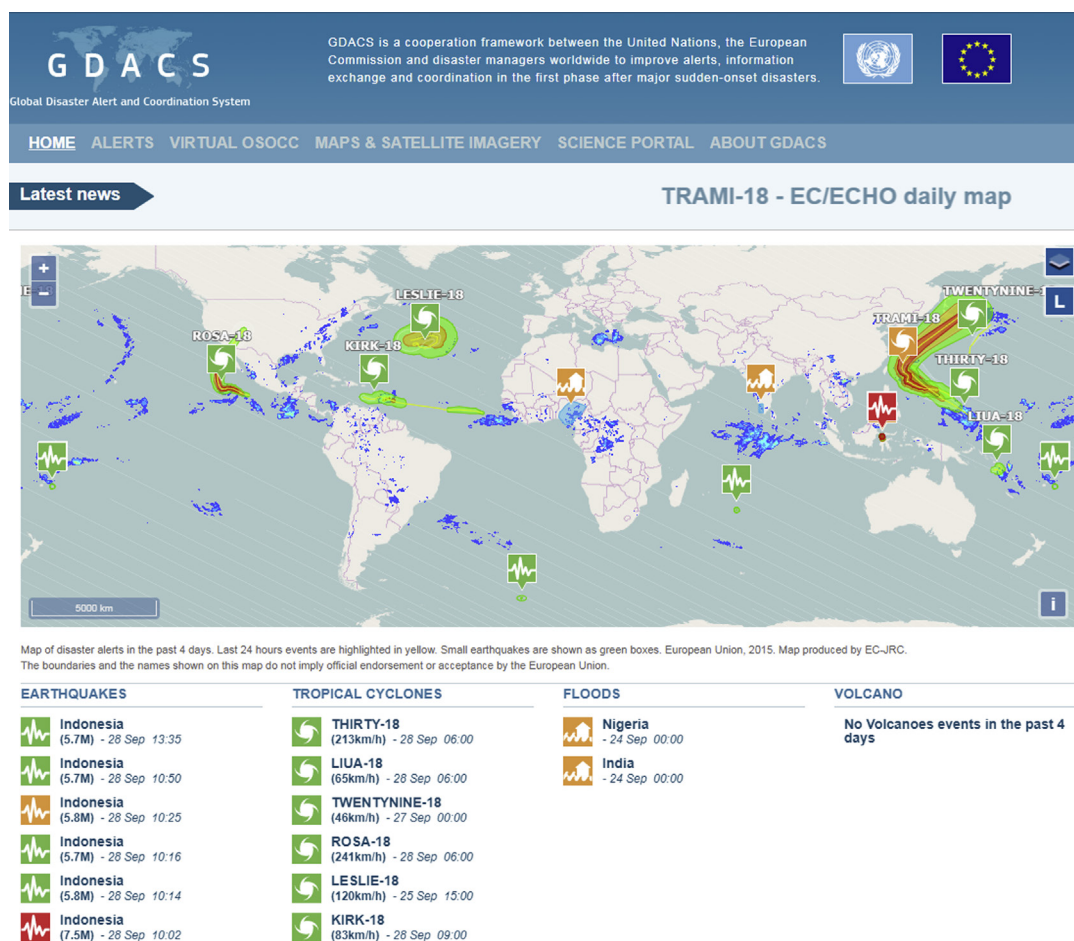


The European Commission's Emergency Response Coordination Centre was built in close collaboration with the Joint Research Centre.



Box 1: Global Disaster Alert and Coordination System

The JRC has worked since 2002 with the Commission's emergency response service (DG ECHO) to develop systems to forecast and monitor disasters for the European continent and globally. The Global Disaster Alert and Coordination System (GDACS, www.gdacs.org) was started in 2004 (De Groeve et al., 2006) and has been continuously developed in close synergy with DG ECHO and the UN Office for Coordination of Humanitarian Affairs, as well as emergency services of countries worldwide. Its development is driven largely by acute needs during disasters for which innovative solutions are built during the emergency and later integrated in the system. For example, a global tsunami calculation system was piloted during the 2004 tsunami in Indonesia and deployed in GDACS in 2005 (Annunziato, 2005, 2007). Similarly, GDACS was expanded to include global storm surge calculations associated with cyclones after the disasters of Katrina (2005, US), Nargis (2008, Myanmar) and Yasi (2011, Fuji and Australia). The in-house developed hydrodynamic model called Hyflux designed for dam break and nuclear accidents was adapted to model cyclone storm surges, with reliable and operational results (Probst and Franchello, 2012). Since then, it has been incrementally improved and radically redesigned based on operational experience (Probst and Annunziato, 2017).



The Global Disaster Alert and Coordination System is the result of over 15 years of collaboration between scientists and practitioners



Coordination Centre in 2013 (European Commission, 2018). We continue to deliver and improve, including through a networked approach with academia and industry (Fonio and Annunziato, 2018), most of the crisis management systems through a virtuous feedback loop between new research and the challenging environment of real crisis management. Innovation requires a constant interaction among scientists, practitioners and, crucially, the **private sector**, which can turn experimental ideas into reliable knowledge services. The **Copernicus Emergency Management Service** must be considered a major success story of this trilateral partnership in the EU. Originating in research, in 2014, it became an operational service that is contracted out to an ecosystem of European industry.

Right Information, Right Time, Right Format, Right Place

In most cases, science advice is not a challenge of lack of knowledge but rather of abundance of knowledge (Boersma et al., 2017). Scientists must learn what information to provide to whom at what time and in what format, so the information is directly relevant in the decision-making process of practitioners. In crisis management, this is often a daily or ad hoc briefing where strategic and tactical challenges are discussed. We have provided such advice for over a decade and have learned some lessons on timeliness, clarity and uncertainty.

Timeliness: For sudden-onset disasters, such as earthquake and tsunamis, speed is of the essence. The **Copernicus Emergency Mapping Rapid Mapping Service** (<http://emergency.copernicus.eu/mapping/>) is the operational outcome of years of research at JRC (Al Khudhairy et al., 2009; Corban et al., 2011) and in EU research programmes (e.g., SAFER project) on how to speed up the acquisition, processing and delivery of satellite-based mapping products. With delivery times less than 24h, the Copernicus service now provides useful evidence during crises. Having access to science advice under predictable service level agreements is important.

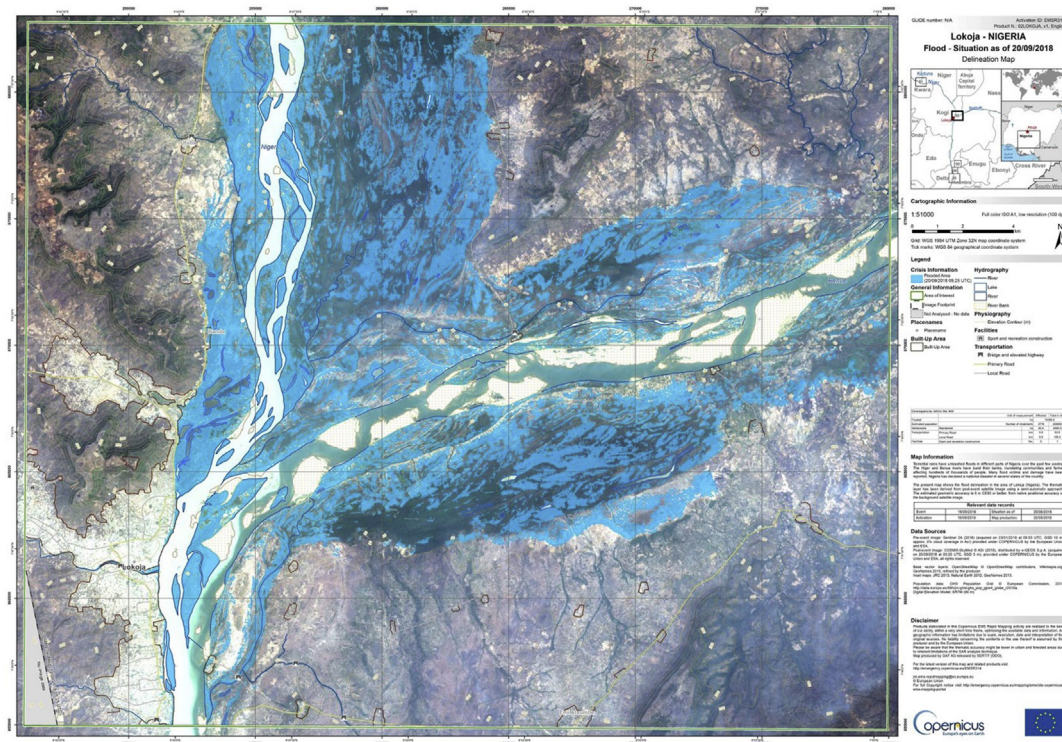
Following this example, our ad hoc science advice during emergencies is now being turned into a similar service: the **European Natural Hazard Scientific Partnership**. This service aims to bundle competences from several Member States to provide an EU-wide science advice service and will ensure scientists are available 24/7 in case of need. It is a service that is complementary to the science advice mechanisms of Member States (De Groeve and Casajus Valles, 2015).

Clarity: There is no need to communicate the full scientific complexity of a situation to make a decision on how to manage the crisis. On the contrary, an overload of information can be counterproductive and lead to bad decisions. Science advice is most effective if translated into clear and concise bullet point style information. For example, together with DG ECHO, we provide a daily overview of the main disasters (**ECHO Daily Flash**, <https://erccportal.jrc.ec.europa.eu/ECHO-Flash>) as well as a daily map to illustrate the most important event of

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Example of a map produced by the Copernicus rapid mapping service during severe floods in Nigeria in September 2018.

the day (**ECHO Daily Map**). These products are the result of years of fine-tuning the translation of science into action-oriented briefs.

Uncertainty: Even with the best science, no model or expert can know the future completely. Communicating probabilities, degrees of certainty and gaps in knowledge is a challenging task as decision-makers prefer a world in black and white. A good practice on communicating uncertainty in clear and useful graphics is the **European Flood Awareness System** (EFAS, <https://www.efas.eu>). EFAS forecasts of extreme floods are complex. Uncertainty of an ensemble of meteorological forecasts, meteorological and hydrological observations and land surface information is propagated through a deterministic hydrological model to assess the likely impact. The uncertainty of the resulting flood forecasts is visualised in graphs that allow users to understand reliability and consistency of forecasts at a glance.

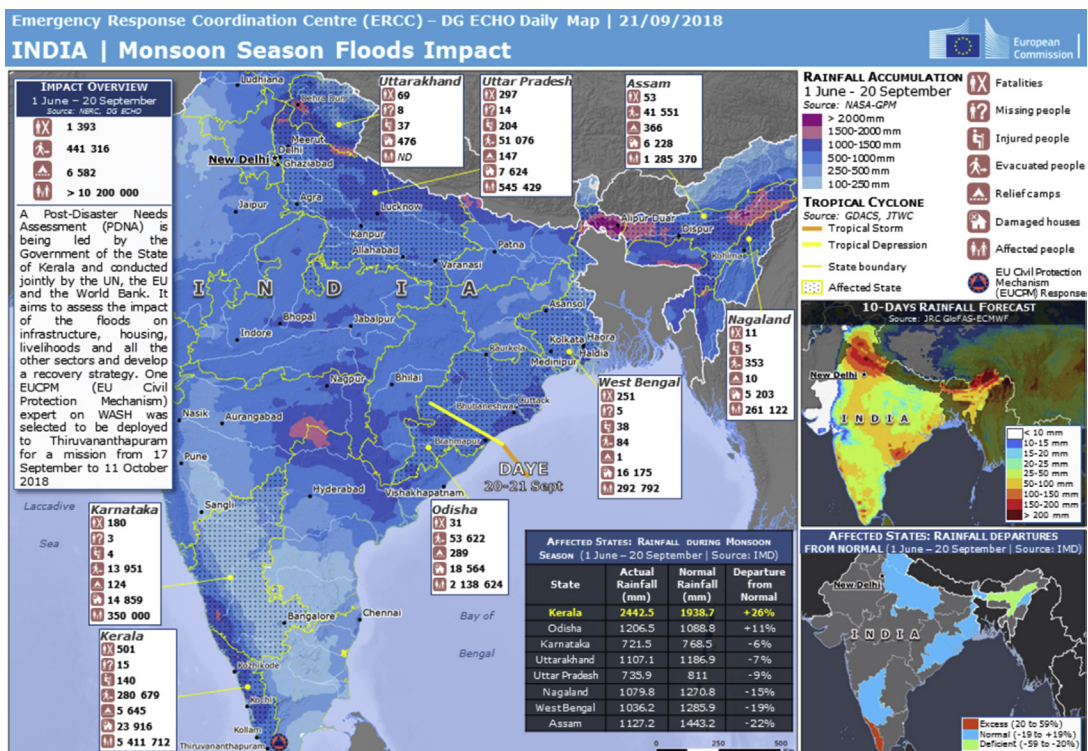
A Map Is a Thousand Words

Delivering science advice to a policymaker or a practitioner is a nontrivial task. Facts alone, without context or interpretation, are not enough to create meaning in the mind of the decision-maker. Instead, communication of science needs clear narrative (Allen et al., 2017): how



does this disaster compare to the previous one? Is this the worst ever, and is there a trend? How likely is this disaster to be influenced by climate change? Where is this disaster happening? How will affected people cope?

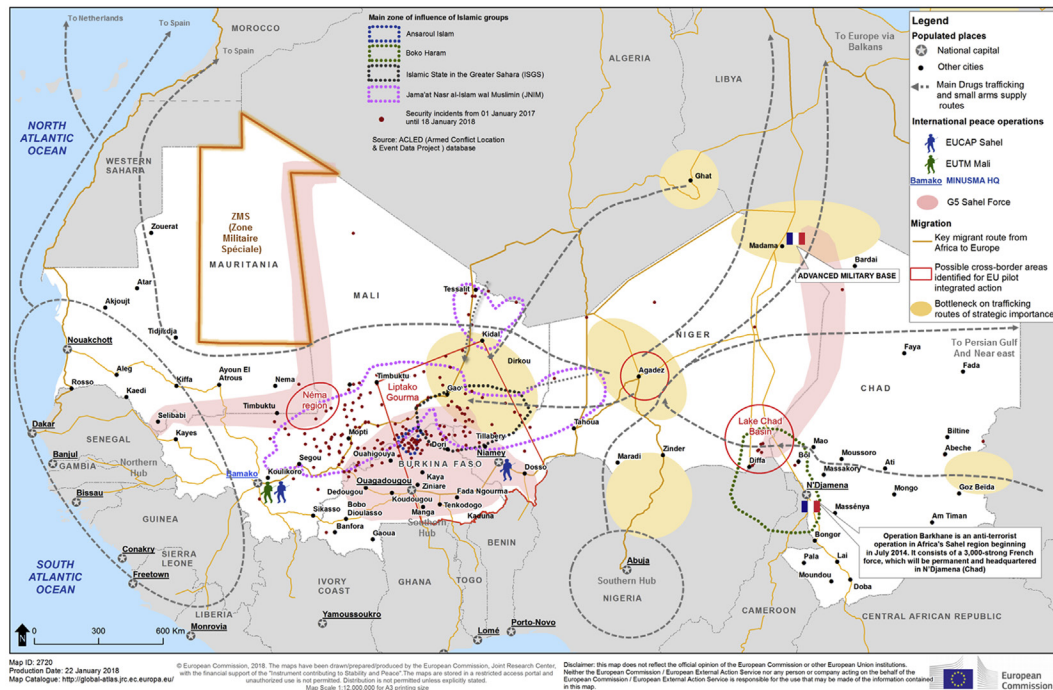
We have built extensive expertise in building narratives using maps, in particular in the area of crisis and emergency mapping. Modern geographical information systems allow combining many different datasets in a single map, overlaying layer over layer. Maps not only present information geographically but also can show evolution in time, historical background, thematic information and context information. JRC teams collect and triangulate open-source data and subsequently represent them in maps. To facilitate map reading, it is important to use consistent templates, styles and symbology, preferably following **internationally agreed practice** (e.g., [OCHA, 2012](#)). We are defining mapping standards for the Copernicus Emergency Management Service ([Broglia et al., 2010, 2013](#)), and we are collaborating with UN organisations to develop good practices, including coordination mechanisms to **avoid duplication** of efforts when several organisations make the same map ([IWG-SEM, 2015](#)).



Example of Daily Map of 21 September 2018. Use of standard symbols and standard templates facilitates the integration of maps in standard operating procedures.



G5 SAHEL - Security related aspects



Example of crisis map over Sahel, part of the Science and Peace portal of the JRC.

Good Science Advice Is Built on a Foundation of Trust

No decision-maker will blindly trust advice. She or he will judge the value of the advice based on past experience of the advisor. **Trustworthiness** is built through frequent interaction and a history of good advice and met expectations. As disasters are rare events, such interaction can be forced through exercises or simulations. Tabletop exercises are excellent opportunities to introduce new science and tools in decision-making process at local, national or global level, as demonstrated recently in the Global Flood Partnership (Salamon et al., 2018), which led to the launch of the **GFP Support Service**. We are investing, together with research partners in the EU, in making such interactions more systematic (Fonio and Annunziato, 2018). In the DRIVER+ project, we lead the work on developing a **pan-European Test-bed for crisis management** capability development enabling practitioners to create a space in which stakeholders can collaborate in testing and evaluating new products, tools, processes or organisational solutions.

Transparency is equally important, both for data and methods. Science advice should not be a black box, in particular for public policy where accountability towards the citizen is of primordial importance. On the contrary, science advice is best based on open data and open



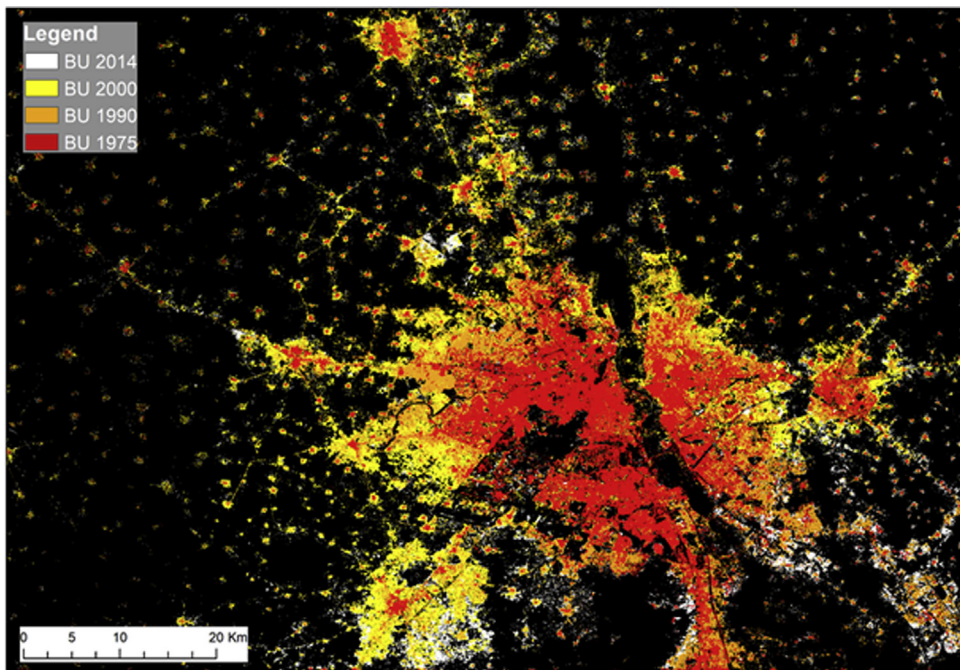
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methods, which are reproducible and can be reviewed by peer scientists. One good example at JRC is advice based on the Global Human Settlement Layer (GHSL, <https://ghsl.jrc.ec.europa.eu/>), a **new open and free tool for assessing the human presence on the planet**. The data and methods were published early on (e.g., [Pesaresi et al., 2016](#)), its artificial intelligence algorithms produce explicit rules and a wide community of experts in the **Human Planet Initiative** (<https://ghsl.jrc.ec.europa.eu/HPI.php>) are vetting and developing

the products. GHSL-derived information is now instrumental in urbanisation policy and also contributes to policies in sustainable development, disaster risk management and climate change.

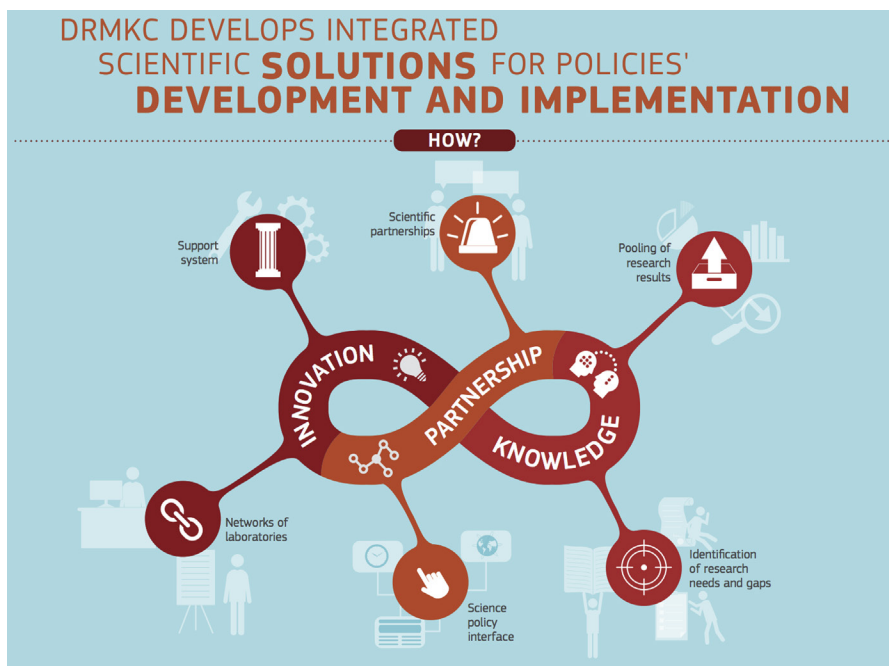


Example of the Global Human Settlement Layer for New Delhi, India, based on Landsat data. The colours illustrate the growth of the city from 1975 (red) to 2015 (white).



Transdisciplinary Learning Through Networking and Partnerships

No expert or single organisation can be sure to provide comprehensive science advice on everything. As a scientific organisation providing scientific advice, it is crucial to establish long-term partnerships with complementary organisations to leverage and exploit expertise and skills beyond the own organisation (UNISDR, 2016; Clark et al., 2017). For example, the Global Wild-fire Information System (<http://gwis.jrc.ec.europa.eu/>) is a JRC-led initiative under the umbrella of the Group of Earth Observations that is bringing together existing information sources at regional and national level in order to have a comprehensive view and evaluation of fire regimes and fire effects at global level (San Miguel, 2017). We also champion the Global Flood Partnership (<https://gfp.jrc.ec.europa.eu/>), the Global Drought Observatory (<http://edo.jrc.ec.europa.eu/gdo>) and the Index for Risk Management (INFORM, <http://www.inform-index.org/>), each with a mix of scientific, practitioner and government members (De Groeve et al., 2015; Vogt et al., 2017; Marin Ferrer et al., 2017). These partnerships allow our scientists to learn efficiently from others and to build capacity of international partners by providing our own open-source tools and knowledge. Chapter 10 focuses on how to ensure that different interests common for partnerships do not jeopardise the quality of the science for policy work.



JRC's Disaster Risk Management Knowledge Centre (DRMKC) facilitates information and knowledge while enhancing the connection between science operational activities and policy



Even more important is to invest in building or participating in international and transdisciplinary networks to increase exposure to new knowledge and alternative views. This can start new conversations across boundaries of scientific disciplines, policy areas or international borders. The JRC's Disaster Risk Management Knowledge Centre (<https://drmkc.jrc.ec.europa.eu/>) is an excellent example of how this can work. The multifaceted Knowledge Centre enables thousands of participants in EU Member States to learn from each other and spread widely ideas, research results, good practices and opportunities for collaboration.

Whether it is for horizon scanning, foresight, long-term climate adaptation, mid-term disaster prevention or short-term emergency management, a broad understanding of the complex landscape of disaster risk management is the foundation for good science advice.