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METHODOLOGICAL PROPOSALS FOR ADDRESSING AGROECOLOGICAL DESIGN IN PERIURBAN AREAS: A CASE STUDY IN THE EDGES OF MILAN (ITALY)

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ABSTRACT

This study aims to develop an ecological-based design model, applying the theoretical basis of landscape ecology and phytosociology on a pilot area located in the Milan South-Eastern rural edges. The goal was to integrate an all-inclusive approach for agroecological regeneration. Three main guidelines were identified: 1. the rehabilitation of landscape texture; 2. internal diversification; 3. environmental consistency. The study led to a global evaluation of the ecological functionality of the different environmental compartments, analysing their weaknesses and resiliences. Consequently, design criterions were defined, regarding the landscape level (ecotopes diversification) and the single ecotope level (vegetational standards), reconfiguring the current uses and functions and enhancing the biological and structural diversity within the agroecosystem. Finally, an evaluation of the benefits on ecological functionality was carried out, as well as a qualitative assessment of the ecosystem services that can be delivered. This approach enabled to make direct comparisons between actual and project scenarios, supporting the readability of the rebalancing effects attainable on the environmental, social and economic scale.

Keywords: *Landscape ecology, Agroecological design, Ecosystem services, Peri-urban, Italy.*

INTRODUCTION

There is growing sensibility towards peri-urban areas role in strategic planning processes (European Commission, 2019). Current social, economic and environmental features do configure challenging scenarios regarding the capability of cities to absorb and redirect actual and potential impacts and disequilibrium of urban systems towards a resilient and durable reconfiguration of its processes (European Commission, 2013). European metropolitan planning latest trends are moving towards a de-centralized approach, aiming to recognise the interdependencies and interconnection between urban and rural systems as essential topics for attaining a sustainable integrated metropolitan development (SUL & NBS Partnership, 2018; Climate Adaptation Partnership, 2018; Rossi, 2005).

In line with Global, European and National guidelines (United Nations, 2019; IPCC, 2019; European Parliament & Council, 2013; EEA, 2012), Milan Metropolitan City (Lombardy, North of Italy) has adopted different strategic planning tools directing towards an integrated approach to urban development. The most relevant are the *Milan Food Policy Pact* (Montpellier Declaration, 2019), the *AQST "Milan Rural Metropolis"* (a Framework Agreement for Territorial Development based on the strengthening of the urban-rural matrix) (Regione Lombardia, 2015) and the recently adopted *Milan PGT* (Comune di Milano, 2018), built on the main axes of connection, inclusion, resilience, decentralisation, regeneration.

In this perspective, regenerating rural peri-urban areas implies a multi-compartments integration of social, economic and environmental issues, embracing their direct and indirect mutual impacts and benefits (Zasada, 2011). On the ecological side, strong interactions occur between the urbanised matrix and the neighbouring rural and natural areas, thus strongly influencing the ecological dynamics of biotic and abiotic systems, concerning their resources, energetic and biotic flows (Donadieu, 1998; McDonnell M.J. *et al*., 2008). Consequently, environmental stability, complexity, inner diversification and hence, resilience of peri-urban rural systems are highly influenced by the way the urban system interacts and relate itself with rural outskirts. When facing ecological re-design issues in such contexts, it is primarily important to take into account this network of mutual interactions, allowing a correct interpretation of the ecological functioning of environmental and landscape features and thus, a coherent and effective design setup. In this regard, landscape ecology and phytosociology sciences can give a consistent contribution.

Within this framework, this study was focused on developing an ecological design model for peri-urban rural areas, outlining an evaluation reference framework for the improvement of their environmental resilience.

This model was applied on a pilot area located in the Milan South-Eastern rural edges, namely an area of 73 ha of agricultural land located in the first strip of the Vettabbia Valley (inside the Rural Park South Milan), next to the last city buildings, an area marked by a deep historical background (Figure 1). The peculiar location of the pilot area regarding urban fabric, its historical role towards the city and the existence of different previous agro-ecological design visions developed during the last years make this area a fitting candidate for studying peri-urban ecological dynamics. Specifically, the OpenAgri project linked to the European program of Urban Innovative actions (www.uia-initiative.eu/en) and the Milano PortaVerde 2030 project (Comune di Milano, 2019), which directly carries on the OpenAgri vision of creating an Agroforestry Park for agroecological experimenting, were the starting landmarks of this study.

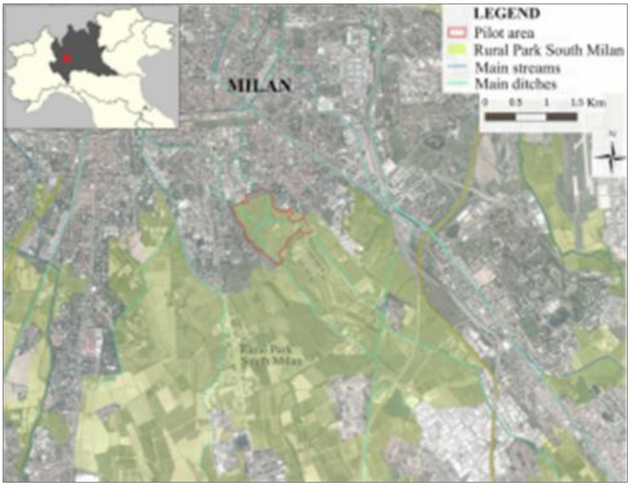

Figure 1. The study area location (Milan, North of Italy) (*Source: Author's elaboration).

Materials and methods

In order to achieve the above-mentioned goals, the study was developed through 4 main steps (Figure 2). In all steps, the main focus was addressed on the natural system, considered as an environmental unit synergistically interacting with anthropic and agricultural matrices.

Figure 2. Methodological setting: the four main steps of the study.

Firstly, a preliminary analysis was carried out, aimed at characterising the current state of the area, regarding its environmental, landscape, social and historical traits. GIS diachronic analysis at large and small scale allowed an overall characterization of the main ecologically significant features (www.geoportale.regione.lombardia.it). Global BioClimatics tools (www.globalbioclimatics.org) allowed a bioclimatic classification of the area (Rivas-Martinez *et al*., 2011). Onsite surveys were focused on collecting floristic, vegetational, faunal and observational data. A floristic list was edited, allowing a chorological and ecological interpretation (Pignatti, 1982; Pignatti *et al*., 2017-19; Pignatti *et al*., 2005; Domina *et al*., 2018; Guarino *et al*., 2012; Brusa and Rovelli, 2010). Physiognomic and structural vegetation patterns were studied, referring to phytosociological guidelines of Zurich-Montpellier school (www.prodromo-vegetazione-italia.org). A monitoring program for avifauna and entomofauna (Odonata and Lepidoptera) was set up during six months, allowing an interpretation of the ecological characters of existent faunal biocenosis (Cunningham and Johnson, 2006; Pollard and Yates, 1993; Ketelaar and Plate,

2001). Landscape ecological patterns were studied, based on the landscape ecology approach (Dramstad *et al*., 1996; Baudry and Burel, 1998; Forman and Godron, 1986), namely through a functional and morphological analysis, examining its spatial layout and its connectivity, fragmentation and ecotone properties.
The second evaluation phase was developed through a multi-level and multi-compartment assessment of the preliminary analysis results, outlining the overall weaknesses and potentialities of the area. This evaluation was the starting point for the identification of design criterions, adjusting them to local ecological needs.
A final assessment of the project scenario influences on the overall ecological functionality was carried out merging diversified theoretical approaches linked to ecological design and Ecosystem Services assessment (MEA, 2005; Grant, 2012; Malcevschi and Lazzarini, 2013).

Theoretical framework for agroecosystem distinctive features

On the theoretic side, the strengthening of environmental stability was identified as the main goal for the ecological reconfiguring, considering it as the expression of a dynamic equilibrium state of the system, depending on the inner mutual support of auto-regulation processes. Within agroecosystems, the natural trend towards diversification is constantly interrupted, keeping the system at low level of complexity (pioneer behaviour), where high productivity is supported by constant external inputs intended to control ecosystem regulation processes through outside drivers (Gliessman, 2007). Thus, supporting agroecosystem stability demands to re-balance the disturbances linked to the lack of self-sufficiency of the system (Gliessman, 2007). In this regard, the recovery of agroecosystem inner diversification was identified as the key action tool, in the perspective of a global balancing of anthropic and natural functions (Fabbri, 1997; Battisti, 2004; Gliessman, 2007; Malcevschi *et al*., 1996; Franco, 2000; Burel, 1992; Baudry and Burel, 1998; Burel, 1996; Forman, 1995; Forman and Godron, 1986). This meant to focus the strategic re-design of the area taking into account functional and dynamic features of its natural and semi-natural elements, considered as fully integrated in the rural matrix. Globally, this issue was developed, in all its steps, addressing at three main ecological organisation levels (space-related and time-related): 1. landscape level; 2. ecotope level; 3. single species level.

RESULTS AND DISCUSSION

1.Preliminary analysis results

Floristic characterization showed a significant presence of allochthonous species (22%; 16% invasive alien species). Geophytes and therophytes percentages were interpreted as linked to recurrent disturbance conditions. Ellenberg's Indicator values (Pignatti *et al*., 2005; Domina *et al*., 2018; Guarino *et al*., 2012) showed a slight preference for higher insolation, temperature and soil acidity conditions among allochthonous species.
Phytocenosis characters were linked to open habitat properties, with a low level of diversification, due to the dominance of nitrophilous, ruderal and invasive exotic

species. They were attributed to the vegetation stages of the secondary dynamic, linked to synanthropic substitution series and initial dynamisms (Verde *et al.*, 2010).

Animal communities were found to be dominated by synanthropic species, linked to low habitat quality traits, according to literature (Baietto and Padoa-Schioppa, 2008; Battisti, 2004).

Concerning the landscape features, it was identified a low level of connectivity between the spontaneous phytocenosis within the area, a low-mitigated impact of barriers and compromised ecotone functionalities.

2.Ecological functionality evaluation

Preliminary analysis results allowed a global interpreting and evaluation of the ecological functionality of the different environmental compartments and their mutual relations. The landscape system, the natural system (hedgerows and tree lines, woods, riparian and boundary phytocenosis), the hydric and irrigation system and the productive agroforestry system were assessed. Their specific weaknesses and resiliency were evaluated by drawing up synoptic schemas highlighting their current impacts and potential contributions to the overall environmental stability of the area (an example is shown for the landscape level) (Figure 3).

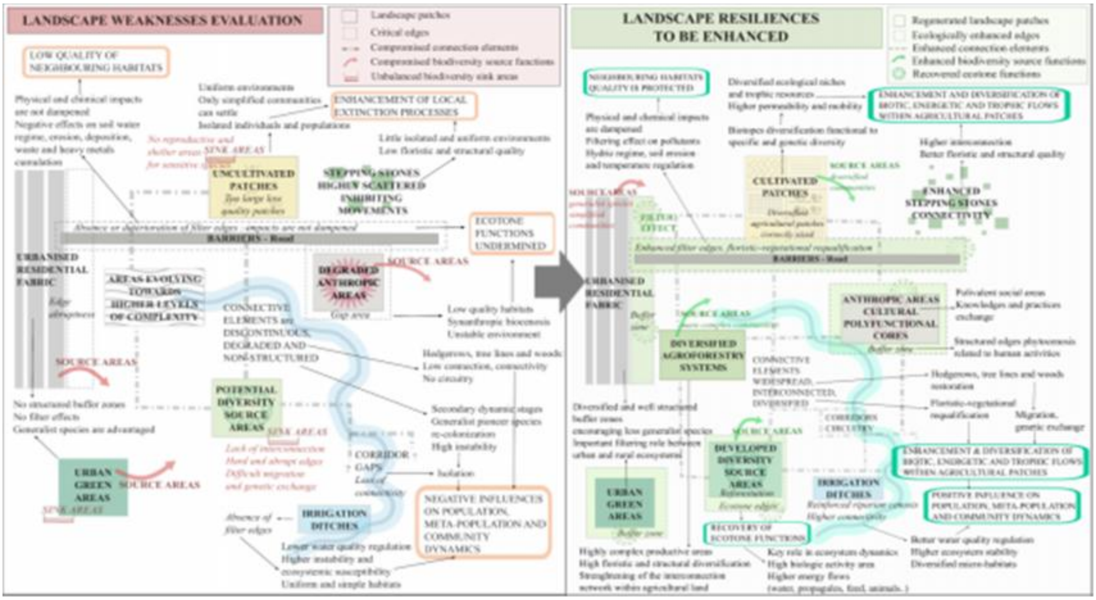

Figure 3. Synoptic schemas for the evaluation of landscape ecological weaknesses and potentialities (*Source: Author’s elaboration).

3a. Identifying a design approach

Based on this global assessment, the methodological approach for intervention was outlined. Three main guidelines were identified: 1. the rehabilitation of landscape texture; 2. internal diversification; 3. environmental consistency.

At the landscape level, priority was given to the rehabilitation of landscape texture and its spatial and dynamic ecological features (connection, connectivity, circuitry, ecotone functions), which were taken into account through a qualitative estimate (Figure 4).

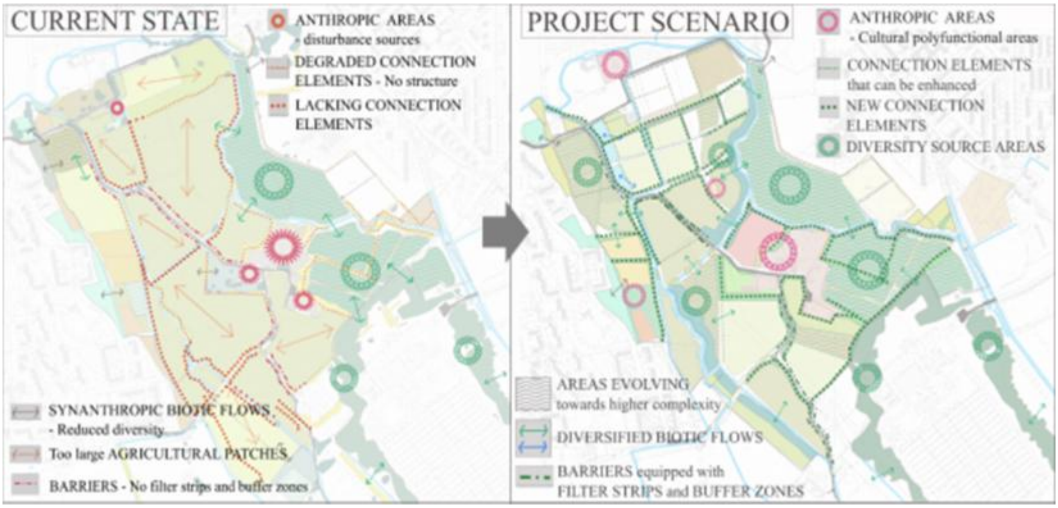

Figure 4. Evaluation of the potential effects of landscape rehabilitation on the ecological functionality within the area (*Source: Author's elaboration).

At the ecotope level, it was identified a functional and dynamic approach for interpreting current biocenosis behaviour and its possible adjustment through design interventions. The focus was addressed on the ecological niche concept, namely by studying the distinctive traits of the different habitats and their related ecological and dynamic functions. Current biocenosis were related to recurrent disturbance conditions, first successional stages and to open spaces properties. Thus, their dynamic role was identified in soil covering and first soil preparing conditions. The environmental conditions predispose to the settlement of R-strategy species (Gliessman, 2007; Odum and Barrett, 2005), thus enhancing competitive, predatory and parasitic ecological behaviours. These conditions lead to the simplification of current biocenosis, in terms of ecosystem structure and inner biodiversity.

Hence, potential interventions were focused on modifying the populations and community roles within the ecosystem (physical space, trophic role, interspecific relations) through the ecotope restructuring, thus adjusting the current trends towards a higher equilibrium between competitive, predatory, parasitic, mutualistic and commensal roles. The main guideline was identified in the encouragement of intermediate successional stages within phytocenosis, (insertion of medium-long cycles species with slower dynamic trends, the increase of structural diversification, the stabilization of micro-climatic site conditions, organic matter storage, soil structuring, nutrients and trophic resources availability). Thus, newly inserted phytocenosis were conceived as drivers for the system evolution towards a higher environmental overall stability, able to support more complex communities, where R-strategy species are balanced by K-strategy species.

At the single species level, selection criteria were identified in: 1. consistent native species [in reference to local climacic vegetation series (Verde *et al*., 2010; Brusa and Rovelli, 2010) and to site environmental conditions]; 2. synecological and syndinamic behaviour (for identifying species able to progressively substitute the exotic ones); 3. their insertion modalities and necessary predisposing conditions (in reference to the specific site needs for species settlement and stabilization over the time). In this perspective, shrubs were considered as key design elements, for their soil-building capabilities and their site condition stabilization role.

3b. Design development

The above-mentioned methodological assessment brought to a global reconfiguring of uses and functions within the area (Figure 5).

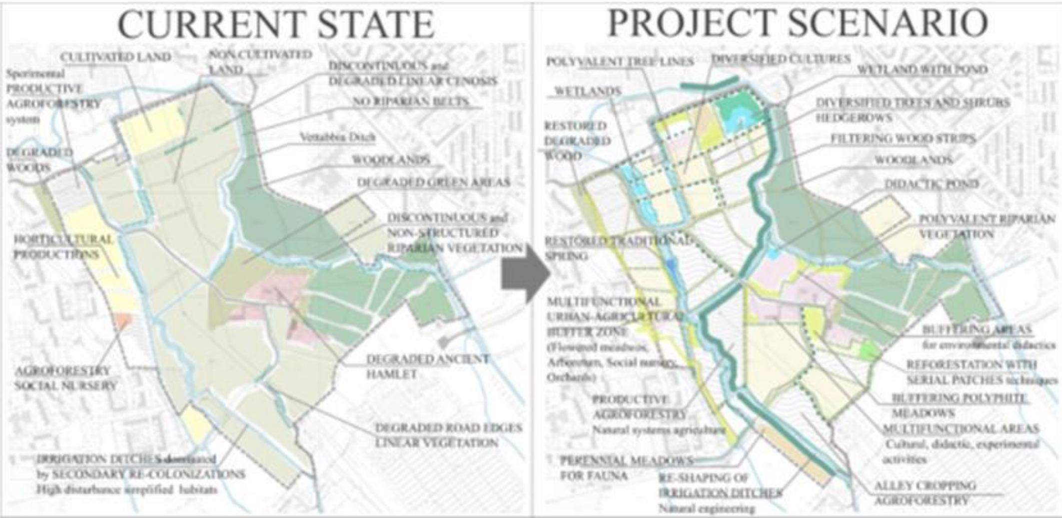

Figure 5. The project's transformation scenario (*Source: Author's elaboration).

Interventions were studied within six different actions: 1. linear cenosis equipment (hedgerows and tree-lined networks); 2. requalification of the riparian system; 3. wood patches re-conversion to native cenosis; 4. edges strips requalification; 5. hydric and irrigation systems ecological integration; 6. productive agroforestry systems implementation.

Ecotope diversification resulted in the insertion of a variety of habitats, environmental structures and cenosis, with different primary functions (preparatory, predisposing, protective, regulating, connective, naturalistic, feed-supplying, and also recreational and didactic). For example, the hedgerows system was reconfigured aiming at maximizing its polyfunctionality, recovering its interconnection, its cenosis stratification, texture and floristic diversification. Their sought functions were: soil protection, microclimatic regulation, ecological corridor, biodiversity support, trophic and food supply, pollination services delivering.

An important design theme were edges and boundaries in-between natural and anthropic patches and barriers. Their morphologic and spatial configuring was aimed at enhancing buffering effects towards anthropic impacts. Buffer zones along urban edges play an important role in filtering and creating relations, thus supporting a positive integration and permeability between the two systems, mitigating the impacts of urban dynamics on biodiversity and environmental quality. The higher environmental quality was sought through an appropriate species selection (native species belonging to climacic successional series).

4.Project scenario evaluation

An overall evaluation of the benefits on ecological functionality expected from the landscape project reconfiguring was carried out. The aim was to put in evidence its positive influence on the system capability to enhance and preserve environmental stability. These results are summarized in the Figure 6, which underlines the overall regulating benefits coming from the multi-level, multi-compartment and multi-strategy approach implemented in this study.

Finally, a qualitative assessment of the ecosystem services (ES) that can be generated was implemented (Figure 6), linking each intervention category to the different types of ES (Malcevschi and Lazzarini, 2013; MEA, 2005), evaluating their importance for delivering the ES. This enabled to make direct comparisons between actual and project scenarios, thus supporting the readability of the rebalancing effects and added value attainable on the environmental scale, as well as on its social and economic implications.

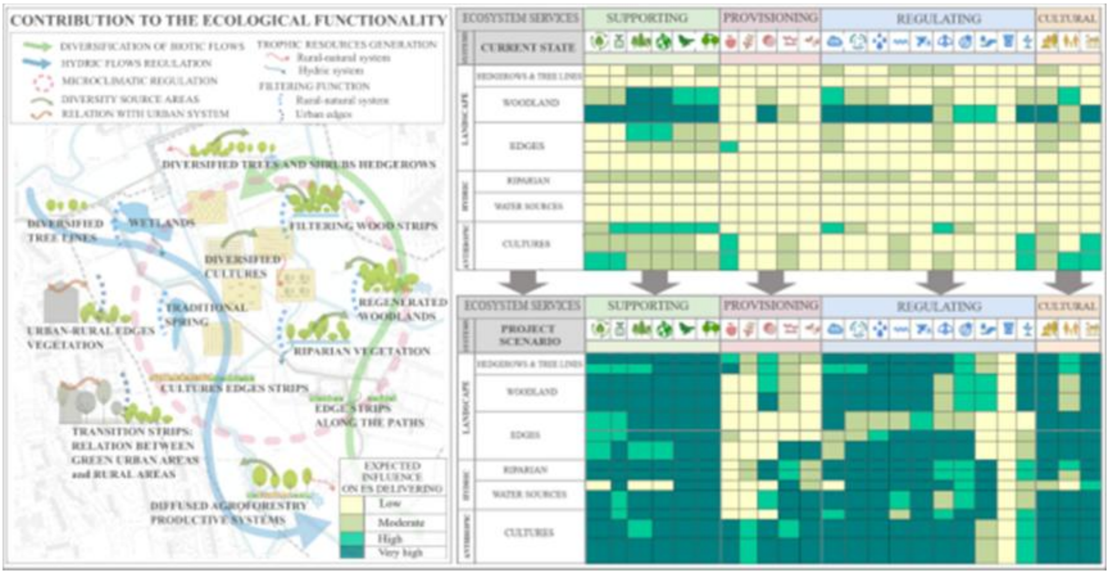

Figure 6. Evaluation of the benefits attainable on ecological functionality and on the delivering of Ecosystem Services (*Source: Author's elaboration).

CONCLUSION

Through this study, it was possible to outline an all-inclusive approach for regenerating rural peri-urban areas, embracing their diversified ecological issues and putting in evidence key strategies for the enhancement of environmental stability parameters.

Agroecological design role in mitigating environmental and social outskirt weaknesses and in generating new resources and services was highlighted.

Therefore, this methodological framework is suitable for the implementation on peri-urban contexts similar to the provided case study.

Further integrations of these methodological proposals would enhance their environmental effectiveness, namely by developing monitoring strategies over the time and by including a quantitative assessment of landscape features, inner resources changes, and ES delivering.

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