Design, implementation and test of a serious online game for exploring complex relationships of sustainable land management and human well-being

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ABSTRACT

Land is a limited resource providing various services. Decisions on land use shape the distribution of these life support functions and thus require understanding of complex feedbacks between decisions on land use and human resource appropriation. Due to multiple nonlinear feedbacks between management, productivity, environmental quality, and human well-being, complexity is an inherent property of land systems. We present an educational game, which aims at illustrating options of sustainable land management to the interested public, students and stakeholders. The game provides the opportunity to govern a country by exploring how contrasting dimensions of sustainability (economy, environment and social conditions), can be harmonized regionally, while continuously being threatened by global trade fluctuations. The game was tested by several groups of students from high schools and universities. The feedback shows that the game is a valuable tool in environmental education initiating learning the complexity of feedbacks in land use and resources appropriation.

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Software availability

Name: LandYOUs
Version: 1.1
Contact: landyous@sustainable-landmanagement.de
Accessible at: www.landyous.org
Supported languages: English, German
Software required: Standard web browser
Programmer: PiSolutions GmbH, Markkleeberg, Germany, info@pisolution.de

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1. Introduction

Sustainable land management is among the grand challenges of the next decades (Foley et al., 2011; Garnett et al., 2013). Multiple requirements, such as production of food and energy, provision of space for living and infrastructure or maintenance of ecosystem function and biodiversity, put high pressure on the limited land resources. Land use management of a given region has to fulfil criteria of sustainability with respect to environmental, economic and social performance. Simultaneously, fulfilling all requirements of sustainability has to be achieved while maintaining ecosystem services and biodiversity (Tscharntke et al., 2012). Understanding landscapes with their multi-functionality increases complexity of feedbacks to be considered, but also provides opportunities for

solutions in sustainable land management (Seppelt et al., 2009). Although regionally focused, land management strongly depends on global trends. Management decisions on land use on a local or regional scale can have off-site or external effects, which might remain unconsidered if solely focussing on land management in a region of interest (Seppelt et al., 2011, 2013). One approach to manage land more sustainably involves the integration of stakeholders from the beginning of planning processes (Voinov and Bousquet, 2010) and may lead to sophisticated decision support tools as result (see for example McIntosh et al., 2011; Oxley et al., 2004; Volk et al., 2010). As the matter of sustainable land management concerns our society as a whole, it is important to increase public awareness and understanding of this concept.

Among different didactic tools for raising awareness of environmental questions, serious games form an innovative strand, which gains more and more attention (Barreteau et al., 2007). Here, we present a newly developed computer game entitled LandYOUs, which increases an understanding of the challenges in sustainable land management among pupils and students from the age of 14, interested public and stakeholders from land management. In an interactive and entertaining way, players learn about the complex interplay of economic, social and ecological aspects, and the impacts of land management on human well-being and nature conservation. Thus, LandYOUs aims at bridging the gap between landscape modelling and environmental education. A system dynamics model of LandYOUs simulates the complex feedbacks and interrelations of land systems management. The game serves as a training tool, which encourages systems thinking and discovering the nature of nonlinear cause–effect relations. The LandYOUs serious online game has been launched in 2013. This paper presents the concept and implementation of LandYOUs, as well as the evaluation of the first user survey. Finally, further improvements and utilisation of LandYOUs are discussed.

2. Concepts of serious games in environmental education

Games represent valuable tools for communication and educational purposes. They provide an easy transmission of complex and serious topics by increasing players' motivation and interest to understand them. Crookall (2011) provides an overview of the recent development of simulations and games, and strengthens the importance of serious games. Garris et al. (2002) suggests that one of the reasons why serious games receive an increasing attention is the shift in the field of learning: from a traditional approach to a "learner-centred model", in which learners take an active role in the educational process instead of being pure recipients. Eisenack (2012) points out that the effect of "positive connotation" of games helps achieving the educational purpose. Multiple studies investigate the effectiveness of games for educational purposes. For instance, Virvou et al. (2005) show the effectiveness of the VR-ENGAGE educational software with a gaming aspect particularly for students who show a poor performance in the domain taught prior to their learning experience with the game. Gosen and Washbush (2004) provide a summary of exemplary studies evaluating the success of simulation and gaming. The authors list several empirical studies advocating the experiential learning as an effective approach. At the same time, they point out that these results should be treated with caution, and emphasize the importance of enhancement of consistent validation standards for experimental learning methods.

Various games with educational purpose have been recently developed in the environmental field. KEEP COOL is a board game focused on aspects of climate change (Eisenack, 2012). In FUTURE VOLTAGE, the player controls the electric power supply system (Benders and de Vries, 1989). FISH BANKS (1989), another well-

known example of an online game, which is based on the original board game version, is addressing the topic of renewable resource management. The ÖKOLOPOLY® board game from 1978, a pioneer among environmental educational games, was using system dynamics as underlying simulation model. This board game was later transformed into the computer game ECOPOLICY® (Vester, 1984)[1].

Ulrich (1997) provides an extensive survey on simulation games within the field of environment and sustainability. The author's results showed that combination of high quality content and design with a proper administration of simulation games (such as provision of supplementary material, background information or alternative languages) supports the effectiveness of games in environmental education.

These findings were very helpful during the development of LandYOUs, which has the following core idea: players step into the role of a governor who controls the land use of a virtual country by various capital investments. Rather than quantitative processes, the game focuses on qualitative processes of land management, as in the KEEP COOL board game (Eisenack, 2012) or ECOPOLICY® (Vester, 1984). LandYOUs was designed as a serious online game for three main reasons. First, it can be quickly distributed to a wide public and thus allows a fast and effective communication of complex issues of land management. Second, computer games allow direct incorporation of complex system dynamics and, thus, are particularly suitable for the field of land use management. Thirdly, it allows the use and application without any limitations on licenses or other restrictions. It is therefore suitable to initiate discussions on the topic sustainable land management at various locations and situations. LandYOUs was designed to offer an appealing graphical user interface to positively affect the gaming experience and support learning.

3. Model concept and implementation

3.1. Overview

After starting the game, the graphical user interface with the main elements is displayed: the land use map, indicator panels with feedback relationships, policy investment controls, and various interactive help and annotations options (for GUI, see Section 3.4). At the same time all initialization procedures are executed, see Supplementary Information A (SI A) Section 7.1. In each out of ten rounds maximum, the player then decides on investments in any combinations of measures on agriculture, afforestation, settlements, nature conservation or education, see SI A 7.2. Based on these investments, land use changes are estimated; feedbacks to all other indicators within a nonlinear discrete dynamic system are evaluated; the users score is estimated; and the new budget is calculated, see SI A 7.3–7.6 and below.

The underlying model links decisions on five policy measures with spatially explicit land use change and a dynamic feedback system that characterizes the socio-environmental system.

3.2. Purpose and basic principle of the model

To demonstrate various options and feedbacks of land management decisions, the core function of the underlying model of the game LandYOUs is to provide an aggregated system dynamics model with a reduced number of state variables, which get input from a spatially explicit map representing land use. Although very much aggregated, the model should be capable of qualitatively capturing real world patterns, e.g. reproducing reasonable patterns

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[1] http://www.frederic-vester.de/deu/ecopolicy/, last visit: 2013–10–13.