COMMUNICATING FLOOD RISK TO THE PUBLIC BY CARTOGRAPHY

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Abstract
Flood risk communication plays an important role in risk management, because it can strengthen people's risk awareness and can motivate them to take precautionary actions. To inform the public about flood risks, the use of flood maps is encouraged by the recent EU Flood Directive (2007/60/EC). Mapping flood risks deals with the challenges of representing risks in a way people can understand and interpret them correctly. In this contribution, the use of flood maps is discussed within risk communication. Attention is further given to the cartographic principles of flood mapping and to the role of the Internet in communicating flood risks via web cartography. Eventually, the state of the flood risk mapping in Flanders (Belgium) is discussed, considering the theoretical aspects previously handled.

Keywords: risk communication, flood hazards, flood mapping

1 Introduction

During the past decade, many countries suffered large economic losses from flood disasters. Main reasons for these recent losses are the increased risk of flooding from climate change and a growing vulnerability to floods. As more and more people move into areas with higher flood risks, an increase in casualty risk is also expected to occur in the upcoming years (Siegrist and Gutscher, 2006). Governments around the world face the challenge of controlling and mitigating these risks in an efficient and durable way. Moreover, the governments are responsible for informing the general public about flood risks, flood protection and personal safety measures.

As underlined in the new EU Flood Directive (2007/60/EC), flood risk communication plays a significant role within flood risk management. The objective of this directive is to establish a framework for the assessment and management of flood risk in Europe, emphasizing both the frequency and magnitude of a flood as well as its consequences (de Moel et al., 2009). The EU Flood Directive requires that the member states develop flood hazard maps and risk maps as a basis for flood risk management plans, which are to be realised by the end of 2015 and later on updated every six years. It is further required that these information tools are available to the general public (Hagemeier-Klose and Wagner, 2009).

Flood hazard or risk maps can serve as a basis for spatial planning, local hazard assessment, emergency planning, technical protection measures and raising risk awareness among the public (EXCIMAP, 2007). A well designed flood map can lead to a high attention level and to further information seeking by the users (Hagemeier-Klose and Wagner, 2009). As such, cartography can play an important role in communicating flood risks to the general public.

This study draws attention to the use of maps as aid for effective communication of flood risks to the public. Starting from the available literature, flood risk communication is discussed as well as cartographic principles within flood mapping. A brief discussion on flood risk mapping on the internet is also given. Taking theoretical and empirical findings on risk mapping into account, the state of the flood risk cartography in Flanders (Belgium) is finally discussed.

2 Background

2.1 Communicating flood risks to the public

Flood hazards are world-wide considered as one of the most significant natural disasters in terms of human impact and economic losses. For most residents, flood risk is a low-probability hazard, indicating that an inundation is statistically expected to occur once in awhile. To the general public, however, low-probability hazards are difficult to understand and interpret (Bier, 2001). As a result, people often tend to underestimate these risks. Communicating flood risks to the public in a refined and understandable way is crucial for a number of reasons (Rowan, 1991): (i) building trust in the communicator, (ii) raising awareness (e.g. of a potential flood hazard), (iii) educating, (iv) reaching agreement (e.g. on a particular strategy or investment plan) and (v) motivating action (e.g. precautionary measures against flooding of residence). Hagemeier-Klose et al. (2009) emphasize the role of flood risk communication to strengthen people’s risk awareness and to motivate the population at risk to take preventive actions and to be prepared for an emergency case. Risk communication should be adjusted to the specific needs of the people at risk to give them the possibility of judging their own risk situation and making informed decisions according to preparedness and personal safety measures.

However, communicating flood risks to the public involves several difficulties. Keller et al. (2006) mention the problem for people of correctly interpreting risks with low probabilities but high consequences, such as a flood disasters. Slovic (1987) showed that people care more about the number of people that is exposed to threats and the familiarity they have with the threat (experience), than paying attention to statistical probabilities. Covello et al. (1986) point out following problems related to risk communication in general: (i) “the public” is not a homogeneous entity; instead, there are many publics, each with its own interests, needs, concerns, priorities, and preferences, (ii) the choice of one communication strategy often requires a complex balancing of multiple, competing objectives (e.g. community’s “right to know”, costs of unnecessarily alarming people, etc.) and (iii) divergence of viewpoints, as governments usually provide aggregate or population statistics, while individual citizens are more likely to view risks from a microperspective.

2.2 Mapping floods

Cartography can be defined as a form of communication, because it can be used as a form of spatial language for describing locations, discussing places and interpreting two-dimensional arrangements of features (Monmonier, 1993). Due to the spatial characteristics of flood hazards, maps are an ideal way to inform the public about the danger of these hazards. However, maps have a strong visual impact and wrong use of cartographic techniques can lead to wrong interpretations of the message (Bartels and van Beurden, 1998).

Types of flood maps

Flood maps exist in many different forms, but in general it is possible to distinguish between flood hazard and flood risk maps. While flood hazard maps contain information on the probability and/or magnitude of a flood event, flood risk maps depict additional information about their consequences (e.g. economic damage, number of victims, etc.). Various parameters can be used to denote the flood hazard, such as flood extent, water depth, flow velocity, duration and the rate at which the water rises. Out of these parameters, water depth is one of the main factors of importance with respect to flood damage (and consequently flood risk). In their study on flood maps in Europe, de Moel et al. (2009) show that flood extent maps are the most common type of flood maps, followed by historical flood maps and water depth maps. The use of flood risk maps is less common, although it is now required in the EU Flood Directive (cf. Introduction).

Cartographic principles in flood mapping

A *good* flood map allows efficient and target-oriented communication of flood risk. However, *good* is difficult to define; when is a map *good enough*? Obviously, a flood map needs to be easily understandable, clearly arranged and accompanied with clear and simple explanations. But the question remains: how should a flood map look like to fulfil these needs? The European RISKCATCH project (2008) aimed at finding an answer to this question. Using eye-tracking techniques, a set of 17 complementary but different risk maps was shown to test persons, including hazard specialists, people concerned, and laypersons. These tests resulted in a map template suggestion that fulfils the requirement to serve as efficient communication tool for specialists and practitioners in hazard and risk mapping as well as for laypersons (cf. Figure 1). The use of map symbology, textual elements, map contrast with background information and the position of various elements (e.g. title, legend) were found to have an important visual impact on the map reader (Spachinger et al., 2008).

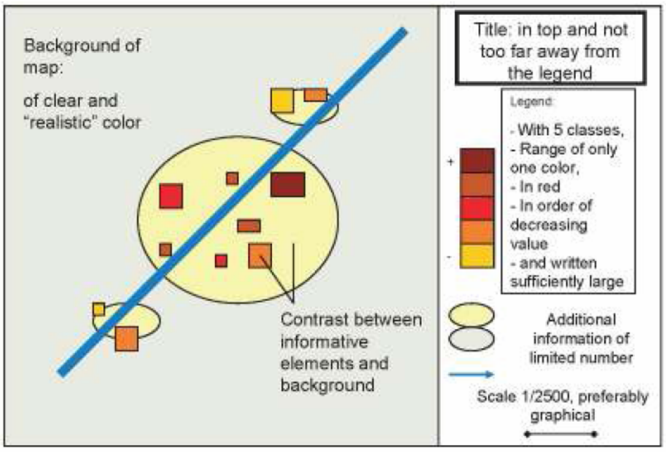

Figure 1 Risk map suggestions, according to the findings of the RISKCATCH project (Spachinger** et al.**, 2008)

Map symbology and colour constitute the principal components of a map's perceptibility. They have not only a strong visual impact on the map reader, they also represent most of the thematic information on a map. Especially colours can have an important value in flood mapping, on condition that they meet the people's expectations. Blue colours for example are associated with water. It would be confusing to laymen if other colours than blue (e.g. red or orange) were used to represent flood hazard zones. However, for flood risk maps, the use of red colours might be a good choice. As they are generally associated with danger, red colours constitute a better representation for information on economic damage and/or number of victims. The use of greyscale values (e.g. from light to dark, representing categories for risk intensity, water depth, etc.) is encouraged, although the number of classes often poses some difficulties. If too few classes are used, the map may obscure the contour of the data distribution. Too many classes can make it difficult for the map reader to make a distinction between the classes (de Moel et al., 2009). Map symbols are less useful for representing the flood hazard or risk itself, however, they can provide important benefits for identification and localisation (e.g. location of dikes, bridges, safe areas or remarkable buildings such as museums and churches).

Instead of adding map symbols to the flood map, a (simplified) topographic map can be used as background. These maps should not contain too much information as this would result in an overload of information, making the map unreadable. However, the maps should still represent a sufficient level of detail, so that a land owner is able to recognise his own parcel of land (Hagemeier-Klose and Wagner, 2009). However, a high level of detail might result in a false sense of accuracy, since hazard maps for extreme events are based on extrapolations (e.g. flood hazard with 1000-year-probability).

Although it might seem obvious, a map is not a map if it lacks basic map features such as a legend, a scale bar and a north arrow. This holds also for flood hazard and flood risk maps. The legend should contain all the features visible on the map. Also, the category classes have to be comprehensible and readable at first sight. Scale bar and north arrow are necessary items for the map reader to correctly interpret the map scale and its proportions (Spachinger et al., 2008).

Flood risk cartography on the internet

Today, dynamic and interactive maps on the web are more popular than ever. It is estimated that more than 200 million of maps are distributed through the internet on a daily basis, which is more than the number of paper maps printed each day (Peterson, 2003). Hagemeier-Klose and Wagner (2009) believe that the dissemination of flood maps via the internet can form an important way of bringing flood information to the public. When combined with real-time data on water levels and precipitation, web flood maps can hold information of vital importance to inhabitants in flood prone areas.

Flood maps exist in two forms on the internet: static and dynamic. While static web maps are fixed (no user adaptations possible), dynamic web maps are adjustable to the user’s preferences. Static web maps are highly similar to printed maps, and should therefore follow the same cartographic principles. Because of their interactivity and adjustability, more *freedom* exists in dynamic web maps. It’s up to the user to decide which information is to be shown on the map. However, apart from this interactivity, a dynamic web map should just as well follow the cartographic semiology regarding colour, background contrast and map elements.

3 Flood risk mapping in Flanders

3.1 River floods

In the past decades, Flanders (northern part of Belgium) has suffered several river floods, causing substantial damage to buildings, roads, agricultural fields, etc. As Flanders is one of the most densely populated and industrialized regions in Europe, a decent water management policy is needed. This insight has brought the Flemish government to develop a risk-based methodology which focuses on minimizing the consequences of floods instead of avoiding high water levels (Vanneuville et al., 2003). In the meantime, several studies have been undertaken to determine flood risks along all major rivers and streams in Flanders. At a local level, information is provided on structural investments along these rivers (dikes, storm walls, etc.), however, this communication is often restricted to the cost price of the investments and maintenance and to the length of time that is needed for the completion of the works. Printed maps are often found in leaflets and internal notes. However, due to their limited edition, these maps are rarely consulted by the citizens. Newspapers sometimes publish large scale flood maps, e.g. to depict regional flood areas. Obviously, these low detail maps are not useful for the citizen to determine whether his or her property is in a flood prone area.

In recent years, several websites have been launched in Flanders to inform the public about historical, actual and future river floods. The Flemish Agency for Geographical Information (AGIV) has created a so-called "geo-window" on flood prone areas in Flanders. This geo-window is part of a number of windows, where people have freely access to various geographical information, such as soil quality, orthoplans, land use, business grounds, etc. Each geo-window runs a GIS-based user interface, providing zooming functions and layer adjustments. One such geo-window contains flood prone areas based on historical data and potential flood risk zones (cf. Figure 2). By default, the geo-window starts by showing only the flood risk zones in Flanders. The user can add historical flood areas (either naturally or recently flooded areas) by ticking layers on or off (in a pop-up window). The application further allows the user to zoom in by address. The user's address is subsequently marked with a purple dot. This way, one can immediately check whether his or her address is situated in a naturally or recently flooded area or in a flood risk zone. The use of colours in this web-application is limited to the flood (risk) areas. This promotes the readiness of the map, certainly in combination with the black-and-white topographic map as background. However, street names are not present on this topographic map, which makes identification difficult for the user. Also, the colour choice might be confusing. Dark blue is chosen for flood risk zones, recently flooded areas are depicted in pale blue, and naturally flooded areas are shown in orange. It would be more logical if blue colours were used for flood hazard maps (both naturally and recently flooded areas) and orange or red colours for flood risk zones. Nevertheless, if the user needs more information on the map colours, a legend can be opened via pop-up.

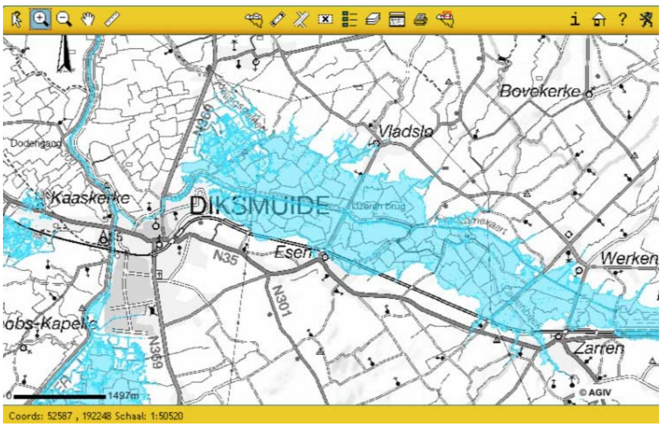

Figure 2 Web-application ("geo-window") on flood prone areas in Flanders (AGIV)

In Flanders, two institutes measure and manage actual information on water levels and precipitation and publish this information on the Internet. Flanders Hydraulics Research does so for the navigable waterways (www.waterstanden.be), the Flemish Environment Agency (VMM) performs measurements along unnavigable waterways (www.overstromingsvoorspeller.be). The web-applications of both agencies contain maps for each of the eleven river basins in Flanders. In both applications, users can click on various measurement points and receive graphical information on gauge levels. Flanders Hydraulics Research distinguishes three measurement points: water levels, water discharge and precipitation (cf. Figure 3). The Flemish Environment Agency does not provide information on water discharge. For two basins (Dender and Dijle), a network of “forecast points” is instead presented (cf. Figure 4). At these locations, the user can request simulated water levels 48 hours in advance. Critique water levels are indicated on the map, as well as expected flood areas (orange for non-critical floods, red for critical floods. Flanders Hydraulics Research does not provide forecasts for water levels nor for critical floods. Regarding localisation and background information, apparent differences exist between both web-applications. The VMM provides toponyms for cities at the basin level and a topographic background at large-scale level. The maps of Flanders Hydraulics Research are all small-scale (at basin level) and contain just hydrotoponyms. This makes localisation and identification very difficult for the general public. Unlike the geo-window (AGIV) previously discussed, the web applications of Flanders Hydraulics Research and VMM are more straightforward in their structure. No pop-up windows are needed to change the layers or consult the legend. Yet, both websites are less suitable for the public, because of the information presented. Water levels are difficult to interpret for the general public. Due to the distinction between navigable and unnavigable waterways, it is also difficult for the people to obtain an overview. Both websites exist independent of each other.

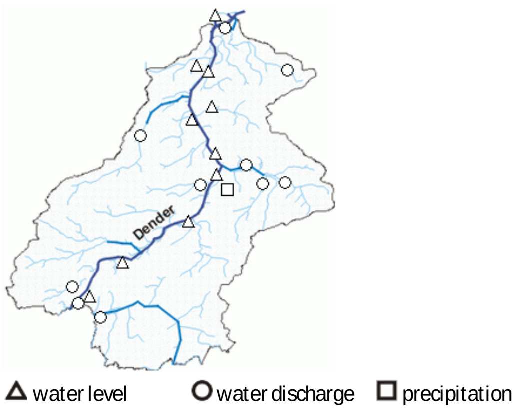

Figure 3 Web-map with overview of measurement points (Dender basin) (www.waterstanden.be, 2009)

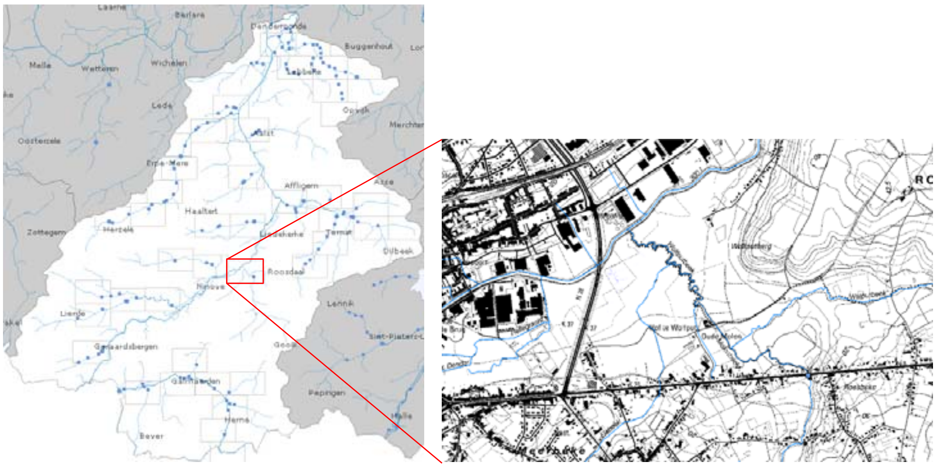

Figure 4 Web-maps for Dender basin (overview and detail) (www.overstromingsvoorspeller.be, 2009)

A fourth website discussed here also contains maps on flood prone areas, but its primary goal is judicial. With respect to the recent Flemish Parliamentary Act on Integrated Water Policy (18th of July 2003), the Flemish government has introduced a “water-test” or “water-checkup” which is legally liable to ensure that licenses, policy plans and programs are conceived in a way that does not harm water systems (Meire and Goris, 2004). The website www.watertoets.be therefore contains a tool to set up a dossier. A static small-scale of Flanders can be consulted to determine flood sensitive areas. Those who want a more detailed view are redirected to a geo-window (managed by AGIV) with these flood sensitive areas (cf. supra).

3.2 Coastal floods

Located to the south of the North Sea, the Flemish coastline measures only 65 km but accommodates nearly 0.4 million people (which is approximately 4% of the Belgian population). During the summer period, this number increases by approximately 0.3 million resident tourists.

In the past, the Flemish coast has suffered severe losses from coastal flooding. In the winter period of 1953, the coastal North Sea area was hit by a grave storm surge, leading to vast floodings in the Netherlands, United Kingdom and Belgium. Because the time of the storm surge peak coincided with the time of spring-tide high water, the total water-level reached heights that, in many locations, exceeded those recorded ever before. The resulting disaster in terms of loss of life and damage to infrastructure was enormous (Gerritsen, 2005). Since this catastrophic event, structural investments (dike heightening, beach feeding, etc.) and technological advances (weather forecasting, emergency planning, etc.) have raised safety levels substantially in comparison to the situation of 1953 (McRobie et al., 2005). Nevertheless, due awareness of coastal flood risks remains indispensable. As a consequence of the climate-change induced sea level rise and the expected growth in tourism and economy in the coastal area, parts of the Flemish coast are considered to be vulnerable to coastal floods, not only with regard to material damage but also to human vulnerability.

Recent research (Kellens and De Maeyer, 2009) has demonstrated the public need for more information on coastal defence policy. In a large-scale survey among inhabitants and residential tourists of coastal communities, 65% of the respondents express a lack of information on coastal defence policy. It seems the inhabitants are not fully aware of the consequences of coastal floods nor do they know what to do or how to prepare appropriately. European Interreg projects such as COMRISK (2005) and SafeCoast (2007) already emphasized the need to communicate coastal flood risks to the public. A survey in the SafeCoast project revealed that almost 60% of the people would find maps very useful for evacuation escape routes (Knolle et al., 2007). However, in current national projects (Integrated Coastal Safety Plan, CLIMAR), insufficient attention is given to the communication aspect, not to mention cartography as communication tool. At present, no flood maps of the coastal area are available to the public.

4 Conclusions

The importance of flood risk maps in risk communication is more and more being recognized in literature. Because of their visual impact, flood maps are ideal instruments to inform the general public about flood hazards and strengthen people's risk awareness. In Europe, the use of flood maps is recently encouraged by the EU Flood Directive as a basis for flood risk management. The Directive also emphasizes the need to inform the public about these risks. Although the Flood Directive enforces 2015 as deadline for the first risk management plans, several EU member states have already made remarkable progress on this.

In Flanders, the EU Flood Directive is seen as an opportunity to extend the methodology on flood risk calculations and to continue investigating in the mitigation of these risks. At this point, however, insufficient attention has been given to the communication of these risks. Printed maps are only distributed in reports and leaflets with limited edition. Web maps on the contrary have more exposure, but lack user-friendliness. For river floods, web maps exist for both navigable and non-navigable waterways, providing actual information on water levels, water discharge and precipitation. For several river basins, a 48 hour forecast can be consulted. The AGIV's geo-window on flood prone areas contains historical information on naturally and recently flooded areas. Together, these websites provide a wealth of information for the user. However, this variety of information makes them also very complex and technical. The information presented might be suitable for the expert, but is certainly not appropriate for the general public. Moreover, some cartographic principles are neglected in these web-applications. Colours are not always used according to the natural association (blue for water, red for risk), a legend is often not visible (or can only be shown via pop-up) and toponymy is mostly too restricted (street names at the local level would be interesting for identification). As for coastal floods, no web maps are available to the public yet. This is partly due to the fact that research on coastal flood risks has only recently been started. However, the need for communication and information has already been expressed by the public. It will be essential to inform the inhabitants of the coastal area about coastal defence structures and flood risks in the near future.

Flanders faces the challenges of visualizing flood hazards and flood risks in a clear and understandable way. The subsequent development of web maps is encouraged, but printed maps should not be forgotten. A major part of population still has no or limited access to the internet. As a continuing study, the impact of the flood maps on the public can be investigated. It would, for example, be interesting whether flood hazard maps and risk maps contribute equally to the public's awareness or not.

Acknowledgements

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