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Climate change effects at your doorstep: Geographic visualization to support Nordic homeowners in adapting to climate change

Tina-Simone Neset [a, *], Erik Glaas [a], Anne Gammelgaard Ballantyne [a, b], Björn-Ola Linnér [a], Tomasz Opach [c], Carlo Navarra [a], Jimmy Johansson [d], Anna Bohman [a], Jan Ketil Rød [c], Michael Goodsite [b, e]

[a] Department of Thematic Studies — Environmental Change/Centre for Climate Science and Policy Research, Linköping University, 58183, Linköping, Sweden
[b] Department of Business Development and Technology, Aarhus BSS, Aarhus University, Birk Centerpark 15, 7400, Herning, Denmark
[c] Department of Geography, Norwegian University of Science and Technology, Dragvoll, NO-7491, Trondheim, Norway
[d] Information Visualization Group, Linköping University/Norrköping Visualization Centre C, 601 74, Norrköping, Sweden
[e] SDU Department of Technology and Innovation (ITI), Campusvej 55, DK5230, Odense M, Denmark

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ABSTRACT

The complexity of climate information, particularly as related to climate scenarios, impacts, and action alternatives, poses significant challenges for science communication. This study presents a geographic visualization approach involving lay audiences to address these challenges. VisAdapt™ is a web-based visualization tool designed to improve Nordic homeowners' understanding of climate change vulnerability and to support their adaptive actions. VisAdapt is structured to enable individual users to explore several climate change impact parameters, including temperature and precipitation, for their locations and to find information on specific adaptation measures for their house types and locations. The process of testing the tool included a focus group study with homeowners in Norway, Denmark, and Sweden to assess key challenges in geographic visualization, such as the level of interactivity and information. The paper concludes that geographic visualization tools can support homeowners' climate adaptation processes, but that certain features, such as downscaled climate information are a key element expected by users. Although the assessment of interactivity and data varied both across countries and user experience, a general conclusion is that a geographic visualization tool, like VisAdapt, can make climate change effects and adaptation alternatives tangible and initiate discussions and collaborative reflections.

1. Introduction

The Nordic countries are facing several expected climate change and weather-related effects such as increased annual average precipitation and temperature, more frequent and intensified cloudbursts, an increased number of days with extreme high temperatures (i.e., heat waves), and potentially more days with strong winds (IPCC, 2013; Juhola et al., 2014). Anticipated impacts include increased variation in water runoff levels, higher humidity, increased coastal erosion and number of landslide events, as well as larger-scale sea level rise. All these impacts pose new challenges for society, not least for urban planning, the building and insurance sectors, and homeowners. To increase Nordic homeowners' capacity to cope with climate change and weather-related extreme events, a Nordic research collaboration has designed and developed a visualization-supported web tool. This paper presents the results of the tool development and evaluation process involving the designated end-user group—private homeowners. The paper analyses the overall results of the evaluation process based on three dimensions of the concept of the map-use cube (MacEachren, 1994; MacEachren et al., 2004), i.e., user profile, knowledge, and interactivity, to provide structured guidance for future tool development.

In recent decades, the Nordic countries have experienced severe damage and rising costs related to extreme weather events, such as flooding and storms. A subsequent increase in the number of compensation payments made to homeowners has been noted by the insurance industry, which is expecting a further rise in payments throughout the region in coming years (Danish Insurance

* Corresponding author.
E-mail address: Tina.neset@liu.se (T.-S. Neset).

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Association, Finance Norway, Federation of Finnish Financial Services, & Insurance Sweden, 2013). The impacts of climate change and extreme weather events on private residential buildings have been addressed by an increasing number of scientific studies (e.g., Lisø, 2006; Nie, Lindholm, Lindholm, & Syversen, 2009; de Wilde & Coley, 2012). Anticipated risks in the region include various forms of leakage and flooding due to increased and intensified precipitation (Kvande & Lisø, 2009; ten Veldhuis, Clemens, & van Gelder, 2011), mould and rot due to increased humidity (Almås & Hygen, 2012; Nik, Sasic Kalagasidis, & Kjellström, 2012), and health risks due to intensified heat waves (Guan, 2012; Nikolowski, Goldberg, Zimm, & Naumann, 2013).

Against this background, we designed a web-based visualization tool, VisAdapt™, to meet the requirements of Nordic homeowners. The tool content includes some of the key climatic and weather-related impacts that might influence Nordic homes over the coming 40–60 years. In an effort to improve basic communication (Wibeck, Neset, & Linnér, 2013), the tool incorporates concrete measures for reducing these potential risks, linking them to the selected region and impacts.

Several online map-based tools focusing on climate vulnerability and adaptation are available, published by national or international agencies, research institutes, or private-sector organizations (Neset, Opach, Lion, Lilja, & Johansson, 2016). Initiatives like the ESRI climate resilience app challenge[1] have shown the great potential of map-based applications focusing on e.g. flood risk mapping, rainwater harvesting or urban heat waves. Multiple examples of such tools target the general public, but often without clear links to adaptation measures. Several tools have been established as part of more generic climate communication websites providing information on climate impacts and climate adaptation on separate parts of the site. A challenge addressed when designing the VisAdapt tool was how to integrate both climate information and adaptation measures into one comprehensive visual interface, while providing a certain level of human computer interaction (Card, Moran, & Newell, 1980) adapted to the intended audience. VisAdapt thereby seeks to take an additional step toward helping a specific target group—homeowners—to explore climate change risks and adaptation alternatives in their own regions and for their specific house types.

2. Geographic visualization

The development of the VisAdapt tool draws on the concept of geographic visualization or geovisualization (MacEachren & Kraak, 2001), which developed during the late twentieth century. Geovisualization integrates “approaches from visualization in scientific computing, cartography, image analysis, information visualization, exploratory data analysis, and geographic information systems to provide theory, methods, and tools for visual exploration, analysis, synthesis, and presentation of geospatial data” (MacEachren & Kraak, 2001:3). Geospatial data are relevant to addressing numerous challenges, so we find geovisualization applications in many disciplines and adapted to various user groups: experts and specialists, users with moderate cartographic skills and experience, as well as lay users. Geovisualization solutions provide flexibility in data exploration ranging from sophisticated interactive multiple linked views (Andrienko & Andrienko, 1999; Roberts, 2005) used mostly by knowledgeable and experienced users (Andrienko & Andrienko, 2007) to simple tools such as interactive weather forecast maps that can be used by everyone. In interactive geovisualization tools, geospatial data exploration is often facilitated by the integration of map and data displays that support information acquisition and extraction as well as knowledge construction (MacEachren et al., 2004). Key elements of geovisualization tools are graphical data representation as well as an interactive user interface (Bishop, Pettit, Sheth, & Sharma, 2013), which together help communicate complex multidimensional issues (MacEachren et al., 2004). The rethinking of mapping that has taken place during recent years (Dodge & Perkins, 2009; Kitchin & Dodge, 2007, p. 335) bears great relevance on the conceptualization of geographic visualization, expanding the perspective of mapping far beyond data representation, and emphasizing that ‘maps are practices – they are always mappings; spatial practices enacted to solve relational problems’ (Kitchin & Dodge, 2007, p. 335), which points towards the importance of considering the user interaction and contextualization of maps. This paper explores the multiple dimensions of a map based tool, relating to the transition from traditional cartography to geovisualization as discussed by MacEachren and Kraak (2001) in relation to the three dimensions of the map-use cube (MacEachren, 1994). As illustrated in Fig. 1, the communication of predefined messages (i.e., presenting the known) has expanded to encompass the possibility of acquiring new knowledge (i.e., knowledge acquisition/exploration), significantly increasing the level of interaction. The development of interactive geovisualization tools has similarly gone along with a shift in audience from a public (lay/broad) audience toward a more private (expert) audience. Applying this framework to describe and evaluate VisAdapt allows for more generic guidance for future tool development.

Referring to the map-use cube shown in Fig. 1, we developed the VisAdapt tool for a lay audience (i.e., the public), and argue that it represents already known knowledge and features a relatively high level of interactivity (MacEachren, 1994; MacEachren et al., 2004). Evaluation efforts focused on the specific end-user group, on assessing whether the level of interactivity was adequate for this end-user group and for the purpose of the tool, and on the extent to which the included information was considered relevant and comprehensible. The design and development of VisAdapt draws on basic principles of geographic visualization and additional elements of information visualization.

Usability evaluation has become a common approach to study the benefits of map based interactive displays (Nivala, Brewster, & Sarjakoski, 2008). We however apply the map-use cube as an analytical lens through which we evaluate end-user reflections regarding the form, interactivity, and the knowledge structure of the VisAdapt tool. We did this through focus group interviews with participants from the target audience of Nordic homeowners. As

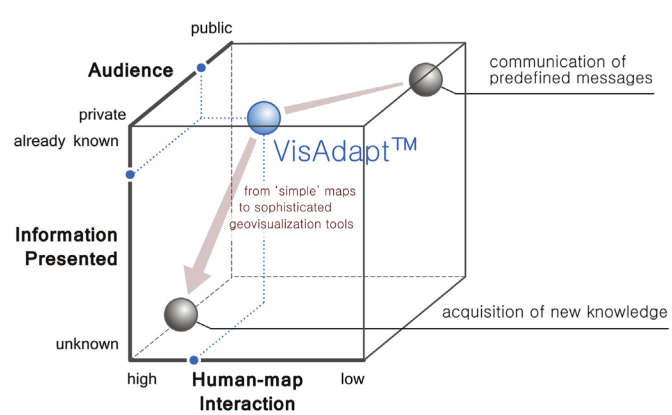

Fig. 1. The role of a geovisualization tool changes depending on its target audience's level of expertise, level of interactivity (human-map interaction), as well as its data content (whether it shows already known or unknown information).

[1] http://www.esri.com/software/landing_pages/climate-app.