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Affective appraisal of 3D land use visualization

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ABSTRACT

In this paper we discuss the affective appraisal and affective response of users to three different visualization types: colored raster cells, 2D-icon and 3D-icons. For that we developed a dedicated multi-layered visualization of current and future land use in the Netherlands, that may allow policy-makers to assess and compare land use scenarios. This Google Earth based visualization, abbreviated GESO, facilitates users by means of the three different visualizations of current and future land use. It is often assumed that 3D-visualization improves the cognitive understanding of scenario outcomes. There are many uncertainties, however, about the affective responses to 3D-visualization. A between-subject experiment has been designed to compare viewers' responses to the three types of visualizations on affective appraisals of the environment. 3D-icon visualization elicited the highest affective appraisals and positively influenced perception of the environmental quality. Moreover, the results demonstrated that 2D-icons and 3D-icons, compared with colored raster cells, did not improve the efficiency or accuracy of the participants in this experiment. The results provide evidence that the visualization type may influence the affective appraisal of the environment represented. The need for further research is discussed, especially regarding the question whether these types of visualizations may influence judgement and decision-making in environmental planning.

1. Introduction

As with many areas under the influence of urban conglomerations, the Dutch land area is subject to a continuous land use transition, especially in the direction of ongoing urbanization. According to studies conducted by The Netherlands Environmental Assessment Agency (PBL), the demand for housing area will increase by at least 120.000 ha, according a trend scenario, and at most 190.000 ha, according the increased spatial demand scenario, in the period 2010–2040 (Milieu-en Natuurplanbureau, 2007). These demands will have a high impact on other land uses, especially agricultural production and nature conservation, and will thereby influence the environmental and landscape quality in many ways. The PBL conducts scientific studies on future land use to support Dutch policy-makers at regional and national administrative levels who discuss sustainable development of the land, taking into consideration improvement of the mutual accommodation of space and society. The concept of mutual accommodation may contribute to improve environmental conditions and is able to respond adequately to environmental challenges such as food supply, CO_2 reduction, and offsetting a rising sea level.

1.1. The challenge of visualization

The results of studies such as those of the PBL are offered to policy-makers and stakeholders as reports, including maps showing current and future land use. The Sustainable Outlook is one of these reports that must be produced every 4 years (Milieu-en Natuurplanbureau, 2007). It is intended as a source of information that can serve in discussions on the impact of middle and long term (through 2040) land use changes and their environmental, ecological, and spatial effects. Land use transitions for the Dutch land area are based on the simulation of land use development using the dedicated modelling software Land Use Scanner (Hilferink & Rietveld, 1999). The Land Use Scanner produces geo-referenced raster data sets that cover the full extent of the Dutch land surface (41,528 km^2), presenting land use in the near future. Each raster cell spans 100 by 100 m and shows one land use class. The maps created from these datasets also cover the full extent of the Netherlands, are color-printed on A4-size, have legends of 10 land

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use classes, and present the land use classes according a specific scenario in a particular year.

The maps are created in the first place to support policy-makers in detecting and understanding land use changes and their impacts on the physical environment. Currently, a change in color hue in these maps only depicts the transition to a different type of land use. Consequently, impacts are difficult to interpret from these maps (Fig. 1). Changes, such as the effect of low-density residential development on open landscape, or the effects of scale enlargement in agriculture, need to be interpreted by the policy-makers themselves (Borsboom-van Beurden, Van Lammeren, Hoogerwerf, & Bouwman, 2006).

The PBL has noticed such usage difficulties arising from the maps (Borsboom-van Beurden et al., 2006). The main Sustainable Outlook map users, policy-makers on National and Regional administrative levels, comment negatively on the excessive amount of detail on the A4 paper size, the similarity of colors, and the fact that the maps cannot easily be compared with other maps in the report. Such comparisons are essential for placing contemporary land use classes and patterns side-by-side with scenario-based outcomes. Allowing users to easily detect changes between the current and future situations, as well as between various possible future situations, will improve interpretation of the maps, as well as the processing of information by users. Given the recent developments in three-dimensional (3D) visualization (e.g. Appleton, Lovett, Sünnenberg, & Dockerty, 2002; Paar, 2006), the PBL has started a number of projects to search for a better communication platform for policy-makers (see also Hudson-Smith, Evans, & Batty, 2005). The first project took off in 2004 and aimed at meeting two challenges. First, the nominal land use map was to be transformed into a 3D-visualization, based on the assumption that a 3D-presentation could tackle the observed problems. Secondly, such a 3D-visualization was to be made accessible by an interactive interface, using the latest geo-information technology.

Although 3D-visualization seems to offer many advantages (see Ant Ozok & Komlodi, 2009), which shall be outlined in the next section, the outcome of the technical development projects showed that its potential could not yet be fully realised at that time and "might even be a mission impossible" (Borsboom-van Beurden et al., 2006). A major difficulty was posed by the nature of the land use model output data (spatially coarse grid cell data, and long term changes) and the absence of visual information about spatial structure and coherence. The latter has been addressed in the landscape feature (LF) approach (Momot, 2004; Van Lammeren, Momot, Olde Loohuis, & Hoogerwerf, 2005) in which topographical information and landmarks (Al-Kodmany, 2001; Lynch, 1960) were included (Borsboom-van Beurden et al., 2006). This LF approach intended to enable the recognition of characteristic patterns of the Dutch land area according to principles of accuracy, representativeness, and legitimacy (Sheppard, 2001; Sheppard & Cizek, 2009). Thanks to the arrival of Virtual Globes (Butler, 2006), and the high resolution data layers available within them certain intentions of the LF approach have been actualized and are now at our disposal.

1.2. Articulation of the challenge

The above-stated expectation of the policy-makers is in line with most users and designers, who intuitively prefer realistic 3D representations of environments. This assumes that such a representation results in near-effortless comprehension and provides an accurate assessment of the environment that is represented (Al-Kodmany, 2002). This faith in realistic displays is, however, often misplaced, because for many tasks low-fidelity visualization tools offer superior functionality and performance (Hegarty,

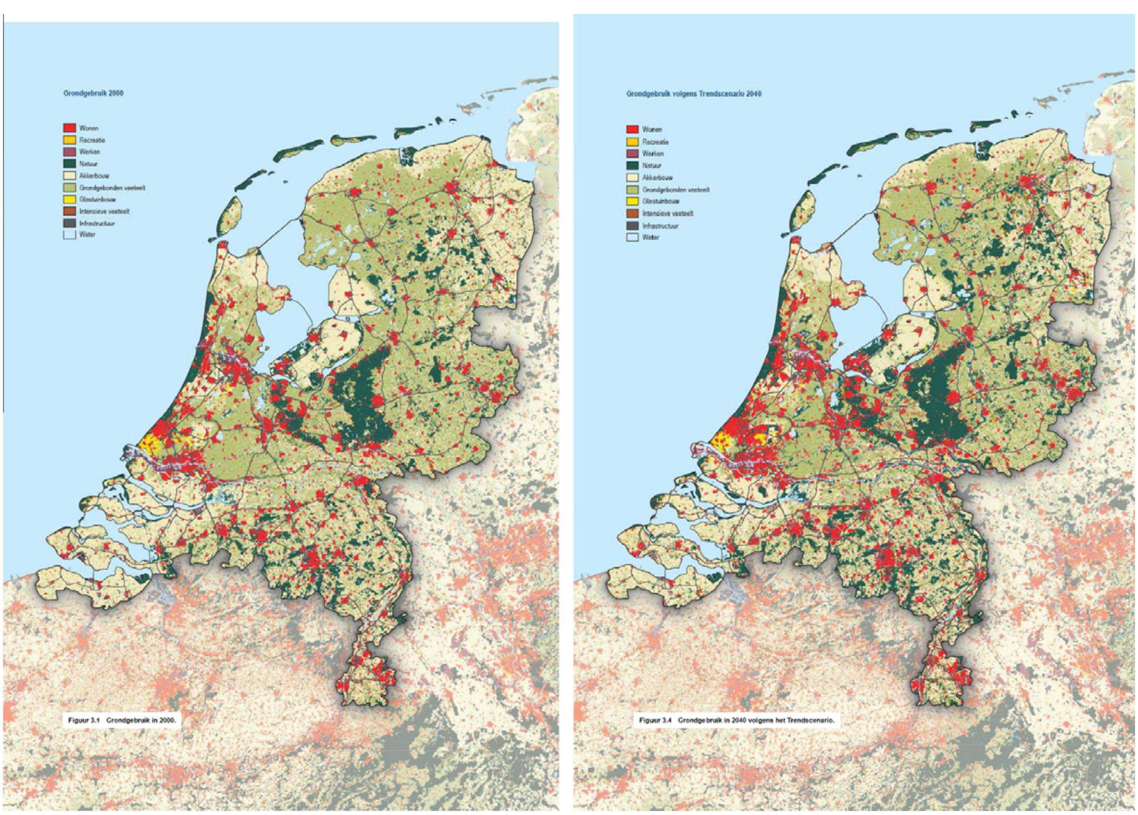

Fig. 1. The A4 land use maps – *left:* land use 2000; *right:* trend scenario land use 2040 (Milieu-en Natuurplanbureau, 2007).