Research Paper

Wildland–urban interface — A functional approach to planning for climate resilient development

Themistoklis PELLAS, National Technical University of Athens, Greece

Theodora PERROU, COPERNICUS SEA, European Union Satellite Centre, Spain

Vasileios GIMISIS, P GIMISIS S.A., Greece

Abstract

This paper theorises the wildland–urban interface with respect to climate resilient development, which the Intergovernmental Panel on Climate Change, accounting for human, ecosystem, and planetary health, defines as the integration of climate adaptation and mitigation for sustainable development. Drawing on literature on the notions of land function and functional area, relevant lines of research in land system science, spatial planning, and spatial development, it posits a framework for delineating spatial units, applicable to the study and preparation of spatial plans.

Keywords

Wildland–Urban Interface, Climate Resilient Development, Planning, Land Function, Functional Area

1. Introduction

Delineating the wildland–urban interface (WUI) is a vexing problem. Extant definitions demarcate it with respect to wildland vegetation, human presence, and their relation, based on land cover, or recently also fire ignition probability, and typically their scope is wildfire risk reduction (Bento-Gonçalves and Vieira, 2020; Johnston and Flannigan, 2018; Li *et al.*, 2022; Miranda *et al.*, 2020; Modugno *et al.*, 2016; Stewart *et al.*, 2007). Planning and land research though, appraising climate risk (exposure and vulnerability to climate-related hazards), postulates a broadened scope that links climate adaptation, climate mitigation, and development, and enables policy, modelling, and data adjust locally (downscale) and integrate (mainstream) into planning for all types of territories beyond administrative boundaries (Fayet *et al.*, 2022; Finn and Miller, 2022; Seto *et al.*, 2021). The present paper responds to that knowledge gap. Therefore, it expands upon previous studies that characterise and map the WUI to theorise the potential of this type of territory to contribute to climate resilient development by drawing on literature on the notions of land function and functional area, relevant lines of research in land system science, spatial planning, and spatial development. Accounting for human, ecosystem and planetary health, the Working Group (WG) II of the Intergovernmental Panel on Climate Change (IPCC) defines climate resilient development for its contribution to the Sixth Assessment Report as a framework to integrate adaptation to climate and related risks and mitigation of greenhouse gas emissions for sustainable development (IPCC, 2022a).

Table 1. Wildland–urban interface delineation.

Approach	Scope	Aspect 1	Aspect 2	Aspect 3
Prevalent	Wildfire Risk Reduction	Vegetation (Land Cover)	Human Presence (Land Cover)	Relation (Land Cover)
Emerging	Wildfire Risk Reduction	Vegetation (Land Cover)	Human Presence (Land Cover)	Relation (Fire Ignition Points)
Proposed	Climate Resilient Development	Vegetation (Land Cover & Land Use)	Human Presence (Land Cover & Land Use)	Relation (Land Function)

Source: Authors' elaboration.

The motivation for this paper originates from spatial plans dealing with recovery from WUI fires that occurred in Attica and Evia, Greece. The wildfire that broke out in Eastern Attica on the 23rd of July 2018 resulted in 103 civilian fatalities. This has been the second-deadliest wildfire event in the 21st century, after the 2009 bushfires in Australia, and the second-deadliest weather-related disaster in Greece, after the major heatwave of July 1987. The National Observatory of Athens, following Tedim *et al*. (2018), classified it as an extreme wildfire event of the highest category (Copernicus Emergency Management Service, 2018; Lagouvardos *et al.*, 2019). The Special Urban Plan of Municipal Units Nea Makri and Rafina of Municipalities Marathonas and Rafina–Pikermi was commissioned to the Technical Chamber of Greece by the Ministry of the Environment and Energy in 2019 and completed in 2020, with a revision in 2021, before passing into law in 2022 (Presidential Decree, Official Government Gazette 398/D/2022). From the 3rd to the 18th of August 2021, the megafire in Northern Evia had burned 508.876 km^2 and affected 5,513 individuals (Copernicus Emergency Management Service, 2021; Giannaros *et al.*, 2022). The Special Urban Plans of Municipality Istiaia – Aidipsos and of Municipality Mantoudi – Limni – Agia Anna are part of the Reconstruction Plan for Northern Evia which was initiated in 2021 with support from private sponsors and will be completed through an Integrated Territorial Investment under European Union's (EU) Cohesion Policy 2021–2027. The spatial plans for Attica and Evia integrate recovery and comprehensive planning, incorporating fire protection directly in provisions for the natural and built environment or indirectly in provisions delimiting spatial dimensions and the pattern of spatial organisation and development. They are expected to be a benchmark for Local Urban Plans and Special Urban Plans, scheduled for completion by 2025 under the latest urban policy reform, covering over 700 municipalities or municipal units, in accordance with new technical requirements that, for the first time in Greece, mandate provisions for climate change and disaster recovery.

The paper first presents the research background, including literature on land function and functional areas. Next, it proceeds to the research approach, outlining the conceptual framework, and links it to the new technical requirements of Local Urban Plans and Special Urban Plans in Greece, before concluding.

2. Research background

Land function refers to the capacity of land to provide goods and services and differentiates from land cover (the physical surface of land) and land use (the purpose for which land is exploited) (Verburg *et al.*, 2009). The term land function may not be employed and instead refer to the impact (commonly for ecosystem services, for instance biodiversity) of land cover and land use change from supply (policy, environment) and demand (population, economy) drivers of urbanisation (ESPON, 2020a; Felix, Houet and Verburg, 2022; Schrammeijer, Malek and Verburg, 2022; van Vliet *et al.*, 2016). In such a direction, the European Environment Agency (EEA, 2018) developed a land systems approach, which combines

drivers, pressures, state, impacts and responses in a cause-effect framework. Differently, the Joint Research Centre (JRC) of the European Commission implements the LUISA (Land Use-based Integrated Sustainability Assessment) Territorial Modelling Platform for ex-ante evaluation of EU policies, which groups and combines indicators according to land functions, such as provision of work, provision of land and water-based products, provision of housing and transport, provision of regulation by natural physical structures and processes, and supporting ecosystems and biodiversity (Jacobs-Crisioni *et al*., 2017; Lavalle *et al*., 2020, 2015).

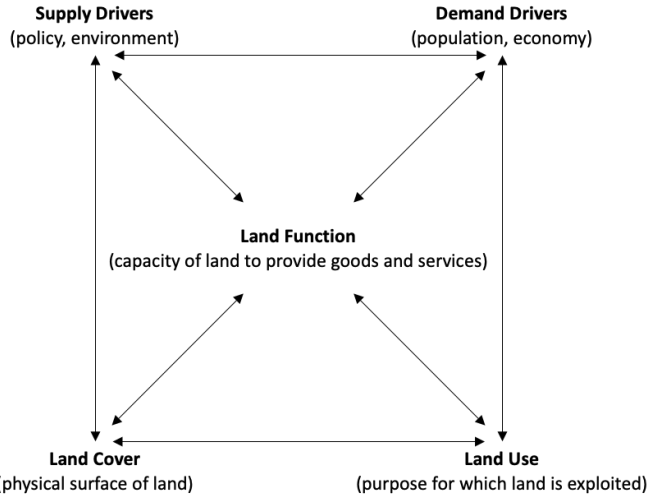


Figure 1. Land function. Source: Authors' elaboration.

A functional area refers to a spatial unit delineated to serve a specific analytical or policy purpose beyond administrative boundaries, based on one or more defining criteria corresponding to the other land concepts of land cover, land use, land function, supply or demand drivers (Cavaco *et al.*, 2022; Harrison, Galland and Tewdwr-Jones, 2021; Paasi and Metzger, 2016; Wandl and Hausleitner, 2021). The Organisation for Economic Co-operation and Development (OECD, 2020) developed a methodology to define and map functional areas covering an entire national territory based on multidirectional commuting flows. The Preparatory Study for the 17th Session of the Council of Europe Conference of Ministers Responsible for Spatial Planning (CEMAT) distinguished between functional and potential functional (cohesive) areas and identified cross-border cooperation areas, transnational macro-regions, functional urban areas, functional rural areas, clusters and innovative regions, areas under industrial restructuring, touristic areas, free economic/trade zones, sparsely populated areas, areas with population at risk of poverty, areas with important natural heritage (natural landscape), areas with important cultural heritage (built landscape), areas with complex cultural heritage (multifunctional landscape), mountain areas, delta areas, island areas, coastal areas, and river catchment areas (Ivanov *et al.*, 2017). The ESPON project FUORE — Functional Urban Areas and Regions in Europe (ESPON, 2020b) deployed a dasymetric approach based on the 1 km^2 European Reference Grid (Grid_ETRS89-LAEA, Commission Regulation (EU) 1089/2010) to map border areas, coastal areas, functional urban areas, green infrastructure, island areas, mountain massifs, maritime service areas, and sparsely populated areas. The theme "governance of new geographies" (referring to areas divergent from administrative borders, in need of territorial strategies for policy programming with functional perspective to cope with the shared challenges they face from spillovers and externalities of development) is one of the four Thematic Action Plans prioritised in the recently approved ESPON 2030 Programme (2021TC16RFIR004).

Table 2. Functional area.

Drivers / *Land Types*	Policy	Environment	Population	Economy
Land Cover	•	•••	•	•
Land Use	•	•	•••	•••
Land Function	•••	••	••	••

TABLE 2 LEGEND	LOW	MEDIUM	HIGH
CORRESPONDENCE	•	••	•••

Typical correspondence between land concepts (land types and urbanisation drivers) for delineating functional areas.

Source: Authors' elaboration.

3. Research approach

This paper posits a framework for delineating spatial units, anchoring concepts, techniques, and data. It follows a clear separation of the notions of land cover, land use, land function, and functional area, and is based on a mapping approach, referring to policy impact analysis and suitability analysis on a regular grid (ESPON, 2020b; Malczewski and Jankowski, 2020; Medeiros, 2020). Attending to the discrepancy arising from demarcating the boundary of an area for a certain solution space (Haasnoot *et al.*, 2020) and analysing or planning within that boundary for another, it delivers a solution to redefine a type of territory and identify appropriate spatial units. Deploying the framework would entail three actions. First, to allocate to each grid cell data for land cover, land use, and drivers (policy, environment, population, economy) for a specific purpose, from datasets that are publicly available and have global, regional, or local coverage, and either they are, or they are edited to be comparable, by devising a correspondence table between the categorisation of those having global or regional coverage and those having local coverage. Second, to derive land function by evaluating for the specific purpose the link between the data for land cover, land use, and drivers, and in the case of having more than one land functions, to evaluate their positive (synergy) or negative (trade-off) link. Third, to determine for each grid cell whether it belongs or not to the functional area by ranking the relevance to the specific purpose of the data for land cover, land use, and land function. The result would be under this functional approach that chosen grid cells represent in two-dimensional space the functional area geographically (X, Y: Longitude, Latitude), and the same grid cells organised differently, the land function or functions analytically (X, Y: Land Types, Drivers). Hence, a specific type of territory, as the WUI, would differentiate from other types not only or not necessarily because of the geographical boundary, but because of the different analytical organisation of the grid cells with respect to a land function or functions.

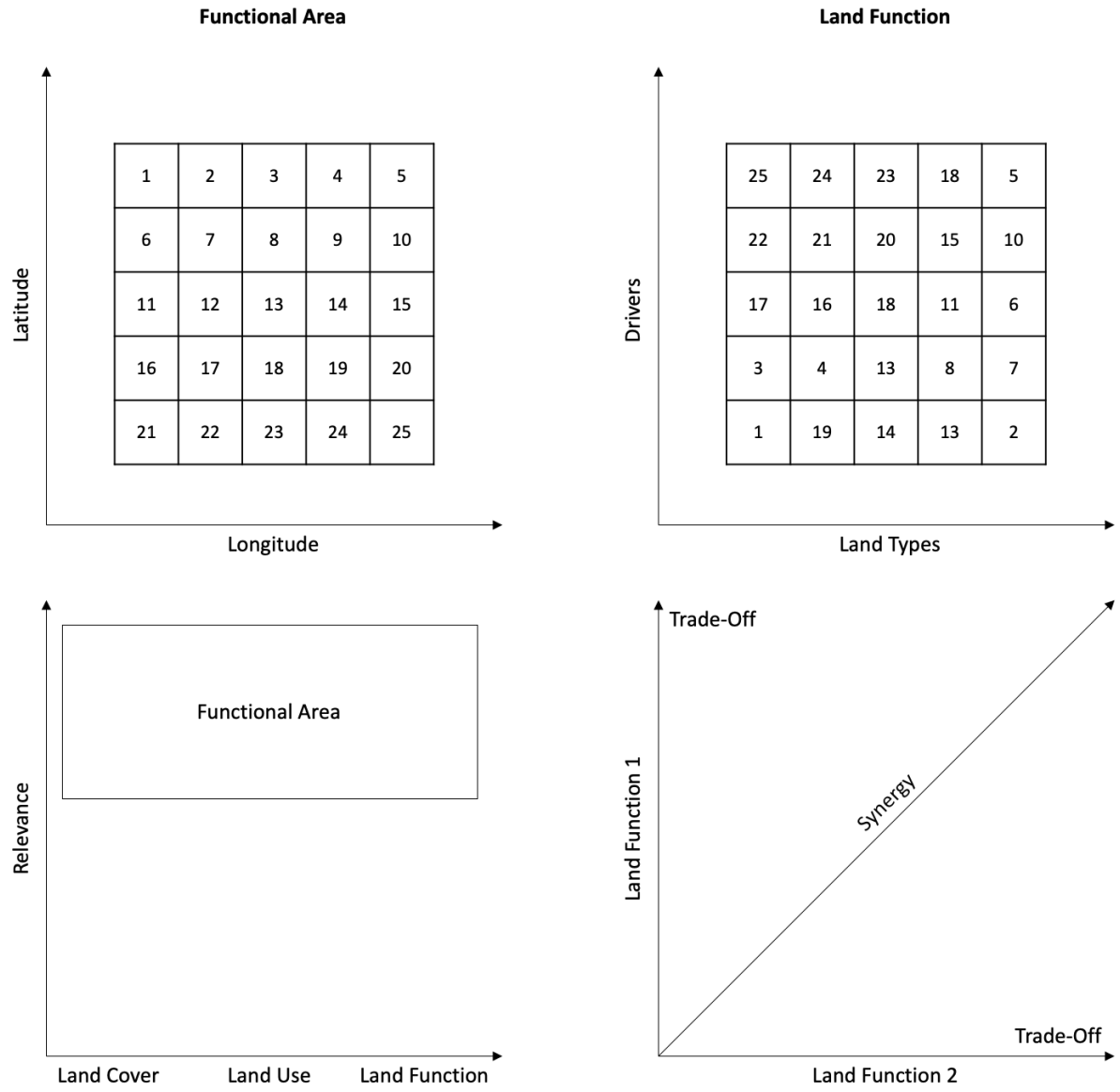
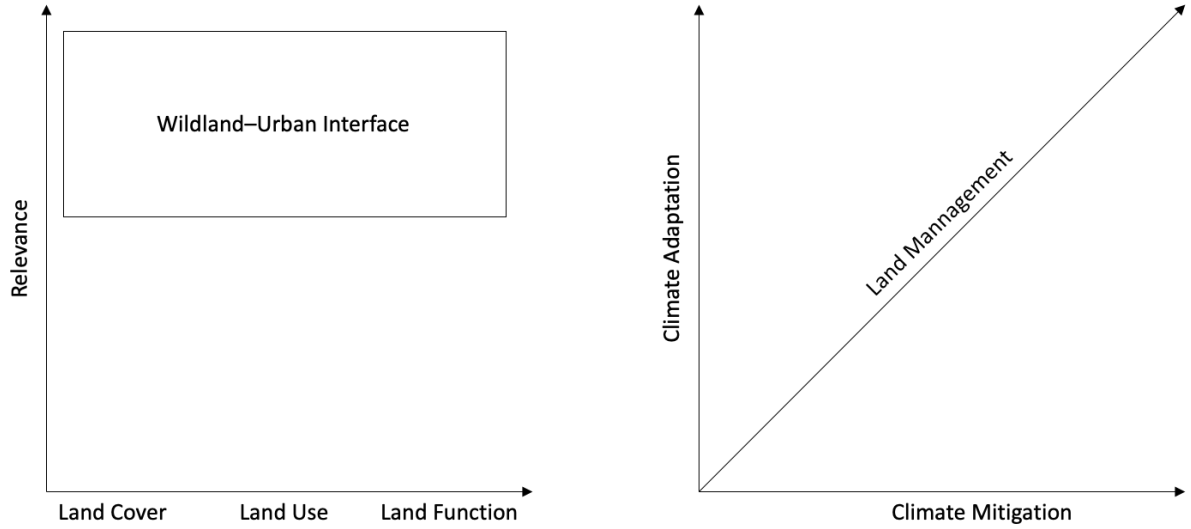


Figure 2. Functional approach. Source: Authors' elaboration.

Delineating the WUI for climate resilient development would mean that, differently to the prevalent approach that would delimit the spatial boundaries based on land cover (for example forests, shrubland, and grassland for wildland vegetation, artificial land for human presence, and the intersection of their buffer distances for the relation between wildland vegetation and human presence) and then examine within these boundaries other elements that could condition the capacity of land to provide goods or services (for example forest conservation, protection, and restoration for climate adaptation and carbon sequestration through soil carbon management in cropland and grassland, agroforestry, and biochar for climate mitigation, and circular economy for development), with the proposed framework such other elements would considered to delimit the spatial boundaries. Relevant data sources and classifications with global or regional (continental) coverage would be: (1) the Global Human Settlement Layer (GHSL) project, which recently made available the GHSL Data Package 2022 (Schiavina *et al.*, 2022), and applies the Degree of Urbanisation method (Dijkstra et al., 2021; European Commission, FAO, UN-Habitat, ILO, OECD, and The World Bank, 2021); (2) the EU's Land Use and Cover Area frame Survey (LUCAS) (d'Andrimont *et al.*, 2020; Eurostat, 2022); (3) the IPCC Data Distribution Centre (DDC) (Stockhause *et al.*,

2019), regarding the contributions of WGI (IPCC, 2021), WGII (IPCC, 2022a), and WGIII (2022b) to the Sixth Assessment Report (AR6), as well as, the special report on climate change and land (IPCC, 2019). Local coverage could indicatively refer to country-specific land use classifications and, among other data, to downscaled climate data, which in the case of Greece would be respectively the Presidential Decree 59/2018 (Official Government Gazette 114/A/2018) and climate projections data produced by the National Observatory of Athens and the Academy of Athens in the framework of EURO-CORDEX, available from the Ministry of Environment and Energy.



Regarding WUI – climate resilient development, relevant data categories that would be analysed in relation to others could be indicatively, besides common types (such as woodland), also abandoned areas (Eurostat, 2022) in addition to forest-based management (IPCC 2022a), carbon sequestration in agriculture (IPCC 2022b), and fire management (IPCC, 2019). Concerning GHSL, these could be vegetation intensity (Pesaresi and Panagiotis, 2022) and suburbs or peri-urban area (Schiavina, Melchiorri and Freire, 2022), though new data would in general provide an added value to the analysis: total built-up surface and the built-up surface allocated to dominant non-residential uses (Pesaresi and Politis, 2022a), building height (Pesaresi and Politis, 2022b), total built-up volume and built-up volume allocated to dominant non-residential uses (Pesaresi and Politis, 2022c), morphological settlement zone (vegetation intensity, water surfaces, road surfaces, functional use, building height) (Pesaresi and Panagiotis, 2022), land fraction (Pesaresi and Politis, 2022d), residential population (Schiavina, Freire and MacManus, 2022), Degree of Urbanisation stage I Level 2 (urban centre grid cell, dense urban cluster grid cell, semi-dense urban cluster grid cell, suburban or peri-urban grid cell, rural cluster grid cell, low density rural grid cell, very low density rural grid cell, water grid cell) (Schiavina, Melchiorri and Pesaresi, 2022), Degree of Urbanisation stage II Level 2 (city, dense town, semi-dense town, suburbs or peri-urban area, village, dispersed rural area, mostly uninhabited area) (Schiavina, Melchiorri and Freire, 2022).

Figure 3. Wildland–urban interface – Climate resilient development. Source: Author's elaboration.

4. Technical requirements of Local Urban Plans and Special Urban Plans

Recent planning and land reforms in Greece have been conditioned by the Economic Adjustment Programmes under the Greek Loan Facility (2010–2011), the European Financial Stability Fund (2012–2015) and the European Stability Mechanism (2015–2018), the European Semester (2018–present) and the enhanced surveillance framework (2018–2022), and the Recovery and Resiliency Fund (2021–2026). Reforms, for example the completion of the national land registry and the ratification of forest maps (European Commission, 2022) and the implementation of urban planning (European Commission, 2021; Official Government Gazette 2931/B/2022, 2406/B/2022, 6046/B/2021, 3589/B/2021), develop in tandem even if detached in the solution space (Haasnoot *et al.*, 2020) bounded by developmental, operational, and spatial dimensions, for which law, though they are not limited to it, provides a window into their boundary conditions (Du *et al.*, 2022), hence it would be adequate to refer to them here, for illustrative purposes only, by referencing the development Law 4887/2022 (Official Government Gazette

16/A/2022), the administrative Law 3852/2010 (referring to the responsibilities of local authorities, including operational–business planning, Official Government Gazette 87/A/2010; Trutkowski and Hlepas, 2018), and the planning Law 4759/2020 (Official Government Gazette 245/A/2020). To link the proposed framework, regarding delineating the WUI for climate resilient development, to the new technical requirements of Local Urban Plans and Special Urban Plans (Official Government Gazette 3545/B/2021 and 510/B/2022), this paper differentiates between three types of integration. Low (core) integration referring to the chapter themes that correspond to climate or disaster recovery. Medium (analytical) integration referring (in addition to the first type) to the chapter themes that correspond to scenario planning, planning indicators (urban planning standards), and planning instruments. High (expansive) integration referring (in addition to the first and second types) to the chapter themes that correspond to the link (either input or output) to other interventions (projects, plans, policies) or administrative divisions (adjacent municipal units or municipalities). The rationale is that comprehensive plans like these are structured to cover a broad problem-set, but not tackle a single matter in isolation, therefore targeting one type of territory for a specific purpose pertains to different aspects of the overall approach devised to deliver a planning proposal for the pattern of spatial organisation and development of an area.

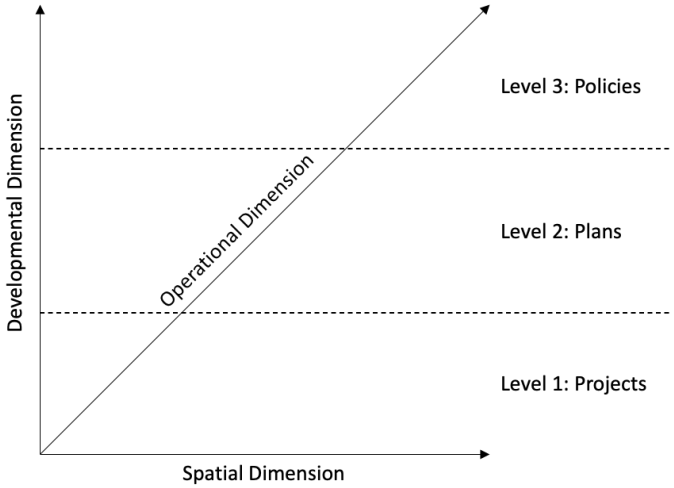


Figure 4. Solution space for planning. Source: Authors' elaboration.

Table 3. Integration into Local Urban Plans and Special Urban Plans.

Chapter Theme	Low (Core)	Medium (Analytical)	High (Expansive)
Climate			
Disaster Recovery			
Scenario Planning			
Planning Indicators			
Planning Instruments			
Other Interventions			
Other Administrative Divisions			

Source: Authors' elaboration.

5. Discussion and conclusions

Applicable to analysing and devising spatial plans, the contribution of this paper is conceptual, a framework for delineating spatial units, following a clear separation of the notions of land cover, land use, land function, and functional area, based on a mapping approach. Planning for climate resilient development is a timely matter facing professionals, presented recently in the PAS Report 601 of the American Planning Association (Bucchin and Tuley, 2022), and this paper highlights the relevance it has to the direction wildfire management would have to move to further attend to prevention, particularly at the WUI, instead of almost entirely suppression (Moreira *et al.*, 2020). This paper provides a basis for further research, which, taking stock of the challenges facing land systems (Meyfroidt *et al.*, 2022), could include case studies to gain insights into spatial plans involving peri-urban areas, comparative (methodological) studies on the spatial delineation of WUI areas, and theoretical, methodological, and empirical studies on defining appropriate spatial units for climate resilient development.

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