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Assessing the potential impacts of climate change on traditional landscapes and their heritage values on the local level: Case studies in the Dender basin in Flanders, Belgium

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ABSTRACT

The Landscape Atlas of Flanders describes the traditional relic landscapes in Flanders (Belgium), characterized by important heritage values and more specifically by natural-scientific, historical, sociocultural and aesthetic values. These heritage landscapes constitute a considerable part of the common cultural heritage and are therefore managed by specific landscape management plans. However, these plans do not address climate change vulnerability and adaptation, while this is considered as an important driving force of landscape change. This change may impact on the unaffected traditional character of heritage landscapes and cause these valuable landscapes to deteriorate. In this study, we assess and map the potential overall impact of climate change on two relic landscapes in Flanders and map possible adaptation measures on a detailed level to allow insertion in the landscape management plans. Detailed synthesis vulnerability and adaptation maps are elaborated in a GIS, based on the results of impact- and model studies. The vulnerability maps indicate that both case studies are sensitive to climate change. In particular, forest desiccation, wind throw, crop deterioration, soil erosion and flooding might affect the landscape quality and threaten the natural-scientific, historical and aesthetic heritage values of the landscapes. In order to preserve these heritage values, the adaptation maps present possible adaptation measures, which are sustainable and nondestructive with respect to the landscape quality. Although adaptation will cause change as well, it offers more chances to preserve the heritage values of the landscapes. To be effective, detailed climate change vulnerability and adaptation maps should be included in the binding landscape management plans.

Introduction

Like in most parts of the world, the climate in Belgium is changing. Measurements of the Royal Meteorological Institute show an increase in the mean temperature of 2 °C between 1833 and 2009 (Brouyaux et al., 2009). The Intergovernmental Panel on Climate Change (IPCC, IVth Assessment Report, 2007) predicts a further increase in the mean temperature between 1.8 and 4.0 °C by 2100 compared to 1990. Measurements of the total yearly precipitation in Belgium have also shown a rising trend of +7% since 1910. Between 1833 and 2009, the mean winter precipitation rose by 15% (Brouyaux et al., 2009). Winter precipitation is predicted to increase 3–50% by 2100, while in summer a decrease of up to 50% is estimated (Ntegeka et al., 2008). Moreover, evaporation will increase with higher temperatures (Boukhris et al., 2008) and the water availability of soils will decrease, especially in summer (Manabe et al., 2004). Finally, storms will become more frequent and intense due to global warming (Frei et al., 2006). All these changes can be considered as primary effects of climate change. Secondary effects are flooding and drought, which in turn induce tertiary effects such as impacts on nature and agriculture, for example the extinction of species as a result of drought. The combination of these effects can cause drastic changes to landscapes, which are seen as quaternary effects (Pedroli et al., 2010).

So far, most studies on the impact of climate change have been sector-oriented (e.g. the EEA Report, 2008; the Stern Review, 2007) and have focused on above-country scale (Rannow et al., 2010). The impact of climate change on the local level and landscapes, however, has rarely been analyzed. In particular, intact traditional, cultural landscapes deserve special attention as these are part of our common heritage, like stated in the World Heritage Convention (1972). According to this convention, 'cultural landscapes' are "at the interface between nature and culture, tangible and intangible heritage, biological and cultural diversity – they represent a closely

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woven net of relationships, the essence of culture and people's identity" (Rössler, 2006). Often, the management approach of such landscapes is oriented towards preventing changes, like climate change. However, it would be more beneficial to tackle inevitable changes, and thus reinforce the resilience of the system (Bieling et al., 2011; Lemieux et al., 2011). Bieling et al. (2011) describe resilience as "the ability to deal with disturbances or change without altering the essential characteristics of the system in question". This approach focuses on how to dynamically adapt to processes of breakdown and renewal, rather than on conservation.

This paper follows the resilience approach and presents an integrated assessment of the potential impact of climate change and the possible adaptation measures in two specific case studies in Flanders. In particular, two traditional landscape relics, characterized by considerable heritage values and differing in landscape type, were selected. Traditional landscapes contribute to the cultural heritage value of a place as they are the combined result of the natural capacities of an area and the human land occupation throughout history before the end of the 18th century (Antrop, 2003). The relics of Flanders' traditional landscapes are mapped in the Landscape Atlas, based on four heritage values: the natural-scientific, historical, socio-cultural and aesthetic value. Each value is estimated by a set of concise criteria: coherence (the strength of the relations between the composing elements of a landscape or ensemble), legibility (the degree to which parts of a landscape or the whole landscape structure can be recognized and understood) and soundness (degree of maintenance and care of the landscape site or element). Based on this methodology, relic zones and anchor places were identified (Antrop, 2003). Anchor places are small ensembles that consist of different features related by a unique historical development, which form almost intact landscape entities (Van Eetvelde and Antrop, 2005). Fig. 1 provides an overview of the anchor places in Flanders. These anchor places represent the most valuable landscapes of Flanders concerning the cultural heritage, and constitute a considerable part of the remaining common heritage. Therefore, they need special care and attention and an integrated landscape management (Van Eetvelde et al., 2010). This is achieved by the implementation of a new legislation by which anchor places can be designated as 'heritage landscapes'. Following this procedure each heritage landscape is attributed a landscape management plan and management commission, including local stakeholders (Antrop and Van Eetvelde, 2007). However, these plans, and spatial planning in general, are missing detailed vulnerability and adaptation maps to limit the potential effects of climate change. To fill this gap, the threats and risks that climate change presents for landscapes should be assessed using detailed local vulnerability maps in order to outline adaptation plans and preserve the heritage values of the landscapes in the anchor places from deterioration.

In this study, we took up this challenge for two anchor places in Flanders. The first case is situated in the hilly east of the Dender basin; the second is located in the Dender valley (Fig. 1). The aim of the study consists of identifying which threats of climate change the landscapes in both case studies are exposed to, based on the available knowledge from peer reviewed and 'grey' literature, output from model studies and expert judgement. So far, research about the potential effects of climate change in Belgium has been conducted by different institutions, though mostly focussing on one specific aspect of climate change (e.g. soil erosion, flooding etc., see 'Background: predicted effects of climate change and possible adaptation measures in Flanders'). In our study, we attempt to synthesize this information for the two case studies, giving an overview of the potential risks threatening their landscapes as a result of climate change. Therefore, the knowledge obtained from former impact studies is translated into detailed vulnerability maps, locating the risks and threats. Furthermore, possible adaptation measures are determined and translated into corresponding adaptation maps. The maps are produced using GIS-analysis, a method recognized to have a large potential for vulnerability and adaptation assessment (Kasperson and Kasperson, 2001).

Background: predicted effects of climate change and possible adaptation measures in Flanders

In support of the vulnerability and adaptation maps we provide an overview of the predicted effects of climate change in Flanders, which could have an impact on landscape, and summarize a number of possible adaptation measures.

Forests

Higher evaporation due to higher temperatures combined with a decrease in summer precipitation (Boukhris et al., 2008) may cause forests to desiccate. Especially forests located on rich soils are vulnerable (Vos et al., 2007). In addition, desiccated trees are more sensitive to forest fires (de Jonge, 2008) and new diseases and pests shifting northwards (De Groof et al., 2006). As a consequence of more frequent and more intense storms, weakened forests will also become more vulnerable to wind throw (Schlyter et al., 2006). Consequently, a more effective forest management is required. This includes maximizing ecological diversity, e.g. by introducing new tree species to face the new conditions (Dolman et al., 2000; Metzger et al., 2008), replacing coniferous forests by deciduous forests as these are less prone to forest fire (Veeneklaas, 2008) and strengthening the forest structure by connecting different forests (Noss, 2001).

Surface water

Increasing winter precipitation associated with climate change will lead to higher peak flows of rivers. During storms, this will increase the flood risk (Dolman et al., 2000), especially in rivers of which the active floodplain has been strongly reduced as a result of flood levee constructions such as dikes (Pedroli and Harms, 2002). Several measures can counter this by increasing the water storage capacity: creating more space for rivers by restoring their natural hydrodynamic function (Pedroli et al., 2002; Vos and Kuiters, 2007), broadening and/or deepening ditches, safeguarding valleys from new buildings (de Jonge, 2008), constructing water retention reservoirs, etc. (Dolman et al., 2000).

In summer, drought will become a danger as well: decreases up to 40% in low flow are expected in Flanders by 2100 (Boukhris et al., 2008). This will cause pesticides, nitrates and phosphates to be less diluted, increasing the risk of toxic effects and eutrophication (Vos et al., 2007). A number of measures for reducing flood risks may also resolve the drought problem, assuring a more constant groundwater level (Vos and Kuiters, 2007) and minimum flow in dry periods (EEA, 2007). However, vigilance about drought issues is recommended because specific drought response is slower than adaptation related to floods. A possible explanation is that floods are often perceived as more threatening and sudden than droughts, which evolve more slowly and have more indirect consequences (Huntjens et al., 2010). Milligan (2004) even states that "droughts and heat waves are the hidden disaster of Europe".

Agriculture

First, the predicted increase in the mean temperature and CO_2-level will improve photosynthesis and respiration, possibly leading to overgrowing vegetation on grasslands (Hughes, 2000), but also resulting in higher crop yields in temperate regions (Olesen and Bindi, 2002; Reidsma et al., 2009). As a consequence, some land might become available for other crops (Rounsevell et al.,