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Contents

EDITORIAL

The importance of managing flood risk

Flooding can bring profound and lasting effects on citizens, businesses and agriculture. According to the Centre for Research on the Epidemiology of Disasters' (CRED)[1] global statistics on natural hazards, the 416 flood events in Europe from 1980 and 2009 which are classified as 'significant' affected 8.9 million people, caused 2,546 fatalities and incurred economic damages of over €75 billion.

This Thematic Issue brings together recent research that gives us insight into changes in European flood risk policy, which could help policymakers deal with the projected increases in flood risk.

'Flood risk' is defined as the likelihood of a flood occurring (from any source) combined with its associated effects on people, commerce and the environment. The risk can be altered by anything that changes the probability of flooding and/or its consequences. For example, flood risk can be affected by changes in the way a river responds to rainfall, or by socio-economic change, such as changes in agricultural practice. Thus flood risk is not static but responds to social, economic and environmental changes, such as the changes in precipitation identified in the IPCC Fourth Assessment report[2], which suggest that there will be an overall increase in flood risk in most scenarios of future climate, although the risk will vary considerably, depending on the region.

The greater risk of floods means that flood risk management has become a major challenge, both in engineering and societal terms. Flood risk management schemes aim to decrease the probability and impact of floods - taking into account factors that include the avoidance of development in areas likely to flood, to ensuring that local populations are informed and know what to do in the event of a flood. Thus flood risk management needs a holistic approach which takes into account the problems of rainfall, rivers and flooding, in addition to the problems of societal planning and administration. During the last two decades, many Member States have used this holistic and proactive approach in their flood risk management programmes.[2]

Managing residual risks has become a priority, with a focus placed on enhancing the resilience of individuals, businesses and communities to flooding. Residual flood risks are those which remain even after flood risk management measures have been put in place. For example, when a large flood causes damage by overcoming a flood bank which is designed for smaller flooding events.

The importance of flood risk management in EU policy is encapsulated in the 2007 Floods Directive[3]. The Directive, which has been adopted in every Member State of the EU, sets out a framework for managing and reducing risks. Under the Directive, the first round of preliminary flood risk assessment, flood risk mapping and production of Member States' flood risk management plans is underway, with a completion date of December 2015.

Two articles in this issue address flood risk at the European scale. **'New estimates of climate change's economic and physical consequences in Europe'** covers aspects of the recent Projection of Economic impacts of climate change in Sectors of the European Union (PESETA)[4] project. Findings from this project suggest that, by 2100, climate change could lead to annual damages from river flooding for the EU that cost €14 to €21.5 billion a year. **'A European scale assessment of river flood risk'**, indicates that the average annual damage from river flooding is highest in Europe for many Eastern countries, Scandinavia, Austria and the UK, as well as some areas of France and Italy.

The European Flood Alert System (EFAS), which generates twice-daily forecasts of river floods up to 10 days in advance of each event, has not been fully integrated into Member States flood risk management programmes. **'Improving use of the European Flood Alert System'** identifies the effects of cultural and institutional barriers (such as persuading institutions to

make use of EFAS's medium-term flood forecasts, rather than short-term warning systems) to integrating EFAS into national flood warning systems.

Flash floods are challenging to observe and conventional networks to measure rainfall and river flow are not always sufficiently dense to be in the right place to monitor such events. **'Flash floods in Europe characterised'** describes how an improved understanding of flash flooding, and therefore an improved flood risk management, could be achieved through post-flood observations, a re-examination of weather radar data and through the use of combined weather and hydrological modelling.

The connection between land use, land management and flooding is complex, but action on these may also form part of flood risk management plans. **'Land use change and land management influence floods in small catchments',** presents a study which investigated how land cover changes in Slovakia in recent decades have affected the frequency of flood events in small catchments. The management of forest activities such as logging, and activities that reduced rainfall absorption, seemed to have influenced the frequency of flooding. **'Steps to improve flood resilience on the ground'** highlights three case studies that provide insight into how resilience is put into practice. Two of the case studies (Flanders in Belgium and Niedersachsen in Germany) suffer from lowland river flooding, while the third, Calabria, in Italy, experiences flash floods. Findings showed that, although flood management tools were in place, they were sometimes unused and often poorly understood by local residents.

Emergency flood plans in England and Wales, France and the Netherlands are reviewed in the article, **'How well do flood emergency plans meet management needs?'** The essential information needed for effective flood emergency plans is identified in the article. This includes details on plan activation (i.e. triggers, such as flood levels that lead to action), details on flood hazard and impacts and evaluation.

Most respondents to a recent, large-scale European survey, claimed not to have prepared themselves for floods, even though they knew that their property was at risk of flooding. Some key results of this survey are presented in the article **'Communicating flood risk: public awareness does not ensure public preparedness'**. The survey findings indicate that fear-inducing communication campaigns aimed at increasing public awareness of floods are inadvisable, given that, for most people, being worried about a potential hazard does not mean they will be more prepared.

The economics of flood risk management should be evaluated in terms of efficiency, that is, the sum of a project's costs and benefits over its lifetime. **'Multi-criteria analysis - the better way to evaluate flood management'** describes how this approach captures the overall value of non-structural measures, such as warning and evacuation systems, that are effective in meeting specific standards of flood protection.

New research summarised in **'The Floods Directive: lessons from Germany for effective implementation'** suggests that management decisions at the catchment scale should be discussed with stakeholders, such as local water boards, at sub-catchment levels, who play a central role in flood risk management. Although an essential part of the process, experts should not be the sole decision makers. The findings of scientific studies, such as those highlighted in this flooding Thematic Issue, can prove essential to the design of effective flood risk management strategies.

However, the recent FLOODrisk 2012 conference[5] highlighted some important barriers between science and policy, such as the tendency for scientists to only share their findings within their scientific community.

As a result of these discussions, actions to improve flood risk management through a better science-policy interface, such as setting up a professional body for flood risk management, are in preparation.

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1 See www.cred.be
2. Klijn. F., Samuels, P. and van Os. A. (2008). Towards flood risk management in the EU: State of affairs with examples from various European countries. *International Journal of River Basin Management* 6 (4):307-321.
3. IPCC. (2007). *Climate Change 2007: The Physical Science Basis* - Summary for Policymakers. Climate Change 2007: World Meteorological Organisation.
4. See http://peseta.jrc.ec.europa.eu
5. www.floodrisk2012.net

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Theme(s): Climate change and energy, Environmental economics, Natural hazards, Water

New estimates of the physical and economic consequences in Europe of climate change

Research into future climate scenarios suggest that by 2100, climate change could lead to annual damages in the EU from river flooding alone of €14 billion to €21.5 billion, with more people affected than today, and a reduction in household welfare.

"For river flooding, the researchers found that the number of people affected annually (compared to the 1961-1990 baseline) could rise by around 250,000 to 400,000 per year, depending on the climate future."

The White Paper on Adaptation from the European Commission sets out a framework to reduce the EU's vulnerability to climate impacts. It highlights that much remains unknown about the potential impacts of climate change on the European economy, different economic sectors and geographical regions.

A study conducted within the PESETA project[1] investigated economic and physical effects of climate change on five key areas: river floods, coastal areas, agriculture, tourism and human health, while considering how these impacts could vary for EU different regions. The researchers modelled the impacts under two IPCC scenarios of climate change for the 2080s involving high-emissions (A2) and low-emissions (B2), assuming that future climate would affect the current economy.

The combination of models used with these scenarios led to four possible climate futures, with average temperature rises of 2.5°C, 3.9°C, 4.1°C or 5.4°C. The study considered temperature and precipitation changes for individual regions, amongst other climate variables, and assessed the projected impacts of the four climates on the economy, in terms of changes to household welfare (i.e. satisfaction derived from household consumption and leisure).

For river flooding, the researchers found that the number of people affected annually (compared to the 1961-1990 baseline) could rise by around 250,000 to 400,000 per year, depending on the climate future. Western and central Europe had most flood impacts in all climates considered, but a reduction in spring snowmelt floods led to north eastern Europe experiencing less flood damage in the four scenarios.

For coastal flooding, the estimated increase in number of people affected annually (compared to 1995) varied with the temperature increase. The 2.5°C increase, coupled with 49cm sea level rise, affected 775,000 people, whereas the 5.4°C increase and 88cm sea level rise affected 5.5 million. The ranges of loss in household welfare and drop in GDP were 0.16-0.46% and 19-0.24%, respectively.

The researchers cautioned that the study probably underestimates the impacts of climate change through uncertainties in the modelling and the exclusion of potential impacts from possible climate catastrophes and non-market impacts, such as ecosystems and extreme weather.

A separate study[2], involved a pan-EU assessment of fluvial flood risk, also under the climate scenarios A2 and B2. The researchers estimated fluvial flood risk up to the year 2100 with several models which captured climatic, oceanic, hydrological and atmospheric processes. Overall, the costs of estimated annual flood damages for the EU were expected to total €14-15 billion (in constant prices of 2006) under the B2 scenario, and €18-21.5 billion under the A2 scenario.

Current annual flood damages in the EU amount to €6.4 billion. Although only two climate scenarios were used, the researchers suggest that both are plausible, and that their assessment provides decision makers with an indication of future flood developments and a basis for exploring flood management measures.

Source: Ciscar, J-C, Iglesias, A., Feyen, L. *et al.* (2011) Physical and economic consequences of climate change in Europe. *Proceedings of the National Academy of Sciences.* Doi:10.1073/pnas.1011612108.

1 *PESETA (Projection of Economic impacts of climate change in Sectors of the European Union based on boTtom-up Analysis) was supported by the European Commission. See: http://peseta.jrc.ec.europa.eu/*

2. *Feyen, L., Dankers, R.,Bódis, et al (2012) Fluvial flood risk in Europe in present and future climates. Climatic Change. 112(1): 47-62. DOI 10.1007/s10584-011-0339-7.*

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Theme(s): Natural hazards, Environmental information services

A European scale assessment of river flood risk

Researchers have created a simple tool to analyse the risk of river flooding across almost all of Europe, and to estimate the associated economic losses. They found that Eastern Europe, Scandinavia, Austria and the UK are the regions and countries most at threat.

"...policymakers need to be able to identify flood risks to help design and implement effective mitigation strategies."

Since 2000, there have been several major floods in Europe, causing significant damage to property and loss of life. As the frequency of such extreme weather events increases under current scenarios for climate change, and growing populations mean that more buildings are erected on floodplains, policymakers need to be able to identify flood risks to help design and implement effective mitigation strategies.

The European Directive on the assessment and management of flood risks[1] requires all EU Member States to identify flood risk along all of their rivers and coastline and create flood risk maps by 2013 and flood risk management plans by 2015. However, there is no current assessment of overall flood risk across all of Europe.

To address this, the researchers, with support from the EU ADAM project[2], developed a Europe-wide tool to provide an assessment of the direct risk, in economic terms, from river flooding. They combined data on three aspects of risk: exposure - which is the value of assets at a given location threatened by flooding; vulnerability - defined as the lack of resistance to damage; and hazard - describing the magnitude of the flood and the probability of it happening.

Data on exposure came from the CORINE Land Cover map for Europe, and information from previous studies allowed the researchers to estimate the value of the land at each location. To keep the tool relatively simple, the researchers calculated the vulnerability of the assets under threat as a function of the depth of flooding they were exposed to. Hazard information came from a 1km resolution Flood Hazard Map, which combined the Pan-European river network database with a digital terrain model to define five hazard classes.

Combining all three elements resulted in a series of damage maps that included data on flood depth, land cover and land value and damage. The researchers then aggregated these detailed maps to provide regional and national-level results more useful for economic modelling and policy formulation. The results were shown as annual average damage in a region.

The research identified that average annual damage was highest for Eastern Europe, Scandinavia, Austria and the UK, as well as some areas in France and Italy. The researchers note that the tool may overestimate the potential economic losses, although such conservative estimates do serve to draw attention to high risk areas and counterbalance the lack of information on risk from rivers too small to be captured in the scale of the analysis.

Source: Lugeri, N., Kundzewicz, Z.W., Genovese, E., Hochrainer, S., & Radziejewski, M. (2010) River flood risk and adaptation in Europe – assessment of present status. *Mitigation and Adaptation Strategies for Global Change.* 15 (7): 621-639. DOI: 10.1007/s11027-009-9211-8.

1. *See: http://ec.europa.eu/environment/water/flood_risk/index.htm*
2. *ADAM (ADaptation And Mitigation Strategies: supporting European climate policy) was supported by the European Commission under the Sixth Framework Programme. See: http://www.tyndall.ac.uk/adamproject/about*

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Improving use of the European Flood Alert System

Cultural and institutional barriers, coupled with a lack of confidence about whether and how to use it, mean that the European Flood Awareness System (EFAS) has yet to be fully integrated into national flood warning systems, according to a recent study.

"...none of the 29 flood forecasters interviewed used the EFAS to trigger earlier responses and instead preferred to rely on short-term warning systems, thus reducing the chances of 'false alarms'."

EFAS is a European Commission warning system for floods from rivers, for which it generates twice-daily forecasts up to 10 days in advance of a flood. The EFAS was developed by the EU's Joint Research Centre (JRC) in Ispra, Italy, from the results of an earlier Fifth Framework programme collaborative research project.

It began issuing alerts on an experimental basis in 2005 before making the transition to full operational status in 2012 as part of the Commission's wider Global Monitoring for Environment and Security (GMES) Emergency Management Service. EFAS uses ensemble prediction systems (EPS) used in weather forecasting to determine a range of possible outcomes given the large uncertainties about the underlying weather and its evolution.

The study investigated the communication, understanding and use of information from the EFAS during the pilot phase of its experimental development. Data on the use of EFAS alerts for flood management were obtained from 69 formal interviews conducted between 2008 and 2010 with weather forecasters, civil protection authority officials and policymakers in 17 countries across Europe. These data were compared with feedback from users of the EFAS, collected since 2003, at meetings and in annual reports.

EFAS alerts are communicated via a password protected website, which can be checked daily by forecasting agencies that have signed a formal memorandum of understanding with the JRC. In terms of perception, site visits and interviews revealed that these medium-term 'pre-alerts' for transnational rivers were often deemed as unnecessary or too uncertain for operational use. Locally-calibrated, fine-resolution models, which could deal with smaller-scale issues, such as flash floods, were preferred.

Medium-term alerts from EFAS were used to raise internal awareness within forecasting centres. However, none of the 29 flood forecasters interviewed used the EFAS to trigger earlier responses and instead preferred to rely on short-term warning systems, thus reducing the chances of 'false alarms'. More effort is therefore needed to encourage institutions to make use of medium-term flood forecasts.

Improved communication of how flood thresholds are calculated is also needed so that EFAS users can understand how the information can be integrated into their own warning systems. In turn, the EFAS team needs to understand more about the requirements of local flood forecasters responsible for managing both large river floods and also small-scale floods beyond the scope of EFAS.

The research also highlights deeper questions about how useful earlier warnings issued at higher thresholds of uncertainty are; institutions need to balance safety with damage to their reputation and incurred costs if warnings do not lead to flood situations. Despite this, changes made to the EFAS, such as the introduction of hydrographs (which measure the rate of flow of water at a specific point), have led to increased user satisfaction and demonstrate the effectiveness of user feedback. The study predicts that confidence in the EFAS will grow as the system continues to improve.

Source: Demeritt, D., Nobert, S., Cloke, H.L., Pappenberger, F. (2013) The European Flood Alert System and the communication, perception, and use of ensemble predictions for operational flood risk management. *Hydrological Processes.* 27: 147-157. DOI: 10.1002/hyp9419.

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Theme(s): Natural hazards, Water

Flash floods in Europe characterised

Improved understanding of flash flooding could be achieved through post-flood observations, re-examination of weather radar data and the use of combined weather and hydrological modelling, according to the recent HYDRATE research project. This information can be used to improve flash flood forecasting.

"Characterising flash floods is important to developing improved predictions and preparations for flash floods."

Flash floods are serious natural hazards that are caused by intense rainfall and are usually associated with extensive flooding. They typically arise very quickly (often less than six hours between rain falling and flooding) and can endanger lives and damage infrastructure through their swift flow and the debris carried in the flood waters.

Characterising flash floods is important to developing improved predictions and preparations for flash floods. However, because flash floods arise so quickly and at a relatively local scale (usually affecting catchments less than 1000 km^2 in area), they are a challenge to observe. In addition, conventional networks to measure rainfall and river flow are not always sufficiently dense to be in the right place to monitor flash flood events

As part of the EU HYDRATE project[1], 25 major flash floods in Europe from the period 1994-2008 were investigated to gain a better understanding of processes that occur in catchments after intense rainfall and which lead to flash flooding. The selected flood events occurred in a belt across the continent, from the Mediterranean to Continental regions.

It was revealed that discharge data were obtained from post-flood surveys in just over half of the catchments, whereas for smaller catchments (less than 100 km^2 in area) discharge data from post-flood observations amounted to about 80% of cases. This highlights the difficulty in observing flash floods by means of stream gauge networks and suggests that flash floods sites should routinely be visited after each event to collect data on flood response. The research produced practical guidance on undertaking these post-event surveys.

In addition, the climatic region influenced the flash flood events, with those occurring in the Mediterranean and Alpine-Mediterranean regions (Catalonia, Crete, France, Italy and Slovenia) mostly happening during autumn. Flash floods in the Continental region (Austria, Romania and Slovakia) usually occurred during summer. Furthermore, flash floods in the Mediterranean region were generally more intense, covered a larger area and lasted longer than in the Continental region. The impact of the climatic region on the potential scale of the flash flood should be considered when flash flood warning systems are prepared.

The study also suggests that certain catchments may be more susceptible to flash flooding because the properties of the catchment (e.g. topographic relief and the steepness of slopes) could increase orographic rainfall and enhance concentration of runoff. Further research is needed to better identify relationship between catchment characteristics and such effects.

In addition, the degree of soil saturation before the flood was found to affect the magnitude of the flash flood, suggesting that it is important to take the initial soil moisture conditions into account when forecasting flash flooding. Finally, the researchers consider the use of weather radar to obtain the rainfall patterns and the modelling the runoff generation from rainfall in flash flood situations.

Sources: Marchi, L., Borga, M., Preciso, E., Gaume E. (2010). Characterisation of selected extreme flash floods in Europe and implications for flood risk management. *Journal of Hydrology.* 394: 118-133. Doi:10.1016/j.jhydrol.2010.07.017.

Gaume, E. and Borga M. (2008). Post-flood field investigations in upland catchments after major flash floods: proposal of a methodology and illustrations. *Journal of Flood Risk Management* 1(4):175-189.

1 *HYDRATE (Hydrometeorological data resources and technologies for effective flash flood forecasting) was supported by the European Commission under the Sixth Framework Programme. See: www.hydrate.tesaf.unipd.it*

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Theme(s): Land use, Natural hazards, Water

Land use change and land management influence floods in small catchments

Research from Slovakia suggests that the total area of change in land cover, as well as land management practices, are more important in generating floods than the type of land cover change, such as deforestation.

"...the frequency of flood events increased as the total area of land cover change also increased in a catchment."

Although weather and climate are the main drivers of flooding, changes in land cover can also influence the occurrence and frequency of floods by changing the responsiveness of river flows to rainfall. In Slovakia, where the study was conducted, flooding is a serious problem and over the last two decades has been mainly been local and in small rural catchments.

In this study, the researchers used a statistical approach to investigate how land cover changes in the period 1990-2006 affected the frequency of flood events in the period 1996-2006 in small catchments (covering 5 to 150 km^2) in Slovakia. Using computer-aided visual interpretation of CORINE Land Cover satellite images[1], land cover changes were identified and flood events were identified from reports from relevant institutes and government bodies, as well as from press reports. Total areas of land cover changes were correlated with flood frequencies. In addition, land cover changes that either accelerated or decelerated runoff were identified.

Changes in land cover occurred in nearly all of the small catchments studied - 1652 out of 1678. The total area of land cover change was 3,755 km^2. Deforestation was responsible for 22% (827 km^2) of the change, converting land to transitional woodland-scrub vegetation. 7.9% of the change in land cover was from the conversion of arable land, vineyards and orchards to agricultural land with complex patterns.

In addition, the frequency of flood events increased as the total area of land cover change also increased in a catchment. This was particularly evident in catchments that had very high potential to flood, but less evident in catchments with high to moderate flooding potential.

However, the study did not find that land cover changes which promote accelerated runoff were more likely to lead to increased frequency of flooding than land cover changes which slow down runoff. Runoff occurs when the rate of rainfall is greater than the rate that the land can absorb the rainfall and can lead to flooding.

Although the researchers expected to find that the overall area of land cover change could be related to the frequency of flooding in small catchments, the researchers did not anticipate that the type of land cover change appeared not to affect the frequency of flood events. For example, deforestation in a catchment did not seem to influence the frequency of flooding.

It appears as though the management of forest activities, such as road and ditch construction, logging and other activities that compact soils and reduce rainfall infiltration, may play a larger role in contributing to floods than whether the land is forested or deforested.

Overall, the total area of land cover change together with management practices of the land influence flooding in small catchments, but the type of land cover change, such as deforestation, is a less significant contributory factor to flooding.

Source: Solín, L., Feranec, J., Nováček, J. (2011). Land cover changes in small catchments in Slovakia during 1990–2006 and their effects on frequency of flood events. *Natural Hazards*. 56:195–214. Doi 10.1007/s11069-010-9562-1.

1. *See: www.eea.europa.eu/publications/COR0-landcover*

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Theme(s): Natural hazards, Water

Steps to improve flood resilience on the ground

Modern flood risk management is placing more emphasis on improving the resilience of communities prone to flooding. By examining three case studies, a recent investigation has provided insight into how resilience is put into practice, suggesting that clearer identification between the roles of different actors and better communication to the public is needed for successful implementation.

"...it appears from these three case studies that roles and responsibilities of different actors involved with flood management may need to be more clearly defined."

The concept of resilience is a promising framework to prevent and mitigate the impacts of flooding. Measures to increase resilience include better preparation (e.g. supply of sand bags, knowledge of emergency procedures), but also communication strategies for evacuation and emergency management plans. These measures are already known, but they are not often implemented in an integrated and effective way.

The research, funded through the EU ERA-Net CRUE initiative[1], analysed three case study areas prone to flooding, which provided more detail on challenges for resilience and highlighted opportunities to bring the concept into practice.

Two of the case study areas are prone to lowland river flooding (Flanders in Belgium, Niedersachsen in Germany), whilst the other (Calabria, Italy) suffers from flash floods, triggered by intense precipitation. The research compared current practices in the case study areas, considering the three main components of resilience:

1. **Interplay of actors and sharing of responsibilities**. In all three cases, there was some fragmentation of responsibilities. For example, conflicts in Niedersachsen arose because the areas covered by administrative units do not correspond with the natural boundaries of the river basins. In Calabria, it was not clear who was responsible for enforcing water policy. However, this fragmentation does not always lead to 'chaos'. In Flanders, water checks (assessments of the negative impact of planning on water) occur at a regional level and building permits are granted a local level, but there is a good understanding between the different levels of management.

2. **Flood risk communication and perception**. The perception of flood risk among residents was generally good in all three case studies. As there were no targeted awareness campaigns, this appears to be the result of past experience. However, in Niedersachsen, residents felt they lacked information from authorities. In Flanders, flood maps are available, but residents are not encouraged to use them as there is concern from local officials that the maps may cause alarm. Lastly, in Calabria, attention is mainly given to handling the flood emergencies as they arise, rather than preventing them.

3. **Flood management tools**. The presence of early warning systems and plans varied between case studies. Calabria has no resources or legal framework for flood risk management tools, while Niedersachsen has an action plan, but communities do not consider the flood maps useful as they need to be at a finer scale. They are also not satisfied with existing early warning systems as they are based on water levels, but do not indicate consequences. In Flanders, integrated water management plans are available for most river basins and are at an appropriate scale.

In summary, it appears from these three case studies that roles and responsibilities of different actors involved with flood management may need to be more clearly defined. Flood management tools are in place, but sometimes remain unused and are often poorly understood by local residents. Better communication and more public participation in flood mitigation could rectify this, for example, by using focus groups of stakeholders to tailor flood management tools to local needs and using the internet to publish plans and risks to trusted partners and the general public. More work is needed in terms of flood modelling and developing flood management maps, and this needs to be better communicated into policy implementation and to the public.

Source: Schelfaut, K., Pannemans, B., van der Craats, I. *et al.* (2011) Bringing flood resilience into practice: the FREEMAN project. *Environmental Science & Policy.* 14:825-833. Doi: 10.1016/j.envsci.2011.02.009

1 This study was conducted under FREEMAN project, supported by the European Commission-funded ERA-Net CRUE initiative. See: www.feem-project.net/FREEMAN/index.php and www.crue-eranet.net

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Theme(s): Environmental information services, Natural hazards, Risk assessment

How well do flood emergency plans meet management needs?

The importance of comprehensive flood emergency plans is becoming increasingly recognised. A new study has evaluated plans in England and Wales, France and the Netherlands. It was found that, although plans perform well in terms of organisation and communication, they are lacking in more technical aspects, such as the provision of flood hazard maps and evacuation plans.

"The researchers suggest that their approach is useful in identifying gaps in flood plans and developing solutions."

In recent decades, flood risk management policies have changed significantly and shifted their focus from providing defences and crisis response in floods, to improving overall flood resilience. The formulation and testing of flood emergency plans at national and local levels represents this progress, but the plans need to be evaluated and compared to stakeholder requirements in order to ensure they meet their needs.

The project investigated which elements of flood risk management are addressed in plans in England and Wales, France and the Netherlands, as well as the level of detail within the plans.

From a review of emergency plans and consultation with stakeholders in the three countries, the study team identified 22 important aspects of the emergency plans for floods. The plans were quantitatively scored on the level of detail they provided for each of these aspects in terms of low (score of 1), medium (score of 2) and high detail (score of 3).

The scores over the 22 aspects were then totalled and averaged to provide an overall evaluation of the plans, where an average score less than 2 indicates 'room for improvement', an average score above 2 indicates the plan is 'acceptable', and a score of 3 indicates the plan is 'good'. A range of aspects were explored, for example, the study scored the level of detail given to the allocation of roles and responsibilities and the provision of flood hazard maps.

The plans for both England & Wales and France had an 'acceptable' overall score, whilst the Netherlands' plan had room for improvement. The results indicated that emergency plans varied in the level of detail they provided for different types of information. In England and Wales, two flood plans did not include flood hazard maps or state if they were available elsewhere, whilst in the Netherlands, flood maps were more detailed with information on maximum water depths and velocities.

The researchers observed that many of the plans seemed to use generic information on flooding, perhaps from other sources, which were not customised to local or regionally-specific issues.

In all three cases, aspects of plans related to organisation, such as roles and responsibilities, were provided with a high level of detail and scored well. However, they all had room for improvement in the information provided on the possible impacts of floods on businesses, infrastructure and people, and on evacuation plans.

Through a survey, completed by 208 people, the study then explored what makes an emergency plan effective according to primary stakeholders, such as local authorities, and compared this to what the plans actually provided.

The survey provided a picture of the type of information considered valuable in a flood emergency plan. This indicated that details on plan activation, i.e. triggers, such as flood levels that lead to action, were deemed important, as well as details on flood hazard and impacts and evaluation. Although the latter is in place in most plans, there is a lack of detail on other aspects, such as flood hazard maps and triggers, indicating a gap between stakeholder requirements and what is actually in the plans.

The researchers suggest that their approach is useful in identifying gaps in flood plans and developing solutions. The work helped in developing a framework called FIM FRAME that can be used to assess and improve emergency plans for floods[1]. This research project was commissioned as part of international collaboration under CRUE ERA-NET[2].

Source: Lumbroso, D, Stone, K. & Vinet, F. (2011) An assessment of flood emergency plans in England and Wales, France and the Netherlands. *Natural Hazards* 58:341-363.

1. *Lumbroso, D., Di Mauro, M,, Tagg, A., Vinet, F. and Stone, K. (2012) FIM FRAME: a method for assessing and improving emergency plans for floods. Nat. Hazards Earth Syst. Sci., 12, 1731-1746, 2012*
2. *See: www.crue-eranet.net*

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Communicating flood risk: public awareness does not ensure public preparedness

The majority of respondents to a recent, large-scale European survey claim not to have prepared themselves for floods, even though they know their property is at risk of flooding and they are worried about the effects. A set of key recommendations for flood communications were developed from the survey's findings, intended to improve community preparedness as part of effective flood management plans.

"...results confirm that, for most people, being worried about a potential hazard does not increase preparedness. "

While flood managers may perceive flood risk in terms of statistical probabilities, the general public's sense of risk is strongly linked to past experiences and emotional factors. These differences in risk perception have seen the failure of many communication strategies intended to increase public preparedness for floods. For instance, major flood warnings issued by the Environment Agency in the UK in 2007 and the Netherlands' 2006 'Think Ahead' campaign both had a poor response as they did not adequately account for the public's perception of their own risk.

A better understanding of public risk perception could therefore improve communications, vital to the European Directive on the assessment and management of flood risks[1] which requires flood risk management plans to take social, as well as physical, factors into account. To this end, the researchers, funded through the EU ERA-Net CRUE initiative[2], issued questionnaires to 13 communities, identified as at-risk from floods, across Belgium, Finland, Germany, Ireland, Italy and the UK.

The survey explored three key concepts: *awareness of flood risk, worry about floods and preparedness for flooding*. A total of 1375 questionnaires were completed. From the responses, the researchers drew up recommendations to guide communication strategies.

Of the respondents, 80% said they knew that they lived in a flood-prone area and, unsurprisingly, this awareness was linked to past experiences. Information campaigns that draw on flood victims' knowledge could therefore be valuable for those who have not witnessed floods.

The 20% of respondents that were unaware of the risk may be of concern. The researchers partly linked this low awareness to overconfidence in structural flood defences, and suggest that the technical language used by engineers to describe the level of protection offered by these structures can be difficult for others to understand. They therefore recommend providing understandable statements to explain that structural measures do not protect against all flood events. They also recommend more open discussion of flooding in the media by responsible agencies to further increase public acceptance of risk.

Of the respondents, 65% said they were worried about floods. Participants who had higher levels of education were less worried than those with lower levels, possibly because they tend to have higher incomes and would find it financially easier to repair flood-damaged property or replace lost belongings. Demographic information, such as this, can help tailor information campaigns to specific groups.

Crucially, the majority reported to be unprepared for floods, including many who knew they were at risk or were worried about flooding. Just 34% felt prepared. The researchers advise against communication campaigns that increase fear of floods as their results confirm that, for most people, being worried about a potential hazard does not increase preparedness. Instead, they recommend that flood managers provide specific information on easy-to-implement flood mitigation measures, to give householders more confidence in protecting their property, and locally-tailored information on safe evacuation routes.

1 http://ec.europa.eu/environment/water/flood_risk/index.htm

2. This study was conducted under the URFlood and FREEMAN projects, supported by the European Commission-funded ERA-Net CRUE initiative 'Flood resilient communities – managing the consequences of flooding'. See: www.crue-eranet.net

Source: Bradford, R. A., O'Sullivan, J. J., van der Craats, I. M., *et al.* (2012). Risk perception – issues for flood management in Europe. *Natural Hazards and Earth System Sciences*. 12: 2299-2309. Doi:10.5194/nhess-12-2299-2012. This study is free to view at: www.nat-hazards-earth-syst-sci.net/12/2299/2012/nhess-12-2299-2012.pdf

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Multi-criteria analysis - the better way to evaluate flood management

According to a recent study, flood risk management projects should be economically evaluated in terms of their efficiency, i.e. the sum of the costs and benefits of a project over its lifetime. This would capture more fully the value of non-structural measures, such as warning and evacuation systems, that are better in terms of effectiveness related to hydrological protection standards..

"The study applied three different evaluation approaches in the two cases: effectiveness, cost-effectiveness and efficiency."

Flood risk management can employ both structural measures, such as embankments and floodwalls, and non-structural measures, such as land use planning and warning and evacuation systems. Although economic evaluations of structural measures have been conducted, few have been carried out for non-structural measures.

As part of the Era-Net CRUE project Flood-Era[1], the study demonstrates how economic costs and benefits can be evaluated for both structural measures and non-structural measures, in two case studies on the Mulde River, Germany: Erlln and Grimma. For the Erlln case, it compared the construction of a new ring dyke with a hypothetical resettlement plan of inhabitants. For Grimma, it compared a local warning system with an initiative that integrated flood protection into the old town wall.

The study applied three different evaluation approaches in the two cases: effectiveness, cost-effectiveness and efficiency. Effectiveness is the degree to which a measure achieves a specified target, in this case, protection against a flood event of a level of severity that has a 1% risk of occurring each year. Cost-effectiveness relates the costs to the degree to which it achieved the flood-protection target mentioned above. (This is usually expressed as the costs per percentage of achieving the target, i.e. the costs to avoid 1% of the damages caused by a flood event each year.) Lastly, efficiency applies a cost-benefit analysis, i.e. the sum of benefits due to damage avoidance minus the sum of the costs of the measure.

For the Erlln case study, both the ring dyke and the resettlement achieve the flood protection target, so are considered 100% effective. However, the cost-effectiveness of achieving the goal is better for the ring dyke (€3.9 million total investment, or €390,000 per 1% of achieving the target) than for the resettlement programme (€6.8 million total investment, or €680,000 per 1% of achieving the target). This is because resettlement would involve paying a large compensation, more than twice the construction costs of the new ring dyke.

According to the study, both options are economically inefficient as costs outweigh the benefits of damage reduction. For the ring dyke, the net present value (benefits minus costs) is between -€1.4 and 3.3 million, whilst for the resettlement option the net present value (NPV) is between -€4.5 million to -€4.9 million. A negative value for the NPV indicates that costs are greater than benefits.

For the Grimma case study, effectiveness of the integrated flood protection is again 100%, but the warning system achieves only 19.5% efficiency of reaching the flood protection target. However, the warning system is more cost-effective per 1% of target achievement - €137,000 – as opposed to the cost of the floodwall option (€230,000).

The study demonstrates that both effectiveness and cost-effectiveness, at least if related to providing a specific standard of hydrological protection, are unable to consider all benefits in terms of damage reduction and might therefore favour structural over non-structural measures. As such, the study recommends a shift from hazard reduction to overall risk reduction and suggests using cost-benefit analysis to evaluate flood risk management initiatives in a better way. However, in practice, cost-benefit is often unable to consider all kinds of costs and benefits such as environmental effects, which are not easily measurable in monetary terms. Therefore the researchers recommend embedding cost-benefit analysis in a wider multicriteria evaluation framework.

1 The work described was supported by the project Flood-ERA of the ERA-NET CRUE Funding Initiative on FRM Research as well as by the European Community's Sixth Framework Programme, through the grant to the budget of the Integrated Project FLOODsite. See www.floodsite.net

Source: I. Meyer, V., Priest. S. & Kuhlicke, C. (2012) Economic evaluation of structural and non-structural flood risk management measures: examples from the Mulde River. *Natural Hazards*. 62:301-324. Doi: 10.1007/s11069-011-9997-z.

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The Floods Directive: lessons from Germany for effective implementation

The European Directive on the assessment and management of flood risks[1] (the Floods Directive) represents a shift towards holistic and catchment-oriented management of flood risk and is likely to prompt changes to policy in many Member States. New research from Germany suggests that effective implementation of the Floods Directive is likely to be greatly aided by the participation of stakeholders and communication between groups.

"...communication, between different stages of development and between groups of participants, is key to effective flood risk management plans."

Flooding is a serious problem across Europe and has caused substantial damage, in terms of environment, human health and economic losses. The Floods Directive aims to reduce these negative impacts, not by completely eliminating floods, but by a thorough understanding of the risks and carefully tailored policies. This represents a substantial shift in flood policy for most Member States, which have in the past focused on protection against flood threats rather than risk management.

In this study, researchers used two case studies to evaluate whether the Floods Directive can permanently change the way flood risk is dealt with in Europe. In the first case study, researchers focused on how well the Directive was accepted by decision makers in the German part of the Rhine river basin. A total of 17 interviews were conducted with professionals from governmental water authorities, municipalities, local water boards and other relevant organisations.

Overall, there was a high level of acceptance and most individuals agreed that the move towards a risk management based approach was a valuable step. There was a slight split in opinions regarding decision making. Some professionals embraced stakeholder participation in the decision making process, where others believed that non-experts should not be involved. However, regardless of these differences, all respondents felt that the short timeframe of the Floods Directive meant that it would be difficult to meet all its aims.

The second case study was a one-year project set up in Bavaria, Germany, designed to identify the best strategies for successful implementation of the third step of the Floods Directive, the development of flood risk management plans.

The researchers conducted online research of policy documents and 23 interviews with administration and stakeholder groups. In addition, four workshops designed to encourage stakeholder participation were set up, two with professionals and two with other stakeholders, including regional planning, agriculture and nature protection groups. These workshops used interactive techniques, such as planning simulations and role play.

Four main recommendations were identified from the Bavarian case study: decisions at the catchment scale should be discussed with local stakeholders at sub-catchment levels, because these local actors play a central role in flood risk management, such as communicating with the public and land use planning etc.

Experts, although an essential part of the process should not be the sole decision makers; all stakeholders should be encouraged to participate, especially municipalities. Methods to improve this dialogue, such as workshops aimed at developing solutions, should be included. Finally, communication, between different stages of development and between groups of participants, is key to effective flood risk management plans.

Source: Heintz, M. D., Hagemeier-Klose, M., Wagner, K. (2012). Towards a Risk Governance Culture in Flood Policy—Findings from the Implementation of the "Floods Directive" in Germany. *Water.* 4: 135-156. DOI: 10.3390/w4010135.

1 *See http://ec.europa.eu/environment/water/flood_risk/index.htm*

A selection of articles on Flooding from Science for Environment Policy's News Alert.

A global risk assessment of river and coastal flooding (17/12/2012)

A new study provides the first global estimates of river and coastal flooding, highlighting past and future trends, and indicates that Asia and Europe are two of the regions that are worst affected. The researchers suggest that their methods could be useful in developing a global framework for flood risk assessment.

'Soft' flood defences to protect riverside biodiversity (14/12/2012)

Riversides that are unprotected by flood defences are home to more diverse plant communities, according to a new study. According to the researchers of the study, 'soft' approaches to flood management, which work in harmony with natural processes, could help promote biodiversity in flood-prone regions.

Improving flash flood risk management for Europe (1/3/2012)

An analysis of flash flood forecasting in Europe has produced recommendations for emergency planners and others to improve flood risk management in vulnerable regions. In particular, the researchers recommend improved data collection and sharing, a common European policy for flash flood forecasting, and that local risk management recognises the specific challenges presented by flash floods.

Classifying water bodies for flood risk management (29/7/2010)

Climate change is expected to increase the intensity and occurrence of regional floods in Europe. A recent study has examined existing natural and constructed retention (or holding) basins that can be adapted to provide flood defences. As part of the study, a classification system for flood defence structures was developed to help Member States design sustainable flood risk management plans.

To view any of these in full, please visit: *http://ec.europa/science-environment-policy*, and search according to publication date.

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