Land Use Policy 73 (2018) 434–446

Contents lists available at ScienceDirect

Land Use Policy

journal homepage: www.elsevier.com/locate/landusepol

Designing landscapes for sustainable outcomes – The case of advanced biofuels

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ARTICLE INFO

Keywords:
Ecosystem services
Biodiversity
Participation
Decision-making
Multifunctionality
Computer models
Cellulosic ethanol
Sardinia

ABSTRACT

The design of socio-ecological landscapes to provide simultaneously multiple benefits has become a key concept in current sustainable development thinking and an attractive goal for policy makers. However, its application in the practice of landscape management has proved difficult. In this study, we develop an approach for practical application of landscape design to advance multifunctionality and sustainable outcomes. We combine ideas of landscape ecology with methods for collaborative decision-making to deal with the practice of designing landscapes. Our approach consists of six components including (a) definition of boundaries and scales, (b) assessment of local values and concerns, (c) knowledge development, (d) stakeholders participation, (e) collaborative decision-making and (d) monitoring. We test the approach on the case of advanced transport biofuels. These technologies have attracted attention in recent years as a means to achieve climate, energy and development goals avoiding the environmental and socio-economic risks of conventional biofuel technologies. The findings suggest that the landscape design approach has the potential to guide the planning of complex biofuel projects for sustainable outcomes improving local acceptability of potentially controversial projects.

1. Introduction

For millennia ecosystems have been modified by humans to cheaply and reliably produce desired services such as food, feed and materials such as fibre and timber (Ellis et al., 2013). The management of ecosystems has traditionally focused on sectorial approaches without concern about their multifunctional nature (Bennett et al., 2009). However, recent decades have seen the emergence of the sustainability discourse and a call to redirect research efforts to meet human-induced landscape challenges (Palmer et al., 2004; Lambin and Meyfroidt, 2011). In this context, the design of landscapes to simultaneously provide multiple benefits has become a key concept in current sustainable development thinking (Termorshuizen and Opdam, 2009; O'farrell and Anderson, 2010) and an attractive goal for policy makers.

Multifunctional landscapes are created and managed to integrate human production and landscape use into the ecological fabric of an ecosystem maintaining critical ecosystem functions, service flows and biodiversity (O'farrell and Anderson, 2010). An important concept for studying landscape multifunctionality is that of ecosystem services as the benefits that ecosystems, either natural or managed, provide to humans (Mea, 2005). Structurally integrating ecosystem services into landscape management holds important opportunities for improving sustainability and resilience (Lovell and Johnston, 2009; De Groot et al., 2010). However, the application of the scientific knowledge of ecosystem services in the practice of landscape management has proved difficult (Nassauer and Opdam, 2008; Musacchio, 2011; Clark and Nicholas, 2013).

The aim of this study was to develop and test an approach for the practical application of landscape design to advance multifunctionality and sustainable outcomes. Combining ideas of landscape ecology with methods for collaborative action, our approach deals with the practice of designing landscapes for sustainable outcomes as a complex task. As an activity, the process of landscape design has attracted increasing attention due to the shift from a governmental model in which governments are the single actors responsible for environmental management to a governance model in which a wide range of actors share that responsibility (Kooiman, 2003; Opdam et al., 2015). In landscape governance, the wide array of actors and interests at stake increases the complexity of the decision making process. In this context, reaching agreement on actions to change landscape configurations requires cooperation between actors and across governance scales (Newell et al., 2012) taking into account the features of the social system (including stakes, values and concerns) as well as the biophysical conditions (Westerink et al., 2017).

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https://doi.org/10.1016/j.landusepol.2018.02.023
Received 5 October 2017; Received in revised form 9 January 2018; Accepted 12 February 2018
0264-8377/

The results of this study provide insights into the suitability and limitations of landscape design as a practical means to govern landscapes at appropriate scales (Nassaur and Opdam, 2008; Lovell and Johnston 2009; Termorshuizen and Opdam 2009; Musacchio 2011). As an instrument of landscape governance, our application of landscape design builds on ideas from place-based discourses about sustainability (see Potschin and Haines-Young, 2013). In particular, interpreting the concept of landscape as place provides the context in which problems can be framed, values understood, choices made and conflicts resolved allowing a more socially grounded management of ecosystems (Potschin and Haines-Young, 2013). The model of governance advanced by our approach is grounded on the idea of design as the ability to create 'possibility spaces' (De Landa and Ellingsen, 2008) within which desirable futures can be shaped. Therefore we see design as a value rich process centred on deliberation about goals, values, interests and outcomes (Swaffield, 2013).

We present evidence through the case of advanced transport biofuels. Transport biofuels have attracted attention in recent years for the unwanted effects that their expansion could cause to ecosystems and communities, directly or indirectly, affected by their supply chains. The biofuel case is of particular interest here because of the risk of conflict between global dynamics, aimed at an expansion of these systems to achieve climate and energy security goals, and the priorities and concerns of local communities affected by these systems. Advanced biofuel technologies, which rely on waste, residues and perennial crops cultivated on less productive land, are expected to reduce these risks (IEA, 2010). However, evidence suggests that their deployment might suffer the same problems as conventional technologies (Mohr and Raman, 2013; Batistella et al., 2015). As a case study, we selected the experience with advanced biofuels in Sardinia (Italy) where a developer initiated one of the first projects for large-scale production of cellulosic ethanol from dedicated energy crops in Europe.

In the reminder of the article, we illustrate the conceptual basis of our landscape design approach (Section 2) before we introduce the approach and its six components in Section 3. While the results of the case study are presented in Section 4, we dedicate limited space to the details of the assessment of local values and concerns (Di Lucia and Ribeiro, 2018 forthcoming), and to the co-development of knowledge (Anejionu et al., forthcoming). The findings of the study are discussed in Section 5 before the conclusions are presented.

2. Conceptual basis

2.1. Landscape design and the challenges of sustainable biofuels

The term 'landscape approach' has been used to describe a range of approaches for dealing with landscape attributes in an integrative and transdisciplinary way (Tress and Tress, 2001; Sayer et al., 2017). The approach has developed within a variety of scientific disciplines such as ecology, developmental economics, sociology and political sciences (see Arts et al., 2017). In landscape ecology, the emergence of landscape design reflects the transition from a focus on the study of the relationship between spatial pattern and ecological processes (Turner, 1989) to the inclusion of the human components of landscapes and the interactions with processes and patterns (Leitao and Ahern, 2002). In this context, landscape design has emerged as a spatially explicit process in which landscape patterns are intentionally changed to provide ecosystem services while meeting societal needs and respecting public values (Nassauer and Opdam, 2008). In this process, new landscape configurations are designed through deliberative processes about values and goals and are then tested for their functionality through scientific methods (Swaffield, 2013).

Since the release of the Millennium Ecosystem Assessment report in 2005 (Mea, 2005), the term 'ecosystem services' has become a keystone concept to link society and the environment (Costanza et al., 1997; De Groot et al., 2012). In the Mea (2005) ecosystem services are defined as "the benefits people obtain from ecosystems". The framework of ecosystem services has been debated in the scientific literature (Schröter et al., 2014) because of its predominantly anthropocentric character and lack of attention to the intrinsic value of nature (Luck et al., 2012). However, the assumption behind its widespread adoption is that by providing information about their services, ecosystems may be rightfully considered in environmental management (see Opdam et al., 2015).

While many challenges remain to structurally integrate the concept of ecosystem services into the practice of landscape design (De Groot et al., 2010), the concept of multifunctional landscapes has emerged from the literature of ecosystem services (Fry, 2001; Naveh, 2001). Here multifunctionality has been described as achieving multiple objectives, or functions, at the same time. However, promoting multifunctionality requires the understanding of complex dynamic systems (Southern et al., 2011), careful consideration of the inherent contributions of various landscape features to multiple goals (Lovell and Johnston, 2009), and the recognition of synergies and trade-offs (Freeman et al., 2015). There is agreement that this knowledge and understanding can only be developed in a transdisciplinary fashion (Nassauer and Opdam, 2008) in which scientific knowledge from a variety of disciplines is integrated with traditional and local knowledge (Tress et al., 2005).

Similarly, the design of biofuel landscapes is a process of considering context relevant principles and information (Duvenage et al., 2013) and requires knowledge about the current distribution of ecosystem services, of potential winners and losers, as well as the perceived needs and expectations of stakeholders in relation to these services (Dale et al., 2016; Dale et al., 2017). The provision of this knowledge is challenging because biofuel systems are (relatively) new and have significantly expanded (Di Lucia, 2013) involving a wide range of disciplines and stakeholders and generating unknowns and large uncertainties (Lattimore et al., 2010). A further challenge of landscape design for biofuels is the identification of appropriate spatial and temporal scales at which to examine social, economic and environmental effects (Parish et al., 2013). Due to the wide range of complex ecological and socio economic effects often operating over broad spatiotemporal scales, determining the appropriate mix of scales, from local to global, to address local concerns while reconciling these with dynamics at higher levels, is a major challenge for the practical implementation of landscape design for biofuels (Dale et al., 2016).

2.2. Landscape governance and collaboration for biofuels

Since landscapes are characterised by the connections between multitudes of socio-ecological components, their design fits well with ideas of a governance model of societal steering. Interest in landscape governance is connected to the growing number and role of private parties and citizens actively engaged in public decision making, and to the decentralization of governmental powers to lower levels of command (Beunen and Opdam, 2011). The governance model takes into account the complexity of today's society and the importance of informal institutions and actors, including interest groups and citizen organizations, who bring a variety of sometimes competing perspectives in the decision process (Kooiman, 2003; Westerink et al., 2017). Since governance requires more than one actor, collaboration could contribute to effective landscape management (Innes and Booher, 1999; Bodin et al., 2016). Collaborative modes of management and decision making have sprung up since the 80 s in reaction to technocratic modes, which characterised the 60 s and 70 s (Wondolleck and Yaffee, 2000). Collaborative modes recognise the need to ground decision making and management in good science but understand that technical factors are only one of the many considerations in decision making (Wondolleck and Yaffee, 2000).

In a meta-analytical study of the literature of collaborative governance, Ansell and Gash (2008) suggested that a number of variables