

Landscape ecology: an integrative discipline for sustainable development achievement

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Diagnosis

Since human beings began to use and shape the land, their influence on their environment has kept on growing so that currently, little or no ecosystem in the world is now considered as untouched [1]. For this reason, most landscapes are currently referred to as biocultural landscapes: generated by both natural and anthropogenic processes[2]. Human activities have worldwide consequences on landscape structure as well as ecosystem functioning [2, 3]. This phenomenon is referred to as anthropisation, anthropogenic effect, as well as many other terms [4]. Currently, in the majority of cases it consists of urban sprawl and peri-urbanisation , deforestation and agricultural expansion [2, 5, 6]. This induces pressures on ecosystem processes and land scarcity in terms of resources exploitation to support human life [2].

Anthropogenic disturbances are of major concern in various disciplines and policies. However, most studies are very specific to their thematic, creating their own reference framework without connection with other research on related purposes in other disciplines. This plethora of terms and concepts in turn impedes comprehensive tackling of that issue and complementarity between studies. In this contribution, we aim to broaden the perspective by exploring anthropogenic environmental pressures and responses at landscape scale. We chose to focus on agricultural landscapes, because of their dominance in Western European countries and their crucial role for providing ecosystem services.

Theoretical frameworks

Landscape ecology is at the crossroads between Ecology and Geography. It aims at combining spatial structure, the scope of geography, and ecosystem processes, the scope of ecology [7]. This discipline has a strong integrative nature due to its spatial-based explanatory power of ecological processes and its multiscale approach, centred on the landscape. The latter is defined as a heterogeneous land area composed of a cluster of interacting ecosystems[8]. Its central hypothesis, the pattern / process paradigm, allows to infer the impact of the spatial structure of the landscape on the ecological processes occurring within and among the ecosystems [9], that determine the relative abundances and distributions of organisms [10]. Landscape ecology is motivated by a need to understand the development and dynamics of pattern in ecological phenomena and the role of disturbance in ecosystems [11].

Landscape ecology paradigms and methods make it suitable for combination with different disciplines and analysis frameworks. Therefore, this discipline can be of major interest for the monitoring of anthropogenic disturbances, but also frames the responses to give to anthropogenic landscape change, addressing the challenge of sustainable development: preserving ecological functioning as well as human development. In the present approach, we combined it with the Driver Pressure State Impact Response (DPSIR) and multi-level perspective frameworks, land planning, functional, restoration and agro- ecology into a comprehensive, logic and action-oriented analysis framework.

The DPSIR framework is increasingly used in research related to environmental regarding the relationship between the ecological and human dynamics in a comprehensive and transdisciplinary analysis [12, 13]. According to this system analysis view, the Drivers (distant causes, demographic, social and economic development) exert Pressures on the environment, which modifies the State of the environment, such as the provision of adequate conditions for health, resources availability and biodiversity [13]. This leads to Impacts on human and ecosystem health that may elicit a societal Response to address those problems[13]. This response can be directed towards any step of the causal chain, though addressing distant causes such as economic context is often more difficult to achieve [4].

To explore the socio-economic context in which these actions can be undertaken, the Multi-level perspective is used. As landscape ecology focuses on the landscape and the upper (region) and lower (ecosystem) scales, the multi-level perspective studies how societal changes, that can drive, for example, responses to environmental issues at different DPSIR stages, develop from niche behaviours to broader habits over the longer term (cultural change)[14, 15].

Restoration ecology addresses the different types of responses that can be given to environmental disturbances. It is structured around different activities, such as ecological restoration, conservation, environmental management, compensation or enhancement [16]. Ecological restoration consists of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed [16]. Environmental management is the process of enhancing an ecosystem towards less disrupted ecological processes and spatial patterns. Applying compensation or enhancement actions to disturbed ecosystems in order to develop their functional analogy to existing natural ecosystem, even exploit it, is a form of environmental management [17]. This action is typically undertaken in agroecology.

Agroecology is defined as the application of ecological concepts and principles to the design and management of sustainable food production systems [18]. It aims to provide the basic ecological principles for how to study, design and manage agroecosystems that are both productive and natural resource conserving, and that are also culturally sensitive, socially just and economically viable [19]. In this meaning, it addresses the issue of land scarcity and sustainable development in a land-sharing perspective [20]. It has also a political dimension, some political agroecologists also argue for a more demand-driven, participatory approach of agricultural practices design and agricultural land planning [19]

Explanation of the data

Here we develop an integrated framework based on the aforementioned schools of thoughts and methodology. We develop two parts: monitoring (diagnosis) and response actions.

In the monitoring part, we review the concepts and methods used to assess anthropogenic changes (land use and land cover change, naturalness, hemeroby, novel ecosystems), exploring different branches of ecology and geography. The strengths and weaknesses of the existing approaches are then used as a basis to develop a new analytical framework: we propose a restoration-oriented type of reference state for anthropisation assessment and we develop a general methodology to quantify landscape anthropisation. Our methodology combines object-oriented and gradient analyses and is based on the assessment of ecosystem disturbance, landscape configuration dynamics and easily acquired data sets (remote sensing). This indicator framework is based on the Rüdissler, Tasser [21] "distance to nature" indicator.

In the Response part, with a view to foster sustainable development, we propose land-planning based on a combination of land sparing and land sharing actions [20]. We first present some operational activities corresponding to niche initiatives [15, 17]. Restoration and conservation in a land sparing view, but also land sharing views, such as ecosystem services enhancement in multifunctional agriculture [17, 22, 23] will be presented. We finally show how a landscape ecology perspective can spatially combine those apparently divergent response options in a multi-scale land-oriented approach and explore the social, political and economic constraints and stakes of this approach.

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