Cartography M.Sc.

Master thesis

Improvement of Decision Making and Communication in Disaster Risk Management through Cartographic Dashboards

Rosalie Stephanie Kremser

Technical University of Munich

TECHNISCHE UNIVERSITÄT WIEN Vienna University of Technology

TECHNISCHE UNIVERSITÄT DRESDEN

UNIVERSITY OF TWENTE.

2020

Improvement of Decision Making and Communication in Disaster Risk Management through Cartographic Dashboards

submitted for the academic degree of Master of Science (M.Sc.)
conducted at the Department of Aerospace and Geodesy
Technical University of Munich

Author:	**Rosalie Stephanie Kremser**
Study course:	**Cartography M.Sc.**
Supervisor:	**Dr.-Ing. Mathias Jahnke**
Reviewer:	**Dr. M. Mingshu Wang**
Cooperation:	**Alexander Klaus (GAF AG)**

Chair of the Thesis
Assessment Board: Prof. Dr. Liqiu Meng

Date of submission: 10.09.2020

Statement of Authorship

Herewith I declare that I am the sole author of the submitted Master's thesis entitled:

"Improvement of Decision Making and Communication in Disaster Risk Management through Cartographic Dashboards"

I have fully referenced the ideas and work of others, whether published or unpublished. Literal or analogous citations are clearly marked as such.

Munich, September 10th, 2020 Kremser, Rosalie Stephanie

Abstract

Disasters are becoming increasingly present in our everyday lives. The Tianjin explosion in 2015 is a disturbing illustration of how devastating the effects of poor disaster risk management can be. Since disaster risk is a complex interplay between vulnerability, exposure and hazards, the analysis and evaluation of these factors is of critical importance. The responsibility of this objective lies in disaster risk management in order to ultimately minimize this risk and increase resilience to prevent disasters such as the Tianjin explosion in 2015 from occurring in the future.

In this context, the aim of this master's thesis was to evaluate the usability of dashboards for disaster risk management and to investigate whether decision making and the communication flow could be significantly improved in comparison to traditional solutions such as static maps.

Within the scope of this master's thesis, a dashboard prototype was designed and developed on the basis of a static map of the Tianjin explosion in 2015, under consideration of the user needs of a previously identified core user employed in the field of disaster risk management. By conducting several user tests, expert interviews and analyses, a high usability of dashboards for disaster risk management purposes was ultimately found. Furthermore, a general improvement of decision making processes and communication flow by dashboards has been identified in the course of a potential analysis. Finally, by conducting an online survey, the concept of the dashboard prototype was transferred to the disaster risk management community in order to investigate how the various disaster risk management stakeholders generally estimate the usability and relevance of dashboards in this field.

Keywords: dashboards, disaster risk management, decision-making, communication flow, interactivity, usability, cartography

Acknowledgments

Firstly, I would like to thank the coordinators of this wonderful master's programme for their endless support and for creating a creative environment where goals and ideas can be freely realized. You, especially Juliane Cron, make it possible to offer a unique learning atmosphere to young motivated people from all over the world.

I am deeply grateful for the opportunity to write this master's thesis about the usability of dashboards in disaster risk management. This field has accompanied me for a long time and this thesis provided me with the opportunity to gain profound background knowledge as well as to engage with a topic which entirely fascinates me. For this reason, I would like to thank my supervisors Dr.-Ing Mathias Jahnke and Alexander Klaus for their dedicated support, advice and cooperation. For encouraging the realization of my own ideas and objectives and for providing me with the freedom to do so!

Furthermore, I would like to thank all my friends and colleagues for taking the time to participate in the user tests during the difficult COVID-19 period, for reviewing my thesis and for sharing their valuable inspirations and feedback with me.

A particular acknowledgment is also owed to the experts working in the field of disaster risk management who have shared their expertise and positive feedback with me and who took the time to participate in the online survey. I am aware that this was not something that could be taken for granted!

Finally, my deepest gratitude belongs to the people who I love most and who are the closest to me. I cannot thank you enough for your support, opinions and comfort in difficult times, which have not only accompanied me through this master's thesis, but throughout the entire time of my studies. Without you it would not have been possible and you are part of this result. This is especially true for both of my parents who have had my back in the most important moments and who have always been my safety shelter. I am eternally grateful to you for making this education possible - from the very beginning all the way to the end.

Contents

1 Introduction **5**
1.1 Background, Problem Statement and Motivation . . . 5
1.2 Research Identification . . . 6
1.2.1 Research Objectives . . . 6
1.2.2 Research Questions . . . 7
1.3 Hypotheses . . . 7
1.4 Innovation . . . 7

2 Literature Review **8**
2.1 Disaster Risk Management - an Overview . . . 8
2.1.1 Definitions and Terminology . . . 8
2.1.2 Disaster Risk Management Cycle . . . 13
2.1.3 International Disaster Risk Community . . . 16
2.2 Disaster Risk Management in Cartography . . . 20
2.2.1 The Use of Cartography in Disaster Risk Management . . . 20
2.2.2 Modern Trends in Cartography - Dashboards . . . 27

3 Core User Identification, Data Description and Study Area **33**
3.1 Tianjin Disaster, China . . . 33
3.1.1 Core User Identification . . . 33
3.1.2 Data Description, Background and Study Area . . . 34
3.2 EMSN034: Coastal flood risk analysis for population and assets, Portugal . . . 36
3.2.1 Data Description, Background and Study Area . . . 36
3.2.2 Focus Group . . . 38

4 Methodology **39**
4.1 Requirements Analysis . . . 39
4.1.1 Core User Needs . . . 39
4.1.2 Expert Interviews . . . 41
4.2 Potential Analysis . . . 41
4.2.1 EMS034 Dashboard - Portugal . . . 41
4.2.2 Focus Group Test I . . . 43
4.3 Dashboard Prototype . . . 44
4.3.1 Tianjin Dashboard . . . 44
4.3.2 Focus Group Test II . . . 47
4.3.3 Qualitative Feedback . . . 48
4.4 Sector Analysis . . . 48
4.4.1 Online Survey . . . 48

5 Results **50**
5.1 Requirements Analysis . . . 50

5.1.1 Core User Needs . . . 50
5.1.2 Expert Interviews . . . 51
5.2 Potential Analysis . . . 53
5.2.1 Focus Group Test I . . . 53
5.3 Dashboard Prototype . . . 57
5.3.1 Focus Group Test II . . . 57
5.3.2 Qualitative Feedback . . . 59
5.4 Sector Analysis . . . 60

6 Interpretation and Discussion **63**
6.1 Requirements Analysis . . . 63
6.2 Potential Analysis . . . 64
6.2.1 Focus Group Test I . . . 64
6.3 Dashboard Prototype . . . 67
6.3.1 Focus Group Test II . . . 67
6.3.2 Technical Aspects and General Issues . . . 68
6.3.3 Qualitative Feedback . . . 68
6.4 Sector Analysis . . . 69

7 Conclusion and Outlook **71**
7.1 Conclusion . . . 71
7.2 Outlook - Future Trends in Disaster Risk Management, Cartography and Dashboards . . 73

Chapter 1

Introduction

1.1 Background, Problem Statement and Motivation

Floods, droughts and tropical storms - due to their increasing numbers the evaluation and analysis of natural and anthropogenic disasters has progressively gained importance in the last decades. Enormous resources are being invested in the corresponding disaster risk management, which has led to the development of an originally very small community into an entire industry. This trend is additionally being accelerated by climate change, leading to a constant growth of this industry.

The acquisition, visualization and analysis of risk-relevant data constitutes an integral part in the disaster risk management of natural and anthropogenic hazards, in order to ensure the protection of humans and their property. Thereby risk assessment and crisis management for natural and human induced hazards, but also geopolitical and other emerging risks like pandemics, make strong use of cartographic visualization techniques. A good up-to-date example is the case of the corona virus (COVID-19), ravaging in a time while this master's thesis was written. As seen in Figure 1.1 during this crisis countless cartographic dashboards and other cartographic visualizations were created to inform, manage and assess different aspects of the crisis. This provides a small impression, how greatly these cartographic products are in demand and how well they can serve for improved vulnerability assessment and decision making in disaster risk management.

Simultaneously, the field of cartography is constantly evolving, providing more and more possibilities and tools for better and detailed risk and vulnerability assessment. This trend is supported and accelerated by faster and better hardware. These developments include for example more interactive and web-based maps and cartographic visualizations. Flexible and interactive dashboards even take it a step further by constituting a powerful visualization tool in disaster risk management, providing the possibility to integrate a variety of those interactive maps, supporting graphs and indicators for presenting information in a coherent and intuitive manner.

However, until today, the use of static maps and written reports are still primary communication tools used in disaster risk management. The aim of this master's thesis is to investigate, whether the process of decision making, vulnerability assessment and the communication flow in the field of disaster risk management can be improved with the aid of dashboards. Intentions are hereby to make these processes faster and more intuitive, bundle risk-relevant information more efficiently and to create an understanding on a deeper level. This will be achieved within the framework of a requirements analysis by designing a concept and its implementation for a dashboard with interactive maps and visualizations. Within the scope of an additional potential analysis the performance of dashboards compared to static maps will be evaluated. If the potential analysis proves to be successful, a specific and sophisticated dashboard prototype will be created in collaboration with a core user from the disaster risk community. Subsequently, it will be evaluated if the concept of a dashboard can be applied within the entire disaster risk community.

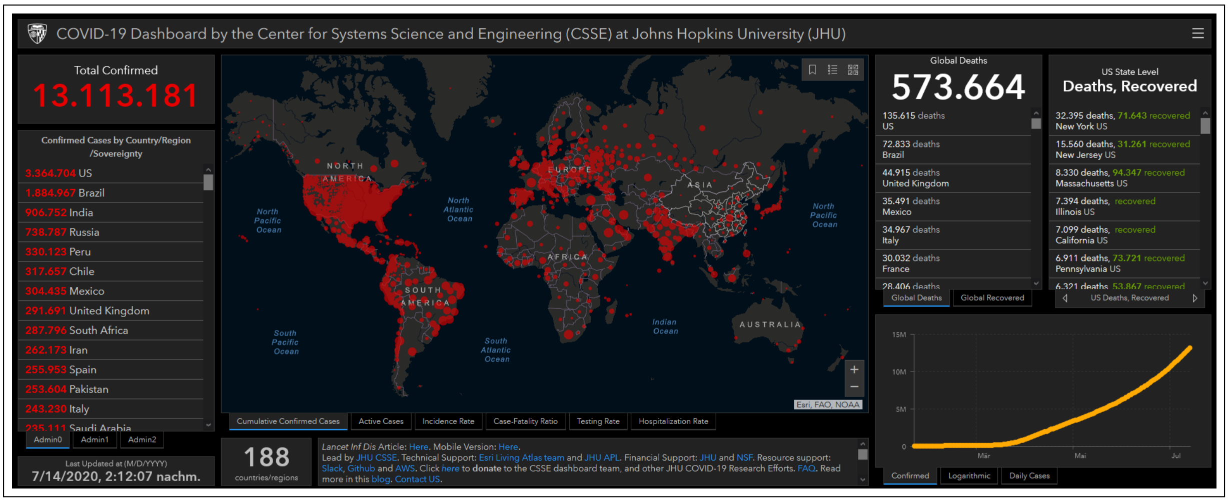


Figure 1.1: COVID-19 dashboard by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University (JHU). Retrieved from: Johns Hopkins University (2020)

1.2 Research Identification

The overall research focus of this thesis is to analyze the potential and the added value of dashboards in disaster risk management compared to conventional and currently frequently used methods like static maps and reports. Within the scope of this investigation and development three main research objectives and one sub-research objective with corresponding research questions have been defined. The aim is to test the usability of dashboards and to identify whether they would make the risk assessment and decision making process more intuitive with a specific focus on the field of disaster risk management. Additionally aspects, like increased user satisfaction of a potential core user are also investigated. Finally, the investigation is expanded to other potential user groups and how the entire disaster risk community perceives dashboards as a risk assessment tool is examined.

1.2.1 Research Objectives

I Identify whether decision making and communication flow could be improved by the interactive character of a dashboard compared to static maps.

II Identify whether dashboards as interactive cartographic visualizations are a useful tool for risk and vulnerability assessment for disaster risk management purposes.

- i Identification of a core user and his or her needs within the disaster risk industry for a user-centered dashboard design. Furthermore, identify whether the dashboard will be accepted by the core user as an alternative to static maps.

III Investigate whether the concept of a dashboard as an interactive cartographic visualization is applicable to other potential user groups, working in the disaster risk industry in different sectors.

1.2.2 Research Questions

I

- Can the overall communication flow and decision making processes regarding the efficiency and accuracy of information capture be improved by using dashboards for risk and vulnerability assessment in disaster risk management?
- What are the advantages of dashboards over static maps?

II

- Is the concept and the use of a dashboard applicable for risk and vulnerability assessment in disaster risk management?
- How can the concept of a dashboard prototype be constructed so that it applies effectively and with a high user satisfaction for risk and vulnerability assessment within disaster risk management?

i

- What are the needs of a potential core user for a dashboard, working in disaster risk management?
- How should the dashboard be designed and conceived to be accepted by the core user and to provide a good qualitative feedback?

III

- Is the concept of a dashboard scalable to different institutions, organizations and companies working in disaster risk management?
- How high is the willingness to use dashboards in disaster risk management?

1.3 Hypotheses

Interactive cartographic visualization tools like dashboards will be an upgrade for risk and vulnerability assessment for natural and human induced disasters and geopolitical risks. They will contribute to improving decision making processes and the overall communication flow of risk relevant information. Additionally, there will be an advantage in the design process for a dashboard-prototype if user-conceptions and ideas are part of the implementation in the sense of "user-centered design".

1.4 Innovation

The innovation character will be that new cartographic visualization techniques like dashboards will be implemented into the user environment within the disaster risk community, in order to improve and optimize the process of risk and vulnerability assessment as well as decision making and communication flow in disaster risk management. It aims to promote a more intuitive way of using maps and cartographic visualizations during decision-making processes and to help to take more informed judgments through smart information bundling. In this context, dashboards may be an innovative alternative to "outdated" methods as static maps and reports.

Chapter 2

Literature Review

This chapter provides sound background knowledge on cartographic visualization techniques in disaster risk management. An overview is given on how these techniques are linked to decision making and the communication of risk relevant information. A specific focus is put on the role of dashboards in these processes. The terms risk, vulnerability, hazard, exposure, dashboards and cartographic visualization techniques are very broad key terms. In order to provide a deep level of understanding of the context, detailed descriptions are outlined in the following.

Chapter 2.1. provides relevant definitions, terminology and aspects of disaster risk management in order to get an overview of the field. Chapter 2.2. focuses on trends in cartographic visualization like dashboards and highlights the relevance for disaster risk management. It also discusses how cartography is a powerful tool for decision making and for the communication of risk relevant information in disaster risk management.

2.1 Disaster Risk Management - an Overview

2.1.1 Definitions and Terminology

In order to get a profound comprehension of **disaster risk management**, some key terms related to disaster risk management and reduction need to be explained.

Vulnerability

The concept of **vulnerability** is crucial for the understanding of the purpose and operation of disaster risk management.

According to the United Nations Environment Programme (2010) vulnerability is defined as "the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard. Vulnerability is the result of the whole range of economic, social, cultural, institutional, political and even psychological factors that shape people's lives and create the environment that they live in."

Vulnerability addresses the crucial conditions that increase the susceptibility of elements at risk to the impact of a hazard. Elements at risk include society and individuals, assets and other elements, objects and processes that are susceptible to damage and destruction. Vulnerability is not a fixed term linked to elements at risk. For example it can vary within a population by subgroup (income level or type of livelihood) and may increase complexity in risk assessment and vulnerability measurement by *changing* over time. The degree of potential damage through the impact of a hazard is defined through the areas vulnerability (UN-SPIDER, 2020c).

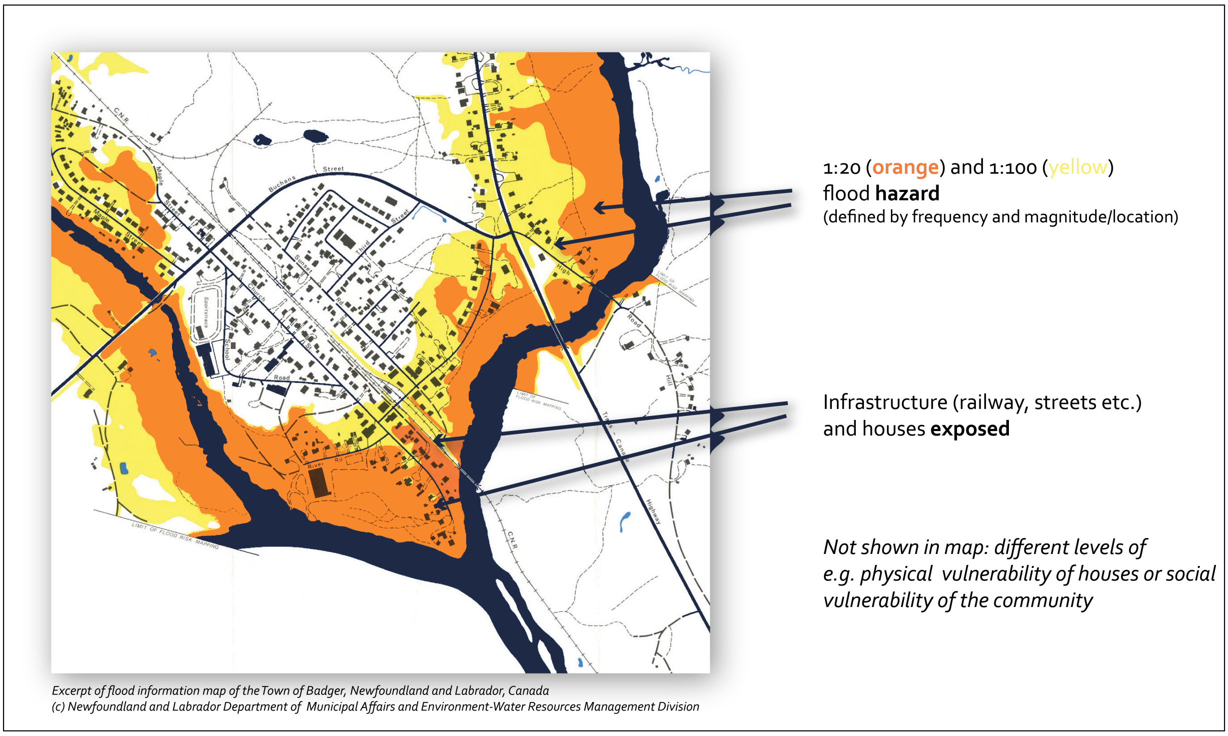


Figure 2.1: Map about flood risk in Newfoundland. The orange and yellow layer represent the flood risk with different return periods (20 and 100 years). Exposed houses and railways lie are located within these layers. Not shown in map are different levels of vulnerability. Retrieved and adapted from: UN-SPIDER (2020a)

Exposure

As well as understanding vulnerability, the concept of **exposure** is fundamental for understanding disaster risk management. UNISDR (2009) defines exposure as "the people, property, systems, or other elements present in hazard zones that are thereby subject to potential losses".

Exposure can be understood as the stock of property and infrastructure exposed to a hazard (Prevention Web, 2020a).

Exposure is, differently to vulnerability, directly related to the *situation* elements at risk (people, infrastructure, housing, production capacities and other tangible human assets) are located within hazard endangered areas (UN-SPIDER, 2020c). As well as vulnerability, exposure is *dynamic and varies* across temporal and spatial scales - highly dependent on economic, social, geographic, demographic, cultural, institutional, governance-related, and environmental factors (UNISDR, 2016).

An example of how exposure of objects are linked to a hazard (outlined in the following section) can be viewed in Figure 2.1.

Hazard

According to UN-SPIDER (2020c) a **hazard** is "a process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation. Hazards may be single, sequential or combined in their origin and effects. Each hazard is characterized by its "location, intensity or magnitude, frequency, and probability". This means that a hazard is primarily natural or anthropogenic origin which *may* evolve to the extend of causing a disaster (WHO and EHA, 2002).

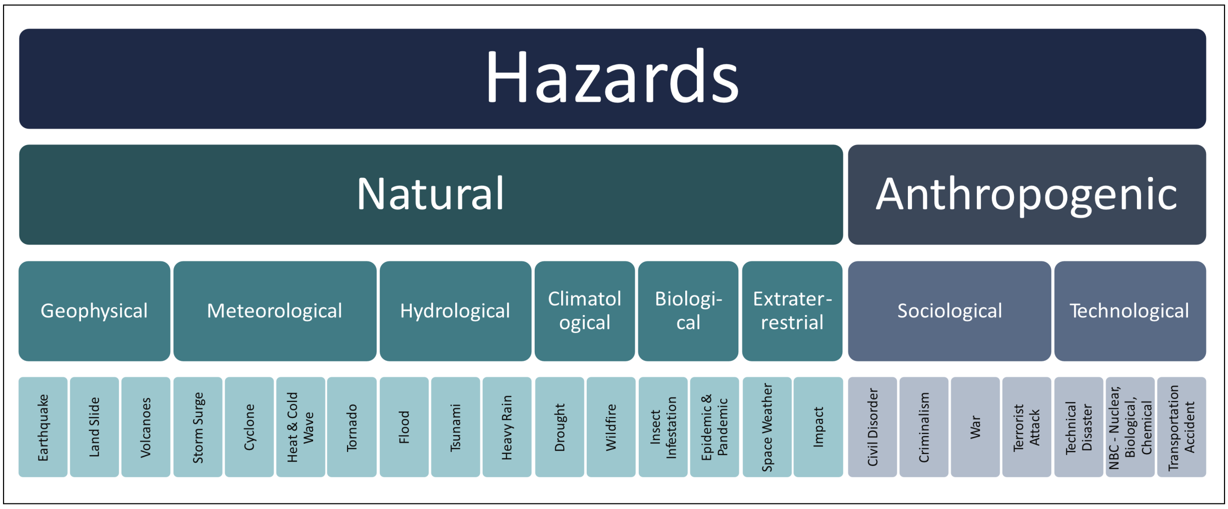


Figure 2.2: Natural and anthropogenic hazards - an overview. Graphic derived from: Prevention Web (2020c) and Munich Re (2020a)

As the last sentence indicates, hazards can be generally divided into two categories: Natural hazards are naturally occurring physical phenomena, which can be divided into five subcategories: geophysical phenomena (earthquakes, landslides, tsunamis and volcanic activity), hydrological phenomena (avalanches and floods), climatological phenomena (extreme temperatures, drought and wildfires), meteorological phenomena (cyclones and storms) or biological phenomena (disease epidemics and insect or animal plagues) (IFRC, 2020). Classification schemes for hazards vary between research institutions. Some also include extraterrestrial phenomena (near-earth objects and space weather) (UN-SPIDER, 2020b). A detailed overview and classification is displayed in Figure 2.2.

The second category are anthropogenic hazards. Anthropogenic hazards can be subdivided into technological or human-induced hazards (complex emergencies and conflicts, famine, displaced populations, industrial accidents and transport accidents). These events are characterized through a human *cause* and they occur commonly in, or close to human settlements. Often environmental degradation, and pollution are closely linked to technological and human-made hazards (IFRC, 2020).

Hazards can often trigger a sub-set of hazards. This can cause a cascading effect like the case of the tsunami-earthquake-nuclear crisis in Japan, 2011 (Prevention Web, 2020b).

Disaster

Another fundamental term that needs to be described is the key term **disaster**. According to UNGA and UNDRR (2016) a disaster is "a serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts." The damage of the affected area through a disaster is hereby commonly measured in physical units by describing the total or partial destruction of physical assets, the disruption of basic services and damages to sources of livelihood.
It is crucial to understand that disasters are not natural in origin, even if the hazard associated with it is. Hazards do not have to turn necessarily into a disaster, for example when no elements at risk are exposed to a hazard. **Essential is that only in combination with vulnerability and exposure conditions a hazard *can* turn into a disaster**. This constitutes the fundamental difference between hazards and disasters. The focus lies here on the *possibility* (Prevention Web, 2020b).

Disasters can not only be classified by their hazardous origin, but also by their *impact* at different scales. The impact of a disaster includes all negative and positive effects (like economic gain and loss) and has

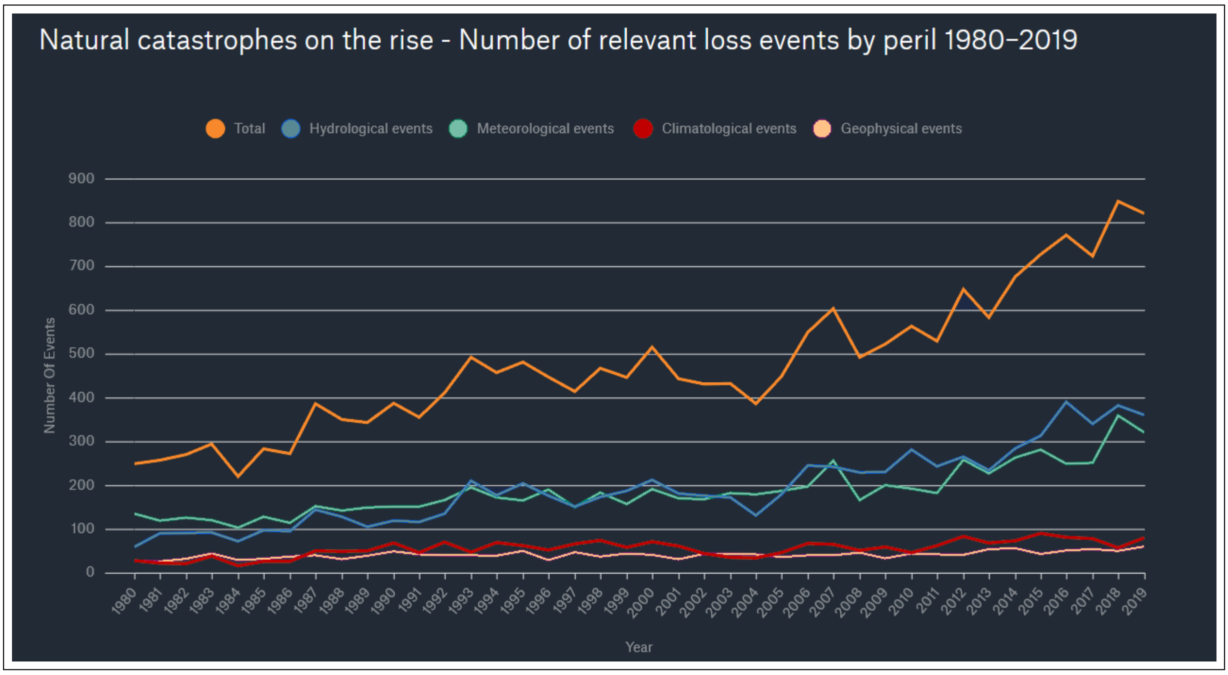


Figure 2.3: Risks posed by natural disasters. Number of relevant loss events by peril 1980–2019. Retrieved and adapted from: Munich Re (2020b)

direct or indirect consequences on the economy, humans and the environment (UNGA and UNDRR, 2016).

A classification by impact is provided by UNGA and UNDRR (2016):

- **Small-scale disaster**: "a type of disaster only affecting local communities which require assistance beyond the affected community."
- **Large-scale disaster**: "a type of disaster affecting a society which requires national or international assistance."
- **Frequent and infrequent disasters**: "depend on the probability of occurrence and the return period of a given hazard and its impacts. The impact of frequent disasters could be cumulative, or become chronic for a community or a society."
- **Slow-onset disaster**: "a slow-onset disaster is defined as one that emerges gradually over time. Slow-onset disasters could be associated with, e.g., drought, desertification, sea-level rise, epidemic disease."
- **Sudden-onset disaster**: "a sudden-onset disaster is one triggered by a hazardous event that emerges quickly or unexpectedly. Sudden-onset disasters could be associated with, e.g., earthquake, volcanic eruption, flash flood, chemical explosion, critical infrastructure failure, transport accident."

The severity of the impact of a disaster is therefore highly dependent on the vulnerability and the exposure conditions of the affected area.

The Database EM-DAT, an international disaster database by the Belgium Centre for Research and Epidemiology of Disasters suggests the following criteria to classify a disaster (CRED, 2020). According to CRED (2020) a hazard turns into as disaster if one of the following criteria is confirmed:

- 10 or more people dead;
- 100 or more people affected;

- The declaration of a state of emergency
- A call for international assistance

Figure 2.3 illustrates the common understanding between scientists that the global occurrence of disasters is frequently rising. According to analysis of the EM-DAT the amount of listed natural disasters has steadily increased in the last decades - from 78 in 1970 to 348 in 2004 (Than, 2005). Monetary economic loss or loss of lives, caused by natural (or anthropogenic) disasters, is increasing worldwide respectively (Munich Re, 2020b).

A crucial aspect is that disasters must not be mistaken with the terms **emergency**, **crisis** and **catastrophes**. The main difference between those terms is the spatial and temporal scale but otherwise they are interconnected, interdependent and overlap significantly. An event is called **emergency**, when the geographic scale is rather small and the impact can be handled by local authorities - which in the case of a disaster is not possible. The term **crisis** is characterized through its temporal peculiarity - continuing events that may lead to a disaster (Tomaszewski, 2014). **Catastrophes** are very similar to disasters definition wise - but have a bigger impact to physical, social and organizational systems (Quarantelli, 2006).

Disaster Risk:

Since risk is a *forward* looking concept, "Disaster risk is expressed as the likelihood of loss of life, injury or destruction and damage from a disaster in a given period of time (Prevention Web, 2020c)".

Risk represents the presence of vulnerable elements in areas exposed to hazards. The equation in Figure 2.4 demonstrates this coherency. The equation of hazard, exposure, vulnerability and risk illustrates clearly that if a hazard occurs in an area of no exposure, no risk can occur. All terms of the equation must be present to constitute the potential risk for a disaster. Conversely, there is a zero probability for a disaster if one of the terms is missing. From the equation can be also derived that increases in the terms vulnerability and exposure dominate and trigger the overall increase in risk. This trend can be observed worldwide in increased risk of disasters over the past several decades (UNISDR, 2009).

In order to understand the concept of disaster risk more coherently, the following aspects need to be considered:
Disaster risk can due to its *dynamic* nature change through increasing or decreasing vulnerability or exposure of the elements at risk. Risk is an *abstract* concept, and consequences through frequent, low impact events are often hidden. It is crucial to understand that the pattern of disaster risk *reflects* globally the social construction of exposure and vulnerability. Since hazards affect different areas, but exposure and vulnerability depend on socio-economic factors, disaster risk is unevenly distributed around Earth, affecting most those who do not have the means to protect themselves. The complexity of disaster risk is high - many processes and factors, like climate change and globalized economic development, have a direct effect on vulnerability, exposure and hazards, triggering the emergency of new interconnected risks (Prevention Web, 2020c).

Risk drivers triggering disaster risk and indicate development failure are according to UNISDR (2009):

- Poverty
- Inequality
- Poorly planned and managed urban and regional development
- Climate change
- Environmental degradation
- Globalized economic development
- Weak governance

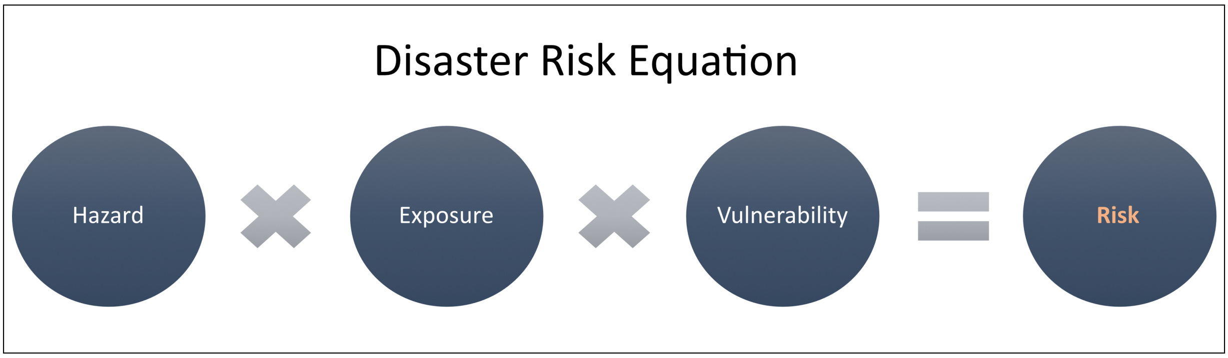


Figure 2.4: Equation of disaster risk. Derived and adapted from: UNDRR (2015b)

Since a disaster is a direct indicator of development failure, disaster risk automatically constitutes a measure of sustainability development (Prevention Web, 2020c).

Disaster Risk Reduction:

The identification and assessment of disaster risk is crucial for the understanding of how to efficiently reduce the risk of disasters. According to UNDRR (2015b), since 1980 over 1.6 billion people have been killed through the impact of disasters. Furthermore, by 2030 the estimated global average annual loss will increase up to 415 billion US dollars - forcing disaster risk to horrendous levels. These numbers show that disaster risk reduction is a *higher-level* problem and affects people, business and governments and different parts of society alike. It is essential to understand that disaster risk reduction must be considered as a shared value - a process only able to function with a multi-sector and human-centered approach (Prevention Web, 2020c).

In order to achieve disaster risk reduction globally, established patterns like high levels of inequality, rapid urban development and environmental degradation need to decrease (UNDRR, 2015a). Future risk can be only prevented, by reducing on the one hand existing risk for example by extenuating risk drivers, but on the other hand strengthening the *resilience* of elements at risk and support their sustainable development. *Resilience* can be viewed as the ability of societies, the economy and other elements and systems at risk to resist, absorb, accommodate, recover from disasters, whilst at the same time improve well-being (UNDRR, 2015b).

For effective disaster risk reduction detailed risk assessment and management is inevitable. Risk assessment, in order to reduce disaster risk in the future, is usually conducted by analyzing trends of, for instance previous disaster losses or in modeling, estimating and predicting future losses (Prevention Web, 2020c). Disaster risk reduction is therefore in special focus and requires particular attention in the formulation of policies and actions.

2.1.2 Disaster Risk Management Cycle

This section provides an overview of the **disaster risk management cycle** - a well established concept that is used to provide profound understanding of how different phases *before, during and after* a disaster are interconnected. The concept can be viewed in Figure 2.5.

Disaster Risk Management Definition

Disaster risk management and disaster risk reduction are interchangeably linked to each other. Disaster risk management can be generally assumed as the *implementation* of disaster risk reduction (UNDRR, 2015a).
As the UNISDR (2009) report states, disaster risk management is "the systematic process of using administrative directives, organizations, and operational skills and capacities to implement strategies,

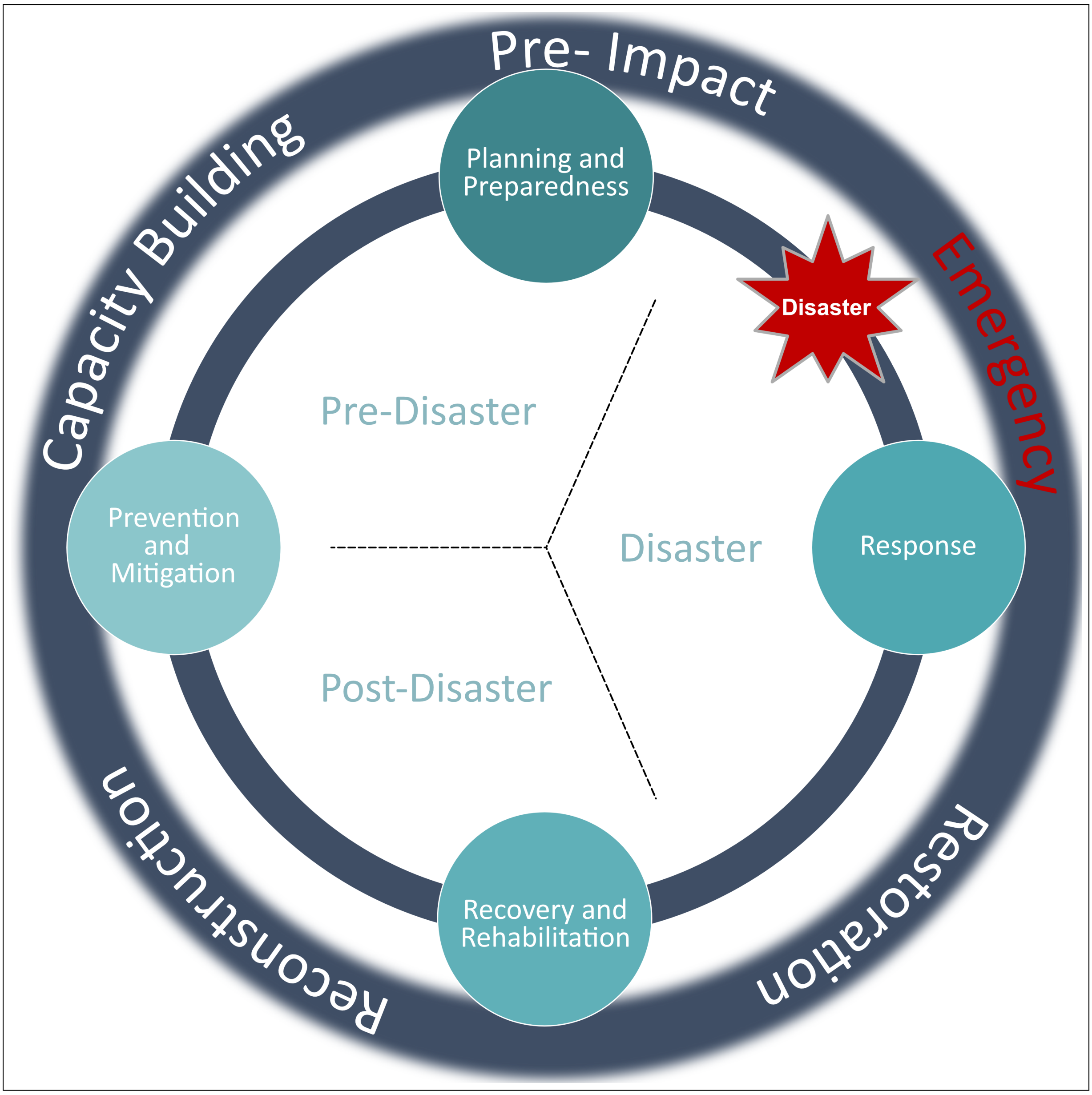


Figure 2.5: Disaster risk management cycle. Retrieved and adapted from: Le Cozannet et al. (2020)

policies and improved coping capacities in order to lessen the adverse impacts of hazards and the possibility of disaster".
It aims to avoid the constitution of new risks, addresses and decreases pre-exisisting risks and transfers and disseminates the risk of future disasters. Disaster risk management implements this contingency by taking measures and activities for preparedness, response, recovery and prevention (UNISDR, 2009). Figure 2.5 displays disaster risk management as a continuous cycle, constituting the basic concepts for the implementation of these measures. On a higher level disaster risk management aims to strengthen the *resilience* of a society to resist and recover from disasters (Prevention Web, 2020c).

Especially huge disasters like Hurricane Katrina in the United States, 2005 and the Fukushima disaster in Japan, 2011 show that disaster risk management frequently gains importance and must be managed on an *ongoing* basis. Efficient disaster risk management requires a network of many stakeholders like governments, development institutions and other partners to work cooperatively together and have the possibility to share risk relevant information and data (GFDRR, 2014).

The availability of more detailed data on hazards, exposure, vulnerabilities and losses increased the accuracy of disaster risk management in the last decades and leads to more efficient measures to prevent, prepare and financially manage disaster risk (OECD, 2012).

Preparedness and Planning

The term **preparedness and planning** in the disaster risk management cycle includes all accessible knowledge about capacities of governments, professional response and recovery organizations, communities and individuals or other vulnerable elements within an area exposed to a hazard. Preparedness and planning constitute the first step within the disaster risk management cycle. It is a key aspect to efficiently combine this knowledge in order to take actions and measures for effectively anticipating, responding, recovering and taking prevention steps, from the impacts of likely imminent or current hazard events or conditions. This includes all planning activities for the case of a potential disaster. This means for instance installing early warning systems, identifying evacuation routes and preparing emergency supplies (Prevention Web, 2020b).

The UNDRR (2015b) report states that key activities related to disaster preparedness include strengthening the policy, technical and institutional capacities of institutions ideally at all levels in regional, national and local disaster risk management. Especially relevant is strengthening capacities of technological hardware and software (crucial for disaster risk assessment and management), training measures for rescue teams and preparing material resources. Also the exchange of information, the coordination of early warning systems, initiating disaster risk reduction measures early and preparing disaster response are key components in disaster preparedness - ensuring amongst other things that the dialogue between relevant agencies and institutions is secured at all levels.
Disaster preparedness is a *dynamic* concept. An integral aspect is that plans and policies need to be periodically reviewed and updated with particular focus on the most vulnerable areas and groups. This is relevant in order to ensure rapid and effective disaster response in case of an disaster event and to be able to support recovery and mitigation measures at an early stage.

Response

The **response** component within the disaster risk management cycle is defined as "the provision of emergency services and public assistance during or immediately after a disaster in order to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of the people affected (UNISDR, 2009)". Response can be viewed as emergency and disaster management during or immediately after a disaster has happened. Emergency and disaster management describe the "state in which normal procedures are suspended and extra-ordinary measures are taken in order to avert a disaster (WHO and EHA, 2002)".

The location aspect is most critical in disaster response. Fast and reliable information is crucial for reaching the affected areas and to provide first aid (HOT OSM, 2020a). Within the response phase the overall aim is to meet immediate and short-term needs. The transition to the recovery and rehabilitation phase proceeds often smoothly.

A typical example of response measures is the *activation* of early warning systems, to effectively provide a system that allows communication between all stakeholders. Early warning systems also provide the foundation for the interoperability between adjacent countries, agencies and neighboring cities (UNISDR, 2020). Another example are mapping services including the rapid mapping service from the Copernicus Emergency Management Service[1] and HOT OSM. These services aim to provide reliable information about the affected location. Using satellite and drone imagery in order to rapidly generate map data, these services supply maps, for instance to provide a fast overview for NGOs.

[1] https://www.copernicus.eu/en/services/emergency

Recovery and Rehabilitation

The **recovery and rehabilitation** phase states the beginning of the restoration and, when possible, the improvement of the facilities, livelihoods and living conditions of the communities affected by the occurred disaster. Ideally this is conducted under the long term objective of reducing disaster risk factors through sustainable measures.

Often the recovery and rehabilitation phase begins during or shortly after the response phase (for instance emergency shelters constitute the foundation of a new village). Especially this phase within the disaster risk management cycle provides valuable opportunities to apply the *"built back better principle"* by developing and conducting measures to reduce the disaster risk.

Ideally, the recovery and rehabilitation phase is based on pre-existing strategies and policies developed in the preparedness and planning phase, in order to enable clear institutional responsibilities and public participation. The effect of rising public awareness and increasing resilience of communities helps to collectively reduce exposure and vulnerability to future hazards (UNISDR, 2009).

Prevention and Mitigation

While **prevention** is the "outright avoidance of adverse impacts of hazards and related disasters", **mitigation** describes the "lessening or limitation of the adverse impacts of hazards and related disasters (UNISDR, 2009)." Full prevention is an *abstract* concept in order to completely avoid potential adverse impacts through a perfect preparedness and planning phase. In reality this concept is hardly fully applicable, which is why the concept of mitigation seizes. This is the reason why the terms prevention and mitigation are often in interchangeable use.

Various actions and strategies can be conducted in order to lessen the scale and severity of hazard impacts significantly. These actions include engineering techniques and hazard-resistant construction, as well as improved environmental policies and public awareness. Concretely, examples could be dams or embankments that prevent flood risks, land-use regulations that do not permit any settlement in high risk zones, and seismic engineering designs that ensure the survival and function of a critical building in earthquake zones. If these measures fully prevent a 100% the disaster risk, it is referred to as prevention. Everything less than a 100% prevention is called mitigation (UNISDR, 2009).

2.1.3 International Disaster Risk Community

This section addresses some important practitioners and mechanisms of the international disaster risk management community and the network behind it. A diverse range of companies, institutions, organizations and governmental authorities are working in the field disaster risk management. They all contribute individually to disaster risk management and collaborate often to form policies, take measures, provide risk relevant data and information and to conduct disaster risk assessment. They are unified by the fact that they all take part in one or more different stages within the disaster risk management cycle.

International Organizations

International organizations are an association of at least two states or other subjects of international law, which is established on a permanent basis. It usually operates across national borders and performs supranational tasks. International organizations function as a key part in disaster risk management by establishing and providing communication and administrative structures across borders.

A prominent example of an international organization is the **United Nations**. The United Nations has many different bodies for tasks related to disaster risk management that involve in some aspect the management of disasters, humanitarian relief, or related activities. In the following a few of those United Nations organizations are named.

The Relief Web, a sub organization of the Office for the Coordination of Humanitarian Affairs, is a United Nations funded organization which aims to serve as an information management coordination role through the collection, maintenance, and dissemination of humanitarian information to the humanitarian community. It provides a collection of information from more than 4,000 key sources, including humanitarian agencies at international and local levels, governments, think-tanks, research institutions, and the media (OCHA, 2020).

UN-SPIDER is the United Nations Platform for Space-Based Information for Disaster Management and Emergency Response, an official mandated UN program with the goal to provide comprehensive space-based information within the full disaster risk management cycle. The mission of the UN-SPIDER program includes for example to provide transitions between different disaster management communities, for instance in form of workshops including participants from governments, NGOs and academia (Backhaus et al., 2010). UN-SPIDER also functions as a *gateway* to spatial and temporal information to support disaster risk management (Tomaszewski, 2010).

The PreventionWeb is a "a collaborative knowledge sharing platform on disaster risk reduction (DRR), managed by the UN Office for disaster risk reduction (UNDRR)(UNDRR, 2020)." The website offers a range of knowledge products and services to facilitate the work of disaster risk professionals. The PreventionWeb additionally functions as a knowledge base. It provides daily and weekly alerts in disaster risk reduction and definitions of key concepts for understanding risks related to disasters (UNDRR, 2020).

NGOs

NGOs are non-governmental organizations which are defined by their voluntary character and their independence of governments. While they are non-profit making, they take directions in international assistance in natural and human-made disasters. They distinguish themselves from other forms of organizations in the field by taking quick actions during the response phase within the disaster risk management cycle, with the aim to save as many lives as possible with the given funds (Mondal, Chowdhury, & Basu, 2015). However, they also take other specific roles in different stages of the disaster risk management cycle apart from their strong activities in the response phase.

In the preparedness and planning phase, *before* a disaster has occurred, tasks include:

- Training and capacity building of NGO staffs and task forces
- Set up of information channels to affected districts
- Advocacy and planning
- Regular contact with control rooms

During a disaster within the response phase the focus is on:

- Activate warning dissemination to reach the target groups
- Help administrations for wide dissemination of warning
- Immediate rescue and first-aid, including psychological aid, supply of food, water, medicines, and other immediate need materials
- Ensuring sanitation and hygiene
- Damage assessment

With the *ending* of the direct emergence, NGO’s also provide aid in the recovery phase:

- Technical and material aid in reconstruction;
- Assistance in seeking financial aid;
- Monitoring

Well known NGOs are for example the International Federation of Red Cross and the German Federal Agency for Technical Relief (THW), a German civil protection and disaster relief organization of the federal government run by volunteers and full-time staff.

Private Sector

Due to the dense network of stakeholders within the private sector, it is difficult to classify its role within the disaster risk management cycle. Generally, scientists agree that the private sector is very involved in disaster risk management - having a direct impact on the economic stability of a country (Izumi & Shaw, 2015b). Examining businesses on a local level, the main involvement is to ensure the continuity of business during and after a disaster.

Izumi and Shaw (2015a) identify five ways how businesses and stakeholders are directly engaged in disaster risk management in the private sector:

- "Direct assistance to communities"
- "Disaster preparedness for own business"
- "Developing innovative products based on business, technology, and expertise"
- "Joint projects with NGOs, governments, and international organizations as implementer"
- "Establishment of private foundations, NGO's, and trusts"

The role of the private sector as an integral component within disaster risk management and has been accepted for several years on an international level. However, it is recognized more recently that a multi-stakeholder concept is key for successful involvement of the private sector. Historically, private sector actions were mainly in the preparation and planning phase and in the recovery phase accordingly located. An example would be an engineering office conducting reconstruction after the occurrence of a disaster (Johnson & Abe, 2015).

With increasing focus on disaster risk reduction the GFDRR (2014) identifies the following sub-sectors which provide significant risk relevant information for managing disaster risk - shifting the focus in private sector activities also to the mitigation and prevention phase:

- "The insurance sector - essential quantification of disaster risk"
- "The construction sector - quantifying the potential risk expected in the lifetime of a building, bridge, or critical facility"
- "The land-use and urban planning sectors - for robust risk analysis for driving likewise the investment in protection measures"

Examples of businesses working in disaster risk management within the private sectors are for instance the Munich RE Group - one of the biggest re-insurance worldwide. Their services include for example providing risk relevant information about global warming and furthermore the assessment of risk for a potential hazard for their customers.
Another example is the GAF AG. The GAF AG is a company that is (amongst providing other services and tasks) the executive force by conducting rapid mapping services for activations within the Copernicus Emergency Management Service for worldwide disasters.

Academia

Academia in disaster risk management includes the overall community of students and scholars in higher education at colleges, universities, scientific research and development institutions engaged with disaster risk. Expert scientific knowledge provided by academia is by now integral part within disaster risk management.

In general, academia performs tasks mainly within the prevention and mitigation phase as well as providing risk relevant information and data. Data and information are frequently used for planning purposes during the planning and preparedness stage within the disaster risk management cycle. Academia often provides the scientific foundation of key concepts which are then applied and used by the industry in the private sector. However, the usage is also in other sectors well established.

Within a declaration document on disaster risk reduction, following commitments from science to disaster risk reduction are addressed by AMCDRR (2012):

1. Research - For promoting, prioritizing and advancing research on natural, social, engineering and technological aspects of disaster risk in an integrated environment
2. Integration - Taking the role as a coordinator by ensuring integration of disaster research programs, policies, and applications across disciplines. This includes also the contribution to enhancing policy making and capacity building for effective disaster risk reduction and sustainability
3. Global Standards - Development and coordination of globally recognized standards. This includes standards about "open source information, disaster loss data, procedures for documentation and analysis of events, guidelines and frameworks for integrated and effective disaster risk management and sustainable development."
4. Awareness - Increasing the sensibility of decision-makers and the public by "promoting effective, integrated, demand-driven, evidence-based disaster risk initiatives and increased advocacy."
5. Education - Support holistic and scientific based approaches in natural hazards and disaster risk education and training.
6. Increase Funding - "Motivate funding sources (public, private, humanitarian, development, scientific, etc.) to allocate priority funding to address the urgent need for applied and basic integrated research on disaster risks."

Additionally, research in disaster risk reduction contributes to the identification of scientific disaster knowledge gaps between science and technology (Izumi, 2016). The increasing importance of complete, reliable and scientific correct data for disaster risk management leads to a development that has consequently marked a change in the role of science for the management of risks and hazards at the policy level (Albris, Lauta, & Raju, 2020). This change includes adaption in practices, plans, and ideas in the domain of disaster risk reduction - leading eventually to more sophisticated solutions for informed decision making (Shaw, Izumi, & Shi, 2016).

Prominent examples of institutions within the research sector that are contributing to research and development in disaster risk management include the GFZ Potsdam (German Research Centre for Geosciences). The GFZ coordinates for instance projects like GITEWS (German Indonesian Tsunami Early Warning System). Another example is the Centre for Research on the Epidemiology of Disasters (CRED) at the School of Public Health of the Université catholique de Louvain. CRED maintain the EM-DAT, a global database on natural and technological disasters. Main aims are rationalizing decision-making for disaster preparedness and the provision of an objective basis for vulnerability assessment and priority setting (CRED, 2020). Further examples are the German Aerospace Center (DLR), European Space Agency (ESA) and as well the United States Geological Survey (USGS) - institutions all engaged in a variety of research and development projects in disaster risk management.

Governmental Authorities

Local and federal governmental authorities include all governmental linked organizations, institutions and administrations at all levels involved in civil protection against all kinds of natural and human-induced disasters (including sometimes war). The task of local and federal governments is to provide support in disaster risk management including "information-sharing, coordination, managing scarce resources and conducting crisis management exercises (BBK, 2017)."

A characteristic aspect is that local and federal governments are usually the first ones to respond, after a disaster has happened. Meaning, they are the first ones to conduct risk assessment, decision making, and being responsible for information sharing and a functioning communication flow for often several hours and days (Col, 2007).

Shi (2012) identifies three main key concepts of governments in integrated disaster risk management based on practices in China:

1. "Overall leadership - taking measures politically, socially, culturally, and economically, that include resource assurance and technical support"
2. "Engaging civil society"
3. "International cooperation - governments are obligated to fulfill their humanitarian role, in order to politically carry out disaster reduction diplomacy"

Further measures include: planning and preparing civil protection, providing training (basic and advanced) for decision-makers and top executives, maintaining information and coordination service, warning and informing the public and strengthening civil self-help (BBK, 2017).

2.2 Disaster Risk Management in Cartography

The importance of disaster risk management has been increasingly recognized in recent decades - with the result that there is a growing urgency and significance to get engaged with the subject in a number of different fields likewise. This trend also evolved in the field of cartography, where disaster risk management has become an essential component. The role of cartography is particularly interesting for disaster risk management because it is not only useful for presenting causal correlations in a spatial and temporal context, but also serves as a powerful tool for decision making and risk assessment and improves the understanding and communication of risk-related information at a deeper level.

2.2.1 The Use of Cartography in Disaster Risk Management

This section reviews, why mapping spatial and temporal information constitutes an integral part and is frequently used in disaster risk management. Crucial aspects about cartography in disaster risk management are outlined and highlighted in the course of this section.

Due to the reason that disasters are fundamentally of *spatial* but also of *temporal* character, cartography is of crucial importance for disaster risk management, by being able to link and visualize both aspects. Although cartography has been involved in disaster risk management for a long time, the recognition and appreciation of the power of maps by the public, has even increased the importance of cartography in the last years. The fundamental coherence that cartography fosters spatial thinking is a key aspect. By providing the possibility to represent critical aspects about the situation of a disaster through map-making, is one of the reasons, why cartography plays a key role in disaster risk management (Tomaszewski, 2014).

Cartography allows people involved in disaster risk management to understand the geographical context behind disaster situations. Cartography provides hereby the ability to understand questions about the spatial and temporal aspects of disasters. Basically, cartography tries to visualize what, how and why disasters happen or have happened, in a spatial and temporal context. These questions allow people, involved in disaster risk management, to conduct detailed interpretations about disaster situations, facilitate decision making and reasoning on a deeper level. This constitutes the foundation for profound situational awareness for disaster events, and processes linked to it. The *situational awareness* regarding a disaster is fundamental in disaster risk management in order to bring them under control or keep them controllable. Therefore, the contribution to achieving *situational awareness* is a key aspect, why cartography is so frequently used in disaster risk management (Tomaszewski, 2014).

Humans are visual creatures. It has been proven, that causal relationships can be better understood, when they are visualized. At this point the approach of cartography applies. Cartography uses visualization tools, like geo-information systems (GIS) and remote sensing to implement measures in the planning, response, recovery and prevention phases. These tools have the effect through visualizing the geographical context, to increase the *situational awareness* in disaster risk management (Tomaszewski, 2014). By transferring risk-relevant information through the visualization channel, this effect is achieved in a very structured and efficient way - and information can be perceived in a much more intuitive way, than for instance a report.
In the following, selected case studies that were conducted in the individual phases are listed below, to provide a clear impression how disaster risk management is conducted with maps and cartographic visualizations. Measures in form of meaningful maps within the different stages include:

Cartography in Preparedness and Planning

The first step in the planning and the preparedness stage within the disaster risk management cycle is to establish the basic requirements and conditions to conduct cartographic activities. This includes the procurement of geo-information systems, preparing and processing essential data sets, the necessary technology to do so and to provide all necessary processes and services that are used during other disaster risk management cycle phases.

This includes for instance the preparation and production of reference layer sets and other geo-information layers that may provide an overview over the geographical context, the access to databases and the establishment of technological structures for people to share data and risk relevant information.
Common tasks conducted by cartography in the preparedness and planning stage are:

- Evacuation route planning
- Evacuation zone planning
- Scenario overview through reference maps
- Identification of vulnerability and elements at risk
- Preparing timelines for possible disaster and their event dynamics, including possible secondary events
- Preparing databases with all necessary information for the case of an emergency

For example the risk and recovery service from the Copernicus Emergency Management Service, provides a mapping service for on demand provision of geo-spatial information. The service supports emergency risk management not related directly to the response phase but for preparedness purposes (and also prevention and disaster risk reduction) of vulnerable areas. The service includes the provision of maps about possible impact assessment and exposure analyses on asset and population, reference maps, land use and land cover data sets for planning and preparedness purposes (Copernicus Emergency Management Service, 2020).

Many case studies exist for particular vulnerable areas. An example of an up-to-date case study, where cartography in combination with remote sensing is used for preparation purposes is a case study by (Amarnath, Matheswaran, Pandey, Alahacoon, & Yoshimoto, 2017), conducted in the Bagmathi Basin, India. In this area it is at present impossible to *prevent* the occurrence of extreme flood events, due to high monsoonal rains. Disaster planning is conducted in this case study through "robust hydrodynamic models to develop flood extent maps in conjunction with freely available remote sensing imageries at different scales". The approach was designed to prepare and provide input information in near real time. Mapping flood extends with MODIS remote sensing data was conducted, in order to be prepared for the response phase in the case of a flood disaster is happening.

Cartography in Response

Cartography in the response stage within the disaster risk management cycle is probably the most recognizable phase from a public point of view.

Cartography is crucial to identify in the response phase of the disaster risk management cycle the location, the type and impact of a disaster. Prominent and impactful portrays of the progress of ongoing human-induced and natural disaster through cartographic visualizations and maps in media news, leave a vivid impression. Cartography often provides an overview and rising public awareness over a disaster situation, for instance the progress of the spreading of a pandemic like the COVID-19 as flow maps, or the path of a hurricane visualized on maps. Furthermore, cartography often plays a key role in showing how a disaster situation is handled by task-forces and involved practitioners like NGO's during the response phase. Mapping in the response phase serves as a key function for coordination activities and *situation awareness* through (real time) maps for the identification of progress during a disaster. Narrowed down, cartography can be viewed in the response phase as a *situational awareness* support mechanism (Tomaszewski, 2014).

Frequent tasks, where cartography is involved in the response phase after a disaster has happened, include:

- Disaster warning through geo-information systems - e.g. real time weather or real-time earthquake information through geo-information systems or mobile apps
- Rising the awareness of a situation through cartography by e.g. real time tracking of a hurricane path
- Hot Spot Mapping - e.g. current states of forest fires
- Density Mapping - e.g. the frequency of 911 calls after a disaster has happened or social media tags linked to disasters
- Real time cartography for decision making for involved practitioners, task forces and emergency operation centers
- Fast damage assessment in getting first information about the degree of destruction through a hazard
- Crisis mapping by volunteers

One example for concrete cartographic involvement within the response phase is the rapid mapping service of the Copernicus Emergency Management Service. This service "consists of the on-demand and fast provision (hours-days) of geo-spatial information in support of emergency management activities immediately following disaster. The service is based on the acquisition, processing and analysis, in rapid mode, of satellite imagery and other geo-spatial raster and vector data sources, and social media when relevant." Entities and organizations at regional, national, European and international level active in the field of disaster risk management (including the EU Member States and international Humanitarian Aid organizations) are enabled to claim this service (Copernicus Emergency Management Service, 2020).

A similar service is provided Humanitarian OpenStreetMap Team - with the difference that volunteers are engaged to map, validate and contribute key skill sets, by developing and maintaining the technical tools behind the service (HOT OSM, 2020b).

The warning app "NINA" provided by the Federal Office of Civil Protection and Disaster Assistance (BBK) includes functions, which enable users to select places and areas, for which they would like to receive alerts. Also warning messages are included in the map view and additionally, the provision of warning tips for emergency situations are provided, for instance how to protect oneself (BBK, 2020).

Ikeda and Inoue (2016) developed with a Multi-Objective Genetic Algorithm (MOGA) a system for route planning, in order to support survivors and refugees during a disaster situation. The proposed system has three objective functions, which are: evacuation distance, evacuation time and safety of evacuation route in order to increase safety during a disaster situation.

Cartography in Recovery and Rehabilitation

Since the transitions between the recovery phase and the immediate response phase (and as well sometimes the mitigation phase) are overlapping and often not clear defined, it is crucial to ensure that the cartographic infrastructure is maintained and available during the whole recovery process. An intensive response phase can burn a lot of money, resources and capabilities - also in the field of cartography. It is therefore crucial to ensure that enough capabilities remain in order to conduct the recovery process efficiently - in the best case after the *"built back better principle"*. Cartographic capabilities include sufficient computational infrastructure, reference data-sets and the availability of skilled, in cartography trained personnel. The capabilities contribute to stabilizing and conducting recovery measures after a disaster (Tomaszewski, 2014).

Common measures in disaster recovery tasks where cartography provides support, are for instance in the field of construction (e.g. the monitoring of rebuilding and redevelopment of houses and neighborhoods). Hereby mitigation measures are oftentimes already in the recovery process included, for instance the identification of potential risks and vulnerabilities for more *resilient* rebuilding. But also public health often relies on cartography e.g. in site selection issues for health centers, after a disaster has occurred (Tomaszewski, 2014).

According to Rinner (2007) recovery tasks linked to cartography often refer to:

- "Geocollaboaration - the coordination of spatial activities related to long term recovery, which include the involvement a variety of different practitioners in disaster recovery conducted with the help of maps and spatial representations"
- "Restoring Critical Infrastructure - Cartography support the planning of vulnerability and restoration activities through visualization official proximity and distribution of critical capabilities of power, water, electricity and transportation systems"
- "Debris Cleanup - Cartography provides the crucial technology for planning, analyzing, modeling debris clean up activities
- Recovery Planning - Cartography is involved in the initial planning processes of broader disaster recovery activities"
- "Maps can be used as the visual, spatial representations of ideas, arguments,and discussion points that focus on how a community rethinks and re-imagines itself after a major disaster has physically, psychologically, and economically impacted the community"

MacEachren (2005) proposed a framework for the particular role of cartographic visualization as a support mechanism in the geo-collaborative process: He states that maps are the objects of collaboration. Maps can be seen as symbols that abstract the efforts of actors working together on the recovery processes, as mentioned above. MacEachren (2005) also mentions that maps enable support for human dialogue, information sharing, negotiation, and discussions. Maps constitute hereby excellent tools to reformulate and re-express concepts, visualize opinions and to share risk relevant information. Finally, they also are crucial for coordination purposes. Maps and cartographic visualization are fundamental to support coordinated activities, especially within the short term recovery phase.

Following a case study conducted by Soulakellis et al. (2019) is a good up-to-date example on how scientists are working on recovery tasks. Soulakellis et al. (2019) used a real time kinematics system, terrestrial photogrammetry, unmanned aircraft systems and terrestrial laser scanner for collecting accurate and high-resolution geo-spatial information. This was implemented in order to conduct 3D mapping, 3D modeling and damage classification grades for detailed damage assessment after an earthquake event in Lesvos, Greece. This research constituted the foundation for recovery and rehabilitation processes. Contreras, Blaschke, Tiede, and Jilge (2016) conducted as similar case study, by monitoring recovery after earthquakes through the integration of remote sensing, GIS, and ground observations. They detected changes in buildings during the recovery processes by visual analysis, through automated change detection, using a set of decision rules formulated within an object-based image analysis framework.

The above mentioned Copernicus Emergency Management Service also supports actors involved in recovery processes via providing mapping services. The products provided by the service include detailed damage assessment analyses over affected areas, reconstruction monitoring and post disaster risk assessment (Copernicus Emergency Management Service, 2020).

Cartography in Mitigation and Prevention

Cartography constitutes a key position in modeling disaster mitigation activities as hazard and risk scenarios by assessing vulnerability (socially, physically and economically). Cartography in disaster mitigation is often linked to an interdisciplinary context - requiring connection across multiple areas like earth science, sociology and environmental sciences. In the ideal case, cartography efficiently helps to reduce vulnerability towards potential hazards by for example strengthening the *resilience*. Fung (2012) mentions that the use of cartography to "inventory, analyze, visually represent, and ultimately understand and manage risks as a means to improve resilience continues to grow."

Hence, cartography used as a tool for disaster mitigation includes mainly techniques to conduct risk and vulnerability assessment, in order to understand where prevention and mitigation can be effective and helpful. A common cartographic technique to assess and quantify vulnerability and risk include spatial indexing. Spatial indexing is the process to assigning numerical or qualitative values linked to social variables (e.g. education level, gender, age) or physical variables (building materials or proximity to flood zones) to a preexisting spatial unit or geographical region. The numerical or qualitative values represent the level of risk or vulnerability within a geographical context. Other cartographic mitigation and prevention measures include loss estimations and hazard proximity assessments (Tomaszewski, 2014).

Mendes, Tavares, and Santos (2019) conducted a case study were exactly these social variables were assessed. Social vulnerability variables like vulnerable age groups and housing conditions were identified and then evaluated according to the educational and economic situation. Furthermore, emergency infrastructures were assessed for infra-municipal risk practitioners and planners, in order to improve the overall information management.

Other mention-worth case studies in this context are:

- Ebert, Kerle, and Stein (2009), who examined physical vulnerability variables like building materials observed via remote sensing and GIS for understanding social vulnerability in urban environments
- Remo and Pinter (2012), who conducted a detailed case study about loss estimation using the the multi-hazard risk assessment software HAZUS in order to provide mitigation measures for earthquakes in Illinois
- Hatrushi and Mubarak (2017) determined the potential areas that will be affected by sea level rise using GIS and remote sensing techniques in order to create the basis for mitigation measures and prevention
- Parvez et al. (2017) did a study on seismic hazard assessment to provide the essential structures to conduct mitigation measures and reliable prevention as to improve building codes, particularly for the protection of critical infrastructures and for land use planning
- Grinberger, Lichter, and Felsenstein (2015) used visualizations techniques as detailed dynamic web-mapping simulating global resilience measures, effects on residential and non-residential capital stock and population dynamics in order to assess the resilience

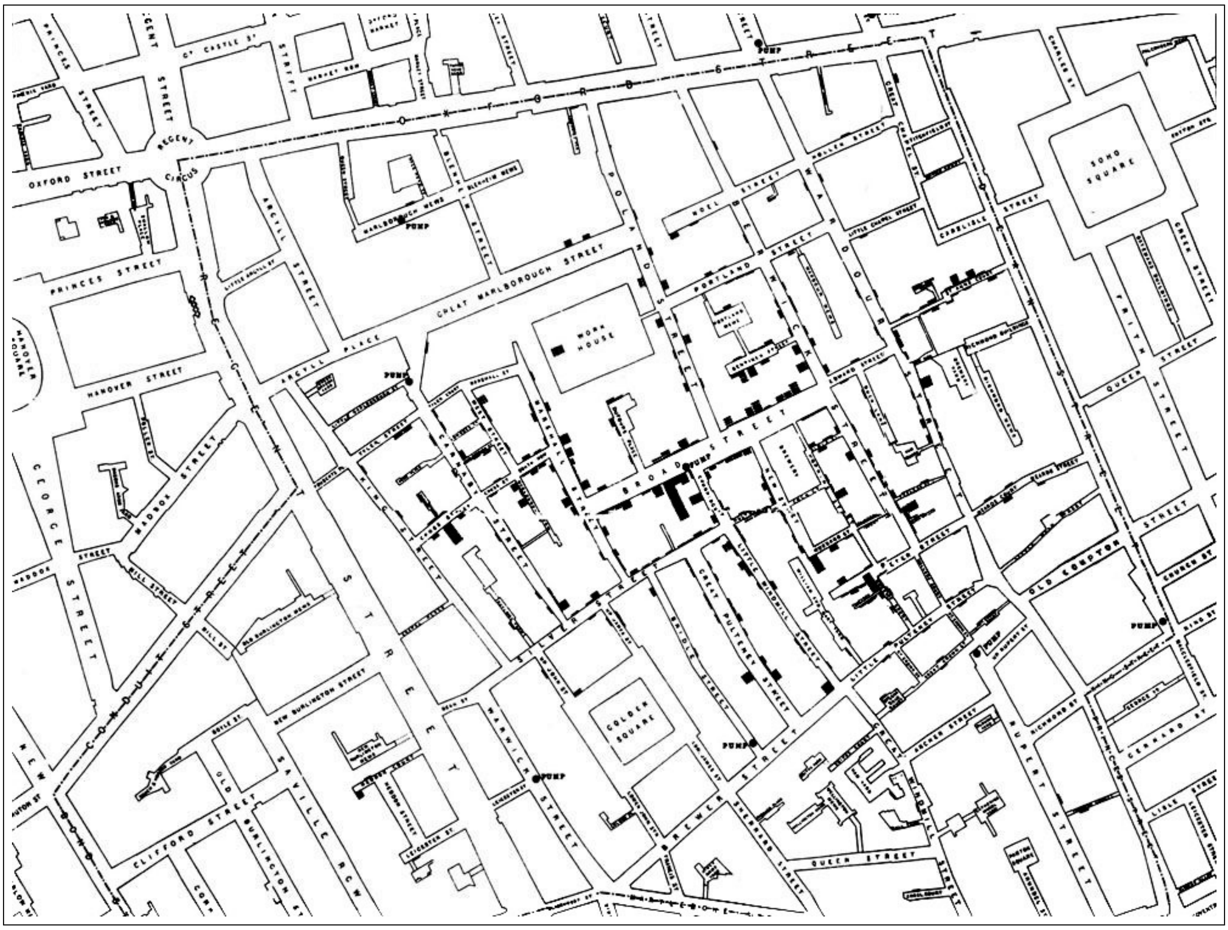


Figure 2.6: Cholera map of John Snow, created in 1854 during a deadly cholera breakout in London. Cases are highlighted in black on the map

Decision-Making and Communication of risk-relevant Information through Cartographic Visualizations over Time

A very prominent and historic example of how disaster risk management was conducted with maps in the past is the **Cholera Map** by John Snow (Figure 2.6), which was created in 1854. By *visually tracking* the cholera cases (highlighted in black on the map), John Snow was able to trace back the cholera outbreak to a single contaminated water pump. The cartographic visualization has been the key element in this example and has provided the **cornerstone** for the *decision* to turn off this water pump in order to prevent further infections.

Through their ability to provide access to the *situational awareness* linked to a disaster, maps or cartography in general constitute therefore a powerful tool, to facilitate better and more informed decision making. *Situational awareness* is the fundamental basis for informed and effective decision making. Disaster practitioners for instance need to have sound knowledge which evacuation roads exist and where they are exactly located. In order to perform reasonable and sophisticated decisions, the context of *situational awareness* is crucial, in order to decide for instance, which evacuation road to take. Another example would be that it needs to be clear, where different population groups are located within an exposed area. This is crucial in order to decide, which are the most vulnerable and may need aid most *urgently*.

The more comprehensive and timely risk relevant information is provided, the better the medium can be used for in-depth decision making. **This is the reason why in cartography the trend develops towards real time, web-based and interactive maps, because of their ability to display a range of risk relevant layers *intuitively*** (Tomaszewski, 2014).

The reaction on disasters highly depend on the stakeholders perception of risk and the strategies applied to protect their interests (Ceccato, Fernandes, Ruiz, & Allis, 2014). Only the involvement of all stakeholders, especially the public participation of local stakeholders in political, economic and social decisions, ensure a sustainable development process in disaster risk management. The identification of the individual perceived high risk areas, is hereby a key component to achieve sustainable development (Eden, 1996). Ceccato et al. (2014) suggest that better solutions can be achieved, when all stakeholders work commonly together by reviewing the perspectives of other stakeholders mutually. Basic requirements are hereby that "decision-making entities are receptive to new ideas and flexible in their adoption" as well as innovative and interdisciplinary research.

Padilla, Creem-Regehr, Hegarty, and Stefanucci (2018) state that "People use visualizations to make large scale decisions." Hence the identification and mapping of different risk perceptions of individual stakeholders constitutes the critical first step for decision processes in disaster risk management. The transfer of spatial information plays hereby often an important part in decision making, planning activities and risk analysis. Especially the use of maps in decision making has several advantages - they are understandable, in the best case even without verbal aid, show the intended information fast and efficient and reveal the geographical context. Pfeiffer et al. (2008) argue that the visualization aspect supports collaboration, analytical reasoning, problem solving and decision-making.
Especially web-cartography and new geo-information system tools evolved through rapid technical advances in the last years. Coming with dynamic and interactive visualizations methods, they are of great potential, because of their strengths in "visual exploration, analysis, synthesis and especially processes to interact, combine and exchange complex data sets and information".

Knowledge exchange between heterogeneous groups is often a critical point, because it is often a difficult task to combine views and perspectives of different stakeholders involved in disaster risk management. The visualization of data through maps can be extremely helpful, in order to illustrate risk relevant information comprehensively and combine different attitudes of stakeholders, in order to provide the possibility of mutual solution finding processes on different stages and various levels within the disaster risk management cycle.

The GeoWebEX for instance, is an online system for supporting group collaborations on geographical information. This includes maps and imageries, and the opportunity to capture and share local/domain knowledge in real time (Butt, Mahmood, & Raza, 2018). Systems like this can initiate "reflection processes among users, which in turn helps to efficiently and effectively communicate research results for improving and supporting planning and decision-making (Pfeiffer et al., 2008)." Another example for knowledge exchange in disaster risk management is a web-map provided by Asgary and Kari (2017), which reviews disaster risk reduction projects around the world - to make knowledge exchange more accessible and the communication flow easier.

Spatial knowledge is enhanced through communication via cartographic products (Abbot et al., 1998). **The effect of browsing, navigating and zooming within cartographic context supports the interactive and intuitive comprehension of temporal and spatial aspects.** Maps can support the discovery of trends and interrelationships that otherwise might be overlooked or not appropriately acknowledged and understood - as for example when presented in reports (Pfeiffer et al., 2008). On the other hand maps enable, by their interactive character the communication of findings between different stakeholders and thus initiate and foster learning processes between different groups. This bears the potential to identify key aspects and problems more efficiently, than through different media (Siebert, 2005).

Aerial and satellite color images achieved by remote sensing have been proven to be especially successful and useful in providing a clear overview for the identification of elements at risk and constitute therefore a good basis for decision making (Svatonova & Kolejka, 2017). Insar based modeling approaches provide very easily understandable maps addressed to decision-makers after post disaster events, especially earthquakes (Béjar-Pizarro et al., 2018). Web geo-information systems can be, through their quick response well applied to decision making support, due to their functions of spatial analysis and the capability to analyze high amounts of data (Bo, Xiaxin, Ping, & Yanru, 2009).

Map products in combination with web-geo-information systems and remote sensing have following advantages in decision making processes and improvement of communication:

- They provide a useful way to reach city planners and policy makers
- They facilitate insights into different locally-constructed realities
- Maps function as a communication tool to provide results to the wider public and respective policy makers
- Through their meaningful appearance they promoting participatory decision-making processes
- The interactive character of cartographic visualizations provides new opportunities to stimulate the communication processes
- Cartography helps initiating reflection processes among users
- Maps can function as the transfer medium between local perceptions, coping and different adaptation strategies
- Map visualizations allow to merging geo-spatial and socio-economic data

As mentioned before, disaster develop and change in the course of a period of time, and therefore always include a temporal component. When up-to-date information is available to actors at all levels, the opportunity of properly planning, managing and monitoring processes is given (R. Few, Ahern, Matthies, & Kovats, 2004). Therefore the process and interaction between *situational assessment and awareness* remains a constant factor during a disaster event. Cartography can essentially help to improve and channel the flow of information needed, to help disaster management stakeholders to identify and assess situations. The ability of cartography with the support of geo-information systems, of being able to display and manipulate quickly geographically referenced data, is crucial for disaster risk management. **The fast updateable character of maps (especially interactive and web-based) immensely helps to reflect changes in the situation and can be crucial for decision support processes in disaster risk management.**

Summarized cartographic visualizations of up-to-date (even real time), interactive and web based (available for a vast range of stakeholders) information, hold an immense potential for decision making processes. In the best case they function as a communication exchange platform of different views and perspectives and foster mutual solution findings.

2.2.2 Modern Trends in Cartography - Dashboards

Dashboards - an Overview

Dashboard Definition

Since the term **dashboard** is very broad and appears in several contexts, a clear and consistent definition, which covers all different kinds of dashboards, is hard to state. Originally, the term dashboard was derived from car dashboards, allowing drivers to view and monitor the most important information and functions of a car (Rininsland, Heydt, & Navarro Castillo, 2016).

Generally, dashboards can be viewed as a specific type of data visualization.They typically contain a range of dynamic and interactive graphics, diagrams and maps to display information about performance, structure, patterns and trends (Stehle & Kitchin, 2020). These types of graphics and maps include for example: flow and choropleth maps, radial/polar plots, bar and stack charts, 3D Space cubes and many more. The dashboards which are discussed and subject of this thesis can be defined as following: "A dashboard is a visual display of the most important information needed to achieve one or more objectives, which is consolidated and arranged on a single screen so the information can be monitored at a glance (S. Few, 2006)." S. Few (2017) also mentions that dashboards are a "a predominantly visual information display that people use to rapidly monitor current conditions that require a timely response to fulfill a specific role."

Main benefits of dashboards are their interactive and intuitive character, which greatly facilitates analysis and exploration. Since dashboards integrate well designed graphs, charts, maps and optionally additional information, they are a very efficient medium to communicate information and data intuitively and very comprehensible. They are in general considered as very useful, because of their efficient character to combine various data and information (from sometimes different sources) - making it easy to identify problems and facilitate decision making (Rininsland et al., 2016). Main goals include "optimizing decision making, enhancing operational efficiency, increasing data visibility, driving strategy and transparency, reducing costs, and facilitating communication". Additionally, they provide at-a-glance reading, coordinated views, tracking data and both private and shared awareness (Sarikaya, Correll, Bartram, Tory, & Fisher, 2018). Dashboards are especially feasible to track changes "over time with respect to a defined geography". This implies that they allow the user to track and compare data and information over time and space (Stehle & Kitchin, 2020). **This circumstance make dashboards ideal tools in combination cartography.**

Dashboard Types and Use

By now, dashboards are in some form in use and present in almost every industry, non-profit and service organizations and both public and private institutions. The use of a dashboard can be characterized by its type, the audience and the domain it is used in. The use of dashboards can either be out of strategic, analytical, operational, tactical or informational reasons. The strategic dimension may for example emphasize trends. Analytical and tactical dashboards can be used for summarizing the performance of processes and indicators. Operational dashboards contain often the function to display performance metrics. The informational dimension of dashboards for instance can be used for communication and learning purposes. This type of dashboard "exist to communicate or educate the reader, who may lack the context surrounding the presented data" and raise awareness in the user (Sarikaya et al., 2018).

Sarikaya et al. (2018) state that the audience can be quantified into the four groups "public, social, organizational and individual". A public dashboard is used for general consumption, a wide range of people having access to it, whilst a organizational dashboards are reserved for the members within an organizational construct. Individual dashboards are usually not shared, and only for private use, while social dashboards are shared with individuals, who fit into the context.

Dashboards can be subdivided and characterized also by their level of interactivity. Sarikaya et al. (2018) distinguishes "between three types of interactivity: tools may allow a user to design (or customize) the dashboard; they may allow faceting of the data through data filters and slicers; and they may allow modifying the state of the data and world based on the data presented within the dashboard."

Interactive and dynamic functions of dashboards are proposed by Goh et al. (2013) and include regularly:

- "Organize multiple windows"
- "Receive and show real time information"
- "Record analysis histories"
- "Filter out data to focus on relevant items"
- "Sort items to expose patterns"
- "Derive values of parameters from the database"
- "Select one or more parameters, and show statistical analysis result"
- "Add, delete, edit the selected data"

- "Inquire the real-time location and condition information of the selected items"
- "Map the data according to various functions"
- "Show different icons according to different items (such as different risks)"
- "Share views and annotation to enable collaboration"
- "Guide users through analysis tasks"
- "Select items to highlight, manipulate, zoom in or zoom out"
- "Navigate to examine high level patterns and low level details"

Usually, dashboards contain not necessarily all of those elements. Nevertheless, it is significant that almost all dashboards contain at least some of these elements. The number of these elements is depended on the degree of interactivity.

Dashboards also support evaluation tasks, for example if goals and objectives are achieved. They are very useful to reveal information efficiently, providing more time for strategic planning aspects. Since dashboards are powerful visualization tools, they are able to create an impact and facilitate messaging and communication in a very impressive and sustainable way. Through their clear way of providing an overview over large and many data sets from different sources, they can ideally be used within the context of big data, as they support certainty and confidence for their users (Rininsland et al., 2016).

The application in areas where dashboards are in use is, as indicated before, very broad. Main application fields include Business Intelligence (BI), Education, Smart Cities, Social Organizations, Health Management, Personal Visual Analytics, Disaster Risk Management, and the Insurance Sector.

Dashboard Design

Generally, most dashboards are designed for a single screen use. The aim is often to tailor the design in a way that the ability to absorb and understand the displayed information and data is maximized as efficiently as possible. The individual elements of a dashboard need to be designed and ordered in a way that the users attention is channeled to the specific element and that they serve the individual purpose of the dashboard. Attributes (visual variables) that are linked to the visual perception like color, form and position, support the intended purpose and help channeling the users attention (Rininsland et al., 2016). A visual hierarchy hereby supports the user in quickly locating the important aspects and information. Therefore a pre-defined hierarchy, clear sections and a logical layout should provide a sensible flow within the dashboard and supports the scalability and maintenance of the system (Yalcin, Elmqvist, & Bederson, 2018).

An important aspect is that during the design process the horizontal and vertical space ratio needs to be considered. For example a dashboard designed for a desktop with a lot of horizontal space may not be sufficient for a small mobile screen with rather a lot of vertical space. Generally, the single screen results in a selection of only the most crucial and important information. To be of efficient use, this key aspect needs to be regarded, because of the limited amount of space and the different ratios.

In designing a dashboard, the most difficult part can be to prevent the dashboard from being overloaded and crowded with information, and consequently causing confusion. It may be difficult to find the balance and channel and bundle a lot of information efficiently enough to provide good overviews and to enable trend recognition and decision making. Responsive design during the implementation of graphs and charts are therefore an integral part, aiming to reduce distraction and confusion of the user.

Tableau[2] is a commercial software for creating dashboards. On the website, guidelines are provided in how to efficiently design a dashboard (Tableau, 2020). Point 1.-3. constitutes thoughtful planning

[2]https://www.tableau.com/

purposes, in order to develop an efficient design process and eliminate pitfalls. Point 4.-7. concerns the actual design process of the dashboard and point 8.-10. outlines the refinement of the dashboard.

1. "Know your audience"
2. "Consider display size"
3. "Plan for fast load times"
4. "Leverage the sweet spot"
5. "Limit the number of views and colors"
6. "Add interactivity to encourage exploration"
7. "Format from largest to smallest"
8. "Leverage tooltips, the story within your story"
9. "Eliminate clutter"
10. "Test your dashboard for usability"

User focused design helps especially in the first and the last point of the general workflow within design process. In the beginning effective visualization design is often coupled with the integration of user needs and requirements (Roth, Ross, & MacEachren, 2015). On the other hand in the last steps of the design process, the feedback of users is often crucial to identify gaps and to refine the product (McArdle & Kitchin, 2016).

Dashboards for Disaster Risk Management

This section focuses on the specific use of dashboards in disaster risk management. It outlines their purpose and key aspects within this field and finishes off with selected and concrete examples, in which situations dashboards in disaster risk management are utilized.

Dashboards in disaster risk management are used for effective decision support during crisis situations (Kantsepolsky & Mordecai, 2018). In this context they are especially useful for decision making in disaster risk management, because they are able to display sensitive information about temporal and spatial aspects very accurately (Saha, Shekhar, Sadhukhan, & Das, 2018). The visualization of risk relevant data and information through dashboards constitutes an integral part in strategical, tactical and operational management, (as mentioned in the Section **Dashboards Types and Use**) during the disaster risk management cycle (Kantsepolsky & Mordecai, 2018). Geographic maps, graphs and charts in an interactive environment help as an integrated approach immensely, to extract, view and integrate diverse information (Saha et al., 2018).

Interpretation of large temporal and spatial data sets during phases within the disaster risk management cycle by static maps, graphs and reports is **limited**. Dashboards contribute through their efficient way of communication geo-spatial information from often different and diverse data sources to the creation of a dynamic environment for exploration and analysis of trends, and also for the identification of weak points (Saha et al., 2018). Dashboards can bridge hereby the gap between static maps, graphs and diagrams, and on the other hand models that are detached and limited in control. They help in crisis situations to quantify unexpected and unpredictable generated effects and provide a sound basis for being able to detect them (Kantsepolsky & Mordecai, 2018).

By visualizing various decision support information dashboards have the ability to function as a "system of a system". They combine and provide data from multiple sources and sensors to enhance information streams in frequent intervals and deliver value in analytical tasks for decision makers in different sectors, including control centers, rescue-, public- and crisis-response teams (Kantsepolsky & Mordecai, 2018).

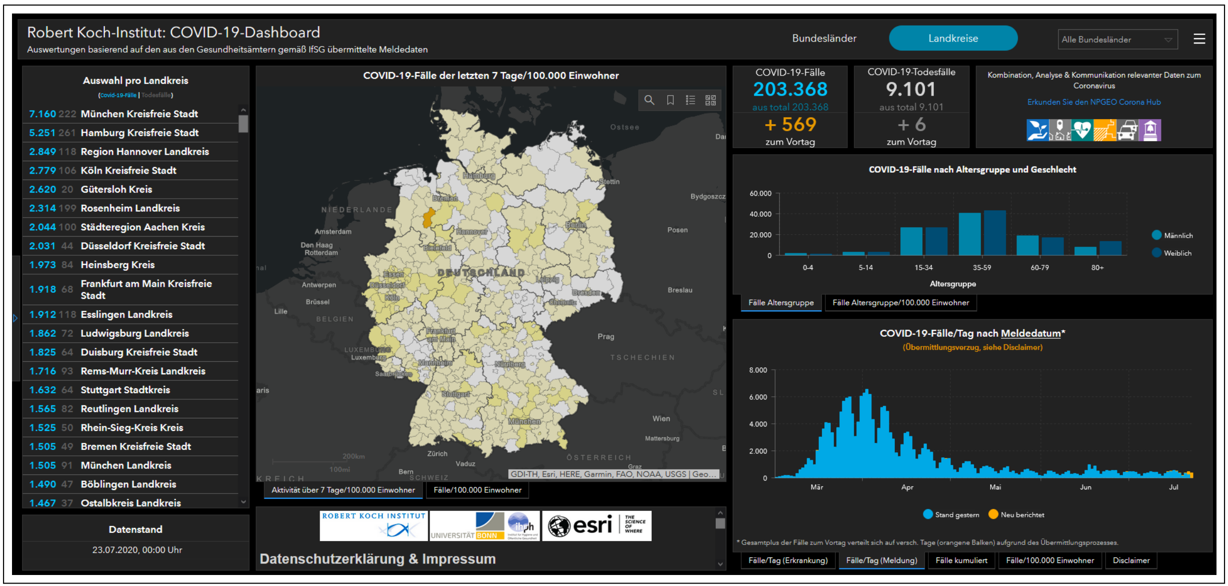


Figure 2.7: Robert Koch-Institute: COVID-19-dashboard. Retrieved from: Robert Koch-Institute (2020)

Dashboards aim to support decision making of emergency services and allow real time monitoring of risks and various hazards (Horita et al., 2014). On the other hand they also support accessing the situation by providing situational disaster data (sometimes real-time) to the general public, which is potentially affected by the disaster. Much of real time data and crisis relevant data is not easy accessible and is often dispersed across multiple platforms. Dashboards are able to provide the crucial intersection to access the data reliably. Therefore dashboards may help strengthen the *resilience* by channeling data and providing a platform, that helps communicating risk relevant data and makes it accessible. Especially, tactical dashboards are useful for aggregation and accessibility of crisis information in real time for humans impacted by a disaster. Furthermore, dashboards can even function as crowd sourcing data channels - where those people benefit most by uploading and sharing content, which are most affected by a disaster. Common features supported by dashboards in disaster risk management include built-in solutions for crisis events, life event feeds and webcam display for situational overviews (Tilley & Pettit, 2019).

Dashboards within the Disaster Risk Management Cycle:

In the preparation and preparedness phase dashboards efficiently support analyzing, planning and the evaluation of tasks (Janssen & Bharosa, 2010). Dashboards can efficiently bundle and visualize information of for instance evacuation routes and safe areas and provide through interactivity calculations on shortest routes. They also help to estimate, track and monitor the performance of rescue teams, fire departments, agencies, organizations and other stakeholders by visualizing performance indicators, with the purpose to provide overview and improvement of the performance, before an disaster event strikes (Janssen & Bharosa, 2010). Dashboards assist communities in preparedness and they are able to provide estimations on potential hazards through hazard indexes (Horita et al., 2014).

In the response phase dashboards have a huge effect on maximizing the efficiency and support the management of actions during and directly after a disaster. Concretely, dashboards may support real time mapping and map placed sharing, extend and enhance the *situational awareness*, improve the multi-modal communication and contribute to monitoring safety progresses (Kantsepolsky & Mordecai, 2018). Dashboards assist communities in the response phase by providing updated information about current states of hazards trough images and hazard indexes (Horita et al., 2014).

As an example for the use of dashboards in the recovery phase, Zheng et al. (2010) provided a dashboard that dynamically provides the individual interests of different stakeholders - with the aim to predict information about recovery purposes that are most needed by the individual stakeholder within a community network.

The relevant information can be reviewed within the dashboard directly. A focus in this project is to foster collaboration between different members of the community network, provide information exchange and to improve the communication.

In prevention and mitigation dashboards help visualizing vulnerable zones and areas, analyze and identify critical points and elements at risk. This has often a direct effect in even preventing the need of a rescue of vulnerable elements, or at least considerably reduce the rescue time and to plan further mitigation measures. Dashboards often also visualize the susceptibility and exposure to certain hazards with the help of risk indexes (Saha et al., 2018).

It is generally difficult to state a general indication of the phase, in which dashboards are used most intensively or are most valuable. Due to their flexible design, they can be used in a wide range of disaster risk management applications and can be tailored and designed to meet the individual requirements of the users. This is probably one of the main reasons, why dashboards are so popular at present - and especially in disaster risk management.

Prominent dashboards in disaster risk management include **the Robert Koch-Institute: COVID-19-Dashboard** displayed in Figure 2.7. The dashboard provides a detailed presentation of the transmitted COVID-19 cases in Germany by county and state[3].

[3] https://experience.arcgis.com/experience/478220a4c454480e823b17327b2bf1d4

Chapter 3

Core User Identification, Data Description and Study Area

3.1 Tianjin Disaster, China

Figure 3.1: Image of the Tianjin explosion depicting the explosion site including destroyed vehicles and tossed containers. Retrieved from: The New York Times (2015)

3.1.1 Core User Identification

As mentioned in Chapter 1.1 **Background, Motivation and Problem Statement** the current state of the art is that many companies, institutions and organizations working in disaster risk management are working on the basis of reports and static maps.

The GAF AG is a medium-sized company in Munich, Germany. They offer geo-data, technology, solutions, products as a comprehensive end-to-end service portfolio. Their projects include earth observation data,

Figure 3.2: Overview over the study area **Tianjin Port, Tianjin, China**

geo-products, integrating space technologies into real world applications, including in disaster risk management. Often these orders and projects in disaster risk management include the creation and use of static maps for i.e. print purposes, as for example in their activities in Copernicus Emergency Management Service. They constitute the executing force and produce and prepare the map data and the maps themselves (GAF AG, 2020).

Within the scope of this thesis, GAF AG was contacted as a **potential core user** and they agreed to become part of this master's thesis and provide the data basis. It was discussed and elaborated that on the basis of their provided data, the potential of dashboards can be investigated within the field of disaster risk management through the development of a dashboard prototype. Researching and integrating new cartographic visualization methods is also of interest for employees of GAF AG, in order to make for example customer orders more innovative and to be "up-to-date". The concrete benefit for GAF AG within this master's thesis is provided through the introduction and implementation of innovative cartographic tools such as dashboards, in order to bundle risk-relevant information more interactively and effectively, to support decision-making in the event of a disaster and to potentially increase customer satisfaction regarding their orders.

3.1.2 Data Description, Background and Study Area

The data basis that was made available is based on an order of Munich Re involving loss assessment following the Tianjin Disaster 2015. The disaster was caused by an explosion in the port of Tianjin, one of China's largest ports and trading hubs.
On the August 08th, 2015, the illegal storage of toxic and highly explosive and flammable chemicals (ammonium nitrate) caused a massive explosion. A total of 173 people died, at least 80 of whom were firefighters, nearly 800 people were injured and 300 homes were destroyed (Mortimer, 2016). Apart from

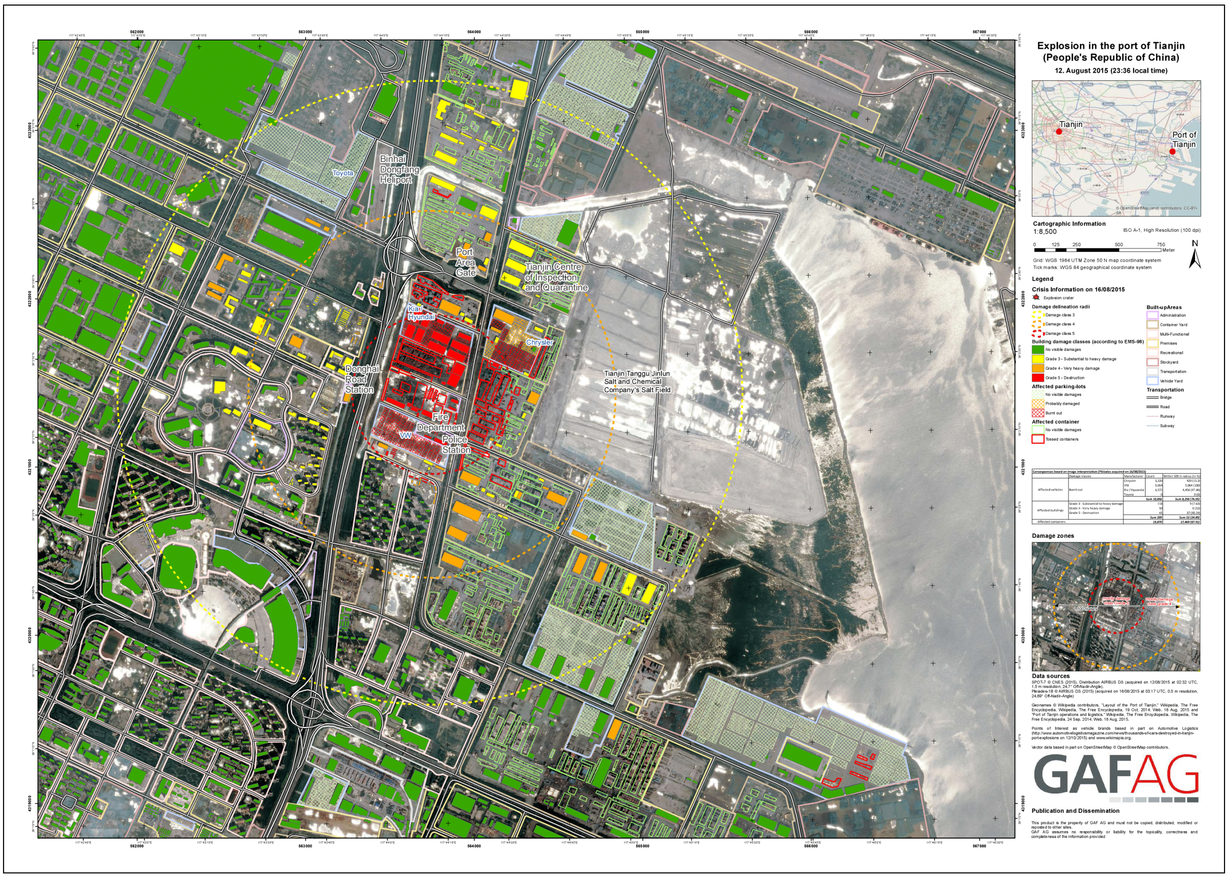


Figure 3.3: Map of the damage assessment conducted by GAF AG on behalf of the order by Munich RE.

this, the explosion caused insurance losses of around 1.5 billion Euro, as a large number of new cars and containers were stored in the vicinity of the explosion (Deutsche Welle, 2015). The exact cause is still not precisely determined.

Within the classification by impact, provided in Chapter 2.1.1, this disaster falls into the category **"Sudden-onset disaster"**, because the hazardous event (chemical explosion) emerged extremely quickly and unexpected. It is an **anthropegenic** disaster, because of its *human-induced* origin. Additionally, the mentioned *risk drivers* in this case are **"poorly planned and managed urban and regional development, globalized economic development and weak governance"**.

Munich Re had commissioned the order, in order to facilitate damage assessment after the disaster due to the destroyed buildings, containers and cars and to gain an overview. This case can therefore be assigned to the **response category**.

The concrete data basis is a **static map**, produced for the damage assessment by GAF AG as a PDF (Figure 3.3) and the corresponding shapefiles. The shapefiles as vector data display different thematic aspects of the explosion like affected cars, tossed containers, different destruction classes of buildings etc. In addition, an orthophoto was supplied, taken on August 12th, 2015 and August 16th, 2015 from the satellites SPOT-7 and Pleiades 1-B.

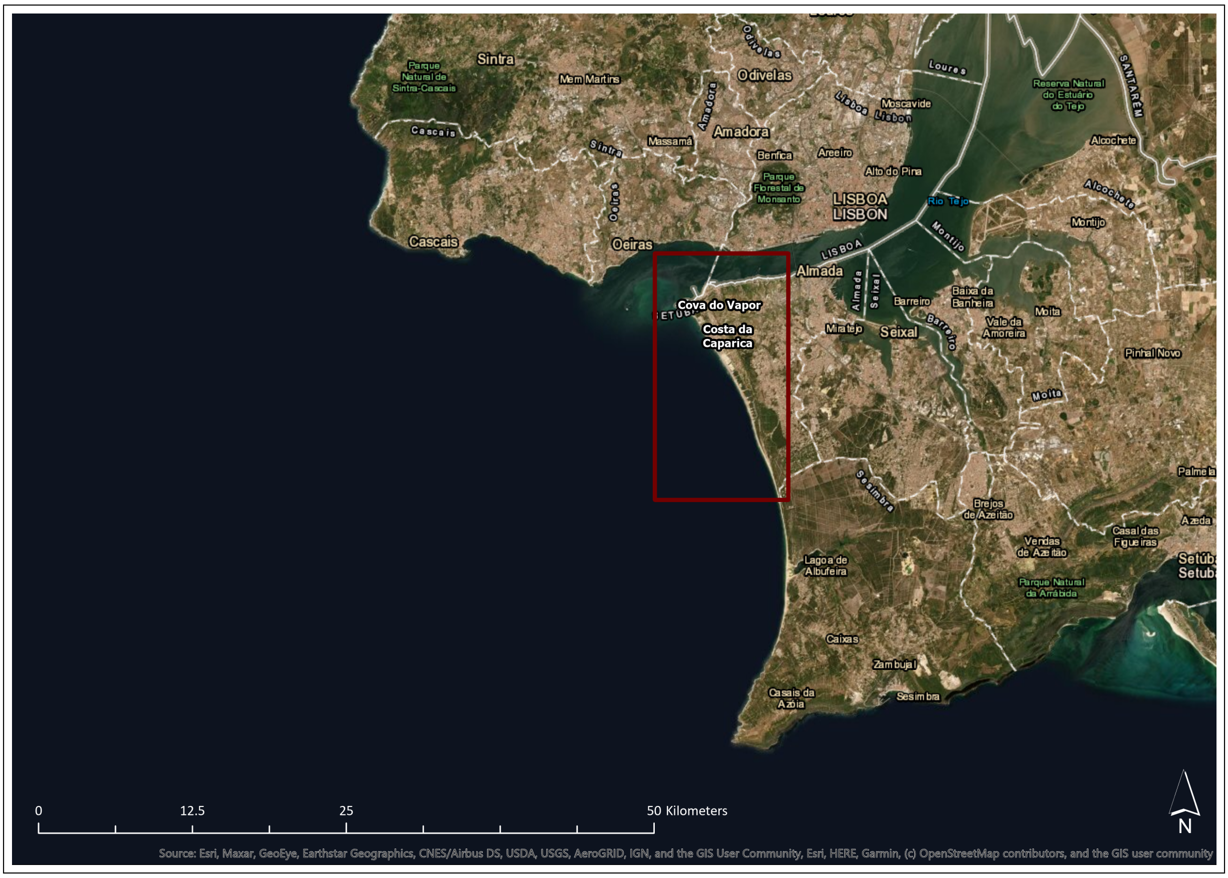


Figure 3.4: Overview over the study area **Costa da Caparica, Setúbal, Portugal**

3.2 EMSN034: Coastal flood risk analysis for population and assets, Portugal

3.2.1 Data Description, Background and Study Area

Before the *actual* construction of the prototype for **the core user GAF AG**, another data source was also researched, which was able to serve for a **pre-test** to investigate the potential of dashboards over static maps. The second data source was intended to test the benefits of dashboards, reached by creating a high level of **comparability** between static maps and dashboards in the context of a *potential analysis*. The data should make it possible to highlight the potential of interactivity (provided by dashboards and interactive maps) in terms of improved effectiveness, efficiency, correctness of information and user satisfaction within the area of disaster risk management. The static map and data of **the core user GAF AG** was not considered suitable for this *potential analysis*, because the map itself was too complex and contained too many information, therefore the high comparability between dashboard and static map would not have been achievable.

As a second data source the EMS activation "EMSN034: Coastal flood risk analysis for population and assets, Portugal" was selected from the risk and recovery service of the Copernicus Emergency Service. This EMS activation was created for an area, the **Costa da Caparica, Setúbal, Portugal**, with a high tsunami risk (Figure 3.4).

Besides the tsunami risk, this region reflects different vulnerability values for its elements at risk, which are represented by vulnerability indicators (physical and socio-economic) in the course of this activation, in order to get a comprehensive picture of the situation.
In the course of this activation spatial indexing as described in Chapter 2.2.1 **Cartography in Mitigation**

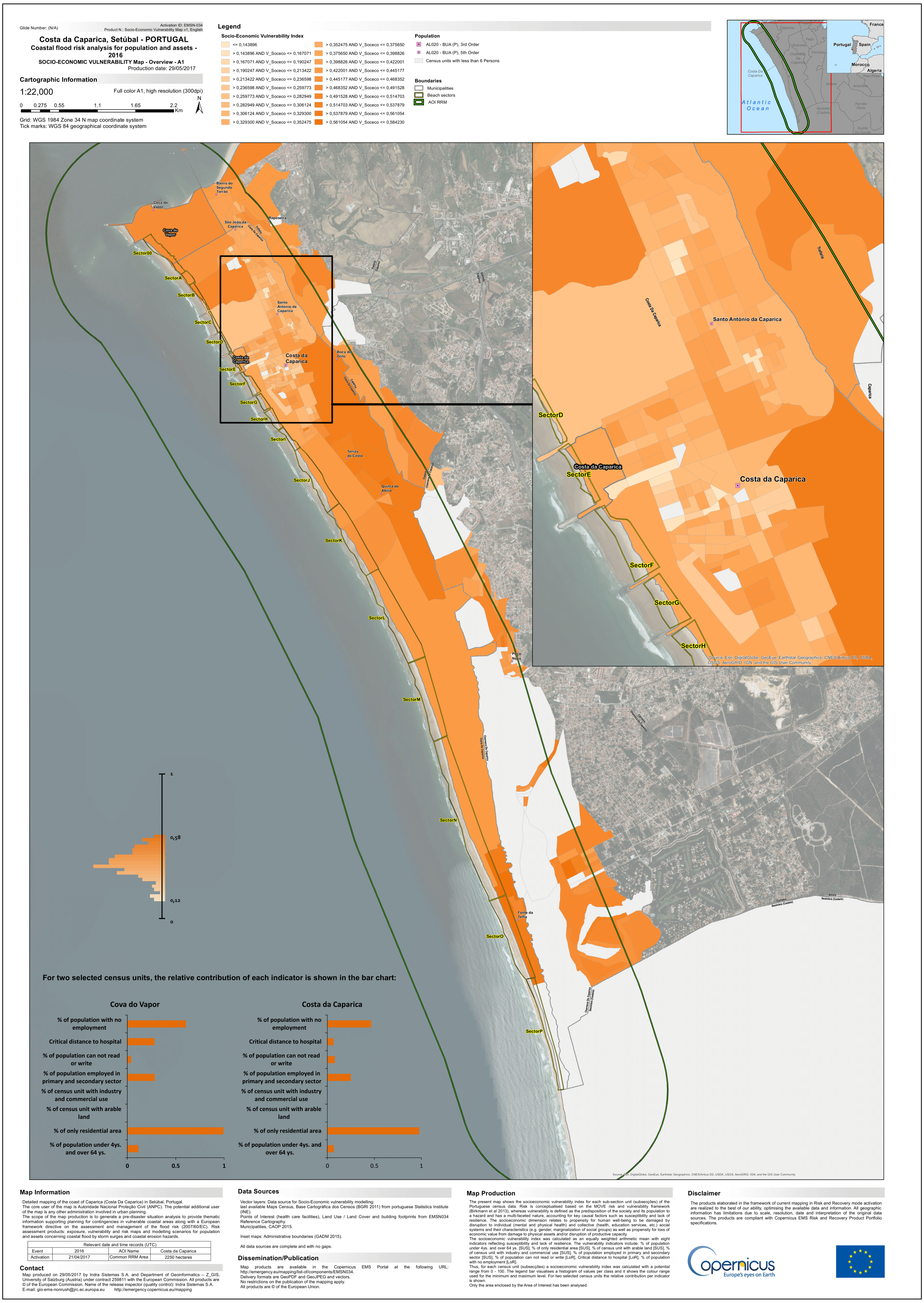


Figure 3.5: Map of the EMS Activation **EMSN034: Coastal flood risk analysis for population and assets, Portugal**. Map displays the socio-economic vulnerability on the **Costa da Caparica**. Retrieved from: Indra Sistemas (2017)

and Prevention was conducted - making this activation a **prevention and mitigation case**. Extensive cartographic products, showing different vulnerabilities, risk assessment, recordings of evacuation routes of Costa da Caparica were provided as static maps, with an additional report within the course of this activation in the year 2017. *Risk drivers* related to this activation are **"poverty and inequality"**, covered and included within the socio-economic vulnerability index.

One single static map (out of 16 in total within this activation) was selected as a starting point, which depicts the socio-economic vulnerability index of the Costa da Caparica. This index incorporates variables like vulnerable age groups, similar as mentioned in the case study by Mendes et al. (2019), in Chapter 2.2.1. The map additionally includes supporting graphs and can be viewed in Figure 3.5. This example was chosen, because it allowed well to transfer the static map into an interactive dashboard with a high degree of similarity. Additionally the supporting graphs could also be easily transferred into a dashboard. The data is available on the homepage of the EMS Risk and Recovery Activation[1], as a geo-database. The original data has the data format "OpenFileGDB".

3.2.2 Focus Group

The assembly of a focus group was necessary to evaluate the usability of dashboards and test their potential over static maps. The actors involved in disaster risk management come from very different domains and often have diverse backgrounds. Therefore, a group of students with a high degree of relevance to disaster risk management and climate change was selected for the focus group tests.

In order to have a certain homogeneity for the comparability in this focus group, all participants (34 in total) in this study were between 20-35 years old, originate from the "geo-area" or at least have a relation to disaster risk management (e.g. a doctor working on the corona station during the crisis). Emphasis was placed on testing the benefits of interactivity over static products, which was then transferred to disaster risk management and dashboards.

[1] https://emergency.copernicus.eu/mapping/list-of-components/EMSN034

Chapter 4

Methodology

This chapter outlines the comprehensive methodology of implementing a *sophisticated* dashboard prototype for disaster risk management purposes. The dashboard is created in collaboration with the **core user GAF AG**, who normally uses mostly static maps for disaster risk management purposes. The methodology is divided into four sections.

Prior to the **actual** dashboard prototype design and its construction (in collaboration with the **core user GAF AG**), a *requirements analysis* was conducted, in the form of two qualitative expert interviews and an additional interview with the **core user GAF AG**. Simultaneously, a relatively *simple* dashboard was created for a comparison in order to investigate the strengths and differences of dashboards and static maps for disaster risk management purposes in form of a *potential analysis*. The actual methodology for the creation and design of the initial dashboard prototype for the **core user GAF AG** is described in the section *dashboard prototype*. The final part of this chapter provides the methodology for conducting a *sector analysis* in order to determine how the concept of the dashboard prototype is perceived in different sectors in the field of disaster risk management.

A detailed flow chart visualizing the methodology and its coherences is displayed in Figure 4.1.

4.1 Requirements Analysis

The *requirements analysis* is divided into **two** parts. Firstly, *specific* user needs of a designated core user within the disaster risk community were identified. The **core user GAF AG** was questioned in a qualitative interview about his needs, ideas and expectations in the sense of a "user-centered design". Based on this identification and with the aid of the data provided, the development of the **Tianjin Dashboard** prototype was carried out on the one side.
Additionally, the *requirements analysis* included on the other side the identification of more *generic* key features that should be included in a dashboard which is supposed to be used for disaster risk management purposes. These are provided by the *external* opinion of two experts. Interviewing experts was a crucial aspect in this master's thesis, as the experts have extensive and sound experience in disaster risk management and developed and implemented dashboards and interactive visualization tools themselves. Their technical expertise and rich experience were considered as a sound foundation for the creation of a dashboard prototype in disaster risk management.

4.1.1 Core User Needs

Qualitative Interview

Following the agreement of the GAF AG employee to act as a core user, a qualitative interview was conducted as part of the *requirements analysis* in order to identify user needs as the foundation of a

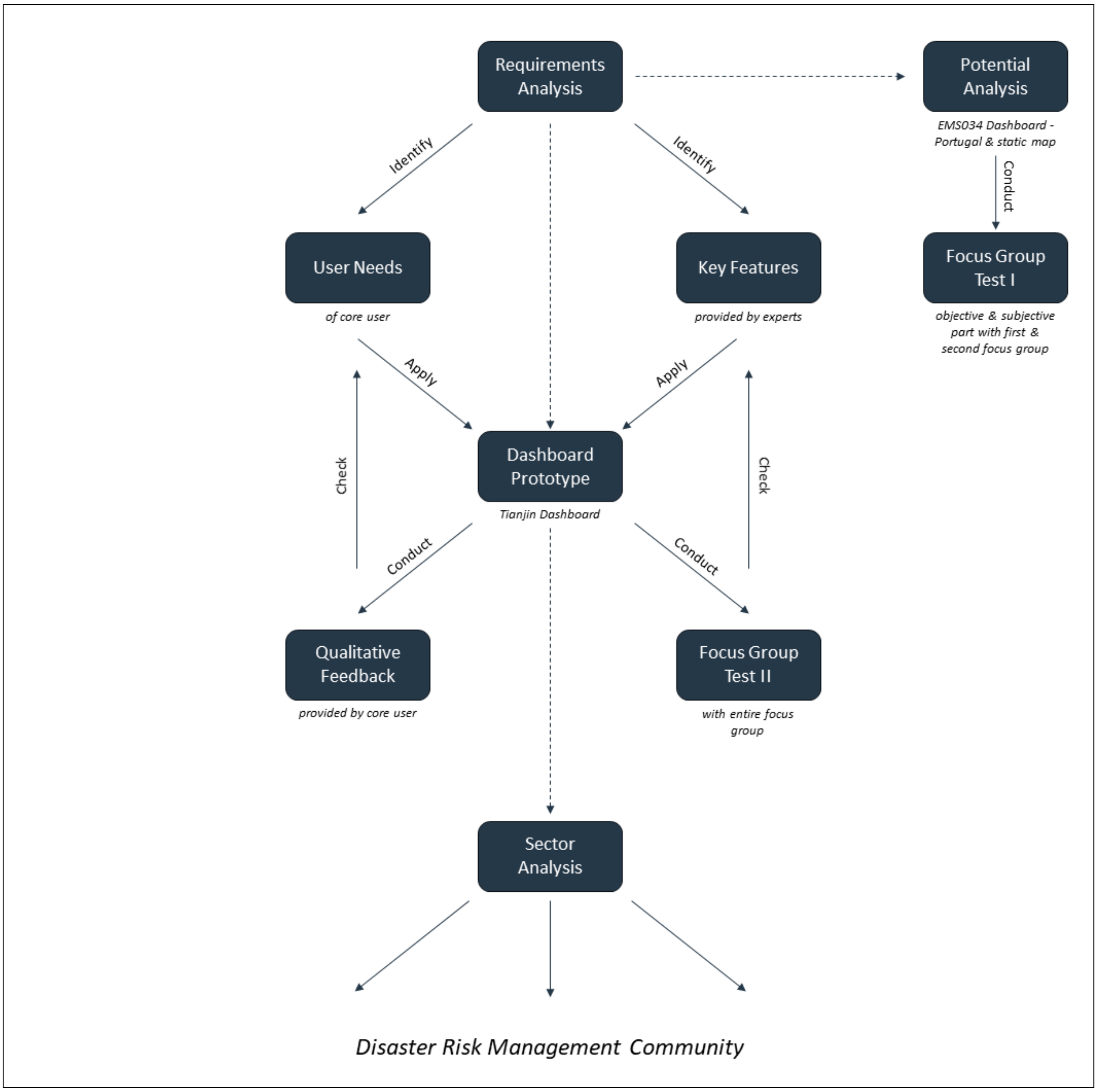


Figure 4.1: Individual conducted steps of the methodology visualized as a workflow-chart

"user-centered design" process. For this purpose, a catalog of questions was compiled, which intended to guide the core user through the qualitative interview. In total, eight key questions were included. Permission was granted to record the interview on video during the interview for subsequent transcription and evaluation purposes.

The aim and purpose of the catalog of questions was to identify the *particular* requirements, ideas and expectations of the **core user GAF AG** for a prototype-dashboard in disaster risk management and to establish the general framework conditions. Particular attention was paid to the fact that the questions were asked in a way that the user requirements were expressed in the form of significant *core aspects*. Since the **core user GAF AG** is also an expert in the response area of disaster risk management, he was also consulted about trends and challenges concerning cartography and disaster risk management. The catalog of questions and provided answers (German) by the core user can be found in Appendix 1.

4.1.2 Expert Interviews

Qualitative Interview

Due to their high level of expertise and profound experience in disaster risk management and dashboards, two interviews with experts were conducted. The experts have both designed and implemented one or more dashboards or interactive cartographic visualization tools for disaster risk purposes. They are employed at Munich Re, an international reinsurance company with a focus on natural and anthropogenic disasters, and at the Fraunhofer Institute, one of the biggest research centers in Germany.

Both interviewees were contacted, in order to elaborate *key features* regarding dashboards in disaster risk management within this master's thesis. The eight interview questions per interview with slight distinctions were designed in the form of a guided question catalog, to provide both interview partners the possibility to share their perspectives and estimates in form of *key features* for cartography, dashboards and disaster risk management. Permission was granted to conduct audio recordings of the interviews for subsequent transcription and analysis. The transcribed interviews are included in the Appendix 2 and 3.

Primarily, the focus was directed to general assessments and opinions about dashboards in disaster risk management. The interview was intended to provide the opportunity to pinpoint *key features* of disaster risk management dashboards, which would be **relevant and generally valid**. Nevertheless, the questions were not intended to be asked too precisely, in order to leave enough scope for own ideas and conceptions and to be able to meet the requirements of the **core user GAF AG**. In addition, the interview was conducted, in order to obtain the experts' assessment of future trends and challenges in disaster risk management with regard to cartography and dashboards.

4.2 Potential Analysis

The *potential analysis* serves the purpose of highlighting the advantages of interactivity (provided by dashboards in terms of **efficiency, correctness of information, effectiveness and user satisfaction**) in the area of disaster risk management compared to static maps e.g. for print purposes. For this reason the dashboard "EMSN034: Coastal flood risk analysis for population and assets, Portugal" (in the following named **EMS034 Dashboard - Portugal**), which is based on the static map (Figure 3.5) of EMSN034-activation, was created. Potential benefits of interactivity were tested through the comparison of the original static map and the **EMS034 Dashboard - Portugal**, which provides the interactive features, with the help of the participants of the focus group.

4.2.1 EMS034 Dashboard - Portugal

As the basis for the dashboard the example "EMSN034: Coastal flood risk analysis for population and assets, Portugal" mentioned in the data description in Chapter 3.2 was selected . Given the high potential for comparability, this example was considered to be sufficient, because the main static map and the displayed graphics on the map could be efficiently transferred to an interactive web map. This web map, in turn, could be subsequently transferred into an interactive dashboard with supporting graphs and indicators.

Creation of Dashboard

The creation of the **EMS034 Dashboard - Portugal** is divided into four steps.

Firstly, the geo-database was downloaded and uploaded into QGIS[1], a geo-information system (GIS). QGIS is an open source software, that allows to create, edit, visualize, analyze and publish geospatial

[1]https://qgis.org/de/site/

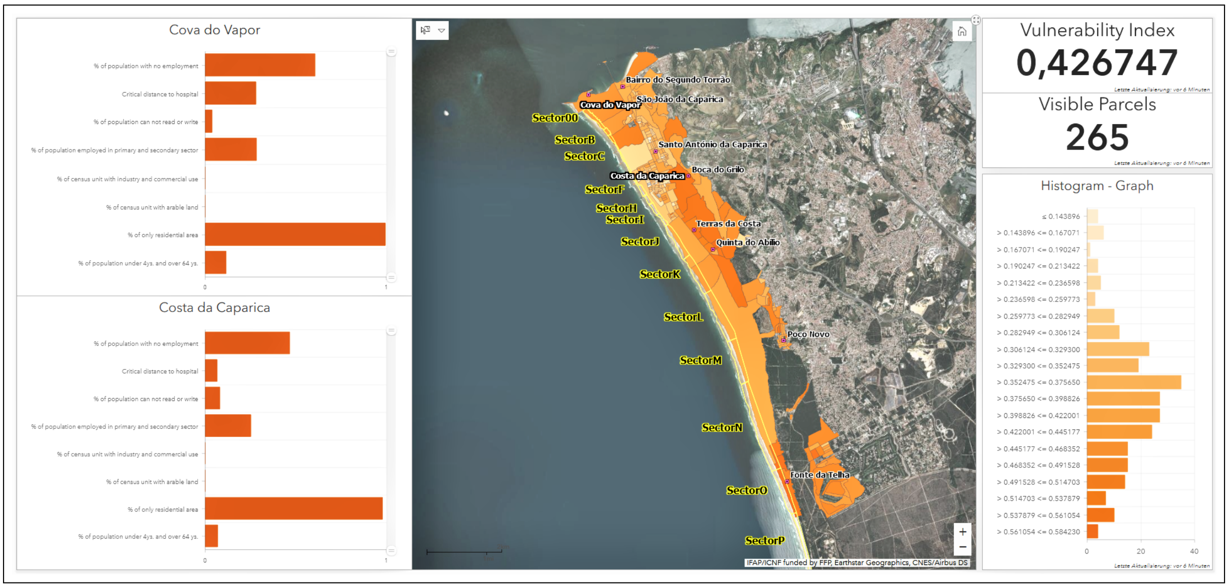


Figure 4.2: Dashboard of the EMS Activation **EMSN034: Coastal flood risk analysis for population and assets, Portugal**. Dashboard displays the socio-economic vulnerability on the **Costa da Caparica** with interactive features

information. In QGIS the required data was converted from the original format "OpenFileGDB" into shapefiles, in order to enable subsequent processing of the data in ArcGis Pro[2].

Secondly, these shapefiles were imported into ArcGIS Pro. ArcGis Pro is a single desktop geo-information systems application from Esri and part of the Esri Geospatial Cloud. The software supports data visualization, advanced analysis and management of reliable data in 2D and 3D. ArcGIS Pro is closely connected to the ArcGIS platform, which supports data sharing in ArcGIS Online[3] and ArcGIS Enterprise[4] via Web-GIS. In ArcGis Pro the attribute tables were pre-processed and the values were classified to match and correspond to the 20 classes of the original static map. In addition, the field calculator was used, to perform calculations and attributions for later visualization purposes. For classification purposes, the exact color coding was identified using the hex color codes in the original static map and subsequently applied to the shapefiles in ArcGIS Pro, in exactly the same way in order to achieve the highest degree of comparability. Since the exact satellite image, used in the original map was not available, ESRI World Image was used instead. The substitute is applicable, because the original print map has a correspondingly small scale and therefore no high resolution satellite image was needed. Labels of city names and regions were prepared in ArcGIS Pro, in a way that they would correspond largely to the original static map. The aim in ArcGIS Pro was to ensure that the main map could be transferred *as accurate as possible* to a web map. For the export as a web map the coordinate reference system was adapted from "WGS 1984 Zone 34 N" to "WGS 1984 Major Auxiliary Sphere geographic coordinate system". The map was then exported from Arcgis Pro to ArcGis Online with the individual shapefile layers as a web map.

Thirdly, small changes were made in the "Map Viewer" in ArcGis Online. ArcGIS Online as part of the Esri Geospatial Cloud is a cloud based software, that connects and displays data via interactive web maps. In the "Map Viewer", the transparency of the underlying satellite image ESRI World Image was adjusted to match the transparency of the original static map and pop-ups were configured. Eventually, the finer details were executed for ensuring the comparability to the original static map.

The web map was then used in a fourth step as a foundation for ArcGis Dashboards. ArcGis Dashboards[5]

[2]https://www.esri.com/de-de/arcgis/products/arcgis-pro/overview
[3]https://www.esri.com/de-de/arcgis/products/arcgis-online/overview
[4]https://enterprise.arcgis.com/de/
[5]https://www.esri.com/de-de/arcgis/products/arcgis-dashboards/overview

is a software application that allows interactive data visualizations on a single screen. Part of the ArcGIS platform, ArcGis Dashboards is designed to support decisions-making, to visualize trends and monitor for example status in real time.

Since and as stated in the literature review in Chapter 2.2.2 - **Dashboards - and Overview**, the term dashboard is defined very broadly and very universal, the dashboards mentioned in the following sections all have approximately the following characteristics: information is conveyed by presenting location-based analytics, using intuitive and interactive data visualizations on a single screen. In addition, they can include graphs and indicators to help bundle information, such charts, gauges, indicators, scales, lists, details, and more integrated content as media and text. These additional elements may be interactively connected with the main map and also interconnected for exploratory purposes. The dashboard elements can be flexibly customized if desired and external content and other web apps can be flexibly integrated. Dashboards can be grouped as "sub-dashboards" to achieve more levels of abstraction and can be made freely available and published. The dashboards mentioned here refer **exclusively** to dashboards created with the ArcGIS software.

The dashboard created for the *potential analysis* has a total of six elements, including the interactive web map. Following interactive (main) functions were integrated: **hovering, selecting, filtering, zooming and panning**. After the web map was integrated into the ArcGIS Dashbaord Builder the individual socio-economic vulnerability indexes, two series diagrams, of the areas "Costa De Caparica" and "Costa do Vapor", were created on the basis of the shapefile for the socio-economic vulnerability index, in the same way they are present in the original static map. Selecting was enabled during the creation process. In addition, the information hovering function has been added, so that the user can see the relevant information interactively. Furthermore, the individual bars of the graphs can be enlarged or reduced as required. Moreover, the classification was visualized as a series diagram "Histogram Graph" by count, based on the original data of the socio-economic vulnerability index, designed after the presentation of the graph in the original static map. The function filtering was enabled, so that the number of visualized area units in the map would adapt to the selection of a class. Additionally, two further interactive indicators were created. One of them supports the visualized "Area Parcels" and shows the exact number visible on the map, depending on the filtering of the "Histogram Graph". Another indicator shows the exact vulnerability index, depending on the selection of the main map.

During the creation of the **EMS034 Dashboard - Portugal**, it was ensured that the dashboard could be adequately displayed on a 13 inch screen. After the creation the **EMS034 Dashboard - Portugal** was published as "public" and can be viewed in Figure 4.2[6].

4.2.2 Focus Group Test I

After the creation of the **EMS034 Dashboard - Portugal**, the original static map was downloaded in the highest quality for the focus group test I. For testing the benefits of interactivity provided by dashboards and static maps, the focus group described in Chapter 3.2.2 was divided into two subgroups à 17 participants. The **first focus group** solved the tasks with the **EMS034 Dashboard - Portugal** (and tested therefore the interactive functions) and the **second focus group** had to solve the tasks with the original static map (Figure 3.5).

The user test questions were set up in a way to evaluate the **efficiency, correctness** (of the answers provided by the participants), perceived **effectiveness and user satisfaction** by using the medium "static map" and "dashboard". The purpose of the test questions was to determine whether **interactivity** (provided by the dashboard), through functions such as **hovering, selecting, filtering, zooming**, would have an impact on the efficiency, effectiveness, user satisfaction and correctness of the given answers by the participants. The intended determination was to identify, how the results would be influenced by the medium and how they differ, when compared. The reason for testing efficiency, effectiveness, user

[6] https://tu-muenchen.maps.arcgis.com/apps/opsdashboard/index.html#/41d65b634f4c40c7a1172ac5212daa3c

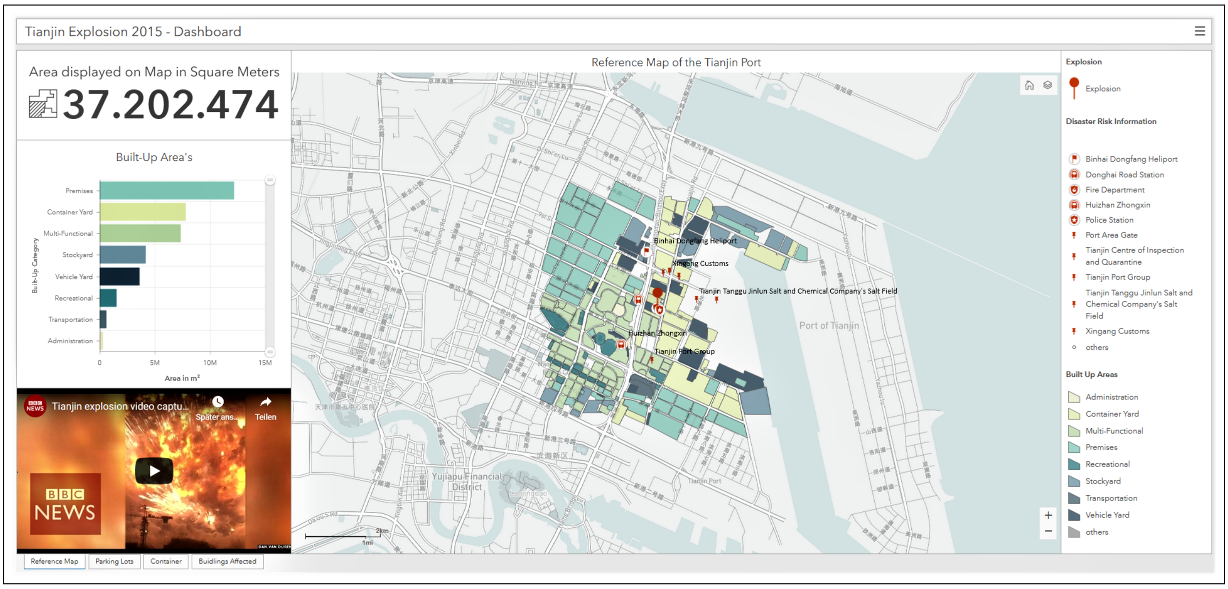


Figure 4.3: The reference map of the Tianjin harbor within the **Tianjin Dashboard**

satisfaction and correctness of information is, because they have a significant impact on decision making and communication flow in disaster risk management and conclusions on the usability of the tested medium in disaster risk management could be drawn. The test was divided into **an objective and a subjective part** (Kinkeldey, MacEachren, & Schiewe, 2014). Tasks in the objective part included mainly *where and what* questions and tested for **efficiency and correctness** of the answers of both tested media "static map" and "dashboard" (Roth et al., 2015). Focus in the subjective part is given on the perception of **effectiveness and user satisfaction** of the participants related to the used medium (Kinkeldey, MacEachren, Riveiro, & Schiewe, 2017).

Regarding the structure of the initial test, firstly a short introduction into the topic in both focus groups was provided and additionally for the dashboard **first focus group**, a short introduction to the basic functions of the dashboard was provided. The participants, then would have a short period to acquaint themselves briefly with the topic.
The whole test was designed to take ten minutes. The answers of the participants were marked on the enclosed questionnaire and an adjacent map. Both test versions for the **first focus group** and the **second focus group** can be found in Appendix 4 and 5.

4.3 Dashboard Prototype

4.3.1 Tianjin Dashboard

The general aim of the prototype dashboard was to explore the potential added value and usability of dashboards in disaster risk management through their interactive nature as an alternative to conventional methods like static maps and reports. In addition, the aim was to determine whether companies, institutions and organizations involved in disaster risk management are motivated to integrate the use of dashboards into their daily business.

The general conception of the **Tianjin Dashboard** as a prototype, was based on the answers of the qualitative interview of **core user GAF AG**. In addition, it was aimed, to incorporate the key features of the *requirements analysis* (see Section 4.1.2) in the most appropriate manner into the design process of the dashboard.
The actual conception of the **Tianjin Dashboard** prototype is highly similar to the one of the **EMS034 Dashboard - Portugal**. However, since the **Tianjin Dashboard** is based on a larger and more complex

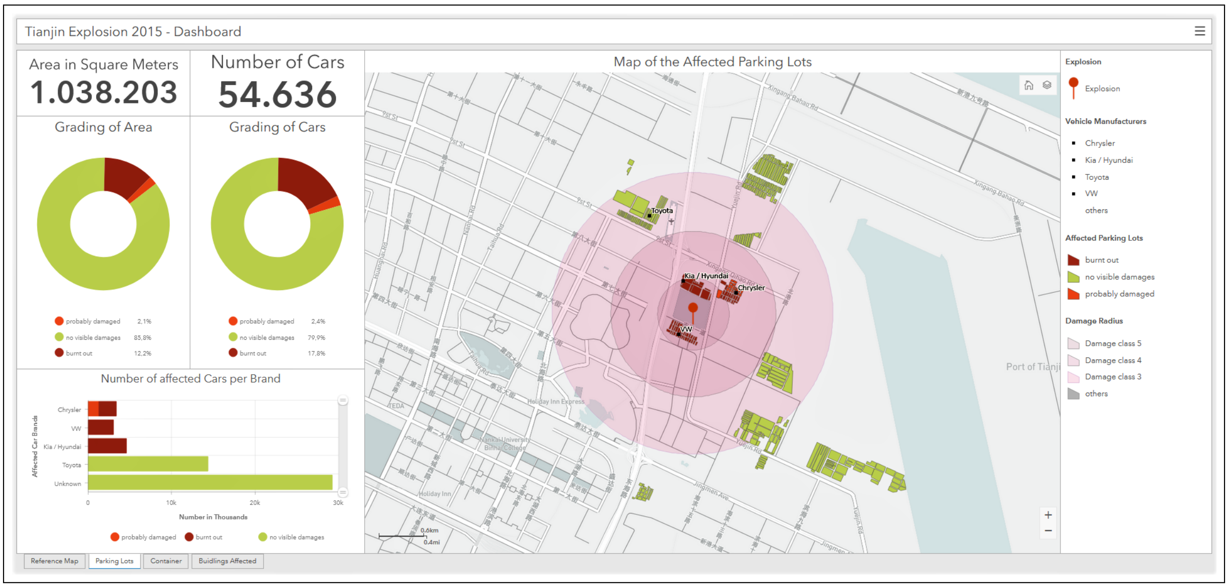


Figure 4.4: Affected vehicles by the Tianjin explosion within the **Tianjin Dashboard**

data base, the **Tianjin Dashboard** is much more sophisticated and advanced in its functions and explorability. Additionally, the production of the dashboard was much more time consuming and challenging.

In terms of design, the dashboard was kept minimalist and simple, and the choice of colors reflects the respective themes and was kept consistent. The design guidelines from Tableau (2020), listed in Chapter 2.2.2 **Dashboard Design**, were aimed to be applied. The structure and design of the dashboard was first sketched on paper in several attempts. At this point, the thematic structure was already established, since the shapefiles of the data foundation included numerous different subjects related to the Tianjin explosion. Relatively at the beginning, some tests with parts of the dashboard were carried out, in order to test the design aspects and to get to know the functions of the software. In the process, various design ideas were established and then rejected again.

The individual steps for the subsequent technical creation of the dashboard is described below and is divided into four steps.

Firstly, the shapefiles of the data basis were fully imported into an ArcGis Pro project. Since, the data basis of the shapefiles would have been too complex to be implemented into a single dashboard, the division into thematically different maps was already conducted in ArcGIS Pro, which subsequently could be integrated into different "sub-dashboards" at a later stage. The created maps distinguish themselves in the thematic content they represent. A reference map was created, one that shows the vehicles on parking lots, which were affected by the explosion, one that deals thematically with the tossed containers and one that shows a different damage grading of the affected buildings. The purpose of the thematic structuring in the preliminary stage, is to allow and provide different levels of abstraction, implemented later in the process of creating the dashboard itself.
A large part of the work in ArcGIS Pro is focused on the pre-processing and data formatting processes, of the attribute tables of the original shapefiles, in order to be able to display them adequately in the dashboard software at a later stage. In addition, the shapefiles were symbolized and labels were placed on the maps in ArcGIS Pro. For the export as web map, the coordinate system was changed to "WGS 1984 Major Auxiliary Sphere geographic coordinate system" as it was the case for **EMS034 Dashboard - Portugal**. One individual map after another, was exported as a web map to ArcGIS Online and published, so that in ArcGIS Online four web maps would exist for the different topics of the Tianjin explosion.

Secondly, a basemap was created using the Mapbox[7] software and released as WMTS via the API. Mapbox

[7]https://www.mapbox.com/

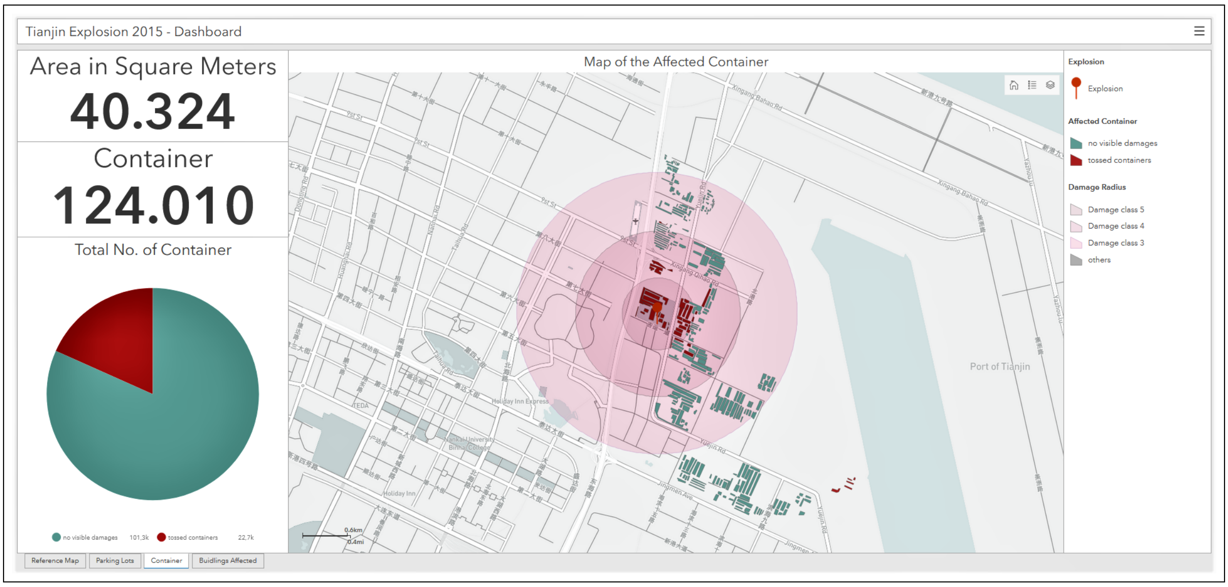


Figure 4.5: Affected container by the Tianjin explosion within the **Tianjin Dashboard**

is an open source mapping platform for custom designed maps. The APIs and SDKs are the building blocks to integrate location into any mobile or web app. Mapbox was used because it offers a lot of freedom in designing web maps and is an alternative to the provided basemaps by ESRI.

Thirdly, since the design always changes slightly during the export to ArcGIS online, small changes within the maps were adapted in the Map Viewer and the pop-ups were configured. The WMTS layer, of the custom created basemap, was then added to the individual web maps. After the layout was refined, the individual maps were finally configured for the transfer into the ArcGis Dashboard software.

The following fourth step involved the integration of the individual maps in succession as "sub-dashboards" using the ArcGIS Dashboard software (Figure 4.3, Figure 4.4, Figure 4.5 and Figure 4.6). Each individual dashboard is accessible via a tab and the display changes then accordingly. These abstraction levels were created to provide a better overview of the overall situation, by dividing the sub-dashboards logically according to the individual thematic topics. The step, to differentiate the maps into their respective themes such as affected vehicles, has been implemented in order to provide more exploratory scope and create more space for supporting graphs and indicators. The main web maps have been enriched by supporting elements (e.g. pie charts, series graphs, partially embedded media and indicators), which are mainly based on the map's data source. They provide *additional exploration* possibilities and highlight underlying topics, which would be otherwise *missed*. Because they are mostly based on the data source of the map, they are linked interactively to the web map. They are adaptable accordingly to the user needs, to increase the intuitiveness and comprehension of each topic item and to create a deeper comprehension level.
As mentioned above in the design process, the layout of the individual graphs and charts have been technically adapted, to mirror the colors of the main map. The intention was to avoid confusion of the user and to increase intuitive comprehension.
In general, different interactive functions are represented and implemented into the dashboard, in order to create a high degree of interactivity and intuitiveness. This is achieved, for example by **hovering, filtering, zooming and panning, selecting individual elements, pop-ups, automatic adjustment of information displayed in the elements, reducing and enlarging information as desired, flexible arranging and grouping of elements, selecting and deselecting layers** and many more. The **Tianjin Dashboard** includes two of the three types of interactivity mentioned in the Sarikaya et al. (2018) case study (Chapter 2.2.2). It enables the user to customize the dashboard and allows for faceting of the data through data filters and slicers. The fully exploreable **Tianjin Dashboard** containing the four

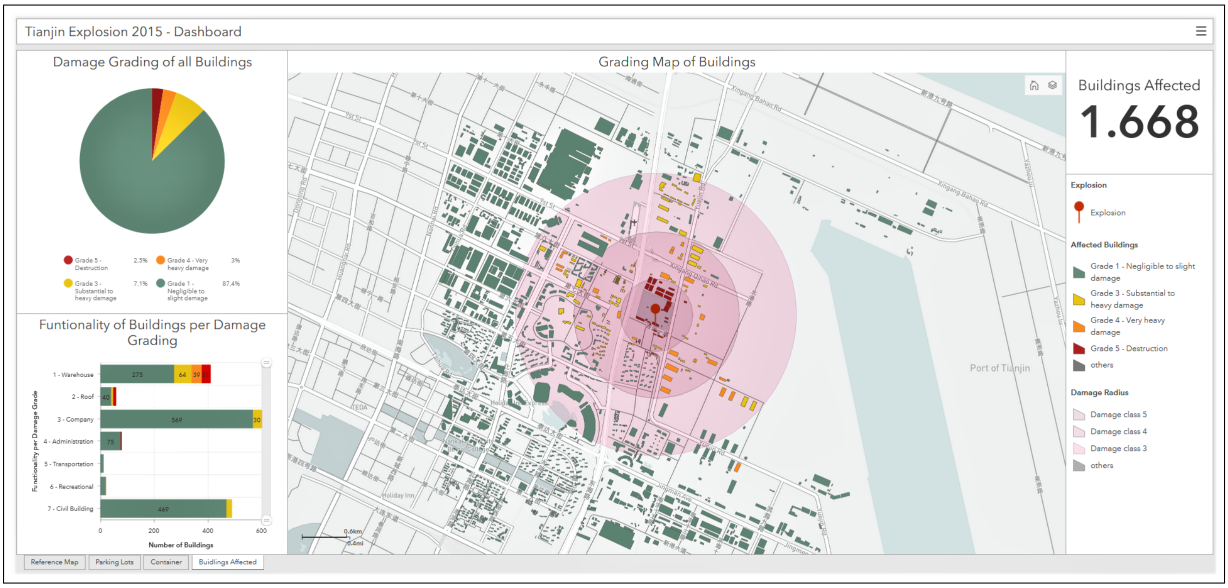


Figure 4.6: Affected buildings by the Tianjin explosion within the **Tianjin Dashboard**

sub-dashboards (Figure 4.3, Figure 4.4, Figure 4.5 and Figure 4.6) can be accessed online[8].

ArcGIS WebApp Builder

As an additional feature, for an even higher level of exploration, a fifth step was implemented, by the creation of a web app with the ArcGIS Web App Builder[9], based on the supplied orthophoto (Figure 4.7). ArcGIS Web App Builder is an intuitive application for creating 2D and 3D web apps. It includes powerful tools for configuring full-featured HTML apps. Added maps and tools can be displayed and used immediately in the app. ArcGIS Web Applications offer many highly exploratory features, such as comparison sliders, which allow you to display a section of one or more layers on the map. These are functions that are not available in ArcGIS Online or ArcGIS Dashboards itself, but could be easily integrated into the created **Tianjin Dashboard**.

In a response case like the Tianjin explosion, such functions as comparing and measuring distances and areas, integrated in a web app can be immense help for assessing the situation. For instance, they enable a high intuitive comparability between satellite images and corresponding graded layers and this can have a significant influence on the correct assessment of the situation. For the actual implementation, the orthophoto was integrated into the Web App Builder including the shapefile layers of the Tianjin disaster and various functions, such as measuring area and distance and the above mentioned sliders were added to achieve improved comparability. The web app was launched and implemented as an additional tab in the **Tianjin Dashboard**.

The web app was explicitly not implemented as a dashboard. ArcGIS Dashboards offer the possibility to efficiently integrate the additional functions provided by the Web App Builder into an application. In the end the web app was only integrated for the purpose of achieving a even higher degree of exploration of the data and to provide the possibility, if required by the **core user GAF AG**.

4.3.2 Focus Group Test II

Another survey was conducted with the same focus group mentioned previously in Section 3.2.2. This time all 34 participants were asked for their assessment, and were **not** divided into two groups, as previously in

[8]https://tu-muenchen.maps.arcgis.com/apps/opsdashboard/index.html#/b67945389976438e9349ae27f7e953ec
[9]https://doc.arcgis.com/de/web-appbuilder/

Figure 4.7: Web application created for further exploration purposes on the base of the Pleiades-1B satellite image

the scope of the *potential analysis*.

The participants of the survey helped to verify and reconcile the *key features* that have been identified in the *requirements analysis* in Section 4.1.2, without being aware of them. The aim was to evaluate, whether the created **Tianjin Dashboard** prototype is compatible with the common *key features*, which were considered as important by the experts.

Before the initial survey was performed, a small tutorial was conducted with the 34 participants, in order to introduce them to the **Tianjin Dashboard** subject (Appendix 6).

Subsequently to the tutorial, the survey was executed. For this survey a questionnaire with ten statements was created, which could be evaluated by the participants. This questionnaire can be found in Appendix 7. This survey was intended to be completed in 15 minutes by the participants.

4.3.3 Qualitative Feedback

Feedback was obtained from the **core user GAF AG** in the form of a feedback questionnaire. This questionnaire with the resulting answers of the employee can be viewed in Appendix 8.

Satisfaction and added benefit of the created **Tianjin Dashboard** was reviewed, as well as whether the **core user GAF AG** would consider using dashboards permanently and increasingly for disaster risk management purposes.

For this purpose, the questionnaire with eight questions was created based on the previously identified *core aspects*, where the assessment and evaluation could be provided as bullet points. This questionnaire was handed over to the potential **core user GAF AG** for completion and was subsequently evaluated.

4.4 Sector Analysis

4.4.1 Online Survey

An online survey was conducted, in order to test, if the concept of a dashboard is applicable and scalable to other potential user groups and stakeholder, working in the field of disaster risk management, but in different sectors. This survey was also conducted to identify if differences between different sectors for the application of a dashboard exist.

The survey contained six questions and was created online using the SoSci Survey[10] - a professional online survey tool. After the creation the online survey was released for public completion. Potential risk managers were targeted, contacted and asked to complete the survey. The questions of the survey can be reviewed in Appendix 9.

[10]https://www.soscisurvey.de/

Chapter 5

Results

5.1 Requirements Analysis

The *requirements analysis* is divided into **two** parts. Firstly, *specific* user needs of a designated core user within the disaster risk community (**core user GAF AG**) are identified. Based on identification of these *core aspects* and with the aid of the data provided, the development of the **Tianjin Dashboard** prototype is carried out on the one side. Additionally, the requirements analysis includes on the other side the identification of more *generic key features* that should be included in a dashboard that will be used for disaster risk management purposes. These are provided by the *external* opinion of two experts, who have longstanding experience in the field and have designed and implemented dashboards themselves. These *key features* are also incorporated into the conception of the dashboard as part of the *requirements analysis*.

5.1.1 Core User Needs

An essential aspect was the inclusion of GAF AG as a potential core user for the **Tianjin Dashboard** prototype from the early beginning of development. The GAF AG is a company with long-term experience in disaster risk management and has produced innumerable cartographic products.

After the **core user GAF AG** had approved the use of the data collected in 2015 for the creation of a static map of the Tianjin explosion, it was therefore reasonable to conduct a qualitative interview. The requirements and needs of the **core user GAF AG** were to be identified as *core aspects* in the sense of "user-centered design", for the dashboard development within the course of the interview.

The following *core aspects* were identified after the evaluation of the interview.

Core aspects:

- Fast and intuitive data and information capture provided by the medium dashboard
- Appropriate interconnection and efficient consolidation of information and data through interactive maps, graphs and indicators
- Profound and clear comprehensibility of the additional information content provided by the graphs and indicators
- Meaningful visualization of information providing, at best, support in the decision making process in the case of a catastrophic event
- Exploratory data analysis with the incorporation of the user of the dashboard

- Increase of potential client satisfaction through dashboards as a potentially presentation medium for business orders
- Appealing design and visualization of data in the interactive maps and graphs included in the dashboard
- Provided benefit compared to currently products such as static maps in disaster risk management

5.1.2 Expert Interviews

In order to get an idea of the requirements for dashboards used for disaster risk management purposes, two expert interviews were conducted as a qualitative study. The interviewed persons work in the field of disaster risk management in the Munich RE Group and the Fraunhofer Institute.

The interviewed experts have created either one or more dashboards in the field of disaster risk management themselves. They worked on them and implemented their ideas and requirements. The interviews were conducted in order to determine a number of *key features* they consider as important related to dashboards in disaster risk management. The *key features* would then be considered during the design and conception process of the dashboard prototype. The results of these *key features* are highlighted below and some additional generic aspects concerning design and structure of dashboards in disaster risk management are summarized in the subsequent section.

Key Features

In addition to identifying the user needs of **core user GAF AG**, the intention here was to obtain *independent and external* opinions which would additionally guide the design and conception process of the dashboard prototype. The experts' expertise was intended to ensure that the final result of the dashboard prototype is most coherent and applicable for disaster risk management purposes. Moreover, it was considered that only common *key features* were being asked for, since dashboards are very dependent on their actual purpose. Furthermore, this approach helped to avoid conflicts with the expectations and needs of **core user GAF AG** and allowed space for the implementation of own conceptions. Nevertheless, the generally valid and relevant aspects were intended to be determined. The results of the *key features*, which were identified in the course of these interviews are outlined below.

Key features:

1. Little effort in the use
2. High intuition
3. Efficient bundling of information
4. Exploring the complexity of the database
5. No overloading of information
6. Enabling the identification of trends, correlations and coherences
7. Central arrangement of the maps
8. Graphs and indicators to support comprehension of topic
9. Easy to use, regardless of expertise and knowledge of topic
10. Fun to operate

General Aspects about Planning, Design and Structure of a Dashboard in Disaster Risk Management

This section shortly outlines rather general aspects noted by the experts, which partly were considered during the construction process of the dashboard prototype.

Firstly, it must be considered (if taken very strictly) that the design and construction of the dashboard may be very depended on the exact purpose and adjustments may vary from case to case. Nevertheless, it is possible to identify some general considerations and aspects, which are relevant and generally applicable to dashboards, especially in disaster risk management.

The employee of Munich RE (personal interview, May 25th, 2020, Appendix 2) noted that during the planning stage of a dashboard, a planning-intensive approach to conceptualize the dashboard is a basic requirement for a successful prototype, especially in disaster risk management. Many discrepancies, inconsistencies and errors can be avoided by a high degree of planning. This aspect plays a significant role in the field of disaster risk management, where sensitive issues, fast decision-making and the cooperation different stakeholders is often part of the agenda. Errors can be particularly severe, as dashboards are often intended to provide an all-encompassing and complex view, and are intended to facilitate an error-free process for presenting, visualizing, and analyzing sensitive and risk-related data.

The employee of the Fraunhofer Institute (personal interview, May 26th, 2020, Appendix 3) explained that for the concrete structure of a dashboard, coherent graphic design of the displayed elements constitutes an integral aspect. The structure and arrangement of maps, graphics and other elements depends mainly on the purpose of the dashboard and the importance of the displayed information. In addition, the structure of a dashboard must be coherent and a *common thread* should exist. The purpose may change over time during a disaster, for example when the progression of a disaster evolves over time. For this reason, attention should be paid to flexibility in the structure. This can include, for example, integrating an active changing of the views of different kinds of data for improved usability, at an early stage or the provision of different levels of abstraction, in order to preserve a high flexibility. Lastly, the structure of the dashboard should enable the establishment of a visual hierarchy that can reflect the importance of the information (Employee Munich RE, personal interview, May 25th, 2020, Appendix 2). Similarly and independently, the employee of the Fraunhofer Institute (personal interview, May 26th, 2020, Appendix 3), stated that a visual hierarchy and a logical structure is crucial and should be considered during the construction process. An intuitive framework is of particular importance, in terms of that people who are technically less inclined (compared to experts in the field of cartography and GIS) or who come from different fields and sectors can also get on well with the operation. This also ensures that the information retrieval process runs smoothly.

For the concrete design of a dashboard in disaster risk management, the choice of color plays a crucial role, as colors are often polarizing. For example, the color red symbolizes danger. This connection is also important in relation to potential sources of confusion. Therefore, the design and the choice of color plays a major role for assessing disaster situations and needs to be considered during the dashboard design (Employee Munich RE, personal interview, May 25th, 2020, Appendix 2). The employee of the Fraunhofer Institute (personal interview, May 26th, 2020, Appendix 3) stated that it was important to him that the colors "catch the eye" in his dashboards and thus contribute optimally to the comprehension of the context and the *situational awareness*. For the concrete design, he believes there is a wide range of possibilities to visualize the data in different colors, but it needs to be ensured that the overall concept is coherent and harmonizes with the actual intention of the dashboard.

According to the often contained cartographic elements in dashboards in disaster risk management, both experts agreed independently from each other that generally spoken, the main map should supposed to be the focusing element, because it attracts the attention of the user. The Employee of Munich RE (personal interview, May 25th, 2020, Appendix 2) stated that in her opinion, the element map within the dashboard is extremely important and should due to its high expressiveness be arranged centrally. She also notes

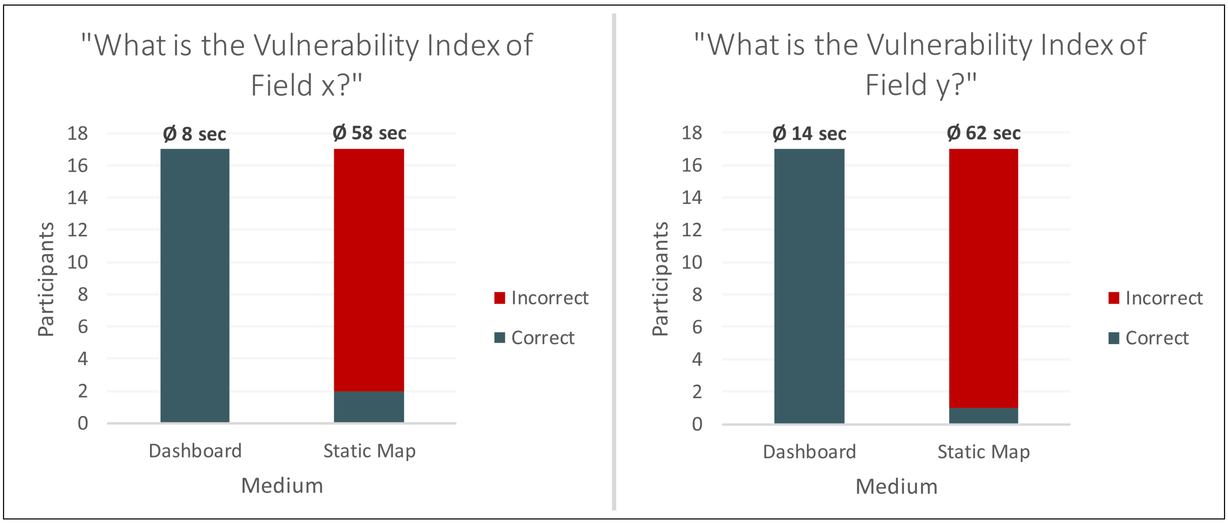


Figure 5.1: Results of task one and two of the focus group test I within the scope of the potential analysis

that it is often helpful, when the map is reduced in information in order to avoid confusion. The space around the map is, in her opinion, well suited to provide additional information, figures and statistics. An interactive and large map in a dashboard is especially helpful for decision making, because of its intuitive way to provide the information.

Finally, the employee of the Fraunhofer Institute (personal interview, May 26th, 2020, Appendix 3) sums up relevant aspects concerning design and structure of dashboards very well: "In the conception and design process, it is important to prepare data and information graphically in a way that is suitable for the target group so that process sequences and changes in the situation can be summarized clearly and comprehensibly at a glance." The design and structure of a dashboard should be tailored to minimize the effort required from the user. Nevertheless, it should be ensured that the complexity of the data basis is fully exploited. **It is a balancing act in planning to design the dashboard to be intuitive and self-explanatory, while still ensuring that the full complexity of data exploitation is maintained.**

5.2 Potential Analysis

In order to investigate the applicability of dashboards for vulnerability and risk assessment in comparison to conventional methods, a *potential analysis* was carried out through a direct comparison. This potential analysis was divided into an **objective part** and a **subjective part**.

Dashboards and static maps are difficult to compare due to their individual complexity as a medium. Rather, it was therefore only examined whether the *interactivity* provided by the dashboards has a concrete influence on the **correctness and efficiency** (objective part) on the results. In more detail, it was attempted to quantify the influence of various interactive functions such as **selecting, zooming, filtering, and hovering** on the results. The influence of perceived **effectiveness and user satisfaction** was examined within the subjective part.

5.2.1 Focus Group Test I

Objective Part

The objective part of the focus group test was performed to evaluate **correctness and efficiency** based on the answers of the provided medium. The **first focus group** was assigned the dashboard containing interactive functions, while the **second focus group** was assigned the static map (Section 4.2.2).

Figure 5.2: Fields x and y, which were mentioned in task one and two

The first two test questions asked for the value of the vulnerability index of a parcel within the map. It was sufficient to state the correct class in order to solve the task successfully.

Figure 5.1 illustrates the results of these two questions. In task one *"What is the Vulnerability Index of Field x"*, it was tested if the function **selecting** would have an influence on the result. Findings clearly show that all participants of the dashboard group (**first focus group**), where selecting the field was enabled, were able to solve the task correctly (success rate: 100%) by specifying the correct class and value of the vulnerability index.
In contrast, only two participants out of 17 in the **second focus group** could state the correct class (success rate: 12%). On average, the dashboard group was approximately 50 seconds faster, which is roughly seven times faster than the **second focus group**.

A similar result was attained for task two *"What is the Vulnerability Index of Field y"* also depicted in Figure 5.1. In this case, the vulnerability index of a slightly smaller field was questioned, requiring the combination of the function **selecting** and **zooming** if the participant was part of the **first focus group**. Since the static map was available as an PDF, it was also possible to zoom. Fields *"x and y"* can be viewed in Figure 5.2.

Similar to the first task, the dashboard group performed better. All participants of the **first focus group** were able to provide the correct value and class (success rate: 100%), while the results of the **second focus group** were worse compared to the preceding task. Only one person out of 17 could indicate the correct class (success rate: 6%). On average, the dashboard group was 48 seconds faster, in other words around four times faster than the **second focus group**, operating with the static map.

Task three *"Where on the map is the Vulnerability Index the highest? Please mark/circle the areas with the two highest classes on the adjacent map."*, involved testing for the function **filtering**. There was no correct solution of the task in that sense, because this task would have been too challenging for the group operating with the static map. This task focused on the accuracy of how the areas were mapped as the marked solutions. While in the **second focus group**, working with the static map, areas were only roughly and sometimes even incorrectly sketched, the task was solved considerably more precisely by the dashboard participants. The participants of the static map needed 71 seconds on average, while the participants of the **first focus group** completed the task on average in 118 seconds. The dashboard group therefore took 47 seconds longer to complete this task, than the group working with the static map.

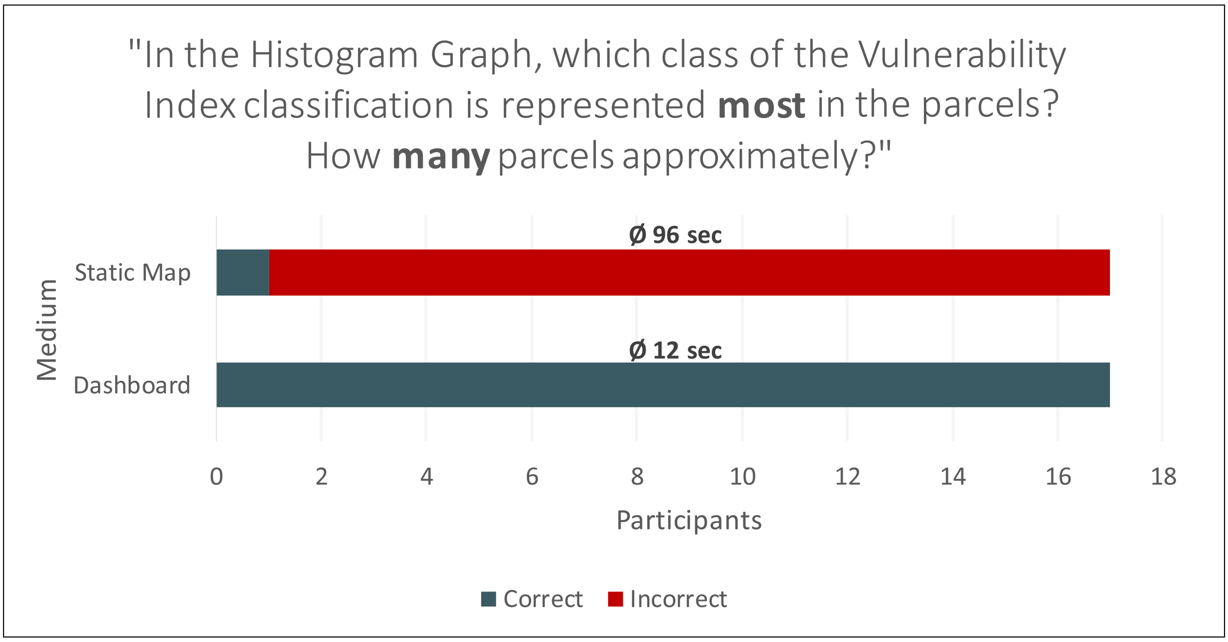


Figure 5.3: Results of task four of the focus group test I within the scope of the potential analysis

Task four *"In the Histogram Graph, which class of the Vulnerability Index Classification is represented most in the parcels? How many parcels approximately?"* (Figure 5.3) also tested for the function **filtering**. By analyzing the histogram graph, the participants were asked to estimate which class is most represented in the classification, and how many parcels are represented in the map by this class. The classification in the dashboard could be filtered by class - the interactive map would then change accordingly, displaying only the parcels of the filtered class. An indicator would additionally count the visible parcels on the map, when a class is filtered.
The participants of the static map group had to estimate the correct value using the graph included in the static map. 17 out of 17 participants in the dashboard group were able to indicate the correct solution, hence correct class and correct number of parcels within this class. In the static map group, 14 out of 17 could indicate the correct class. However, only one participant was able to solve the task entirely correctly, including specifying the correct number of parcels. The **second focus group** needed on average 96 seconds to solve the task, the **first focus group** needed 12 seconds. This results in an eight times faster performance by the dashboard group.

The last two questions (task five *"In graph Cova do Vapor: What is the value of % of population with no employment?"* and task six *"In graph Costa da Caparica: What is the value of % of population can not read or write?"*) in the objective test section included the effects of the function **hovering** with regard to the results. In the dashboard, the function **hovering** was enabled, while the **second focus group** had to estimate the result by analyzing the two graphs included in the static map. The results can be viewed in Figure 5.4.

The duration of these two tasks did not differ as much as in previous tasks, although the dashboard group was slightly faster (seven seconds in task five and six seconds in task six). However again, the dashboard group performed significantly better in terms of the correctness, of the provided solutions in these two tasks. In task five and six the dashboard group achieved a success rate of 100%. Meanwhile, the participants of the **second focus group** achieved a 6% success rate in task five (with one correct answer in total). In task six approximately 30% of participants scored exactly the right solution with five correct answers out of 17.

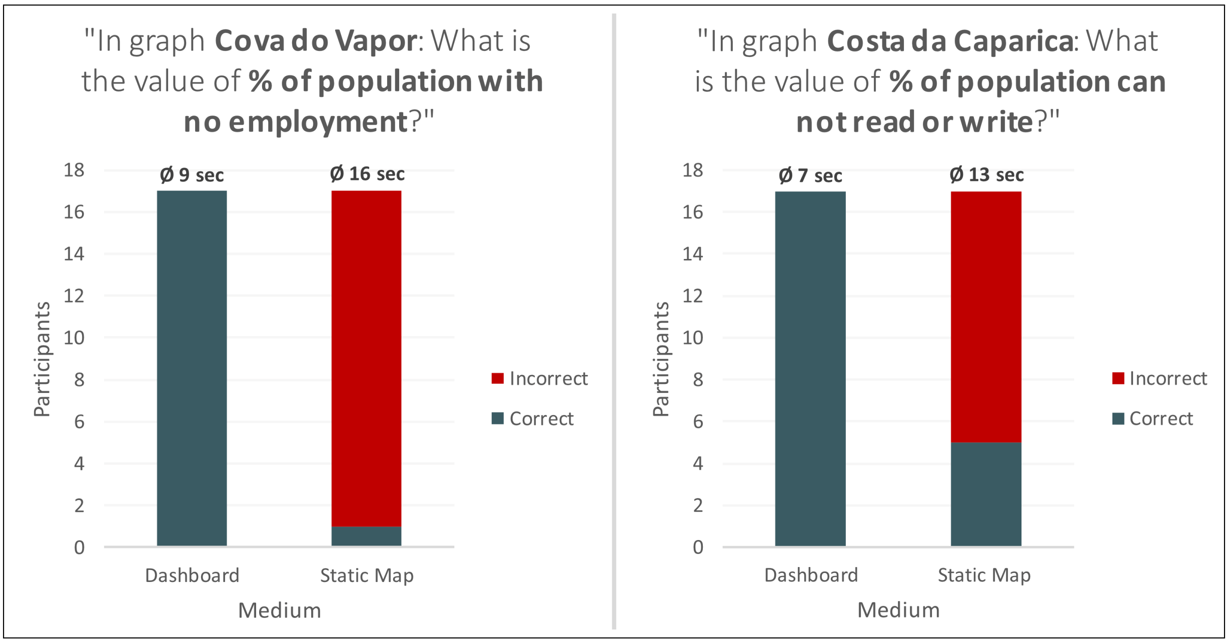


Figure 5.4: Results of task five and six of the focus group test I within the scope of the potential analysis

Subjective Part

The subjective part rather had the purpose to investigate how the participants assessed the **effectiveness** of the medium and the **degree of user satisfaction** linked to the used medium and how the medium was generally perceived throughout the objective test part (positive, neutral or negative). A general aim was hereby to examine if people would like to operate with the specific medium within the disaster risk management context.

In order to assess the individual opinions, all participants of the **first focus group** and the **second focus group** had the opportunity to provide a rating in the course of an evaluation of statements and, if desired, to leave a comment to provide further explanations for their reasons.

Results of the statement evaluations can be viewed in Figure 5.5, comparing the different opinions of the static map group and the dashboard group to the individual statements. It is noticeable that all statement evaluations of the **first focus group**, who operated the dashboard are relatively uniform, thus perceived the medium similarly during the interaction. The opinions expressed by the **second focus group**, who worked with the static map, are much more heterogeneous. Some reasons for this aspect are provided in the discussion section.

In the evaluation of statement one *"I could solve the tasks easily"* all participants of the dashboard group **agreed or even completely agreed** with the statement. In the static group, opinions were much more mixed for various reasons, but more than half of the participants working with the static map either **did not agree or did not agree at all**.

To the statement two *"I had fun solving the tasks"* 16 out of 17 participants in the dashboard group were **in agreement, or even completely agreed** by a majority. The group that operated with the static map also had fun solving the tasks. However, a significant aspect is that approximately one third of the participants stated that they had a **neutral** opinion, therefore the solving of the tasks was not perceived as positively as compared to the dashboard group.

Regarding statement three *"I find the medium intuitive"*, the majority of the dashboard group voted to **agree completely, and the remainder agreed** with the statement, implying that the medium was perceived as intuitive. In the group that used the medium static map to solve the tasks, a majority of the participants

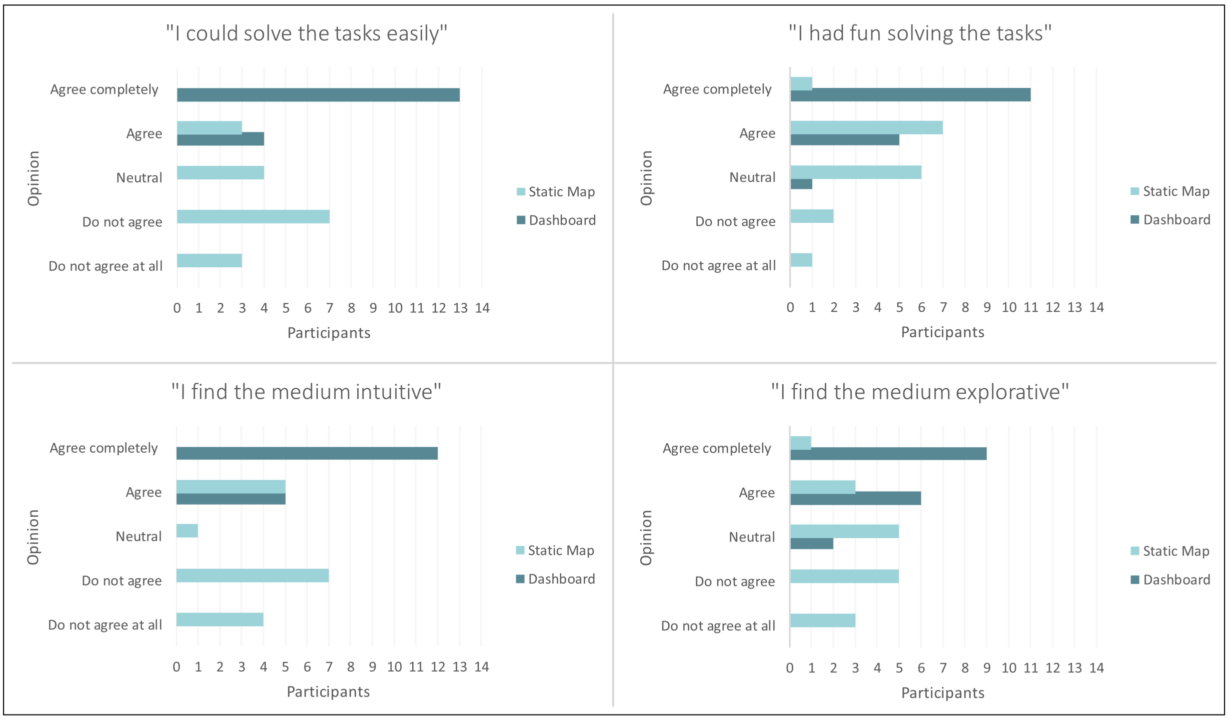


Figure 5.5: Results of statement evaluation of the focus group test I within the scope of the potential analysis

did not find the medium intuitive, but a significant proportion (five out of 17) nevertheless considered it to be intuitive. The opinion was therefore distributed very unevenly between the participants. Reasons for this aspect are explained in the discussion.

Likewise to statement three, in statement four *"I find the medium explorative"*, the majority of the dashboard group **agreed** with the statement and perceived dashboards as explorative, however not as strongly as it was perceived as intuitive. As for the medium static map, all possible opinion ratings are represented in the evaluation spectrum, indicating a very diverse perception of the medium. Approximately one half of the participants found it little or not at all explorative, a solid third expressed a **neutral** opinion and the remainder either **agreed or completely agreed**.

5.3 Dashboard Prototype

5.3.1 Focus Group Test II

The aim of the focus group test using the medium **Tianjin Dashboard** was to cross-check the *key features* identified through the expert interviews within the *requirements analysis* and to determine if they applied to the dashboard prototype.
The 34 participants (the complete focus group in this case) of the test were not familiar with the *key features* or the interviews and were asked again, similar to the subjective part, to submit an opinion evaluation on ten statements (in which the *key features* were evaluated).

As a general observation regarding the evaluation of the ten statements, it is possible to observe that the **Tianjin Dashboard** has been perceived as **very positive**. The 34 participants who completed the survey in the course of the focus group test II generally expressed the feedback that they enjoyed working with the medium in the context of disaster risk management. The overall results can be found as a collection of the visualized statement evaluation in Figure 5.6.

In general, the statements *"I find the central placement of the map helpful"*, *"The graphs and indicators*

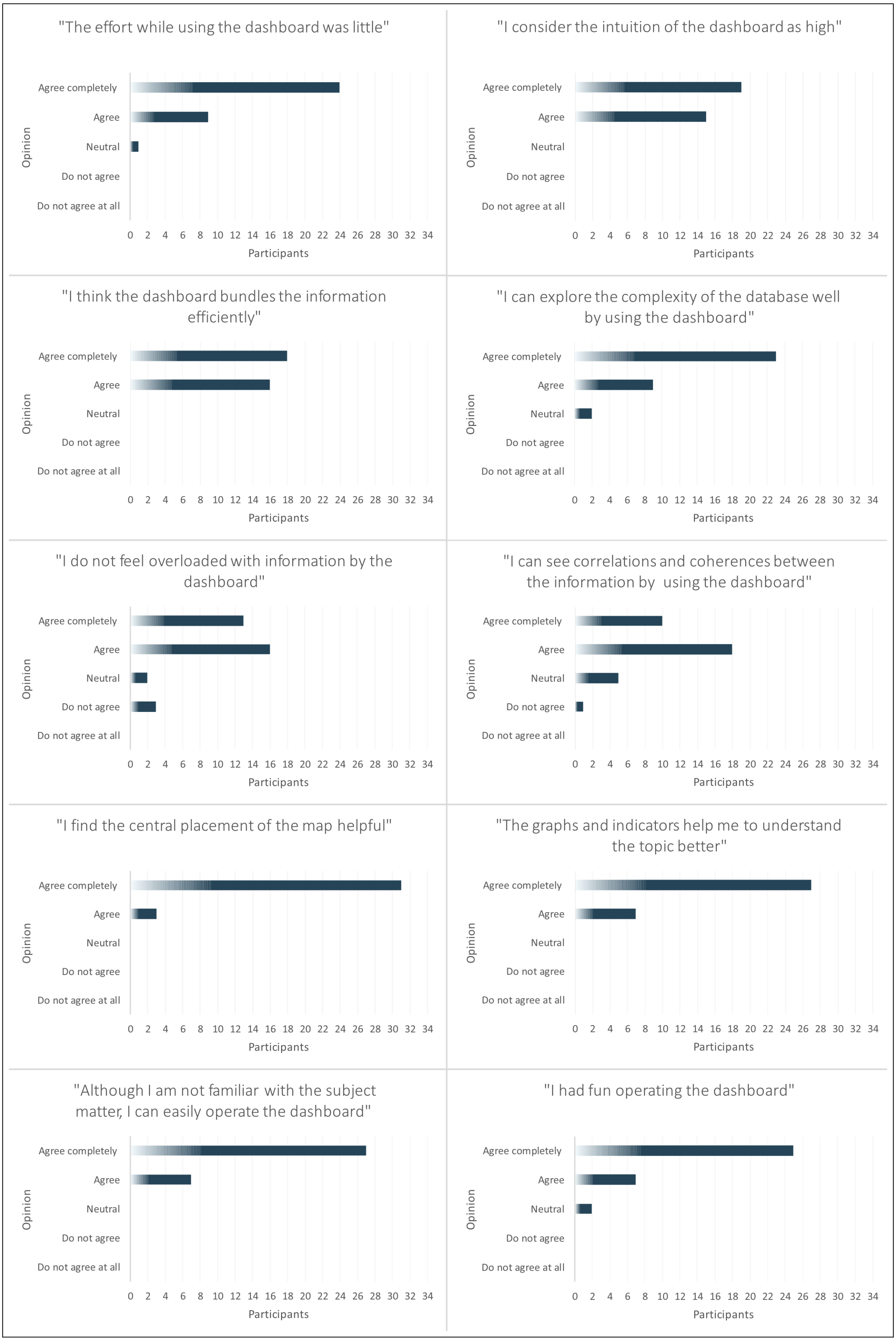


Figure 5.6: Results of statement evaluation of the focus group test II within the scope of dashboard prototype conception

help me to understand the topic better" and *"Although I am not familiar with the subject matter, I can easily operate the dashboard"* received the most approval or were rated most positively. In these cases the majority of the 34 participants **agreed completely** and the proportionally small remainder **agreed**.

Similar observations can be recognized in the statements *"I consider the intuition of the dashboard as high"* and *"I think the dashboard bundles the information efficiently"*. These statements are not as extremely positive affirmed as the statements mentioned beforehand. There exists an approximately equal share of **agreement and complete agreement** in these statements, which constitutes the overall rating of the statements also very positive.

Also the statements *"The effort while using the dashboard was little"*, *"I can explore the complexity of the database well by using the dashboard"* and *"I had fun operating the dashboard"* were rated as overall positive and no participant disagreed with these statements. A small percentage of the participants expressed a **neutral** opinion regarding the statements.

The most diverse opinions resulted in the statements *"I do not feel overloaded by the information"* and *"I can see correlations and coherence between the information by using the dashboard"*. The majority of the participants **agreed or completely agreed** with the statements, but some participants also felt overwhelmed by the volume of information or were not able to detect correlations or connections as well.

5.3.2 Qualitative Feedback

For the purpose of completeness within the user-centered design process, qualitative feedback was requested from **core user GAF AG**, subsequent to the construction of the dashboard prototype and the cross-validation of the *key features*. The prototype was demonstrated internally within the company and a qualitative feedback survey was subsequently submitted. The qualitative feedback with the answers of the **core user GAF AG** can be reviewed in the Appendix 8 (German version only).

Within the feedback survey, reference was made to the *core aspects* identified in the *requirements analysis* which according to the **core user GAF AG** were relevant and an assessment of the validness of the *core aspects* with regard to the **Tianjin Dashboard** was asked for.

In general the prototype was very well received, similar to the cross validation of the *key features*. The following section contains a summary of the qualitative feedback from the **core user GAF AG**.

Core user GAF AG pointed out that *"due to the different layers and their attributes the capture of the information and data was very easy"*. A fast and intuitive comprehension of the data is therefore given. Moreover, he argued that *"information and data are suitably linked and efficiently bundled"* through the **Tianjin Dashboard** prototype. In response to the question whether the additional information content of the graphs and indicators helps understanding the topic of the Tianjin explosion well and in detail, he replied *"the information was presented in an easily understandable way and was sufficiently detailed"*.

It was also asked whether the **Tianjin Dashboard** could support decision making in the event of a disaster. The feedback given on this question was *"since the focus can be placed on damaged and destroyed objects, the presentation can contribute to decision making"*. Furthermore, **core user GAF AG** stated that *"due to the large amount of information displayed, the user can be directed towards the topic and gain a comprehensibility on a deep level"*, meaning he believes that the user operating the dashboard is involved and can examine the data exploratively.

Regarding the question of whether dashboards could increase customer satisfaction, the **core user GAF AG** noted that *"for a large number of customers, the descriptive presentation of data, could increase customer satisfaction through the use of a dashboard (easier grasp of the information and focus on the essentials)"*.

He was also satisfied with the design and visualization. He thinks that *"the color scheme and combination of colors are selected intuitively. Discreet presentation of the base map is ideally chosen in order to*

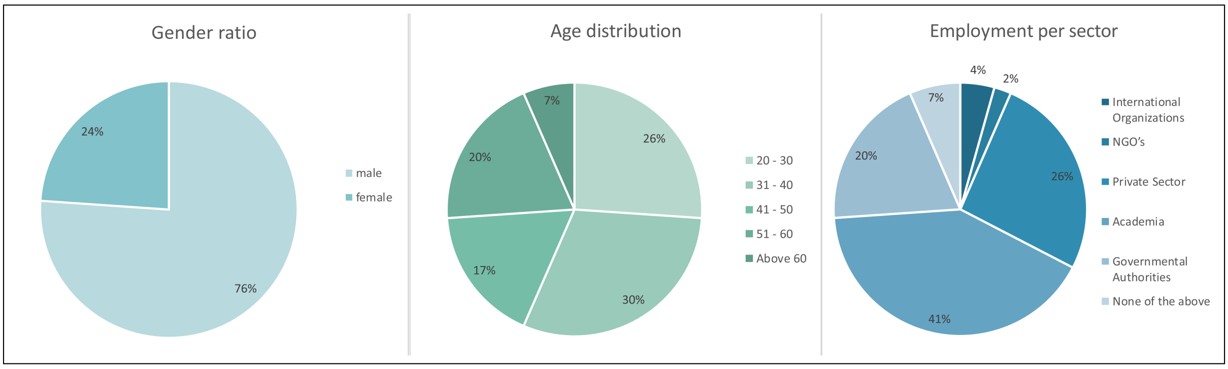


Figure 5.7: General statistics of the stakeholders of the disaster risk community participating in the online survey

visualize the damage appropriate." Finally, it was asked if the **core user GAF AG** thinks that dashboards could add value and benefit to current products in disaster risk management. He answered: *"In my opinion, a dashboard represents a clear added value compared to a static map. The user can decide for himself or herself which information can be depicted, with simultaneous quantitative evaluation of the displayed elements."*

5.4 Sector Analysis

In an attempt to obtain an encompassing picture of the overall media usage with a special focus on the use of dashboards in the disaster risk management community, a *sector analysis* was conducted on the basis of an online survey.

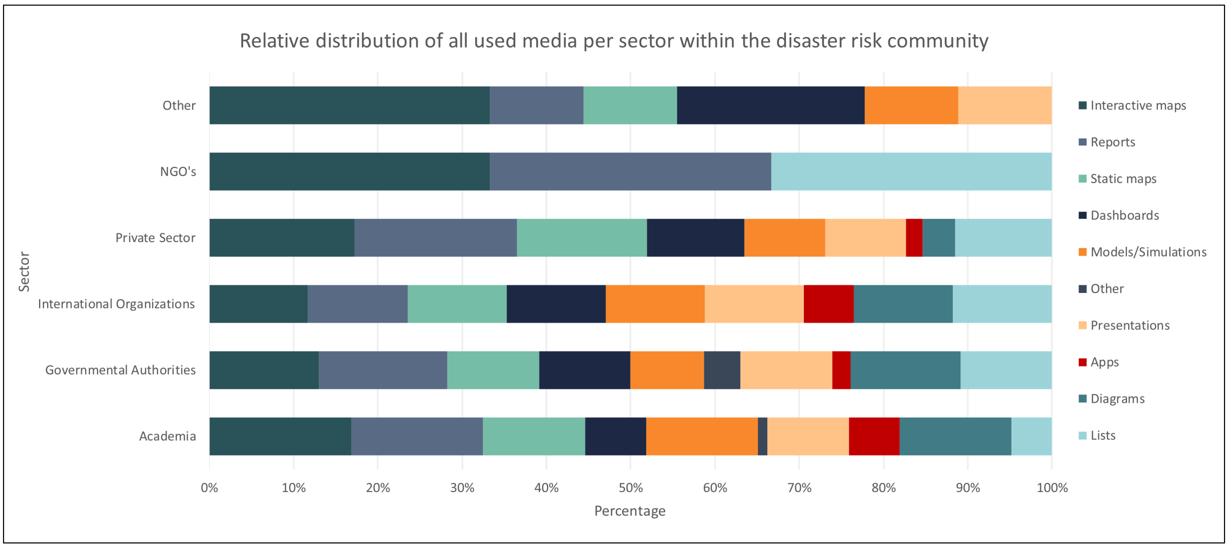


Figure 5.8: Relative distribution of all used media per sector within the disaster risk community as reported by the stakeholders

In total **46** stakeholders from different sectors within the disaster risk community participated. The gender ratio, age distribution and employment per sector of the participants of the online survey is presented in Figure 5.7. Approximately $\frac{1}{4}$ of the participants are female, $\frac{3}{4}$ are male, while most of the participants were between 20-40 years old. Approximately $\frac{2}{3}$ of the participants are employed within the private sector or academia. Stakeholder employed in the governmental authorities sector represent 20% of the respondents who participated in the online survey. NGO's and international organizations together with **three** participants out of **46** account for a share of only 6%, thus making them the least represented sector

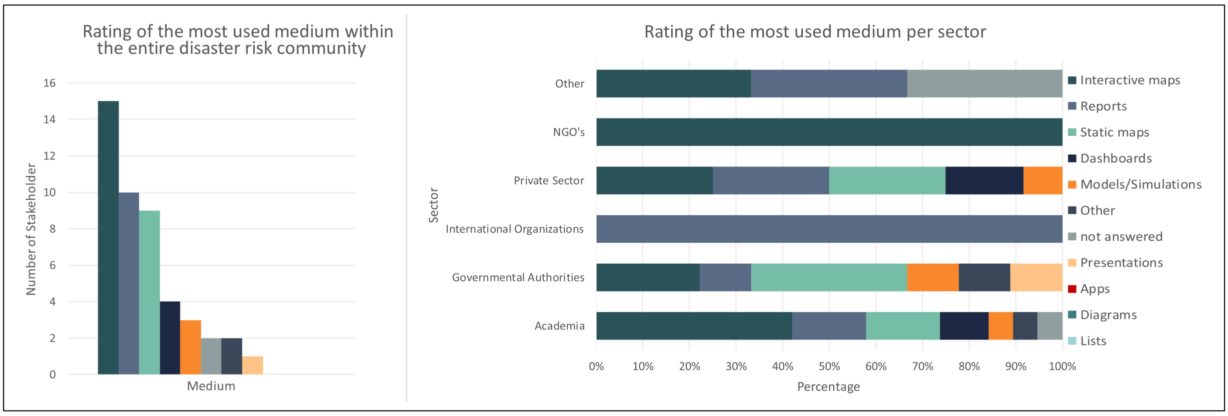


Figure 5.9: Left: rating of the most used medium within the entire disaster risk community represented as absolute counts. Right: rating of the most used medium represented as relative share sector wise

wise within this analysis. The remaining 7% constitute a share not falling into any of the above-mentioned sectors. For instance, unemployment is included in this category.

Figure 5.8 illustrates the distribution of the relative share of all listed media used by the participants working within the respective sector, divided by sector. The graph shows which media are used at what percentage in the individual sectors and what differences in the use of the media can be observed within the individual sectors. For example, it can be seen at a glance that the use of apps is limited to the sectors academia, private sector and governmental authorities and that interactive maps, reports and static maps account mostly for largest shares in all sectors.

This condition is also reflected in Figure 5.9, reinforcing this point. Figure 5.9 presents the results (*"Most frequently used media in disaster risk community"*) of a question from the online survey as a visualization, in which all **46** stakeholders from the disaster risk community, regardless of the sector employment, were asked to specify the medium they use most frequently. In this graph, the absolute number of the most frequently used media (selected by each individual stakeholder) is shown. It can be observed that interactive maps account for the largest share with **15** stakeholders selecting this type of medium, closely followed by the medium report, selected by ten stakeholders and static maps, a medium which was nine times selected. **Four** participants out of all **46** participating stakeholders stated that they use dashboards most frequently.

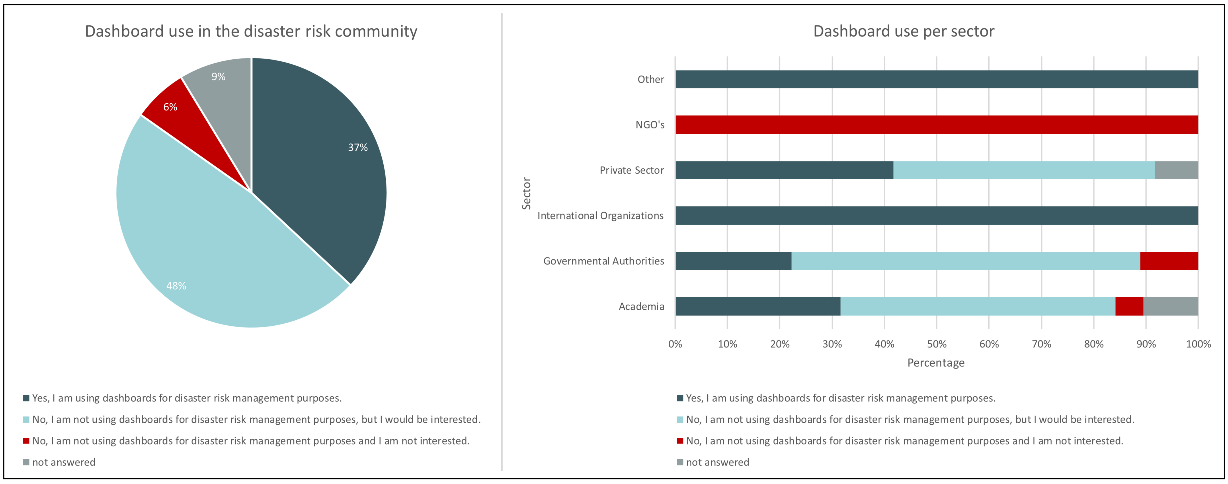


Figure 5.10: Opinion of stakeholders with regard to the perceived relevance of dashboards for disaster risk management purposes. Left: concerning the entire disaster risk community. Right: divided by sector

In the following graph *"Most frequently used media per sector"*, in the right of Figure 5.9 these results can be reviewed sector-wise and offer a more detailed insight. It is noticeable that especially in the academia sector, the proportion of interactive maps is particularly high at over 40%. In the private sector, for example, the shares of static maps, reports, interactive maps as most frequently used media are relatively balanced upon the stakeholders employed within this sector.

Finally, the online survey explored opinions regarding the willingness towards the use of dashboards for disaster risk management purposes (Figure 5.10). A rough third of the participants responded that they already use dashboards for disaster risk management purposes. Approximately half of them (48%) do not so but would be interested in using them and approximately 6% neither use dashboards nor is interested in using them for disaster risk management purposes. The graph *"Dashboard use per sector"* on the right side in Figure5.10 shows the results in more detail for each sector. One information that can be derived from this graph is, for example that in the private sector none of the participants stated that they neither use dashboards nor are they interested in using them for disaster risk management.

Chapter 6

Interpretation and Discussion

In this chapter the results of the individual findings of this study are critically evaluated and analyzed. Furthermore, the discussion contents are establishing a reference to the research objectives specified in Chapter 1.2.1.

The main content of this chapter is to critically evaluate how well the medium dashboard might be used for disaster risk management purposes, like risk and vulnerability assessment. In particular it is discussed how effective, efficient and correct the risk-relevant information is provided by a dashboard in relation to conventional methods like static maps and how satisfied users are with the individual medium.

6.1 Requirements Analysis

The *requirements analysis* for dashboards used for disaster risk management purposes consisted of the two expert interviews and the interview with the **core user GAF AG**.

Regarding the expert interviews, it is important to note that although the experts have many years of experience and a high level of expertise in the field, a crucial aspect to acknowledge is that these are two individual opinions. These are inevitably characterized by a certain degree of subjectivity regardless of the questioning for generally valid aspects and therefore most likely cannot be generalized to the full extent.
It is also of importance to consider that dashboards are highly dependent on their actual purpose. Conversely, this implies that (although the *key features* application should be *generally valid* for disaster risk management purposes) each case should always be examined in detail on an individual basis.
Nevertheless, both expert opinions constituted an extremely valuable contribution to this study and proved to be a fundamental component in the development of the prototype.

The same applies to the user needs identification in the course of the interview with the **core user GAF AG**. It is crucial to acknowledge that the user needs identification applies explicitly to this specific case, the Tianjin Explosion 2015, and cannot be arbitrarily extended to any other dashboard in disaster risk management. The prototype was developed on the basis of an individual order in the form of a static map, implying an individual case scenario. For similar cases, the user needs may presumably be valid, however, as well this requires case-by-case consideration and is dependent on the actual purpose.

Nevertheless, the opinions of the three experts are of enormous value precisely because of their long-standing expertise, which is applied in market-leading companies and institutions within the field of disaster risk management and furthermore because the entire community is simply not that large. In general, all three expert opinions reflect the views, perspectives and needs regarding the usability of dashboards in disaster risk management and provide a valuable insight into this community.

6.2 Potential Analysis

6.2.1 Focus Group Test I

It is important to recognize that minor human induced errors may have occurred during the execution and performance of the test, which could possibly lead to small distortions in the results. However, these small human-caused irregularities in the test procedure should usually be compensated by the quantity of participants, so no significant impact on the overall result should be expected.

Objective Part

In general the correctness of the answers and the efficiency, for instance how quickly answers could be provided using the medium, allow fundamentally important insights into how well the medium can be used for decision making and for communicating risk-relevant information in disaster risk management. Faster and more accurate transfer of risk-related information and data can consequently improve decision making and the overall communication flow.

The static map may be valid to be used for the comparison, because it is an official map of the European Union Copernicus Programme of 2017. In addition, objectivity was ensured in the user test questions and only information that reflected the original function of the static map, e.g. finding out the vulnerability index in an area on the map, was queried. Nevertheless, the differences are enormous to what degree the results of the objective part (tasks one, two, four, five and six) reflect the better performance of the dashboard group compared to the static map group, in terms of efficiency and the correctness of the given answers. This implies that the provided interactivity has a significant influence on correctness and efficiency of the provided answers. Moreover, this is a strong indicator that through the provided interactivity, decision making and communication flow may be improved through dashboards for specific application purposes in disaster risk management.

The only case where the dashboard group was temporally inferior (in terms of the time needed to solve the task) to the static map group was in task three *"Where on the map is the Vulnerability Index the highest? Please mark/circle the areas with the two highest classes on the adjacent map."* It is reasonable to assume that within the static map group the areas were mostly drawn superficially and swiftly on the map, whereas the task could be solved much more accurately and precisely using the dashboard. This may have accounted for the difference in time. This task also indicates that static maps generally may provide a relatively reliable overview of the state of risk and vulnerability assessment, while dashboards may be used to explore the database in more detail and produce more accurate results.

Subjective Part

The focus in this part is on analyzing the user satisfaction of the medium and the overall assessment of the perceived effectiveness of the used medium in the frame of focus group test I. A high degree of agreement in the statement evaluation of statement one *"I could solve the tasks easily"* and two *"I had fun solving the tasks"* correlates with a high level of user satisfaction or is indicative accordingly. Statement three *"I find the medium intuitive"* and four *"I find the medium explorative"* allow to draw inferences about how effectively the medium is perceived. Intuitiveness and exploration have a direct impact in how effectively a medium is perceived. This circumstance can be extended and applied to the field disaster risk management. In a first step, the findings of each medium are being individually evaluated and then put in comparison to one another.

As already mentioned in the results section in Chapter 5.2.1, the provided opinions in the scope of the subjective part were much more homogeneous within the dashboard group compared to the static map group. This provides considerable potential for discussion and interpretation. Yet a number of reasons for this varying spectrum of opinions can be traced back in the provided commentaries, particularly regarding the medium static map. A selection of individual commentaries can be review in Figure 6.1 at the end of this section.

Indications of the high approval rate of participants in the dashboard group for the statement one *"I could solve the tasks easily"* can be detected within the provided comments. Participants expressed that they considered the tasks as easy because they knew exactly at all times what was being expected and knew how to execute the tasks without any difficulty. The participants could therefore solve the tasks with a high certainty and with confidence (resembling the findings in the Rininsland et al. (2016) study), which allows to draw conclusions on the user satisfaction. In addition, participants repeatedly mentioned the supporting effect on the task solution by the high level of intuitiveness and the concise dashboard design. Furthermore, apparently a good visualization and the interactive selecting functions also contributed to solving the tasks easily.

Referring to statement two, the majority of the participants also enjoyed solving the tasks. Fun as a positive emotion, which is linked to a medium, may also allow conclusions regarding the satisfaction of the participants using the dashboard. Besides, people memorize information more easily if it is linked to positive emotions as fun (Kensinger, 2009). Additionally, people prefer to deal with a medium if the associated effort is not too laborious. Through the fun factor, people understand coherences better and engage deeper with the subject matter and are able to remember these coherences more effectively (Danckert & Allman, 2005). Reasons that reflect the high approval rate in statement two *"I had fun while solving the task"* within the dashboard group might be manifold. For example, it was stated that the participant enjoyed solving the task because of the novelty of the medium, which was not previously known, but which was nevertheless relatively easy to understand. It was also stated that the high analyzing factor with regard to the provided data contributed significantly to the fact that solving the tasks was fun and therefore working itself with the dashboard was a pleasure.

The high level of agreement with the statement three *"I find the medium intuitive"* may be partially explained by the circumstance that the majority of participants found the dashboard very self-explanatory. While it was stated that the coloring of the classification was considered to be difficult and not at all intuitively, the dashboard as a medium itself was. This also indirectly explains why the task solving was perceived as being easy.

The approval rate of statement four *"I find the medium explorative"* was not quite as high compared to statement three. This can perhaps be explained by the fact that intuitiveness and exploration are to a certain degree mutually exclusive, or rather that the unification of both concepts may become from a certain point on a difficulty. The more intuitive a medium is supposed to be, the more exploration is sacrificed, which in turn is associated with simplicity. Explorativity, conversely, is accompanied by a certain degree of complexity due to the investigative character.
Nevertheless, as already described in the results, the medium was perceived by the majority as explorative. The reasons for this were the involvement of the user, the high explorativity of the data and the map through interactivity and the practical and detailed way of application. Additionally, it was also stated that many functions were fixedly provided or that the data basis was not sufficiently known and therefore the explorativity of the medium was rated neutral.

In general, the results suggest that the medium dashboard is very well suited for vulnerability assessments, and thus indirectly for risk assessment in disaster risk management. The high approval rate within the groups and the high correctness of the answers suggest that the user satisfaction with this medium is high, risk-relevant information could be transmitted correctly and the efficiency is sound due to the speed of the provided answers. Answers could be provided as stated in the comments with a high certainty and confidence as already indicated in Chapter 2.2.2 by Rininsland et al. (2016). In addition, the high approval rate for the statements whether the medium was perceived as intuitive or explorative suggests a high effectiveness in disaster risk management.

As mentioned before, the opinions on all statements within the subjective part related to the static map were quite heterogeneous and the spectrum of opinions is much more diversified.

The majority of participants did not agree with statement one *"I could solve the tasks easily"*, but a part of the participants either had a neutral opinion or agreed. The possible reasons, which might be partly deduced from the provided comments, are diverse.
Many participants mentioned the color classification within the static map was one reason which made the tasks difficult to solve. Highly attention and time consuming were other provided reasons why the solving of the tasks was probably perceived in that high degree of difficulty.
Furthermore, a high degree of uncertainty was often expressed regarding the correctness of the provided answers and the fact that clickable fields might have been helpful in this context. On the other hand, possible reasons for agreement are that the tasks themselves were simple, because basically no complicated things were asked. Often the self-confidence that the tasks were solved correctly, was missing and participants stated that they had to guess a lot. According to a participant, this circumstance had nothing to do with the simplicity of tasks, but more with the map itself.

With regard to statement two *"I had fun solving the tasks"*, the positive response was mainly due to the fact that working with maps is generally considered as very positive, the participants enjoyed puzzling and the topic was regarded as being interesting.
However, it was also suggested that solving the tasks was quite tedious and while solving them in the test environment was fun, participants stated that they would certainly not have the confidence to conduct proper decisions in disaster risk management with the medium. Further, it was pointed out that the static map was not suitable for answering detailed problems and therefore solving the tasks was not considered as enjoyable. This suggests that the participants who had the ambition to evaluate and report precise information were the participants who did not find the tasks enjoyable to solve.

Regarding the intuition of the medium, inquired in statement three *"I find the medium intuitive"*, the medium was in most cases probably perceived as intuitive in the sense that the topic itself is presented in a very comprehensive manner. Derived from the comments of the participants, it is possible to get a quick overview with the aid of the medium. Moreover, it is quite obvious that maps themselves, if they are well-made, have a high degree of intuitiveness.
Contrary to this, however, many participants also considered the medium to be not intuitive at all, since they lacked the interactivity. Curiously enough, many participants indicated that web maps or interactive maps would have been considerably more convenient. It was implied that the static map in this case ought to be utilized at its maximum for *assisting* decision making or generally for providing an overview, however, decisions should not be based solely on the static map.

Concerning statement four *"I find the medium explorative"* whether the medium static map was perceived as exploratory, the widest range of opinions was represented. The participants who had a negative attitude indicated in the comments on the fact it was impossible to explore the database on a profound level and the medium itself was very limited, as zooming was allowed at a maximum. It was criticized that exact data and information could not be retrieved in order to continue investigating on this basis and to be able to conduct assessments. Furthermore, it was remarked that it was practically not possible to compare the vulnerability of two locations. Comparing may be attributed to exploration and is an extremely important aspect of vulnerability assessment in disaster risk management. For example a common task would be the comparison of the vulnerability of two parcels containing different age groups, in order to decide which area needs rescue first in the case of an emergency.
Neutral opinions arose from the fact that although the legend offers comparability, the medium itself was not considered explorative. For the affirmative opinions, the comments provided explanations as for instance that the medium was exploratory at first sight and was therefore well suited for obtaining a brief and overall impression. However, it was explicitly noted that the medium is not appropriate for a more in-depth evaluation and is very dependent on the intention regarding the degree of accuracy to be obtained when working with static maps.

By directly comparing the statement evaluation by the participants from both media, there is a significant

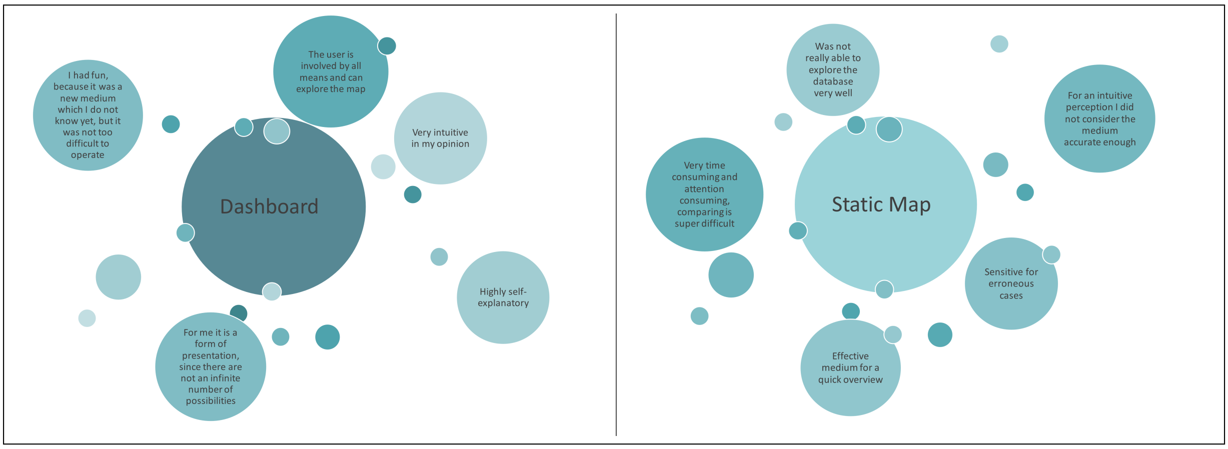


Figure 6.1: Selection of commentaries concerning both dashboards (left) and static maps (right) provided within the subjective part of the focus group test I

indication that user satisfaction was higher linked to the medium dashboard. For instance, the participants enjoyed solving the tasks more because of the medium *itself* rather than because they perceived the subject matter of disaster risk management interesting (as indicated for the medium static map). Moreover, the participants of the dashboard group were considerably more confident regarding the correctness of their answers, hence they perceived the tasks altogether easier. This aspect also suggests a higher user satisfaction while operating the medium dashboard.

By comparing the results, in asking for intuitiveness and exploration, conclusions may in addition be drawn regarding the perception of the compared media in terms of effectiveness. The diverse responses of the participants of the static map group reflect an overall impression that the static map medium is suitable for an overview and is also perceived as effective in this context, but that in general the effectiveness of the dashboard in terms of intuition and exploration may be rated higher.

Finally, an important aspect to consider is that while effectiveness and user satisfaction may have been influenced negatively by the color classification the static map medium, and while this may not have been directly related to the medium itself, it is still a crucial issue of how accurately and efficiently the risk-related information is communicated and transmitted by the medium. The medium dashboard was too affected by the difficult color classification, and yet a positive user satisfaction was observed and, in addition, the medium's effectiveness in terms of intuition and exploration was considered to be very high. This allows the direct conclusion that the high user satisfaction is to a large extent influenced and associated to the medium dashboard itself.

6.3 Dashboard Prototype

6.3.1 Focus Group Test II

Generally, very positive feedback has been received on the **Tianjin Dashboard**. The majority of the 34 participants agreed with all ten *key features* surveyed in the statement evaluation. Therefore, it can be assumed that these *key features* are mostly fulfilled and are applicable to the constructed prototype. Reasons for the generally very positive feedback may be critically discussed with the aid of the provided commentaries of the participants. A selection of some commentaries can be viewed in Figure 6.2.

For instance, participants perceived the dashboard as very detailed and as being able to bundle plenty of information at once. In this context, it was also implied that the individual sub-dashboards were nevertheless not overloaded with information, even though a considerable amount of information was provided. According to some of the participants, various aspects and perspectives on the topic of the explosion could be demonstrated and captured. It was also positively noted that the dashboard makes it possible to comprehend the data and information gradually and therefore comprehend the subject matter on a profound level. In addition, the high degree of exploration which "has made the dashboard playfully discoverable" can be attributed, amongst other reasons, to the positive feedback. Besides, it was remarked that the dashboard is nevertheless very self-explanatory and intuitive.

Technical aspects have also been commented as positive and associated with the positive feedback. This was for example the intuitive navigation through the dashboard's framework, which made it easier to find information rapidly and conveniently. Furthermore, the speed of the displayed results was perceived positively, for instance when clicking on something, the result was presented directly and without delay in an interactive way.

Reasons for rather critical remarks regarding the dashboard prototype are, for instance that some participants were less technically inclined and needed some brief instructions. As a logical consequence, the usability of dashboards depends therefore strongly on the computer affinity of the dashboard users. Presumably, this might also be a possible reason that some of the participants were feeling slightly overwhelmed by the amount of information provided by the dashboard, which was asked in statement five *"I do not feel overloaded with the information by the dashboard"*.

Moreover, some participants apparently lacked the analytical reference to determine trends and correlations queried in statement six *"I can see correlations and coherences between the information by using the dashboard"*. For these participants the dashboard was rather an interactive presentation medium. From the comments, however, it can be deduced that this fact depends on the individual participant in terms of how trends and correlations are ultimately perceived. This indicates that the dashboard prototype certainly satisfied the **majority** of participants and received a high degree of positive feedback, but both extremes encountered their limitations because they were either over- or under-demanded by the software.

6.3.2 Technical Aspects and General Issues

Ideally, the focus group ought to represent the true user group, i.e. employees from the disaster risk management community or a user group that resembles even more to the disaster risk management community, in order to be able to make a truly exact statement in terms of the complete applicability of the *key features* to the dashboard. Furthermore, while 34 participants represent an adequate starting point, more participants certainly would be beneficial and would contribute to more precise results.

However, the fact that dashboards are closely connected to particular applications in disaster risk management as well as the user needs of the individual operator, have a decisive impact in this case. The focus group test II can therefore be conducted because stakeholders in disaster risk management also frequently represent very different areas and are only united by the topic of disaster risk management.

As a last point, it can be mentioned that the dashboard in this case is dependent on the digital infrastructure in terms of the internet connection. This is definitely not true for all dashboards and might be an advantage and disadvantage at the same time. The reason for this is that the dashboard can be accessed from anywhere through an internet connection, however, if not connected there is no access at all.

6.3.3 Qualitative Feedback

The prototype was also received very positively by the **core user GAF AG**, as already outlined in the results section.

This circumstance is promising, as it is a strong indication that the prototype fulfills its purpose in this case and therefore might constitute a useful tool in disaster risk management. A broad application basis can be therefore expected as well in form of a concrete implementation into daily practice. However, as previously noted regarding the two expert interviews, it must be acknowledged that the opinion in question is an individual opinion which, even if objectively intended, invariably contains a degree of subjectivity.

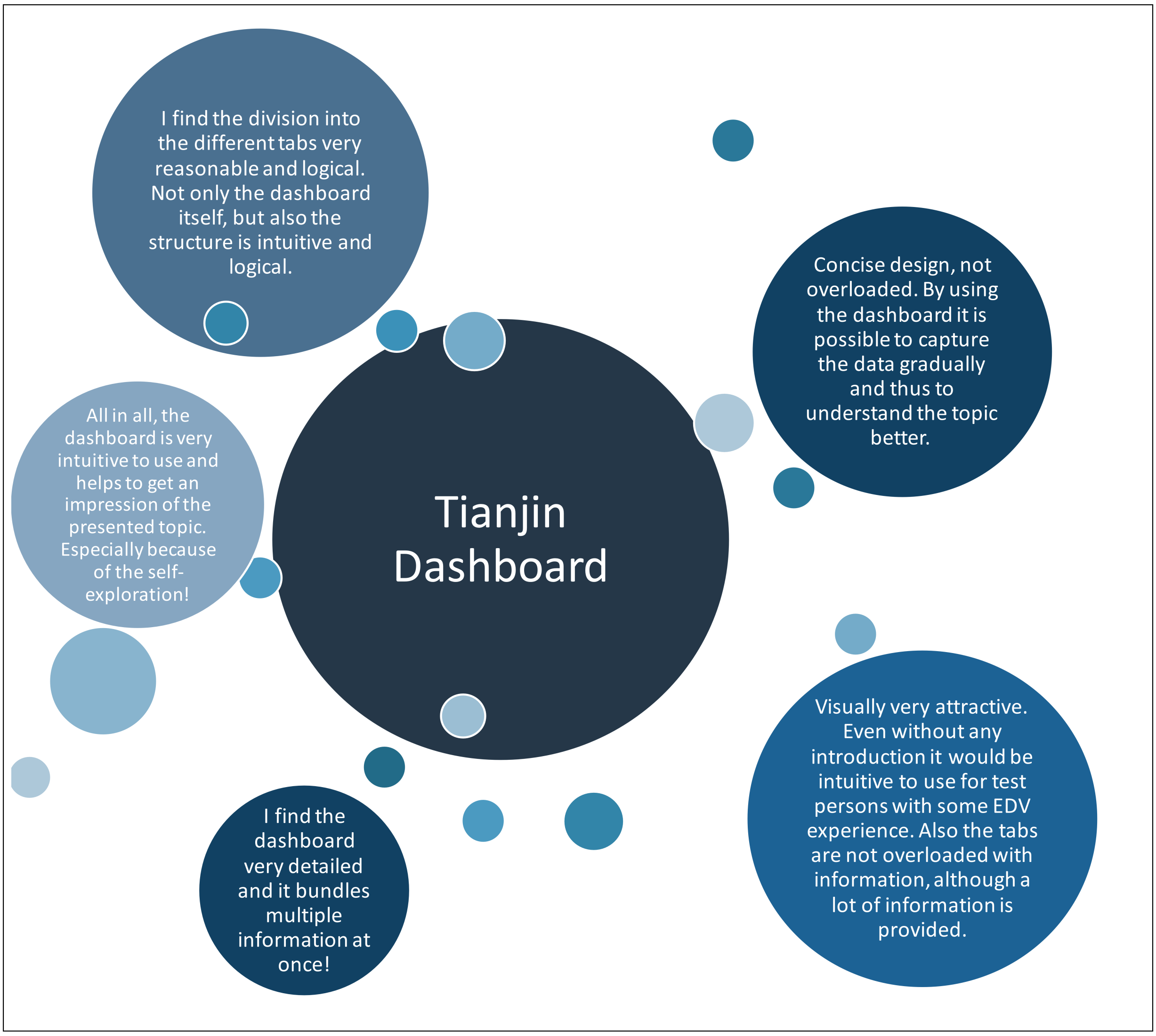


Figure 6.2: Selection of commentaries concerning the **Tianjin Dashboard** provided within the focus group test II

Nevertheless, it is strongly assumed that the dashboard prototype might constitute a useful tool for disaster risk management purposes. Due to the good feedback it can be assumed that the dashboard prototype is applicable in this field.

6.4 Sector Analysis

Perhaps the most relevant point in the discussion of the sector analysis is that it is crucial to be aware that a number of **46** participants may never capture the complete disaster risk community in its entirety and may therefore never be a 100% representative. For the research purposes of this master's thesis, however, it is entirely sufficient, since the research objective ***"investigate, if the concept of a dashboard as an interactive cartographic visualization, is applicable to other potential user groups, working in the disaster risk industry in different sectors"*** is answerable with a high degree of certainty.

From Figure 5.8 it can be deduced that the *"outdated"* media static maps and reports still remain very present in all sectors and account for a high proportion. At the same time, however, it can also be interpreted that the trend towards interactive maps has increasingly found its way into the daily working life of risk managers in disaster risk management. This is especially true for academia, with a share of 40%.

It is plausible in a way, since in the academia sector research for new methods is driven and innovative tools are implemented first. Meanwhile, the share of dashboards and apps is still relatively small, however, it can probably be assumed that this share will increase further in line with the development of the digital world.

It should then be stressed that within Figure 5.8 the *relative* share, not the *absolute* share of all media used per sector is depicted, since otherwise the NGO's and international organization sector would have been entirely underrepresented, as there was only one stakeholder from the NGO sector and two stakeholders of the international organization sector participating in the survey. In this context, it must be taken into account that results concerning the NGO and international organization sector can therefore only be used to a limited extent and conclusions need to be drawn cautiously. This issue is also reflected in Figure 5.9 *"Most frequently used media per sector"*, where the most frequently used medium accounts therefore for 100%, as there was only one participant in the online survey from both sectors who responded to this question (one of the two participants from the international organization sector did not answer this question).

A noticeable aspect of the question concerning the usability of dashboards within the disaster risk community is that while dashboards are apparently already partly used for disaster risk management purposes, the high level of expressed interest in their usage implies that there is a strong demand for dashboards in general.

Ultimately, in order to get a more accurate picture of the entire disaster risk community, more research and newer approaches are needed, in order to further refine this study.

Chapter 7

Conclusion and Outlook

7.1 Conclusion

The aim of this master's thesis was to create and evaluate the usability of dashboards for disaster risk management purposes and to investigate if decision-making and communication flow are significantly improved in comparison to conventional solutions like static maps.

A *sophisticated* prototype was designed and developed based on a static map and by taking into account the user needs of a stakeholder in the field of disaster risk management. Several tests, interviews with experts and analyses were conducted in order to identify if the prototype constitutes a useful tool for disaster risk management purposes. Prior to the actual construction of the prototype, a *requirements analysis* was conducted. In this context, the specific user needs of the **core user GAF AG** were identified as *core aspects* and based on two qualitative expert interviews, general *key features* were determined which are targeted for a dashboard used for disaster risk management purposes.
Furthermore, a *simpler* dashboard was created within the frame of a *potential analysis* before the *actual* prototype was developed. The analysis was carried out to evaluate the potential of dashboards through the provided interactivity in terms of decision making and communication flow in direct comparison to conventional methods like static maps. This analysis was conducted to assess the capabilities of dashboards for disaster risk management purposes.
Ultimately, the concept of the dashboard prototype was extended in the scope of a *sector analysis* to the disaster risk management community, in order to examine how the different stakeholders in disaster risk management generally consider the use and relevance of dashboards in this field.

In order to investigate the different aspects concerning the usability of dashboards for disaster risk management purposes, the following research objectives have been evaluated and the corresponding questions (Chapter 1.2.2) were in the course of this master's thesis answered.

Identify, whether decision making, and communication flow would be improved by the interactive character of a dashboard compared to current methods.

In order to be able to answer the research questions associated with this research objective, the *potential analysis* was conducted. The objective part of the analysis was testing the efficiency (through stopping time) as well as the correctness of the transmitted data and information based upon an example of an European Union vulnerability analysis of the Copernicus Programme.
The testing revealed that the medium dashboard were both more efficient and outperformed the static map in terms of granularity and accuracy in the results.
Since the efficiency or more accurately the time component in communicating risk related information for disaster risk management is often of fundamental importance for decision making processes, it can be concluded that dashboards can be expected to facilitate these processes.

The degree of correctness of the information transmitted was also investigated. This constitutes an integral aspect and is of fundamental importance for the communication flow of risk-relevant data and information within disaster risk management. As the medium dashboard performed significantly better in the focus group test I than the static map, it can be concluded that dashboards generally have the potential to improve the overall communication flow.

The advantages of dashboards over static maps can be summarized primarily as enabling faster and more accurate transfer of risk-related data and information, which effectively can contribute to facilitating decision-making as well as communication flows.

These findings also reflect parts of the content that can be retrieved from the two expert interviews. By incorporating the analysis capabilities regarding trends, coherences and correlations into dashboards directly as functions, dashboards can reduce effort for decision making and consequently facilitate those processes (Employee Munich RE, personal interview, May 25th, 2020, Appendix 2).

Identify, whether dashboards as interactive cartographic visualizations are a useful tool for risk and vulnerability assessment for disaster risk management purposes. And within this context the ***identification of a core user and his or her needs within the disaster risk industry for a user-centered dashboard design. Furthermore, identify if the dashboard will be accepted by the core user as an alternative to static maps.***

In order to be able to provide answers to the research questions associated with these objectives, the *requirements analysis* was conducted. Part of the analysis was the identification of the user needs as *core aspects*. At the same time, *key features* were identified with the help of the external opinions of experts, which would enable dashboards to be a useful tool for disaster risk management purposes and which would provide the basis for the development of the prototype.

In addition, the subjective part of the focus group test I, focus group test II (re-validating the *key features*) and the qualitative feedback provided by the core user (after the construction of the prototype) contributed to providing an answer to the research questions.

The results of the subjective part within the *potential analysis* reflect that dashboards are perceived highly effective in terms of intuition and exploration, especially in comparison to static maps. The high effectiveness of the exploratory character of the dashboard ensures that the data base can be explored very thoroughly and coherences are comprehensible on a profound level. Furthermore, this analysis revealed that dashboards are relatively self-explanatory due to the high degree of intuitiveness. In combination with a high level of user satisfaction while interacting with the medium, these findings contribute to the fact that dashboards represent a useful tool in disaster risk management.

The re-validation of the key features within the focus group test II further emphasizes these findings. The gained profound comprehension of the subject matter of the Tianjin explosion, the efficient bundling of yet a large amount of provided information and the high degree of user satisfaction during the operation of the dashboard suggest the conclusion that dashboards represent a useful tool in disaster risk management. The positive qualitative feedback of the core user also reinforces this outcome and allows to draw the conclusion that the prototype is accepted as an alternative to the static map of which the development was based on.

In addition, some aspects from the expert interviews can also be referenced in this context, making dashboards a useful tool from the experts' point of view. Dashboards allow to explore data sets interactively and exploratively, with fun as an additional motivator. Furthermore it was noted that dashboards provide the ability to investigate and explore data in a very profound way, enabling users to retrieve a maximum of information from the data sets (Employee Munich RE, personal interview, May 25th, 2020, Appendix 2). Through their intuitiveness, dashboards lead very much to the reduction of work density. Dashboards offer an enormous advantage due to their ability to present information in a bundled and multi-layered, but still self-explanatory way. Due to their flexible structure in the composition of their elements, dashboards can grow with the crisis and adapt to new circumstances and insights, which is extraordinarily valuable in disaster risk management (Employee Fraunhofer Institute, personal interview, May 26th, 2020, Appendix 3).

All in all, the collected findings constitute the overall picture that dashboards can be of great use and add value to processes in disaster risk management.

Investigate, if the concept of a dashboard as an interactive cartographic visualization, is applicable to other potential user groups, working in the disaster risk industry in different sectors

An answer to the research questions associated with the third research objective, can be clearly proven by the findings visualized in Figure 5.10. There may be sectoral differences, but 37% are already using dashboards for disaster risk management purposes and 48% are interested in them. As a result 85% of the stakeholders surveyed expressed an interest in dashboards. It can therefore be concluded that the concept of dashboards as an interactive cartographic visualization is applicable, or is even already successfully used. The willingness to use dashboards in disaster risk management can therefore be considered as very high, since more than 80% of the participants of this study support these findings. This proves that the **core user GAF AG**, which has provided very positive feedback regarding dashboards, is not only an individual case, but the entire community values dashboards highly as a medium for disaster risk management purposes.

The conclusion suggests that the *hypothesis* **"interactive cartographic visualization tools such as dashboards can be and upgrade in risk and vulnerability assessment for natural and human-induced disasters and geopolitical risks and contribute to improving decision-making processes and the overall communication flow of risk-related information"** can be considered as **confirmed**. The second *hypothesis* **"during the design process of the dashboard prototype, it is advantageous if the user's conceptions and ideas are part of the implementation in the sense of a user-centered design"** can likewise be assumed as **valid**.

7.2 Outlook - Future Trends in Disaster Risk Management, Cartography and Dashboards

Many experts agree that the number and intensity of natural and anthropogenic disasters continues to increase. The field of disaster risk management is constantly evolving, and its increasing importance has turned a small community into an entire industry with various stakeholders. This industry is growing, also with a view to the future (Employee Munich RE, personal interview, May 25th, 2020, Appendix 2). Settlement is becoming increasingly chaotic in many parts of the world, which has a direct impact on vulnerability and exposure, increasing the risk of being affected by a disaster for many people in the world. This effect is further intensified and accelerated by climate change (Employee GAF AG, personal interview, May 22nd, 2020, Appendix 1).

At the same time, new technologies, such as improved remote sensing systems, some of which now provide daily coverage and report on global events, are constantly evolving and are expected to become even more accurate in the future. Digitization is a major factor in which a great amount of investment is being made. For example, much research and effort is being put into digitizing countries and communities to increase their *resilience* to disasters and bring them up to date with the latest technology (Employee Fraunhofer Institute, personal interview, May 26th, 2020, Appendix 3).

The expert interviews revealed that the trend is probably also developing in the direction of structuring more and more information technically into one application, and even merging several applications into one application. Data sources and data streams will be consumed increasingly and automatically, but also external services and their functions will presumably be bundled increasingly and preferably in single application (Figure 7.1). Moreover, the range of different data sources available will broaden and may be used to provide many different perspectives as well as to refine the general overview. This aspect

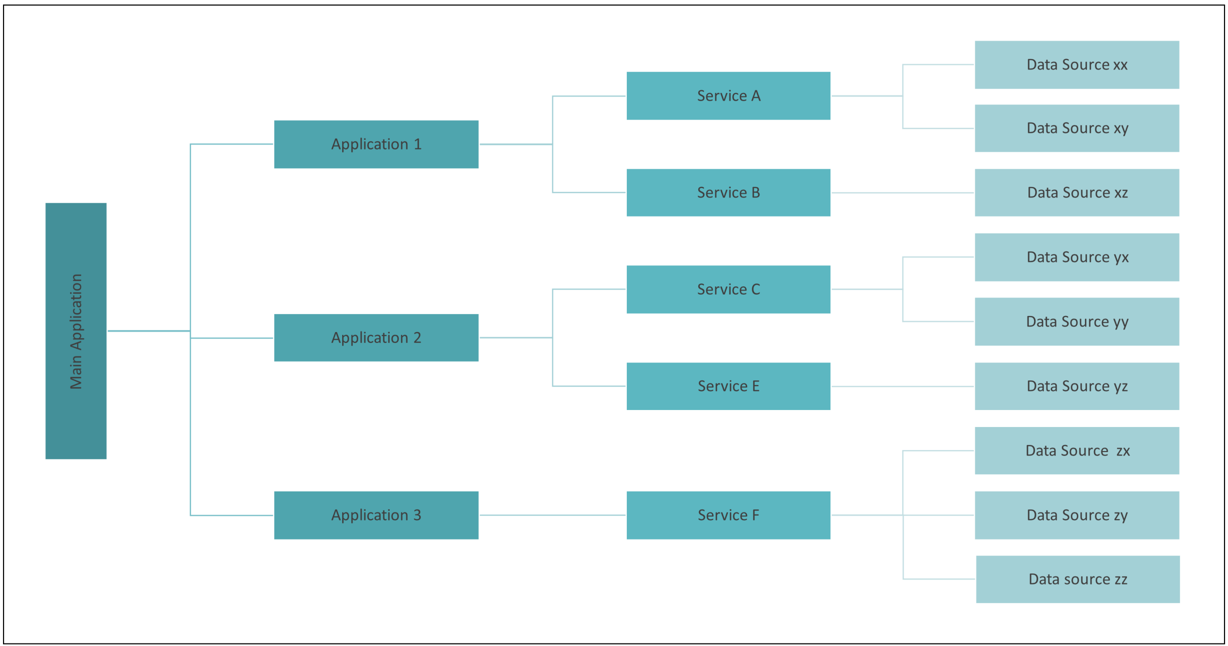


Figure 7.1: Schematic overview of structuring different data sources,services and applications into one main application

will further optimize processes like decision making and improving the flow of communication. In an interdisciplinary context, technology and hardware in data science, and thus also in cartography, are becoming increasingly faster, more transparent and technically advanced. This implies that there are also new opportunities in disaster risk management. Increased fundamental research will lead to a more efficient accumulation of geo-data in the future for better analysis of disasters and as a foundation for visualization (Employee Munich RE, personal interview, May 25th, 2020, Appendix 2).

Both experts independently mentioned that data protection and security is becoming increasingly relevant. Due to continuously rising costs, good and granular data is becoming more and more expensive and difficult to obtain. In general, this is a difficult issue, as good databases are essential in fields such as disaster risk management, for example for civil protection purposes.

With regard to cartographic visualization, experts believe that the trend is moving further away from static print products and towards online visualizations, especially in disaster risk management (Employee GAF AG, personal interview, May 22nd, 2020, Appendix 1). For instance, the situation of COVID-19 demonstrates that dashboards and other interactive cartographic visualizations are gaining increasingly in importance, especially in crisis and disaster situations. The current crisis of the COVID-19 situation reveals the great demand in this field, as countless visualizations on the topic have been published during the present period.

The degree of automation can be expected to continue to rise in the future. With the development of technology, applications in dashboards will probably be able to perform many analyses independently in the future, especially in the context of artificial intelligence. This could mean, for example that satellite images could be automatically analyzed and interpreted by algorithms and these applications and analyses could be incorporated within dashboards. The degree of automation could also have an impact on the exploration of data sources and data streams which could be consumed increasingly in an automated way. Dashboards will continue to excel at presenting different perspectives in a well-founded and consistent manner, allowing for more accurate identification of trends and increasingly easier detection of correlations between different data sets. In this process, dashboards could evolve into entire platforms that bundle many applications and information that enable access as well as sharing of risk relevant information by a broad spectrum of different stakeholders.

These named aspects could help in the future to better cope with disaster situations like the Beirut explosion in Lebanon, which occurred in the final stages of this master's thesis. On August 04th, 2020 an immense explosion detonated in the port of Beirut, killing hundreds of people and hitting a country, that has already been deeply affected by the Syrian War, a deep economic recession and COVID-19 for months.
The similarities of the explosion itself to the Tianjin explosion discussed throughout this master's thesis are devastating. The explosion had a similar catastrophic impact, the dimensions of the dead and injured resemble those of the Tianjin explosion and in fact even the same material detonated.

This is precisely the reason for the fundamental importance and the high demand for thoroughly executed disaster risk management - to ensure that similar disasters will not repeat themselves in the future.

List of Figures

1.1 COVID-19 dashboard by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University (JHU). Retrieved from: Johns Hopkins University (2020) . . . 6

2.1 Map about flood risk in Newfoundland. The orange and yellow layer represent the flood risk with different return periods (20 and 100 years). Exposed houses and railways lie are located within these layers. Not shown in map are different levels of vulnerability. Retrieved and adapted from: UN-SPIDER (2020a) . . . 9
2.2 Natural and anthropogenic hazards - an overview. Graphic derived from: Prevention Web (2020c) and Munich Re (2020a) . . . 10
2.3 Risks posed by natural disasters. Number of relevant loss events by peril 1980–2019. Retrieved and adapted from: Munich Re (2020b) . . . 11
2.4 Equation of disaster risk. Derived and adapted from: UNDRR (2015b) . . . 13
2.5 Disaster risk management cycle. Retrieved and adapted from: Le Cozannet et al. (2020) . 14
2.6 Cholera map of John Snow, created in 1854 during a deadly cholera breakout in London. Cases are highlighted in black on the map . . . 25
2.7 Robert Koch-Institute: COVID-19-dashboard. Retrieved from: Robert Koch-Institute (2020) . . . 31

3.1 Image of the Tianjin explosion depicting the explosion site including destroyed vehicles and tossed containers. Retrieved from: The New York Times (2015) . . . 33
3.2 Overview over the study area **Tianjin Port, Tianjin, China** . . . 34
3.3 Map of the damage assessment conducted by GAF AG on behalf of the order by Munich RE. 35
3.4 Overview over the study area **Costa da Caparica, Setúbal, Portugal** . . . 36
3.5 Map of the EMS Activation **EMSN034: Coastal flood risk analysis for population and assets, Portugal**. Map displays the socio-economic vulnerability on the **Costa da Caparica**. Retrieved from: Indra Sistemas (2017) . . . 37

4.1 Individual conducted steps of the methodology visualized as a workflow-chart . . . 40
4.2 Dashboard of the EMS Activation **EMSN034: Coastal flood risk analysis for population and assets, Portugal**. Dashboard displays the socio-economic vulnerability on the **Costa da Caparica** with interactive features . . . 42
4.3 The reference map of the Tianjin harbor within the **Tianjin Dashboard** . . . 44
4.4 Affected vehicles by the Tianjin explosion within the **Tianjin Dashboard** . . . 45
4.5 Affected container by the Tianjin explosion within the **Tianjin Dashboard** . . . 46
4.6 Affected buildings by the Tianjin explosion within the **Tianjin Dashboard** . . . 47
4.7 Web application created for further exploration purposes on the base of the Pleiades-1B satellite image . . . 48

5.1 Results of task one and two of the focus group test I within the scope of the potential analysis 53
5.2 Fields x and y, which were mentioned in task one and two . . . 54
5.3 Results of task four of the focus group test I within the scope of the potential analysis . . 55
5.4 Results of task five and six of the focus group test I within the scope of the potential analysis 56

5.5 Results of statement evaluation of the focus group test I within the scope of the potential analysis . . . 57
5.6 Results of statement evaluation of the focus group test II within the scope of dashboard prototype conception . . . 58
5.7 General statistics of the stakeholders of the disaster risk community participating in the online survey . . . 60
5.8 Relative distribution of all used media per sector within the disaster risk community as reported by the stakeholders . . . 60
5.9 Left: rating of the most used medium within the entire disaster risk community represented as absolute counts. Right: rating of the most used medium represented as relative share sector wise . . . 61
5.10 Opinion of stakeholders with regard to the perceived relevance of dashboards for disaster risk management purposes. Left: concerning the entire disaster risk community. Right: divided by sector . . . 61

6.1 Selection of commentaries concerning both dashboards (left) and static maps (right) provided within the subjective part of the focus group test I . . . 67
6.2 Selection of commentaries concerning the **Tianjin Dashboard** provided within the focus group test II . . . 69

7.1 Schematic overview of structuring different data sources,services and applications into one main application . . . 74

References

Abbot, J., Chambers, R., Dunn, C., Harris, T., Merode, E., Porter, G., & Weiner, D. (1998). Participatory gis : opportunity or oxymoron. *PLA notes*, *33*, 27–33. Retrieved from http://dro.dur.ac.uk/14113/

Albris, K., Lauta, K. C., & Raju, E. (2020). Disaster knowledge gaps: Exploring the interface between science and policy for disaster risk reduction in europe. *International Journal of Disaster Risk Science*, *11*(1), 1–12. Retrieved February 12th, 2020, from https://link.springer.com/article/10.1007/s13753-020-00250-5

Amarnath, G., Matheswaran, K., Pandey, P., Alahacoon, N., & Yoshimoto, S. (2017). Flood mapping tools for disaster preparedness and emergency response using satellite data and hydrodynamic models: A case study of bagmathi basin, india. *Proceedings of the National Academy of Sciences, India Section A: Physical Sciences*, *87*(4), 941–950. Retrieved from https://link-springer-com.eaccess.ub.tum.de/article/10.1007/s40010-017-0461-7

AMCDRR. (2012). *Yogyakarta declaration on disaster risk reduction in asia and the pacific 2012.* Retrieved May 05th, 2020, from https://www.preventionweb.net/files/29332_10scienceandacademicsfinal3.pdf

Asgary, A., & Kari, D. (2017). Communicating disaster risk reduction through web-map applications. *Global Changes and Natural Disaster Management: Geo-information Technologies*, 91–99. Retrieved from https://link-springer-com.eaccess.ub.tum.de/chapter/10.1007%2F978-3-319-51844-2_7

Backhaus, R., Czaran, L., Epler, N., Leitgab, M., Lyu, Y., Ravan, S., … Villagran de Leon, J. (2010). *Support from space: The united nations platform for space-based information for disaster management and emergency response (un-spider).* Retrieved May 05th, 2020, from http://www.un-spider.org/publications/jbgis-unoosa-booklet

BBK. (2017). *The federal office of civil protection and disaster assistance (bbk).* Retrieved May 05th, 2020, from https://www.bmi.bund.de/EN/topics/civil-protection/bbk/bbk-node.html

BBK. (2020). *The federal office of civil protection and disaster assistance (bbk) - warn-app nina.* Retrieved May 08th, 2020, from https://www.bbk.bund.de/DE/NINA/Warn-App_NINA_node.html

Béjar-Pizarro, M., Álvarez Gómez, J., Staller, A., Luna, M., Pérez-López, R., Monserrat, O., … Herrera, G. (2018). Insar-based mapping to support decision-making after an earthquake. *Remote Sensing*, *10*(6), 899. Retrieved from https://www.mdpi.com/2072-4292/10/6/899/htm

Bo, J., Xiaxin, T., Ping, L., & Yanru, W. (2009). Webgis based information and decision-making support system for earthquake disaster reduction. *2009 Sixth International Conference on Fuzzy Systems and Knowledge Discovery*, 397–401. Retrieved August 06th, 2020, from https://ieeexplore.ieee.org/document/5360040

Butt, M. A., Mahmood, S. A., & Raza, S. M. H. (2018). Geowebex: an open-source online system for synchronous collaboration on geographic information. *Applied Geomatics*, *10*(2), 123–145. Retrieved August 06th, 2020, from https://link-springer-com.eaccess.ub.tum.de/article/10.1007/s12518-018-0204-8

Ceccato, P., Fernandes, K., Ruiz, D., & Allis, E. (2014). Climate and environmental monitoring for decision making. *Earth Perspectives*, *1*(1), 16.

Col, J. M. (2007). Managing disasters: The role of local government. *Public Administration Review*, *67*, 114–124.

Contreras, D., Blaschke, T., Tiede, D., & Jilge, M. (2016). Monitoring recovery after earthquakes through the integration of remote sensing, gis, and ground observations: the case of l'aquila (italy). *Cartography and Geographic Information Science*, *43*(2), 115–133.

Copernicus Emergency Management Service. (2020). *Copernicus emergency management service.* Retrieved May 07th, 2020, from https://emergency.copernicus.eu/

CRED. (2020). *Em-dat disaster criteria.* Retrieved April 26th, 2020, from https://www.emdat.be/frequently-asked-questions

Danckert, J. A., & Allman, A.-. A. (2005). Time flies when you're having fun: temporal estimation and the experience of boredom. *Brain and Cognition*, *59*(3), 236–245. Retrieved August 12th, 2020, from http://www.sciencedirect.com/science/article/pii/S0278262605000989

Deutsche Welle. (2015). *Milliarden versicherungs-schaden in tianjin.* Retrieved June 27th, 2020, from https://www.dw.com/de/milliarden-versicherungs-schaden-in-tianjin/a-18653161

Ebert, A., Kerle, N., & Stein, A. (2009). Urban social vulnerability assessment with physical proxies and spatial metrics derived from air- and spaceborne imagery and gis data. *Natural Hazards*, *48*(2), 275–294.

Eden, S. (1996). Public participation in environmental policy: considering scientific, counter-scientific and non-scientific contributions. *Public Understanding of Science*, *5*(3), 183–204.

Few, R., Ahern, M., Matthies, F., & Kovats, S. (2004). *Floods, health and climate change: a strategic review.* Tyndall Centre for Climate Change Research. Retrieved August 06th, 2020, from https://www.semanticscholar.org/paper/Floods%2C-health-and-climate-change%3A-a-strategic-Few-Ahern/7128ae76bea7fbdc5582799f2112ac78b06d4523

Few, S. (2006). *Information dashboard design: The effective visual communication of data*. Beijing and London: O'Reilly.

Few, S. (2017). *Visual business intelligence – there's nothing mere about semantics.* Retrieved May 17th, 2020, from https://www.perceptualedge.com/blog/?p=2793

Fung, V. (2012). *Using gis for disaster risk reduction - world.* Retrieved May 20th, 2020, from https://reliefweb.int/report/world/using-gis-disaster-risk-reduction

GAF AG. (2020). *Profile | gaf ag | munich.* Retrieved June 26th, 2020, from https://www.gaf.de/content/profile

GFDRR. (2014). *Understanding risk: review of open source and open access software packages available to quantify risk from natural hazards.* Retrieved April 28th, 2020, from https://www.gfdrr.org/sites/gfdrr/files/publication/UR-Software_Review-Web_Version-rev-1.1.pdf

Goh, R. S. M., Wang, Z., Yin, X., Fu, X., Ponnambalam, L., Lu, S., & Li, X. (2013). Riskvis: Supply chain visualization with risk management and real-time monitoring. *2013 IEEE International Conference on Automation Science and Engineering (CASE)*, 207–212. Retrieved August 06th, 2020, from https://ieeexplore.ieee.org/document/6653910

Grinberger, A. Y., Lichter, M., & Felsenstein, D. (2015). Simulating urban resilience: Disasters, dynamics and (synthetic) data. *Planning Support Systems and Smart Cities*, 99–119. Retrieved from https://link-springer-com.eaccess.ub.tum.de/chapter/10.1007%2F978-3-319-18368-8_6

Hatrushi, A., & Mubarak, S. (2017). Assessment of the potential impacts of sea level rise on the coastal plain of al batinah, sultanate of oman. *Global Changes and Natural Disaster Management: Geo-information Technologies*, 125–130. Retrieved from https://link-springer-com.eaccess.ub.tum.de/chapter/10.1007%2F978-3-319-51844-2_10

Horita, F., Fava, M. C., Mendiondo, E. M., Rotava, J., Borges de Souza, V. C., Ueyama, J., & Porto De Albuquerque, J. (2014). Agora-geodash: A geosensor dashboard for real-time flood risk monitoring. *11th International ISCRAM Conference*. Retrieved from https://www.academia.edu/6202727/AGORA-GeoDash_A_Geosensor_Dashboard_for_Real-time_Flood_Risk_Monitoring

HOT OSM. (2020a). *Humanitarian openstreetmap team | disaster response.* Retrieved May 02nd, 2020, from https://www.hotosm.org/impact-areas/disaster-response/

HOT OSM. (2020b). *Humanitarian openstreetmap team | get involved.* Retrieved May 07th, 2020, from https://www.hotosm.org/get-involved

IFRC. (2020). *Types of disasters: Definition of hazard.* Retrieved April 26th, 2020, from https://www.ifrc.org/en/what-we-do/disaster-management/about-disasters/definition-of-hazard/

Ikeda, Y., & Inoue, M. (2016). An evacuation route planning for safety route guidance system after natural disaster using multi-objective genetic algorithm. *Procedia Computer Science*, *96*, 1323–1331.

Indra Sistemas. (2017). *[emsn034] costa da caparica: Socio-economic vulnerability.* Retrieved August 07th, 2020, from https://emergency.copernicus.eu/mapping/ems-product-component/EMSN034_01COSTADACAPARICA_M2-VULNERABILITYSOCEC_OVERVIEWA1/1

Izumi, T. (2016). Science and practical disaster risk reduction: Role of universities and academia in disaster risk reduction – from the discussions at the unwcdrr public forum by apru and irides –. *Journal of Disaster Research*, *11*(3), 454–458.

Izumi, T., & Shaw, R. (2015a). *Disaster management and private sectors: Challenges and potentials / takako izumi, rajib shaw, editors*. Tokyo: Springer.

Izumi, T., & Shaw, R. (2015b). Overview and introduction of the private sector's role in disaster management. *Disaster Management and Private Sectors*, 1–10.

Janssen, M., & Bharosa, N. (2010). Are we prepared? experiences from developing dashboards for disaster preparation. *ISCRAM 2010 - 7th International Conference on Information Systems for Crisis Response and Management: Defining Crisis Management 3.0, Proceedings*. Retrieved from https://www.academia.edu/13287010/Are_we_prepared_Experiences_from_developing_dashboards_for_disaster_preparation

Johns Hopkins University. (2020). *Covid-19 dashboard by the center for systems science and engineering (csse) at johns hopkins university (jhu).* Retrieved August 07th, 2020, from https://coronavirus.jhu.edu/map.html

Johnson, D. A. K., & Abe, Y. (2015). Global overview on the role of the private sector in disaster risk reduction: Scopes, challenges, and potentials. *Disaster Management and Private Sectors*, 11–29.

Kantsepolsky, B., & Mordecai, Y. (2018). Intelligent utilization of dashboards in emergency management. *15th International Conference on Information Systems for Crisis Response and Management (ISCRAM).* Retrieved from https://www.academia.edu/40458509/Intelligent_Utilization_of_Dashboards_in_Emergency_Management

Kensinger, E. A. (2009). Remembering the details: Effects of emotion. *Emotion review*, *1*(2), 99–113.

Kinkeldey, C., MacEachren, A. M., Riveiro, M., & Schiewe, J. (2017). Evaluating the effect of visually represented geodata uncertainty on decision-making: systematic review, lessons learned, and recommendations. *Cartography and Geographic Information Science*, *44*(1), 1–21.

Kinkeldey, C., MacEachren, A. M., & Schiewe, J. (2014). How to assess visual communication of uncertainty? a systematic review of geospatial uncertainty visualisation user studies. *The Cartographic Journal*, *51*(4), 372–386.

Le Cozannet, G., Kervyn, M., Russo, S., Ifejika Speranza, C., Ferrier, P., Foumelis, M., … Modaressi, H. (2020). Space-based earth observations for disaster risk management. *Surveys in Geophysics*, 1–27. Retrieved May 10th, 2020, from https://link.springer.com/article/10.1007/s10712-020-09586-5

MacEachren, A. M. (2005). Moving geovisualization toward support for group work. *Exploring Geovisualization*, 445–461. Retrieved from http://www.sciencedirect.com/science/article/pii/B9780080445311504401

McArdle, G., & Kitchin, R. (2016). The dublin dashboard: Design and development of a real-time analytical urban dashboard. *ISPRS Annals of Photogrammetry, Remote Sensing and Spatial Information Sciences*, *IV-4/W1*, 19–25.

Mendes, J. M., Tavares, A. O., & Santos, P. P. (2019). Social vulnerability and local level assessments: a new approach for planning. *International Journal of Disaster Resilience in the Built Environment*, *11*(1), 15–43. Retrieved from https://www-emerald-com.eaccess.ub.tum.de/insight/content/doi/10.1108/IJDRBE-10-2019-0069/full/html

Mondal, D., Chowdhury, S., & Basu, D. (2015). Role of non governmental organization in disaster management. *Research Journal of Agricultural Sciences*, *Volume 6*. Retrieved May 05th, 2020, from https://www.academia.edu/29174559/Role_of_Non_Governmental_Organization_in

_Disaster_Management
Mortimer, C. (2016). *Tianjin explosion: Gigantic crater left by chinese factory accident revealed.* Retrieved June 27th, 2020, from https://www.independent.co.uk/news/world/asia/tianjin-explosion-photos-china-chemical-factory-accident-crater-revealed-a7199591.html
Munich Re. (2020a). *Natural disasters overview.* Retrieved April 26th, 2020, from https://www.munichre.com/topics-online/en/climate-change-and-natural-disasters/natural-disasters.html
Munich Re. (2020b). *Risks posed by natural disasters: Economic losses caused by natural catastrophes are trending upwards.* Retrieved April 26th, 2020, from https://www.munichre.com/en/risks/natural-disasters-losses-are-trending-upwards.html
OCHA. (2020). *Natural disasters | humanitarianresponse.* Retrieved August 07th, 2020, from https://www.humanitarianresponse.info/en/operations/afghanistan/natural-disasters-0
OECD. (2012). *G20/oecd methodological framework on disaster risk assessment and risk financing.* Retrieved April 28th, 2020, from http://www.oecd.org/gov/risk/G20disasterriskmanagement.pdf
Padilla, L. M., Creem-Regehr, S. H., Hegarty, M., & Stefanucci, J. K. (2018). Decision making with visualizations: a cognitive framework across disciplines. *Cognitive Research: Principles and Implications*, *3*(1), 29.
Parvez, I. A., Magrin, A., Vaccari, F., Ashish, Mir, R. R., Peresan, A., & Panza, G. F. (2017). Neo-deterministic seismic hazard scenarios for india—a preventive tool for disaster mitigation. *Journal of Seismology*, *21*(6), 1559–1575. Retrieved from https://link-springer-com.eaccess.ub.tum.de/article/10.1007/s10950-017-9682-0
Pfeiffer, C., Glaser, S., Vencatesan, J., Schliermann-Kraus, E., Drescher, A., & Glaser, R. (2008). Facilitating participatory multilevel decision-making by using interactive mental maps. *Geospatial health*, *3*(1), 103–112.
Prevention Web. (2020a). *Disaster risk | preventionweb.net.* Retrieved April 28th, 2020, from https://www.preventionweb.net/risk/disaster-risk
Prevention Web. (2020b). *Exposure | preventionweb.net.* Retrieved May 19th, 2020, from https://www.preventionweb.net/risk/exposure
Prevention Web. (2020c). *Hazard | preventionweb.net.* Retrieved April 27th, 2020, from https://www.preventionweb.net/risk/hazard
Quarantelli, E. L. (2006). *Catastrophes are different from disasters: Some implications for crisis planning and managing drawn from katrina.* Retrieved May 03rd, 2020, from https://items.ssrc.org/understanding-katrina/catastrophes-are-different-from-disasters-some-implications-for-crisis-planning-and-managing-drawn-from-katrina/
Remo, J. W. F., & Pinter, N. (2012). Hazus-mh earthquake modeling in the central usa. *Natural Hazards*, *63*(2), 1055–1081. Retrieved from https://link.springer.com/article/10.1007%2Fs11069-012-0206-5
Rininsland, A., Heydt, M., & Navarro Castillo, P. (2016). *D3.js: Cutting-edge data visualization : turn your raw data into real knowledge by creating and deploying complex data visualizations with d3.js.* Birmingham, UK: Packt Publishing.
Rinner, C. (2007). A geographic visualization approach to multi–criteria evaluation of urban quality of life. *International Journal of Geographical Information Science*, *21*(8), 907–919.
Robert Koch-Institute. (2020). *Rki covid-19 germany.* Retrieved August 07th, 2020, from https://experience.arcgis.com/experience/478220a4c454480e823b17327b2bf1d4
Roth, R., Ross, K., & MacEachren, A. (2015). User-centered design for interactive maps: A case study in crime analysis. *ISPRS International Journal of Geo-Information*, *4*(1), 262–301.
Saha, S., Shekhar, S., Sadhukhan, S., & Das, P. (2018). An analytics dashboard visualization for flood decision support system. *Journal of Visualization*, *21*(2), 295–307.
Sarikaya, A., Correll, M., Bartram, L., Tory, M., & Fisher, D. (2018). What do we talk about when we talk about dashboards? *IEEE Transactions on Visualization and Computer Graphics*, *25*(1), 682–692.
Shaw, R., Izumi, T., & Shi, P. (2016). Perspectives of science and technology in disaster risk reduction

of asia. *International Journal of Disaster Risk Science*, *7*(4), 329–342. Retrieved from https://link.springer.com/article/10.1007/s13753-016-0104-7

Shi, P. (2012). On the role of government in integrated disaster risk governance—based on practices in china. *International Journal of Disaster Risk Science*, *3*(3), 139–146. Retrieved from https://link.springer.com/article/10.1007/s13753-012-0014-2

Siebert, H. (2005). *Pädagogischer konstruktivismus: Lernzentrierte pädagogik in schule und erwachsenenbildung* (3. Aufl. ed.). Weinheim and Basel: Beltz Verlag. Retrieved from http://www.content-select.com/index.php?id=bib_view&ean=9783407291486

Soulakellis, N., Tataris, G., Papadopoulou, E.-E., Chatzistamatis, S., Vasilakos, C., Kavroudakis, D., ... Papakonstantinou, A. (2019). Synergistic exploitation of geoinformation methods for post-earthquake 3d mapping and damage assessment. *Gi4DM 2018: Intelligent Systems for Crisis Management*, 3–31.

Stehle, S., & Kitchin, R. (2020). Real-time and archival data visualisation techniques in city dashboards. *International Journal of Geographical Information Science*, *34*(2), 344–366.

Svatonova, H., & Kolejka, J. (2017). Comparative research of visual interpretation of aerial images and topographic maps for unskilled users: Searching for objects important for decision-making in crisis situations. *ISPRS International Journal of Geo-Information*, *6*(8), 231.

Tableau. (2020). *10 best practices for building effective dashboards.* Retrieved May 18th, 2020, from https://www.tableau.com/learn/whitepapers/10-best-practices-building-effective-dashboards?ref=wc&signin=96d49b81298dd4371c546f897de3e3fb

Than, K. (2005). *Scientists: Natural disasters becoming more common.* Retrieved April 26th, 2020, from https://www.livescience.com/414-scientists-natural-disasters-common.html

The New York Times. (2015). *Maps, videos and photos of the explosions in china.* Retrieved August 07th, 2020, from https://www.nytimes.com/interactive/2015/08/13/world/asia/tianjin-china-explosions-maps.html

Tilley, I., & Pettit, C. (2019). A dashboard for the unexpected: Open data for real-time disaster response. *Open Cities | Open Data*, 265–286.

Tomaszewski, B. (2010). *Gateway, bridge and facilitator.* Retrieved May 05th, 2020, from https://www.gim-international.com/content/article/gateway-bridge-and-facilitator

Tomaszewski, B. (2014). *Geographic information systems (gis) for disaster management* (1st ed.). Boca Raton: CRC Press.

UNDRR. (2015a). *Disaster risk: Unisdr global assessment report.* Retrieved April 26th, 2020, from https://www.preventionweb.net/risk/disaster-risk

UNDRR. (2015b). *Global assessment report on disaster risk reduction (gar) 2015: Making development sustainable : the future of disaster risk management*. New York: United Nations.

UNDRR. (2020). *Our services | preventionweb.net.* Retrieved May 05th, 2020, from https://www.preventionweb.net/about/aboutpw

UNGA and UNDRR. (2016). *Report of the open-ended intergovernmental expert working group on indicators and terminology relating to disaster risk reduction.* Retrieved April 26th, 2020, from https://www.preventionweb.net/files/50683_oiewgreportenglish.pdf

UNISDR. (2009). *2009 unisdr terminology on disaster risk reduction.* Retrieved April 26th, 2020, from https://www.undrr.org/publication/2009-unisdr-terminology-disaster-risk-reduction

UNISDR. (2016). *Exposure and vulnerability: To promote and support the availability and application of science and technology to decision-making in disaster risk reduction.* Geneva International Conference Centre. Retrieved April 26th, 2020, from https://www.preventionweb.net/files/45270_unisdrcnws2wg2vulnerabilityandexpos.pdf

UNISDR. (2020). *Essential nine: Ensure effective disaster response - home - beta version: Campaign.* Retrieved May 02nd, 2020, from https://www.unisdr.org/campaign/resilientcities/home/article/essential-nine-ensure-effective-disaster-response

United Nations Environment Programme. (2010). *Risk and vulnerability assessment methodology development project (rivamp) - linking ecosystems to risk and vulnerability reduction - the case* *of jamaica*. United Nations Environment Programme (UNEP). Retrieved April 26th, 2020, from http://wedocs.unep.org/handle/20.500.11822/8879

UN-SPIDER. (2020a). *Disaster risk management.* Retrieved April 27th, 2020, from http://www.un-spider.org/risks-and-disasters/disaster-risk-management

UN-SPIDER. (2020b). *Natural hazards.* Retrieved April 27th, 2020, from http://www.un-spider.org/risks-and-disasters/natural-hazards

UN-SPIDER. (2020c). *Risks and disasters.* Retrieved April 27th, 2020, from http://www.un-spider.org/risks-and-disasters

WHO and EHA. (2002). *Disasters&emergencies.* Panafrican Emergency Training Centre. Retrieved April 26th, 2020, from https://apps.who.int/disasters/repo/7656.pdf

Yalcin, M. A., Elmqvist, N., & Bederson, B. B. (2018). Keshif: Rapid and expressive tabular data exploration for novices. *IEEE Transactions on Visualization and Computer Graphics*, *24*(8), 2339–2352.

Zheng, L., Shen, C., Tang, L., Li, T., Luis, S., Chen, S.-C., & Hristidis, V. (2010). Using data mining techniques to address critical information exchange needs in disaster affected public-private networks. *Proceedings of the 16th ACM SIGKDD International Conference on Knowledge Discovery and Data Mining*, 125. Retrieved August 06th, 2020, from https://www.researchgate.net/publication/221653295_Using_data_mining_techniques_to_address_critical_information_exchange_needs_in_Disaster_affected_public-private_networks

Cartography M.Sc.

User Needs Interview vom 22. Mai 2020 – GAF AG

Zu Anfang möchte ich Sie bitten sich kurz vorzustellen und warum Sie sich für das Feld Disaster Risk Management entschieden haben.

Mein Name ist [redacted] und ich bin seit 15 Jahren bei der GAF AG in München tätig. Meine Tätigkeiten sind hauptsächlich in dem Bereich Emergency Response. Im Genaueren arbeite ich dort als Projektleiter für den Copernicus Emergency Service und betreue das Rapid Mapping. Die GAF AG ist zusätzlich neben dem Rapid Mapping Emergency Service auch im Risk and Recovery Bereich tätig. Dort ist sie aber hauptsächlich zuständig für die Daten-Beschaffung sowie die Bereitstellung von digitalen Geländemodellen (DGM's).

Da Sie der Test User für den Prototypen sind, würde es mich interessieren, welche Bedürfnisse Sie in Bezug auf die Konzeption des Dashboards haben.

Das ist ein wichtiger Punkt, denn ich persönlich habe eher wenig Erfahrung im Umgang mit Dashboards. Deswegen wäre es aus meiner Sicht unglaublich wichtig zu erfahren, was genau Dashboards im Disaster Risk Management leisten können und wie die Funktionsweise ist. Unter Anderem würde mich auch interessieren, welchen Mehrwert Dashboards bieten, im Vergleich zu aktuellen Produkten wie statischen Karten. Die Darstellung von Daten, die wir an unsere Kunden liefern, spielt eine große Rolle. In dem Zusammenhang mit Dashboards ist deswegen ein wichtiger Punkt wie diese Daten aufbereitet sein müssten, um so ein Dashboard bedienen zu können, sowie auf welche verschiedenen Weisen sie in einem Dashboard eingesetzt werden könnten.

Dashboards bündeln zusätzlich zu interaktiven Karten auch andere relevante Informationen und KPI's in z.B. Graphen. Bräuchten Sie ein bestimmtes Verhältnis von Karten und anderen Elementen wie Graphen, Diagrammen etc. in dem Dashboard Prototypen?

Wir sind in erster Linie Daten Provider, also wir beliefern den Kunden mit den Daten, die sie benötigen. Ein besonderer Fokus liegt bei Rückmeldungen von vielen Kunden auf den Kriseninformationen. In dem Zusammenhang bedeutet das, dass neben der Aktualität von Daten, die Produkte auch möglichst zeitnah geliefert werden sollten. Genauigkeit, sowie ein angestrebter Mehrwert von den von uns aufbereiteten Daten spielt eine große Rolle. Das bedeutet, eine große Frage dreht sich darum, wie man diesen Mehrwehrt der Daten optimiert, um auch die Kundenzufriedenheit zu erhöhen. Im Zusammenhang mit Kriseninformation und Dashboards kann dies durch die Kombination von ganz unterschiedlichen Layern geschehen, wie verschiedene Brandflächen oder unterschiedliche Informationen zu Fluten. Zum Beispiel könnte man zusätzliche Informationen zur Größe des Ereignisses, oder aber auch zu Flächen angeben. Konkret bei Fluten wäre die Angabe zur Wassertiefe bei Hochwasserereignissen nützlich. Mir geht es darum, wie man unterschiedlichste Informationen sinnvoll verknüpfen kann, um diese den Kunden adäquat zu präsentieren, ohne das Überforderung bei der Auswertung von Ergebnissen entsteht und man einen zusätzlichen Mehrwert hat.

Daraus höre ich, dass Sie eher den Fokus auf die Darstellung und Visualisierung von Karten legen und Graphen sowie Diagramme eher unterstützende Elemente wären.

Genau, meine Vorstellung wäre, dass der Kunde beziehungsweise der Nutzer sich erst einmal mithilfe der Karte einen Überblick über das Ausmaß und die Größe des Ereignisses schaffen kann und dann im nächsten Schritt Zusatzinformationen zu dem Ereignis/zu den Ereignissen gegeben werden.

Welchen Stellenwert haben kartografische Visualisierungsmethoden und Karten im Disaster Risk Management für Sie? In welchen Bereichen (Planning/Preparedness, Response, Recovery, und Prevention/Mitigation) im Disaster Risk Management sind sie besonders relevant bzw. haben Ihrer Meinung nach besonderes Potential?

Für mich hat die Kartographie einen extrem hohen Stellenwert und Standpunkt. Das habe ich eben auch angedeutet. Der Nutzer beziehungsweise Kunde soll möglichst schnell die Lage erfassen und sich einen Überblick verschaffen können – und da hat die Kartographie natürlich sehr viele Vorteile. Zu den einzelnen Bereichen – dort spielt eigentlich im kompletten Kreislauf die Kartographie oder Karten selbst eine große Rolle, sowohl in der Vorbereitung und Prävention von Ereignissen als auch in der Nachbereitung. Für mich persönlich, da ich im Response Bereich tätig bin, im direkten Nachgang von Ereignissen. Wichtig ist nur, dass andere Anforderungen an Karten gestellt sind, je nach Bereich und man dort unterscheidet.

Können Sie mir spontan drei Begriffe nennen, die Sie mit Dashboards assoziieren? Können Sie mir Ihre Wahl erläutern?

Mit einzelnen Begriffen tue ich mich ein wenig schwer, da meine Erfahrung mit Dashboards eher begrenzt ist. Spontan würde ich aber sagen **zusätzlicher Informationsgehalt** und **Interaktivität**. Zur Erläuterung: Ich finde, Dashboards ermöglichen, dass Informationen so dargelegt werden und so vorher aufbereitet werden, dass sie sehr schnell und intuitiv erfasst werden können. Interaktivität, in dem Sinne, dass der Nutzer auch einbezogen wird und verschiedene Layer explorieren kann. Der zusätzliche Informationsgehalt, der durch Dashboards verfügbar wird, ist zum Beispiel, dass man über 2D Karten hinaus zusätzliche Informationen über Diagramme und Graphen darstellt und entfalten kann. Das bietet enormes Potential, da diese sonst vielleicht bei statischen 2D Karten einfach untergegangen wären.

In die Zukunft geschaut: Wo sehen Sie die Trends

a. Im Risk Management von Naturkatastrophen/Anthropogenen Risiken

b. In der Visualisierung von Geodaten?

Trends zu a) sind, dass eine wesentlich größere Anzahl von Ereignissen in allen Bereichen stattfinden. Statistisch betrachtet sind Hochwasserereignisse und Fluten ganz vorne mit dabei, da sie auch jahreszeitlich bedingt sind. Zudem beobachten wir steigende Trends in Brandereignissen und Waldbränden. Zu anthropogenen Risiken sind zum Beispiel Dürren sehr häufig. Anthropogene Ereignisse wie Dürren sind aber manchmal mit Fernerkundungsdaten zwar evaluierbar, aber schwieriger zu beurteilen. Da haben wir aber auch nicht so viel Erfahrung, wir sind ja eher bei sehr akuten Ereignissen im Response Bereich angesiedelt.

Gibt es denn auch schon eine Erklärung für die Anzahl an steigenden Fällen? Zum Beispiel ist die Erfassung der Krisensituationen einfach besser geworden oder ist gibt es eine Kopplung zum Klimawandel?

Genau, eigentlich ist es beides. Einerseits hat man bessere Erfassungssysteme, also größere und bessere Fernerkundungssysteme. Dort ändert sich wirklich der Blick auf das Weltgeschehen, da wir inzwischen tägliche Abdeckung der Erdoberfläche durch Satelliten haben. Zum anderen spielt eben auch der Klimawandel eine zentrale Rolle. Dazu kommt auch, dass sich Siedlungsgebiete allgemein stark verändern. Diese weiten sich immer mehr aus und damit verbunden eben auch die Größe von den Gebieten, die zum Beispiel von Hochwasser betroffen sind. Das hat dann direkte Auswirkungen auf die Erfassung von solchen Ereignissen.
Bei der Visualisierung von Geodaten stellen wir firmenintern auch fest, dass der Trend sich wegbewegt von 2D Karten als statische Karte hin zu online Visualisierung. Nutzer und Kunden möchten Ihre Daten inzwischen auch online verfügbar haben.

Auch zum Beispiel 3D?

3D ist auch ein spannendes Thema, wird aber zurzeit bei uns gar nicht umgesetzt. Das ist dann eher ein Zukunftsausblick und hängt auch stark vom Ereignis selbst ab. Zum Beispiel bei Hochwasser macht 3D nur begrenzt Sinn, eher dann spontan gesagt bei Hangrutschungen. Das einzige, was mir zum Thema 3D und Hochwasser einfallen würde wäre, wäre bei Überflutungen in urbanen Gebieten, um auch die Wassertiefe des Flutereignisses darzustellen.
Und eben auch hochauflösende genaue Oberflächenmodelle zur Verfügung stehen.

Und von der 2D Karte zur Online Visualisierung. Bedeutet das, dass man die Karten online freigibt und auf sie zugreifen kann? Oder das Karten und andere interaktive Visualisierungstechniken online besser gekoppelt werden können?

Ja, zum Beispiel ist es beim Copernicus Emergency Service so, dass die Daten frei verfügbar sind. Das bedeutet in der Regel, dass jeder auf die Daten zugreifen kann. Und dass bedeutet im Umkehrschluss aber auch, dass nur Daten benutzt und verwendet werden können, die einen gewissen Standard haben, sodass sie eben auch leicht systemseitig dargestellt werden können. Das ist der eine Punkt. Der andere Punkt ist aber auch, dass Daten nicht nur schnell und direkt verfügbar sein müssen und leicht in ein GIS geladen werden können, sondern auch, dass sie direkt verfügbar gemacht werden auf einer Weboberfläche. Das bedeutet, dass der Nutzer sich die Daten nicht mehr downloaden muss, sondern sie direkt auf dem Verteiler verfügbar sind und angeschaut bzw. dargestellt werden können.

Verstehe, und wahrscheinlich auch, dass man von überall her Zugriff auf die Daten hat.

Ja, genau.

Haben Sie zum Abschluss noch einen Aspekt, der im Zusammenhang mit dem Dashboard Prototypen beachtet werden sollte?

Ja, hier lege ich noch einmal den Fokus auf den Mehrwert. Wie kann man zusätzliche Informationen sinnvoll darstellen, damit sie zum Beispiel Entscheidungsfindung unterstützen? Das könnten zum Beispiel Social Media Dateien, die zu Events kursieren, sein, und wie könnte man diese verknüpfen, mit Daten, die wir zum Beispiel schon produzieren.

Ja, genau oder vielleicht auch historische Daten?

Ja, historische Daten sind auch ein guter Punkt. Bei Ereignissen braucht man oft die Vergleichbarkeit. Dort kann man sie als Erfahrungsdaten mit einbeziehen, um abschätzen zu können, wie Ereignisse sich entwickeln.

Cartography M.Sc.

Leitfadeninterview vom 25. Mai 2020 – Munich RE:

Die Fragen beziehen sich auf das interaktive kartografische Online-Tool der Munich RE.[1]

Zu Anfang möchte ich Sie bitten, sich kurz vorzustellen und zu erläutern, warum Sie sich für das Feld Disaster Risk Management entschieden haben.

Mein Name ist [redacted] und ich arbeite bei der Munich RE im Bereich Reinsurance and Development. Dort betreue ich den NatCatService, das beinhaltet Datenbankenthematiken, aber auch noch weitere Aspekte. Ich bin seit 2001 bei der Munich RE, seit 2005 betreue ich die Datenbank und seit 2017 leite ich den NatCatService.

Kurz zu meiner Ausbildung: Ich bin Geografin und habe hier in München Geografie, Fernerkundung und Geologie studiert, absolvierte einige Praktika und habe Berufserfahrung im Verlagswesen gesammelt. Letztendlich kam ich dann zur Münchener Rück. Dort bin ich dann letztendlich geblieben, weil die Tätigkeit genau das darstellte, was ich eigentlich machen wollte.

Sie leiten den NatCatService der Munich RE Group, der ein innovatives Analyse-Tool zur Visualisierung von statistischen Daten über Naturkatastrophen zur Verfügung stellt.
Deshalb würde es mich interessieren, welche generellen Punkte und Schlüsselaspekte im Design von Dashboards im Disaster Risk Management aus Ihrer Sicht beachtet werden müssen.

Also erstmal zur Entwicklung des Tools und was wir innerhalb der Münchener Rück mit der IT konkret programmiert haben: Auf der Basis der Erfahrung, die ich innerhalb der gesamten Aspekte der Datenanalyse habe, entstand die Initialzündung daraus, dass wir gesehen haben, dass es unendlich viele Möglichkeiten gibt, wie wir unsere Statistiken visualisieren können. Dabei lief es immer auf dieselbe Darstellungsform hinaus: Zeitreihen über Anzahl an Schäden, Prozentverteilungen und Tabellen von tödlichsten/teuersten Ereignissen. Die variablen Faktoren hängen von der Eingabe ab/bzw. was genau der Nutzer abfragen möchte ab: also bei uns der Zeitraum und der Länderscope, die Ebene, auf der ich mich befinde (Welt, Kontinente, Länder) und Naturkatastrophen. Die Abfrage von Naturkatastrophen kann angepasst werden, sodass der Nutzer entscheiden kann, z.B. nur Wetterereignisse zu betrachten, oder zum Beispiel nur Überschwemmungen. Bezüglich der Datenbank – es ist eine sehr komplexe Datenbank, mit vielen Attributen und Variablen, war die Idee, den Aufwand für den Anwender des Tools so gering wie möglich zu halten. Jedoch sollten dennoch alle Fragen mithilfe der Datenbank und zu der Komplexität des Themas beantwortet werden können.

[1] https://natcatservice.munichre.com/

Also verstehe ich das richtig, dass praktisch die Balance gefunden werden musste, diese ganze Komplexität auszuschöpfen, jedoch das Tool dennoch möglichst nutzerfreundlich zu gestalten? Sodass der Nutzer nicht komplett überfordert wird, durch die hohe Anzahl an Informationen und Daten?

Ja genau, und dass es kein Hexenwerk ist, dieses Tool zu bedienen. Der Nutzer soll dieses Tool einfach bedienen können und intuitiv genau die Informationen bekommen, die er auch haben möchte. Deshalb war es wichtig, dass das Tool so gestaltet ist, dass es möglichst einfach zu bedienen ist und dass man keine große Schulung braucht, um damit umzugehen. Außerdem soll es einfach auch Spaß machen, damit zu arbeiten. Und natürlich war auch wichtig, dass wir nicht mehr Informationen herausgeben, als wir eigentlich möchten.

Dass Sie den Spaßfaktor erwähnen, finde ich auch sehr interessant. Ich glaube auch, dass es unglaublich wichtig ist und förderlich ist, wenn man Daten spielerisch explorieren kann, da sich dadurch Zusammenhänge viel einfacher ergeben.

Ja genau, da haben wir auch sehr lange darüber nachgedacht und diskutiert. Für uns als Experten sind die Datenbankthematiken einfach zu verstehen. Wir wollten aber das Tool so konzipieren, dass Kollegen und/oder auch Führungskräfte, die vielleicht nicht ganz so technikaffin sind, sich nicht komplett neu einarbeiten müssen. Mit der Hilfe der Kollegen, mit denen wir das Tool und die Datenbankabfrage getestet haben, wollten wir zudem herausfinden, ob diese sich auch schnell zurechtfinden und die Informationen bekommen, die sie auch benötigen. Das war nicht so ganz einfach da eine Gangart bzw. einen Mittelweg zu finden, aber ich denke, dass ist uns jetzt ganz gut gelungen.

Ein Punkt, der auch noch wichtig zu erwähnen ist, ist folgender: Das Tool läuft jetzt seit gut drei Jahren. Solange haben wir es jetzt am Netz und dabei ist auch herausgekommen, dass diejenigen, die sich in dem Thema Disaster Risk Management befinden und sich gut auskennen, mit dem Tool relativ schnell an ihre Grenzen stoßen. Das liegt einfach daran, dass sie schnell begreifen, wie das Tool funktioniert und welche Möglichkeiten es gibt. Und all so Fragen zu genaueren Informationen, also wie ist z.B. die Situation in einem US-Bundestaat oder einem Bundesland, oder generell zu kleineren Verwaltungseinheiten können wir mit unserem Tool nicht beantworten und deswegen geben wir die Informationen auch nicht heraus.

Ein weiterer wichtiger Aspekt ist auch, wie dieser Datenbestand, oder sogar Datenschatz geschützt werden muss. Das ist schon eine ziemliche Gratwanderung zwischen welche Daten überhaupt genau freigegeben werden und welche nicht. Kann man zum Beispiel einen Studenten vor die Datenbank setzen und dieser schafft es die komplette Datenbank abzuziehen oder kann sie einfach gehackt werden – das waren alles Aspekte, die wir uns ganz genau überlegt haben.

Dashboards bündeln zusätzlich zu interaktiven Karten auch andere risikorelevante Informationen und KPI's in z.B. Graphen und Diagrammen. Gibt es Ihrer Meinung nach, ein optimales Verhältnis von Karten und anderen Elementen wie Graphen in Dashboards?

Der rote Faden, der sich durch das Tool zieht, ist Folgender: Man hat die Hauptkarte, dass ist das mittlere Element, bzw. das fokussierende Element. Dann befindet sich auf der linken Seite ein Bereich, der dreiteilig ist, mit verschiedenen Auswahlkriterien. Dort kann man sich durch verschiedenste Ereignisarten durch die Welt und Kontinente klicken. Dann haben wir zusätzlich noch Länderanalysen und zusätzliche Daten visualisiert, auf Karten und einer Zeitachse. Wir haben uns entschlossen einen fünf Jahreszeitraum vorzugeben, aber man kann manuell die Zahl erweitern und man kann sich einzelne Jahre anschauen. Man kann allerdings keinen Zeitraum kleiner als fünf Jahre betrachten – da müsste man schon Jahr für Jahr einzeln durchklicken.

Ein weiterer Aspekt ist, dass die Überschrift als mathematischer Term generiert wird. Das bedeutet, dass die Karte oder die Endprodukte sich als mathematische Terme zusammensetzen. Das bedeutet wiederum, dass am Anfang immer „Geographical Overview of" steht – „relevant natural loss events (wenn man Erdbebenevents anschauen würde, stände dort Earthquake Events)". Dann kommt der regionale Scope, das wäre dann „worldwide", „Europe" oder bei Länderanalysen würde dort „Germany" stehen. Und zum Schluss steht als Term der Zeitraum, den man unten im Tool auswählen kann.

Für uns war auch wichtig, dass die relativ vielen Darstellungsformen gut organisiert sind. Die Darstellungsformen findet man auf der rechten Seite im Tool unter „Produkte". Wenn man dort draufklickt, zum Beispiel auf „No. of Events", sind diese Produkte nicht mehr in der Auswahl, sondern hintereinandergeschaltet, sozusagen wie beim online shopping. Dort war der Gedanke aber auch, dass dieser Reiter nicht zu einer Hyper-Komplexität führt, wenn man sich jetzt auch noch in diesem Reiter durch die Produkte klicken könnte, die dann alle automatisch generiert und zur Verfügung gestellt werden.

Verstehe, dass wäre dann wahrscheinlich noch einmal ein höheres Abstraktionslevel, wenn man noch eine Ebene weiter gehen könnte.

Ja, ganz genau. Das haben ich einfach aus der Erfahrung heraus entschiedenen, da ich den Bereich Analyse, Service und Anfragen schon sehr lange betreue. Oftmals ist es zum Beispiel für Menschen auch schwierig zu verstehen, wenn die Überschrift „alle Naturkatastrophen weltweit" anzeigt und Menschen mich dennoch fragen, ob das jetzt nur Wetterkatastrophen sind. Mir geht es einfach darum, dass Menschen, die keine Fachleute sind, die Informationen genauso sicher nutzen können und mit den Daten arbeiten können, wie echte Profis.

Dieser Punkt beschreibt wahrscheinlich auch eine Art Trade-Off, den Sie eben angedeutet haben. Das Tool wird simpel genug gehalten, dass es sich von allein erklärt, aber eben auch komplex genug, Informationen vielschichtig und auf mehreren Ebenen darzustellen. Aber ich denke, das genau ist die Kernthematik bei Dashboards. Es ist ein ziemlicher Balanceakt, sich genau zu überlegen, welche Informationen werden freigegeben, wie interaktiv kann ich das Dashboard gestalten, ohne den Nutzer zu überfordern und wie stelle ich gleichzeitig dennoch viele Daten und Informationen komplex, jedoch schlüssig dar.

Ganz genau. Letztendlich kann man das auch darauf zurückführen, dass man Fehler vermeidet. Das ist auch ein wichtiger Punkt: Unsere Daten werden gerne genutzt und für alle möglichen Thematiken interpretiert. Da möchten wir auch keine Vorlage für Falschinformationen bieten, das finde ich unglaublich wichtig.

Dennoch ist es ziemlich kooperativ und nett, dass Sie dennoch die Daten und Informationen über so ein Tool zur Verfügung stellen.

Nun gut, die Idee und der Hintergrund waren natürlich auch, bei uns im Fachbereich Aufgaben und Arbeit zu minimieren. Und das ist tatsächlich auch so eingetreten. Ich denke, man kann sagen, dass die Anfragen, die wir bekommen zu 95% über das Tool abgewickelt werden. Ein weiterer Punkt ist der hohe Automatisierungsgrad. Aus dem Tool kann nur eine PDF abgezogen werden, etwas, was von der Qualität her noch verbesserungswürdig ist. Jedoch verlangt alles andere, was grafisch hochwertiger sein soll, so viel mehr an IT-Aufwand und Qualität, insbesondere wenn es um die Kartendarstellung geht. Ein Beispiel wäre, dass die Karten, die in der Süddeutschen Zeitung abgebildet werden, noch klassischer Weise mit GIS und/oder auch PowerPoint erstellt werden. Dies geschieht dann noch manuell, da man berücksichtigen muss, dass die Auswahl der Ergebnisse oder auch die Beschriftung angepasst werden kann und muss. Da hat unsere IT-Abteilung sofort gesagt, dass wenn man den ganzen Prozess automatisieren möchte, dies ziemlich problematisch wäre, da es einfach zu viel Zeit verschlingen würde und auch zu viel kostet.

Verstehe, dass sind dann wahrscheinlich auch viel individuellere Anfragen. Aber man kann schon eine gewisse Pragmantik heraushören, wenn Sie sagen, dass 95% der Anfragen über das Tool abgedeckt werden und die restlichen 5% hochwertig, über Geoinformationssysteme aufbereitet werden.

Ja genau, das ist jetzt vielleicht wenig überraschend, aber wir waren immer sehr großzügig mit unseren Informationen und haben auch viele Daten geteilt. Mein Standardspruch ist, dass wir Analysen vom Schüler bis zum Weißen Haus gemacht haben, und das ist tatsächlich auch so. Da war auch ziemlich viel Finanzwirtschaft vorhanden. Jetzt, drei Jahre später ist „State of the Art“, dass Daten das neue Gold sind. Und gerade die gesamte Disaster Risk Reduction Community hat sich zu einer gesamten Industrie weiterentwickelt, dort verändert sich gerade wirklich die Welt. Das ist auch der Grund, warum das Tool im Moment nicht mehr mit den 2019er Zahlen geupdated wird. Wir arbeiten gerade an einem reduzierten Scope, sodass wir nur noch die Welt-Grafik zur Verfügung stellen, jedoch keine Detailanalyse mehr frei verfügbar machen. Die kann dann über eine Bezahlfunktion zukünftig erworben werden. Das hat nicht den Grund, dass wir in dem Zusammenhang immens viel erwirtschaften könnten – dafür sind die Daten auch nicht valide genug. Allerdings ist die Herstellung der Daten alles andere als kostenneutral, und was keinen Preis hat, das hat auch nicht wirklich einen Wert. Also in der Hinsicht findet schon gerade ein Umdenken statt, dass finde ich aber auch in Ordnung.

Stimmt, das hat auch einfach etwas mit Datenschutz zu tun.

Genau. Wenn zum Beispiel jemand für seine Masterarbeit Graphen verwenden möchte, dann verlangen wir natürlich kein Geld – darum geht es auch gar nicht. Wir haben nur ganz viele institutionelle Fälle aus der Finanz- und Versicherungswirtschaft, oder auch ganz stark Modellierungen, die auf der Grundlage von unseren Daten gebaut werden. Das sind dann oftmals Lizenzprodukte mit horrenden Beträgen und da kann es nicht sein, dass wir dies praktisch frei Haus mit unseren Daten finanzieren und fördern, das ist eigentlich der Kernpunkt. Letztendlich fallen dadurch natürlich auch alle anderen hinten runter, aber man muss dann eben auch einen Tod sterben.

Ich kann mir auch vorstellen, dass es einfach auch an dem Bekanntheitsgrad der Münchener Rück liegt. Da im Zusammenhang mit Naturkatastrophen die Münchener Rück schon als Arbeitgeber in der Assoziation steht. Ich denke, wenn man ein kleines Unternehmen oder eine kleine Institution ist, hat das einfach auch nicht so einen großen Wirkungsgrad.

Das ist das eine. Natürlich sind wir als Konzern ein Schwergewicht. Das ist manchmal ein Fluch, manchmal ein Segen. Aber andersherum haben wir auch einfach den Anspruch die beste und umfangreichste Informationsquelle über Naturkatastrophen zu sein. Den Anspruch hatten wir schon immer, und deswegen sind wir letztendlich auch Marktführer, was diesen Punkt angeht. Deswegen liegt die Messlatte aber auch sehr hoch - aber das ist auch gut so und soll auch so sein. Um dies aufrechtzuerhalten, muss man sich aber auch eben ein wenig ändern und anpassen. Es ist aber nett, dass Sie sagen und das ist auch mein Anspruch, dass wenn man an Naturkatastrophen denkt, man eben auch an die Münchener Rück denkt.

Gerne, dass kann ich auch nur zurückgeben. Ich denke in meinem Studienumfeld, also in der Geo/IT/Kartographie Branche, ist die Münchener Rück schon ein Name. Das ist zumindest meine Wahrnehmung.

Dann noch einmal zu den kartographischen Visualisierungsmethoden: Welchen Stellenwert haben diese und Karten im Allgemeinen im Disaster Risk Management für Sie? Und gibt es da Ihrer Meinung nach, ein optimales Verhältnis von Karten und anderen Elementen wie Graphen, Diagrammen etc. in Dashboards?

Für mich persönlich haben sie einen sehr hohen Stellenwert, denn durch die Visualisierung hat man einfach unendlich viele Möglichkeiten. Aber wenn man diesen Bogen überspannt – Sie studieren ja GIS und Kartographie - und man unendlich viele Karten produziert, die man dann am Ende auch nicht mehr voneinander unterscheiden kann, dann bringt das natürlich auch nichts.

Als Beispiel, zusätzlich zum NatCat Analyse Tool ist ein gutes Beispiel die John Hopkins Covid-19 Dashboard Darstellung. Ich finde, dass ist ein ganz gutes Beispiel und passt zu Ihrem Thema, denn da sieht man wirklich den Aufbau eines Dashboards im Disaster Risk Management ganz gut. Man hat die Hauptkarte, auf die der Fokus gelegt wird und die auch ein Hingucker ist, und dort schaut man hauptsächlich drauf und arbeitet damit.

Zusätzlich ist es bei uns eher so, dass es noch ein „mouse hover – over – Feature“ gibt, wodurch die großen Ereignisse praktisch automatisch mit Namen gekennzeichnet werden, wenn man den Mauszeiger darüber bewegt, und Datum, Region und Gesamtschaden angezeigt wird. Das bedeutet, dass der User eine Karte hat, wo er sich ausprobieren kann und ich denke das reicht auch erstmal im Hauptfeld bzw. im Hauptmenu. Und bei Country Profiles haben wir dann eben noch mal drei Sonderanalysen. Wenn man diese aufruft, wird auch jedes Mal eine Karte mit der Analyse als Hauptkarte dargestellt.

Verstehe. Sie meinen, dass extra Daten und unterstützende Informationen untergeordnet sind innerhalb der Visualisierungshierarchie.

Genau, man hat das zentrale Element Karte – ganz mittig, aber sehr reduziert. John Hopkins arbeitet genauso. Im Mittelfeld ist die Karte - die Statistiken und Zahlen sind drumherum angesiedelt.

Verstehe, damit die Karte vermutlich auch ein Alleinstellungsmerkmal hat und der Fokus genau darauf gelenkt werden kann.

Genau, denn das Schlimmste ist wirklich Verwirrung durch zu viele Informationen. Wir arbeiten auch mit der EEA in Kopenhagen zusammen, schon seit vielen Jahren haben wir mit dieser Institution eine Arbeitsgemeinschaft – das ist die europäische Umweltagentur. Und dort gibt es oftmals eben auch Expertenmeetings, wo einzelne Wissenschaftlergruppen ihre Arbeit vorstellen. Und bei Präsentationen, mit 20 Karten, die hintereinander gezeigt werden, steigt einfach jeder aus. Aber ja, um das noch einmal zusammenzufassen: Das Kartenelement finde ich persönlich total wichtig, aber zentral, groß und dann reduziert.

Wenn man sich jetzt noch einmal die einzelnen Bereiche anschaut: in welchen Bereichen (Planning und Preparedness, Response, Recovery, Prevention und Mitigation) sind Karten besonders relevant, beziehungsweise haben Ihrer Meinung nach ein besonderes Potential?

Damit meine ich, würden Sie sagen, dass Karten in einem dieser Bereiche einen ganz besonders hohen Stellenwert haben, oder würden Sie einfach sagen, sie werden in allen Bereichen häufig genutzt?

Welchen Trend ich schon bemerke, ist dass unsere Daten und Auswertungen gerne für Eingangsstatements und Übersichten genommen werden. Das praktisch mit unseren Zahlen und Grafiken der Rahmen gesteckt wird und das kann man eigentlich in jedem Bereich der Disaster Risk Reduction anwenden. Vor allem, wenn man Vergleiche ziehen möchte. Zum Beispiel bei Ländern und Regionen, gilt im Prinzip das gleiche, und zwar wenn ich einen Punkt untermauern möchte, kann ich dafür eine Karte oder Grafik zeigen, die diesen Punkt unterstützt. Ansonsten geht das dann doch sehr in Richtung wissenschaftliches Arbeiten, was dann auch noch einmal auf andere Art und Weise funktioniert. Und mit unseren Daten werden viele Studien in den unterschiedlichen Bereichen geschrieben.

Also Sie meinen, dass es schon eine starke Bereichsabhängigkeit gibt.

Ja genau.

Können Sie mir noch drei Begriffe nennen, die Sie mit Dashboards assoziieren und mir danach Ihre Wahl erläutern?

Drei Begriffe weiß ich jetzt nicht ganz genau. Aber was ich erwarte, wenn ich so ein Dashboard aufmache ist, dass das Material gut aufbereitet ist, also sprich Karte, Grafiken und Statistiken vorhanden sind. Dann erwarte ich, dass es in der Bedienung schlüssig und anwenderfreundlich ist und keine Dead Ends vorhanden sind. Bei dem John Hopkins Dashboard ist mir aufgefallen, dass wenn ich ein einzelnes Land auswähle, ich bei der Suche dorthin komme und auch die Statistik angezeigt bekomme, aber es dann keinen Zurück-Button zur Welt gibt. Das ist zwar nur eine Kleinigkeit, aber man muss das Dashboard dann schon komplett neu laden.

Verstehe, also man sollte darauf achten, dass das Design und die Handhabung schlüssig sind, und der Kreis sich auch schließen kann.

Genau.

In die Zukunft geschaut: Wo sehen Sie die Trends

a. **Im Risk Management von Naturkatastrophen und anthropogenen Risiken wie Pandemien?**
b. **In der Visualisierung von Geodaten?**

Ich denke, der Trend geht dahin, sehr viele Informationen in eine Applikation zu bündeln. Das kann dann weitergeführt werden, dass der Kunde, oder jemand der mit den Daten arbeitet, seine eigenen Zusatzdaten hinzufügen kann, und diese explorieren und analysieren kann. Der Trend geht auch ganz stark in Richtung Automatisierung – wie werden die Daten aufbereitet und konsumiert? Das kann man auch daran beobachten, wie diese Tools gebaut werden. Wir haben natürlich auch einige davon, die ganz unterschiedliche und externe Datenquellen anzapfen. Dann wird zum Beispiel die Erdbeben Magnitude vom USGS bereitgestellt. Also, es geht darum, dass man Dienste miteinander verbindet und nicht nur die Dienste selbst, sondern auch deren Funktionen, und dass man es schafft diese in einer Applikation zu gliedern. Ich denke es wird alles digitaler, schneller, transparenter und technisch immer ausgeklügelter. Ich habe zum Beispiel auch einen ganz guten Kontakt zum DLR. Dort wird auch daran geforscht, wie man Geodaten effizient anreichert und mit unterschiedlichen Zusatzinformationen bestückt. Man kann zum Beispiel ein Luftbild auswerten und zusätzlich Social Media Dateien anzapfen. Und allgemein, denke ich, geht es darum einen Überblick zu entwickeln und man die digitale Welt in ihrer Gesamtheit sieht und diese dann auch zusammenbringt.

Genau, dass sehe ich eigentlich auch so, wie Sie sagen. Es geht darum verschiedene Informationsquellen zu bündeln, um das Große Ganze gut erkennen zu können. Und auch, dass man möglichst viele Perspektiven einnehmen kann, um Probleme unterschiedlich zu beleuchten und Aspekte und Trends festzustellen.

Ja genau, und eben auch der Spaß Faktor. Welche Informationen und Zusammenhänge kann man aus Daten herausholen? Zum Beispiel haben wir einmal Wetterdaten mit Einbruchsdaten kombiniert und konnten feststellen, dass wenn schönes Wetter war, auch die Einbrüche zurück gingen – bzw. andersherum die Anzahl der Einbrüche bei schlechtem Wetter stieg. Also, mein Punkt ist einfach, dass Geodaten das große Potential bieten, ganz unterschiedliche Zusammenhänge zu erkennen. Das könnte man jetzt auch zum Beispiel auch auf die Corona Zeit anwenden. Die Zahl der Einbrüche müsste jetzt eigentlich gegen null gegangen sein, da alle zuhause sind. Solche Fragestellungen werden eben auch versucht aus den Daten herauszukitzeln. Und dazu gehört auch, dass man Daten zusammenbringt, die jetzt erst einmal nichts miteinander zu tun haben.

Verstehe, es wird also nach Korrelation zwischen verschiedenen Datensätzen geschaut.

Genau, oder ob es irgendwelche Informationen gibt, die man aus den Daten noch herausziehen und zusätzlich analysieren kann. Der NatCatService ist alles andere als Big Data. Dagegen sind wir eine mini Datenbank. Wir sind sehr hochwertig in der Anlage, aber im Grunde sind wir eher eine Datenmanufaktur. Big Data ist einfach noch einmal anderes vom Schwerpunkt her und bietet deswegen auch andere Möglichkeiten.

Vermutlich hat auch beides einfach seine Vorteile. Ich denke im Zusammenhang mit Big Data stellt sich eben oftmals die Frage nach der Datenqualität und ob diese hoch und genau genug ist. Wie steht der Aufwand, diese Daten aufzubereiten in Relation zu einer kleinen, aber sehr gepflegten Datenbank.

Genau, dass ist eben eine dieser Fragen, wo dort die Reise hingeht. Also reicht es für die Zukunft, dass man eine kleine Datenamanufaktur hat, oder ist ein anderer Ansatz besser und Datenqualität spielt nicht mehr so eine große Rolle, sondern zum Beispiel eher Schnelligkeit in der Beschaffung. Das ist im Moment ziemlich spannend, aber da kann ich leider auch keine klare Antwort geben. Es gibt unendlich viele Möglichkeiten in der Technik und in der IT, aber wenn man diese Möglichkeiten nutzt, sollte es auch sinnvoll sein. Halb blind irgendetwas auszuprobieren, ist dann auch etwas schwierig.

Ich könnte mir auch gut vorstellen, dass sich beides als wahr erweist und es einfach zwei unterschiedliche Ansätze sind. Dass man einerseits, die Daten, die man hat, möglichst gut und hochwertig aufbereitet und pflegt, um viele Informationen ableitbar zu machen und diese eine gute Analysebasis bieten. Und andererseits, dass im Zusammenhang mit Big Data die Technik immer besser und genauer wird. Im Grunde schließen sich beide Ansätze ja auch nicht aus, es sind einfach nur zwei verschiedene Herangehensweisen.

Jedoch zum Abschluss: Haben Sie noch ein gutes Beispiel für ein Dashboard, das Ihnen spontan einfällt?

Also wie gesagt, das Dashboard von der Johns Hopkins Universität finde ich gut gelungen. Ich denke es ist optisch noch verbesserungswürdig, aber ich finde gut, wie die Informationen aufgeteilt sind. Wir selber arbeiten intern auch mit Dashboards und haben diese im Gebrauch. Dort gilt das gleiche wie für das Analyse Tool: Im Grunde muss es selbsterklärend, innovativ und intuitiv sein und nicht überladen sein. Im allerbesten Fall werden keine Rückfragen generiert, sodass die Leute wirklich gut selbst damit Arbeiten können, denn wenn es zu kompliziert ist, ist dann damit auch nichts gewonnen. Ich glaube, das waren die wichtigsten Punkte.

Cartography M.Sc.

Leitfrageninterview vom 26. Mai 2020 – Fraunhoferinstitut:

Es wird sich hauptsächlich auf das Covid-19 Dashboard [1] bezogen.

Zu Anfang möchte ich Dich bitten, sich kurz vorzustellen.

[redacted]. Von der Ausbildung her bin ich Geoinformationsexperte und GIS Spezialist. Ich habe Anthro-Geographie und Sozialwissenschaften studiert und im Master Geoinformationswissenschaften, GIS und Remote Sensing. Beschäftigt bin ich seit 10-15 Jahre in diesem Bereich und habe mich konstant weitergebildet, da ich immer einen großen Wissensdrang hatte und sich die Technik zudem ständig verändert. Beruflich bin ich zurzeit am Fraunhoferinstitut beschäftigt und wir unterstützen Kommunen im Prozess der Digitalisierung und versuchen dort neues Potential zu erschließen.

Du hast selbst ein Dashboard zur Covid-19 Thematik erstellt.
Deshalb würde es mich interessieren, welche generellen Punkte und Schlüsselaspekte im Design von Dashboards im Disaster Risk Management aus Deiner Sicht beachtet werden müssen.

Während der Corona Krise habe ich das Potential gesehen, um mit öffentlich-rechtlich zugänglichen Daten Informationen zur Krise zu visualisieren, die jedem verständlich und zugänglich sind. Das war im Januar, als das Robert Koch Institut zum Beispiel nur drei Parameter zur Verfügung gestellt hat (Tote, Infizierte, Genesene). Die Daten waren hierbei auf Landesebene aggregiert – also ziemlich grob. In Deutschland waren zu diesem Zeitraum auch noch keine Fälle gemeldet – das geschah erst vier Wochen später.

Ich habe versucht, diese ganzen verschiedenen und unterschiedlichen Datenströme zu konsumieren, die mir erhältlich waren und diese gebündelt auf einem Dashboard der ESRI Software darzustellen. Das waren lange Zeit nur eben diese drei Parameter, bis wir nach und nach mehr hinzugefügt haben. Als die Zahlen nach und nach gestiegen sind, wurden diese nicht mehr nur nach Ländern aggregiert, sondern auch auf Bundesebene. Dabei hat zunächst ein kleines Team vom SWR eine große Rolle gespielt, die versucht haben mithilfe der R Programmiersprache Daten von den Gesundheitsministerien im SWR Gebiet aufzunehmen, zu visualisieren und dann wieder aufzuspielen. Dies geschah in Form von relativ simplen Karten und Visualisierungen auf der Homepage des SWR selbst. Aber da die Daten dadurch öffentlich zur Verfügung gestellt wurden, konnte ich diese dann wiederrum konsumieren für mein eigenes, in der Planung befindliche, Dashboard. Zunächst habe ich alles noch per Hand und manuell

[1] https://fraunhofer-iao.maps.arcgis.com/apps/MapSeries/index.html?appid=eaa9b8c67d52488b95c4fe57aa3f7cb2

gemacht, im Nachhinein dann automatisiert mithilfe von Python Scripten. Die Daten habe ich dann über die ESRI Enterprise Plattform visualisiert und automatisiert. Deswegen muss ich heutzutage nicht mehr viel selbst machen.

Wie funktioniert das? Über eine Python API?

Nein, es werden Daten im CSV Format eingelesen. Neben Baden-Württemberg stellen wir auch Fälle aus Bayern da. Daten aus Bayern werden allerdings nicht öffentlich zur Verfügung gestellt, sondern hier benutzen wir eine Technik namens WebScripting. Über ein Script werden Daten auf einer Website automatisch abgegriffen, wenn diese nicht zur Verfügung gestellt werden. Zusammengefasst gibt es viele unterschiedliche Wege und Arten Daten zu konsumieren, um diese ins Dashboard aufzunehmen.

Anders herum, bergen viele verschiedene Datenströme, gerade auch aus externen Quellen, Risiken. Um das SWR Beispiel aufzugreifen: Dort wurden neulich die Ursprungsdatenquelle und der Output verändert. Das hatte zur Folge, dass ich meine kompletten Daten im Dashboard wiederum anpassen musste und die Arbeit von zwei Monaten zunichte gemacht wurde. Im Grunde bedeutet dies, dass wenn neue Parameter hinzukommen oder sich original Daten ändern, muss auch das Dashboard von seiner Struktur her angepasst werden und Daten neu aufbereitet und eingegliedert werden. Das eigentliche Dashboard sind praktisch die letzten 5% der Arbeit. Viel mehr Aufwand steckt in der Datenaufbereitung, dass Daten zueinander passen, das Dashboard Design, die Überlegungen welche Daten man genau abbildet und wie sie zueinander passen. Die Vorarbeit ist der eigentlich große Teil der Arbeit, die man leistet.

Das bedeutet, dass Deiner Meinung nach der Datenaufbereitungsprozess, sowie Bündelung der Datenquellen, der Desingprozess, kartographisches Design und die Überlegungen, wie die verschiedenen Elemente zusammenpassen und interagieren können, den größten Aufwand ausmachen?

Genau, die Kunst der Stunde ist, sich gute Daten zu suchen, und diese so auszuwerten und aufzubereiten, dass man sie gut verwerten kann und sie zusammenpassen. In unserem Fall, da wir ein Live-Dashboard erstellt haben, ist dies besonders wichtig. Da muss die Datengrundlage, von dem Datensatz, den man aufzeigen möchte, einfach sauber sein und es dürfen keine Fehler vorhanden sein. Die Prämisse ist ein wenig so, dass man am Anfang viel Zeit in die Planung und Aufbereitung investiert, sodass man im Nachhinein nicht ständig am Fehler ausmerzen und umstrukturieren ist.

Das finde ich sehr interessant, was Du beschreibst – da Du ja auch sehr klein angefangen hast. Hattet Ihr denn auch einen Punkt, wo Ihr noch einmal komplett alles neu strukturieren musstet, da irgendwelche Parameter/Elemente nicht gepasst haben? Also, was ich meine ist, wurde zu einem

Zeitpunkt eine komplett geupdatete Version des Dashboards noch einmal hochgeladen oder wurde nur nach und nach das Dashboard erweitert?

Wie ich anfangs schon erwähnt hatte, haben wir eigentlich mit ganz simplen Parametern angefangen und einer Karte. Die zwei Elemente haben wir dann interaktiv verbunden und dann wurde von Woche zu Woche beschlossen, welche Aspekte man erweitern kann. Das Dashboard ist praktisch mit der Krise gewachsen. Im Nachhinein ist dieses Dashboard einfach nicht von heute auf morgen entstanden, sondern hat sich über die letzten Monate seit Anfang Januar bis heute entwickelt. Und erst seit ca. zwei Monaten sieht es ungefähr so aus, wie der aktuelle Stand. In den letzten zwei Monaten haben sich nur noch Kleinigkeiten geändert – zum Beispiel die Displayanzeigen oder Quellen wurden ein wenig verändert/angepasst, da man bei Live-Daten bzw. öffentlich rechtlich zugänglichen Daten wirklich darauf achtgeben muss, alle Referenzen bis aufs kleinste Detail anzugeben, damit die Rückverfolgung stimmt und man das Dashboard genauso, mit den angegeben Quellen nachbauen könnte.

Zusätzlich wurden im Nachhinein auch die Karten untereinander verbunden und das Verhältnis von externen Datenquellen/ESRI Datenquellen angepasst. In dem Zusammenhang kann man auch noch erwähnen, dass das Hochladen zu unterschiedlichen Zeiträumen von original Datenquellen beachtet werden muss, falls man Vergleiche ziehen möchte. Zum Beispiel werden Daten von Ministerien/Landesbehörden zu anderen Zeitpunkten veröffentlicht als, wie zum Beispiel vom Robert Koch Institut (diese Daten sind mit zwei Tagen Verzögerung verfügbar, da diese politisch abgesegnet werden müssen). Da können schon unterschiedliche Uhrzeiten einen Unterschied machen. Es muss klar sein, dass Daten unterschiedliche Meldeketten haben und es darauf ankommt, wie diese gesammelt und verfügbar gemacht worden sind.

Um das jetzt noch einmal kurz zusammenzufassen: Schlüsselaspekte sind hauptsächlich, dass Daten sauber und vereinheitlicht sind, ein logischer und ausgeklügelter Designprozess, strukturierte Vorarbeit, ein detaillierter Aufbereitungsprozess der Daten und ein hoher Automatisierungsgrad (bei Live Dashboards). Stimmt das?

Ja, ganz genau.

Könntest Du kurz den Designprozess erläutern? Wie bist Du ungefähr vorgegangen und gab es eventuell Schwierigkeiten? Also wie entstand die Idee hinter der Anordnung der Elemente und auf welche Designaspekte bist Du genau eingegangen?

Das ist ein wenig schwierig zu erklären. Um das Ganze herunterzubrechen: Hauptsächlich Learning by Doing. Während des Erstellungsprozesses des Dashboards habe ich mir Gedanken zu Farbkombinationen gemacht und mich auch an anderen Dashboards orientiert, wie zum Beispiel dem

John Hopkins Dashboard. Um mein Dashboard dann selbst auch abzuheben, habe ich da ein wenig mit Farbkombinationen gespielt und mich dann am Ende für rosa/lila Töne entschieden – da diese sehr kräftig sind und auf dunklem Hintergrund ins Auge springen. Am Anfang fand ich die Farbthematik auch ein schwieriges Thema, da Farben sehr polarisierend sind. Letztendlich habe ich mich für die klassische Ampellogik entschieden – rot für tote Menschen, orange für Betroffene und grün für Genesene. Später kam dann der Parameter Neuinfizierte hinzu, für diesen wollte ich eine neutrale Farbe benutzen. Ich habe eben sehr viel ausprobiert und wichtiger als die Farbharmonie war mir, dass Farben herausstechen und man direkt den Kontext erfassen kann.

Und vermutlich auch, dass die richtige Botschaft gesendet wird.

Genau, das ist sehr wichtig, dass die richtige Botschaft ankommt und man direkt den Überblick und die wichtigsten Thematiken erfassen kann. In unserem Fall sind das die Confirmed Cases, Tote, Genesene etc. Das kommt aber auf den Kontext an, in welchem das Dashboard erstellt wurde. Die Botschaft kann man dann immer noch erweitern und unterstützen, bei uns zum Beispiel, in dem man dann zusätzliche Informationen wie die Gesamtzahlen angibt und man die Darstellung wechseln kann.

Bezogen auf den Designprozess. Wie bist Du vorgegangen? Hast du Dir Tipps und Vorgänge aus dem Internet zusammengesucht, vielleicht auch Tutorials aus dem ArcGis Dashboard Design Network angeschaut und danach Dein Dashboarddesign entworfen?

Ja, so ähnlich. Aber ich habe es jetzt ohne konkrete Tutorials gemacht, da ich mich schon länger mit Dashboards beschäftige und auch schon mehrere gebaut habe. Deswegen habe ich nach Gefühl designed und Grafiken eingefügt und keine offiziellen Guidelines benutzt. Eher nach dem Ansatz, ich habe viel ausprobiert, mit den Möglichkeiten und Werkzeugen, die ich habe und dadurch versucht die Daten auf verschiedene Art und Weise darzustellen.

Verstehe, würdest Du diesen Ansatz denn auch jemandem raten, der ein Dashboard noch nie selbst konzipiert hat?

Ja, auf alle Fälle, einfach um ein Gefühl für das Tool zu bekommen. Außerdem gibt es auch jede Menge ESRI Tutorials, die für jeden, dem eine Lizenz zur Verfügung steht, zugänglich sind. Diese Tutorials arbeiten mit schon existierenden, simplen Datensätzen. Das müssen ja am Anfang keine Echtzeitdaten sein wie bei uns, sondern einfach Datenquellen, die eben auch schon bestehen und von ESRI zur Verfügung gestellt werden. Das ist besonders wichtig auch für Menschen, die noch nicht so viel Ahnung von der eigentlichen Technik haben, um zu lernen, wie viele Aspekte eigentlich hinter dem Designprozess und der Konzeption stehen und auch welche Möglichkeiten überhaupt existieren.

Meine persönliche Ansicht ist, dass dies zum Beispiel auch für Manager und Führungspositionen wichtig wäre, sich mit dem Design und der Konzeption ein wenig zu beschäftigen, um den großen Arbeitsaufwand zu verstehen, der hinter so einer Erstellung von einem Dashboard steckt. Dort ist die Ansage doch oft „mach doch einfach mal schnell" – was eben in der Realität oftmals nicht der Fall ist. Die Daten am Ende zusammenzufügen ist dann der kleinste Teil der Arbeit. Der viel größere Teil ist, sich ein gutes Konzept zu überlegen, der Designprozess, die verschiedenen Tools, Datenaggregation und Einheitlichkeit – gerade bei Echtzeitdaten, und schlussendlich, dass am Ende das Gesamtkonzept stimmt und auch alles harmoniert.

Dashboards bündeln zusätzlich zu interaktiven Karten auch andere risikorelevante Informationen und KPI's in z.B.Graphen und Diagrammen.
Gibt es Deiner Meinung nach, ein optimales Verhältnis von Karten und anderen Elementen wie Graphen in Dashboards? Bei vielen Dashboards sieht man zum Beispiel ziemlich deutlich, dass man eine einzelne Hauptkarte hat, und die zusätzlichen Informationen drum herum angegliedert werden, als unterstützende Funktion. Wie viel Wert muss man Deiner Meinung nach, auf die Hauptkarte legen und viele viel auf unterstützende Grafiken? Hast Du da ein bestimmtes Verhältnis im Kopf?

Man könnte zum Beispiel annehmen, dass man 50% des Platzes der Hauptkarte geben möchte, von dem kompletten verfügbaren Platz und der restliche Platz wird auf unterstützende Karten/Graphen/Diagramme gelegt. Oder als zweites Szenario, dass der User Focus gezielt und hauptsächlich auf die Hauptkarte gelegt wird, und diese einen Großteil des Platzes einnimmt.

In meinem Fall ist das so, dass die Karte am Anfang dominiert hat, mit auf jedenfall > 50%, da am Anfang noch gar nicht so viele Parameter zur Verfügung standen, die jetzt einen Großteil des Platzes auf der rechten Seite einnehmen. Und Karten sind einfach auch deswegen wichtig, da diese eine Art Eye-Catcher sind, also sollte da auf jedenfall auch der Fokus draufliegen. Das liegt daran, dass Menschen Karten auch sehr gerne mögen und gerne anschauen. Nach und nach wurden aber auch andere Informationen zu den Landkreisen sehr wichtig, das heißt der Platz der Karte ist geschrumpft, da diese Informationen relevanter für die Nutzer waren. Durch Zoom und Transparenz von verschiedenen Elementen und Interaktivität kann man aber diesen Aspekt ganz geschickt lösen und die Verhältnisse entsprechend anpassen.

Zusammengefasst: Es ist also vom Nutzer abhängig, wie das Verhältnis zwischen Karten und Graphen ist und wird entsprechend zugeschnitten und angepasst.

Ganz genau, zum Beispiel im Corona Dashboard kann der individuelle Nutzer direkt nach dem Ort filtern, und die Karte zoomed automatisch dorthin. Dasselbe funktioniert auch mit mehreren Orten. Wichtig ist, dass der Nutzer aufs Dashboard schauen kann, und direkt die Informationen bekommt, die er auch wirklich braucht. Und das am besten schnell und intuitiv, mit nur relevanten Informationen und ohne großes Suchen. Menschen sind manchmal träge und faul und arbeiten sich ungern in neue Konzepte ein. Gerade deswegen haben Dashboards aber ein Riesen Potential, da sie sehr selbsterklärend und intuitiv sind und man mit wenigen Klicks an Informationen kommt, die ersten wichtig und relevant sind, oder manchmal eben auch nur interessant.

Genau, das sehe ich auch so. Ich glaube, deswegen ist der Designprozess auch so wichtig, da dort eben viel Wert daraufgelegt werden muss, dass das Dashboard letztendlich eben selbsterklärend und man sich nicht groß einarbeiten muss. Und das zudem auch Menschen, die nicht vom Fach sind, leicht an Informationen kommen und dass es intuitiv ist.

Ja, ganz genau. Ich habe das auch versucht Dir in einem Satz in der E-Mail zusammenzuschreiben: „In der Konzeption und im Designprozess ist es wichtig, dass man Daten und Informationen zielgruppengerecht grafisch aufbereitet, um Prozessabläufe und Veränderung der Situation einfach auf einen Blick übersichtlich und verständlich zusammen zu fassen sind."

Wenn man den Schwerpunkt auf die Kartographie legt: welchen Stellenwert haben kartografische Visulisierungsmethoden und Karten für Dich? Unteranderem zum Beispiel für Disaster Risk Management Zwecke? In welchen Bereichen sind sie besonders relevant, beziehungsweise haben sie Deiner Meinung nach besonderes Potential?

Meiner Meinung nach ist die Kartographie sehr wichtig und hat auch einen immensen Stellenwert im Disaster Risk Management. Oftmals wird Kartographie (auch Web-Kartographie) eben auch immer noch unterschätzt – da zoomen zum Beispiel auf den ersten Blick langweilig erscheint. Das man aber Informationen auf verschiedenen Leveln gleichzeitig betrachten kann, hat eine immer größere Relevanz. Gleichzeitig bieten Karten den großen Vorteil Informationen schnell und übersichtlich darzustellen und ermöglichen, Zusammenhänge zu erkennen. Das ist das eigentliche Potential der Kartographie und der Geoinformatik: sie hat immer einen Raumbezug und eventuell zusätzlich auch noch einen Zeitbezug und das ist es, was die Kartographie eigentlich so wertvoll macht.

Ja genau, wir Menschen sind eben auch visuelle Wesen. Wir verstehen Zusammenhänge einfach viel schneller durch Anschauen anstatt, indem wir uns die gleichen Informationen durch fünf Minuten lesen beschaffen.

Korrekt. Das Lernen wir schon von klein auf und spielt auch im Job eine große Rolle, wenn die Informations- und Arbeitsdichte unglaublich hoch ist. Da ist es viel hilfreicher und zeitsparender sich Visualisierungen und Karten anzuschauen, anstatt sich 30 bis 100 Seiten Reports durchzulesen.

Ja genau, deswegen ist es meiner Meinung nach auch wichtig, Leute im Fach Kartographie auszubilden. Geodaten sind heutzutage in hohem Maß frei verfügbar, was ja auch wichtig ist und durch opensource Programme wie QGIS kann man diese auch gut verarbeiten. Dennoch ist es unglaublich wichtig, da Karten, wie jetzt zum Beispiel im Disaster Riks Management, auch oftmals kritische Aspekte darstellen, dass man dort gleichzeitig auch ein kritisches Auge hat, z.B. aus welchen Quellen die Daten kommen. Damit Karten einfach auch objektiv und sachlich sind und nicht nur für bestimmte Zwecke und Meinungen genutzt oder zum Teil missbraucht werden.

Ja, genau richtig. Ich denke das richtige Wort an der Stelle ist, dass man sehr wissenschaftlich und aber auch zielgruppengerecht arbeitet.

Als kleines Beispiel: Kurz bevor ich nach Deutschland gekommen bin, habe ich für die OECD in der Ukraine gearbeitet. Dort ging es oftmals eben auch um Kriegsthematiken. Und in diesem Kriegsgebiet hatten wir Leute, die aktiv im Feld gearbeitet haben und die benötigten komplett andere Informationen als zum Beispiel Manager, die nach Minsk geflogen sind, um politische Entscheidungen/Auseinandersetzungen zu führen oder einen Waffenstillstand zu verhandeln. Das hatte den Effekt, dass diese Personen zum Teil wirklich fundamental anderen Informationen benötigt haben. In dem Zusammenhang ist es unglaublich wichtig, dass man das, wenn man im Disaster Risk Management arbeitet, eben auch erkennt und diese Informationen auf unterschiedliche Art und Weise aufbereitet.

Denselben Umstand kann man auch in der Corona Zeit beobachten. Politiker arbeiten auf einem ganz anderen Level und brauchen Informationen oftmals unglaublich komprimiert als z.B. Personen, die auf Landkreisebene arbeiten. Die brauchen oftmals viel detaillierte Informationen, zum Beispiel, wo genau unterstützt werden muss. Auf noch einer Ebene tiefer beim Roten Kreuz oder den Malteser hat man noch einmal andere Anforderungen als zum Beispiel im Vergleich zu Gesundheitsämtern, die Daten oftmals aggregiert anschauen.

Du meinst also die unterschiedlichen Kartographieaspekte müssen stark bereichsabhängig und zielgruppengerecht betrachtet werden und können dann erst effizient und spezifisch genutzt werden?

Ja, genau. Und vor allem auch bei der Dashboard Thematik ist es unglaublich wichtig sein Konzept an den Bereich und die Zielgruppe anzupassen. Bei mir war es noch ein wenig schwieriger, da ich ziemlich viele Menschen adressieren wollte und Informationen für alle verfügbar machen wollte. Deswegen lag der Schwerpunkt bei mir darauf, es möglichst simpel zu halten und nicht zu kompliziert zu gestalten. Und mir war wichtig, dass ich einen WOW-Effekt erreiche und die Leute auch erstaune.

Kannst Du mir spontan drei Begriffe nennen, die Du mit Dashboards assoziierst? Kannst Du mir dann Deine Wahl kurz erläutern?

Datenverfügbarkeit ist ganz wichtig. **Geduld** spielt zudem auch eine große Rolle in dem Prozess des Aufsetzens. Oftmals läuft vieles nicht direkt so, wie man es sich vorstellt und man wird oft auch mit Fehlern oder Schwierigkeiten konfrontiert, wie zum Beispiel beim SWR, als der komplette Datensatz umgestellt wurde und deswegen nichts mehr funktioniert hat und man sich neue Lösungen ausdenken musste, damit das Dashboard als finales Werkzeug einsetzbar ist. Zudem spielt **Expertise** eine große Rolle. Oftmals erlebe ich bei uns am Institut diese „Mach-mal-schnell Mentalität", die aber gar nicht so umsetzbar ist. Dashboard Design und Implementierung dauert seine Zeit – auch bis man diese Expertise akquiriert hat. Dann ist wichtig, dass man sich mit der Thematik auskennt und versteht, dass diese Ihre Zeit braucht, da sonst gerade, wenn es ins Detail geht oder es sich um sensible Informationen handelt, schnell Fehlinformationen/nicht relevante Informationen aufgezeigt werden. Insbesondere, wenn sich Menschen, die eigentlich nicht vom Fach sind, der Werkzeuge bedienen.

Genau, das wäre der schlimmste Fall. Dass andere Botschaften gesendet werden und darauf hin Fehlentscheidungen getroffen werden, die gar nicht in der Intention waren.

Das stimmt. Menschen glauben Karten und deswegen sind Karten schon ein mächtiges Werkzeug. Egal, ob sie jetzt in einem Dashboard verbaut sind oder als Poster ausgedruckt sind – Karten haben immer eine gewisse Macht und Wirkung, unabhängig davon, ob sie Zusammenhänge korrekt darstellen oder nicht. Das ist ein bisschen wie mit Statistiken. Deswegen finde ich den dritten Begriff Expertise eben auch ganz wichtig, da man diese benötigt, um so ein Dashboard oder Karten im Allgemeinen zu erstellen und aufzubauen.

In die Zukunft geschaut: Wo siehst Du die Trends a) Im Risk Management von Naturkatastrophen und anthropogenen Risiken wie Pandemien? b) In der Visualisierung von Geodaten?

Mein persönlicher Wunsch ist, dass insbesondere in Deutschland, wenn es um Datenschutz geht, dieser nicht überhandnimmt, obwohl er wichtig ist. Es ist einfach immer noch immens schwierig an Daten heranzukommen, wenn man nicht gerade in einer großen Institution arbeitet. Gerade feine und granuläre Daten sind kaum zu bekommen – denn je mehr eine Firma bei der Akquisition Arbeitsaufwand in die Aufbereitung steckt, umso weniger werden diese freigegeben, bzw. man muss fast immer dafür zahlen. Ein gutes Beispiel sind Verkehrsdaten, an die man nur sehr schwierig herankommt – es sei denn man möchte viel Geld dafür bezahlen. Deswegen wäre es wichtig, dass zumindest mehr Daten zu Forschungszwecken oder zum Bevölkerungsschutz verfügbar gemacht werden, vielleicht nicht zum Bearbeiten, aber zumindest zum Informieren. Denn nur durch die Visualisierung von verschiedenen Datenquellen kann ein umfassendes Bild geliefert werden, was genau im Umfeld wirklich passiert und wie Zusammenhänge entstanden sind. Da sehe ich den Trend wirklich in der interaktiven Visualisierung. Durch das Lesen von Reports wird man sich keinen Überblick schaffen können. Aber das ist eben auch das Interessante an GIS. Und deswegen glaube ich dort an die Weiterentwicklung – aber der Stichpunkt ist eben auch der Mut, die entsprechenden Daten zur Bearbeitung zur Verfügung zu stellen.

Aber ist dies nur Dein persönlicher Wunsch oder denkst Du wirklich, dass der Trend Richtung Datenschutz geht? Oder ist das Länderabhängig?

Ich denke, dass das zur Verfügung stellen von Daten nicht so leicht realisierbar ist, heutzutage. Viele Institutionen schauen sehr genau auf Ihre Daten. Besonders in Süddeutschland ist es sehr schwierig an Daten zu kommen, aber es ist tatsächlich Umfeld abhängig. Zum Beispiel ist Köln ein gutes Beispiel, was die opensource Daten Bereitstellung angeht. Köln hat schon vor Jahren angefangen stadtbezogene Daten zur Verfügung zu stellen und zu digitalisieren. Dort sind schon einige Schritte in die richtige Richtung getan worden. Auch die Umsetzung der Digitalisierung ist wirklich gut – man kann daraus einfach richtig gut profitieren.

Schaut man jedoch Richtung Süddeutschland, also nach Bayern und Baden-Württemberg ist die Einstellung und Mentalität eher konservativ und das spiegelt sich auch in der Datenbereitstellung wider. Daten werden dort anders gehandhabt und bereitgestellt, da spreche ich aus eigener Erfahrung. Und das ist ein wenig schade, denn wenn man eine gute Absicht hat und etwas für die Gesellschaft tun möchte, bekommt man eben oftmals keine Daten frei zur Verfügung gestellt – außer vielleicht man hat noch persönliche Connections.

Zusammenfassend: Der Trend geht dorthin, dass Daten eher besser geschützt und privatisiert werden?

Genau, gerade zum Beispiel auch im Versicherungsbereich wird sehr darauf geachtet, was herausgegeben wird und was nicht. Dass ist dann eben auch die Kehrseite der Medaille, dass Daten nicht missbraucht werden können. Es ist insgesamt eine Wanderung auf einem sehr dünnen Grad, aber ich wünsche mir für meinen Teil, dass es in Zukunft ein wenig einfacher wird.

Und denkst Du, dass Dashboards im Trend liegen? Gerade in Corona Zeiten sieht man sehr gut, dass viele Kartenvisualisierungen aus dem Nichts und schnell erstellt werden.

Absolut, dass kriege ich hier auch in der Forschung ganz gut mit, denn viele Mitarbeiter und Manager hätten gerne ein Dashboard. Andersherum kennen sich viele Menschen gar nicht so genau mit der Thematik aus, und wissen nicht genau was dahintersteckt.Denn Dashboards sind viel komplexer als einfache Visualisierungen. Ich denke, Dashboards sind ein willkommenes Werkzeug in allen Branchen. Und auch wenn man sich eine Firma oder Institution anschaut, intern oder extern, Dashboard sind einfach sehr stark darin, Informationen zu bündeln und diese einfach und intuitiv zu visualisieren. Ich würde hier sogar sagen, dass es sich im Endeffekt um einen graphischen Report oder man von **graphischer Berichterstattung** sprechen kann.

Genau, ich denke Dashboards geben einem auch die Möglichkeiten Daten und Informationen spielerisch zu erforschen durch die Interaktivität, Zoom Effekte und so weiter. Durch die hohe Intuivität sind Dashboards einfach sehr verständlich und man versteht Zusammenhänge und Trends besser, als wenn man sich 10 Seiten Report durchliest oder eine vielleicht nur statische Karte anschaut.

Ja, ganz genau. Dashboards sind von der Haptik her auch anders, dort liegt ein besonderer Stellenwert drauf und man sich viel mehr mit der eigentlichen Thematik beschäftigt. Mein Wunsch wäre eben auch, dass Dashboards nicht nur interaktiv und Informationen ausgeben, sondern, dass Informationen auch eingeholt werden können. Indem User auch Ihren Beitrag leisten und sehen können, indem man Umfragen und Feedback direkt in das Dashboard einbaut, oder auch nur auf andere Websites verweist.

Stimmt. Einen Schritt weiter gedacht wäre auch, wenn Dashboards als ganze Plattformen genutzt werden könnten, wo User richtig eingebunden werden, und auch Daten hochladen bzw. auswerten könnten.

Ja stimmt, aber im Zusammenhang mit Corona wäre dies auch aus Datenschutz kaum möglich, da es sich um sensible Daten handelt. Aber ja, allgemein gesehen gibt es da sehr viel Potential. Man muss sich immer nur die Frage stellen, wen oder was man genau erreichen möchte, und dann gibt es eigentlich auch kein Limit in den Möglichkeiten. Damit der Nutzer Dashboards auch annimmt, müssen diese dann eben auch ästhetisch ansprechend sein, aber Schönheit wird eben auch unterschiedlich wahrgenommen.

Appendix 4

Cartography M.Sc.

Questionnaire Dashboard (English Version)

1. Personalities (optional)

Sex:

Age:

2. Objective Part

Questions	Answer
Question 1: What is the Vulnerability Index of Field x?	
Question 2: What is the Vulnerability Index of Field y?	
Question 3: Where on the map is the Vulnerability Index the **highest**? Please circle the areas with the **two highest** Classes on the adjacent map.	
Question 4: In the Histogram Graph, which Classification of the Vulnerability Index is represented **most** in the area units? How **many** cases approximately?	
Question 5: In Graph **"Cova do Vapor"**: What is the **value** of "% of population with no employment"?	
Question 6: In Graph **"Costa da Caparica"**: What is the **value** of "% of population can not read or write"?	

3. Subjective Part

	Do not agree at all	Do not agree	Neutral	Agree	Agree very much
Statement 1: I could solve the tasks easily **Comment:**	☐	☐	☐	☐	☐
Statement 2: I had fun solving the tasks **Comment:**	☐	☐	☐	☐	☐
Statement 3: I find the medium "Dashboard" intuitive **Comment:**	☐	☐	☐	☐	☐
Statement 4: I find the medium "Dashboard" explorative **Comment:**	☐	☐	☐	☐	☐

Cartography M.Sc.

Questionnaire Static Map (English Version)

1. Personalities (optional)

Sex:

Age:

2. Objective Part

Questions	Answer
Question 1: What is the Vulnerability Index of Field x?	
Question 2: What is the Vulnerability Index of Field y?	
Question 3: Where on the map is the Vulnerability Index the **highest**? Please circle the areas with the **two highest** Classes on the adjacent map.	
Question 4: In the Histogram Graph, which Classification of the Vulnerability Index is represented **most** in the area units? How **many** cases approximately?	
Question 5: In Graph **"Cova do Vapor"**: What is the **value** of "% of population with no employment"?	
Question 6: In Graph **"Costa da Caparica"**: What is the **value** of "% of population can not read or write"?	

3. Subjective Part

	Do not agree at all	Do not agree	Neutral	Agree	Agree very much
Statement 1: I could solve the tasks easily **Comment**:	☐	☐	☐	☐	☐
Statement 2: I had fun solving the tasks **Comment**:	☐	☐	☐	☐	☐
Statement 3: I find the medium "Static Map" intuitive **Comment**:	☐	☐	☐	☐	☐
Statement 4: I find the medium "Static Map" explorative **Comment**:	☐	☐	☐	☐	☐

Cartography M.Sc.

Tutorial Tianjin Dashboard:

Dear user,

You've just seen a simple example of static map use/dashboard use in Disaster Risk Management. The Dashboard under the following link [1] is a little more complex in structure and more extensive in its functions.

It illustrates different aspects of the Tianjin Disaster in 2015 - in this Disaster several circumstances led to a massive chemical explosion. In this explosion 173 people died, several hundreds were injured and an insurance loss of more than 1.5 billion Euros was incurred.

The actual dashboard contains various sub-dashboards to explore the various issues, such as damaged buildings and destroyed vehicles and containers.

Tutorial:

- **Reference map:** You are currently viewing the reference map, an overview map of various types of buildings in the explosion environment.

➔ ToDo: Now click 1x on the **"Multi-Functional"** bar in the **Graph "Built-Up Area".**

How much area in the entire disaster area does this type of building represent?

Answer: ______________________

➔ ToDo: Now click on "Parking Lots" one tab further down on the left, to access the next Dashboard.

- **Parking Lots**: Here you can see an overview map of the affected vehicles in parking lots. Known car companies affected by this explosion were for example Toyota, but also VW and Chrysler. The parking lots with the vehicles show different damages summarized in damage grading.

➔ ToDo: In the **Pie Chart "Grading of Cars"** click on the dark red color **"burned out".**

How many vehicles are affected?

Answer: ________________________

[1] https://tu-muenchen.maps.arcgis.com/apps/opsdashboard/index.html#/b67945389976438e9349ae27f7e953ec

Which brands mainly?

Answer: ________________________

➔ ToDo: Click again on the dark red color "burned out" to get all parking lots displayed again.

➔ ToDo: Click in the **series diagram No. of affecter Cars per Brand** in the category **Chrysler** on the light red part **"probably damaged".**

*How many vehicles of **Chrysler** are **„probably damaged "?***

Answer: ________________________

➔ ToDo: Click one tab further on the "Container" Dashboard.

- **Container** Here you can see an overview map and various supporting diagrams showing the damaged and overturned containers caused by the explosion.

➔ ToDo: In the **pie chart Total No. of Container** click on the light red part **"tossed containers".**

How many m² is the affected area of the tossed containers?

Answer: ___________________________

➔ ToDo: Click one tab further on the "Buildings Affected" Dashboard.

- **Buildings Affected**: This more complex overview map includes various aspects of the damage to the buildings affected by the explosion. The colors of the buildings represent the different damage classes (Damage Grading). The diagrams also contain supporting information on the exact cause of damage and the functionality of the buildings.

➔ ToDo: Explore the data basis as you like and try to understand the connections. You can also return to the other tabs.

Cartography M.Sc.

Questionnaire Tianjin Dashboard (English Version)

1. Personalities (optional)

Sex:

Age:

2. Assessment

	Do not agree at all	Do not agree	Neutral	Agree	Agree very much
Statement 1: The effort while using the dashboard was little.	☐	☐	☐	☐	☐
Statement 2: I consider the intuition of the dashboard as high.	☐	☐	☐	☐	☐
Statement 3: I think the dashboard bundles the information efficiently.	☐	☐	☐	☐	☐
Statement 4: I can explore the complexity of the database well by using the dashboard.	☐	☐	☐	☐	☐
Statement 5: I do not feel overloaded with information by the dashboard.	☐	☐	☐	☐	☐
Statement 6: I can see trends, correlations and coherences between the information by using the dashboard.	☐	☐	☐	☐	☐
Statement 7: I find the central placement of the map helpful.	☐	☐	☐	☐	☐
Statement 8: The graphs and indicators help me to understand the topic better.	☐	☐	☐	☐	☐
Statement 9: Although I am not familiar with the subject matter, I can easily operate the dashboard.	☐	☐	☐	☐	☐
Statement 10: I had fun operating the dashboard.	☐	☐	☐	☐	☐

Comment:

____

____

____

____

____

Cartography M.Sc.   GAFAG

Qualitatives Feedback von dem Test Nutzer der GAF AG

Liebe/r Mitarbeiter/in der GAF AG,

Im Rahmen meiner Masterarbeit untersuche ich den Nutzen von Dashboards im Disaster Risk Management. Dafür habe ich ein Dashboard auf der Basis einer statischen Karte der GAF AG zu der Tianjin Explosion 2015 erstellt. Ihr Feedback stellt dabei einen wertvollen Teil meiner Masterarbeit dar! Das Dashboard kann man unter folgendem Link[1] aufrufen und lässt sich am besten ab einer Bildschirmdiagonale von 14 Zoll darstellen.

1. Ist Ihrer Meinung nach, eine **schnelle** und **intuitive** Erfassung der Daten gegeben?

   Antwort: Aufgrund den nach unterschiedlichen Layern und deren Attributen aufgeteilten Informationen war die Erfassung sehr einfach.

2. Sind die Informationen und Daten Ihrer Meinung nach durch die interaktive Karte, die Graphen und Indikatoren **adäquat miteinander verknüpft** und **effizient gebündelt**?

   Antwort: Die Informationen wurden passend miteinander verknüpft und effizient gebündelt.

3. Hilft der zusätzliche Informationsgehalt der Graphen und Indikatoren die Thematik der Tianjin Explosion **gut und detailliert zu verstehen**?

   Antwort: Die dargestellten Informationen wurden leicht erfassbar dargestellt und waren ausreichend detailliert.

4. Sind die Informationen **sinnvoll dargestellt** und könnten die **Entscheidungsfindung** in einem Katastrophenfall unterstützen?

   Antwort: Da sich der Fokus auf beschädigte/zerstörte Objekte legen lässt, kann die Darstellung zur Entscheidungsfindung beitragen.

5. Wird Ihrer Meinung nach, der Nutzer mit einbezogen und kann dieser die Daten **explorativ erkunden**?

   Antwort: durch die Vielzahl der dargestellten Informationen kann der Nutzer an das Thema herangeführt werden.

6. Könnten Ihrer Meinung nach Dashboards als Präsentationsmedium für Kundenaufträge einen Einfluss auf die **Kundenzufriedenheit** haben?

---

[1] https://tu-muenchen.maps.arcgis.com/apps/opsdashboard/index.html#/b67945389976438e9349ae27f7e953ec

Antwort: für eine Vielzahl von Kunden kann die anschauliche Aufbereitung von Daten über ein Dashboard die Kundenzufriedenheit (leichtere Erfassbarkeit der Information, Fokus auf das Wesentliche etc.) haben.

7. Sind das **Design und die Visualisierung** des Dashboards, der Karten und Graphen Ihrer Meinung nach ansprechend?

   Antwort: Farbgebung und Kombination der Farben sind intuitiv gewählt. Zurückhaltende Darstellung der Hintergrundkarte ideal gewählt, um die Information des Schadensfalles gut zu visualisieren.

8. Denken Sie, dass Dashboards einen **Mehrwert** zu aktuellen Produkten wie statischen Karten im Disaster Risk Management darstellen könnten? Wenn ja, welchen genau?

   Antwort: Ein Dashboard stellt aus meiner Sicht einen deutlichen Mehrwert gegenüber einer statischen Karte dar. Der Nutzer kann für sich selbst entscheiden, welche Informationen dargestellt werden, bei gleichzeitiger quantitativer Auswertung der dargestellten Elemente.

Vielen herzlichen Dank für Ihr Feedback. Sie können mir Ihre Antworten gerne stichpunkthaltig zurück an rosalie.kremser@gmail.com senden.

Schöne Grüße

Rosalie Kremser

ScoSci – Online Survey for the Sector Analysis

Link: https://www.soscisurvey.de/dashboards2020/

Cartography M.Sc.

Dear participant,

Thank you very much for your participation. In the scope of my master's thesis I am investigating whether **decision-making and communication of risk-relevant information** can be improved by using **cartographic dashboards** in disaster risk management.

The time required for the survey is approximately five minutes. The questionnaire contains six questions.

- Your participation in this study is completely **voluntary** and you can withdraw at any time. You are free to skip any question that you choose.
- All information you submit is **anonymous**. The publication of results will be in aggregated form so that a recognition of identities is not possible.
- All **data** is stored in a database solely for the purpose of this thesis. Raw data will not be passed on to third parties.

For the analysis I need single individual and personal data (age and sex). All data will be kept strictly confidential and anonymized, so that no conclusions can be drawn about you personally. This work is written under the supervision of the Chair of Cartography at Technical University Munich. Your data will only be evaluated and archived by the Chair of Cartography and me as part of this research. If you have any questions, please contact me at rosalie.kremser@gmail.com.

Thank you for sharing your opinion. Your assessment provides a valuable contribution to the research on the use of cartographic dashboards in disaster risk management!

Pause the interview | Next

B.Sc. Rosalie Kremser, Technische Universität München – 2020 | 0% completed

Cartography M.Sc.

1. What is your age?

[Please choose]

2. What is your sex?

[Please choose]

Back | Pause the interview | Next

B.Sc. Rosalie Kremser, Technische Universität München – 2020 | 20% completed

Cartography M.Sc.

3. In which sector are you currently employed?

Please specify the field you are currently working in.

- ◯ International Organizations (i.e. UN Bodies) ________
- ◯ NGO's ________
- ◯ Private Sector (Insurance, Automotive) ________
- ◯ Academia (Universities, Research Centers) ________
- ◯ Governmental Authorities ________
- ◯ None of the above (please specify) ________

Back | Pause the interview | Next

B.Sc. Rosalie Kremser, Technische Universität München – 2020

40% completed

Cartography M.Sc.

4. Which media do you mainly use for the management of disaster risk relevant information and data?

Please tick the corresponding answers.

- ☐ Reports
- ☐ Static maps (i.e. for print purposes)
- ☐ Interactive maps (i.e. web maps)
- ☐ Dashboards (i.e. cartographic dashboards)
- ☐ Presentations (i.e. PowerPoint)
- ☐ Lists (i.e. Excel)
- ☐ Diagrams
- ☐ Models/Simulations
- ☐ Apps
- ☐ Other ________

5. Which medium do you use most?

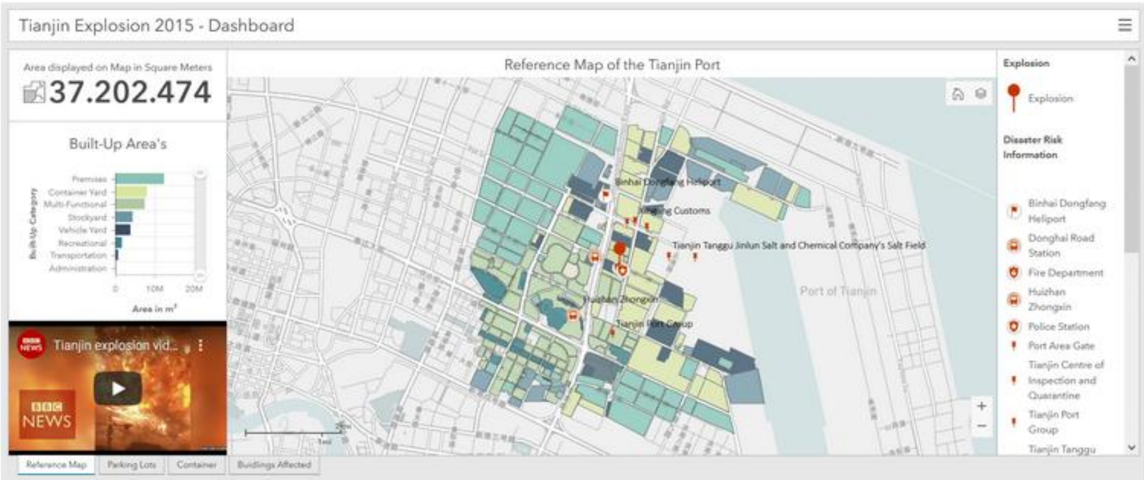
[Please choose]

Back | Pause the interview | Next

B.Sc. Rosalie Kremser, Technische Universität München – 2020

60% completed

Cartography M.Sc.



Source: https://tu-muenchen.maps.arcgis.com/apps/opsdashboard/index.html#/a1b8f607b377408fb9861dd2e4766976 (Proper display requires at least a 13 inch screen size.)

Infotext: Dashboards are through their intuitive character and efficient information bundling a popular medium in disaster risk management for visualizing risk-relevant data and information. The dashboard shown above constitutes an example of how these kinds of dashboards can be configured and was developed as part of my master thesis. It was designed for a response case (disaster assessment directly after an event) and illustrates through four sub-dashboards various aspects of the Tianjin Explosion 2015.

6. Do you already use dashboards for disaster risk management purposes?

You may specify the purpose and/or the reason in the comment field below the answers.

- ○ Yes, I am using dashboards for disaster risk management purposes. Additional comment:
- ○ No, I am not using dashboards for disaster risk management purposes, but I would be interested. Additional comment:
- ○ No, I am not using dashboards for disaster risk management purposes and I am not interested. Additional comment:

Back | Pause the interview | Next

B.Sc. Rosalie Kremser, Technische Universität München – 2020

80% completed

Cartography M.Sc.

Thank you for completing this questionnaire!

We would like to thank you very much for helping us.

Your answers were transmitted, you may close the browser window or tab now.

B.Sc. Rosalie Kremser, Technische Universität München – 2020