Where Should We Place It? The Potential of a Serious Planning Game Approach for Participatory Planning Processes in the Context of Renewable Energy Development

Thomas Schauppenlehner[1], Mathias Baumgartinger-Seiringer[1], Karl Bittner[1]

[1]Vienna Institute of Landscape Development, Recreation and Conservation Planning; University of Natural Resources and Life Sciences · thomas.schauppenlehner@boku.ac.at

Abstract: Game-based approaches are promising tools for enabling participation and collaboration in the expansion of renewable energy. The main advantage is that complex social-economical, technical or ecological interdependencies can be integrated as part of the game-logic to illustrate a broad range of impacts and synergies for different scenarios. Many of these approaches are paper-based although computers can support these decision-making processes by providing more comprehensive game logics, visualisations, calculations and real-time indicators (e. g., biodiversity measures, viewsheds, etc.). This article presents a computer-supported planning game for discussing the impacts of agrivoltaics (AV) at local level by collaborative development of different energy scenarios using a game-based approach. Results indicate that the provision of real-time indicators allow an objective discussion of different trade-offs. However, it is important for group work that the computer inputs do not interfere with the process, which is what we want to achieve with the development of a new human-machine interface.

Keywords: Serious games, 3d visualisation, renewable energy, participation

1 Introduction

The expansion of renewable energy requires space and is increasingly encroaching on various aspects of the landscape. This causes a variety of conflicts such as impacts on biodiversity, land use competition (e. g., tourism or agricultural production) or negative visual landscape impacts. Although existing expansion plans and zoning at national or federal level aim to manage and steer this expansion in a favourable manner, they often encounter resistance at regional and local level. The main issues here are mostly of spatial origin, because renewable energy requires different conditions (e. g., wind speeds, distance regulations, land use, topography, etc.), which means that they are usually concentrated in landscapes and thus significantly change them (PASQUALETTI 2011). On the other hand, questions of justice arise that often receive little attention in current procedures, especially with regard to the inhabitants of a region. (WÜSTENHAGEN et al. 2007, BATEL 2020).

This suggests that participation is particularly important in this area in order to consider local characteristics and conditions in planning processes and increase acceptance for the expansion of renewable energy through joint decision-making. However, the potential effects and interactions of renewable energy infrastructure on the landscape are very complex and diverse, which requires appropriate data bases and modelling in order to provide a valid basis for decision-making for different expansion paths or development scenarios.

Serious games are a promising tool in the field of landscape planning for the involvement of citizens in planning processes and have a potential for making the impacts and trade-offs of

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various decisions tangible. They can help to determine environmental preferences, explore human interactions, and can support public multidisciplinary decision-making (BISHOP 2011). While many landscape-related game approaches are analogue and paper-based (see GAPINSKI et al. 2022 or GUGERELL et al. 2018), new advances in computer technology especially for realistic real-time visualisations (SCHAUPPENLEHNER et al. 2019) are increasingly enabling the use of this technology in participatory processes. Despite their usefulness supported by scientific studies (PAPADIMITRIOU 2022), serious games are not widely used in planning practice, which is often argued to be due to their high complexity and the associated development costs.

This article presents a computer-aided approach for participatory planning of agrivoltaics (AV) using an interactive planning game. The main objective is to answer the question whether complex participatory processes can be supported by technical approaches with reasonable effort. To this end, the developed game approach will be tested and discussed in two workshops. The focus is on the potential for decision-making processes as well as technical functionalities and barriers.

2 Project Background and Methods

The research project *Potential analysis of AgriVoltaics in Austria in the context of climate change – with special respect to environmental, economic and social aspects* assesses the potential of AV in Austria for climate change mitigation with special respect to (techno-) environmental and social aspects. To evaluate specific potentials, synergies as well as conflicts regarding agricultural production and landscape impacts at local level, workshops were conducted in two Austrian municipalities.

Stakeholders were invited to contribute with their local knowledge using a serious planning game approach and comprehensive 3D visualisations. The aim of the game was to reach 2030 and/or 2050 goals for renewable energy development (EUROPEAN COMMISSION 2023) at the municipality level by defining potential zones for the establishment of AV. The participatory planning process was supported by a new type of human-machine interface in which little building blocks allow the game to be controlled. The games workshops were introduced with comprehensive information on AV technologies, impacts on landscapes and other land uses, game content and gameplay. After the game, there was a reflection session on the result as well as on the game and its game-based and technical elements. The results are based on a qualitative evaluation of the workshop.

2.1 Involvement of People in Participatory Processes

Participation describes a broad range of concepts and methods for the involvement of people in decision-making processes. They address the increasing complexity of problems by establishing networks of decision-making relationships between organisations, governments and civil society (VAN DRIESCHE & LANE 2002). Addressing landscape-related aspects, article 6 of the European Landscape Convention (COUNCIL OF EUROPE 2000) emphasises the need to increase awareness among the civil society, private organisations, and public authorities of the value of landscapes, their role and changes to them. By involving civil society in planning processes, a joint development and design of the immediate living environment can take place, where specific local knowledge can be integrated.

The obvious need to involve a broader public in social and ecological issues depends heavily on the process design and the selection of participation methods and technologies. As ICT-based approaches become more important in this context, the question of how to interact with the machines is increasingly important.

In order to classify different methods of human-machine-interaction (HMI) with regard to participatory research processes, it is necessary to separate different levels of interaction between the involved people and the temporal dimension of collaborative actions to create a continuum of computer-supported participation.

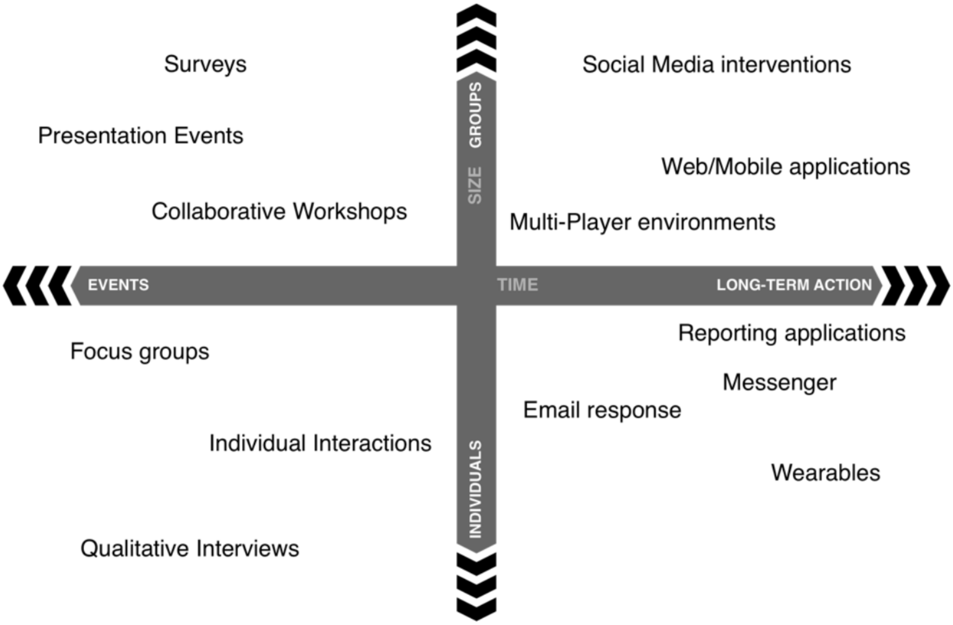

Fig. 1: A continuum of computer-supported participation between the temporal dimension and the level of interactivity (SCHAUPPENLEHNER 2023)

As shown in Figure 1, this field ranges from solitary individual actions to long-term interventions in diverse group settings with permeable and fuzzy borders between those categories. ICT has created a broad range of tools and apps with different purposes and meanings. Many of those tools are mobile applications or web services, where people can respond or contribute within surveys, games, applications or Citizen Science actions.

A deficiency of most of these ICT approaches are the limited possibilities for joint collaborations in a physical manner (e. g., workshops). Computers tend to be used for presentations in this context, rather than for interaction. A major issue are the existing human-computer-interfaces that do not work well within groups (SCHAUPPENLEHNER et al. 2020).

2.2 Physical Objects as Computer Interface

Maps as representations of a planning region are central to all spatial planning processes and are often used in collaborative processes as a common basis for thinking, marking and drawing in order to ultimately make joint decisions. Gesturing on a map is an important tool for communication in urban planning, and paper maps are often presented in this context to sketch ideas using marker pens or pin nails (DEINET & KRISCH 2002). However, navigating digital maps in such workshops can be difficult, as traditional input methods such as mouse and keyboard creates barriers and allow only few people to actively interact with the map. To overcome these obstacles, the operation of the computer equipment must be fully integrated into the process of co-production of knowledge within a participatory setting which requires new interfaces for computer interaction.

As humans, we are familiar with gestures and the use of physical objects to build or emphasise something in our everyday communication. Therefore, automatic recognition of physical objects or gestures can be a technical solution to translate these actions and elements into data or computer commands (RAHEJA et al. 2018, SNYDER 2013).

Consequently, a unique map-based input method was developed and tested in the workshops. Figure 2 shows the functionality and operation of this interface: A projector is suspended above a table along with a camera. The projector renders an image onto the table and creates the map-based game board, where the players can place little building bricks. Each brick can represent a (planning) object/zone or perform a map operation such as panning or zooming. The video stream from the parallel mounted camera is analysed in real-time using an object recognition script (OPENCV TEAM 2020) in terms of location, brick colour and brick size. The location on the projected game board is transformed directly into a geographical coordinate system and, by recognizing the colour and size of the brick, different models (in this case different AV systems) can be integrated without further input.

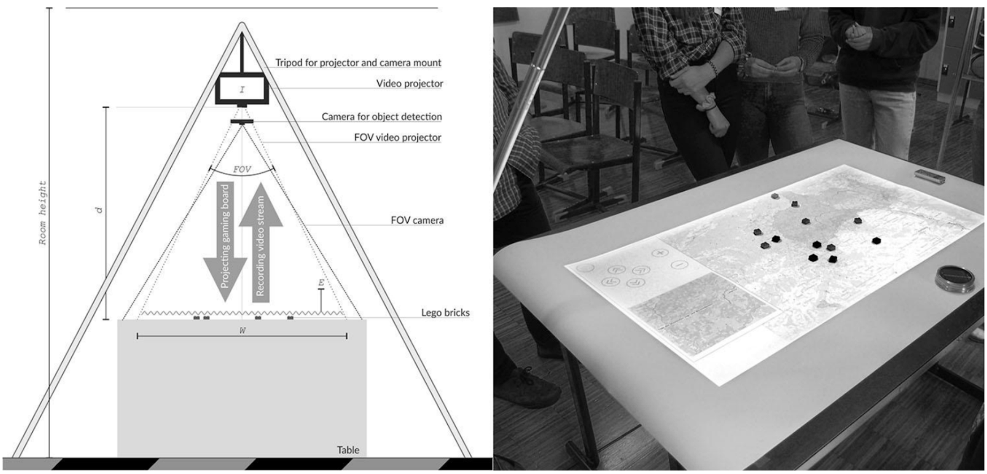

Fig. 2: The interactive game table based on GIS data and game token recognition for computer-supported serious games and collaborative planning processes

The advantage is that the technical aspects of the computer interaction fade completely into the background and the participants can engage in an immediate dialogue, for example, the development of scenarios. However, the computer in the background provides feedback on the actions taken, e. g., in the form of indicators, visualisations or the updates of game objectives.

3 Results

Two workshops were conducted in two Austrian municipalities with 12 participants in total (6 persons per workshop) representing the municipality, farmers and local renewable energy stakeholders. With a game board of approximately A0 size, it was comfortable for each participant to view the map and to contribute to the game. We recommend that the number of participants should not exceed 10-12 people in order to enable a good flow of the game. The workshops have shown that the human machine interface using the haptic building blocks interface works seamless within the workshop setup (see Figure 3). It was particularly exciting to observe that just the introduction to the interface with the familiar and often positively connoted bricks (through experiences in their own childhood or through playing with children) led to a great deal of attention and proactive behaviour. There was virtually no misrecognition of bricks by the system. Even under different lighting situations and setup conditions, the game board interface worked very reliably.

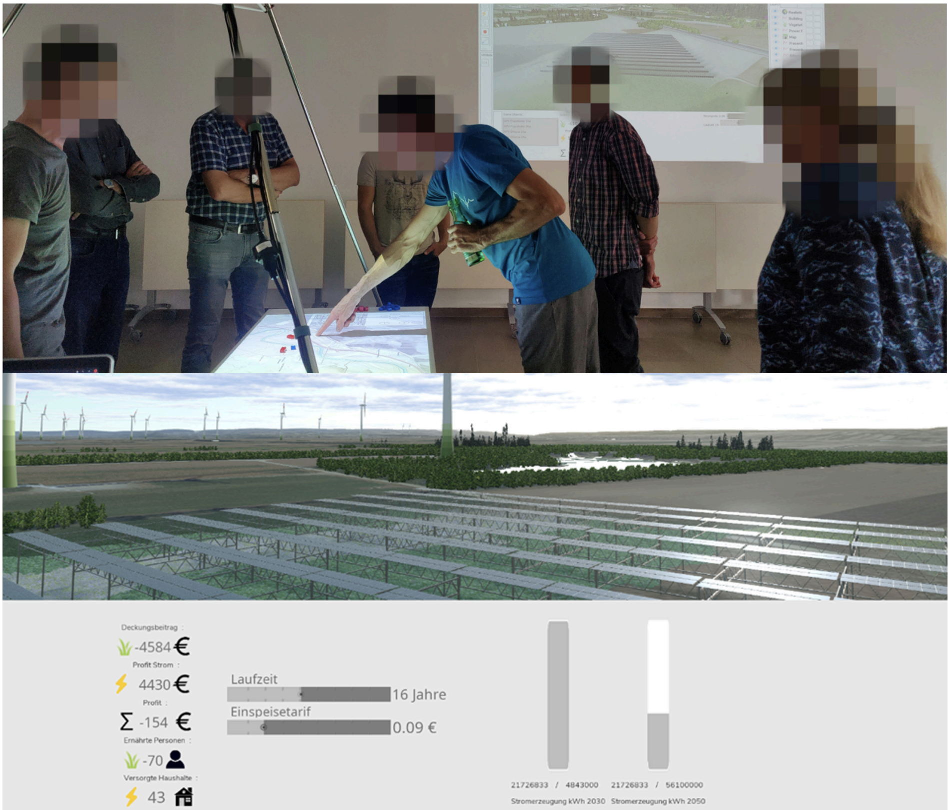

Fig. 3: Workshop scene with a group of participants playing the game on the interactive table (left) and the output display (right) presenting different indicators in real-time addressing the visual impact (3D visualisation), effects on agricultural production/profit and produced energy (numbers in the lower left section) and the achievement of the game objectives (2030 and 2050 goal) (bars in the lower right section)

After a short introduction, the participants were invited to record their thoughts and ideas on the table using the buildings bricks. There were no obstacles to touch or operate the game. The immediate feedback from the computer regarding potential energy production, effects on agricultural yields and the landscape impact (see Figure 3) was of great importance and enabled immediate reflection and reaction to previous game moves. As a result, a collaborative map was produced containing potential AV development zones and exclusion areas as well as potential development locations (see Figure 4).

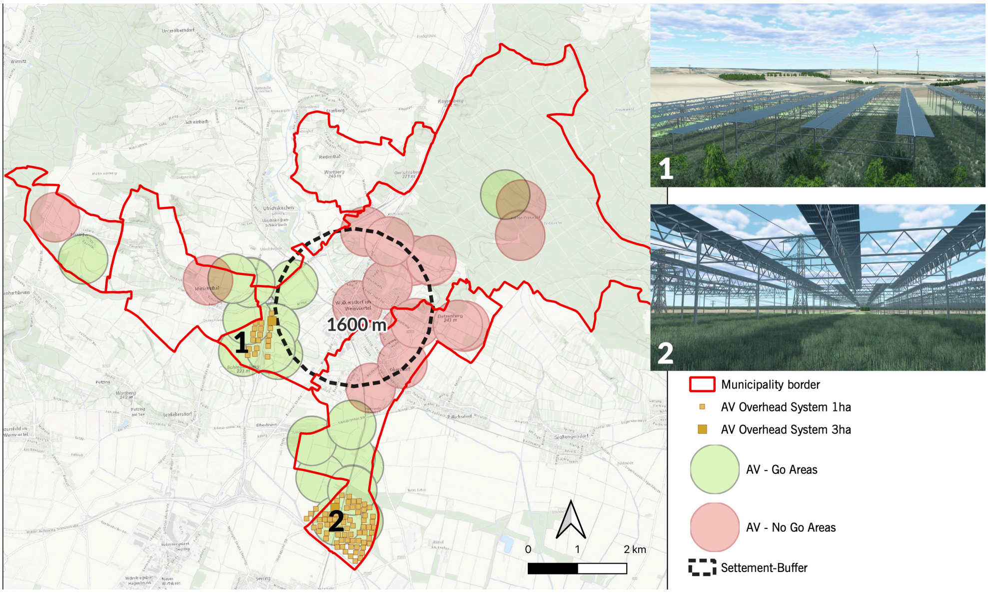

Fig. 4: Result map of the gameplay and visualisations from one case study region

The map shows that there was a broad consensus to concentrate the AV installations in the south and west of the municipality. The immediate settlement area and the forest in the north were largely excluded. With regard to the detailed location of the facilities, the proximity to the highway was preferred and attention was paid to the lowest possible visibility from the settlement area by considering terrain edges. Other factors that were discussed were soil quality and the impact on other uses such as hunting.

With this approach we were able to bundle local knowledge regarding landscape impact, soil qualities, conflicts of use as well as grid infrastructure and implement it in a collaborative simulation game to identify and discuss questions regarding the social acceptance of AV with a qualitative approach. The direct feedback of AV installations on food production, energy production, and economic impacts in the game led to a very active discourse on the potentials of this technology and resulted in the possibility of dual use in particular being highly valued. From a technological point of view, we were able to show that geodata and maps as a basis for interactive serious games engines have a high potential to enable joint planning and discussion especially for the expansion of renewable energy.

4 Discussion

Our approach has shown that the use of computers and ICT technology can support participatory planning and group processes in physical workshop environments. The prerequisite for this, however, is that there are also suitable interfaces so that the group processes are not hindered by complex computer input. The focus here is often reduced to mobile devices and relies more on individual contributions via apps and websites (surveys, opinion polls, citizen science actions) than on supporting events at a common location.

With regard to a possible use in planning practice, we were also able to show with our approach that this can also be realized with comparatively inexpensive technical equipment which means that it has a potential to be used in different planning scenarios. However, it should be borne in mind that the interaction possibilities can be overwhelming and that a very careful introduction to the topic is required in order to make meaningful decisions in the group process.

The very easy access to the game and the possibilities to recognize direct impacts on other uses (landscape, agricultural production) and to adjust parameters (e. g., feed-in tariffs) were positively emphasised. These level of interaction and feedback cannot be provided in static paper-based games (GAPINSKI et al. 2022). As other studies have shown, a gaming approach also promotes knowledge exchange and mutual learning (HASSAN & HAMARI 2020).

From this, a clear recommendation can be derived to use these new possibilities of participation especially in the site planning of renewable energy on a broad level, in order to create awareness on the one hand, to integrate local knowledge and to create a common and equitable planning base.

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