Simulating change in cultural landscapes: towards a Historic Landscape Modelling approach.

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Summary

In this study a new GIS-based protocol to simulate future change in cultural landscapes will be described. This Historic Landscape Modelling approach will build on the methodology employed in landscape ecology to simulate land-use/land-cover change. HLC (Historic Landscape Characterisation) will be used as a reference dataset to identify spatio-temporal patterns and infer the impact of specific driving forces on landscape change. The outcomes of this study will advance the understanding of landscape dynamics and will inform future landscape planning and cultural heritage management.

KEYWORDS: computer modelling, Historic Landscape Characterisation, landscape change

1. Introduction

Today, more than 80% of World's landscapes have already been influenced by human activities and are generally characterised by different levels of modification and change. Recent studies suggest that landscape change is likely to increase at a significant rate within the next years (particularly in developing countries), depending on the trends in main driving forces of land-use/cover change. Landscape management and planning should guide, harmonize and manage landscape changes instead of completely stopping the change, as in traditional conservation approaches. To do so, there is an urgent need for effective methods and tools for identifying threats and opportunities in future landscapes and also advocating positive landscape change, based on a well-investigated base of evidence that includes both natural and cultural heritage. As today's landscapes are the result of past processes, understanding their long-term evolution is of critical importance to infer their future development (Antrop, 2005).

2. Monitoring historic landscape change using GIS technologies

Historic landscape characterization (HLC) is a GIS-based method employed to represent and study anthropogenic landscapes, with a particular focus on their historical development (Turner, 2006). The integration of GIS to manage the spatial variability of landscape character, and databases to record landscape transformations over time, has disclosed the complex dynamics of historic landscapes and enabled the identification of spatio-temporal patterns that were previously overlooked. The

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interpretation of HLC datasets is based on the production of thematic and interactive maps showing the evolution of the studied landscapes. The analysis of landscape character and its diachronic change relies on the expert assessment (carried out by landscape researchers) of these maps. Although such qualitative approach has provided useful interpretations of landscape evolution, we argue that it doesn't exploit the full potential of the digital datasets produced with HLC. Spatial statistics tools are routinely employed in other disciplines (from landscape ecology to economical geography) to analyse GIS-based datasets that are similar to HLC (Pietrzak *et al.*, 2014). The identified patterns are often used to simulate future landscape change, in order to explore the consequences of specific driving forces. By applying some of these quantitative methods to Historic Landscape Characterisation data, we should be able to model cultural landscape change. This would contribute to overcoming the current speculations about future landscape development, which are exclusively based on the visual assessment of HLC. An increasing reliability of future landscape scenarios will prove extremely useful for the purposes of landscape planning and cultural heritage management.

3. Historic Landscape Modelling

The main objective of this study is to produce a new methodological protocol to model the evolution of historic landscapes and simulate future scenarios of cultural landscape change. A computer based simulation framework, derived from landscape ecology, will be implemented using the HLC as a reference dataset. After a thorough assessment of the main machine-learning techniques used in land-cover modelling, a regression-based approach has been identified as the most appropriate for the specific purposes of our research (Atak *et al.*, 2014). HLC datasets recently created for Boğsak area in Turkey (**Figure 1**), represents the ideal case-studies for testing this novel methodology, as they record critical changes in the rural landscape occurred during the second half of the 20th century. Boğsak is located in the South of Turkey, near the city of Silifke. Traditionally a rural area, it has experience an increasing growth of industrial activities (especially quarries) and a significant improvement of the road network in the last twenty years, and these processes are rapidly changing the demographics and land-use in the region. The consequences for land-cover have already been explored, but the impact of this rapid modernisation on the historic landscape has never been assessed. In fact, this was the primary reason for the development of the HLC in the area.

Since changes in the land-cover and changes in landscape characters are conceptually different, the methodologies borrowed from landscape ecology had to be adapted to the nature of HLC datasets, and strengths and limitations of the resulting protocol had to be evaluated. Spatial and attribute data of HLC (vector polygons connected with a relational database) were reclassified to produce the 10 different types for simulation. Social, economic and ecological drivers of change were considered for the simulation, and their influence on the spatial and temporal variation of landscape character was analysed and interpreted. Geographical proxies of these drivers were produced using a Digital Elevation Model, and maps of the main roads, rivers and cities of the region. A soil depth map was also created as proxy of agricultural suitability. These maps were produced using ArcMap 10, with GRASS 7 utilized for specific tasks. These driver maps were tested in the first iteration, and other dynamics drivers have been added to the model in later iterations (ongoing). The "suitability to change" of the different landscape character types was also addressed, in order identify those components of historic landscapes that are less affected by the previously identified drivers. Logistic regression was carried out using R, to investigate the correlation between the spatial variability of drivers and the presence/absence of each landscape character type. The final step was the simulation of landscape change between the 1990s and the 2010s, based on different combination of driving forces. This was undertaken using CLUE modelling framework (Conversion of Land Use and its Effects) (Veldkamp and Fresco 1996), implemented in Dyna-CLUE software. The outputs of this simulation were validated against the actual HLC of 2010 (produced from contemporary cartographic resources) in order to assess the accuracy of predictions. Although calibrations simulation parameters (in particular the elasticity of each landscape type) and a revision of the selected drivers seem necessary, preliminary results are very promising, and enable an initial assessment of the potential of this approach, which has been called Historic Landscape Modelling (HLM).

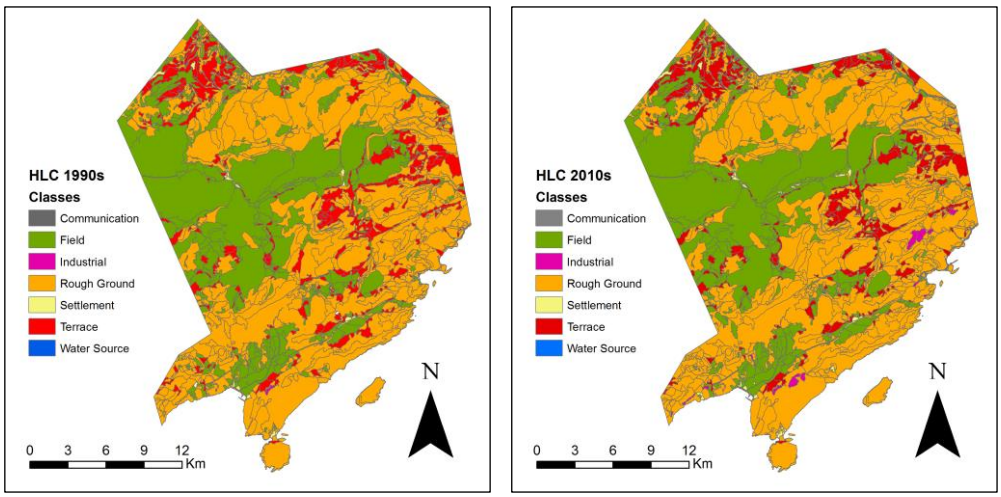

Figure 1 HLC of Boğsak: distribution of landscape character classes in the 1990s and 2010s

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