LARGE-SCALE WIND ENERGY FARM DEVELOPMENT AND ITS IMPACTS ON THE LANDSCAPE: A REVIEW OF THE GREEK CASE

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ABSTRACT

The expansion of large-scale onshore wind turbines supports climate goals and reflects broader energy transition strategies, yet it often conflicts with the values and meanings embedded in local landscapes. As landscape is increasingly understood as a lived, cultural, and perceptual experience, the resulting landscape transformation raises concerns about identity, place attachment, and democratic planning. This review article examines the impacts of large-scale wind energy development through a socio-cultural analysis of landscape change, focusing on key dimensions of landscape within the framework of protection, management, and planning as outlined by the European Landscape Convention (ELC). Using the widespread development of industrial wind farms in Greece as a case study, it also offers insights relevant to broader geographic contexts. The paper advocates for more nuanced, small-scale energy solutions that respect landscape diversity, character and identity and are grounded in rational spatial planning, public consultation, and a coherent energy strategy. It concludes with guidelines for the appropriate siting of wind farms and proposes measures for improved implementation, including innovative renewable energy alternatives.
Keywords: wind energy farms (WEFs), landscape scale, landscape dimensions, socio-cultural impacts, landscape transformation, European Landscape Convention

INTRODUCTION

Renewable energy has emerged as a key alternative to the depletion of fossil fuels such as oil, coal, and natural gas, which currently meet the majority of global energy demands. According to the REN21[1] *Renewables Global Status Report* (2024[2]), modern renewables account for approximately 13 % of global energy production. Despite this progress, energy demand continues to grow, and fossil fuel consumption has yet to decline significantly. Within the renewable share, modern heat energy—derived from biomass, geothermal, and solar heat—represents 4.9 %, while biofuels contribute 1 % (REN21, 2024:16). Ember's *Global Electricity Review* (2024) reports that renewables supplied a record 30 % of global

[1] Renewable Energy Policy Network for the 21st Century
[2]https://www.ren21.net/wp-content/uploads/2019/05/GSR2024_GlobalOverview_Full_Report_with_endnotes_web.pdf

electricity in 2023. In the EU, renewable energy consumption rose from 8.5 % in 2004 to 24.5 % in 2023[3].

Greece has positioned itself as a notable actor in wind energy development within the EU. According to the *Wind Energy in Europe* report (Wind Europe, 2023)[4], Greece ranked among the top ten EU countries for new wind installations, with wind energy covering 20 % of national electricity demand. Unlike other leading countries such as Denmark, the UK, Germany, and the Netherlands, which also invest in offshore wind, all of Greece's installations are onshore (see Fig. 1).

The International Energy Agency (IEA, 2023) highlights a global shift in energy supply between 2010 and 2021, with fossil fuels dropping from 90 % to 82 % of the mix. In Greece, lignite-fired electricity production decreased dramatically—from 60 % in 2005 to just 10 % in 2021—substantially reducing the carbon intensity of electricity generation. These shifts suggest a transition towards more sustainable and diversified energy systems, aligning with global climate targets. IEA (2024) projects that clean electricity from renewables and nuclear will meet all new demand through 2026, with renewables expected to surpass coal by 2025, driven largely by developments in China.

Greece is currently undergoing a critical phase in its energy transition, shaped by a complex interplay of environmental, economic, and policy factors. Between 2000 and 2022, the country reduced its greenhouse gas emissions by approximately 40 %, attributed to improved energy efficiency, lower emissions intensity, and reduced consumption during economic crises and the COVID-19 pandemic (Tsepi *et al*., 2024; Panagiotopoulos & Roukanas, 2024). Nevertheless, significant challenges remain, including high energy dependence on Russia and inefficiencies in buildings and transport (Panagiotopoulos & Roukanas, 2024). Kotroni *et al*. (2020) found that economic growth in Greece continues to correlate with increased CO_2 emissions.

Policy instruments such as the "Fast Track Law" (Law 3894/2010) and the Special Framework for Spatial Planning and Sustainable Development for Renewable Energy Sources (OJG 2464/2008) have played a pivotal role in accelerating investment in wind energy. As a result, wind power capacity reached 5.355 MW at the end of 2024, a 2.4 % increase from the previous year (Fig. 2). The Hellenic Wind Energy Association (HWEA) estimates this capacity will exceed 6.5 GW within two years (HWEA, 27/1/2025[5]). One of the government's strategic goals is to connect the most densely populated islands to the mainland grid by 2030, enhancing energy reliability and supporting renewable integration[6].

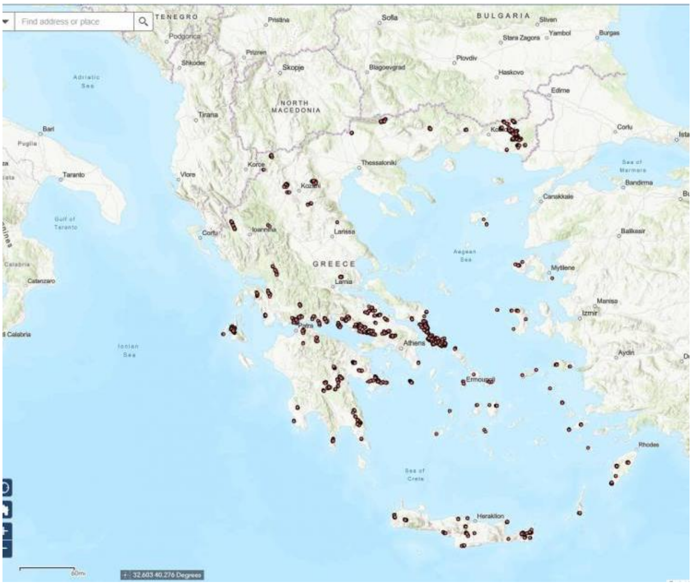
[3] https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20241219-3

[4] https://windeurope.org/intelligence-platform/product/wind-energy-in-europe-2023-statistics-and-the-outlook-for-2024-2030/

[5] https://eletaen.gr/deltio-typou-i-statistiki-tis-aiolikis-energeias-stin-ellada-2024/

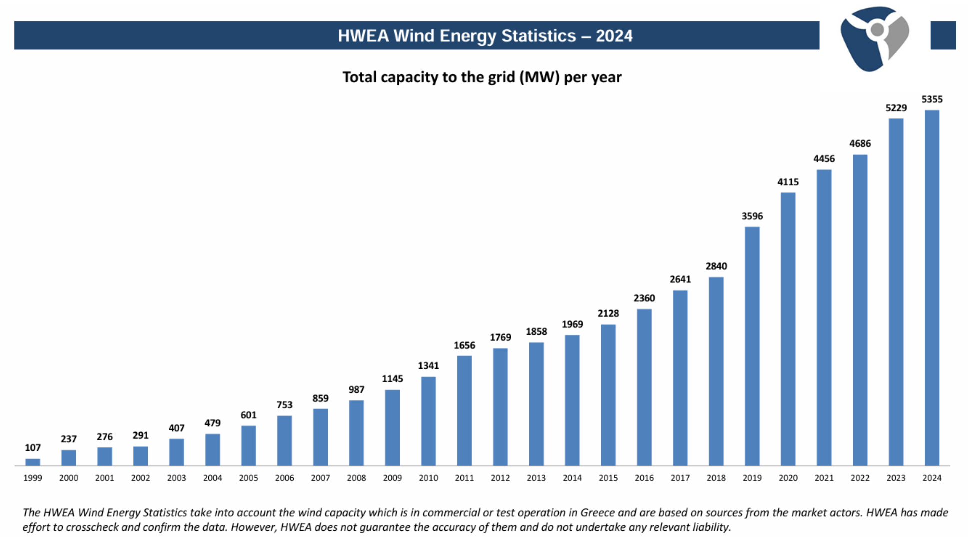
[6] Greece has more than 6,000 islands, of which only 227 are inhabited. 15% of the population of Greece lives on the islands (1,650,000 people).

Fig. 1: Map of the active Aeolian parks in Greece (5.226MW)



Source: HWEA

Fig. 2: HWEA Energy Statistics 2024



Source: HWEA

However, large-scale, fast-track installations of renewable energy sources (RES) are not the only viable method for harnessing renewable energy. This raises critical questions about their suitability in terms of landscape sustainability. Wind energy, along with geothermal, solar, hydroelectric, wave, tidal, and biomass sources, can be deployed in more diverse and potentially less disruptive ways.

This study investigates the landscape implications of accelerated wind energy investments within the broader framework of sustainable landscape management. It examines the spatial characteristics of such projects, their territorial interventions, the landscape transformations and the associated social responses. Building on this analysis, the study proposes a comprehensive framework for assessing critical landscape-related dimensions. It seeks to enrich the discourse on wind energy development by identifying appropriate tools and strategies for landscape governance, aligned with the principles of the European Landscape Convention (ELC). Although the empirical focus is on Greece, the insights and recommendations offered are of wider relevance, contributing to global discussions on the sustainable integration of renewable energy infrastructure within diverse landscape contexts.

Introduction to the concept of "landscape"

The term *landscape* has been defined in various ways, including as a portion of the Earth's surface perceived at a glance (Jackson, 1984:3) and as the mirror of spatial evolution (Ananiadou-Tzimopoulou, 1992:10). Since the 1980s, as human geography evolved, landscape has been understood not only as a physical view but also as a *way of seeing* (Cosgrove, 1984), incorporating the subjective, ideological, and ethical dimensions of perception (humanistic tradition) alongside the socio-economic structures of power, dominance, and control in space (Marxist tradition).

During the 1990s, the focus shifted from "structures" to "relationships", and landscape came to be viewed as a comprehensive framework for understanding the complex, fluid, and multi-layered relations between humans and space (Harvey, 1989; Featherstone, 1991; Soja, 1996). It has since been conceptualized as both physical space and its representation—as signifier and signified, frame and content, surface and substance (Hadjimichalis *et al.*, 2012:235; Mitchell, 1994). Landscape's significance, both as an idea and as a practice, gained recognition among geographers such as Olwig (1996:645).

During the next century, there is a shift from the dominance of the visual to the importance of the totality of senses through which space is experienced. A transition from representation through theory to the embodied practices and lively integrated experiences (without one excluding the existence of the other – in fact, one constitutes the continuation of the other) (Lorimer, 2005, 2007; Dewsbury *et al.,* 2002). This transition involved emphasis to experiential practice through the human body (e.g., experiencing through hiking, driving, cycling, climbing, gardening) and recognized the importance of the totality of senses through which the landscape is experienced (Wylie, 2007). The landscape is described as the "interconnection between self, body, knowledge, and land" (Wylie, 2007:1), and one of the fundamental claims of such more-than-representational geographies is that if people think through their bodies, they should also think, act, connect, and interact with their landscape through their bodies (Wylie, 2007).

In the early 21st century, attention shifted from visual dominance to the multisensory and embodied experience of space. This transition from representational theories to lived, corporeal engagement (Lorimer, 2005, 2007; Dewsbury *et al.*, 2002) emphasized the experiential and performative aspects of landscape. Everyday activities—walking, gardening, climbing, or driving—became recognized as ways of engaging with landscape through the body. According to Wylie (2007), landscape constitutes the "interconnection between self, body, knowledge, and land" (p. 1), and more-than-representational geographies assert that if people think through their bodies, they also interact with and interpret landscapes through embodied experiences.

The sensory and material dimensions of landscape—such as textures of stone and wood, the scent of flowers, or the sound of sheep bells—are now understood as integral parts of how landscape is lived and felt. This perspective reframes landscape as a "medium of seeing itself", transforming the observer into a participant and the landscape into a "living space" rather than a passive scene (Wylie, 2007:149).

Landscape is thus conceived as a *dynamic system of relationships* rather than a static structural condition and as a field of coexistence for multiple cultural and environmental processes (Moraitis, 2015). It embodies a layered interplay between culture and nature, artificial and natural elements, and connects opposing binaries—subjective and objective, real and imagined, beautiful and ugly, ideal and realistic, symbolic and material, formed and formless, feminine and masculine (Cosgrove & Daniels, 1988; Terkenli, 1996). The world is defined and redefined through the continuous negotiation of these two poles that define the field of human exploration: the subjective and the objective. This duality of the landscape (landscape duality) (Cosgrove & Daniels, 1988:7) is perhaps its greatest value (Terkenli, 1996).

Crucially, landscape emerges from both subjective and inter-subjective experiences. Subjective perceptions are shaped by individual traits and personality, while inter-subjective dimensions draw on shared moral, perceptual, and cultural codes (Terkenli, 1996). In recognition of this complexity, the European Landscape Convention (ELC; Greek Law 3827/2010) frames landscape as a multidimensional resource and common heritage essential to individual and social well-being. It defines landscape as "an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors" (CoE, 2000).

THE CHARACTERISTICS OF WIND ENERGY PROJECTS AND THE INTERVENTIONS IN THE FIELD

From the first decade of the 21st century, the nature of RES investments has significantly evolved. Historically, windmills—dating as far back as the 19th century or earlier—were integrated into the landscape, serving both functional and symbolic purposes. They secured the "community bread" and embodied the ideals of collective stewardship and the "governance of the commons". During the industrial era of the 20th century, this tradition gave way to the development of Aeolian parks and the installation of wind turbines measuring 30–40 meters in height (under 100 kW) during the 1980s. By the 1990s, turbines had grown to 50–60 meters with outputs reaching up to 750 kW.

Post-2000, technological advancements enabled the construction of even larger turbines—often over 100 or even 150 meters tall—especially for offshore installations, with power outputs now reaching up to 15 MW and weights exceeding 200 tons. This marked a shift toward a new era of intensive energy production. However, the increasing size and industrial character of these turbines have raised substantial concerns regarding their integration into landscapes (Colafranceschi *et al*., 2021; Brittan, 2001). Their stark technological appearance often clashes with natural environments, posing significant aesthetic challenges (Brittan, 2001).

In terms of spatial configuration, wind turbines are typically installed on ridgelines with low shrub vegetation and are connected via underground medium-voltage cables. Wind farms also include control cabins (enabling remote operation of turbines) and voltage conversion substations. Developers usually select areas deemed to pose minimal environmental disturbance—arguing that they are neither inhabited nor of tourist/leisure interest, and that appropriate distances between turbines are maintained. However, this is not always the case. There are examples of WEFs situated in protected NATURA 2000 areas or in island regions dependent on tourism, where the scale of the landscape is incompatible with that of the wind turbines. Although the environmental terms of WEF projects include provisions for restoring the landscape following decommissioning, guarantees for such restoration are lacking. In several cases, wind parks have been abandoned without the promised rehabilitation.

The environmental interventions required for such installations intensify with project scale and include: the construction of new earth roads (ranging from tens to hundreds of kilometers per project), trenching and cabling for medium- and high-voltage lines over vast distances, major excavations for reinforced concrete foundations for each turbine, and the formation of large platforms and squares. These processes are followed by extensive backfilling and compaction works, as well as the creation of construction sites that often lead to significant accumulations of waste and unused materials.

Despite these challenges, WEFs can offer positive contributions to the landscape. They reduce the environmental footprint of energy production by replacing fossil fuel-based infrastructure, which often degrades landscapes through mining, pollution, and industrial development. Wind farms symbolize progress toward renewable energy and reflect a region's commitment to sustainable development and climate action (Nazir *et al.*, 2020; Jaber, 2014). However, one must ask: can societies truly bear the cost of such landscape transformation?

The ecological transition is, fundamentally, a cultural one. Like all radical changes, it introduces new symbols whose meanings are often unclear during their initial emergence. It is therefore unsurprising that all types of renewable energy infrastructure generate concern and skepticism within local communities, raising essential debates around landscape protection and identity (Cosmo, 2023). While society may recognize the potential of these installations as clean and inexhaustible energy sources, hesitation remains—particularly due to the vast physical and symbolic footprint of wind turbines (Pasqualetti, 2011). Opposition to WEFs often arises from conflicts between diverse social values and identities—spanning technology, economy, and rural or pastoral ideals (Phadke, 2011). Can the benefits of renewable energy truly outweigh the cost of altering landscapes that are deeply intertwined with local cultural and natural heritage?

CHARACTERISTICS OF THE GREEK LANDSCAPE CASE

The Greek landscape is marked by significant diversity but also by simultaneous trends toward homogenization, fragmentation, and chaotic sprawl (Hatzichristos, 2011; Hadjimichalis *et al.*, 2012). Among its key challenges are environmental pollution, frequent natural disasters and inadequate responses to them, desertification and abandonment of rural areas, unregulated waste disposal, urban encroachment on meadows and forested zones, uncontrolled and out-of-plan construction, the absence of comprehensive land-use planning, and poorly managed tourist development (Pavlis, 2012).

The relationship between Greeks and their landscape is often described as fragmented, problematic, and culturally underdeveloped. The development of landscape conscience among modern Greeks remains at an early stage when compared with other European nations (Pavlis, 2012; Pavlis & Terkenli, 2017; Terkenli & Pavlis, 2012). The rapid urbanization and rural depopulation that started in the 1950s and continues to this day have had a profound effect on population distribution, significantly altering the collective psyche of modern Greek society (Kanarelis, 2009; Damianakos, 2002, Papadopoulos & Baltas, 2023). As a result, there is currently little evidence of a widespread sense of the landscape as a shared, common good.

The Environmental Impact Assessments (EIAs) and technical reports for WEF projects, often led by RES companies, tend to reduce the concept of landscape to a mere visual schema. They frame the perception of landscape disturbance as purely subjective, frequently asserting "zero landscape burden" or promising "landscape restoration upon project completion". However, such claims are largely utopian or unrealistic, as the complex realities of implementation often prevent meaningful restoration. In many cases, space—and by extension, landscape—is treated as a flat, one-dimensional plane defined by movement and distance, or as a neutral "environment" with limited spatial or cultural depth. Landscape is thus typically reduced to its aesthetic qualities alone. Furthermore, dialogue among key actors—such as developers, authorities, local governments, and the public—is rarely grounded in a holistic understanding of landscape as a product of human–environment interactions.

The *Special Framework for Spatial Planning and Sustainable Development for RES* (OG B 2464/2008) does not take into account the ELC[7], nor does it adopt modern landscape science approaches or heed relevant EU recommendations on landscape integration. Notably absent is reference to guidance such as the chapter “Landscape and Wind Turbines” in the *Landscape Dimensions* report by the Council of Europe (2016)[8], the *Landscape and Wind Turbines* report of 3–4 May 2014[9], or the 2014/4073 report by Commissioner for the Environment Janez Potočnik addressed to the Greek Minister of Foreign Affairs. Likewise, the *Enerscapes* project report (2013)[10] underscores the urgent need to protect the cultural and ecological character, values, and qualities of landscapes from the degradation and depletion associated with wind farm development.

The Report of the project Enerscapes (2013) stresses the need for protecting the cultural and ecological landscape character, values and qualities from wind farm deterioration, depletion and uncontrolled development, inefficiencies in local governance, the lack of local awareness, and the inadequacy of RES promotion policies and planning processes. All these challenges point to a critical need for landscape study, analysis, and evaluation.

Tools such as *Landscape Character Assessments* and *Landscape Capacity Assessments*, widely used in other contexts to understand, monitor, and evaluate landscapes, are still not implemented in Greece.

As Kyvelou & Gourgiotis (2019) note, landscape policy in Greece still relies primarily on foundational levels of spatial planning. Progress was made with the introduction of *Special Landscape Plans* in the *Regional Spatial Plans* between 2014 and 2016, intended as a means to apply the ELC. A core principle is that effective landscape policy—both on land and at sea—requires the integration of evolving planning approaches and an understanding of the landscape as a dynamic socio-ecological system.

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[7] By the moment the law introduced (2008), the ELC (2000) had not been voted as a Greek Law (3827/2010)

[8]https://rm.coe.int/landscape-dimensions-ch-1-landscape-and-wind-turbines-by-emmanuel-cont/16808cd561

[9] https://rm.coe.int/16806f40b3

[10]http://www.juntadeandalucia.es/medioambiente/portal_web/web/temas_ambientales/paisaje/sistema_informacion_paisaje/proyecto_enerscapes/enerscapes_finalpublication.pdf

However, the landscape sections included in Greece's regional spatial plans remain insufficient. They often struggle with the conceptualization, interpretation, and assessment of landscapes. They lack legislative authority—serving only as non-binding guidelines—and are developed without the involvement of social scientists. This omission prevents the adoption of a holistic landscape approach, limiting the capacity to address issues of public participation, governance, and the emerging cultural economy of space (Terkenli, 2006; 2025). These shortcomings also hinder the integration of phenomenological and more-than-representational geographical perspectives (Wylie, 2007; 2018; Lorimer, 2005; Salwa, 2022; Wang, 2023), which are vital to understanding how landscapes are lived, experienced, and valued.

THE SOCIAL REACTIONS TO THE MASSIVE INSTALLATION OF LARGE INDUSTRIAL AEOLIAN PARKS IN GREECE

Following the 2008 economic crisis—which catalyzed a broader reconsideration of the human–space relationship—the debate surrounding industrial WEFs in Greece acquired an increasingly spatial and cultural dimension. The massive installation of large industrial WEFs is not the only possible means of exploiting RES; nevertheless, this approach has provoked widespread and intense social reactions, particularly among local populations who possess a more profound understanding of landscape meanings. The study of these reactions is highly significant, as they may represent the first organized, large-scale mobilizations around landscape-related concerns—beyond purely environmental ones—within Greece and potentially elsewhere [11]. These mobilizations may signal a broader transition from environmental to landscape activism, although these two forms of activism are not mutually exclusive.

The key concerns of landscape activists include:

a. The large scale of the investments (large size, concentration, and extent) in relation to the scale and carrying capacity of the landscape,

b. Negative impacts on avifauna, fossil records, Natura 2000 areas, and sensitive ecosystems;

c. Potential degradation of slow and sustainable tourism, including ecotourism, agritourism, and cultural tourism;

d. Adverse effects on the sustainable management of natural and cultural resources, such as agriculture and livestock farming;

e. Detrimental consequences for both natural and cultural heritage;

f. The significant profits garnered by wind energy companies through exploitation of the 'commons', potentially deepening socio-economic inequalities;

g. Disruption of prospects for localized sustainable development;

h. Inadequate provision of information and the lack of meaningful public consultation and engagement from the outset;

i. Depreciation of land values in affected areas;

j. Generation of surplus electricity primarily intended for export rather than local use;

k. The relatively small number of job opportunities created in the wind energy sector;

l. General lack of public involvement and democratic deliberation;

m. Insufficient compensatory benefits for local communities.

The ELC explicitly mandates each signatory to "increase awareness among civil society, private organizations, and public authorities of the value of landscapes, their role and

[11] Interactive map of landscape activist movements: https://tinyurl.com/kinhmata

changes to them", and to "define landscape quality objectives" through public consultation (Article 6). These objectives are to be achieved through awareness-raising, education, and the training of citizens, schools, and professionals—both in the private and public sectors—on landscape issues.

Public participation and consultation are central principles of the ELC. In this context, there must be accessible and adequate information provided to the public—not only about the potential benefits but also the socio-environmental, cultural, and economic impacts of wind energy developments. Public involvement is essential to democratic governance and sustainable development, ensuring that diverse views and interests are acknowledged, thereby leading to more inclusive and legitimate decision-making processes.

Equally important is Traditional Ecological Knowledge (TEK)—the accumulated knowledge and practices of local communities developed through long-term interaction with specific landscapes—which contributes meaningfully to environmental and cultural stewardship (Souther *et al*., 2023). As Roe (2012) notes, in many cases, local concerns about landscape degradation are rooted not in aesthetics alone, but in the deeply embedded social, cultural, and economic values associated with the landscape. These values take generations to establish and are central to notions of identity, character, and heritage.

The large-scale deployment of WEFs in Greece—particularly in Natura 2000 sites—has triggered widespread opposition. Local communities argue that licensing procedures are largely symbolic, offering limited opportunities for meaningful consultation, while environmental NGOs advocate for a moratorium on new permits until comprehensive spatial planning frameworks are put in place. The Hellenic Ornithological Society has voiced strong concerns regarding WEF impacts on bird populations and ecosystems. WWF Greece has criticized the regulatory framework, claiming it operates under intense pressure for procedural streamlining, while Greenpeace—despite its general support for RES—demands proper siting and the establishment of local energy cooperatives.

Various initiatives and events reflect growing civil society engagement. The Chamber of Environment and Sustainability organizes informative events such as the scientific conference *"Designing (at) the Limits of Small Islands"* (6/11/2024), or public meetings-discussions such as *"Wind Turbines – Photovoltaics – Aquaculture. Is this the Future of the Municipality of Eretria?"* (19/1/2025) or "*What future do we want for Paros? Prompted by the new Local Urban Planning Scheme for the island of Paros*" (15/3/2025). These events aim to clarify the concepts of sustainable development and spatial planning, and highlight the importance of environmental protection and landscape/ecosystem carrying capacity.

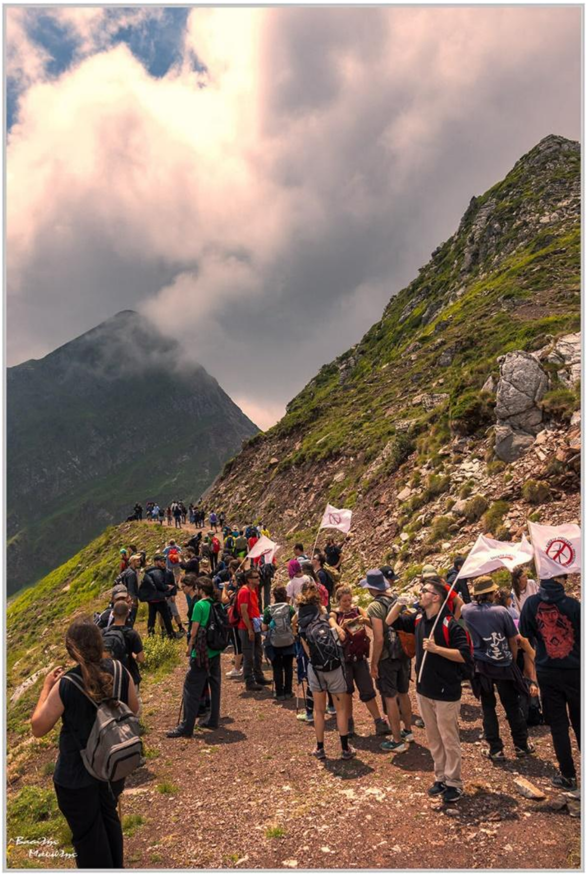
Grassroots resistance continues to grow across the country—from the north to the south—including regions such as Drama, Kozani, Grevena, Agrafa, Larisa, Trikala, Phthiotis, Aetolia-Acarnania, Nafpaktos, Kalyvia, Lavreotiki, Evia, and the islands of Tinos, Andros, Naxos, Paros, Amorgos, Ierapetra, and Heraklion. The Regulatory Authority for Energy, Waste & Water (RAEWW)'s interactive map (https://geo.rae.gr/) graphically illustrates the high density and wide distribution of WEF projects across the country, intensifying public concern. Local communities are increasingly engaging in organized resistance, which has, in some instances, led to direct confrontations with police forces. Mountaineering clubs, local associations, and citizen groups have united under the slogan

"Free Mountains without Wind Turbines", voicing opposition to the industrial colonization of mountain landscapes[12].

The core issue lies in the unprecedented scale of wind energy development: currently, approximately 20,000 turbines are under evaluation, licensing, or construction across more than 1,500 sites nationwide. The Central Union of Municipalities of Greece (KEDKE) has expressed concern about the lack of regulation in siting, yet it has been criticized for not taking a stronger stance against policy changes that bypass local governance mechanisms

Similar cases of social resistance have been documented internationally. Pasqualetti (2011) explores analogous conflicts in the U.S., Mexico, and Scotland, highlighting how socio-cultural and territorial contexts shape public responses. Likewise, Wüstenhagen *et al*. (2007) stress that the perceptual integration of wind energy into landscapes—visually and culturally—is vital to the successful territorial implementation of energy policy. Colafranceschi *et al*. (2021) further emphasize that such integration is key to fostering public acceptance and ensuring the long-term sustainability of wind energy projects. Spanos & Petropoulou (2024) refer critically to similar cases of energy conflicts around the globe.

Fig. 3: Protests in Niala, Agrafa, photo Vasilis Manolis



[12]Greece is a highly mountainous country, with mountains and hills covering approximately 80% of its territory, making it one of the most mountainous countries in Europe

Fig. 4: Protests in Athens, source: agrafasos

IMPACTS OF THE WEFS ON THE MULTIDIMENSIONAL LANDSCAPE

The landscape dimensions can be classified as follows:

a) Geological-geomorphological-climatic,
b) Ecological,
c) Visual-aesthetic,
d) Socio-economic,
e) Historical-archaeological-national, and
f) Experiential.

This classification reflects the evolving understanding of the landscape concept and aligns with established criteria for landscape analysis. These dimensions encompass both physical-geographical and human-geographical characteristics, highlighting their interdependence and mutual influence. Together, they shape landscapes as complex entities perceived and interpreted through the full spectrum of human senses, underscoring that landscapes exist only through lived experience.

A critical analysis of these dimensions, along with a preliminary assessment of the potential impacts of large-scale wind energy investments, forms the basis for general assumptions that should inform future WEF projects. However, further empirical research is essential to fully capture and understand the scope and implications of such developments.

Geological-geomorphological-climatic dimension of the landscape

This dimension focuses on the diversity of landforms—such as mountains, seas, capes, bays, peninsulas, and plains—along with geological characteristics (e.g., karst formations, geothermal fields) and local microclimatic conditions. These natural features are essential to landscape identity and function.

For large-scale WEF developments, evaluating the geological stability and soil-bearing capacity of a site is critical. Such projects may also necessitate complementary infrastructure, including slope stabilization, landslide prevention, and water drainage systems. In many cases, significant issues related to soil erosion may emerge (Tavoularis, 2023). Geomorphology also plays a key role in shaping local microclimates (Cook & Martin, 2017).

Microclimatic conditions, in turn, influence the production of region-specific agricultural goods (Chen *et al*., 1999; Kaffine, 2019). However, WEFs can disrupt these conditions, impacting both vegetation and soil cover (Aksoy *et al*., 2022). In rural settings, large-scale energy projects may also affect precipitation patterns (Kaiser *et al*., 2011; Zeng & Viswanathan, 2012). Wind turbines modify microclimates by mixing atmospheric layers—redistributing warm, rising air with cooler layers—thus functioning similarly to fans. This turbulence can raise soil temperatures, with notable temperature differences recorded during summer nights. The extent of these effects depends on the size of the installation, atmospheric flow, local environmental conditions, and seasonal factors (Tabassum-Abbasi *et al*., 2014; Walsh-Thomas *et al*., 2012; Zhou *et al*., 2012, 2013; Miller & Keith, 2018).

Table 1: Site-Specific and Generic Barriers of Wind Energy Farms (WEFs) to the geological-geomorphological-climatic dimension of the landscape

Landscape dimension	Barrier Type	Description	Examples
	Site-Specific Barriers	Context-dependent and unique challenges that vary by location, tied to specific landscapes or environmental conditions	
Geological-geomorphological-climatic dimensions of the landscape	Geological and Geomorphological Constraints	Soil stability and bearing capacity issues requiring assessments. Potential risks of groundwater contamination due to deep excavations and construction activities.	Karst formations, geothermal fields, mountainous terrain, leakage of construction materials into aquifers.
	Microclimatic Impact	Wind farms may alter temperature, humidity, and rainfall patterns.	Increased nighttime temperatures, soil moisture loss.
	Vegetation and Soil Degradation	Land cover changes due to road networks, turbine foundations, and excavation, leading to soil erosion and degradation.	Desertification risk in arid areas, increased runoff affecting agricultural land.
	Infrastructure Challenges	Need for additional structures for slope stabilization and water drainage	Landslide prevention, reinforced road networks.
	Generic Barriers	Common challenges across various locations	
	Soil stability and bearing capacity concerns	Large-scale wind energy projects require assessment of soil stability, with challenges in areas with	Wind farms in mountainous areas may face issues with soil stability, requiring reinforcement measures such

		complex geological formations or steep slopes.	as slope stabilization to prevent landslides.
	Soil degradation and erosion	The construction process, including road building and excavation, can lead to erosion and soil degradation, especially in areas with fragile soil cover.	Roads built for turbine access in island regions prone to erosion could exacerbate soil loss, leading to further environmental degradation.
	Impact on local microclimate	Wind farms can alter the microclimate by mixing warm and cold air, potentially changing temperature and humidity.	Installation of wind turbines in agricultural areas could alter local microclimates, affecting crops that depend on specific temperature and humidity levels.
	Alteration of vegetation and soil cover	Large-scale WEF projects can disturb local vegetation and soil, leading to land degradation and a change in local ecosystems.	Construction of roads and turbines may disrupt local vegetation, leading to increased soil erosion and loss of biodiversity.
	Changes to rainfall patterns	WEFs may affect local rainfall patterns by altering the atmospheric flow, which could influence agriculture and local ecosystems.	Wind farms may alter precipitation patterns, leading to drier conditions in agricultural zones that depend on regular rainfall.
	Risk of desertification in high-risk areas	Areas at risk of desertification could experience exacerbated soil degradation and loss of vegetation due to large-scale wind energy developments.	Wind farms built in desertification-prone areas, such as the Aegean islands, could worsen soil erosion and accelerate the desertification process.

The physical footprint of WEFs significantly alters the geomorphology of the landscape. Infrastructure development requires extensive spatial expansion, road construction, deep excavations for cable installations, and foundation placement for each turbine. These interventions can lead to widespread soil disturbance and degradation. Of particular concern is the erosion of existing and newly built road networks, which is intensified by rainfall and the heavy machinery used for turbine transport. Such erosion can lead to long-term environmental damage and financial losses that may outweigh any compensatory benefits provided to local communities.

Furthermore, several areas in Greece—including the Aegean islands—have been identified as highly susceptible to desertification (Kosmas *et al*., 1999, 2000, 2014). The *National Action Plan for Combating Desertification* (Government Gazette 99605/3719) outlines strategic measures to prevent and mitigate such risks. Many of the regions prioritized for future wind energy development fall within these high-risk zones, calling for a more cautious and landscape-sensitive approach to WEF planning and implementation.

Ecological Dimension of the Landscape

Greece is home to ecologically rich areas, many of which are protected under the NATURA 2000 network. These regions support a remarkable diversity of flora and fauna, including numerous rare, vulnerable, endangered, and legally protected species—some of which reproduce exclusively or primarily within the country. They also serve as important habitats and migratory corridors for species that pass through or nest in Greece (Handrinos & Akriotis, 1997; Bourdakis & Vareltzidou, 2000; Legakis & Maragkou, 2009).

Scientific research indicates that the development and operation of large-scale WEFs can significantly affect avian and bat populations. Impacts may occur during migration, nesting, and breeding periods, especially for species with large wingspans or low reproductive rates (Hayes, 2013; Lehnert *et al*., 2014; Carrete *et al.,* 2012; Dahl *et al*., 2012; Tesfahunegny *et al*., 2020; Furness *et al*., 2013). In some cases, WEFs have been shown to disrupt migratory routes and alter daily flight behaviors of birds (Lucas *et al*., 2021).

Beyond species-specific effects, WEF developments may also undermine broader ecological functions tied to traditional agricultural landscapes. In several targeted investment areas, land management practices such as terracing, hedgerows, and natural corridors have shaped distinct rural landscapes that act as vital biodiversity refuges (Rackham & Moody, 1996/2004). These features not only sustain ecological health but also contribute to the cultural and visual character of the countryside.

A major gap in current environmental assessments of WEF projects is the lack of long-term planning regarding turbine decommissioning. There is often no clear strategy for restoring ecosystems, biodiversity, and landscapes to their original or ecologically functional state after the operational life of the turbines—typically around 20 years—despite the expectation that technology will evolve by then. This omission raises concerns about the potential for permanent ecological degradation, unless robust post-investment restoration plans are integrated into project design and policy frameworks.

Table 2: Site-Specific and Generic Barriers of Wind Energy Farms (WEFs) to the ecological dimension of the landscape

Landscape dimension	Barrier Type	Description	Examples
	Site-Specific Barriers	Context-dependent and unique challenges that vary by location, tied to specific landscapes or environmental conditions.	
Ecological dimension of the landscape	Biodiversity Loss and Habitat Disruption	WEF installations impact species that are rare, vulnerable, endangered, or globally significant, altering ecosystems and disrupting habitats.	Disturbance in NATURA 2000 areas, destruction of breeding/nesting sites.
	Bird and Bat Mortality	Turbines pose a direct threat to flying species, particularly those with larger wingspans and lower reproduction rates.	Collision risks for migratory birds, displacement of bat populations.
	Disruption of Migration and Movement Patterns	Wind farms alter the migratory routes and daily movement of certain species.	Interference with birds' seasonal migration, changes in feeding and nesting behaviors.
	Loss of Agricultural Biodiversity	Traditional landscapes with ecological management elements (terraces, hedgerows, corridors) are degraded, reducing biodiversity.	Removal of crucial refuges for flora and fauna, loss of pollinators.

	Lack of Decommissioning and Restoration Plans	No clear policies on site rehabilitation after WEFs reach the end of their operational life.	Unclear strategies for biodiversity restoration, abandoned infrastructure impacting ecosystems.
	Generic Barriers	Common challenges across various locations.	
	Biodiversity Loss and Habitat Disruption	WEFs alter ecological relationships, affecting predator-prey dynamics and food chains.	Decline of key species affecting overall biodiversity balance.
	Long-Term Environmental Uncertainty	Insufficient research on the long-term ecological effects of WEFs.	Potential unforeseen consequences on flora, fauna, and soil stability.
	Conflicts with Conservation Policies	Wind energy projects may contradict national and international conservation frameworks.	Incompatibility with protected area regulations, legal challenges in ecologically sensitive zones.

The visual-aesthetic dimension of the landscape

The visual dimension of the landscape is central to how humans decode space and make sense of their surroundings. Through perception—shaped by cognitive and neurological processes—the landscape becomes not merely a physical setting but an image, a spectacle, or a representation. This image, whether material, imaginary, or symbolic, is constructed within the human mind. Visibility and representation require a certain "distance" between the observer and the observed, enabling the landscape to reflect ideological, cultural, and ethical aspects of the human gaze. In this way, the observer is situated within a world that is simultaneously material and symbolic, subjective and objective (Terkenli, 2005).

The introduction of wind turbines into a landscape can significantly affect how it is perceived and valued. For instance, local acceptance of wind energy development is often influenced by visual exposure to turbines. Long-term exposure tends to reinforce perceptions of visual intrusion or dominance (Świdyńska *et al*., 2024).

Key factors shaping the visual-aesthetic dimension include the landscape's character, features, and scale. The character of a landscape results from the unique combination of its elements, giving rise to a distinct 'sense of place' that differentiates one area from another (Swanwick, 2002). Landscape features—such as elevations, hedgerows, stone enclosures, pathways, and traditional buildings—embody both ecological and cultural significance. However, many of these features, especially stone structures, are at risk of disappearing due to the decline of traditional building knowledge and practices (Kizos & Koulouri, 2006; Rackham & Moody, 1996/2004).

Scale is a critical concept in understanding the landscape. It provides a framework for interpreting the environment from the local to the regional level and challenges the notion of a "one size fits all" model in spatial planning. Both horizontal coverage and vertical height of structures must be assessed in relation to the inherent characteristics of the landscape. For example, in a setting characterized by modest dwellings, pine forests, low stone walls, and gentle relief, wind turbines exceeding 100 meters in height would appear incongruous and disproportionate, disrupting the visual harmony and coherence of the place (Scottish Natural Heritage, 2009).

The aesthetic value of the landscape transcends its functional use, emerging from sensory and emotional experiences such as beauty, tranquility, harmony, sacredness, and historical resonance. These qualities enrich human life and well-being by enabling deep, contemplative engagement with place. At the same time, aesthetic experience is not entirely subjective—it also involves intersubjective criteria shared across communities and cultures (Adorno, 1970/2000; Terkenli, 1996). As Kirchhoff (2014) points out, energy infrastructures can conflict with widely held aesthetic ideals, underscoring the need for spatial planning that respects and reflects collective visual values.

The integration—or lack thereof—of large-scale WEFs into the visual landscape is influenced by a number of factors: the form, shape, color, line, and texture of the turbines, their size, density, and spatial extent, and the broader context of mass energy production for export. These installations may dominate the landscape, altering its identity and provoking questions about power dynamics, land use, and local control (Mitchell, 2008). Moreover, such interventions are not limited to visual disruption; they may also have cascading ecological consequences, further affecting landscape quality.

In Greece, these concerns are particularly pressing in protected areas and Landscapes of Special Natural Beauty, a designation established under Law 1650/1986. In such contexts, the visual-aesthetic dimension of the landscape is not only an environmental and cultural asset but also a legal and ethical consideration in planning decisions.

Table 3: Site-Specific and Generic Barriers of Wind Energy Farms (WEFs) to the visual-aesthetic dimension of the landscape

Landscape dimension	Barrier Type	Description	Examples
	Site-Specific Barriers	Context-dependent and unique challenges that vary by location, tied to specific landscapes or environmental conditions.	
Visual-Aesthetic Dimension of the Landscape	Disruption of Landscape Character	WEF installations alter the visual coherence, identity, and sense of place of a landscape.	Large-scale wind turbines in traditional rural settings or cultural landscapes.
	Scale Incompatibility	The height and density of wind turbines contrast with existing landscape features, leading to visual disharmony.	Wind turbines exceeding 100m in areas with small-scale farmsteads, forests, or rolling hills.
	Impact on Designated Scenic and Protected Areas	WEFs in protected landscapes (e.g., Landscapes of Special Natural Beauty, NATURA 2000 sites) reduce their aesthetic and cultural value.	Wind farms in areas with historical or ecological significance, affecting heritage views.
	Loss of Aesthetic Enjoyment and Serenity	The presence of industrial structures in natural or cultural landscapes diminishes aesthetic experiences.	Wind farms in locations valued for tranquility, sacredness, or scenic beauty.
	Generic Barriers	Common challenges across various locations.	
	Visual Dominance and Skyline Intrusion	Large WEF installations disrupt the natural or cultural skyline, overpowering existing landscape elements.	High-density wind farms in open countryside, coastal areas, or mountain ridges.
	Subjective and Inter-Subjective Aesthetic Perceptions	Public perception of wind farms varies based on cultural, ideological, and personal aesthetic values.	Opposition to wind farms due to perceived industrialization of nature.
	Lack of Spatial Planning for Landscape Integration	Inadequate planning for WEF placement results in poor	Misalignment between wind energy expansion

		visual integration and spatial dissonance.	and landscape aesthetics.
	Transformation of Traditional and Symbolic Landscapes	WEFs alter landscapes with historical, symbolic, or artistic significance.	Wind farms impacting the visual integrity of culturally important landscapes.

The socio-economic dimension of the landscape

The socio-economic dimension of the landscape refers to the processes through which landscapes are produced, reproduced, and consumed. These processes are shaped by socio-economic relations of production, which determine the form, structure, and function of landscapes within specific historical and technological contexts. Often marked by contradictions, these relationships influence whether natural and cultural resources are managed sustainably and collectively, or whether they are subject to exploitation and the appropriation of surplus value. A comprehensive understanding of the landscape thus demands insight into these underlying dynamics (Mitchell, 2008; Terkenli, 2006; Cosgrove, 1984).

In this context, large-scale, fast-tracked wind energy projects illustrate the growing influence of the Aeolian industry in both shaping and consuming rural landscapes. These oversized industrial installations do not merely generate energy—they also function as symbols of market dominance, reflecting the power imbalance between corporate interests and local communities. Such developments contribute to the transformation of rural economies from production-based systems into large-scale energy production hubs signifies a shift in power relations, sovereignty, and control, directly influencing the production and consumption of landscapes.

Such investments are expected to impact the productive sectors of local economies, traditionally based on agriculture and livestock farming, leading to potential alterations in the form, functions, and management of ecosystems. Wind energy facilities are known to affect agricultural and pastoral activities, potentially displacing livestock units and threatening the viability of local food systems such as beekeeping. These disruptions extend beyond economic implications to impact social relations and the organization of rural life. As most WEFs are installed on public land, concerns have emerged about speculative appropriation, often supported by subsidies but offering limited benefit to local or regional development. Chatzimichalis (2014) emphasizes this dual process of green grabbing by highlighting the 'appropriation of public land by subsidized speculative investments with limited contribution to local/regional development' (2014:115) and the 'indirect appropriation of food resources through the conversion of arable land into industrial use' (2014:118). Siamanta (2019) examines the phenomenon of green grabbing as a process that reinforces socio-economic inequalities, adversely affecting local shepherds and farmers, small-scale and domestic electricity consumers, and contributing to ecological distribution conflicts. In post-crisis Greece, wind energy facilities are promoted as a socio-ecological fix to both economic recession and climate change, yet they often prioritize market interests over local livelihoods, equity, and inclusive development. Spanos & Petropoulou (2024) argue that, in Greece as well as in other contexts, investments in green energy are frequently motivated less by genuine commitments to mitigating climate change and more by the pursuit of capital accumulation through processes of land dispossession—dynamics that, in certain instances, constitute forms of green grabbing. They contend that enterprises engaged in such activities are often entangled in environmental conflicts, particularly where violations of environmental legislation are evident.

The result is the production of homogenized industrial landscapes, tailored to serve the needs of the wind energy industry but often in tension with other sectors—most notably, tourism. The tourism industry plays a significant role in landscape branding and management, relying on cultural narratives, symbolism, and scenic integrity through myths, images, stories, and ideologies. In island and mountainous regions, ecotourism—such as birdwatching and nature-based tourism—has become a key support system for small-scale rural economies. Yet, these activities are vulnerable to the environmental and visual impacts of WEFs, especially in areas of high biodiversity. The expansion of alternative tourism that depends on intact natural and cultural landscapes may be constrained or altogether obstructed by industrial development (Kipperberg *et al*., 2019).

Table 4: Site-Specific and Generic Barriers of Wind Energy Farms (WEFs) to the socio-economic dimension of the landscape

Landscape dimension	Barrier Type	Description	Examples
	Site-Specific Barriers	Context-dependent and unique challenges that vary by location, tied to specific landscapes or environmental conditions.	
Socio-economic dimension of the landscape	Transformation of Local Economies	WEF development shifts rural economies from agricultural and livestock-based production to industrial energy hubs, disrupting traditional livelihoods.	Relocation of livestock units, reduction of agricultural land, impact on beekeeping.
	Impact on Local Tourism and Ecotourism	WEFs affect tourism sectors reliant on intact landscapes, cultural heritage, and biodiversity.	Decline in birdwatching, wildlife tourism, and nature-based tourism.
	Land Appropriation and Resource Reallocation	WEF installations often take place on public land, limiting access and altering land-use patterns.	Conversion of arable land into industrial energy zones, restricting local agricultural activities.
	Weak Contribution to Local Employment	Few permanent job opportunities are created, mainly for unskilled labor, failing to boost the local workforce.	Employment limited to temporary construction jobs and low-skill positions (e.g., guards, cleaners).
	Negative Effects on Rural Mobilities and Repopulation Efforts	The creation of industrialized landscapes discourages rural mobilities and efforts for rural residence, recreation or entrepreneurship.	Urban dwellers reconsider relocating to rural areas due to landscape transformation.
	Generic Barriers	Common challenges across various locations.	
	Market-Driven Development and Unequal Power Relations	The wind industry prioritizes profit over local socio-economic needs, leading to uneven regional development.	Energy supply decisions dictated by corporate interests rather than local needs.
	Absence of Consultation and Social Dialogue	Limited stakeholder engagement and top-down decision-making processes exclude local communities from planning.	Minimal participation of local actors in decision-making regarding WEF placements.
	Green grabbing	Green grabbing is the appropriation of land and resources in the name of	Privatization of public lands often leased at low cost to private investors

		environmental goals (climate change), often at the expense of local communities.	with minimal local employment creation, rising energy costs for small users and unjust development
	Commodification and Homogenization of Landscapes	WEFs turn landscapes into standardized industrial zones, diminishing their uniqueness and multifunctionality.	Loss of diverse rural land uses, turning landscapes into sites of energy production.
	Conflicts Between Renewable Energy and Alternative Land Uses	WEF expansion competes with existing land-use strategies, such as agriculture, cultural heritage conservation, and tourism.	Reduction in agricultural productivity, fragmentation of cultural landscapes.
	Long-Term Social and Economic Uncertainty	The long-term impacts of WEF projects on local socio-economic structures remain unclear, especially post-decommissioning.	Lack of planning for landscape restoration after turbine lifespan ends.

Additionally, rural Greece has recently witnessed the emergence of a cultural economy tied to post-crisis urban-to-rural mobilities. Motivated by economic hardship and changing lifestyle preferences, urban households are relocating to provincial areas, driving new forms of residence, recreation, and entrepreneurship (Gkartzios & Scott, 2015; Kasimis & Zografakis, 2014; Kasimis & Papadopoulos, 2013). However, the proliferation of large-scale wind parks poses a threat to this trend by diminishing the aesthetic and cultural qualities that attract new settlers and investment, thus impeding potential rural revitalization.

The promised employment benefits of wind energy projects often fall short. Energy companies typically offer limited local job opportunities, mostly low-skill positions (e.g., guards, maintenance workers), with few prospects for long-term or meaningful employment. Claims of substantial contributions to local labor markets are frequently overstated.

Overall, there is a noticeable lack of meaningful dialogue among market actors, state authorities, and local communities. Decision-making is often centralized and opaque, privileging industrial profitability over social and ecological sustainability. As Mitchell (2008) argues, landscapes are increasingly reconfigured to serve the imperatives of capitalist production and energy demand, with little regard for their socio-cultural or ecological roles. The introduction of oversized energy infrastructures—as new dominant symbols—risks undermining the integrity and identity of rural landscapes, with long-term consequences for local economies, governance, and quality of life.

The historical-archaeological-national dimension of the landscape

Landscapes are not solely defined by their contemporary functions; they are layered spaces—palimpsests—that carry the imprints of past civilizations, historical events, and cultural practices (Bender, 1993; Crang, 1998; Muir, 1999; Rackham & Moody, 2012). As such, they operate as living archives, offering insight into the temporal continuity of place and bearing witness to the evolution of human societies. Through their forms, structures, and embedded symbols, landscapes become mosaics of cultural heritage, revealing how social groups have inscribed their identities, memories, and values upon the land over time.

This historical depth imbues landscapes with symbolic and national significance. They serve as sites where collective memory, myth, and geography intersect, cultivating a shared sense of belonging (Mumcu *et al*., 2017; Soovali *et al*., 2003; Häyrynen, 1998; Schama, 1995). Landscapes thus play an essential role in the formation and negotiation of national identity, which is not static but continually redefined through shifting geographical, functional, and symbolic contexts (Terkenli, 2001). As Massey (1995:187) asserts, "if the past transforms the present, helping to construct it, then the present also constructs the past"—emphasizing the dynamic reciprocity between memory and contemporary meaning.

Indeed, as Meinig (1979:164) notes, "every mature nation has its symbolic landscapes [...] which constitute part of the collective series of ideas, memories, and emotions that bind people together". Terkenli (2010:45) further highlights the landscape's centrality to nation-building, underscoring that 'the landscape is one of the most significant components of the ideological basis for constructing nations'. Through state narratives, monuments, and protected sites, the landscape is often mobilized to support national imaginaries and reinforce territorial legitimacy.

Table 5: Site-Specific and Generic Barriers of Wind Energy Farms (WEFs) to the historical-archaeological-national dimension of the landscape

Landscape dimension	Barrier Type	Description	Examples
	Site-Specific Barriers	Context-dependent and unique challenges that vary by location, tied to specific landscapes or environmental conditions.	
Historical-archaeological-national dimension of the landscape	Impact on Archaeological Sites	Wind energy projects may disturb or damage unexplored or vulnerable archaeological sites through construction activities such as road openings and foundation excavations.	Destruction or alteration of ancient ruins, burial sites, or other heritage sites during WEF construction.
	Loss of Landscape as Palimpsest	The installation of WEFs may erase or disrupt the historical layering of a landscape, undermining its symbolic and historical value.	Destruction of historical layers that connect the present to past cultural and historical memories.
	Threat to National Identity and Cultural Symbolism	Landscapes embody national history and identity; the ideological foundation of nationhood is deeply rooted in the landscape itself; the introduction of industrial WEFs may alter these landscapes in a way that weakens or transforms the national connection people have to them.	Disruption of symbolic landscapes tied to national identity or historical events, such as monuments or battlefields.
	Reduction in Sense of Belonging	If people can no longer recognize their identity in their landscapes, it can lead to disconnection from heritage and culture.	Communities feeling alienated from landscapes that once reflected their historical or cultural narratives.
	Generic Barriers	Common challenges across various locations.	
	Destruction of Cultural Memory	Large-scale industrial installations may overshadow or obscure cultural	Widespread installations in areas of cultural or national importance,

		landscapes, erasing the connection between people and their historical environment.	reducing the visibility of cultural landmarks.
	Fragmentation of Historical Narratives	WEFs may fragment or distort the continuity of historical and archaeological stories embedded in the landscape.	Disturbance of landscapes that are integral to national myths, legends, or historical events.
	National Identity Conflict	Conflicting interests between preserving a national heritage and developing modern energy infrastructure may lead to ideological divisions.	Tension between the development of renewable energy projects and the preservation of national heritage, particularly in culturally significant areas.
	Lack of Recognition of Cultural Value	National and cultural heritage may not be sufficiently prioritized in planning decisions related to WEF installations.	Oversight of historical or cultural importance when selecting sites for wind farms.

However, this palimpsestic quality of the landscape is increasingly threatened by large-scale industrial interventions, particularly those associated with wind energy development. Infrastructure works—such as extensive road construction, excavation, and the installation of turbines—pose significant risks to unexplored or undocumented archaeological sites. These interventions may result in the irreversible damage or loss of historical layers, thus severing critical links to the past and disrupting the continuity of cultural memory embedded in the land.

When such transformations obscure or erase the traces through which people recognize themselves and their histories in the landscape, a rupture in identity can occur. Landscapes function as mirrors of collective cultural expression and societal choice (Meinig, 1979). If these mirrors no longer reflect the people who inhabit them, a sense of dislocation and alienation may emerge. In such cases, communities may be compelled to redefine their identities, not through inherited cultural landscapes, but through new geographies shaped by market imperatives.

These evolving dynamics underscore the power relations inherent in landscape production. The imposition of market-driven priorities—often at the expense of historical, cultural, and archaeological values—illustrates the growing dominance of capital in reshaping not only the physical but also the symbolic dimensions of the landscape (Mitchell, 1994; 2008). This raises critical concerns about the extent to which current development practices respect, preserve, and integrate the deep temporal and cultural layers that constitute landscape identity.

The experiential dimension of the landscape

The experience of landscape transcends visual perception, encompassing a broad array of sensory engagements—including touch, smell, taste, and sound—that contribute to a holistic understanding of place (Wylie, 2017; Bourassa, 1991). While efforts to preserve visual aesthetics and architectural heritage often dominate landscape protection agendas, there is growing recognition of the multisensory character of landscapes and the critical role of non-visual stimuli in shaping spatial experience and identity.

Sound, for instance, plays a pivotal role in defining the atmosphere and emotional resonance of a place. The widespread installation of industrial WEFs has been shown to significantly increase noise pollution, particularly through low-frequency sounds that may contribute to sleep disturbances and broader psychological impacts among nearby residents (Ellenbogen *et al*., 2024; Tabassum-Abbasi *et al*., 2014; Bakker *et al*., 2012). Similarly, landscapes possess distinctive olfactory signatures, or "olfactory maps," which include both pleasant and unpleasant odors—ranging from the aroma of blooming vegetation and local cuisine to smells from sewage systems, pig farms, or olive oil production facilities.

The tactile dimension of landscape emerges through physical interaction with material surfaces—such as the textures of cobblestones, marble slabs, rough pavements, or earthen paths—which evoke particular spatial and emotional responses. Likewise, a "taste map" reflects the culinary identity of a region, where local ingredients, traditional foodways, and preparation techniques connect gastronomy to landscape experience and regional heritage (Stefanou & Stefanou, 2005). These layered sensory experiences reinforce the embodied and affective dimensions of landscape, anchoring memory, identity, and belonging.

Noise pollution, especially from continuous turbine operation, can contribute to the degradation of both environmental and sensory quality, posing potential risks to physical and psychological health. These effects are particularly pronounced during the construction phases of wind energy projects, when noise levels escalate. Addressing this issue requires specialized acoustic assessments that measure not only the frequency and intensity of turbine noise but also its impacts on human well-being and landscape perception. Recent research also highlights how turbine-related sound affects wildlife habitats, particularly those of predator species, with scientists employing advanced computational methods to assess and mitigate ecological impacts (Nazir *et al*., 2020).

Moreover, the psychological dimensions of noise exposure—such as the "nocebo effect", where individuals report adverse health symptoms based on negative expectations rather than direct physical causes—must also be taken into account (Simos *et al*., 2019). These responses, classified under the broader category of idiopathic environmental intolerance, underscore the need for inclusive approaches that combine empirical evidence with a deeper understanding of community perceptions and lived experiences regarding wind turbine noise.

Large-scale wind energy developments also have the potential to disrupt outdoor recreation, and rural tourism, which are increasingly important to the socio-economic revitalization of rural areas. Rural tourism is an evolving concept shaped by time and place, yet grounded in enduring core values—like environmental protection—that align with UNWTO and UN SDGs (Rosalina, 2021). Agritourism has emerged as a "smart chance" for sustaining mountain rural environments by diversifying farm income, sustaining agrifood systems, valorizing the role of producers, preserving and renewing local traditions, and combating depopulation (Ciolac *et al*, 2020; Ivona & Privitera, 2022; Partalidou & De Matteis, 2024). Nature based tourism involves visits to relatively undisturbed natural areas, focusing on scenery, wildlife, and natural reserves, encompassing education, recreation (Lee, 2013) and adventure elements, and a series of nature based solutions (Padma *et al*., 2019).

Since the 1990s, rural areas have been reshaped by de-agriculturalization, socio-economic integration, and increased pluriactivity, forming a 'new rurality' (Kasimis & Papadopoulos, 2013). In recent years, the Greek countryside has witnessed a surge in outdoor and mountain activities, such as hiking, rock climbing, mountain biking, jeep safaris, and hunting, alongside traditional agricultural labor and rural practices (Belias, 2019; Karagianni *et al*., 2019). Simultaneously, there is increasing recognition of the ecological, economic, and cultural value of rural and agricultural landscapes. For instance, traditional practices like masticulture, raisin production, and olive cultivation are now seen as vital heritage landscapes (Gkoltsiou *et al*., 2021). These developments underscore a growing 'back to the land' / 'back to the countryside' movement that blends modern approaches with traditional practices (Kasimis & Papadopoulos, 2013; Figueiredo *et al*., 2020), while also aiming to enhance quality of life and promote place-based economies grounded in local culture, the environment, rural landscapes, and territorial assets (Pavlis, 2017; 2024).

Wind energy infrastructures, however, may obstruct access to these landscapes, fragment existing trail networks, and diminish the aesthetic and recreational value of natural areas. This can severely compromise rural development strategies focused on experiential tourism, cultural heritage valorization, and landscape-based innovation. As such, a comprehensive and participatory spatial planning framework is needed—one that integrates environmental, social, cultural, and economic considerations to ensure that renewable energy transitions do not undermine the experiential integrity and developmental potential of rural landscapes.

Table 6: Site-Specific and Generic Barriers of Wind Energy Farms (WEFs) to the experiential dimension of the landscape

Landscape dimension	Barrier Type	Description	Examples
	Site-Specific Barriers	Context-dependent and unique challenges that vary by location, tied to specific landscapes or environmental conditions.	
Experiential dimension of the landscape	Noise Pollution from Turbines	Continuous exposure to turbine noise during operation or construction stages can degrade the landscape's experiential quality, leading to health issues such as sleep disturbance, stress, and psychological burdens.	Turbine noise affecting nearby residents and wildlife, with heightened impacts during construction.
	Turbine Noise Impact on Predator Habitats	Noise pollution can disturb predator habitats, leading to disruptions in local ecosystems and wildlife behavior.	Decreased presence of local wildlife due to turbine noise affecting animal senses and habitats.
	Disruption of Hiking Trails and Recreational Spaces	The installation of WEFs can alter or block established hiking trails, reducing opportunities for outdoor activities like agrotourism and ecotourism.	Hiking trails disrupted by WEF installations in rural or mountainous areas, reducing accessibility for outdoor enthusiasts.
	Aesthetic and Sensory Degradation	The visual and auditory presence of large-scale WEFs may diminish the scenic and sensory experience of natural landscapes.	Obtrusive turbines affecting the tranquility of rural areas known for their natural beauty and recreational appeal.
	Health Concerns Due to Noise (Nocebo Effect)	Psychological impacts such as "nocebo effect" (health complaints due to perceived environmental intolerance) may be exacerbated by turbine noise, affecting local residents' quality of life.	Complaints about headaches, stress, and sleep disturbances from local residents living near turbine installations.
	Impact on Local Tourism Activities	Tourism activities that rely on natural, quiet, and aesthetically pleasing environments (e.g., hiking,	Decline in ecotourism and agrotourism activities due to the presence of turbines

		rock climbing, mountain biking) may be hindered by the presence of large-scale wind farms.	disrupting natural aesthetics and peace.
	Generic Barriers	Common challenges across various locations.	
	Cultural and Experiential Disconnect	Local communities may feel a disconnect from the landscape if its sensory experience is altered, affecting their sense of place and cultural ties to the environment.	Loss of sensory experiences such as smells, sounds, and tactile elements of the landscape due to industrialization.
	Negative Impact on Rural Recreation and Education	Educational and recreational activities that depend on the natural state of landscapes (e.g., research, environmental education, or nature-based recreational activities) may be negatively affected by the industrialization of landscapes.	Difficulty in developing or maintaining ecomuseums, cultural/educational trails, and nature-based recreational activities due to the presence of wind farms.

DISCUSSION

The integration of large-scale WEFs into the landscape is not merely a technical challenge— it is fundamentally a socio-cultural issue that requires alignment with the sense of place and societal values (di Cosmo, 2023). Landscapes are inherently social and cultural constructs, and their transformation through energy infrastructure raises profound questions about identity, equity, and sustainability. The development of such projects risks privatizing commons, reshaping rural territories, and jeopardizing both natural and cultural resources. A particularly noteworthy aspect, especially when considering that it was not accomplished even by the broader, large-scale processes of change (Van der Sluis, 2013).

This is not solely a matter of visual aesthetics or symbolic representation. Rather, it involves a set of complex, site-specific, and more generalized barriers (as detailed in Tables 1–6) that can significantly shape public acceptance. Social dimensions of renewable energy transitions—often underappreciated—may, in fact, be as critical as technical ones (Pasqualetti, 2011). Key factors such as attachment to landscape, preservation of cultural heritage, safeguarding of local livelihoods, and meaningful community engagement are central to how wind energy projects are perceived and received.

To date, public consultation processes regarding the installation of wind farms—and more broadly on issues of public interest—remain inadequate. Conducted primarily through the opengov.gr platform, participation is limited to a small segment of the population, as the majority of citizens are neither sufficiently informed about the existence of this mechanism nor encouraged to engage with it. Furthermore, the time frame during which consultations are open is often insufficient for stakeholders to become adequately informed and to develop considered positions. In terms of information accessibility, crucial project data is not always fully available, and there is a lack of public presentations that objectively outline both the potential benefits and adverse impacts of such developments. Information dissemination is frequently undertaken by self-organized and self-mobilized citizen groups, often in the absence of institutional involvement. Moreover, there is a lack of transparency concerning how consultation feedback submitted via opengov.gr is processed and the extent to which it informs decision-making or project implementation. These shortcomings raise significant concerns that merit the attention of the Council of Europe.

In the absence of inclusive dialogue and participatory planning, the imposition of large-scale WEFs risks reinforcing local resistance, escalating social tensions, and undermining the very goals of a just and sustainable energy transition. Opposition to these projects often reflects deeper connections to the land, encompassing a wide array of environmental, socio-economic, and cultural concerns. These include issues such as geological instability, erosion, soil degradation, changes to microclimates, biodiversity loss, habitat fragmentation, disruption of cultural heritage, visual impacts, and potential conflicts with rural economies reliant on tourism and agriculture. Moreover, broader themes of social justice and the long-term viability of energy infrastructure further fuel resistance.

Such reactions are not merely conservative responses to change. Instead, they speak to the role of landscapes as lived spaces, cultural repositories, and economic resources. Addressing these concerns calls for a more integrated and nuanced approach—one that considers not only the technical feasibility of wind energy but also the intricate socio-environmental dynamics that shape each landscape.

To this end, three distinct scenarios offer different pathways for wind energy development, each reflecting varying priorities in the balance between renewable energy goals and landscape values:

1. Maximum Installation (Scenario 1) – This scenario prioritizes maximizing energy output, often resulting in extensive landscape transformation. While effective in terms of energy production, it brings significant visual, ecological, and socio-economic consequences, potentially eroding local identity, deterring tourism, and affecting biodiversity.
2. Balanced Approach (Scenario 2) – A compromise model that aims to harmonize energy needs with landscape conservation. It emphasizes careful spatial planning, reduced turbine density, and smaller-scale installations. This approach tends to be more socially acceptable and supports mechanisms like property value monitoring and fair compensation.
3. Landscape-First Approach (Scenario 3) – This scenario gives precedence to the protection of landscape functions—natural, cultural, and economic. It involves a moratorium or rejection of new onshore WEFs, favoring alternatives such as offshore wind, solar energy, or decentralized microgrids. It reflects the values of communities that prioritize heritage, ecological health, and rural development over large-scale industrial interventions.

In regions with particularly sensitive or saturated landscapes, the second or third scenario is generally more appropriate. Natural resource exploitation must be rational and context-aware to avoid irreversible damage to assets crucial for local development—particularly in island regions. As Lothian (2008) argues, WEFs should ideally be located in areas of lower scenic quality, where their presence may have a neutral or even positive effect, while high-quality or iconic landscapes, especially coastal zones, should be avoided.

Ultimately, the siting of wind farms must follow integrated spatial planning principles and involve early and meaningful public consultation, in line with Directive 85/337/EEC and the Aarhus Convention. Clear guidelines for appropriate placement are outlined in Table 7, providing a framework to ensure that energy transitions do not come at the cost of landscape degradation or social alienation.

Table 7: Guidelines for the Suitable Placement of Wind Energy Farms (WEFs)

Category	Criteria
Suitable Areas for WEFs	
Non-sensitive landscapes	Areas of lower scenic quality (e.g. industrial zones) with less visual, ecological, cultural, social and economic impact.
Non-protected zones	Areas outside nature reserves, national parks, and UNESCO sites to avoid biodiversity conflicts.
Offshore locations	Offshore regions, where feasible, to minimize land-based environmental, socio-economic, cultural and visual impacts.
Minimize impact on population	Ensure distance from densely populated areas to reduce noise, visual, and social effects. Employ advanced mapping and planning techniques to identify optimal locations.
Unsuitable Areas for WEFs	
High-quality landscapes	Scenic and culturally significant landscapes (e.g., coastal areas, high mountains).
Protected nature & landscape areas	Nature reserves, cultural heritage sites, and biodiversity hotspots to prevent environmental harm.
Areas with strong local attachment	Regions where communities have deep cultural, social, or economic ties to the existing landscape.
Recommended Size of Installations	
Smaller-scale installations	Fewer turbines per site for better public acceptance and landscape compatibility.
Limited turbine height	Ideal height range of 20-40 meters to balance efficiency with visual, geological, morphological, ecological, etc, integration.
Site-specific design	Adapting installation size and layout based on landscape characteristics and socio-cultural impact.

In Greece, there is a pressing need to update spatial planning legislation, particularly the Special Spatial Planning Framework for RES and Sustainable Development. This revision must reflect the varying scales of wind turbines, taking into account their relationship with contemporary landscape concepts and aligning with the principles of the ELC (Greek Law 3827/2010, CoE, 2000). It should also introduce inclusive, qualitative criteria for integrating wind turbines into the landscape, in line with EU recommendations regarding wind farm placement, as outlined in the Council of Europe's 2011 report Landscape and Wind Turbines (CoE, 2011).

To improve integration, Environmental Impact Assessments (EIAs) must incorporate Landscape Character and Capacity Assessments, giving careful attention to the social dimensions of wind farm projects. These assessments should take into account local geography, historical context, and traditional land use practices. Furthermore, ensuring meaningful community compensation—both at the individual and collective levels—is essential. Involving social scientists, such as sociologists, geographers, and historians, in the evaluation process is also critical. Wind energy infrastructure should not be viewed solely as a technical necessity; rather, it must be understood as a landscape-defining feature that has the potential to reshape spatial identity (Colafranceschi *et al*., 2021).

Wind energy projects should critically consider the issue of electricity tariff reduction, given that wholesale electricity prices do not necessarily result in lower costs for end consumers (Maniatis & Milonas, 2022; Simoglou *et al*., 2014). Particular attention should be paid to the role of major energy corporations within the energy market and the energy exchange, including the impact of state subsidies and their capacity to capitalize on peak demand periods by selling electricity at elevated prices. To what extent can it be considered democratic, ethical, and sustainable for Greek citizens to be required to contribute substantial sums through the imposed Special Levy for the Reduction of Greenhouse Gas Emissions, particularly when these funds are allocated to the promotion of electricity generation from renewable energy sources via controversial fast-track projects that often exhibit significant structural and procedural deficiencies? These issues warrant further investigation by scholars specializing in energy policy, market regulation, and the political economy of energy transitions.

Simos *et al*. (2019) highlight the importance of local community participation in decision-making to foster public acceptance. Additionally, managing wind farms at the local level can help balance energy production with the well-being of the community, ensuring that operational practices are responsive to local needs. A qualitative, landscape-based approach is crucial for ensuring that the development of wind energy facilities aligns with both environmental and social goals, fostering a more inclusive and sustainable vision for the future. By shifting the focus from purely technical performance to a consideration of the landscape and cultural aspects of wind energy integration, we can craft a cohesive vision for the evolving landscape. As wind energy infrastructure increasingly becomes a permanent element of the landscape, it has the potential to redefine local culture and identity (Colafranceschi *et al*., 2021).

A series of proposed measures for improving the integration of wind energy facilities are outlined below (Table 8).

Table 8: Proposed Measures for Improved Wind Energy Farm (WEF) Implementation

Measure Category	Description	Examples
Environmental & Landscape Integration	Ensuring WEF installations align with local environmental and cultural contexts.	
Enhanced Environmental Impact Assessments (EIAs)	Integrating Landscape Character & Capacity Assessments in planning.	Evaluating visual, ecological, and cultural impacts before approval.
Design Considerations for Landscape Compatibility	Using colors, materials, and designs that blend with surroundings.	Earth-tone turbine colors, non-intrusive lighting, reduced turbine size.
Social & Community Engagement	Strengthening public participation and local acceptance of WEFs.	
Improved Bottom-Up Consultation Processes	Promoting participatory decision-making and stronger community engagement.	Public meetings, co-design workshops.
Integration of Local Geography & Culture	Considering local history, beliefs, and land use practices in planning.	Protecting sacred sites, adapting project layout to traditional land use.
Inclusion of Social & Humanities Experts	Engaging sociologists, geographers, and historians in project evaluation.	Interdisciplinary assessments in planning and communication.

Economic & Social Benefits	Enhancing community trust through economic and social incentives.	
Compensatory Benefits for Local Communities	Providing financial, social, cultural, environmental, experiential, quality-of-life, educational, and research-related incentives for affected population.	Community funds, lower electricity rates for locals, municipal revenues, cultural heritage preservation, ecosystem restoration, climate adaptation support, infrastructure development, support for tourism and recreation, local research collaborations.
Local Management & Adaptive Operations	Ensuring energy production aligns with community needs and sustainability.	Community-owned WEFs, shared profits with local stakeholders.
Sustainability & Long-Term Accountability	Ensuring responsible operation and decommissioning.	
Site Restoration After Decommissioning	Guaranteeing financial provisions for dismantling and rehabilitation.	Legal requirements for restoration plans before approval.
Long-Term Monitoring Programs	Assessing social, cultural, economic, and environmental impacts.	Periodic assessments, adaptive management strategies.

Interestingly, Kati *et al*. (2021) suggests a novel spatial planning approach that prioritizes wind farm investments in fragmented areas outside Natura 2000, balancing climate and biodiversity goals, while proposing a sustainable wind energy strategy that minimizes biodiversity impacts by focusing on areas with low conservation value and limited land use conflicts.

This study underscores the potential of combining environmentally friendly energy sources—such as geothermal, solar, hydroelectric, and biomass energy—to enhance energy production both in Greece and globally. Additionally, offshore wind farms, when developed under specific conditions that respect the marine ecosystems (Bailey *et al*., 2014; Alawady *et al*., 2024), considering the recently enacted Maritime Spatial Planning, are becoming an increasingly viable solution in terms of cost-effectiveness and efficiency. Innovations in renewable energy, including wave and tidal energy, underwater current installations, floating solar photovoltaics and wind turbines, vertical-axis wind turbines, and various hybrid energy systems, are contributing to the diversification of energy options, some of which are detailed below (Table 9).

Table 9: Innovative renewable energy options

RES alternative option	Description	Source
Floating Solar Photovoltaics (FPV)	Solar panels installed on water bodies (reservoirs, lakes, canals), reducing land use conflicts and minimizing evaporation.	Cazzaniga *et al*. 2018
Vertical-Axis Wind Turbines (VAWTs)	Smaller, quieter wind turbines with the main components at the base with lower noise that blend into urban and rural landscapes with lower visual impact and better integration into existing structures	Kouloumpis *et al*, 2020
Distributed Solar Microgrids	Decentralized solar energy systems for the generation of electricity from various small-scale sources of energy, reducing dependency on large-scale power plants.	Belrzaeg *et al.*, 2023
Solar Canopies and Integrated PV in Infrastructure	Solar panels integrated into buildings, roads, and parking lots, reducing the need for additional land use.	Markwith, 2025; Benöhra & Gebremedhin 2021
Small Wind and Hybrid Energy Systems	Hybrid renewable energy systems combining low-profile wind turbines, solar panels, and battery storage offer improved generation profiles and cost-effectiveness compared to standalone systems and are suitable for remote and sensitive landscapes.	Venkataraman *et al.*, 2018; Aberilla *et al.*, 2020
Offshore and Floating Wind Turbines	Wind turbines placed at sea or on floating platforms, reducing onshore landscape impact and harnessing stronger winds	Barooni *et al.*, 2022
Green Hydrogen Production Coupled with RES	Using surplus renewable energy (wind, solar) to produce hydrogen as a clean fuel, minimizing direct land impact.	Kakoulaki *et al*., 2020; Herdem *et al*., 2024
Bioenergy from Sustainable Agroforestry and Algae	Biomass energy derived from non-invasive sources such as algae or sustainably managed forests, integrating agriculture and forestry, providing multiple benefits including biofuel production, soil and water protection, and greenhouse gas mitigation.	Thevathasan *et al.*, 2014
Wave and Tidal Energy	Harnessing ocean currents, tides, and waves for renewable power with minimal land use and ecological impact. Wave power installations are quiet, visually unobtrusive, and support marine habitats, making them a promising sustainable energy source as technology advances and costs decrease.	Khan *et al*., 2018
Underwater Current Installations	Deploying turbines in strong underwater currents to generate electricity without disturbing the surface landscape.	Bane *et al*., 2017
Agrivoltaics (Agro-Solar Systems)	Integrating solar panels above vineyards and crop fields, optimizing energy production while protecting crops from extreme weather.	Macknick *et al*., 2019
Innovative geothermal cogeneration system	Utilization of low-temperature geothermal energy for heat, electricity, and cooling, while integrating photovoltaic and hydropower plants for greater energy independence. The project demonstrates a sustainable, multi-RES approach that enhances efficiency and reduces emissions, offering a model for similar global applications.	Zachora-Buławska, *et al*., 2022

The rapid evolution of technology, particularly in the area of energy storage, allows for the adaptation of these solutions to smaller scales. Subsidies for residential wind turbines and photovoltaic systems can also provide immediate and sustainable solutions. Simultaneously, energy-saving policies must be actively promoted to achieve the desired reduction in CO_2 emissions. It is crucial that all forms of energy exploitation are carried out with respect for the landscapes and ecosystems they impact, providing adequate reciprocal benefits for local communities and ensuring sustainability beyond mere economic considerations. By integrating a range of non-economic compensatory benefits, wind energy projects can contribute positively to both people and place, rather than serving solely corporate or national energy agendas. The landscape is a collective resource and common good, belonging to all over time (CoE, 2000).

In this context, comprehensive education and awareness-raising initiatives among local populations, authorities, and relevant services are essential for promoting an understanding of the landscape's concept, role, and value as a shared resource. This approach is vital for fostering sustainable and territorially balanced development.

CONCLUSIONS

The integration of large-scale wind energy farms (WEFs) into landscapes requires a careful balance of technical and socio-cultural considerations, with particular emphasis on local identity, values, and perceptions. Public resistance to WEFs often arises from concerns about their environmental, economic, and cultural impacts, highlighting the need for more balanced and inclusive planning. This study concludes that WEF installations should prioritize landscape preservation, actively involve local communities in decision-making processes, and include comprehensive Environmental Impact Assessments (EIAs) that address both aesthetic and socio-cultural dimensions.

Future wind turbine designs should aim for smaller-scale, well-integrated projects, supported by rapidly evolving technologies, including energy storage solutions adaptable to smaller scales. Affected communities should also be provided with compensatory benefits that extend beyond economic considerations. Furthermore, the exploration of alternative renewable energy sources should be prioritized, focusing on sustainability and respect for local landscapes. Lastly, public education on the value of landscapes as shared resources is critical to fostering long-term social acceptance and promoting sustainable development.

CONFLICT OF INTEREST

The author state that they have no conflicts of interest.

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