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Competing visions? Simulating alternative coastal futures using a GIS-ANN web application

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ABSTRACT

In this paper, we demonstrate the use of scenario building in the context of contested land use visions. We examine a small coastal community located 20 kms south of Lisbon. In Almada – Trafaria/Costa da Caparica, competing stakeholders such as central government, local government, environmental NGO's and private companies each have competing development visions for the area. These include the development of recreation and leisure facilities, a container terminal and the re-naturalization of unused land. We illustrate the added value of the GIS-ANN tool in steering negotiations between these different visions and the potential of a scenario building web application as a tool for problem solving.

The emergence of user-created GIS-based web content in Planning has transformed passive users and consumers of geospatial information into active contributors to the development of spatial visions of the future. It allows stakeholders to gauge alternative future land uses thus making planning and decision-making processes potentially more transparent and democratic. In this paper, we detail a new method that enhances GIS-web-based public participation. We build on a combination of GIS basic capabilities and the data mining methods of Artificial Neural Networks (ANN), namely Multilayer Perceptron (MLP) packaged in a friendly (GUI) user interface that runs on the Google Earth platform. Users will be able to articulate different spatial development scenarios for a specific area, to conduct sensitivity analyses for various competing scenarios and to explore causal connections between them.

1. Introduction

Coastal areas are fragile systems that interface intense human and physical interactions of a non-linear type and consequently represent a conflict-prone habitat of contrasting interests. Human-environment systems, such as those present in coastal areas, are characterized by heterogeneity, non-linear relationships and hierarchical structures that give rise to difficulties in understanding system behavior in response to exogenous factors (An *et al.*, 2005). The villages of Trafaria and Costa da Caparica, located on the South bank of Tagus River, set the territory boundaries of our case-study area. The location near Lisbon and in the Tagus river mouth, along with the rich natural environment makes this location a competitive area for different investments and therefore, the emergence of conflicting interests. Local and national environmental associations would like re-naturalizate the area and adopt environmental protection while the Lisbon Port Authority and central government present financial arguments to support actions for developing a new container terminal in Trafaria that will provide a movement capacity of two million TEU's per year.

This underlying rationale of this paper is to provide answers for assuring a balanced organization and management of the coastal area on the one hand and to solve existent land use conflicts and avoid future discord, on the other. This will help policymakers make better and more informed decisions on future development policies. To deal with this complex system, the model we have developed builds on a bottom-up approach as spatially-extended systems are capable of non-trivial collective behavior. Since these kinds of emergent properties cannot be derived from the properties of individual elements alone it is difficult to predict this behavior. Using computer simulation allows for the precise study of the dynamics which cannot be observed using analytical methods alone (Simões *et al.*, 2009). We use a GIS based artificial neural networks (ANN) web based application model that allows users with basic GIS skills to simulate alternative coastal land use futures. This way, competing development visions can be compared and the trade-offs between them can be articulated.

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2. Case study

Our case study area is located in the Lisbon metropolitan area. The exact location is Trafaria and Costa da Caparica two villages on the south bank of Tagus River within the municipality of Almada 16 km from Lisbon. The first is a small fishing village with 6000 inhabitants and the second is a second-home village with a tourist orientation housing 16,000 inhabitants. The natural environment includes 13 km of beaches with high water and sand quality that attract tourism and consequently leads to conflicts of interests amongst stakeholders that need to be mediated. Over the last decade a serious of potential conflict points have arisen with respect to future land use development of the area. These have been accentuated by natural processes such as erosion and anthropic pressures such as tourist related developments such as golf courses, camping parks and second home residences. In addition conflicts exist over allocation of land use across different functions such as harbor, tourism, leisure, residential and commercial uses and different groups of stakeholders have mobilized such as residents, tourists, and local administration, each with their own preferred vision of future development. A major project initiated by the Lisbon Port Authority for this area is currently in discussion concerning the location of a new container terminal in Trafaria. This is due to occupy a land area of 105 ha of a total of 300 ha and will provide a movement capacity of two million TEU's per year. Besides local opposition from residents and fisherman another project led by national and local environmental associations to re-naturalization and protect the natural landscape has been proposed for the same area. Based on these divergent proposals, scenarios are generated for the development of a container terminal, the ecological project and a baseline scenario with no action, either the terminal or the re-naturalization approach, but under the same two different socioeconomic backgrounds.

3. PPGIS – bridging the gap between the community and decision makers

The term "Public Participation Geographic Information System" (PPGIS) has been used from the 1990s (Rinner *et al.*, 2008; Stocker *et al.*, 2012) onwards. It was initially coined by Schroeder (1996) at the meeting of the National Center for Geographic Information and Analysis. At first, PPGIS evolved as a support tool for decision-making allowing public input and affording citizens the opportunity to express their opinion on political decisions with a geographic component. Subsequently it has evolved as a tool for mediating the interests of various stakeholders.

Geographic Information Systems (GIS) on their own are a powerful support tool for decision-makers (Longley *et al.*, 2001; Geertman, 2002). However, they cannot solve problems linked to the planning process itself. To do so, GIS needs to be integrated with an Information and Communication Technology (ICT) platform (Voss *et al.*, 2004). When built on user friendly platforms, like "Google Earth" (e.g. Stocker *et al.*, 2012), PPGIS web-based allows users to voice their opinions about urban plans thus helping decision-makers in the planning process via an enlarged public consultation forum. These platforms allow the participation of people who wish to propose specific spatial development actions, such as citizens who may be affected by plan proposals and central government and local planning authorities (Mansourian *et al.*, 2011). In sum, a participatory decision-making process aims to solve territorial conflicts and PPGIS is at the centre of the mediating process between stakeholders and decision makers (e.g. CommonGIS) (Voss *et al.*, 2004).

Procedurally, a comprehensive evaluation requires that PPGIS stakeholders' selection should cover different areas of expertise, extensively representing existing spatial conflicts of interests. PPGIS eases the procedure with the exchange of information and a better perception of the study area, allowing greater interaction among the users. However, this method should incorporate a neutral element to moderate the discussion sessions and promote consensus.

In sum, PPGIS is a useful tool for solving complex problems with multiple stakeholders, simplifying the whole process (Voss *et al.*, 2004). PPGIS seeks to integrate public knowledge of a specific area in land use decision making processes (Brown, 2012) aiming to democratize technology and geographical information (Brown and Weber, 2012). Its use helps curb speculative discourse assisting stakeholders to focus on the issue under review, to reduce conflict (Green, 2010) and thus to promote an equitable debate and greater legitimacy in decision-making (McCall, 2003). Current examples of the use of PPGIS, include applications to coastal areas (Green, 2010), the identification of conservation priority areas (Pfueller *et al.*, 2009) and the management of recreation areas in the public domain (Brown and Weber, 2011).

3.1. Limitations and efficiency in decision support

There are nevertheless a series of limits to the use of PPGIS. There are two ways to implement a PPGIS: in person and via web-based delivery (PPGIS vs. PPGIS online). In the first case, the neutral element, i.e. the moderator, has to make a preliminary selection of representative stakeholders and conduct the session. In the case of the web-based approach, PPGIS is able to cover a greater number of elements involved providing a wider debate (Stocker *et al.*, 2012) but is heavily dependent on the existent participation culture and access to technology. A web-based technology built on a familiar and friendly GUI, as is our GIS-ANN model, will definitely help to promote stakeholders participation and reduce some of the technical capacity deficit, which is an issue when wanting to involve local communities in the planning process. Instead of being part of the problem PPGIS helps they become active in the solution. The current application encourages this approach. In the context of the coastal land use conflict under consideration, it suggests envisioning container terminal development being directed in a less environmentally destructive way and designed to ensure re-naturalization while creating jobs and promoting the local economy.

Furthermore, PPGIS online has the advantage that users have more time to reflect on issues and thus time is not an issue as in the face-to-face approach. However, PPGIS must always have personal component in order to cover a portion of the population that does not own or is not familiar with these new technologies (Zhong *et al.*, 2007) despite the disadvantages of displacement and scheduling difficulties of persons involved.

The vast majority of PPGIS applications only allow the exploration of data through the visualization of pre-prepared themes. In some cases platform do facilitate queries to databases as is the case of Virtual Slathwaite – United Kingdom; INFOMAP Orange county Interactive mapping; Interactive Lanscape Plan Konigslutter am Elm, Argumentation Map (ArgooMap), GeoDF or Geolink. However, the widespread use of these platforms only allows stakeholders to visualize the information that is prepared and not to perform any kind of spatial analysis. Consequently, the complexity of GIS interfaces may put inhibit many users who do not feel familiar with this type of platform. (Carver, 2001; Laurini, 2001). In fact, many people still do not have access to computers and internet or do not have the basic knowledge to be able to manipulate these decision support systems (Hawthorne *et al.*, 2008). In many cases, these users have a capacity deficit not only in terms of access but also in the interpretation of geographic data especially when the volume