

GeoTerrace-2026-033**Introducing Belligerative-Recreational Systems: A Spatial Analytical Framework and Clustering Approach for Post-War Smart Specialisation in Kyiv Oblast, Ukraine**

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SUMMARY

Post-war recovery requires new spatial planning approaches capable of integrating the consequences of military impacts with the recreational potential of affected territories. Existing studies have examined belligerative systems and recreational systems separately; however, no integrated spatial category has been proposed to support post-war smart specialisation. The paper introduces Belligerative-Recreational Systems as a new category of spatial systems emerging under the combined influence of military impacts and recreational potential. The study aims to develop and demonstrate a spatial analytical framework and clustering approach for identifying Belligerative-Recreational Systems in Kyiv Oblast as a basis for post-war smart specialisation planning. The proposed framework integrates recreational objects, areas of recreational attractiveness, natural landscape components, and war-related constraints within a unified GIS environment. Spatial clustering is applied to differentiate Belligerative-Recreational Systems according to their combined characteristics and development potential. The approach was tested using Kyiv Oblast, Ukraine, as a representative post-war region where military-induced landscape transformations coexist with significant recreational resources and diverse natural conditions. The results enabled the identification of distinct clusters of Belligerative-Recreational Systems characterised by different combinations of war-related impacts, recreational attractiveness, environmental conditions, and post-war development potential. These clusters provide an operational spatial basis for supporting smart specialisation and identifying territorial priorities for sustainable regional recovery. The proposed concept expands the theoretical basis of post-war spatial planning by introducing a new analytical category of spatial systems and demonstrating its practical applicability through a spatial analytical framework and clustering approach.

Keywords: Belligerative-Recreational Systems; Post-war recovery; Smart specialization; Spatial analytical framework; Spatial clustering; GIS; Recreational attractiveness; Kyiv Oblast.

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Introduction

The full-scale war in Ukraine has fundamentally transformed the functional structure of many territories, creating new challenges for their post-war recovery and long-term spatial development. War-affected areas differ considerably in their natural, environmental, infrastructural and socio-economic characteristics, making the identification of priority development trajectories one of the key tasks of contemporary spatial planning. Among the possible directions of territorial renewal, recreational development deserves particular attention because it simultaneously contributes to environmental restoration, improves human well-being, stimulates local economies and can be implemented progressively even before the complete recovery of other sectors. Consequently, recreational potential should be regarded as one of the priority components of post-war regional development. Recent studies have increasingly focused on war damage assessment using remote sensing and GIS technologies (Yakymchuk et al., 2023; Zhu et al., 2017), post-war recovery and territorial resilience (Assem et al., 2020; UN-Habitat, 2022), and smart specialisation as a strategic framework for regional development (Foray, 2015; Reid et al., 2023). At the same time, research addressing the integration of military-induced landscape transformations with recreational development remains limited. Previous studies have demonstrated the applicability of GIS-based approaches for assessing ecosystem potential and recreational attractiveness (Udovychenko, 2023), while recent research has emphasised the role of behavioural geography and circular economy principles as conceptual foundations for sustainable territorial development and smart specialisation (Koval et al., 2025). Despite these advances, an integrated spatial unit simultaneously accounting for military impacts, recreational potential and post-war development priorities has not yet been proposed.

The absence of such an integrated spatial unit considerably limits the possibility of comparing war-affected territories according to their development potential and constrains evidence-based decision-making in post-war spatial planning. Existing approaches primarily assess either military impacts or recreational resources separately, whereas effective territorial recovery requires their integrated consideration within a single spatial framework. To address this gap, the paper introduces **Belligerative-Recreational Systems (BRS)** as a new category of spatial systems emerging under the combined influence of military impacts and recreational potential. These systems integrate natural resources, recreational infrastructure, military disturbances, safety constraints and post-war development opportunities, providing a comprehensive basis for assessing territorial attractiveness and future development trajectories. The proposed concept is operationalised through a spatial analytical framework integrating recreational objects, areas of recreational attractiveness, natural landscape components and war-related constraints within a unified GIS environment. This framework forms the basis for the spatial clustering of BRS according to their recreational attractiveness and development potential.

The aim of this paper is to introduce the concept of Belligerative-Recreational Systems as a new object of spatial analysis and to demonstrate its practical implementation through spatial clustering for post-war smart specialisation using Kyiv Oblast, Ukraine, as a case study.

Method and Theory

Conceptual Framework of BRS. The proposed research is based on the assumption that post-war territorial development requires a new spatial unit capable of integrating military-induced landscape transformations with recreational development opportunities. Existing spatial approaches generally assess either the consequences of military impacts or the recreational potential of territories independently, whereas post-war recovery requires their simultaneous consideration within a single analytical framework.

Hereafter, the term **Belligerative-Recreational Systems** is used to denote spatial systems characterised by the interaction of military-induced landscape transformations, recreational resources, natural conditions, safety constraints and post-war development opportunities. Unlike conventional recreational systems, BRS reflect not only the availability of recreational resources but also the influence of military disturbances, environmental limitations, accessibility and recovery capacity on future territorial development. Consequently, they represent integrated spatial systems whose attractiveness is determined by the combined effect of natural, recreational and military-related factors rather than by individual components considered separately. The conceptualisation of BRS provides a new analytical perspective for post-war

spatial planning by introducing an integrated spatial category that links environmental recovery, recreational attractiveness and regional development priorities within the context of smart specialisation.

Study Area. Kyiv Oblast was selected as the study area because it represents a natural laboratory for investigating the interaction between military-induced landscape transformations and recreational development opportunities in post-war Ukraine. The region combines territories that experienced temporary occupation and intensive military disturbances with extensive forest ecosystems, river valleys, protected areas and a well-developed recreational network. This unique combination of military impacts, natural assets and recreational resources provides favourable conditions for identifying BRS and evaluating their spatial differentiation. Owing to its pronounced landscape heterogeneity and diversity of development conditions, Kyiv Oblast offers a representative case for testing the proposed Spatial Analytical Framework and demonstrating the practical applicability of the proposed BRS concept for post-war smart specialisation.

Spatial Analytical Framework. The proposed concept was operationalised through a **Spatial Analytical Framework** designed to integrate heterogeneous spatial information within a unified GIS environment (Figure 1). The framework combines three complementary groups of spatial components: 1) the recreational structure of the territory; 2) the natural landscape background; 3) military-induced spatial constraints.

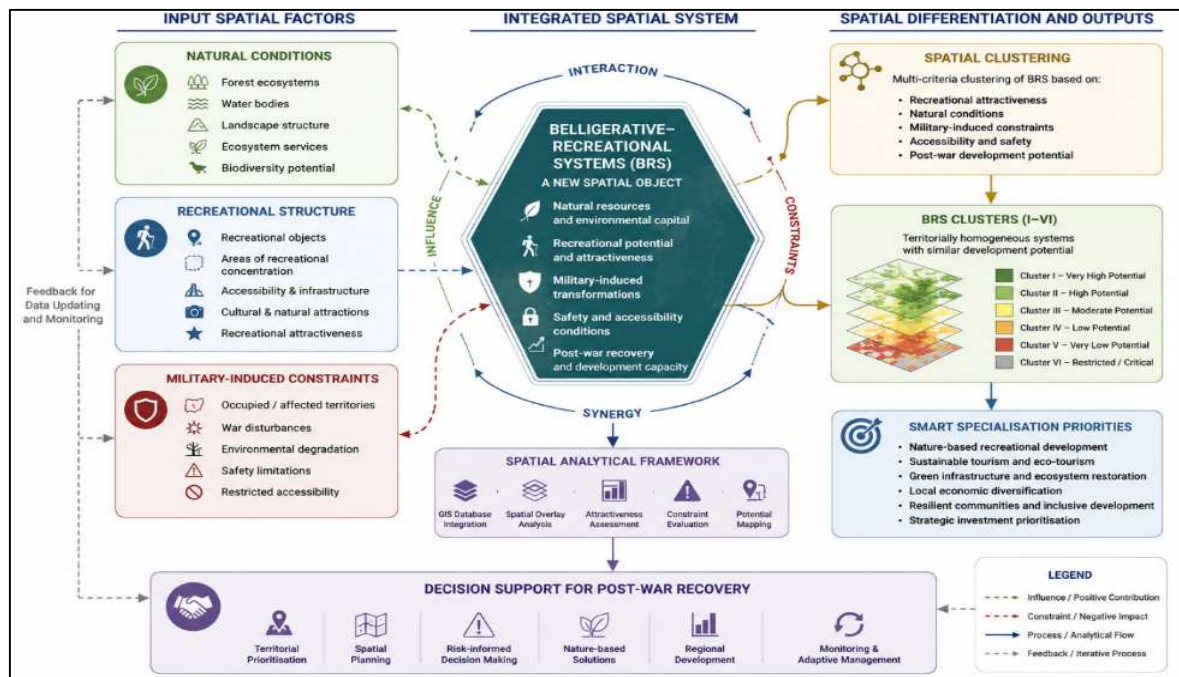


Figure 1. Conceptual Spatial Analytical Framework of Belligerive-Recreational Systems (BRS) for Post-War Smart Specialisation

The integration of these datasets within a single analytical environment enables the transition from a simple inventory of recreational resources to a comprehensive spatial assessment of territorial development potential. Thus, the Spatial Analytical Framework serves as the operational basis for identifying Belligerive-Recreational Systems and their subsequent spatial differentiation.

Spatial Clustering Approach. Following the development of the Spatial Analytical Framework, BRS were spatially clustered according to similarities in recreational attractiveness, natural conditions and military-induced constraints. The clustering procedure was intended to identify territorially homogeneous groups characterised by comparable development potential rather than to perform a purely statistical classification. The proposed approach therefore combines conceptual spatial analysis with GIS-based clustering, allowing BRS to be interpreted as operational spatial units for post-war planning. The resulting clusters provide a basis for comparing territorial systems, identifying spatial priorities and supporting evidence-based decision-making within post-war smart specialisation strategies. A detailed description of the clustering methodology is beyond the scope of this paper and will be presented in a separate methodological publication.

Results

The proposed Spatial Analytical Framework enabled the identification and spatial delineation of **Belligerive-Recreational Systems (BRS)** across Kyiv Oblast by integrating recreational resources, natural landscape conditions and military-induced spatial constraints within a unified GIS environment.

The resulting spatial pattern demonstrates that BRS exhibit considerable territorial heterogeneity in terms of recreational attractiveness and post-war development potential. Rather than reflecting only the spatial distribution of recreational resources, the identified systems represent integrated territorial units (Figure 2) where environmental conditions, recreational infrastructure and military impacts collectively determine future development opportunities.

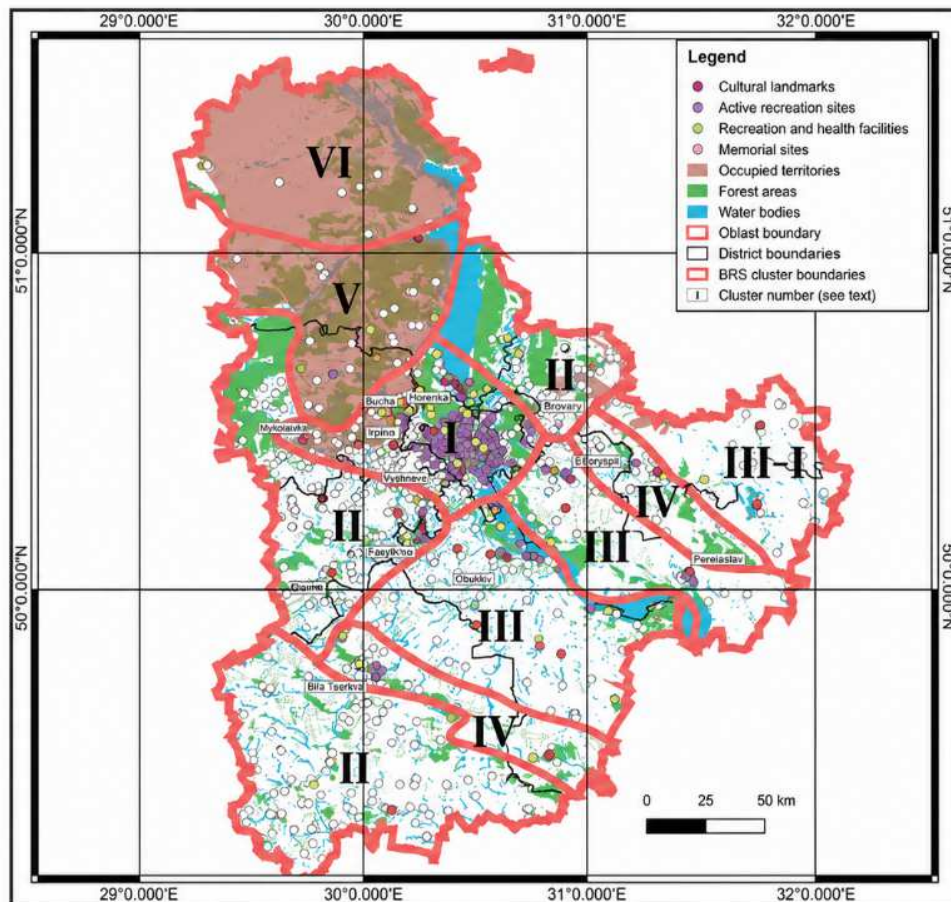


Figure 2. Spatial differentiation of Belligerive-Recreational Systems (BRS) in Kyiv Oblast showing six clusters of recreational attractiveness and post-war development potential

The application of the proposed clustering approach resulted in the delineation of **six spatial clusters (I–VI)** representing territorially homogeneous Belligerive-Recreational Systems with different combinations of recreational attractiveness, environmental characteristics and military-induced constraints. These clusters should not be interpreted as administrative divisions but as operational spatial units supporting comparative territorial assessment and strategic planning. As illustrated in Figure 2, clusters are unevenly distributed throughout Kyiv Oblast and differ substantially in their spatial configuration and development potential. The largest clusters occupy extensive peripheral territories characterised by relatively homogeneous environmental conditions, whereas the central part of the region demonstrates a more fragmented spatial structure associated with higher concentrations of recreational objects, greater landscape diversity and more complex military-induced transformations. Such differentiation confirms that post-war recreational development cannot be addressed using uniform planning approaches but requires territorially differentiated strategies. The obtained clustering results demonstrate the practical applicability of the proposed Belligerive-Recreational Systems concept for post-war spatial planning. By integrating natural conditions, recreational assets and military-related constraints into a single analytical framework, the proposed approach provides an operational basis for identifying territorial priorities and supporting evidence-based smart specialisation strategies.

Conclusions

This paper introduced **Belligerative-Recreational Systems (BRS)** as a new spatial category for integrating military-induced landscape transformations, recreational potential and post-war development opportunities within a unified analytical framework. Unlike existing approaches, the proposed concept considers these components as interacting elements of a single spatial system, providing a more comprehensive basis for post-war territorial assessment and planning. The proposed **Spatial Analytical Framework** demonstrated the practical applicability of the BRS concept through the spatial clustering of Kyiv Oblast. The identified clusters confirmed that war-affected territories exhibit substantial spatial heterogeneity and therefore require differentiated planning strategies rather than uniform recovery approaches. In this context, BRS can serve as operational spatial units supporting evidence-based decision-making and post-war smart specialisation. The proposed concept extends previous studies on GIS-based recreational assessment, post-war territorial recovery and smart specialisation by introducing an integrated spatial object that connects these research directions within a single analytical framework. Consequently, the study contributes not only a practical approach for spatial differentiation of war-affected territories but also a conceptual basis for future methodological developments. Future research will focus on the detailed methodological development of Belligerative-Recreational Systems, refinement of the spatial clustering procedure, comprehensive characterisation of individual BRS clusters and the application of the proposed framework to other post-war regions of Ukraine.

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