The Audience in Mind: An Attempt for a Target-Group-Specific Application to Communicate Climatic Hazards to Decision-Makers

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Abstract: The increasing impact of climate change leads to complex challenges in adaptation and mitigation for politics, administrations, the economy, and the population. For climate hazards to be considered more carefully in planning processes, they need to be communicated more directly to decision-makers, especially on the municipal level. Already existing data from environmental modeling, hydrological simulations, and spatial analysis can support the decision-making to develop more resilient cities and landscapes, when they are recognized. A web application was developed on the district level which focused on the transfer of scientific rigor, visualized in maps by engineers and scientists for other experts into a more accessible and suitable medium for non-experts to equip municipal decision-makers with the necessary knowledge.

Keywords: Climate hazards, science-communication, web experience, decision-making, spatial planning

1 Introduction

This paper describes the process of developing an application that supports municipal spatial planning processes by providing information on climate change related hazards to be considered more careful in planning processes and decision making. The impact of climate change can already be experienced while adaptation and mitigation pose complex challenges which are often insufficiently approached by municipalities (GRAFAKOS et al. 2020, LEE & ROMERO 2023). Various geoportals and map-viewers from federal institutions and state departments, like the "Bayern-Atlas" or the climate-atlas of North Rhine Westphalia provide a wide range of available official datasets on climate change impacts and hazards with scientific and legal rigor. While this is might be ideal for experts and GIS-specialists, maps might be insufficient for the necessary transfer of knowledge to enable decision-makers (DUBOIS et al. 2018). Facing uncertainties and complex demands in spatial planning, local authorities needs to be provided with information on climate hazards and local vulnerability in a more approachable way and easier to be understand (DUBOIS et al. 2018, LAMKER 2016).

The Osnabrück district and university of applied sciences approached this issue together and developed the web application "Klimagefahrenatlas" (atlas for climate hazards) to resolve these issues. The goal was not only to equip decision-makers and stakeholders in politics and administration within the district with information that would empowers them to tackle local issues faster and more focused so they can incorporate potential climate hazards into municipal decision-making processes. But also, to ignite an interest in and the urge to investigate potential hazards, their environment, and necessities by offering an appealing, interactive, and quickly understood portal containing relevant and local information. Comparing the application with Sheppard (2012) "General recommendations for communicating and fostering social change", six of those recommendations were implemented in this novel approach to

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different types of visualization and tangible knowledge on climate hazards at municipal level (Tab. 1).

Table 1: Six recommendations for communication climate change by SHEPPARD (2012, 36–37) and their implementation.

Recommendation	Implementation
Provide understandable, scientifically credible information	The datasets shown within the application were the results of various scientific models from official and reliable sources. The aim was to supply additional, valuable background information that would be needed for a deeper understanding of each hazard. This translation from the scientific language into a more explanatory content was significant for the goal to be achieved.
Use novel, vivid, and concrete imagery and goals	A crucial part of the development was the applications design. It was focused on de-signing an appealing surface with high usability, easily understandable structure, and the implementation of interactive features.
Employ experiential learning	The point of implementing interactive features was not only to make the application more appealing to use, but also to offer learning experience by enabling the audience to use analytic tools by themselves and to discover certain coherences on their own. To achieve this, a dashboard-feature was implemented, allowing the audience to analyse their municipalities vulnerability towards flooding.
Balance negative and positive information	While leading the audience into a pool of information about various hazards, it is necessary to also equip users with tools to handle these risks (SHEPPARD 2012). To do so, the application was used as a platform to introduce the audience to material on each topic, suggestions of strategies and measures as well as references to responsible.
Apply information to the regional or local level	Every data that is shown within the application is presented within a map. The map-scale is sufficient to make statements and to approach the issues at the municipal level. By providing a selection of relevant topics, the audience's attention is directed towards those challenges, which could and should be addressed locally. These suggestions are supported by the findings of (LEE & HUGHES 2017), stating that adaption can only happen, when a hazard is precepted by the decision-makers.
Tailor the communications to the audience	Every feature of this application was developed to be used by an audience with limited time, technical knowledge, and willingness to engage with issues that don't bear direct legal weight.

2 Design and Implementation

2.1 The Applications Design and Structure

To make the application as user friendly as possible, the design focused simplicity and consistency within a clear structure. To prevent the audience from overwhelming, the first introduction to the application was decided to be a simplistic frontpage with an overview of the content where the user can choose a field of interest for further investigation. Anticipating the target-group to use the application when there would be a reason to investigate their municipalities vulnerability, like intense media coverage of ongoing flooding events, heatwaves, etc., an introduction of separate topics to catch this temporary attention seemed beneficial to introduce the application to the users.

While these separated topics primarily targeted users without a technical background by providing necessary and understandable explanations, as well as simple maps, a collection of all the spatial information presented within each topic was designed for the more experienced users to provide a basic web-GIS for quick exploration of cumulative effects or interferences.

Besides the individual topics and the collection, a page with basic information about environmental modelling, their reliability and further explanation was added to the application. Additional information on the included datasets was also incorporated.

2.2 Selecting Relevant Climate Impacts and Spatial Data

To identify fitting geodata on climate hazards, certain criteria were set. Potential datasets must have been existing and had to be available for the regional district of Osnabrück and their municipalities in suitable formats. It was also necessary that the datasets level of detail, scale or cell size allowed statements on a local level. The aim was to make the storage of data as efficient as possible, avoid redundancies and minimize maintenance costs. Since web-map-services (WMS) and -features (WFS) that are already hosted by other (state) departments, these formats were preferred. Furthermore, the tangibility of the datasets was considered. Complex parameters that could hardly be interpreted without technical or scientific knowledge would intensify the effort on tailoring the information for the targeted audience.

The search for fitting datasets ended with selection of suitable geodatasets for five topics with (Tab. 2).

Table 2: Selection of Topics and Datasets

Topic	Datasets
Fluvial flooding	Datasets for different annualities are provided by the state (NIEDERSÄCHSISCHES MINISTERIUM FÜR UMWELT, ENERGIE UND KLIMASCHUTZ 2022). For this application, an annuality of 100 years (100 years flood, HQ_{100}) as well as the extreme event (1.5 times the discharge of the 100 years event, HQ_{extrem}) was taken into consideration. The jurisdictional layers involved in determine flood-plans are depending on a waterbody's significance of the risk for flooding (MÜLLER & JÜPNER 2020). This results in two datasets for each annuality that are partly contradictive. While one dataset presents the flood-plans resulting in the EU directive 2007/60/EC on the assessment and management of flood risks which is mandatory for rivers with potentially severe floodings, the other dataset displays the outlines of decreed flood areas by German water law.
Pluvial flooding	Since there is no coverage of data from hydraulic simulations for pluvial flooding events, as there are in other regions or states, a simple topographic analysis was done by the responsible state department. This dataset is yet unpublished. Since there are overlapping basins with the bordering state which is providing state-wide risk-maps for two different events, the data for the more severe one was also included (BUNDESAMT FÜR KARTOGRAPHIE UND GEODÄSIE 2021).
Heat	A collection from the regional landscape-masterplan of 2023 for district with maps about potential heat islands, ventilation corridors and climatic comfort zones provided by the district itself via WMS (LANDKREIS OSNABRÜCK 2023).

Table 2 (continued)

Topic	Datasets
Erosion	Maps on potential water and wind erosion that are based on the universal soil loss equation are provided by the state department for soil as an WMS (LANDESAMT FÜR BERGBAU, ENERGIE UND GEOLOGIE 2023a).
Drought	Since the regional district of Osnabrück is characterized by agricultural land-use, this topic was also selected. The state department for soil provides a dataset in form of a WMS with the potential additional demand for watering on fields for the different IPCC RCP scenarios (LANDESAMT FÜR BERGBAU, ENERGIE UND GEOLOGIE 2023b, TÖRÖK et al. 2004).

2.3 Processing the Data

The goal of processing the data was to support the audience ability to interpret the content by improve the data's tangibility. To enable the audience to deduce concrete risks from the presented climate hazards, it seemed important to simplify the data to avoid uncertainties and to include additional spatial context by incorporating locations of buildings of public interest, like schools, hospitals, etc.

As described above, the datasets on fluvial flooding provided by official sources did contradict each other partly. These small areas emerged, where differences in methodological approaches or base-data provided different results. To encounter uncertainties that might be related to this issue, a simplified dataset was created by combining the HQ_{extrem} (EU-directive) with the HQ_{100} and HQ_{extrem} (German water-law) in consultation with the districts department for water using geoprocessing in ArcGIS Pro (Fig. 1).

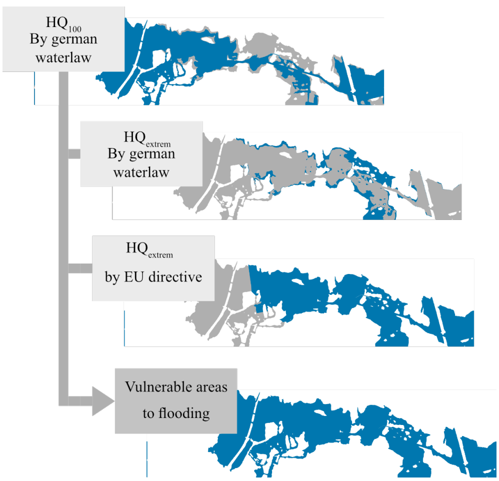

Fig. 1: Combining datasets on fluvial flooding with contradicting expanses of flooding areas, both provided by the lower saxony state ministry for environment, to encounter possible uncertainties. Based on open access data using ArcGIS Pro.

Although the data of each topic did fit the criteria for being in a usable format, the readability needed to be improved for the targeted audience. To increase this, each maps legends was rebuilt while providing a clearer overview with simplistic explanations. By replacing or complemented the existing cardinal scales with ordinal scales, the references were more graspable (Fig. 2).

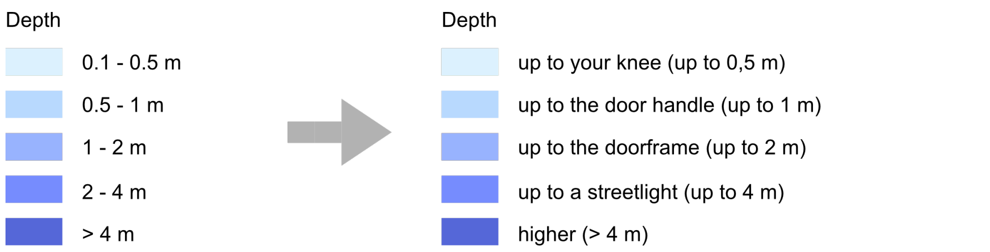

Fig. 2: Example for an adjusted map legend with more graspable references for water depth

While the different datasets display possible hazards, they did not provide any information on risks or vulnerabilities without a proper context. With the assumption, that a simple basemaps would not carry the weight of possible threads, data on buildings of a public interest such as hospitals, fire departments, schools, kindergartens, etc. was collected. To achieve this, the district supplied tables of public institutions and buildings of interest, containing their names and addresses. These tables were processed within a GIS (Fig. 3).

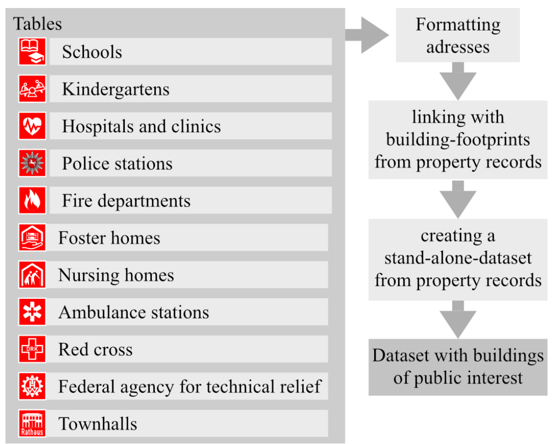

Fig. 3: To include public buildings, records on Schools, Kindergartens, etc. needed to be processed. By formatting the provided addresses, the tables containing the records, a table-join between the data and spatial data of property records was possible.

Using maps with data that fit the set criteria to provide concrete spatial information seems natural. But the ability to interpret the data still strongly depends on the audience spatial and thematic knowledge and could be less fitting for decision-makers (DUBOIS et al. 2018, SCHIEWE 2023, SHEPPARD 2012). Using additional explanations, graphs and indicators might fill this gap. To provide graphs, indicators and the recommended experimental learning experience, a dashboard that would summarize the presented data seemed valuable (YIGIT-BASIOGLU & VELCU 2012). To enable the dashboard to provide areal statistics and an object-related indicators on municipality-specific vulnerability, a database needed to be generated. The geoprocessing of vulnerable areas for flooding with the official and open digital landscape model as well as the property records (building-footprints) resulted in two tables, one containing data on the affected areas by municipality as well as type of settlement (industry, housing and so on), while the other contained the number of affected buildings per municipality (Fig. 4).

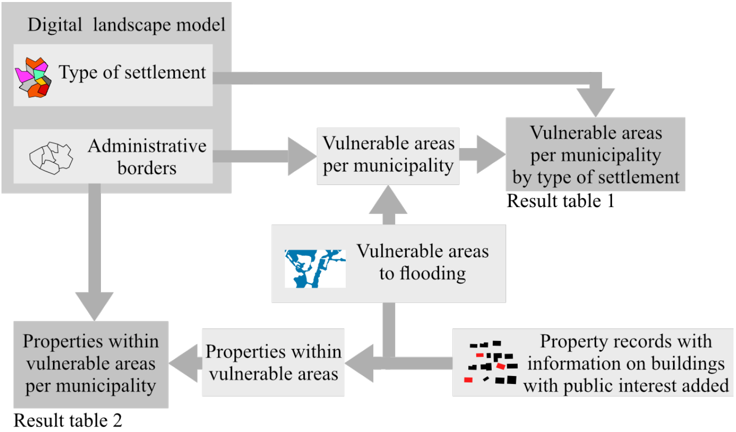

Fig. 4: This figure describes the geoprocessing of spatial data on vulnerable areas, land-use-data, administrative borders, and property records within ArcGIS Pro schematically. By intersecting the administrative borders with the vulnerable areas, the affected area by municipality was identified. Using data on the types of settlement, information on the distribution of vulnerability could be provided. This areal information of vulnerability is referred as result table 1. By joining the footprints of building, enriched with the results described in Figure 3 with the affected area by municipality, a count of affected buildings and a list of affected buildings of public interest was created.

2.4 Implementation

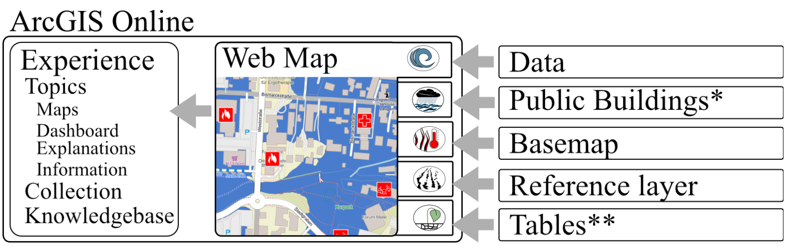

Fig. 5: Implementation of the map's content in an ArcGIS Experience. The example of a map shows the topic fluvial flooding. The reference-layer adds footprints of buildings, streets and other labels which is intended to improve tangibility and the user's ability for interpretation and orientation. For this topic, as well as pluvial flooding and heat, buildings of public interest were also included.

To implement the application, the Web Experience Builder within ArcGIS Online by ESRI was used. According to the design and structure, pages within a new ArcGIS Web Experience were created. A web-map containing the relevant data, a basemap and a reference-layer was created for each topic in ArcGIS Online and embedded in the Web Experience (Fig. 5). The previously described buildings of public interest were also added to the maps on flooding and heat to visualize potential vulnerabilities.

The dashboard was implemented as a self-analysis-tool by taking advantage of the ArcGIS Experience-Builders capabilities to establish data-connections between interactive and dynamic elements. For the implementation of the dashboard for the topic on fluvial flooding, the generated tables, as described above, were also added to the web-map to make them usable within the Web experience. Dynamic text elements, diagrams, and lists were incorporated and connected to the tables. To achieve variating outputs, filters, triggered by selecting a municipality within a list of bookmarks, were implemented. Depending on the selection, the indicators and statistics within the dashboard and the maps extent changed to present a visualization of the municipality's vulnerability in different formats (Fig. 6).

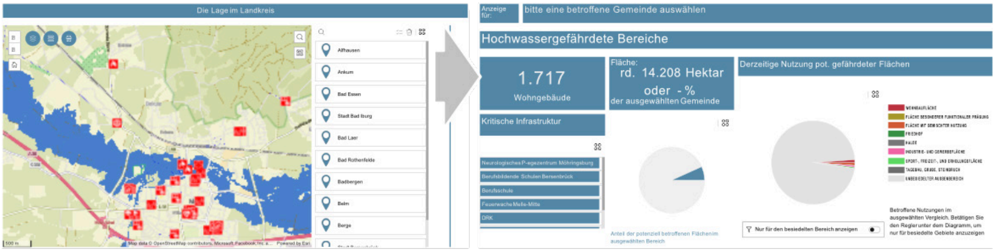

Fig. 6: This figure shows the map for the topic "fluvial flooding" and the implemented, interactive dashboard. Using a dynamic connection between the municipality-layer, listed besides the map frame, and table containing the results of the prior analysis, the statistics shown in the dashboard changes depending on the selected municipality.

Further, basic explanations, tailored for the audience, on the concept of environmental modelling and each topic were drafted, an easy-to-read documentation of the data written, and additional information on the topics as well as possible measures gathered and incorporated in the application (Fig. 7).

Since there was only a little technical know-how needed to use the experience builder, the district will be able to continue and update their application on their own and on demand, despite limited resources. The integration of additional topics, map-contents, etc. can be done easily. To support this, a brief manual was drafted and handed over as well as an automated GIS-Tool to issue new tables to update the dashboard, if necessary.

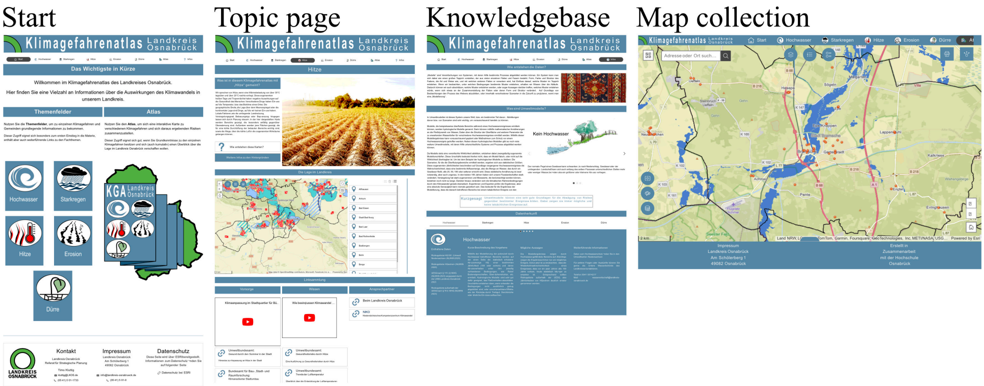

Fig. 7: The finished application contains a starting page, a page for each topic, a knowledgebase, providing information on environmental modelling and the data behind the topics and a map collection for more advanced users

3 Discussion

In the development of the "Klimagefahrenatlas", the application shifted from an application focussed on spatial information to a knowledgebase and decision-making-tool with significant spatial references and local relevance. By now the application is released with limited access for municipal decision-makers. Although first demonstrations to few administrative officials received positive reviews, further evaluation needs to be done. The time of controlled access should be used to survey the applications usability and its impact on the municipal planning process as well as potential flaws. Since the implementation highly concentrated on hazards and vulnerabilities, the recommended balance between negative and positive information by SHEPPARD (2012) should be assessed and adjusted accordingly to the assessment. To estimate the effort to develop the application further, an evaluation of the potential benefits provided by the self-service-analysis-tool is highly recommended. While dashboards, interactive analysis tools and more advanced presentation formats can impact decision-making significantly, the development is also much more elaborate (NADJ et al. 2020, YIGITBASIOGLU&VELCU 2012). For the upcoming public release, further development, based on the evaluation should considered, especially the implementation of further dashboards within the other topics.

Although this application is targeted towards decision-makers, the focus on non-experts could also enable a broader public audience to engage with the provided knowledge and to put additional pressure on local authorities to act (HOWES 2018). Although this application might enable, motivate, or pressure decision-makers to engage with the topic or simplifies administrative officers' workflows when it comes to issuing statements or suggestions, the "Klimagefahrenatlas" cannot replace neither common map-viewers nor face-to-face engagement in following planning processes.

Regardless of the communicative potential and the applications impact on the decision-making, the selected technical approach proofed to be suitable. The ArcGIS Experience-Builder is a tool to implement complex applications and to tailor them according to the user's needs and demands. Furthermore, the possibility to provide self-analyse-tools indicates great potential to simplify and automate GIS-Workflows.

4 Conclusion and Outlook

The "Klimagefahrenatlas" was developed to enable decision-makers at the municipal level to consider climate-hazards within their planning processes more broadly by equipping them with relevant and more approachable and understandable knowledge on local climate-hazards. Spatial data, self-analysis-tools, background-information, and potential adaptations were provided for a selection of potential climate hazards.

To evaluate the applications impact on the decision-making, the first phase of limited access will be used to survey the user's experience. The results of this survey could support further development of this or other interactive application to communicate important topics more effectively.

References

BUNDESAMT FÜR KARTOGRAPHIE UND GEODÄSIE (2021), WMS Starkregengefahrenhinweise Nordrhein-Westfalen (wms_starkregen). https://gdz.bkg.bund.de/index.php/default/wms-starkregengefahrenhinweiskarten-nrw-wms-starkregen.html (10.01.2024).

DUBOIS, G., STOVERINCK, F. & AMELUNG, B. (2018), Communicating Climate Information: Traveling Through the Decision-Making Process. In: SERRAO-NEUMANN, S., COUDRAIN, A. & COULTER, L. (Eds.), Communicating Climate Change Information for Decision-Making. Springer International Publishing, Cham, 119-137. doi:10.1007/978-3-319-74669-2_9.

GRAFAKOS, S., VIERO, G., RECKIEN, D., TRIGG, K., VIGUIE, V., SUDMANT, A., GRAVES, C., FOLEY, A., HEIDRICH, O., MIRAILLES, J. M., CARTER, J., CHANG, L. H., NADOR, C., LISERI, M., CHELLERI, L., ORRU, H., ORRU, K., AELENEI, R., BILSKA, A., PFEIFFER, B., LEPETIT, Q., CHURCH, J. M., LANDAUER, M., GOULDSON, A. & DAWSON, R. (2020), Integration of mitigation and adaptation in urban climate change action plans in Europe: A systematic assessment. Renewable and Sustainable Energy Reviews, 121, 109623. doi:10.1016/j.rser.2019.109623.

HOWES, M. (2018), Transforming Climate Change Policymaking: From Informing to Empowering the Local Community. In: SERRAO-NEUMANN, S., COUDRAIN, A. & COULTER, L. (Eds.), Communicating Climate Change Information for Decision-Making, Springer International Publishing, Cham, 139-148. doi:10.1007/978-3-319-74669-2_10.

LAMKER, C. (2016), Unsicherheit und Komplexität in Planungsprozessen: Planungstheoretische Perspektiven auf Regionalplanung und Klimaanpassung. Dissertation, Dortmund (Verlag Dorothea Rohn).

LANDESAMT FÜR BERGBAU, ENERGIE UND GEOLOGIE (2023a), Metadaten: Abschätzung der potenziellen Erosionsgefährdung durch Wasser. https://nibis.lbeg.de/net3/public/ikxcms/default.aspx?pgid=130 (09.01.2024).

LANDESAMT FÜR BERGBAU, ENERGIE UND GEOLOGIE (2023b), Metadaten: Mittlere Potenzielle Beregnungsbedürftigkeit für den 30-jährigen Zeitraum 2021-2050, Kein-Klimaschutz-Szenario (RCP8.5). https://nibis.lbeg.de/net3/public/ikxcms/default.aspx?pgid=1745 (09.01.24).

LANDKREIS OSNABRÜCK (2023), Landschaftsrahmenplan: Klima und Luft. Osnabrück.

LEE, H. & ROMERO, J. (2023), IPCC, 2023: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. and J. ROMERO (Eds.)]. IPCC, Geneva, Switzerland.

MÜLLER, U. & JÜPNER, R. (2020), Vom Hochwasserschutz zum Hochwasserrisikomanagement. In: PATT, H. & JÜPNER, R. (Eds), Hochwasser-Handbuch. Springer Fachmedien, Wiesbaden, 9-24. doi:10.1007/978-3-658-26743-8_2.

NADJ, M., MAEDCHE, A. & SCHIEDER, C. (2020), The effect of interactive analytical dashboard features on situation awareness and task performance, Decision support systems, 135, 113322. doi:10.1016/j.dss.2020.113322.

NIEDERSÄCHSISCHES MINISTERIUM FÜR UMWELT, ENERGIE UND KLIMASCHUTZ (2022), Umweltkarten – Topic floodmanagement. https://www.umweltkarten-niedersachsen.de/Umweltkarten/?lang=de&topic=Hochwasserschutz&bgLayer=TopographieGrau&catalogNodes=&layers=Grenzen_der_Risikogebiete_HQextrem_HWS (09.01.2024).

SCHIEWE, J. (2023), Kartographie: Visualisierung georäumlicher Daten. Springer, Berlin/Heidelberg.

SHEPPARD, S. R (2012), Visualizing Climate Change: A Guide to Visual Communication of Climate Change and Developing Local Solutions. Routledge.

TÖRÖK, H.-P., GLAS, J., GRUBER, R., BRUMBERGER, V., STRASSER, C., KELLNER, H., MÄRKER-HERMANN, E. & FOLWACZNY, C. (2004), Inflammatory bowel disease-specific autoantibodies in hla-b27-associated spondyloarthropathies: Increased prevalence of asca and panca, Digestion, 70:1, 49-54. doi:80081.

YIGITBASIOGLU, O. M. & VELCU, O. (2012), A review of dashboards in performance management: Implications for design and research. International Journal of Accounting Information Systems, 13:1, 41-59. doi:10.1016/j.accinf.2011.08.002.