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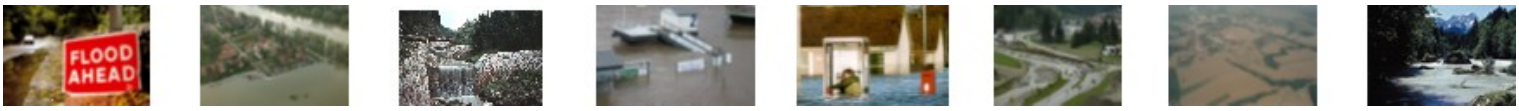
Final Report - Austria



CRUE Final Report Austria

RISK MAP

Improving Flood Risk Maps as a Means to Foster Public Participation and Raising Flood Risk Awareness: Toward Flood Resilient Communities

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Zusammenfassung

Die zentrale Zielsetzung des Projektes RISK MAP ist es, die Visualisierung von Hochwasser-Risikokarten[1] zu verbessern, sodass deren Inhalte von verschiedenen Nutzergruppen besser verstanden bzw. umgesetzt werden können. Hierzu wurde ein partizipativer Prozess entwickelt, der unter Einbeziehung der verschiedenen Nutzergruppen auf deren besonderen Bedürfnisse eingeht, parallel dazu wurden die Entwürfe für Risikokarten mit der Methode des *eye tracking* auf ihre Eignung als Kommunikationsinstrument geprüft. Dieser Zielsetzung folgend wurde untersucht, ob der Inhalt und die visuelle Darstellung der existierenden Karten die Erwartungen der verschiedenen Endnutzer erfüllt, und deren Ansprüchen genügt. Aufgrund der Ergebnisse des Projektes können Empfehlungen bezüglich der Folgenden Punkt ausgesprochen werden:

1. Wie können Endnutzer in den Prozess der Kartenerstellung eingebunden werden (Erstellung und Überarbeitung von Hochwasser-Risikokarten) und wie sieht ein hierzu geeigneter partizipativer Prozess aus?
2. Welche Inhalte sollen in Hochwasser-Risikokarten dargestellt werden für welche Nutzergruppe?
3. Wie kann das Risiko visualisiert werden, um nutzerfreundliche und verständliche Karten zu erstellen?

Zunächst wird die empirische Grundlage des Projektes dargestellt, sowie das Design der Methodik, anschließend werden zusammenfassende Schlussfolgerungen diskutiert.

In jedem der Testgebiete in fünf europäischen Ländern wurde die derzeitige Praxis in Bezug auf die Kartierung von Wassergefahren und Risiko erhoben, der jeweilige gesetzliche Rahmen dargestellt, und existierendes Kartenmaterial analysiert. Interviews und Workshops wurden durchgeführt, um etwaige Schwächen der existierenden Karten zu ermitteln, und um die spezifischen Bedürfnisse verschiedener Endnutzer in Bezug auf Risikokarten zu verstehen. Die Endnutzer wurden klassifiziert, und die drei für diese Studie wichtigen Gruppen umfassten Planung (inklusive der Fachleute, die bereits heute für die Erstellung von Gefahrenkarten zuständig sind), Katastrophenmanagement (im weiteren Sinne, von Angehörigen lokaler Feuerwehren bis zu Vertretern des Militärs), sowie Laien. Basierend auf diesen Untersuchungen wurde das Kartenmaterial angepasst, und in Folge wurde mittels des *eye tracking* Verfahrens überprüft, inwieweit die neuen Darstellungen von den verschiedenen Nutzergruppen verstanden werden (können), bzw. wie das Leseverhalten in Abhängigkeit der kartographischen Darstellung variiert. Aufbauend auf den Ergebnissen dieses Verfahrens wurden die Karten erneut modifiziert, und die Inhalte mit den verschiedenen Nutzergruppen in einer zweiten Serie Workshops diskutiert. Parallel wurde ein Software-Tool entwickelt, das eine Integration von

[1] Der Begriff Hochwasser-Risikokarte wird hier gemäß der *Richtlinie 2007/60/EG des Europäischen Parlaments und des Rates vom 23. Oktober 2007 über die Bewertung und das Management von Hochwasserrisiken* verstanden.

Wissen und Präferenzen verschiedener Nutzergruppen während des Prozesses der Kartenerstellung ermöglicht.

Die Ergebnisse der Studie sind zusammenfassend in drei idealisierten Muster-Risikokarten dargestellt. Insgesamt lässt sich aus dem Vorgehen die Wichtigkeit und Relevanz des Einbezugs von Endnutzern im Prozess der Kartenerstellung belegen. Partizipative Prozesse ermöglichen hier nicht nur die Integration von Wissen, sondern auch die Netzwerkbildung unter den beteiligten Akteuren, was umgekehrt zu einem erhöhten Verständnis von Risikoinformation beiträgt und hilft, die das Risikobewusstsein zu erhöhen.

Wie können potentielle Endnutzer in den Prozess der Kartenerstellung eingebunden werden?

Hierzu gibt es keine Vorgangsweise, die für alle Gruppen von Endnutzern gleichermaßen zu empfehlen ist. Endnutzer aus unterschiedlichen europäischen Ländern, und mit unterschiedlichem kulturellem und institutionellem Hintergrund haben spezielle Bedürfnisse, die sich aus dem jeweiligen Kontext heraus ergeben. Das Grundprinzip ist jedenfalls, das jeweilige Wissen (fachlich, oder auch lokal) zu integrieren, und somit nicht nur die kartographischen Inhalte anzupassen, sondern – insbesondere bei der Nutzergruppe der Laien – als Nebenprodukt des Verfahrens das Verständnis von Risikoinformation zu schärfen, und die Motivation zur Eigenvorsorge zu stärken.

Welche nutzer-spezifischen Inhalte sollen in Risikokarten dargestellt werden?

Die Ergebnisse von RISK-MAP bestätigen die These, dass es für verschiedene Nutzergruppen unterschiedlicher Karteninhalte bedarf. Für eine zielgerichtete Kommunikation muss der Inhalt von Risikokarten den jeweiligen Bedürfnissen angepasst werden.

Die Nutzergruppe aus der (Raum-)Planung benötigt vor allem Information zu den räumlichen Einheiten mit einem erhöhten Überflutungs-Risiko. Der Grad der Gefährdung und die Höhe des Risikos kann hierbei detailliert dargestellt werden, da diese Nutzergruppe im allgemeinen über genügend Zeit verfügt, sich mit dem Inhalt von Risikokarten detailliert vertraut zu machen, um Maßnahmen zu planen und zu implementieren. Die (ökonomischen) Konsequenzen aus Bemessungsereignissen können ebenso dargestellt werden, wie andere soziale oder ökologische Konsequenzen oder Folgen für die Umwelt.

Die Nutzergruppe der Angehörigen des Katastrophenmanagements benötigt vor allem Information über Lage der betroffenen Flächen, die dort gefährdeten Personen, und kritische Infrastruktur, die geschützt werden muss. Neben Information zur Gefährdung und dem sich daraus ergebenden Risiko ist auch strategische und taktische Information wünschenswert, wie beispielsweise Angaben über die Befahrbarkeit von Straßen oder Brücken in Bezug auf das Auftreten dieses Bemessungsereignisses. Für diese Nutzergruppe ist es essentiell, sich schnell auf den Karten orientieren zu können, auch wenn das dargestellte Gebiet unbekannt ist (beispielsweise bei Assistenzeinsätzen).

Die breite Öffentlichkeit (Nutzergruppe der Laien) benötigt reduzierte Information zum Hochwasser-Risiko, gleichzeitig muss diese jedoch graphisch ansprechend und leicht verständlich sein. Die Darstellung der Gefährdung und des Risikos kann hier qualitativ erfolgen, und es sollten nur die nötigsten Informationen dargestellt werden, beispielsweise über die Höhe des Wasserstandes und die Lage und Erreichbarkeit von Schutzräumen.

Die zentrale Aussage in Bezug auf die kartographische Darstellung aus dem Projekt lässt sich wie folgt zusammenfassen: Unterschiedliche Nutzergruppen haben unterschiedliche Ansprüche an Hochwasser-Risikokarten, aus diesem Grund sollte es für jede Nutzergruppe auch eine eigene Karte mit einer individuell entworfenen Signaturenpalette geben. Grundsätzlich sollte die wichtige Information zur Höhe des Risikos graphisch deutlich von der Hintergrundinformation getrennt werden. Die Verwendung selbsterklärender Symbole wird hierbei empfohlen.

Summary

The central objective of RISK MAP was to improve the content and visualisation of flood maps through a participatory process but equally to test whether flood mapping is an effective means and process through which to facilitate participation. By following this objective we asked whether the content and visualisation of existing flood maps really fulfils the expectations and needs of different end user groups. Based on our project findings, overall recommendations regarding the following points are provided:

1. How should stakeholders be involved in the mapping process (creation and updating of flood maps) and what are appropriate participatory processes?
2. Which contents should be included in flood maps for which user group?
3. How should flood maps be visualised in order to produce user-friendly and understandable maps?

Before giving an overall summary of the project findings the empirical basis of this study is outlined as well as the methodological design. The findings and recommendations are based on research undertaken in five different European test sites: Two small Austrian torrent catchments; the Lower Thames River area in England; a section of the Vereinigte Mulde River in the Federal State of Saxony, Germany; the Rivers Vils and Rott in the Federal State of Bavaria, Germany; and the City of Tours at the Loire River in France.

In each of the case studies first the current practices of risk mapping, legal frameworks and existing flood (hazard or risk) maps were analysed. Interviews and workshops were carried out with stakeholders in order to identify shortcomings of existing maps and the specific needs of different stakeholder groups. A set of different but complementary maps was created based on these needs and tested by means of eye-tracking, i.e. the reading behaviour of stakeholders was recorded and analysed. Again maps were adjusted according to the findings of these tests and were discussed again with stakeholders in order to come to case-study specific but also overall recommendation for flood risk mapping. Furthermore, a risk mapping software tool has been developed which facilitates an integration of stakeholder knowledge and preferences into the final map product.

The results of our research underline the value and relevance of participation in mapping. Participation in mapping enables and facilitates a two-way learning process, network building and improved understanding of maps and their interpretation both on the side of the map producers as well as end users. The main end user groups considered in RISK MAP were strategic planners, emergency managers and the general public. In the following section an overview of the most important insights is provided, namely aspects that relate to participation, content as well as visualisation.

How should stakeholders be involved in the mapping process and what is an appropriate participatory processes?

There is not one single best way of conducting a participatory mapping process. Within the case studies the participatory process was conducted by partners in different locations, in multiple institutional and cultural contexts and was hence adapted to the specific requirements and contextual conditions. However, as an overall finding we conclude that the appropriateness depends largely on the purpose of the participatory process. Defining the purpose is hence an important step that should ideally be clarified at the beginning of any participatory process. In a general sense we propose to distinguish between substantive and instrumental rationales. If a participatory process follows a substantive rationale, it aims to increase the breadth and depth of knowledge contributing to the final product by including more contextualised forms of knowledge that cannot simply be reproduced by modelling. The instrumental rationale aims to build trust between different actors or stakeholders in the public and administrative spheres. It may also attempt to contribute to raising awareness and motivation for taking actions to mitigate the impacts of hazards. In this sense, the answer of the question "What should be achieved by the participatory process?" is essential as it has implications for the choice of actors to be involved during the process, the intensity of the process as well as the outcome of the entire process.

Which contents should be included in flood maps for which user group?

RISK MAP confirms the finding that for target-oriented communication, the contents of flood maps need to be adjusted to the requirements of end users as these vary between different end user groups. For example, Strategic planners require maps that show where areas of high risk are, i.e. where there is a need for risk mitigation efforts. Maps also serve as an intermediate product for economic appraisal of flood risk mitigation measures. With regard to hazard information, detailed information on inundation depth is particularly important for events with different probabilities. Regarding information on the consequences of flooding the following contents are of importance: Information on the consequences of specific events should be shown, but also maps showing the annual average damage as a basis for economic appraisals. Furthermore, not only should information on the economic damages be shown but also information on social, cultural and environmental risks in order to show a complete picture of possible consequences. This should also include critical infrastructure, such as bridges, power plants, or hospitals. An aggregation of these different social, economic and environmental risks by means of a multicriteria risk map may be supportive to show overall risk hot spots.

Emergency managers, for example, need easily accessible maps to have quick access to information on affected areas, in the event of an emergency where people need to be evacuated, critical infrastructure protected and evacuation routes determined etc. With regard to the consequences of flooding the following information is most important for emergency management: The number of people at risk from a certain event, i.e. the number of people to be evacuated in case of emergency; critical infrastructure which has to be protected, secured or evacuated (i.e. hospitals, energy or water supply facilities, relevant or blocked roads and

bridges). Apart from traditional hazard and risk information, information on emergency management itself should also be included, such as meeting points, evacuation routes, hospitals, or gauging stations. Again, information should be included which details the level of flooding that these emergency facilities may themselves be at risk from, i.e. when certain evacuation routes are not usable any more.

The public also requires easily understandable and accessible maps, but in contrast to the group of emergency planners with a lower density of information, including only the most crucial information: Information on the extent and depth for events with different probabilities should be presented to highlight streets and individual properties at risk. Furthermore, limited additional information such as evacuation routes, shelter, assembly points may be included providing this information does not overload the map.

How should flood maps be visualised in order to produce user-friendly and understandable maps?

Similar as argued before, multiple topics dedicated to different user groups should not be shown on the same map. E.g. evacuation information (which is necessary for emergency managers) should not be mixed with information on economic impacts (which is more relevant for strategic planning). A map should rather be easily accessible and interpreted, not overloaded with information and high in contrast with regard to the choice of colours and brightness. This implies, for instance, that areas at risk should be clearly visually differentiated from areas not at risk. Furthermore, the research shows that the use of self-explanatory icons or symbols to highlight major risks or the direction of evacuation routes (for example) can facilitate quick access to the relevant contents. Also text should be used within the maps in order to better and more quickly transmit important information, such as information on the number of people to be evacuated. The legend should be sufficiently large, preferably on the right side of the central element of the map, with a limited number of information (not more than five classes of discretisation) comprised from one range in colour only and arranged in decreasing values. The topics in the legend should be organised in a way that it really helps comprehension: Firstly hazard information, secondly major risks, then secondary risks, finally background information.

1 Producers and users of flood (risk) maps

The following recommendations are dedicated to various actors involved in flood risk management and more particularly on the development, production and dissemination of flood hazard and risk maps. A particular group within this setting are persons or institutions responsible for producing such maps: To be more specific, the recommendations in this section focus on the persons who decide how floods mapping should be conducted. These people often belong to public bodies responsible for flood risk management.

Maps are either produced in the same public agencies where flood risk management is carried out, or they are created by external consultancy and engineering companies according to mapping guidelines published by these agencies.

One main finding of RISK MAP is that different users or user groups have very different needs with regard to flood maps, which might not necessarily be in accordance with the needs and views of those producing the maps. Therefore, the map creation process should be led by the requirements of the users. There is a large variety of users who use a different language and pursue different objectives. It is a major aim of the project to inform map producers or decision makers on the specific needs and appropriate processes for engaging different users in mapping and risk communication. The project aimed to encourage a more inclusive approach towards maps production, going beyond the closed circle of those usually involved in producing maps. The rationales for including the different users are outlined below. Before giving a more detailed account, we suggest to distinguish three major user groups which were considered in the RISK MAP project:

Map users from strategic planning

Persons from this group are often from the same agency responsible for the creation of flood maps. In some cases, the producer and user of a map might even be the same individual. However, in other cases end users are members of regional branches of the agency responsible for flood risk management. Maps are used here as a basis for strategic decisions on flood risk management/flood protection measures. People in this group are usually experts by profession in using flood maps and they use them regularly in their daily work. Furthermore, at least in normal decision processes, there is usually sufficient time to study the maps in detail. From our research we know, that map users of this group are able to deal with a high density of information within the maps and that they are able to comprehend more complex content, such as for example exceedance probabilities or annual average damage.

Within this group, we can differentiate between another sub-group; spatial planning end users. This group is usually also involved in contributing to strategic flood risk management but is often located in a different agency or department. By profession they may be less familiar with flood maps and have slightly different requirements on flood maps.

Map users from emergency management

Emergency or disaster management may be institutionally separated from strategic planning in flood risk management. Responsibilities are for example, in the local or regional administrations of municipalities or districts and often also fire brigades or even armed forces are involved. The main purpose of flood maps in this field is to provide quick access to information on affected areas in the event of an emergency, such as people to be evacuated, critical infrastructure to be protected, evacuation routes etc. As flooding (or water) is often not their sole responsibility, users from this group may have less experience with flood maps than map users from strategic

planning who are likely to view the maps on a more regular basis. This poses problems as it may be that this group is less familiar with the scientific concept of risk, i.e. the mapping of annual average consequences, and as such, aggregated information may be less relevant for their day-to-day use of the maps.

Map users from the general public

Citizens are usually neither directly involved in producing the maps nor do they deal with them on a professional basis. However, maps, such as flood hazard maps, are often directed towards them with the aim of raising awareness. We may therefore assume that in general their use of flood maps is generally infrequent and that they have limited experience with the maps. As such, this group in likely to be unfamiliar with concepts such as exceedance probabilities or annual average damages. On the other hand members of the public are more likely to rely on a detailed contextual knowledge which has been gained from previous experiences with flooding (for example). They may hence make valuable contributions to mapping process, providing a different type of knowledge and information to enrich map content and visualisation. Aside from this, there is a further sub-group; the organised public. This group consists of environmental or business interest groups and similar, which represent particular interests.

2 Common recommendations on stakeholder participation processes

How a participatory flood mapping process should be set up and conducted depends largely on the purpose of the process itself. Defining the purpose is hence an important matter that should ideally be clarified at the beginning of a participatory process. In a general sense we propose to distinguish between a substantive and an instrumental rationale. In this sense, the answer to the question “What should be achieved by the participatory process?” is decisive as it has implications for the choice of actors to be involved in the process, the intensity of the process as well as the outcomes of the entire process.

In the following section we provide an example for a participatory process following a substantive rationale. More information on other rationales is given in the overall final project report (http://risk-map.org/outcomes/CRUE_RiskMap_FinalReport_final.pdf/at_download/file).

Substantive rationale

If a participatory process follows a substantive rationale it aims to increase the breadth and depth of knowledge contributing to the final product. Examples are attempts to include more contextualised forms of knowledge that cannot simply be reproduced by modelling exercises. This is evidenced by updated models changing flood extents but also by the very nature of flood risk as an evolving risk. Flooding risk changes over time as landscape and climate change. In order to improve the data and information available on flood risk, traditional modelling can be

supplemented by additional ‘informal’ sources of knowledge. Capturing this knowledge requires a participatory approach to flood risk mapping.

Possible participants

Participants may be both from the professional field of flood risk management (e.g. strategic planners as well as emergency managers) as well as from the public. A decisive criterion, however, would be their expertise. This expertise might be gained either by formal education and hence testified by some kind of degree and/or professional background or it might be gained by experience and personal observation as an informal process of knowledge acquisition. The latter groups may comprise local residents who may have expertise in the mechanisms and a history of flooding in their neighbourhood.

Participatory process

The process would be rather intensive and would comprise a series of meetings. Both representatives from the public as well as representatives with a professional background would be treated as equals which implies that both have an equal right to influence the decision-making process. Such a process aims at creating open and mutual exchange while allowing the identification of different or similar opinions/worldviews/values among and between different actors; on the other hand, it also aims at the participants actively influencing the final decision-making process. To conclude, participation and the degree to which the instrumental and substantive rationales are accommodated should be tailored to the project objectives.

Participation to raise risk awareness

Raising risk awareness is part of the instrumental rationale for a participatory process. Maps are useful tools in raising risk awareness and workshops offer the opportunity to consider the maps in a group situation.

In order to raise awareness of flood risk through mapping workshops, the participants should comprise small groups where those inexperienced and unaware of the risk are able to participate alongside others who have experienced flooding. By working in such mixed groups, participants may interact with each other, allowing those affected by flooding in the past to share their experience(s) and the lessons they learned with each other. Thus, participants should comprise of groups that ideally include individuals with and without experience of flooding. The process should allow time for flood experienced participants to share their experience with those inexperienced, thus raising awareness of the hazard.

Verifying content

The substantive rationale places considerable emphasis on the value of participatory mapping process for improving the accuracy and confidence of maps through stakeholder verification. Stakeholders should include some members of the public that can potentially provide additional 'expert' information to improve or verify the content of maps.

'Experts' may be any person with detailed knowledge of flood history and mechanisms in the area concerned. These experts might be those who generated their 'expert' knowledge through their professional capacity or through personal experience within the area under consideration. As the research demonstrates, and as depicted in Participants may be both from the professional field of flood risk management (e.g. strategic planners as well as emergency managers) as well as from the public. A decisive criterion, however, would be their expertise. This expertise might be gained either by formal education and hence testified by some kind of degree and/or professional background or it might be gained by experience and personal observation as an informal process of knowledge acquisition. The latter groups may comprise local residents who may have expertise in the mechanisms and a history of flooding in their neighbourhood.

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Participants

In order to maximise the breadth and depth of knowledge to enhance and improve maps, it is important that participants comprise a varied group representing many different interests and perspectives.

Participants should include not only those involved in producing maps and the flood risk data depicted within them, but should also include end users such as those involved in emergency response activities or the general public.

Participation should also aim to include professional stakeholders with different but related responsibilities. Bringing these groups together under the unifying tasks of the workshop may help to develop networks and understanding which can improve the potential for joined up working. Participation should be open to all but should not be an obligatory process. Such obligated participants may not be interested in the process or subject and as such both their input and the benefits they receive from being engaged remain particularly limited. In addition, an overall impression of the process as being negative due to their lack of interest in participating may be a negative impression that prevails on future opportunities to participate in different projects.

In addition to covering a range of perspectives, a participatory process that involves both end users and those producing the maps can raise trust in the accuracy and credibility of the maps and those producing them. In addition, the map producers can explain any unclear terms or symbols to improve the comprehension of maps. In turn the map designers are able to identify aspects of their maps that may need improvement to enhance their readability and utility.

Neutral facilitation

The presence of a neutral facilitator is vital to ensure that discussions are focussed on the subject matter. Neutral facilitation also plays a useful mediation role as it places all participants on a more level playing field to facilitate open discussions (instrumental). Facilitators are able to ensure that discussions are balanced with contributions from all participants, reducing the potential for some participants or stakeholders to dominate the discussions unfairly. Facilitators need to be able to manage the process of participation in such a way, when required to do so. Whilst facilitation requires additional resources, these resources are justified as they ensure the process is efficient and remains focussed on the subject.

Timing

Participation at an early stage in the process of map design is important to ensure that stakeholders input can be taken into consideration and is not overly limited by decisions that have already been made. However, participation should take place at an appropriate point, where draft maps are available against which participants can work and input. Participation prior to the production of drafts may be ineffective as participants may struggle without a base for their discussions.

An iterative process of participation is essential to promote the trust and credibility of maps and the participatory process. As such stakeholders should be presented with maps that have been modified based on their input. This enables participants to verify that any changes made to the drafts are satisfactory in addition to demonstrating how stakeholder comments and opinions have been valued. Such an iterative process may result in a more positive impression and trust in the agency producing the maps.

The workshop method

Workshops are a particularly useful method for facilitating participation. By working in small or even one large group, participants are able to share ideas and knowledge with each other and the facilitators. When working in small groups it is advantageous to allow time for the groups to report back to each other so that those points raised in the small groups may be shared with other participants.

As participants are unlikely to be already acquainted, proper attention must be paid to a suitable introduction to the project, the role of participation but also to the participants themselves. A simple round of introductions followed by an ice-breaker task which challenges participants into working together (such as the blank maps task) is essential to quickly establish an open and communicative atmosphere in which to explore the issues.

Evaluation

In order to establish the level of benefit experienced by the participants, it is necessary to conduct an evaluation of the participation event. Questionnaires are a useful tool for capturing the participants' perspectives and evaluation of the workshops in addition to any additional information they may not have been able to contribute during the event. Questionnaires also allow participants to feedback their opinions anonymously which should encourage an honest account and interpretation of their impressions and experience.

Evaluation can be used to identify areas of success and areas for improvement or change. Thus the evaluation forms a key part of the design for a follow up event.

3 Common recommendations on the content of flood risk maps

The question concerning the kind of information (contents) that should be delivered by flood maps is of course of major importance. Flood maps are usually divided into hazard maps, showing information on the spatial extent and/or depth of inundation for flood events of different probabilities, and risk maps, showing also the consequences of these events. Hereby, flood risk maps as defined by the EU Floods Directive show the consequence for specific events with defined probabilities (often also called damage maps), while risk maps in a narrow sense show the consequences for the full range of possible flood events, measured in terms of annual average damage or consequences. Such consequences of flooding could be e.g. the people affected, damage to buildings, inventories or infrastructure, and destructed ecosystems. One major research question in RISK MAP was to find out which of these hazard or consequence items are of major importance for the end users and should be therefore displayed in flood maps.

As stated above, it was a key finding of the project that different end users require different maps, and this is of course also true for the contents of flood maps. In the following section

general findings are presented followed by recommendations on the contents of flood maps before moving on to the recommendations for the different end user groups as specified above: strategic planners, emergency planers and the general or potentially affected public.

General recommendations

Hazard and risk maps, as required by the EU Floods Directive, should be only viewed as an intermediate product for risk communication and management and not as an end-product. The contents which are required in article 6 of the directive build a very good basis for communicating risks to the end users. However, they should not be seen as the final product. As outlined in the Floods Directive, these contents could be extended by other useful information. Furthermore, they should be part of the flood risk management plans (see article 7 of the Floods Directive) and could be further enhanced during the development of these plans.

For target-oriented risk communication the contents of these maps should be further adjusted to the end user needs as different end user groups have different requirements on the contents of flood maps (see specific recommendations for strategic planning, emergency management and the public below).

Where required, risk or emergency management information should be also included in the flood maps. Our case study results showed that many end users (from the public, emergency management as well as strategic planning) find it very useful to have information on existing (or planned) defences, evacuation routes, meeting points, for example, already integrated in the maps. Such map contents have up to now not been required by article 6 of the Floods Directive but could be integrated in the maps in the process of the development of risk management plans.

All maps should refer to a single data basis. It is frustrating for end users if maps refer to different models or model runs. Even if different maps are produced for different end users they should all refer to the same data basis in order to avoid such frustrations.

Digital and printed maps should be viewed as complementary, not as alternative services. The easiest way to allow end users to receive a map according to their needs would be of course a digital map server. By choosing map layers according to their needs individual maps can be created. However, the existence of such map servers does not guarantee that e.g. the public recognises that such maps are really at hand in case of emergency. This means user-specific print-out versions should be produced for the most important user groups. However, as the recommendations for the different user groups in the following will show one map per user group will not be sufficient to show all relevant information. On the other hand, the number of print-out maps should not be too high in order to ensure applicability and avoid information overload. Participatory processes can be used to find out a good compromise.

Frequent updating of maps or at least information on the reference date of the maps seems to be useful for all user groups.

Recommendations for flood maps for strategic planning

As specified more detailed in section 10.2 of the comprehensive final report, map users in this group are usually very experienced in the work with flood hazard and risk maps. Furthermore, at least in normal working situations they have sufficient time to study maps in detail. Hence, they are able to deal with a high density of information displayed on the map

and complex scientific contents. The purpose of flood maps for this group is especially to show where areas of high risk are, i.e. where there is a need for risk mitigation efforts. Maps serve also as an intermediate product for economic appraisal of flood risk mitigation measures. For this flood risk has to be calculated for the situation with, and without, the planned measure(s) in order to estimate their risk reducing effect.

With regard to hazard information especially detailed information on flood extent and depth is required for events with different probabilities. If available also information on flow velocities can also be helpful.

Regarding information on the consequences of flooding the following contents are of importance:

- Information on the consequences of specific events should be shown, but also maps showing the annual average damage are necessary, especially as a basis for economic appraisals.
- As already required by the EU Floods Directive, not only should information on the economic damages be shown but also information on social, cultural and environmental risks in order to show a complete picture of possible consequences. This should also include critical infrastructure, such as bridges, power plants, or hospitals.
- For strategic planning also an aggregation of these different social, economic and environmental risks by means of a multicriteria risk map or a small-scale preliminary risk map can be helpful in order to show overall risk hot spots.
- Maps for strategic planning should also include information on existing flood protection, protected areas and residual risk in these areas.

Recommendations for flood maps for emergency management

The main purpose of flood maps in this field is to enable quick access to information such as affected areas, people to be evacuated, critical infrastructure to be protected, and evacuation routes in the event of a flood.

Maps for emergency management should include hazard information on the extent of events with different probabilities as well as information on critical depth and velocities (when it is no longer possible or save to access certain areas). However, a clear link to alarm stages and critical water levels at gauges upstream, for example need to be established. The question thus is not what area will be flooded during a flood event with a return period of approximately 1:25

(as this is only calculated after the event) but which area will be flooded if the water level rises above certain threshold values.

Also for emergency management, information on existing flood defences and areas protected by these defences is important: e.g. potential weak points in the defence line, at which level a failure of defences is possible and which areas would be affected in such a case.

With regard to the consequences of flooding the following information is most important for emergency management:

- The number of people at risk from a certain event, i.e. the number of people to be evacuated in the case of an emergency.
- Critical infrastructure which needs to be protected, secured or evacuated, i.e. hospitals, energy or water supply facilities, roads and bridges which may have to be closed. Furthermore, information should be given at which level of flooding e.g. roads can still be used and at which level they should be closed.

Apart from traditional hazard and risk information, information on emergency management itself should also be included, such as assembly points, evacuation routes, hospitals, coordination centres, or gauging stations. Again, information should be included which detail the level of flooding these emergency facilities are themselves at risk, i.e. when certain evacuation routes are not usable any more.

Recommendations for flood maps for the public

Many maps are directed towards the public (e.g. to motivate them to prepare for a flood hazard). In contrast to the previous groups, people of this group, in most cases, do not use maps on a daily basis and hence have different needs and requirements in terms of its content. Generally, we recommend that flood maps for the public should not be overly complex and should contain the following basic information.

Firstly, inundation depth information for different specific events should be shown. As normal citizens are not necessarily familiar with the concept of return periods or exceedance probabilities such terms should be avoided and rather terms like “small, medium or extreme event” should be used. Also the extent and depth of historical events could be shown as people can better relate the base information to their personal experience.

Maps for the public do not need to include information on potential consequences of flooding in terms of damages. However, it is important that all buildings and roads in the area are shown on the map so that people can easily orientate themselves and identify if their property would be affected in the case of a certain flood event. Therefore, affected buildings should be highlighted.

Also for the affected population selected information on emergency management displayed in the maps is useful. In particular, information on evacuation routes and assembly points should be included in the maps in order to show people quickly how to behave in case of emergency.

4 Common recommendations on the visualisation of flood risk maps

In order to communicate the above mentioned contents of maps to the end users it is furthermore important that the maps are designed and visualised in a way which can be easily understand by the end users. Based on our predecessor project RISKCATCH (Fuchs et al., 2009a, b) and additional insights gained from RISK MAP by means of eye-tracking tests, accompanying surveys, interviews and workshops some general and specific items can be recommended.

General recommendations:

Some general recommendations on the visualisation of maps have already been derived in the

RISKCATCH project: (1) A map background should be in bright colour to increase the contrast to informative elements, and to avoid an overload of information; (2) the legend should be sufficiently large, preferably on the right side of the central element of the map, with a limited number of information (not more than five classes of discretisation) comprised from one range in colour only and arranged in decreasing values; (3) a sufficiently large scale that the elements of the map are recognisable sufficiently rapid.

These findings have been extended and further specified during the RISK MAP project leading to further recommendations:

- Multiple topics dedicated to different user groups should not be shown on the same map. Evacuation information (which is necessary for emergency managers), for example, should not be mixed with information on economic impacts (which is more relevant for strategic planning).
- The areas at risk should be clearly visually differentiated from areas not at risk. Particularly, areas or properties at risk should be indicated with strong colours, while background information, such as properties not at risk should be kept simple and in pale colours.
- A simple background should be used in order to not dilute the legend information
- Specific icons or symbols can be used to highlight e.g. major risks, the direction of evacuation routes or the direction of the water flows. Ideally such icons or symbols should be self-explanatory. This can facilitate map reading especially for people not familiar with the site
- Text within the maps can enhance and speed up the transmission of important information such as information on the number of people to be evacuated in a certain district which can be transmitted more easily by text than by symbols of different size or colour gradients.

- The topics in the legend should be organized in a way that it really helps comprehension: Firstly hazard information, secondly major risks, then secondary risks, finally background information.
- For hazard maps a gradient of blues should be used, and for risk maps a gradient of red.
- The native language of each categories of readers should be used in the maps

Recommendations for flood maps for strategic planning

Flood risk management actors from strategic planning are usually very familiar with flood maps and – at least in normal decision situations – have enough time to study them in detail, i.e. they are able to deal also with complex visualisation of maps. Therefore, legends with a relatively high number of classes (4-5) can be used. Results had shown that people from strategic planning like to have information on flood hazard and consequences in the same map.

According to these recommendations on visualisation and the recommendations on contents given in the previous section, a typical map for strategic planning is suggested in Figure 1. However, as stated before there should not be only one map for each user group.

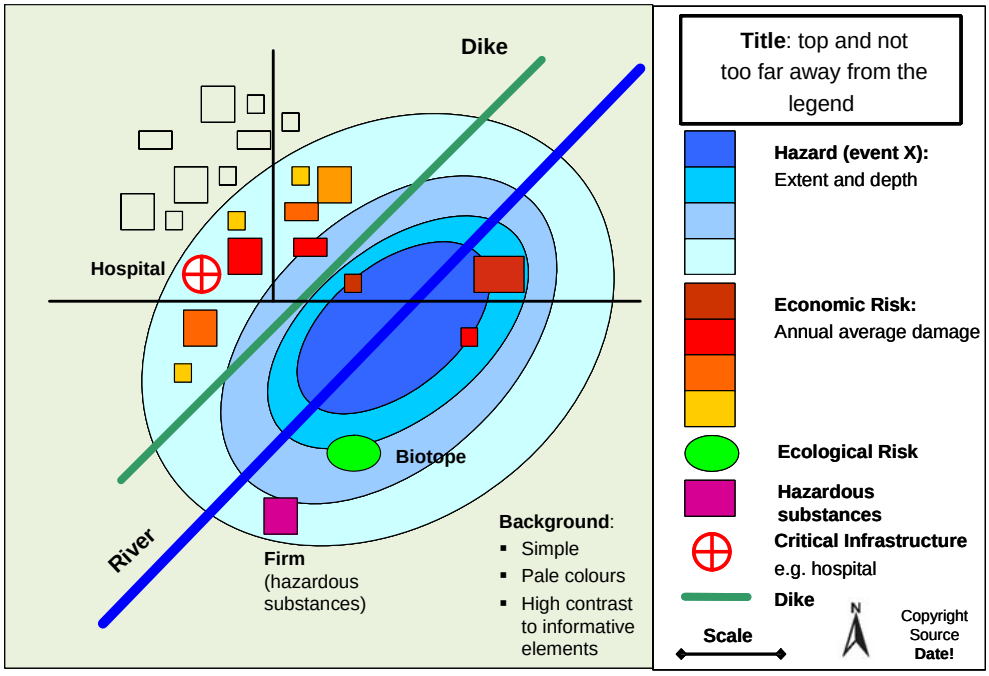

Figure 1. *Idealised map for strategic planning.*

Recommendations for flood maps for emergency management

In case of emergency there is only little time to read maps. Therefore the visualisation should be kept simple:

- Classifications in the legends should not have more than three classes at maximum
- Self-explanatory symbols and text within the map are good ways to visualise the most important information. This is particularly important when there is little time for reading maps so that users do not have keep referring to the legend to receive the information they require.
- Text is furthermore an important tool to quickly transmit information on e.g. number of people to be evacuated, names of important locations, etc.
- Information on flood hazard and consequences should be shown in the same map.

According to these recommendations on visualisation and the recommendations on contents given in the previous section, an idealised map for emergency management is suggested in Figure 2. Again, as stated before, there should not be only one map for each user group.

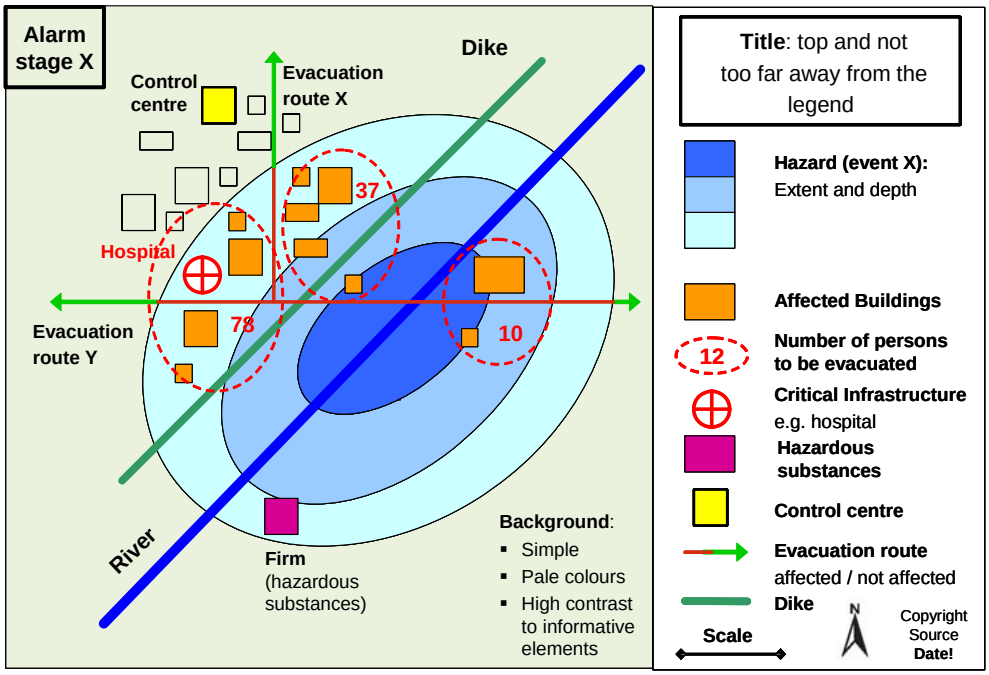

Figure 2. *Idealised map for emergency management.*

Recommendations for flood maps for the public

The visualisation of maps for the public should also be kept as simple as possible, as it cannot be expected that every member of this group is very familiar with map reading:

- Classifications in the legends should not have more than three classes at maximum
- Self-explanatory symbols and text within the map are also good ways to visualise the most important information. Especially when there is little time for map reading maps users do not even have to fully recognise the legend to receive the crucial information.
- However, compared to maps for emergency management the complexity and density of information should be reduced and only the most important contents should be shown and visualised in the maps.

According to these recommendations on visualisation and the recommendations on contents given in the previous section, an idealised map for the general public is suggested in Figure 3. As stated above there should not be only one map for each user group.

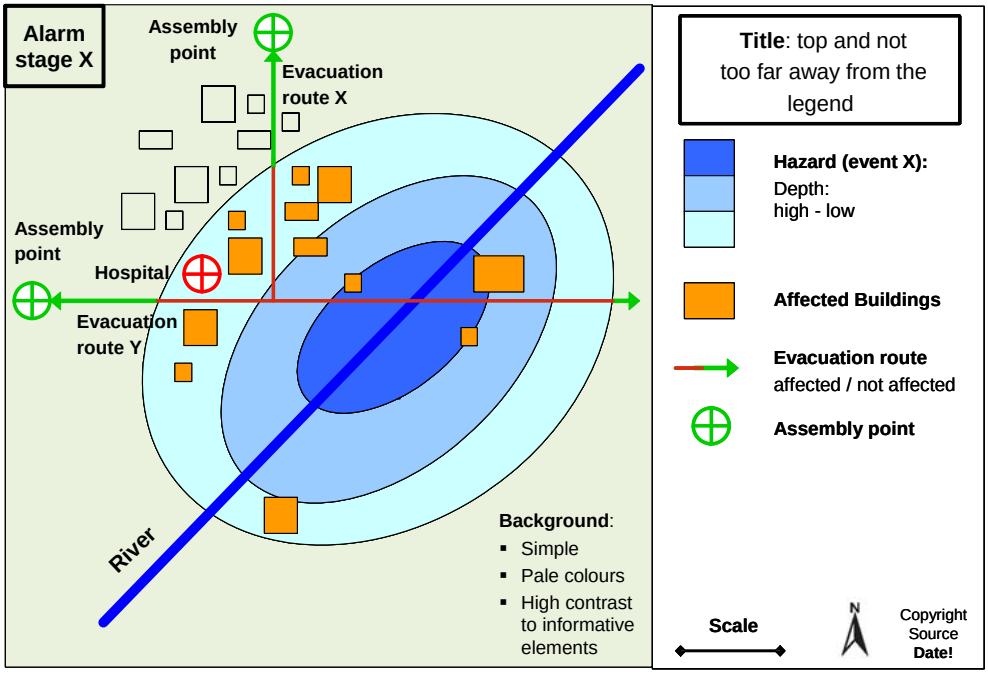

Figure 3. *Idealised map for the general public.*

5 Outlook

Having presented these “idealised” maps it seems to be important to mention again that there is not one ideal map, even for the different user groups. First of all, several digital or printout maps are required to show all important information, like e.g. inundation depth of different events. Secondly, the regional or local requirements on map contents and/or visualisation may differ a lot. Conducting participation processes is therefore in important means to unveil these

local preferences, to enrich the map information by local expert knowledge and to build trust in the maps.

Of course, such participation processes require time and effort. However, such participation processes (or at least formal consultation processes) are nevertheless required by the Floods Directive in the context of the development of the flood management plans according to article 7 of the directive. The flood hazard and risk maps as required by article 6 of the Floods Directive already build a very good basis for communicating risks to the end users. However, they could be further tailored to the end user needs during the process of the development of the flood risk management plans. With relatively little effort e.g. information on risk management or emergency management can be included in the maps. Experience from our case studies showed that it would be worth to take such efforts in order to improve flood maps and their contribution to risk and emergency management and to raise risk awareness.

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Fuchs, S., Spachinger, K., Dorner, W., Rochman, J., and Serrhini, K.: Evaluating cartographic design in flood risk mapping, Environmental Hazards, 8, 52-70, 2009b.

Kunz, M., and Hurni, L.: How to enhance cartographic visualisations of natural hazards assessment results, The Cartographic Journal, 48, 60-71, 2011.

Appendix 1: Findings from visualisation and from Experimental Graphic Semiology[2]

Risk management for flood hazards is based on risk assessment techniques, including methods to determine the hazard potential and procedures to analyse and evaluate the elements at risk exposed. For such management issues, risk maps provide the basis (1) for any planning and implementation of mitigation measures by public authorities as well as for the prioritisation of these measures, and (2) for any activities concerning regional development, land-use and construction engineering. Thus, the overall aim of risk mapping includes (1) the delineation of areas endangered by defined risk thresholds, (2) the assessment of exposure levels in such areas, and (3) the communication of risk to various stakeholders, e.g. politicians, residents and other people concerned. However, as many of these maps are produced by natural hazards specialists rather than cartographers, they often ignore cartographic principles, which results in overloaded and unbalanced maps that are difficult to interpret and to deduce suitable management strategies (Kunz and Hurni, 2011). Therefore, the impact of information on different stakeholder groups and end users has to be assessed in order to provide these issues appropriately.

Using the method of experimental graphic semiology had shown that the structure of maps influences the visual strategy of the readers; therefore, map perception is iconographic. The more accessible visual information is, the more effective it will be in terms of visual transmission of information. Moreover, particular reading behaviour of specialists, sensitised people and laypersons led to the conclusion that perception is anthropic. Hence, risk maps should be compiled according to these different needs, in particular bearing in mind that approximately two thirds of the observation time of individuals is devoted to less than one fourth of the map surface (Fuchs et al., 2009b). Taking the results from the RISKCATCH

project as a basis certain aspects are of general importance with respect to an appropriate visualisation of flood risk; these aspects were taken as an overall framework within the RISK MAP project:

- Coloured zones and written information concentrated approximately 90 % of the number of
- fixations of the individuals tested.
- The concentration of information in the legend needs to be visible (according to the contrast and colour used) and accessible (only a limited number of information), to attract the eye and deliver information.
- The spatial localisation of information considerably influences the perception by the reader.

[2] This was the work package within RISK MAP with a particular contribution from the Austrian project partner

The analysis of the visual strategies of the individuals tested and the results of an expert survey enabled us to identify some shortcomings of current practices in flood hazard visualisation and to suggest general improvements for visualisation of certain map elements.

A visual variable colour hue, value, or saturation is most frequently used for the depiction of hazards processes and large-scale maps are dominated by a spatial symbolisation filled in different colour schemes. The choice of a colour scheme has to be carefully performed as it is not only important for a visually attractive map but also to facilitate the distinction between data classes and the general visual exploration of the data by different stakeholder groups.

The potential of texture and symbols was found to be underestimated by mapmakers, as only few maps exhibit the use of such features, although they can associate map symbolisation with the characteristics of natural phenomenon which facilitates the intuitive interpretation of the map. Apart from the coordination of these elements, maps also have to be adjusted to the needs of different user groups. Therefore, icons indicating major cumulative risks, evacuation pathways or simply the direction of water body flow may be indicated in individual map templates.

The approach of toponomy may be used in addition to the traditional visual variables such as colour hue, colour value, colour saturation; and the shape, size, orientation, texture and transparency of individual elements in order to support the efficient orientation of end users; and to improve the visual accessibility of the map.

As the user group of flood hazard visualisations is heterogeneous, digital interactive environments can offer solutions to customise different map elements according to differing end user needs. We strongly recommend compiling flood risk maps of different content for specific user groups, which can be undertaken by GISs and similar digital environments efficiently from the underlying data sources. As such, an intervention map (produced for emergency management actors) will include different symbolisation than a flood risk map compiled for use in land development planning. As a consequence, supplementary information can be organised according to these different needs, e.g., the legend for lay persons may contain a small number of classes to communicate the general ideas of flood risk in a specific region while for the decision maker this legend may become more complex and multi-faceted in order to deliver as much information as possible.

By using the approach of experimental graphic semiology, the visual and cognitive perception patterns of different end user groups were assessed. The overall aim was to develop rules for the production of graphic documents that are suitable to the specific needs and preferences of multiple end users. The variables that were used to build-up these rules are summarised in Figure A1-1 and include specific semiological variables (form, size, shape, txt, colour) and the overall map content in a greater extent. The variables described in Figure 9.12 are related to the primary map content such as the vulnerability to flooding (colour variable), the population at risk (colour variable) and the migration flows (commuters, colour and size variable), the impacts of the hazard on the environment (economy, ecology, population, colour variable) and the mitigation alternatives (evacuation, colour and direction variables).

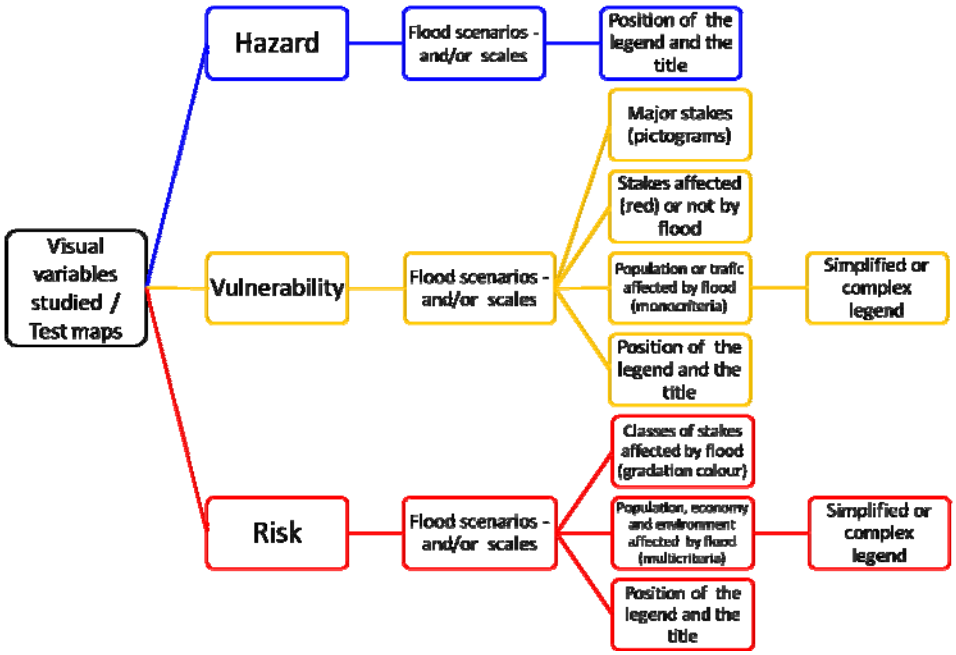


Figure A1-1. *Global logigram for the visual variables studied, in blue variables related to the hazard, in yellow related to the vulnerability and in red related to the summarising risk information.*

The statistic, static and spatial analyses of distribution of eye movements (fixations and saccades) resulted in two significant categories of visual strategies, (1) a linear category along a given axis or direction and (2) a dispersive category originating from the centre of the main graphic element in the map (Figure A1-2). With respect to the latter, the phenomenon of spatial concentration was observed, that is when the spread of the eye movements is limited to the centre and neglecting the peripheral areas of the graphic element. Accordingly the question of scale has to be addressed when compiling risk maps since these neglected peripheral areas provided the hint that the central elements may be depicted by using a larger map scale and therefore focussing on the core information to be delivered. These results confirmed the strong iconographic character of a risk map reported by Fuchs et al. (2009b) as a main result from the RISKCATCH project.

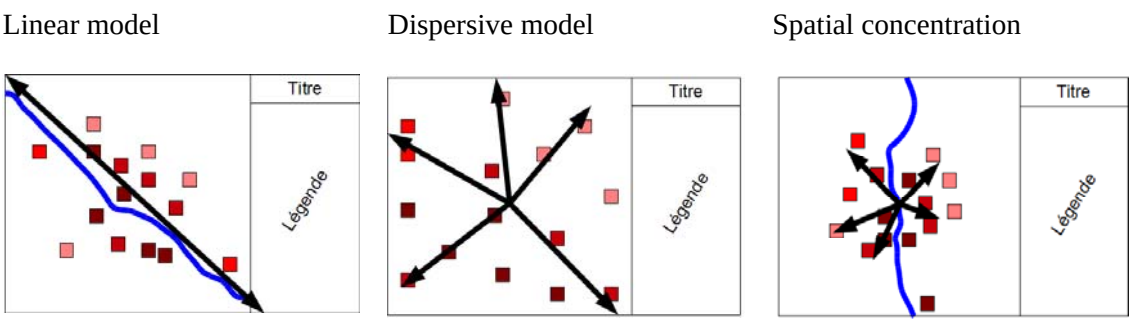


Figure A1-2. *Different patterns in the visual strategies of map reading.*

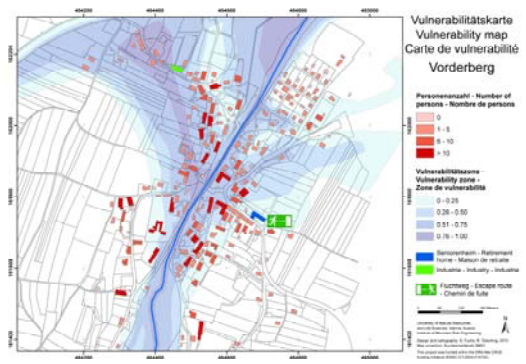
In general the sectorial analysis of the test results confirmed the strong attractiveness of graphic elements such as pictograms, contrast, and textual information to the gaze; as well as toponymy and (for mitigation purpose) linear elements of evacuation and access.

As analysis of the cognitive survey that accompanied the eye tracking tests showed strong correlations between the *density of information* provided and the *complexity* of the map, as well as between the *usefulness for application* in flood risk management and the *aesthetic aspect*.

The interactive elaboration of an idealised flood risk map attempts to assess the preferences of map-readers by giving them the opportunity to draw their preferred maps and to define the individual needs and semiological preferences of map design. Such an approach tends to be very helpful in terms of the analysis and assessment of different stakeholder preferences, and resulted in considerable differences in map design.

In accordance with the results of the eye tracking test and the stakeholder preferences a set of adjusted risk maps was produced in order to acknowledge the recommendations achieved with respect to form and content of risk maps (Figure A1-3). A complete set of modified maps is provided in the Appendix 2.

Initial map



Improved map

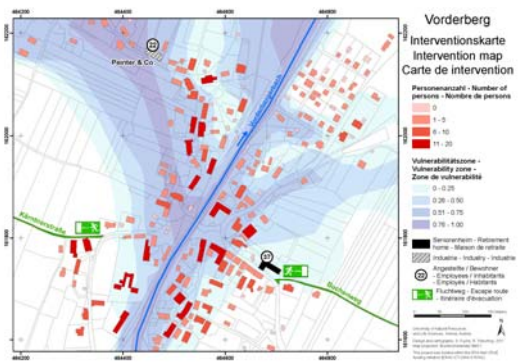


Figure A1-3. *Original risk map (left) and improved map from Vorderbergerbach, Austria, according to the findings of visualisation and experimental graphic semiology. Improvements included the scale of the central graphic element, the toponymy, and more specific information on people at risk and evacuation possibilities.*

A risk map compiled according to these conclusions would result in a visual strategy that is composed from three clear sets of ocular movements (Fuchs et al., 2009b): Starting from the centre, the eye moves to the title of the map, following a vertical axis downwards the legend section and returning back to the central element of the map. If there is sufficient time, the additional peripheral elements of the figurative part are explored subsequently.

However, due to budget constraints, the results of this pilot study are not yet fully representative. They can only provide first hints for further research, with respect to a larger group of test persons as well as with respect to further refinements of the method. In particular

concerning the European Flood Risk Directive, but also with respect to the overall aim of building hazard-resilient communities, future studies might include the applicability of risk maps within flood risk management plans. This is of particular relevance since different methods and guidelines exist in European countries in order to deal with hazard and risk, based on different national legislation. Hence, there is no commonly accepted guideline or template of how risk maps have to be compiled according to scale, design, content, etc. Moreover, due to different administrative organisation (e.g., centralised vs. federal) and multiple technical responsibilities on national scales (e.g., Torrent and Avalanche Control Service vs. Hydraulic Engineering), the compilation of necessary information remains often un-coordinated and even mono-disciplinarily organised between multiple stakeholders. Apart from these constraints it is still not sufficiently discussed which target scale to be used for the compilation of risk information (generalised using aggregated data vs. specific using object-based data). Therefore it might be necessary to compile different risk maps according to different scales, but also to deliver diversified risk information to different target groups and stakeholders.

Nevertheless, the study has proven that a stakeholder-oriented compilation and design of risk maps is of considerable importance in order to deliver information target-oriented. Therefore it is necessary to identify precisely the specific needs of different target groups and stakeholders.

Appendix 2: Modified maps according to the results of EGS

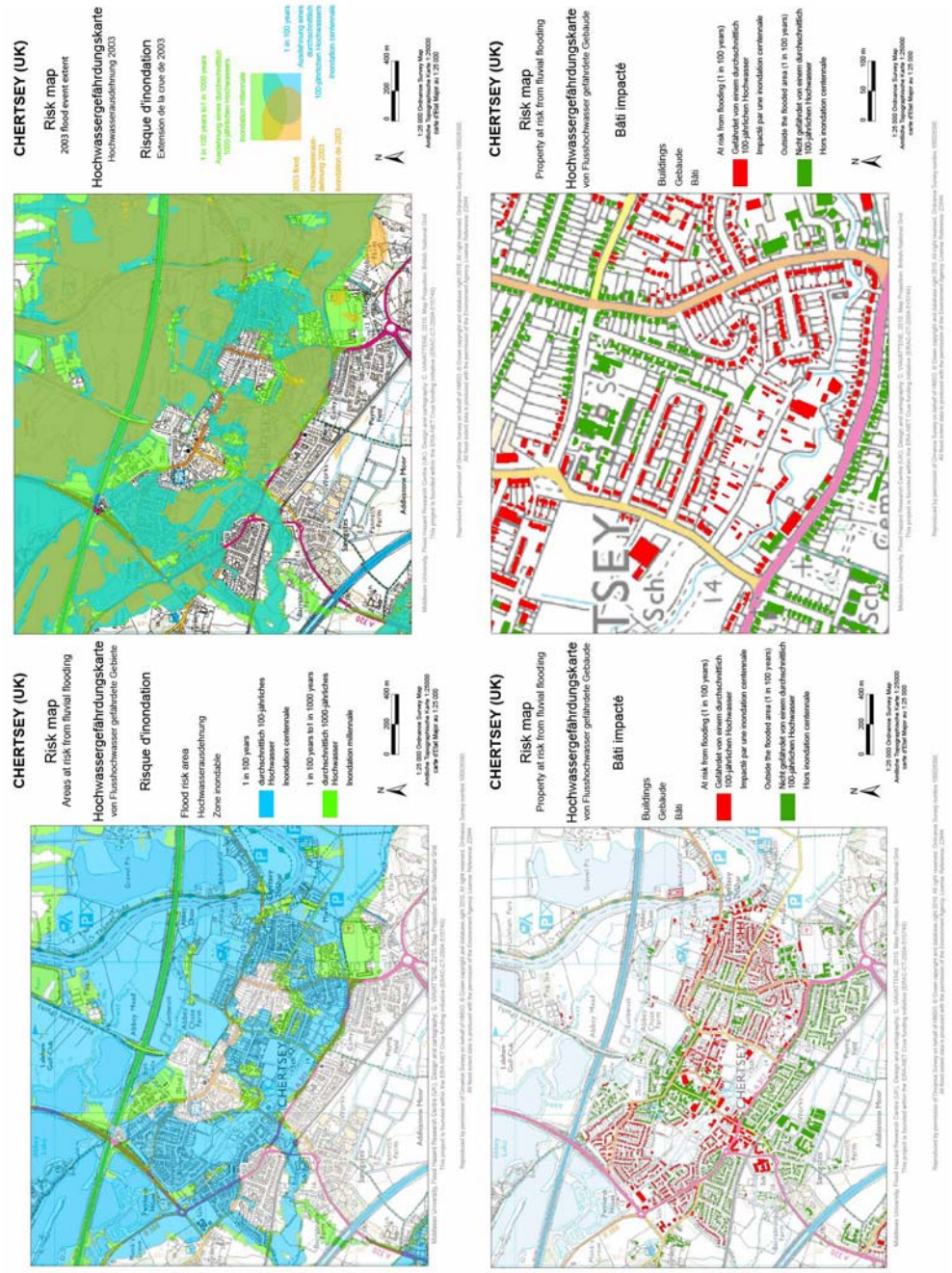


Figure A2-1. *Improved risk maps for the test site Chertsey, UK.*

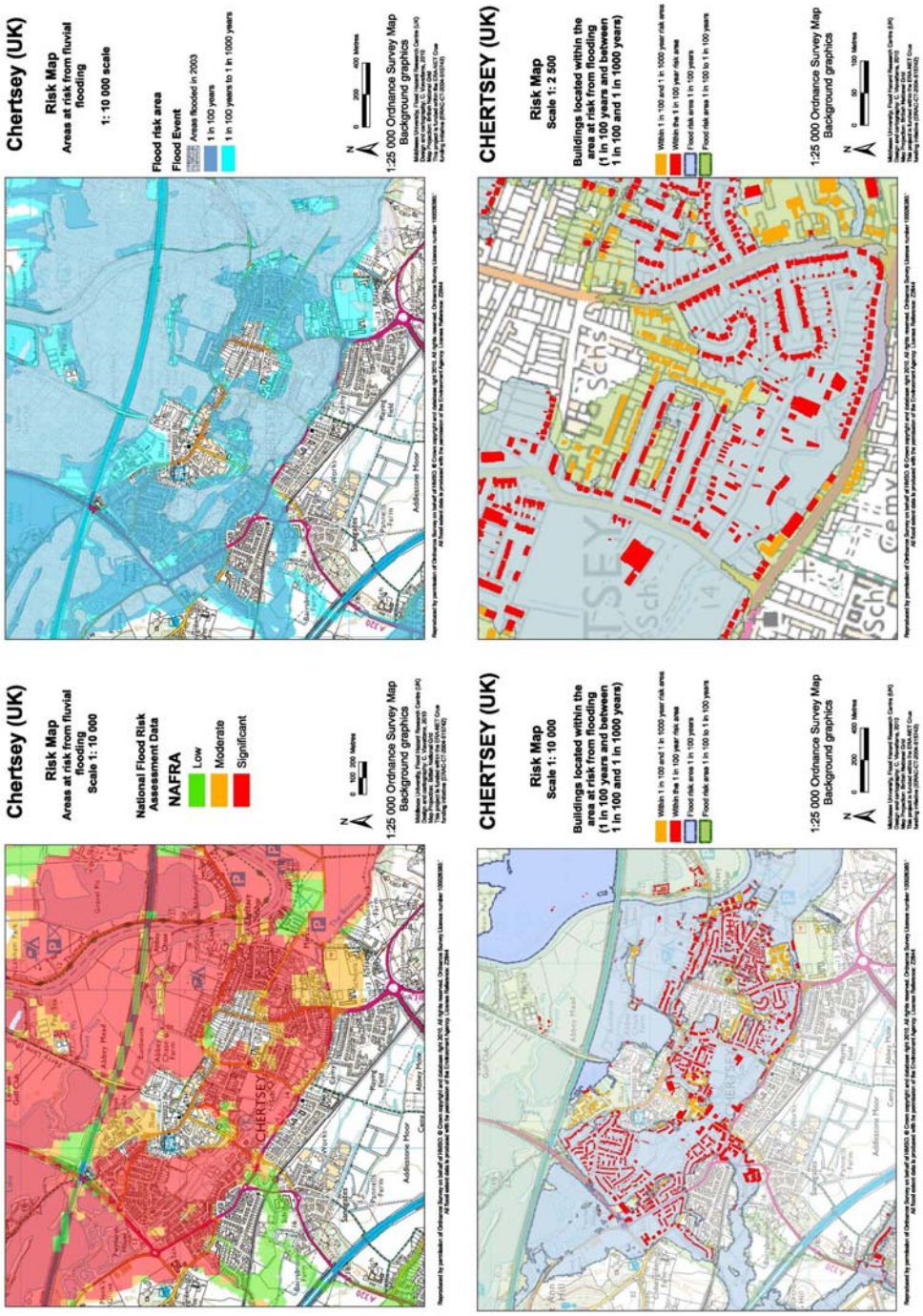


Figure A2-2. *Improved risk maps for the test site Chertsey, UK.*

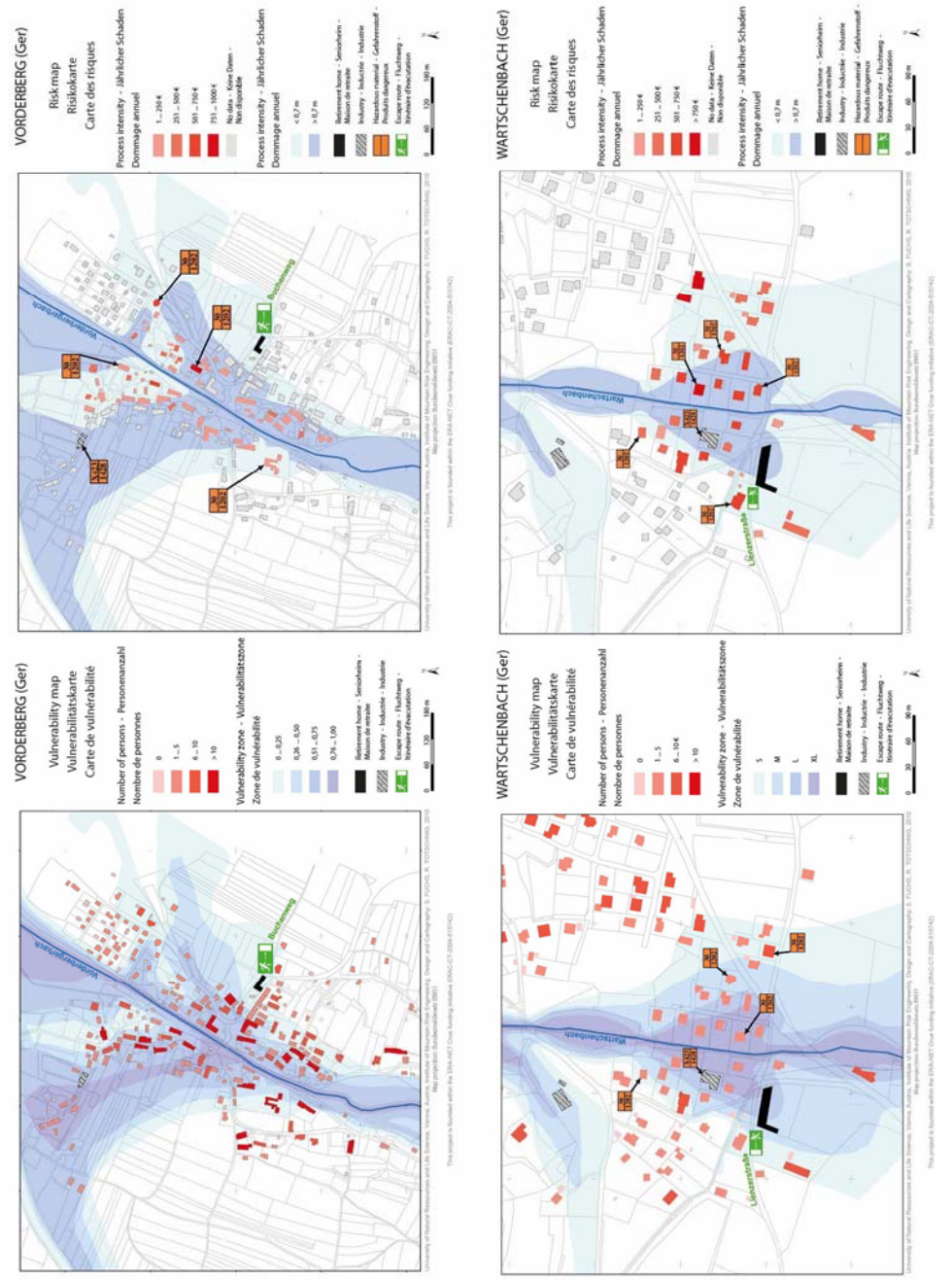


Figure A2-3. *Improved risk maps for the test sites Vorderbergerbach and Wartschenbach, A.*

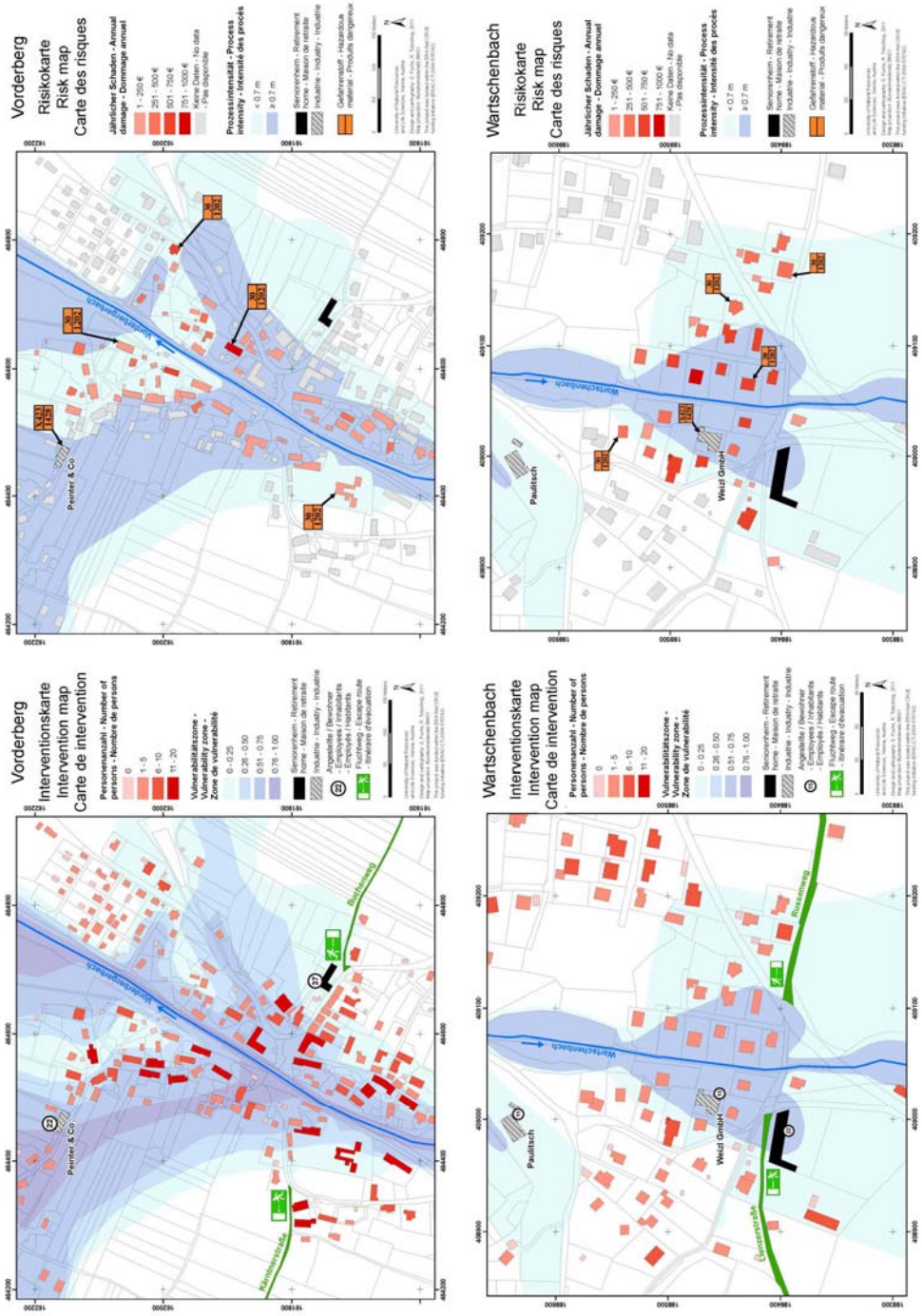


Figure A2-4. *Improved risk maps for the test sites Vorderbergerbach and Wartschenbach, A.*

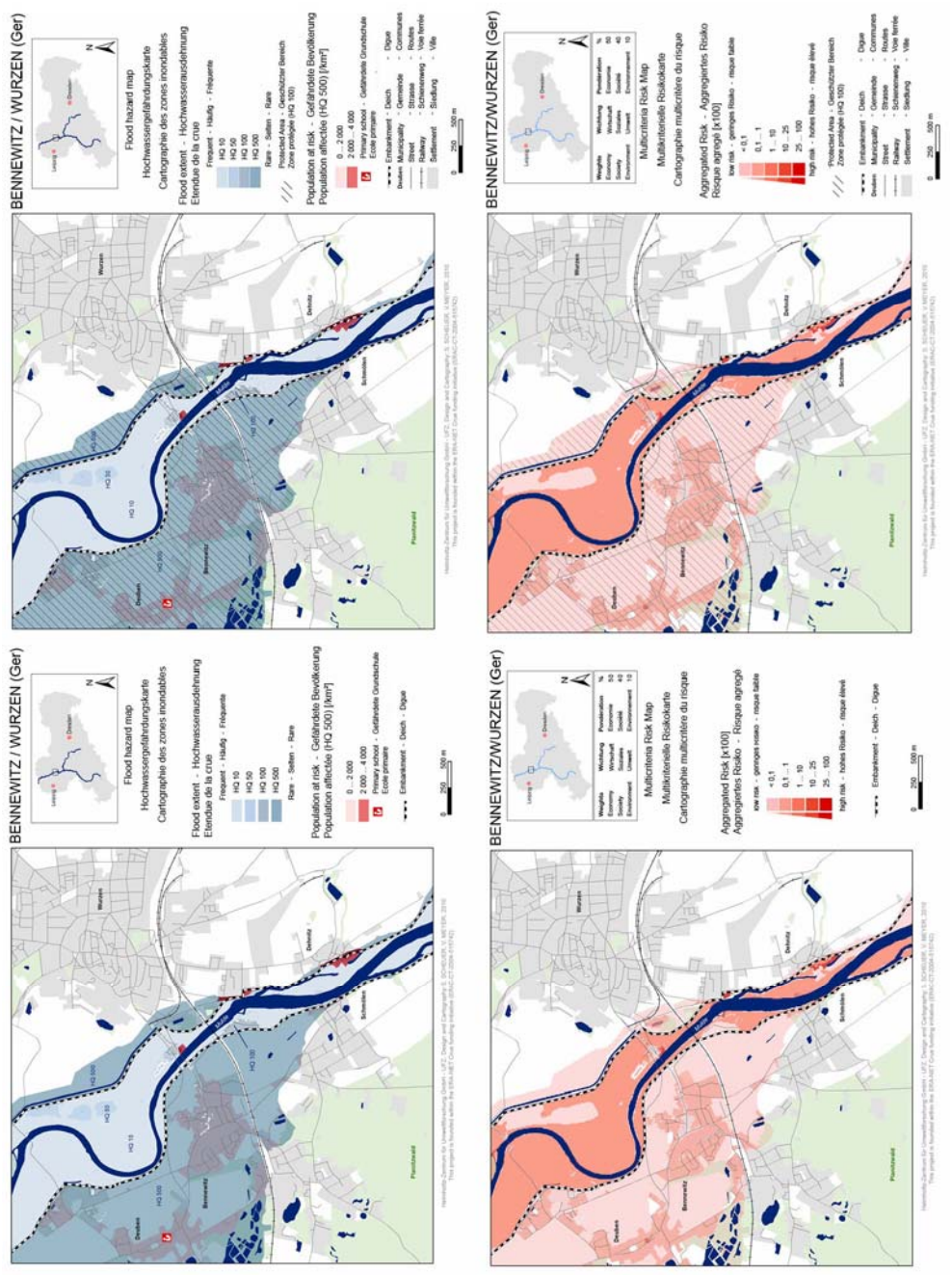


Figure A2-5. *Improved risk maps for the test sites Bennewitz/Wurzen, D.*

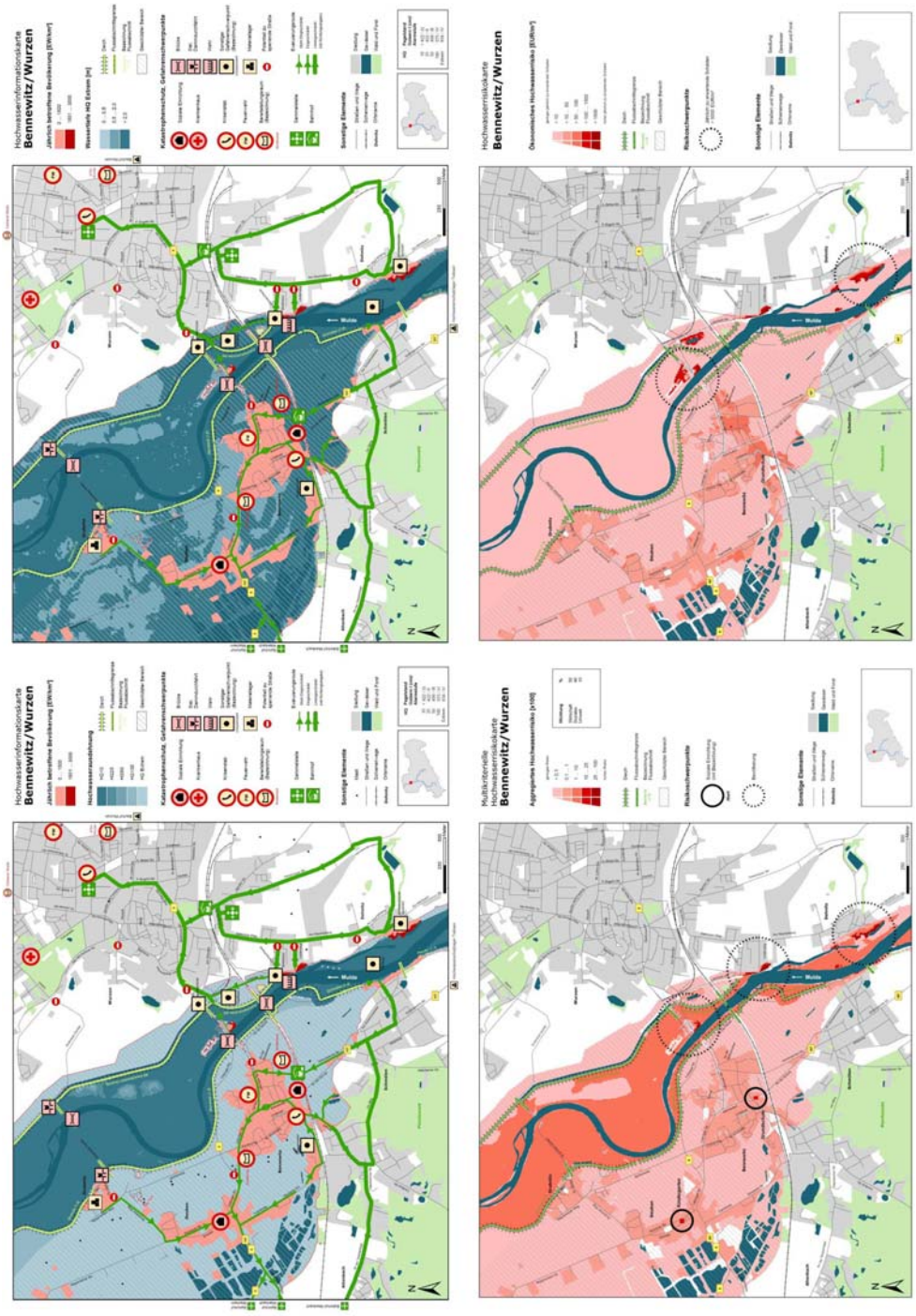


Figure A2-6. *Improved risk maps for the test sites Bennewitz/Wurzen, D.*

The entire set of maps can be accessed via: www.risk-map.org