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Integrated GIS and VGI approach to regional development, heritage landscapes, and nature-based tourism in the North West Highlands UNESCO Global Geopark

Final Master Project

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Abstract

This thesis investigates how visitor movement, trail networks, and heritage landscapes are spatially organised within the North West Highlands UNESCO Global Geopark (NWHG), and how interpretation and visitor planning rooted in landscape conservation can support revitalisation. By using a mixed-methods approach that combines a review of regional planning documents, a Geographic Information System (GIS)-based multi-criteria landscape suitability analysis, and Volunteered Geographic Information (VGI), this study produces a spatially explicit understanding of visitor flows and heritage landscapes in the NWHG.

The analysis reveals a highly uneven geography of use: the top 20% of Kernel Density Estimation (KDE) hotspots occupy only 0.8% of the Geopark yet capture most recorded movement, with 55.8% of all track points and 67.2% of hotspots located within 1 km of roads. Nearly 48.4% of high-intensity hotspots fall inside protected areas, while heritage-rich landscapes remain under-visited. These patterns highlight both ecological pressure and significant opportunities for interpretation-led revitalisation. The GIS suitability model identifies 527.6 km² (24.8%) of the Geopark as suitable for landscape-based revitalisation, with 23.9% of these areas overlapping with the 30×30 protected-area network.

Furthermore, the research conceptualizes NWHG as a contested governance space. By examining the structural tensions between hierarchical regulators and bottom-up peer community networks, the thesis identifies an important governance gap and argues that tools such as VGI can function as vital governance technologies. Similarly to visitor data, by translating community knowledge into spatial evidence, these tools can bridge the gap between horizontal local networks and vertical statutory planning, empowering peripheral communities to negotiate for equitable, place-based territorial management.

Building on these findings, the thesis proposes three regional recommendations: using spatial evidence to strengthen community-led planning of geotourism, institutionalising GIS and VGI as decision-support tools, and expanding participatory VGI approaches across residents and community groups. These recommendations align with strategic frameworks such as NW2045 and HIREP, which call for stronger spatial planning, community capacity building, and evidence-based visitor management.

The study demonstrates that VGI can be a low-cost planning tool well suited to remote regions with limited institutional capacity, and that GIS can provide a transparent and transferable framework for identifying revitalisation opportunity zones. The approach is applicable to other UNESCO Geoparks and Biospheres, and protected landscapes where visitor management, heritage assets, and community needs intersect. Future research should integrate stronger ecological components, nature-based solutions, and design of interpretation sites, to support long-term revitalisation in the context of demographic change and evolving relationships between people, landscape, and identity.

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1. Introduction

The North West Highlands is confronting a period of 'existential crisis' as the region now has fewer people per square kilometre than Lapland, 3,225 residents spread across 2,000 km² (Campsie, 2025). Locked in a vicious cycle where residents are pushed away by the loss of services, jobs, and housing, it is increasingly more difficult for others to relocate or remain (Peach, 2025). With school rolls collapsing by 30-90%, essential services such as health provisions and childcare closing, the volume of second and empty homes along the North Coast 500 corridor contributes to rising house prices, further constraining the ability of people to remain in the area (Campsie, 2025). Yet this decline is unfolding alongside rapid growth in visitor numbers to the region, with 216,900 visitors in 2019 generating £55 million in economic impact and day-visitor numbers rising steadily since 2010 (Global Tourism Solutions, 2019).

This striking contradiction of a region growing emptier, even as its roads, trails, and viewpoints become increasingly crowded, raises questions about what future remains for the region, people who live there and landscape and heritage that requires management and protection. This tension is what drives the present study: a search for ways that the Geopark framework, with its emphasis on heritage, education, and community benefit, might help transform visitor flows and landscape interpretation into tools that support local resilience and meaningful revitalisation.

1.1. Research objectives and questions

The main aim is therefore to understand the spatial organisation of visitor activity and to explore how better landscape interpretation and tourism planning can support rural revitalisation in one of Europe's most remote and depopulating regions. By analysing volunteered GPS tracks alongside geoheritage, natural and historic sites of interest, and infrastructure datasets, the study identifies where visitors concentrate, where opportunities for improved spatial planning exist, and how communities might use it for more coherent tourism development.

Tourism in the thesis is treated mainly as an economic activity. However, it is also approached as a spatial and environmental phenomenon. It intersects with geography through land-use patterns and landscape evolution; with economic history through regional development and historical market dynamics; and with business perspective on local entrepreneurship in attempting to identify and design meaningful visitor experiences. This multidisciplinary perspective allows the thesis to address broader questions about rural transformation, heritage conservation, and sustainable development.

The research is guided by three key questions:

1. **How are visitor flows, trail networks, and heritage sites spatially organised within the NWHG?**
2. **How can visitor and heritage interpretation planning help identify new opportunities for rural revitalisation in sparsely populated, protected landscapes?**
3. **How effective and transferable GIS and VGI approaches can be in supporting communities and Geopark management to plan, manage, and sustain heritage interpretation and tourism?**

To answer these questions, the thesis uses a mixed-methods approach. Qualitative analysis of planning documents and regional strategies is combined with quantitative GIS analysis of spatial datasets. Central to this study is the application of a GIS-based multi-criteria decision-making framework, which synthesises diverse spatial datasets, including volunteered geographic information (VGI) from GPS-enabled visitors. This combination provides a comprehensive understanding of how tourism interacts with the physical landscape and with the socio-economic conditions of a peripheral rural region. The case study situates these questions within the real territorial context of the North West Highlands, drawing on its economic geography, demographic trends, land-use history, and governance structures, as well as the role of the UNESCO Geopark designation.

Ultimately, this thesis argues that nature-based tourism can support rural revitalisation and conservation, but only when embedded in coherent planning framework. The spatial analysis demonstrates that visitor activity is highly uneven, concentrated in a small proportion of the territory, and often disconnected from the wider distribution of heritage and geoheritage assets. This disparity reveals both risks and opportunities: unmanaged hotspots intensify pressure on fragile landscapes, while heritage-rich but under-visited areas remain overlooked. When interpreted through regional planning goals, these findings can provide a practical decision-support tool for contributing to wider revitalisation goals and enhance landscape stewardship, but only if visitor flows, interpretation strategies, and community-led initiatives are aligned with the spatial realities of the region.

1.2. The relevance of the research topic and approach

In the last few decades, rural regions across Europe have undergone exceptional demographic, economic, and environmental transformations, resulting in depopulation, land abandonment, and declining service provision (Lane & Kastenholz, 2015; Loras-Gimeno et al., 2025; Ballesteros et al., 2021). These changes, taking place in regions historically defined by agricultural practices, local knowledge systems, and long-standing human-nature interactions, weakened local economies and threatened the continuity of cultural landscapes. At the same time, current conservation initiatives, such as UNESCO Geoparks and Biospheres, are expanding in scope and ambition, placing new forms of environmental protection and landscape management at the centre of regional planning. The convergence of these trends continues to raise a critical question in today's territorial development: can tourism act as a

meaningful interface between visitors, communities and conservation in achieving revitalization objectives?

This question is particularly relevant in protected rural landscapes, where natural and cultural heritage represent some of the few remaining competitive advantages in regions facing structural decline. Nature-based tourism, ecotourism, and community-based tourism are increasingly promoted as tools capable of generating income, mobilising local assets, strengthening local identity, and supporting conservation (Lane & Kastenholz, 2015; Alcalá, 2018; Rodrigues et al., 2021). Yet the relationship between tourism, development, and environmental protection appears to be very complex, and evaluating benefits remains difficult. Protected areas must balance ecological integrity with recreational access, while rural communities must navigate the opportunities and constraints created by conservation regulations and external economic processes (Ballesteros et al., 2021; White et al., 2024). Understanding how tourism planning can mediate these tensions, while contributing to sustainable development and community resilience, is therefore a central challenge for planners, managers, and policymakers.

Within regional development, rural revitalisation has emerged as a response to 'unassailable urbanisation, ageing populations, and the decline of traditional rural industries,' (Cheer, 2025), meaning that it is fundamentally about addressing structural vulnerabilities and mobilising of the 'countryside capital', the combined social, environmental, and economic assets that underpin rural life (Cheer, 2025). This is particularly challenging in remote and peripheral regions, where structural disadvantages compound the pressures of tourism growth. Unlike rural areas located near urban centres, peripheral territories such as the North West Highlands face chronic issues of geographic isolation, sparse populations, limited public services, and fragile infrastructure networks (Cheer, 2025; Loras-Gimeno et al., 2025). These constraints reduce the capacity of communities to absorb visitor pressure, adapt to seasonal fluctuations, or capitalise on tourism-driven opportunities. At the same time, such regions often possess exceptional natural and cultural assets of dramatic landscapes, distinctive heritage, and a strong sense of place. That in turn makes them highly unique and attractive to visitors and intensify demand for nature-based and experiential tourism (Lane & Kastenholz, 2015).

This paradox means that peripheral destinations experience both heightened tourism appeal and heightened vulnerability: as they attract large numbers of visitors, they lack the institutional, infrastructural, and economic resilience needed to manage them effectively. As a result, fixing development legacies in the peripheral context requires revitalisation strategies that navigate a more complex terrain, balancing the opportunities created by tourism with the structural limitations inherent to remote rural geographies.

Figure 1. Geopark regional context within Scotland

1.3. The case study

A UNESCO Global Geopark is a unified area that contains internationally significant geological features and is managed in a way that integrates protection, education, and sustainable development while using its geological heritage to benefit local communities through initiatives such as geotourism (UNESCO, 2026). This makes them ideal spaces for testing new approaches to rural revitalization and sustainable tourism. UNESCO frameworks also emphasize the importance of bio-cultural heritage, understood as the intertwined ecological and cultural values embedded in landscapes shaped by centuries of human activity. These values are increasingly recognized as key assets for tourism, shaping visitor experiences, trail design, and the interpretation of landscapes (Ballesteros et al., 2021). However, many UNESCO sites struggle to translate these principles into coherent planning frameworks, effective visitor infrastructure, or tangible socio-economic benefits for local communities.

Located in the far north-west of mainland Scotland, the NWHG covers roughly 2,000 square kilometres and, with just over 2,000 residents, is among the most sparsely populated regions in Europe. The area is geologically remarkable, containing the UK's oldest rocks, the Lewisian Gneiss, which is more than three billion years old, and supporting dramatic sandstone mountains alongside fertile limestone landscapes (UNESCO UK, 2025). The Geopark's own story highlights how its complex geology, world-class scenery, and long history of scientific discovery have created a strong sense of place and a globally significant natural heritage (North

West Highlands Geopark, 2025a). It is also a community-run Scottish charity, working to conserve geological heritage, support sustainable rural development, and promote learning.

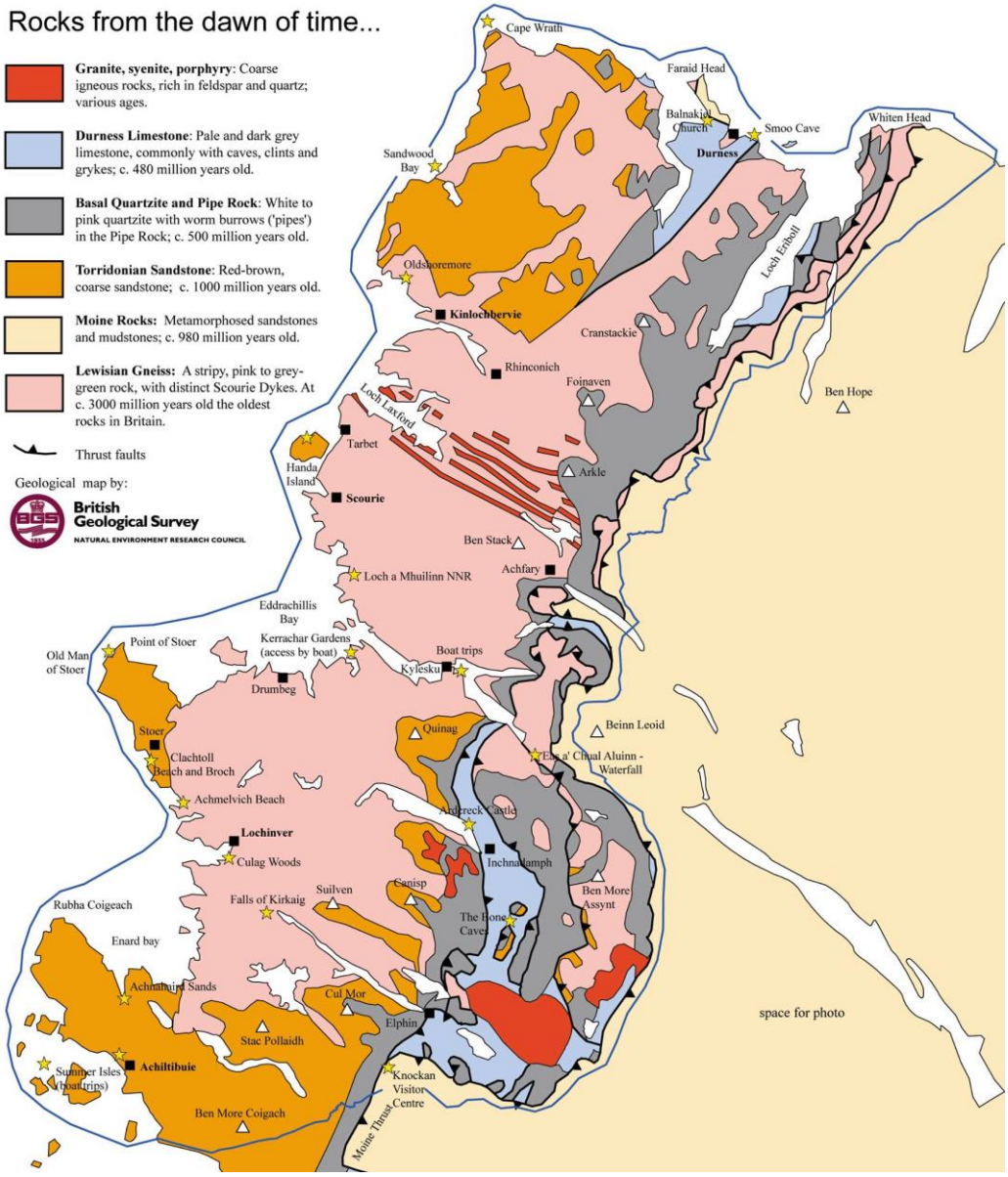

Figure 2. Rocks from the dawn of time. Source: British Geological Survey (2026)

Tourism in the region expanded steadily throughout the second half of the 20th century, driven largely by outdoor recreation and sport tourism. However, in recent decades, initiatives like the North Coast 500 have accelerated this growth, attracting a broader and more diverse range of visitors. As a result, tourism has become a vital economic sector, one that continues to shape local livelihoods while also introducing new pressures and challenges for communities (Ruck, 2020; White et al., 2024). The Geopark's own commissioned research identified significant visitor-management challenges, including parking shortages, litter, path deterioration, and the

absence of coordinated planning structures, particularly around high-pressure sites such as Smoo Cave that receives over 70,000 visitors annually (Groundwork for Slow Tourism, 2021).

Despite its importance, the sector's strong seasonality creates economic vulnerability and limits opportunities for diversification (White et al., 2024). Infrastructure has struggled to keep pace with rising visitor numbers: roads, parking facilities, public toilets, and waste management systems are frequently overstretched during peak seasons (Ruck, 2020). These pressures are intensified by the region's sparse population and extensive geography, which places disproportionate demands on the Highland Council relative to its limited tax base (Ruck, 2020).

Importantly, the ability to distil complex geographies, histories, and cultural meanings into well-managed heritage landmarks and visitor experiences, can strengthen collective rights over distinctive local assets (Anton Clavé, 2010). Managing such processes can help communities maintain organisational control over tourism development to ensure that growth aligns with local priorities and values. The research will attempt to meaningfully contribute to these efforts toward sustainable economic revitalisation that increasingly emphasise the promotion of local heritage through education and tourism, and to the ongoing evaluation of regional heritage and landscape: assets that are central to the identity and appeal of many destinations.

Despite growing seasonal overtourism in the region on the one hand and increasing recognition of geotourism as a tool for sustainable rural revitalisation on the other, little is known about how visitors actually move through NWHG landscapes. In a territory characterised by few official trails and a largely wild outdoor environment, the functioning of trail systems as spatial networks and the ways in which geosites interact with accessibility, infrastructure, and settlement patterns, remains poorly understood.

Rural destinations are still largely overlooked in spatial flow studies (Paulino et al., 2020) and this knowledge gap is particularly significant as the NWHG prepares for new investments, such as the planned visitor centre in Scourie (The Groundwork for Slow Tourism, 2021). The same report highlights substantial and growing visitor pressures across the geopark, yet notes the absence of any coordinated visitor-management mechanism and the lack of spatial data on how visitors move through the landscape. This thesis attempts to address this gap by analysing volunteered GPS data tracks.

In the context of a UNESCO Global Geopark, rural revitalisation can be best understood as a process that strengthens the social, economic, and cultural resilience of remote rural communities by mobilising their geological, natural, and cultural heritage in sustainable and locally meaningful ways. Because geoparks operate through a governance framework that integrates conservation, education, and sustainable development, revitalisation is inseparable from protecting the landscape and reinforcing local identity. A step further from economic recovery, it involves renewing place-based value systems, supporting community agency, and building long-term territorial resilience.

1.4. Methodology

The methodological design integrates a qualitative review of regional planning and governance documents with a quantitative GIS-based analysis that follows established practices in VGI-based visitor monitoring, where GPS tracks are analysed to identify spatial patterns of public use (Jurado Rota et al., 2019), and it also provides a framework for analysing visitor flows, mapping attractions, and supporting data-based planning (Wei, 2012; Yang et al., 2023; Costa et al., 2024). The thesis will pay particular attention to visitor management (mobility and networks), the spatial distribution of attractions and assets (clusters and connectivity), and the strategic planning of experiences and interpretation facilities (opportunities and landscape suitability). The research maps the 64 key geosites identified in the Geodiversity Audit and Action Plan 2013-2016 (NWHG, 2025b) and overlay them with approximately 700 user-generated hiking tracks sourced from Wikiloc. User-generated GPS tracks offer fine-grained insights into visitor behaviour and can complement official datasets (Parker et al., 2013; Flanagin & Metzger, 2008; Elwood, 2008). That data is supplemented with a layer of historic and maritime heritage. A third spatial component, 6 key villages and transport network, will provide essential contextual information for analysing location, distance, and accessibility. Exploring these dimensions of physical planning is especially important in a region characterised by a unique spatial configuration, geographic remoteness, and historically shaped peripherality, where settlement patterns, facility distribution, and infrastructure shortages significantly influence tourism development.

These datasets are integrated into a multi-stage GIS analytical framework that includes:

Table 1. GIS Analytical Framework

Component	***Description***
Kernel Density Estimation	*Identifies high-intensity visitor zones based on clustering of VGI track points.*
Network & Accessibility Analysis	*Measures village-track connectivity and dependence on road infrastructure.*
Terrain Modelling (30-m DEM)	*Excludes unsuitable slopes (>30°) to ensure realistic, walkable terrain.*
Multi-Criteria Suitability Model	*Combines heritage, visitor flows, terrain, and access to map revitalisation potential.*
Village-Buffer Framework	*Applies the suitability model within 10 km influence zones around each settlement.*

1.5. Thesis structure

The introduction of the thesis outlines the research problem, objectives, and relevance. The literature review synthesizes existing research on regional development and rural revitalization, conservation in the context of UNESCO framework, as well as nature-based tourism. Additionally, it introduces and summarizes the role of GIS in tourism planning. The case study

chapter presents the territorial context and governance framework. The methodology chapter explains the mixed-methods approach and the rationale behind the chosen analytical tools, particularly GIS based analysis. The primary output is a complete GIS project package, including harmonised spatial datasets, geosite layers, heritage records, village buffers, KDE hotspot surfaces, and the processed VGI track dataset.

The results and discussion chapter analyses existing plans and policies and their objectives, as well as spatial patterns and tourism-conservation interactions. The dataset provides a replicable foundation for future research on visitor flows, geotourism, and rural revitalisation in protected landscapes. For site management, it offers a practical decision-support tool: managers, planners, and community organisations can use the spatial layers to identify pressure points, plan interpretation facilities, design trails, and evaluate the alignment between visitor behaviour, heritage assets, and conservation priorities.

Finally, the recommendations and conclusions summarize the findings, propose improvements, and reflect on the broader implications for regional development in protected rural landscapes.

2. Literature review

2.1. Regional development and tourism

2.1.1 Theoretical approaches to rural revitalisation

Rural revitalisation has emerged as a central theme in regional development research, especially in territories experiencing long-term demographic decline, economic restructuring, and land abandonment. It highlights the need to diversify rural economies, often through tourism value chains, to reverse negative trends by mobilising local assets and strengthening governance structures (Lane and Kastenholz, 2015; Loras-Gimeno et al., 2025; Ballesteros et al., 2021)

Lane and Kastenholz (2015) argue that rural tourism in developed countries mirrors the trajectory of Butler's Tourism Area Life Cycle (TALC). Butler (1980) conceptualises tourism development as a progression from exploration and involvement to consolidation, stagnation, and potential decline or rejuvenation. Lane and Kastenholz (2015) show how rural tourism has evolved from early, small-scale, community-led initiatives in the 1970s and 1980s into a more complex, diversified, and competitive sector. This "second phase" of rural tourism development is characterised by a shift from simple sightseeing to experiential, activity-based, and heritage-oriented products. Yet, as TALC predicts, this expansion has also introduced challenges: increased competition, uneven governance structures, infrastructural pressures, and the risk of product standardisation.

Loras-Gimeno et al. (2025) addresses the problem with a comprehensive synthesis of policy approaches to rural depopulation. Reviewing 66 peer-reviewed papers, primarily from developed countries (especially Europe and Spain), they highlight that successful revitalisation

requires a holistic mix of social, fiscal, sectorial, and infrastructure policies. Tourism emerges as a significant driver of regional development when local resources and community involvement are leveraged to create sustainable alternatives to traditional land uses. Their review also emphasises the importance of clustering services and leveraging technological and infrastructural investments to enhance accessibility and economic resilience.

A central question concerns how peripheral rural regions can adapt to structural changes, wider economic and social change, such as negative population dynamics and economic decline, while maintaining their own social and ecological resilience. The importance of diversifying rural economies and mobilising territorial assets, particularly natural and cultural heritage to support sustainable development has been proposed as a valid strategy, with tourism widely recognised as a sector capable of generating employment, stimulating small business development, and reinforcing local identity, especially when embedded in broader territorial strategies (Lane and Kastenholz, 2015).

The concept of rural resilience has therefore gained prominence as a framework for understanding how communities respond to demographic and economic pressures. Resilience research highlights adaptive capacity, institutional flexibility, and the ability to reorganise economic activities in response to shocks. In sparsely populated regions, it is closely tied to accessibility, service provision, and the maintenance of social networks (Ibanescu et al., 2023). These factors shape the ability of rural communities to withstand external pressures and to reorganise in ways that support long-term sustainability.

2.1.2 Geoheritage tourism and territorial strategies for revitalisation

A substantial body of case-based research demonstrates how geoheritage and tourism can be strategically integrated to support rural revitalisation. These studies highlight the potential of geotourism to stimulate local economies, strengthen regional identity, and promote sustainable land use practices.

While geoparks are often located in rural areas, the relationship between “rural” and “geoheritage” should not be conflated. Rurality refers to a specific geographical condition shaped by sparse settlement patterns, limited services, distinctive landscapes, and historically embedded productive vocations such as small-scale agriculture or fishing. Geoparks, by contrast, are designated primarily for their geological significance and their capacity to integrate conservation, education, and sustainable development. Many geoparks are situated in rural regions such as the North West Highlands, where challenges are acute and the geopark framework can support revitalisation only when geoheritage is mobilised in ways that reinforce local identity, stimulate community-led entrepreneurship, and connect geological assets to the lived realities of rural people. However, as Cheer (2025) emphasises, revitalisation momentum “does not occur in the absence of investment capital,” and externally driven tourism growth can diminish the local agency.

Alcala (2018) presents Dinópolis in Teruel, Spain, as a model where scientific heritage and tourism are effectively integrated to counteract rural depopulation. The project leverages the region’s rich geological and palaeontological assets through a network of museums,

interpretation centres, and leisure attractions. This approach has boosted the local economy, enhanced quality of life, and attracted nearly 3 million visitors since 2001. Dinópolis case study demonstrates how geotourism can be strategically planned to drive regional revitalisation, linking heritage conservation with sustainable economic growth.

A distinctive feature of the Teruel model is its spatial strategy. The project disperses visitors across multiple satellite centres and thematic trails, each highlighting local fossil sites or geological features. This networked approach reduces pressure on individual sites while encouraging extended stays and broader economic benefits for rural communities. Interpretation centres and signposted geological routes manage visitor flows, ensure site preservation, and enhance educational outcomes. Spatially, the model is notable for its territorial distribution: satellite facilities located in small villages across the province, covering almost the entire area when mapped with a 35 km radius around each site. This strategy promotes economic cohesion and revitalisation not only in the main city of Teruel but also in remote, sparsely populated communities (Alcala, 2018)

Similarly, Ballesteros et al. (2021) examine the Palaeozoic Villages Route (PVR) in the Courel Mountains UNESCO Global Geopark as an integrated strategy for rural revitalisation, sustainable regional planning, and tourism development. The PVR links geoheritage with traditional stone architecture to create a compelling tourism product that attracts visitors and mitigates rural depopulation. Village selection criteria include geological representativeness, architectural preservation, scenic beauty, and available services.

Tourism is shown to drive rural sustainability by increasing visitor numbers, generating revenue for local businesses, and raising awareness of conservation and heritage values, but importantly, especially in remote and peripheral regions, it may flourish while rural decline continues. Targeted improvements generated by tourism, such as increased visitor spending, new jobs and enhanced visibility might not aid deeper transformations beyond the sector, such as demographic stability and strong local governance. Nevertheless, evidence from rural Scotland and Ireland shows that community enterprises can use tourism to manage visitor flows and reduce pressure on fragile rural systems. Price et al. (2025) highlight how regenerative initiatives encourage visitors to ‘dwell,’ and engage slowly with landscapes, and participate in community-led activities, a model particularly relevant for remote regions like the NWHG where unmanaged flows create seasonal strain.

Visitor management strategies, such as distributing flows across multiple villages, combining cultural, geotouristic, and outdoor activities, and addressing practical issues like parking, minimise negative impacts and support coexistence with residents. GIS is used in village selection and includes spatial mapping of tourism resources, services, and geological features. This underscores the value of spatial analysis in heritage tourism planning and offers parallels for managing visitor flows in other UNESCO Geoparks.

Rodrigues et al. (2021) explore how the development and promotion of “geoproducts” within UNESCO Global Geoparks serve as innovative tools for regional revitalisation and sustainable tourism. Geotourism products combine geological features with tourism services, including geosites, trails, museums, visitor centres, and supporting tools such as maps or guidebooks. By

certifying and branding local products, geoparks stimulate small business development and generate employment and supplementary income for rural populations. They are rooted in the rural in how they draw on local assets, shaped by rural social structures, economies, and landscape character, effectively translating these qualities into meaningful, interpretable experiences.

Thematic routes and geo-branded facilities structure visitor movement, support conservation, and maximise educational and economic impacts across diverse locations. Examples from Naturtejo (Rodrigues et al. 2021) illustrate how branded trails, interpretive facilities, and collaborations with local businesses enhance visitor experiences while safeguarding sensitive sites.

2.1.3 The context of economic history and geography of the Scottish Highlands

These conceptual and research grounded contributions to rural revitalization must be understood and situated within the Scottish Highlands's long and complex economic history. The Highlands have been shaped by centuries of policy intervention, market volatility, demographic restructuring, and institutional fragility. These processes produced a distinctive form of regional peripherality that continues to influence land use, settlement patterns, and development trajectories today.

Historically, fishing and sheep industry demonstrates how, from the seventeenth century onward, the Highlands were repeatedly targeted by state-led economic interventions designed not primarily to foster endogenous development but to integrate the region into wider national and British systems. Fisheries policy, harbour construction, and export incentives were framed as tools of modernization and social stabilization, yet they often reinforced dependency on external capital, markets, and institutions. In many instances, the rhetoric of "improvement," masked exploiting natural and human resources for imperial competition (Harris, 2000; Gambles, 2000).

In that sense, the region has been continuously targeted by development plans benefiting the core metropolitan centres that reorganized peripheral regions to serve external economic and political priorities (Pomeranz, 2021). In the Highlands, this dynamic was intensified by the Highland Clearances, which displaced populations from inland glens to marginal coastal settlements. This demographic restructuring inadvertently created the labour base for the expanding herring industry, but it also entrenched a spatial pattern of fragmented settlements, weak local institutions, and limited capital accumulation.

The evolution of the Highland landscape reflects those cumulative effects of centuries of economic restructuring. The Clearances and subsequent agricultural reforms concentrated land ownership in large estates, promoted sheep farming, and displaced communities to coastal crofting settlements. Over time, this produced a sparsely populated region with dispersed settlements, limited infrastructure, and constrained economic diversity. This demographic contraction reshaped both the physical and social landscape: abandoned crofts, underutilized land, and shrinking service provision became defining features of many rural areas. Perchard and Mackenzie (2013) describe how narratives of wilderness and remoteness emerged from

this process, reinforcing external perceptions of the Highlands as a “peopleless” landscape and contributing to its romantic image among visitors.

These historical legacies and structural vulnerability formed the backdrop against which contemporary rural revitalization efforts and tourism development must be understood. Importantly, they provide valuable sources of knowledge in how local heritage can be interpreted and management.

In that sense, these patterns have direct implications for contemporary tourism. As Lennon and Harris (2020) note, the Highlands’ sparse population and limited infrastructure create both opportunities (scenic landscapes, perceived remoteness) and vulnerabilities (infrastructure strain, seasonal dependence). White et al. (2024) further highlight how demographic decline shapes community identity and perceptions of tourism, influencing the social sustainability of development initiatives.

The landscape that tourism now seeks to mobilize, as well as scenic routes and attractions, are in that context the product of long-term historical processes that must be acknowledged in planning and keep as aware of how externally implemented plans for the region often fell short of delivering long-lasting and resilient socio-economic conditions. Connecting these specific conditions of long-term economic change and spatial consequences with its contemporary tourism challenges is essential, as the region’s current vulnerabilities are direct consequences of centuries of externally driven economic restructuring.

Finally, these legacies can offer opportunities and inspirations for powerful narratives of wilderness, remoteness, and heritage of Highlands, that continue to influence identity, land use, and tourism brands of the region. That demonstrates how the Highlands future cannot be planned without understanding its past and how the region’s economic history and geography have created a risky legacy for tourism development. Fewer studies explicitly connect historical patterns of peripherality to current tourism challenges, to explain them in detail and to inform better problem-solving for the future.

The key take out is that tourism in the Highlands is unlikely an isolated contemporary phenomenon, but the latest phase in a long trajectory of peripheralization. That peripherality continues to structure tourism opportunities and risks, and acknowledging this legacy can inform more grounded, spatially coherent, and socially resilient planning for the future.

2.2 Conservation, UNESCO Geopark framework, and tourism

2.2.1 UNESCO frameworks and integrated territorial approaches

UNESCO’s approach to territorial management provides the conceptual foundation for understanding how conservation, tourism, and local development can be mutually reinforcing. The International Geoscience and Geoparks Programme (IGGP) (UNESCO, 2024) promotes a holistic and participatory model in which geological heritage conservation is interlinked with education, sustainable tourism, and socio-economic revitalisation (Figure 3) This model is operationalised through a stepwise planning process beginning with stakeholder engagement and geotourism potential assessment, followed by collaborative visioning, resource

management, product development, visitor management, and continuous monitoring and evaluation (UNESCO, 2024).

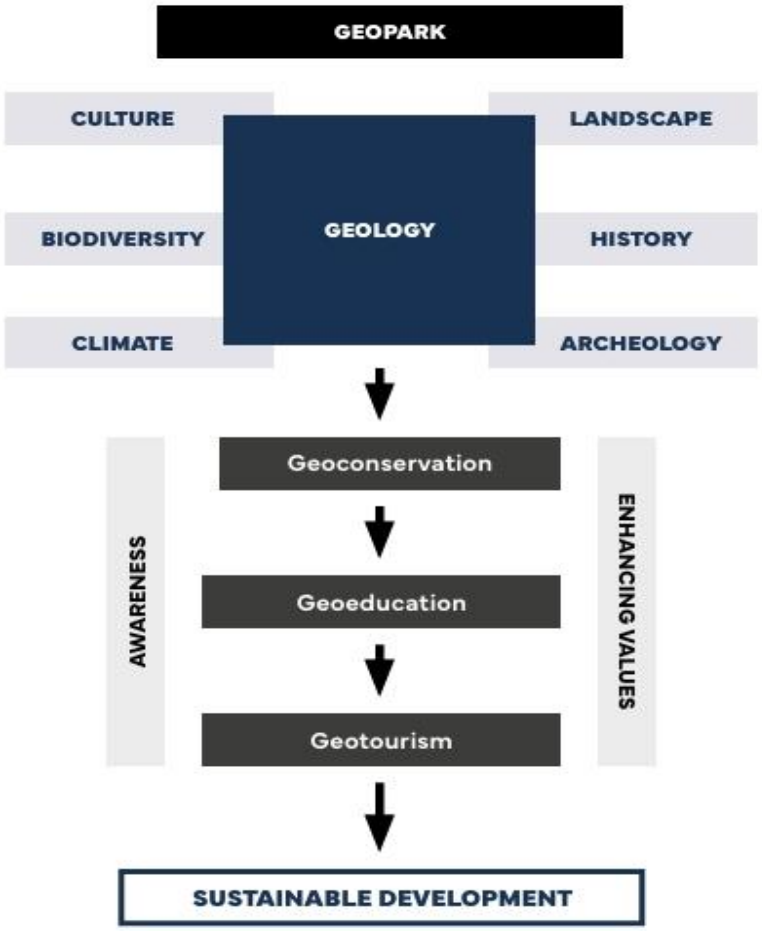

Figure 3. Global Geoparks components and functions. Source: UNESCO (2024) adapted from Woo (2014)

A central principle across UNESCO frameworks is the emphasis on inclusive governance. Successful revitalisation depends on the meaningful involvement of local communities in planning and benefit-sharing, ensuring that tourism development aligns with conservation values and local aspirations (UNESCO, 2024). It positions tourism both as an economic activity, and a mechanism to enhance visitor experience, support conservation through interpretation and education, and generate incentives for protecting natural and cultural assets.

Visitor management is a core component of this integrated approach. UNESCO recommends zoning, carrying capacity assessments, access control, and the development of trails, signage, and visitor centres to disperse visitors and reduce ecological pressure (UNESCO, 2024). GIS-based geotrails and heritage routes, co-designed with stakeholders, can optimise spatial

distribution while enhancing interpretation and visitor satisfaction. Digital communication is increasingly recognised as part of this territorial strategy. Carrion-Mero et al. (2024) demonstrate that well-designed UNESCO Global Geopark websites play a pivotal role in regional revitalisation by improving visibility, supporting geotourism, and fostering community engagement. Their assessment shows that content-rich, interactive platforms strengthen communication and contribute to sustainable development agendas.

Together, these studies establish a conceptual baseline: UNESCO frameworks promote integrated, participatory, and spatially informed planning where tourism is a tool for conservation and regional development (Figure 4). This provides the backdrop against which broader debates on nature-based tourism and conservation can be situated.

Figure 4. The conceptualization of the nature and scope of geotourism. Source: UNESCO (2024) adapted from Dowling (2013)

2.2.2 Tourism, conservation, and governance

The literature on synergies between nature-based tourism and conservation reveals both optimism and caution. While some authors highlight tourism's potential to support conservation (Wardle et al., 2018; Samal & Dash, 2023), others emphasise risks associated with neoliberal governance and market-driven development (Job et al., 2017; Amore et al., 2025).

Wardle et al. (2018) provide a comprehensive review of 70 ecotourism studies, showing that ecotourism is widely promoted as a mechanism to mobilize political, financial, and social support for conservation, particularly in regions facing land degradation, funding shortages,

and weak protected area management. However, they identify a major gap of many studies, as most research focuses on conservation actions rather than measurable outcomes. Similarly, Samal and Dash (2023), reviewing 102 studies, show that ecotourism is most often promoted in developing regions where communities face poverty, resource pressures, and governance challenges. Their findings highlight emerging attention to gender, institutions, climate change, and eco-certification, reflecting a diversification of research themes since 2016.

In contrast, Job, Becken, and Lane (2017) analyse 229 natural World Heritage Sites and argue that protected areas increasingly operate within a neoliberal context where tourism is used to justify conservation through economic benefits. While tourism can generate revenue and support local development, it also risks commodifying landscapes and intensifying ecological pressures. Their study reveals inconsistent monitoring systems and inadequate tourism planning across many sites, undermining both conservation and development goals. Amore et al. (2025) extend this critique to UNESCO Biosphere Reserves, showing that fragmented governance, overlapping designations, and limited policy coherence hinder the integration of conservation, sustainable development, and education. Their metagovernance analysis demonstrates how political and institutional framings shape divergent approaches to sustainable tourism, even within the same UNESCO framework.

Emerging frameworks such as nature-based solutions (NbS) offer new opportunities. Mandić (2019) identifies governance, visitor management, capacity building, sustainable financing, and green infrastructure as key dimensions where NbS can mitigate tourism pressures. Fei et al. (2023) provide a broader temporal perspective through a systematic review of 179 studies on conservation and tourism in World Natural Heritage Sites. They identify three phases of research evolution, from strict conservation (1980-2000) to integrated conservation-tourism approaches (2001-2016), to sustainable tourism and monitoring (2017-present). A key finding is the scarcity of technical and modelling approaches despite their importance for managing tourism impacts. They also highlight that tourism is among the top three threats to World Natural Heritage Sites, reinforcing the need for robust monitoring and integrated planning.

2.2.3 From bio-cultural landscapes and nature conservation to geo-heritage and tourism development

An additional perspective that can aid in understanding relationships and complexities of rural development in recent scholarship, is the emphasis on natural areas not as isolated ecological units, but biocultural landscapes shaped by long-term interactions between people and the environment (Emmet and Nye, 2017). Similarly, when tourism planning assumes a separation between nature and culture, it risks marginalising local knowledge and weakening the social foundations necessary for conservation. In that sense, both rural landscapes and community-led heritage initiatives can create alternative pathways in representation of their regions.

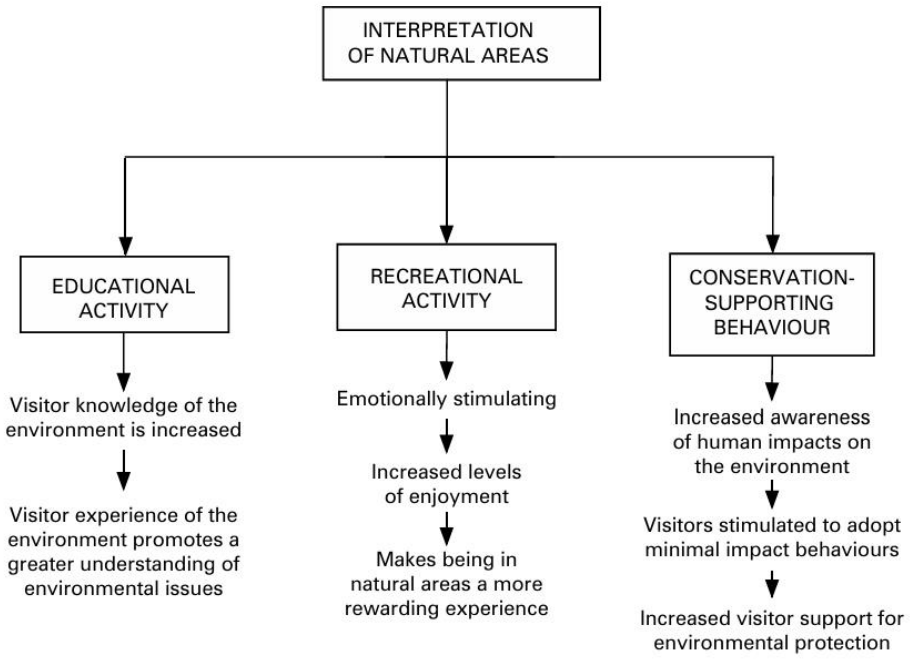

Figure 5. The education-knowledge-awareness relationship embodied within interpretation. Source: Newsome et al., 2013

More holistic approaches integrate spatial analysis with community engagement. In an example of Ligüiqui in Ecuador, heritage mapping managed to bring together archaeological sites, fishing systems, and ecological features into a coherent biocultural framework guiding tourism development (Represa-Perez, 2025). In Hualcayan, Peru, on the edge of one of the most globally popular trekking destinations, PIARA project incorporated archaeological terraces, agricultural fields, and community spaces into trekking circuits, demonstrating how visitor routes can support education, identity, and economic diversification (Bria & Casanova Vásquez, 2022).

That illustrates how creation of a community museum integrating natural and cultural history can strengthened local agency and position heritage as a living, relational resource (Represa-Pérez, 2025) and demonstrate how tourism can support education, cultural continuity, and well-being when heritage is understood as embedded in everyday practices and landscapes (Bria & Casanova Vásquez, 2022). These cases show potential of competitive low impact tourism offer that combine nature-based tourism, heritage and conservation emerging as revitalising local brand.

Infrastructure, visitor centres, trails, interpretive spaces and museums, also shape how visitors understand landscapes and how communities engage with their heritage (Figure 5). Emmet and Nye (2017) argue that cultural and natural heritage are mutually constitutive, and that interpretive spaces can reinforce these relationships when they foreground local narratives. Innovative infrastructures and use of digital media and virtual reality show how creative tools

can animate heritage and support intergenerational knowledge transfer and strengthen cohesion and resilience (Represa-Pérez, 2025; Bria & Casanova Vásquez, 2022)

Spatial planning plays a decisive role in translating these principles into practice. While technical tools such as impact assessments, zoning, and visitor flow modelling are essential, they risk oversimplifying complex socio-ecological systems. Hulme (2011) argues that technocratic frameworks often reduce environmental issues to linear problems, leaving little room for local knowledge, adaptive management, or cultural meaning. For the Northern Scottish Highlands, these insights suggest that tourism development could be grounded in biocultural heritage, crofting and fishing history, peatland landscapes, and community identity.

2.3 Spatial planning and visitor management methodologies

2.3.1 Spatial organisation of rural services and settlement networks

The spatial organisation of rural services and central place dynamics plays a critical role in shaping quality of life, economic opportunity, and long-term demographic sustainability in sparsely populated regions. Rural services, such as shops, fuel stations, medical provision and transport links, exist primarily to support resident populations, whereas tourist services, including accommodation, cafés, visitor centres, and guided experiences, are designed to meet the needs of visitors. Although distinct in purpose, the two are deeply interrelated: tourism can help sustain rural services that would otherwise be unviable, while rural services provide the foundational infrastructure that tourism depends on. In remote regions, this interdependence is structured by central-place dynamics, where a small number of rural hubs concentrate essential services for both residents and visitors.

Price et al. (2025) provide practical examples of how tourism can sustain rural services through community-led models that distribute benefits widely. In their Scottish and Irish cases, social enterprises deliberately support “local suppliers, makers, craftspeople,” and even ensure that income circulates through the community, confirming the importance of rural hubs where tourism strengthens, rather than replaces, foundational services. In that sense, understanding visitor experiences and spatial patterns can be used to deliberately design or reinvent experiences that distribute economic benefits across rural networks by strengthening rural hubs through investment in mobility, digital infrastructure, and community facilities to enhance territorial cohesion and support revitalisation (Loras-Gimeno et al., 2025; Ibanescu et al., 2023).

Tourism planning intersects with these dynamics in several important ways. First, visitor flows often concentrate around existing hubs, placing pressure on local infrastructure while also creating opportunities for service expansion. Second, trail networks, attractions, and interpretation facilities can reinforce or reshape spatial patterns of movement, influencing how visitors engage with rural landscapes (Ballesteros et al.,2021) Third, tourism can support the viability of local services: cafes, shops or accommodation, particularly when in areas where resident populations alone cannot sustain them. Tourist consumption can amplify the economic viability of local products, allowing traditional vocations, cultural practices, and small-scale production to persist in regions where limited local demand and demographic decline would otherwise undermine them.

Small agriculture produced foods, such as cheese, smoked fish or honey, become more viable when sold through farm shops, cafes, or tasting experiences aimed at visitors. Local crafts, knitting, weaving, pottery or woodwork, gain new markets when integrated into visitor centres or trail-linked craft stops. Story-based guided walks, geology tours, or other small rural enterprises, transform rural knowledge and skills into paid services that would otherwise have no formal market.

Understanding how attractions distribution, hiking routes, and infrastructure align with settlement patterns and accessibility contributes to a more spatially coherent understanding of how tourism can support rural hubs and strengthen regional networks. This perspective will be later guiding the research in sparsely populated NWHG.

Finally, Ibanescu et al. (2023) add to discussion the question of integration, where tourism can foster economic resilience and revitalisation in rural areas, particularly when destinations are well-integrated into regional networks. Their findings emphasise that accessibility to nearby medium-sized cities, not necessarily large urban centres, can significantly enhance recovery potential and vitality. Nevertheless, remoteness and peripherality fundamentally condition how effectively urban linkages can drive resilience and revitalisation.

Complementing this perspective, Hee Jeong Yun (2014) explores the significance of cultural amenities in rural economic revitalisation and regional planning. Cultural sites and amenity resources are increasingly adopted by policymakers as central elements in development strategies, contributing to community revitalisation and income distribution. Together, these studies underscore the importance of integrating tourism, cultural assets, and spatial planning to support resilient and sustainable rural development. This role is often played by elements of the rural landscape itself, geological landmarks and iconic landforms, working harbours as well as community halls and social spaces.

2.3.2 Clusters, infrastructure planning, and carrying capacity

Capone (2004) defines tourism clusters as geographically concentrated networks of attractions, services, and institutions that interact to produce a competitive tourism product. This definition aligns closely with the spatial patterns identified by Costa et al. (2024) and Chhetri & Arrowsmith (2008), and both studies reveal clusters of high visitor pressure around scenic viewpoints, waterfalls, and popular walking tracks. Costa et al. (2024) show that clusters of visitor activity correspond to areas with strong landscape appeal, confirming that geological and geomorphological features can drive visitor movement. Their identification of start/end points clustering near parking areas suggests that infrastructure strongly shapes visitor flows.

Chhetri and Arrowsmith (2008) extend this by modelling recreational potential using regression analysis and suitability mapping. Their findings show that high recreational potential clusters around existing trails but also identify latent high-potential zones that could relieve pressure on overused sites. By identifying both high-use and high-potential but underdeveloped areas, the model supports strategic dispersal of visitors, reducing environmental pressure while expanding tourism benefits to less-visited regions. Wei (2012) validates this by arguing that the use of GIS-based methods in planning strengthens tourism's

contribution to regional development through improved resource management and accuracy. In this sense, GIS becomes the toolbox through which clusters can be identified, supported, or strategically redirected.

Li et al. (2023) offer a different but complementary perspective by constructing heritage corridors using the Minimum Cumulative Resistance method (MCR) and Multiple Centrality Assessment (MCA) analysis. Their work shows that clusters of cultural influence, where multiple villages' spheres overlap, form natural nodes for tourism development. This corridor-based approach demonstrates how clusters can be connected, enhancing accessibility, and supporting regional revitalisation. The corridor system highlights areas with high accessibility and cultural density, guiding where to prioritise infrastructure investment, such as signage, transport links, or visitor facilities.

2.3.3 Spatial planning for tourism: visitor flows and experiences

The literature on visitor flows demonstrates how GIS and digital mobility data can transform understanding of tourist behaviour. Costa et al. (2024) provide a relevant example, using Wikiloc GPS tracks to analyse 1,071 pedestrian routes in Alvão Natural Park. Their findings reveal extreme spatial concentrations and strong temporal clustering, and confirm visitor pressures are often not evenly distributed, and how hotspot identification is essential for managing congestion, erosion, and carrying capacity. Also, Costa et al. (2024) methodological contribution is substantial. Their workflow, GPX extraction, GIS conversion and Getis-Ord Gi hotspot analysis, illustrate how VGI can overcome the limitations of traditional surveys. Ultimately, it shows that mobile-app data can serve as a reliable proxy for real visitor behaviour, offering a low-cost, high-resolution alternative to conventional monitoring methods.

Hose (2026), while not explicitly spatially, supplements this perspective by focusing on geotrails and interpretive infrastructure in his analysis of geotrails in the southern Welsh Borderland. He shows how trails cluster around geological features, transport routes, and accessible landscapes and patterns, mirroring Costa et al. (2024)'s findings. Hose's emphasis on vandalism risk, footfall, and site visibility introduces a more critical dimension: interpretive infrastructure must be adapted to site sensitivity and visitor density, linking spatial behaviour to conservation outcomes. His observations that abandoned railways and heritage paths can be repurposed for geotrails, offers original insights for remote geoparks seeking low-impact infrastructure solutions and 'recycling 'of abandoned legacies (Hose, 2026).

2.3.4 The role of GIS in geoparks planning and management

Spatial planning is central to UNESCO's geopark model, and it positions GIS as a foundational instrument for geosite identification, trail design, and infrastructure evaluation (UNESCO, 2024). UNESCO encourages geoparks to use spatial data to inform zoning, carrying capacity, and the integration of conservation and visitor services, ensuring that development remains context-sensitive and aligned with both landscape-scale conservation and regional economic goals (UNESCO, 2024). This institutional framing assumes that GIS-based planning naturally leads to more coherent, evidence-based management, and that spatial analysis should be

embedded in routine decision-making. Wei (2012) adds to this view by highlighting GIS's ability to overlay terrain, transport networks, services, and attractions, enabling multi-layered spatial understanding. However, he also notes that despite its potential, GIS remains underutilised in tourism management and suggests that its practical uptake remains uneven, with many destinations still relying on fragmented or outdated spatial data.

Yang et al. (2023) contributes to this discussion a four-level typology: geovisualization, spatial query, pattern identification, and spatial optimisation, to structure the expanding analytical landscape of GIS. Their typology reveals that much tourism research remains confined to the first two levels, relying heavily on descriptive mapping rather than advanced modelling, but as tourism becomes more data-intensive and spatially complex, role of GIS in tourism is expected to evolve. Yang et al. (2023) argue that emerging technologies, such as mobile GIS, LBS, VR/AR, will enable fine-grained monitoring of visitor movements and site usage, but only if integrated into more sophisticated analytical frameworks. Their emphasis on the spatial context of tourism, understanding both demand (visitor flows, mobility patterns) and supply (distribution of heritage sites, infrastructure), positions GIS as a tool for analysing interactions between people, places, and services.

Rosado-González et al. (2023) provide a similar perspective by examining GIS use specifically within UNESCO Global Geoparks (UGG). Their systematic review of 32 publications (2000-2021) reveals that GIS applications in geoparks are recent, growing, but still limited, with most studies focusing on land-use analysis, geomorphological mapping, satellite remote sensing, and thematic cartography. Similarly to Yang et al. (2023), Rosado-González et al. (2023) also identify emerging opportunities of Mobile GIS, UAVs, participatory mapping, and citizen science, that could enhance real-time monitoring and community engagement, particularly in dispersed rural landscapes such as the Northwest Highlands. Their findings contextualise the broader GIS debate by showing that while conceptual frameworks exist, implementation remains uneven and often constrained by resources or expertise.

2.3.5 A critical look at volunteer GPS data

The increasing use of VGI and GPS-based datasets introduces both opportunities and challenges. Parker et al. (2013) demonstrate that VGI and professional geographic information (PGI) each have distinct strengths: PGI provides authoritative, generalised context, while VGI offers fine-grained, real-time, experiential insights. Importantly, users value update frequency, clarity, and accessibility more than the professional status of the data source.

Flanagin & Metzger (2008) investigate the credibility of VGI. They argue that the rise of Web 2.0 (also known as participative or social web), has transformed geographic information production, enabling millions of users to contribute place-based data through platforms such as Wikimapia or OpenStreetMap. This shift has created a vast pool of user-generated geodata, which can be highly valuable because it often provides "indigenous experience, esoteric understanding of a particular physical environment, and current information about local conditions" (Flanagin & Metzger, 2008). However, the authors highlight concerns about credibility, accuracy, and trust, noting that digital environments lack traditional gatekeeping

and often obscure the source of information. They distinguish between credibility-as-accuracy (objective correctness) and credibility-as-perception (what users believe), arguing that VGI often relies on the latter. The key finding is that VGI can be both powerful and problematic: it enriches geographic knowledge but requires careful evaluation due to inconsistent quality and ambiguous authorship.

Elwood (2008) situates these debates within critical, participatory, and feminist GIS, arguing that VGI is socially embedded and shaped by identity, power, and positionality. This means that spatial patterns in VGI reflect not only visitor behaviour but also who participates, how, and why. Uneven participation can reproduce inequalities, particularly in remote rural areas with limited digital access, an important caution for geoparks relying on VGI for visitor-flow analysis. Elwood (2008) argues that VGI can incorporate "observations and experiential knowledge of new constituencies," including residents, visitors, and marginalised groups, into spatial decision-making.

For geopark management, this means VGI is a valid source of data when combined with credibility assessment and awareness of participation biases. More research is required to better understand both the theoretical and practical applications of VGI, including its benefits and limitations. This includes the need for additional studies that directly compare VGI with other forms of visitor monitoring, such as trail counters and visitor surveys, to evaluate issues such as reliability and usability.

3. Case study

The Northern Scottish Highlands were selected for three reasons. First, the rapid growth of tourism routes such as the North Coast 500 have dramatically increased visitor numbers, raising questions about carrying capacity, infrastructure, and community benefits. Scotland's last wilderness areas are caught in a growing tensions, although they remain relatively undeveloped, with far less infrastructure than many comparable regions abroad, they are increasingly strained by the rapid growth of tourism, forcing a difficult choice between managing and developing these landscapes to protect them or leaving them wild and empty, where unsupervised pressures and negative processes can take hold.

Second, it presents unique territorial management challenges. Compared with other UNESCO Geoparks and Biospheres in Europe, the Highlands stand out for their extreme sparsity of population, limited transport networks, and strong cultural narratives of wilderness. Third, long history of peripherality and land-use restructuring The Highlands' economic history: clearances, estate ownership, crofting, and industry and agricultural decline, provides a distinctive context for analyzing how historical path dependency shapes contemporary tourism opportunities.

The late twentieth century brought new governance regimes to the region, particularly the Highlands and Islands Development Board and later EU cohesion funding, that shifted emphasis from previously described historic developments toward diversification, community

resilience, and endogenous development, exemplified by initiatives such as the University of the Highlands and Islands (McCullough, 2018). Although these reforms did not erase the structural legacies of earlier peripheralization, they marked a significant departure from resource-extractive policy, demonstrating that sustainable regional development depends on aligning external support with local agency (McCullough, 2018).

The creation of the North Coast 500 (NC500) route represents a major contemporary intervention, transforming dispersed rural landscapes into a coherent, marketable tourism product. The NC500 functions as a system linking transport networks, natural landscapes, heritage sites, accommodation providers, local communities, and marketing organisations, producing a 516-mile circuit that attracts diverse visitor segments seeking nature, adventure, heritage, and scenic travel (NC500 Travel Guide, 2025). Its rapid development reflects broader trends in mass tourism, digital promotion, and experiential travel, while also illustrating successful branding of the socially and spatially constructed nature of Highland space, long framed as remote, wild, and culturally distinctive (Lennon & Harris, 2020).

Tourism in the Highlands generates significant economic benefits but also deep structural challenges. Visitor numbers and spending have risen sharply, with room occupancy increasing from 52% to 82% between 2014 and 2018 and attractions experiencing a 29.3% rise in visits (Lennon & Harris, 2020). However, the prevalence of "hit-and-run" tourism and single-night stays reduce local economic capture and increase operational pressures on businesses (Ruck, 2020). Housing markets have been distorted by demand for holiday lets, "disproportionately displacing younger residents" and eroding community networks (White et al., 2024). Socially, tourism brings employment and helps retain population, yet it also produces congestion, loss of local control, and rising "tourismphobia" in small communities overwhelmed by visitor flows. Environmentally, the impacts are also substantial: inadequate infrastructure, littering, erosion, and wildlife disturbance are recurring issues, with single-track roads, limited parking, and insufficient waste facilities intensify pressures, especially in remote areas (Ruck, 2020).

3.1 Stakeholders and local governance system in NWGH: the co-existing governance paradigms and their relational dependency

In the context of the thesis, governance is defined as the formal and informal architectures through which collective decisions are made, resources are allocated, and policies are executed, including spatial plans (Bramwell and Lane, 2011). Regional stakeholders operate within highly institutionalized arrangements that dictate how space is used, how capital and resources are distributed, and who carries the socio-ecological burdens of tourism. By analysing how power asymmetries, resource distributions, and institutional dependencies shape the geographical space of NWHG, we can evaluate and suggest the institutional baseline necessary for the transition from its current model toward structural revitalization and identify how Geopark tourism and community governance can be best positioned to create new opportunities that are the topic of this thesis.

To evaluate the operational realities of regional actors, they must be viewed through two distinct, co-existing governance paradigms that shape the region's socio-economic and planning landscape: hierarchical governance and peer governance.

Hierarchical governance represents vertical top-down authority, structured around formal jurisdiction, statutory legislation, and centralized resource allocation. Bramwell and Lane (2011) define this mode through "systems of governing" and “steering” that allocate resources, deploy formal regulatory policies, and execute top-down bureaucratic control to establish societal order. In the Scottish Highlands, this framework has a historical trajectory spanning centuries, moving from historical landlord-tenant systems to modern state-led regional interventions. Under this mode, power is concentrated in centralized administrative centers (e.g., The Highland Council in Inverness, or national policy hubs in Edinburgh), which enforce statutory constraints, control core infrastructure spending, and operate via regional state planning.

Conversely, peer governance operates as a polycentric, horizontal network that relies on multi-stakeholder partnerships, territorial collaboration, and civic participation. Peer governance generates cohesion through consensus, shared values, and collective action. Bichler (2021) defines this paradigm as self-organizing, inter-organizational networks characterized by structural interdependencies, resource exchanges, shared "rules of the game," and relative autonomy from the formal state. In practice, peer governance prioritizes localized social capital, community wealth building, and territorial preservation and remains highly responsive to endogenous socio-economic needs, such as reversing chronic depopulation and expanding affordable housing as outlined in the NW2045 Vision (Peach, 2025).

Table 2. Vertical governance dynamics in NWHG territory

Stakeholder Profile: structural position and group name	***Level and type of vertical Interdependency***	***Governance impacts***
Top-Down Statutory Regulation: Public authorities (The Highland Council, Scottish and UK Government, VisitScotland)	*Source of jurisdictional law and capital* *The core network depends on this group for macro-infrastructure investment and national development frameworks*	*Geotourism: Regulates tourism routing and sets the national promotional agendas via VisitScotland* *Landscape Conservation: Establishes and enforces the overarching legal protections and planning frameworks* *Regional Revitalization: Directs macro-funding mechanisms like the Addressing Depopulation Fund to target structural rural disadvantage*

Global international heritage organisations (UNESCO)	*Authority to award, monitor, or revoke international designations* *The local management networks depend on this group to maintain global positioning*	*Geotourism: Validates the region as a world-class destination for earth science tourism and lifelong learning* *Landscape Conservation: Mandates strict adherence to international geoconservation guidelines* *Regional Revitalization: Provides the global prestige required to maintain the area's identity and attract high-value inward investment*
Market-Driven Regional Tourism Sector (Venture North, The NC500 network)	*Operates via market-driven models and macro-economic metrics.* *Controls external destination branding and visitor routing*	*Geotourism: Curates the macro-marketing narratives that dictate visitor volume and driving routes across the region.* *Regional Revitalization: Drives immediate economic yield through visitor spend*
Statutory environmental and heritage organisations: (NatureScot, John Muir Trust, Historic Environment Scotland)	*Governs the environmental boundaries of the region* *Direct legal protection powers over designated ancient monuments and historic landscapes*	*Landscape Conservation: Implements active ecological restoration schemes and establishes the protective 30x30 terrestrial habitat networks.* *Regional Revitalization: Embeds historical narratives into the wider landscape identity, creating high-quality educational assets that support diversification*
Landowners (Large private landowners and estates)	*Physical control of large contiguous land parcels. Affects conservation and infrastructure developments*	*Landscape Conservation: Dictates on-site land-use practices, ranging from commercial sporting and hunting pursuits to large-scale carbon sequestration projects* *Regional Revitalization: Creates a fragmented governance landscape that can lock up strategic land needed for development*
Local communities (Permanent Residents, NW2045 Steering Group, Community Development Trusts)	*High resource dependency on public bodies, yet the entire vertical system depends on their labor and social license to function*	*Geotourism: Provides the essential local hospitality, cultural authenticity, and community-led guiding that sustains the sector* *Regional Revitalization: Organizes projects through development trusts to counter acute depopulation and other problems*

Local Economic Actors: Local businesses (SME, Rural Accommodation and Food Providers, Outdoor Activity Operators)	*Financial Recipient and Market Dependent: Highly vulnerable to the allocative choices of regional enterprise networks* *Operate within seasonal market parameters over which they hold no regulatory control*	*Geotourism: Captures visitor spending directly and turns raw heritage assets into sustainable local livelihoods* *Regional Revitalization: Generates year-round employment opportunities, though currently constrained by severe rural staffing and housing shortages*
Economic Drivers: Tourists (Short-Stay Visitors, NC500 Road Users, Outdoor Recreationists)	*High consumer influence through volatile mobility patterns* *Their physical movements, vehicle choices, and spending patterns shape the economic viability of the region*	*Geotourism: Provides the necessary financial demand that supports local museums, visitor centres, and interpretive trails* *Regional Revitalization: Contributes vital revenue to the rural economy but can displace locals by driving the inflation of short-term holiday lets*

The structural intersection of these two paradigms defines contemporary regional friction within the NWHG. While hierarchical governance dictates the legal boundaries of land use and controls macro-regeneration funding, it is structurally and often geographically detached from the remote, lived space of the region (Table 2). Peer governance networks hold the necessary local insight and delivery capacity but lack the statutory authority and capital to act (Table 3).

Table 3. The horizontal governance dynamics in NWGH territory

Stakeholder Profile: Horizontal alliance position and group name	***Level and type of horizontal interdependency***	***Governance impacts***
Local communities (Permanent Residents, Community Trusts)	*Generate the localized social capital, shared values, and social license required to govern the territory* *Co-ordinates horizontal peer networks to manage the shared landscape commons*	*Landscape Conservation: Upholds traditional community-led land management practices, protecting local heritage from extractive development* *Regional Revitalization: Directs community-wealth building projects*
Knowledge and Coordination Network: NWHG and other international heritage organisations	*Functions as a horizontal link for geo-conservation and community development. Creates international prestige* *Connects separate community councils, schools, and local businesses to create shared territorial goals and voluntary management strategies*	*Geotourism: Designates and interprets geological trails, encouraging visitors to spread out away from over-congested hotspots* *Landscape Conservation: Fosters a shared conservation ethos by translating complex geoscience into local environmental stewardship projects*
Co-Dependent Local businesses (Rural Accommodation and Food Providers, Outdoor Activity Operators)	*Economic Peer Partner: Relies on the landscape commons preserved by the community and conservation groups* *Collaborates with local delivery networks to match business practices with the region's identity and capacity*	*Geotourism: Integrates local food, craft, and guiding into the wider geotourism product, increasing average visitor length of stay* *Regional Revitalization: Provides the economic baseline needed to sustain a year-round working population, helping keep local services viable*
Knowledge Peer Partner: Universities and research centres (UHI, British Geological Survey)	*Partners directly with geopark to co-produce localized data and reduce information gaps*	*Geotourism: Provides accessible scientific training for local guides, boosting the quality of community-led interpretation* *Regional Revitalization: Empowers community trusts with the rigorous data needed to justify proposals*
Heritage Stewardship Partners: (NatureScot, Historic Environment Scotland,)	*Resource Exchange: Shares the goal of landscape preservation but often prioritizes ecological protection over economic development*	*Geotourism: Creates integrated cultural-geological itineraries that tell a deeper story of how humans have interacted with the landscape* *Regional Revitalization: Repurposes historic assets into community-run spaces*

Regional Resource Provider: Public authorities (The Highland Council, Scottish Government, VisitScotland)	*Due to overstretched budgets and vast distances, depend on peer networks to maintain public services*	*Geotourism: Relies on community trusts to run local visitor facilities, ensuring that key tourist routes remain operationally viable* *Regional Revitalization: Delegates the delivery of local housing and services*
Private landowners and commercial drivers, regional tourism sector (Venture North, The NC500 network)	*Often operating outside the horizontal network with insular priorities focused on private resource management* *Requires integration into peer governance via initiatives*	*Geotourism: Tourism driving the visitor numbers that support local businesses.* *Regional Revitalization: Wields the power to either block or enable community asset buyouts and local housing initiatives.*
Common Resource Consumers: (Visitors, Outdoor Recreationists)	*Their presence impacts the quality of the resource for others, making them dependent on the infrastructure*	*Geotourism: Drives the demand for authentic, high-quality local products, produces financial income*

The interface between hierarchical structures and peer networks creates complex lines of dependence across the regional landscape (Table 2 and 3). To map these relational dynamics systematically, the interactions between the hierarchical and peer governance spheres can be classified into three distinct categories of dependence.

First, there are high vertical resources and financial dependencies. Peer territorial networks, including the NWHG, localized small-to-medium enterprises (SMEs), and community steering groups, exhibit an existential dependence on the hierarchic axis for core operational capital. Local businesses, community trusts, and regional initiatives remain structurally exposed to the allocative choices of public and development authorities and regional enterprise networks like Highlands and Islands Enterprise (HIE). This financial reliance leaves local actors dependent on centralized funding streams, including state-backed mechanisms like the Addressing Depopulation Fund and precarious post-Brexit UK/Scottish replacement frameworks for EU Cohesion funding.

Second, there is a legislative and regulatory dependency of regional tourism operators and heritage bodies that operate within boundaries enforced by national policymakers and The Highland Council. Consequently, ground-level interventions, such as land-use alterations and local developments, are structurally subordinate to statutory planning laws and the entrenched property boundaries of large private estates.

Third, and most importantly, hierarchic governance exhibits a reverse dependency on horizontal peer networks for the physical execution of its macro-level policies. As documented by the Indigo House (2022) report and the Highlands and Islands Regional Economic Partnership (HIREP) strategy, public authorities operate under severe budgetary constraints across vast, topographically remote geographies. Centralized bureaucracies lack the field-level capacity to monitor dispersed environmental assets and tourism impacts or maintain remote

infrastructure and manage localized public services. Consequently, the state depends directly on community groups, voluntary development trusts, and the Geopark to provide the voluntary labor, site stewardship, and baseline social license required to implement national targets.

3.2 Key stakeholder dynamics and governance dependencies relevant to the thesis

At the core of this system lies a dependency where the regional tourism sector and local businesses rely on two foundational assets: the physical and cultural landscape preserved by conservation and heritage bodies, and the social license granted by local communities. Within this dynamic, tourists act as external drivers whose highly seasonal mobility patterns shape the economic viability of the entire system. This creates regional difficulties and uncertainty. While macro-tourism networks and private resource extractors require the landscape to maintain its pristine, protected aesthetic, their activities generate significant spatial compression.

A primary driver of these tensions stems from conflicting social representations of what tourism planning and landscape heritage management should achieve. As conceptualized by Moscardo (2011), stakeholder groups with significant power, including national marketing organizations, macro-policymakers, corporate tourism actors, and private developers, typically operate within a market-driven representation. This approach frames the destination space primarily as a commercial commodity, prioritizing economic growth, external destination branding, and visitor volume. To maintain structural dominance and exclude alternative local agendas, these actors frequently leverage claims of specialized "purported knowledge" grounded in macro-economic trends and global marketing metrics (Moscardo, 2011). This administrative rhetoric systematically marginalizes the social representations held by local communities and peer networks.

The tension between hierarchical and peer governance becomes even more apparent when examining community involvement through the lens of the "commons", or the collective socio-ecological, cultural, and landscape assets of the region. The geodiversity, cultural assets, and landscapes of the NWHG represent a shared territorial common. As defined by Briassoulis (2002), the common-pool resource (CPR): a concept grounded in a theory established by Ostrom (1990), are characterized by two inescapable attributes: high subtractability, where resource consumption by one actor reduces its availability or quality for others, and high non-excludability, meaning the physical configuration of the resource makes it structurally difficult or impossible to bar potential users. When these vulnerable CPRs are governed exclusively through market-driven frameworks or top-down hierarchic zoning, they inevitably succumb to a localized "tragedy of the commons" (Briassoulis, 2002).

3.3 The Geopark-community core and peripheral dependencies

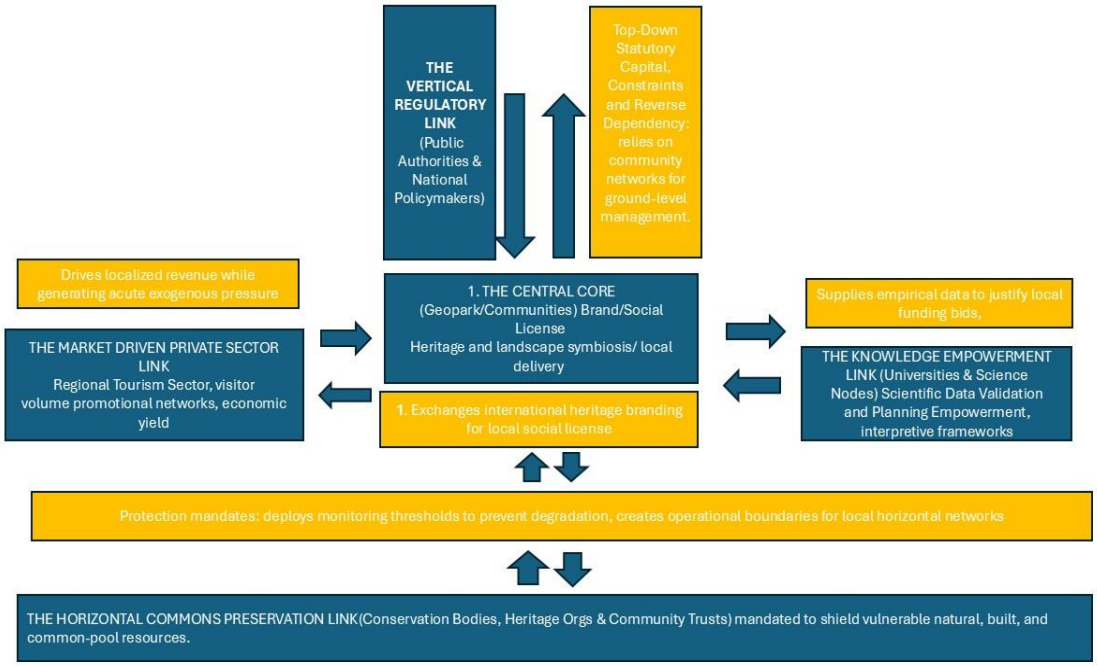

Figure 6. Conceptual model of stakeholders and exchange mechanisms surrounding the central Geopark-Community core

In this 5-point framework, NWHG and Local Communities are positioned as the top horizontal core of the region (Figure 6). The institutional actors (blue rectangles) are separated from their relational mechanisms (yellow). The surrounding governance network illustrates how other stakeholder groups interact with this core, categorized by their vertical statutory positions and horizontal network and resource dependencies.

The Central Core Stakeholders (Geopark and Local Communities) This connection represents the analytical heart of this thesis. The Geopark provides the international UNESCO brand and scientific framework needed to elevate regional status, which directly enhances the credibility and market value of local geotourism. In return, the community provides the local workforce, community assets and social license that keep the geopark operationally viable.

The Vertical Regulatory Link (Public Authorities and Central Core) The Highland Council and national policymakers impose constraints on the central core through land-use permissions, zoning laws. However, an operational tension exists due to a reverse dependency: these underfunded authorities rely directly on horizontal community networks and Geopark to manage territory locally.

The Knowledge Empowerment Link (University and Science Nodes and Central Core) Universities and knowledge networks provide the scientific validation necessary to protect the geological commons and design high-quality geotourism interpretation materials. The knowledge can empower communities to justify funding bids and steer spatial planning toward long-term regional revitalization.

The Market Driven Link (Regional Tourism Sector and Central Core) Market-driven organizations and promotional networks use external branding to maximize visitor volume and economic yield. While this drives commercial revenue for local businesses, it introduces pressures.

The Commons Preservation Link (Conservation and Heritage Bodies and Central Core) Regulators like NatureScot, Historic Environment Scotland, and the John Muir Trust deploy state-delegated regulatory powers to shield vulnerable natural, built, and common-pool resources from degradation.

Using these theoretical frameworks, stakeholders can be organized by how they influence, disrupt, or support this core Geopark-Community cooperation. Within this structural arrangement, the UNESCO Geopark can be positioned as a critical territorial agent. It is physically embedded in the horizontal axis, living in the community landscape, but carries the institutional prestige of the vertical axis through international UNESCO recognition. This unique position allows the Geopark to "translate" localized community needs.

4. Methodology and analytical framework

This research adopts a mixed-methods, secondary data, and spatial approach to examine how visitor flows, heritage and experiences planning, can support both conservation and rural revitalization in the Northern Scottish Highlands. The methodological design integrates qualitative analysis of planning documents and reports, with quantitative spatial analysis using GIS and volunteered GPS data. It is conducted in QGIS Software.

4.1 Analysis of regional planning and governance documents

The analytical questions (Table 4) for the document review were developed and grounded in the aims of the study and the functional roles of regional planning documents. First, the documents were screened to identify recurring themes relating to development and revitalisation, conservation, tourism, and spatial context. These themes were then aligned with the core research objectives and the spatial datasets used in the GIS analysis.

Source documents and reports:

a. Geodiversity Audit and Action Plan 2013-2016

b. Review and Update on NW2045 Vision: Call to Action 2025

c. Rural and Regional Disadvantage in the Highlands and Islands, May 2022

d. Highlands and Islands Regional Economic Partnership Regional Economic Strategy (HIREP) 2025-2035

Table 4. Analytical questions for document review and their purpose

Question	***Rationale***
What are key development and revitalisation objectives and how are they to be achieved?	*To understand what forms of development and revitalisation regional documents prioritise, ensuring the study is grounded in the strategic aims that guide local planning.*
What are various conservation objectives, for landscape and local heritage?	*To identify the protection priorities for landscapes, ecosystems, and heritage, clarifying the constraints and values that shape regional planning.*
What is the local tourism development strategy, particularly for visitor management and heritage interpretation and accessibility?	*To understand how tourism is intended to be managed and interpreted, and how accessibility is framed in policy, providing insight into strategic intentions for visitor behaviour.*
What spatial questions are raised and how to address them?	*To determine which issues, require spatial understanding and how planning documents conceptualise spatial challenges, guiding the need for spatial analysis.*

4.2 Spatial Data and GIS Layers

Geopark boundary polygon - preparation and use

The official boundary of the NWHG was obtained from the UNESCO Global Geoparks online map (UNESCO, n.d.). As no GIS shapefile was available for downloading, the boundary was digitised manually by tracing the official outline displayed in the UNESCO web viewer onto an OS standard base map within QGIS. The digitising process followed standard heads-up digitisation procedures, and the resulting polygon and map were georeferenced to British National Grid (EPSG:27700) and set as a project's Coordinate Reference System (CSR).

This boundary layer provides the spatial frame of reference for the entire analysis. It is used to clip all other datasets (visitor tracks, geosites, protected areas, facilities) to ensure that only features within the geopark are included. It also enables calculation of area-based metrics, mapping of visitor density relative to geopark limits, and consistent visualisation across maps.

The minor limitation is that manual digitisation introduces a small degree of positional uncertainty compared to an official GIS boundary. However, the boundary is sufficiently accurate for landscape-scale visitor-flow analysis.

Geo-sites dataset creation and processing

The geo-site dataset used in this study was derived from the Geodiversity Audit and Action Plan 2013-2016 (NWHG, 2013), which provides the first comprehensive register of key geological and geomorphological sites within the NWHG. The Audit includes all Geological Conservation Review (GCR) sites, most of which lie within Sites of Special Scientific Interest (SSSIs), as well as additional locally important features identified for their scientific, educational, or interpretive value. Each site is described in the Audit with attributes such as

geological significance, accessibility, conservation status, visibility, and interpretation potential.

To integrate this information into project's GIS workflow, all georeferenced locations listed in the Audit were manually extracted and converted into a point shapefile in QGIS. The process followed three steps:

1. Identification of site coordinates from the Audit's location descriptions and grid references.
2. Creation of a point feature for each site, using the listed NWHG reference number 001-064 as the unique identifier.
3. Attribute enrichment, where relevant descriptive fields from the Audit (accessibility, conservation notes, visibility, interpretation potential) were added to the attribute table for later analysis.

In a number of cases, the Audit describes multi-part or linear features such as long valley exposures, using point references. For that reason, several sites contain multiply points for a better spatial representation. This resulted in a total of 80 point features. These limitations mean that distance-based analyses should be interpreted as proximity to the representative location, not to the full spatial extent of the feature.

Advantages of using the Geodiversity Audit as a data source

- Alignment with statutory designations: Many sites are GCR or SSSI features, meaning they already underpin national conservation policy and are recognised for their scientific importance.
- Rich descriptive metadata: The Audit provides qualitative information: accessibility, fragility, visibility, interpretive potential, that can be linked to spatial patterns of visitor movement.
- Relevance to geotourism and revitalisation: The Audit frames geodiversity as a resource for education, interpretation, and ecotourism, aligning directly with the thesis objectives.

Limitations of the geosite point representation

- Point simplification of area-based features: Many Audit sites represent large or complex geological areas (mountain massifs, thrust exposures, cave systems). Representing them as single points simplifies their spatial extent and may underestimate their true proximity to trails.
- Interpretation bias: Sites were selected for scientific significance, not necessarily for visitor relevance, which may create mismatches between heritage value and actual visitor behaviour.

Wikiloc volunteered GPS data

Wikiloc is an online platform where outdoor enthusiasts share GPS tracks and descriptions of their routes, primarily for activities such as hiking, walking, running, cycling, and mountain sports (Wikiloc, 2026). It functions as a large, user-generated repository of trails, where each entry typically includes a GPX track, basic metadata (distance, elevation, duration), user profiles, photographs, textual comments, and timestamps of visits. The usual contributors are recreational hikers, trail runners, and outdoor tourists who record their activities with GPS-enabled devices or smartphones and then upload them to the platform to document, share, or discover routes. Importantly, GPS can provide more accurate and detailed visitor-use data than traditional self-reported methods (Hallo et al., 2012) and its tracking can provide detailed spatial data for protected-area management (D'Antonio et al., 2010).

Justification for using Wikiloc as volunteered geographic information

As a form of VGI, Wikiloc offers spatial data on actual visitor movements and for a sparsely populated, infrastructure-limited region such as the NWHG. With traditional monitoring methods either unavailable, difficult to organize or often too time consuming and expensive to implement (Norman & Pickering, 2017), Wikiloc allows detailed analysis of trail choice, route density, and proximity to geosites and infrastructure and coverage in remote areas. Additionally, the data reflect real decisions made by visitors in the field, including informal paths and route variations that may not appear in official trail datasets. Moreover, it provided rich qualitative context with photographs, comments, and timestamps attached to tracks offering qualitative insight into visitor perceptions, motivations, and experiences, with potential to be used to explore seasonality and temporal patterns of use.

Some limitations of that source of data must be also acknowledged. Wikiloc over-represents visitors who are comfortable using GPS technology and motivated to share their activities, and under-represents casual walkers who do not record or upload their routes. It also tends to emphasise more scenic or challenging routes, potentially exaggerating the importance of certain areas. Despite these limitations, the dataset is well suited to the aims of this thesis: it provides a diverse, spatially detailed approximation of visitor flows that can be integrated with geosite, infrastructure, and land-use data to analyse patterns of access, concentration, and pressure.

Data selection and filtering

For this study, a systematic search was conducted on Wikiloc within the spatial extent of the NWHG. The activity filters were set to hiking, walking, and running, while cycling and other less-relevant activities were excluded to focus on human movement that interacts most directly with trails and geosites.

The initial search results were then manually screened to ensure that only meaningful and spatially coherent tracks were retained. Non-realistic or incomplete tracks were excluded: entries that contained only an arrival point, extremely short or fragmented segments, or clearly

erroneous geometries (straight lines across sea or terrain inconsistent with known access) were removed.

Although several users contributed multiple tracks, the final dataset still reflects a diverse representation of visitors: solo hikers (including women), families, couples, and people of various ages and fitness levels. This diversity is also reflected in the variety of routes (short walks, longer hikes, more demanding runs) and in the qualitative content attached to them (photos, comments, ratings), which together provide insight into how different visitor groups engage with the landscape.

After filtering, a total of 719 tracks were retained for analysis, uploaded between 2015 and 2025.

Data preparation and processing for GIS

The preparation of Wikiloc data for GIS analysis followed a structured workflow to produce both a line layer (routes) and a point layer (track points and associated attributes). Each selected Wikiloc route was downloaded individually as a GPX file, and Metadata such as route name, user, date, and activity type were preserved in file names or a separate log for potential later linkages. All GPX files were loaded into QGIS, but for the purposes of this study, the focus was on tracks to build the line layer representing visitor routes, and track points to build the point layer for more detailed analysis of density and proximity. The Merge Vector Layers tool in QGIS was then used to combine all track layers into a single, unified line dataset.

30 x 30 Protected areas data layer

The 30x30 Protected Areas dataset from NatureScot (2024) was downloaded and clipped to the NWHG boundary to retain only designated areas within the study region. The resulting layer includes nationally recognised conservation designations such as SSSIs, SACs and SPAs and Ramsar, providing a spatial framework for assessing how visitor movement interacts with protected landscapes. NatureScot compiled these into a single dataset to track progress toward the 30% protected-area goal by 2030, and it is up to date as of 31/05/2024. Incorporating this dataset strengthens the interpretation of visitor-flow patterns by linking them to formal conservation designations.

The dataset offers comprehensive national coverage, a consistent classification scheme, and direct relevance to conservation management, making it well suited for analysing recreation-conservation interactions. However, it does not include information on seasonal restrictions, habitat condition, or site-specific management prescriptions.

Villages and Road Network

To represent settlement structure and key access nodes within the geopark, a point layer was created for six principal villages: Achiltibuie, Drumbeg, Durness, Kinlochbervie, Lochinver and Scourie. Village locations were created from Ordnance Survey mapping, and each village was digitised manually as a point feature. These points provide a useful proxy for understanding settlement-based access to the trail network and service availability.

The main road network was extracted from OpenStreetMap (OSM) Standard and includes a variety of tracks that allow it to connect all database features into a single network and clipped to the geopark boundary.

Cultural and historic heritage

To incorporate cultural and historic heritage dimensions, two datasets from the National Record of the Historic Environment (Canmore), maintained by Historic Environment Scotland (2025), were integrated into the GIS workflow. Canmore provides over 320,000 records of archaeological, architectural, industrial, and maritime heritage, supplied by Historic Environment Scotland and partner organisations. Two subsets were extracted for this study: terrestrial Canmore points, representing archaeological sites, historic buildings, industrial remains, and cultural landscapes across the Geopark; and maritime Canmore points, representing wrecks, documented losses, coastal structures, and underwater heritage. Both datasets are supplied in EPSG:27700 and after clipping to the Geopark boundary, terrestrial and maritime records were analysed separately to reflect their distinct heritage functions. Incorporating both terrestrial and maritime Canmore datasets allowed the GIS analysis to capture the full spectrum of cultural-heritage value of the landscape in the Geopark.

4.3 Terrain data

A 30-m resolution Digital Elevation Model (DEM) from the Copernicus GLO-30 dataset is used as the elevation source for terrain and slope analysis (Copernicus Data Space Ecosystem, 2026). Slope is a standard exclusion factor in suitability modeling, and upward slope is a major cost factor in walking routes, and steeper slopes significantly increase travel time and difficulty.

Slopes greater than 30° were classified as unsuitable for hiking-based activities. Slopes around 30° require zig-zag ascent, and around 35° might require scrambling, indicating terrain that exceeds normal walking difficulty and enters mountaineering conditions (Langmuir, 1995).

- It was first set to EPSG:27700 and Clipped to the Geopark boundary.
- Slope was calculated (degrees) using the QGIS *Slope* tool, 30° threshold applied in Raster Calculator to create a binary raster (1 = suitable, 0 = unsuitable).
- Raster was polygonised into vector polygons for overlay with other vector-based criteria.

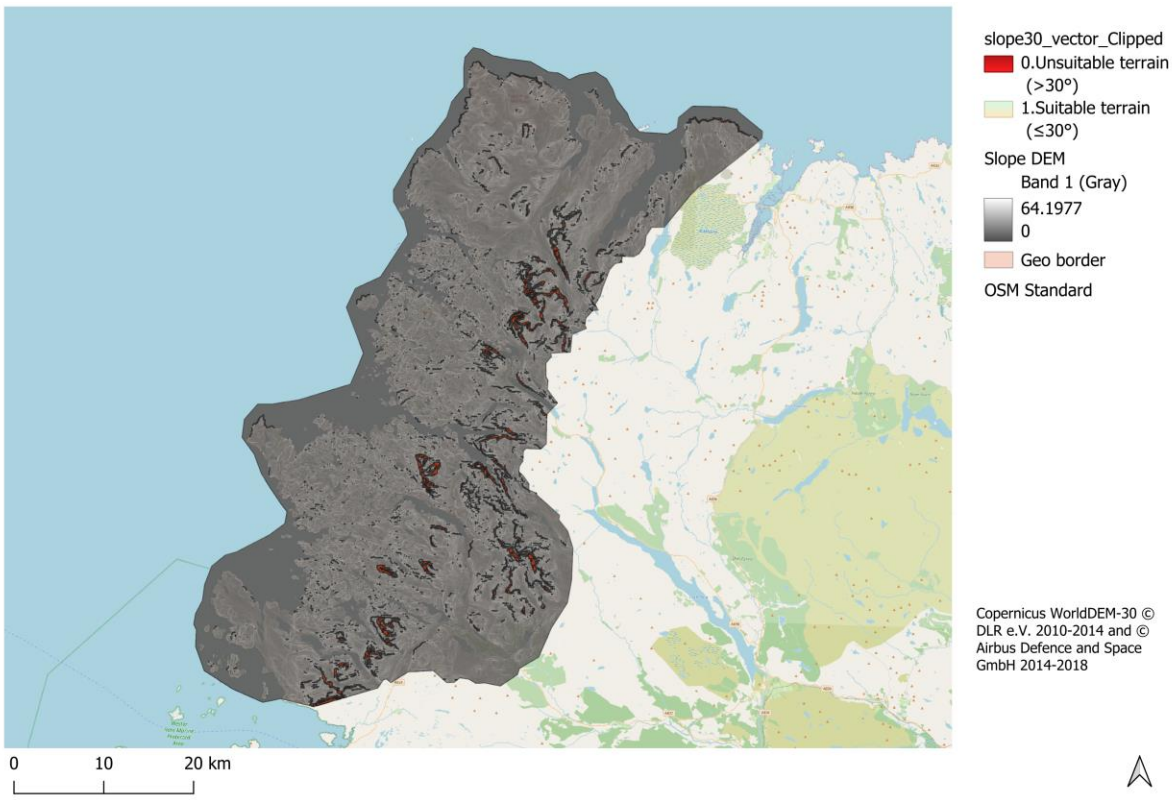

Figure 7. Slope-Based Landscape Suitability Classification.

Open Access repository

As part of the methodological contribution of this research, the GIS spatial dataset and the processed VGI tracks, will be prepared and deposited in an Open Access repository following FAIR data principles (Findable, Accessible, Interoperable, Reusable) (ESRI, n.d.). Ensuring that the data are properly documented and accompanied by metadata, enhances transparency and aligns with best practices in geospatial research. The project will be uploaded to a public repository at Zenodo (n.a.), where it can be cited or reused by researchers and community organisations.

4.4 Kernel Density Estimation (KDE), spatial patterns and organisation of data

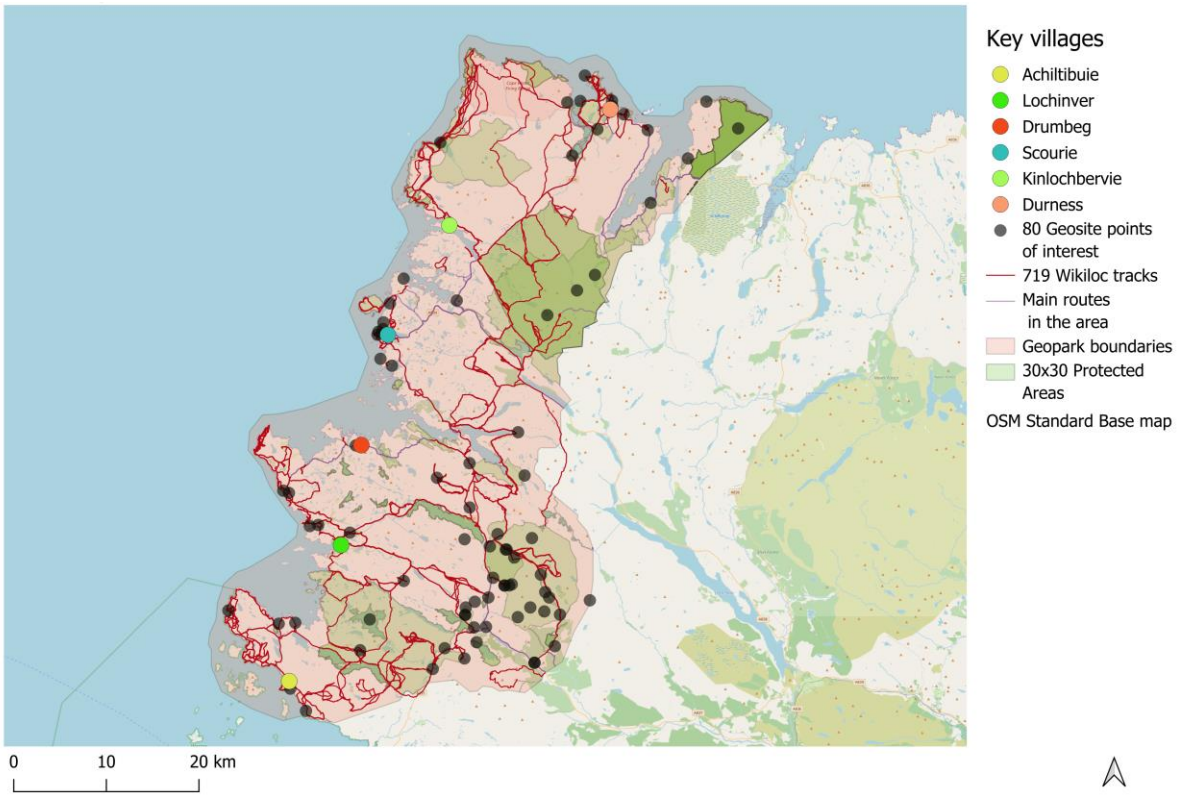

Figure 8. Geopark Overview after the creation of database

KDE is applied to the extracted GPS vertices to generate a raster of continuous surface representing the spatial intensity of visitor movement across the Geopark. The Extract Vertices tool was first used to convert all 719 Wikiloc tracks into point geometry. KDE was then run using a Gaussian kernel, a 300 m search radius, and a 50 m output cell size. The algorithm assigns greater weight to points closer to each raster cell, producing a smoothed representation of visitor intensity that highlights both localised hotspots and broader movement corridors.

Deriving high-intensity zones (top 20%)

Descriptive statistics for the KDE raster were obtained using the Raster layer statistics tool in QGIS, which reported a minimum of 2.55×10^{-12}, a maximum of 4,279.36, a mean of 27.92, and a standard deviation of 129.88 (n = 762,787 pixels).

To delineate high-intensity visitor zones, operational thresholds were defined for the upper 20% of KDE values. Thresholds were derived from the mean and standard deviation of the KDE raster, resulting in approximate cut-off values of 137 (top 20%) for subsequent binary classification. The KDE raster was reclassified into binary hotspot rasters using the Raster Calculator. Cells with KDE values greater than 137 as top-20% hotspots, with all remaining cells assigned to the background class. The hotspot raster was converted to vector polygons

using the Polygonize tool. Only polygons corresponding to hotspot cells (value = 1) were retained, producing discrete hotspot layers for top-20% KDE thresholds.

Calculation of hotspot statistics

For each hotspot layer, the area of individual hotspots was calculated using the Field Calculator, and total hotspot area was obtained by summing all features. The number of hotspots was recorded as the feature count, and hotspot area was expressed both in absolute terms and as a percentage of the Geopark area.

Overlap with geosites and protected areas

To assess alignment between visitor intensity and heritage assets, hotspot polygons were intersected with buffered geosites, and the overlapping area was calculated as a proportion of total hotspot area. Similarly, intersections between hotspots and protected areas were used to quantify the share of high-intensity visitor zones occurring within conservation designations.

4.5 Network and accessibility analysis

Local Accessibility: Distance from Villages to Nearest Track Point (Euclidean Distance)

Local accessibility between the six villages and the walking track network was examined using the "Distance to Nearest Hub (Points)" tool in QGIS. In this configuration, the villages were used as the origin layer (points), and the track network was converted into a dense set of points representing the vertices of each track segment.

Local Euclidean connectivity between the walking track network and the six villages.

In this configuration, the track network was used as the origin layer (lines), and the villages were used as the hub layer (points). For each track segment, the algorithm calculated the shortest straight-line distance from the segment's centroid to the nearest village and generated a connecting line representing this relationship. Distances were classified using natural breaks (Jenks) into five classes, expressed in metres.

Percentage of track segments assigned to each village and infrastructure dependent access metric (tracks, attractions, hotspots).

A pie chart was produced to illustrate the proportion of track segments assigned to each village. The chart shows the relative dominance of individual settlements as access points to the walking network. Infrastructure dependent access metric quantifies dependence on the road network by calculating the percentage of all track points located within 1 km of a road. It provides a simple, interpretable indicator of road-dependent access patterns, supporting later arguments about infrastructure shaping visitor flows.

4.6 Multi-criteria landscape suitability analysis

The final step is a vector-based multi-criteria decision-making approach (MCDM) that models and identifies landscapes with revitalization potential, proposed as a support tool and transparent platform for discussing community-specific opportunities.

MCDM is defined as a family of formal analytical techniques designed to evaluate multiple alternatives against a set of criteria, and to reveal how varying criteria shape and constrain spatial decision outcomes (Greene et al., 2011). In this study, the method incorporates buffered indicators: hotspots, distance-based accessibility measures, village influence zones, and proximity to heritage assets, to represent spatial relationships in a consistent and comparable way. All variables are normalised to a dimensionless 0-1 scale, allowing the model to evaluate the relative suitability of alternative landscape areas within a single decision space.

The model integrates four key and previously analysed thematic domains:

- Geo and natural heritage (geosites)
- Cultural heritage (Canmore terrestrial and maritime sites)
- Visitor movement (GPS tracks and KDE hotspots)
- Landscape context (terrain, access, and proximity factors)

Although the model is set up specifically to identify new potential heritage-rich landscapes away from hotspots and road corridors, its structure is modular. Distances, heritage sites, hotspots, and slope thresholds are adjustable, and new layers can be also added as either value or constrain, to address different research questions or planning scenarios.

- A 1000 m buffer was applied to both geosites and merged terrestrial and maritime Canmore sites to capture their wider landscape. These buffered layers were merged and dissolved to create a single polygon.
- Hotspot polygons were buffered (1000 m) to remove higher intensity visitor zones, and road corridors were buffered (1000 m) to exclude easy access sites and focus on new areas.
- Unsuitable slopes (>30°) were derived from the DEM, reclassified, polygonised, and added as a terrain constraint. All constraint layers were merged and dissolved.

Final suitability output and contextual overlays

- A Difference operation is used to subtract all unsuitable areas, producing the final “suitable landscape” layer.
- This output is then overlaid with protected areas to identify where revitalisation potential intersects with conservation designations.
- Finally, the model is intersected with 10 km village buffers, applied at the end to extract suitability zones for each settlement.

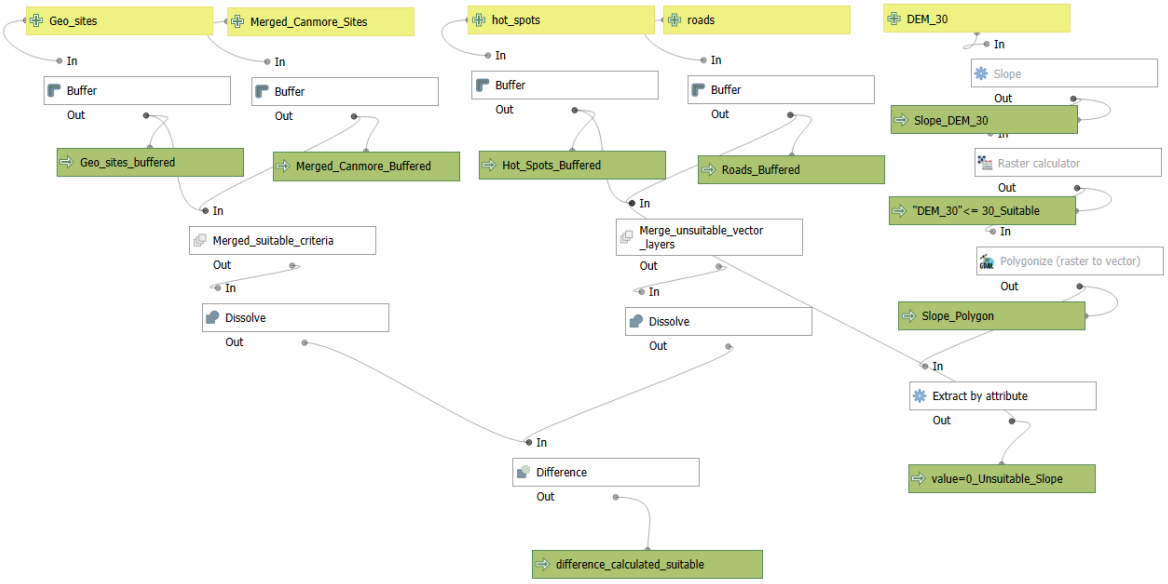

Figure 9. Landscape suitability model

After generating the regional suitability model (Figure 9), the final methodological step applies the results to the 10 km village buffers, representing each settlement's realistic sphere of influence. These buffers capture the landscapes that villages can interpret, manage, or benefit from, and provide a spatial unit for comparing revitalisation potential across the Geopark. Within each buffer, all relevant datasets, heritage, geoheritage, visitor movement, accessibility, protected areas, and the modeled suitable zones are overlaid to evaluate how landscape assets and visitor behaviour align with community opportunities.

Village buffers were allowed to overlap to reflect the reality that landscapes, visitor flows, and heritage assets are shared across settlements, as the study is not focused on strict comparison, but on relational geography. In this approach, features located in overlapping zones contribute to multiple villages, representing shared landscape influence, and therefore appear in multiple counts.

Table 5. Village-level analytical framework for revitalisation suitability

Criterion	***Indicators Used***	***Purpose in the Methodology***	***Reason for Inclusion***
Accessibility	*-Percentage of track segments assigned to each village* *-Slope suitability*	*Measures how strongly each village functions as an access hub for the surrounding network*	*Accessibility determines how easily visitors can reach landscapes from each settlement; villages capturing more track segments have greater potential to support revitalisation without major infrastructure investment*
Cultural Heritage Value	*- Terrestrial Canmore site count* *- Maritime Canmore site count*	*Captures the cultural richness and interpretive depth of each village landscape*	*Heritage assets enrich interpretation, storytelling, and community-led revitalisation; maritime sites reflect the coastal identity of the Geopark*

Geoheritage Value	*- Geosite count* *- Geosites inside suitable areas*	*Assesses geological significance and the potential for geotourism experiences*	*Locating geosites inside suitable areas checks if some sites remain unvisited and highlights new opportunities for interpretation, education, and low-impact tourism development.*
Visitor Engagement	*- Track point density* *- Hotspot count (top 20% KDE)*	*Identifies how visitors currently use each landscape and where activity is concentrated or absent*	*Understanding movement patterns reveals pressure points, under-used areas, and opportunities to redistribute flows*
Modelled Suitability Output	*- Suitable area (km) per village* *- % of 10 km buffer classified as suitable*	*Integrates all criteria into a final spatial assessment of revitalisation potential for each village*	*Synthesises accessibility, heritage, geoheritage, visitor use and slope, into a comparable measure of landscape potential*

4.7 Methodological limitations and advantages

Several limitations arise from the nature of VGI data, the structure of the GIS workflow, and the realities of the landscape and planning context.

VGI offers valuable insight into real visitor behaviour, but it is inherently selective. Wikiloc users tend to be more experienced, technologically engaged hikers, meaning the dataset reflects only a portion of the visitor's population.

The buffer-based approach captures broad patterns of accessibility and landscape influence, but it simplifies the complexity of movement on the ground. A 10 km village buffer effectively represents the spatial reach of rural hubs, and a 1 km road buffer highlights the strong dependence of visitors on infrastructure. Yet these tools cannot reflect qualitative aspects of mobility such as terrain difficulty, scenic value, or informal paths. As noted in rural tourism literature, accessibility is shaped as much by perception and landscape character as by distance; something buffers cannot fully express.

Heritage and geoheritage datasets also carry limitations. While they provide a rich inventory of cultural and geological assets, they do not distinguish between sites that are visitor-ready and those that are fragile, inaccessible, or lacking interpretation. All geosites are treated equally despite varying levels of significance. Some forms of heritage, particularly intangible or community-held knowledge, are not captured at all. This gap between inventory and visitor experience is well recognised in geoheritage planning and affects how revitalisation potential is interpreted. Also, the study assumes that current patterns reflect future potential, which may change if new facilities or trails are developed.

Overall, the methodology captures the spatial structure of visitor movement, the distribution of heritage and geosites, and the role of accessibility in shaping behaviour. It highlights the relative strengths and weaknesses of village landscapes and identifies where revitalisation is most feasible. What it cannot capture is the full diversity of visitor motivations, the quality of

experiences, the social dynamics within communities, or the economic and governance factors that influence implementation. These limitations underline the need to treat this study as a supporting tool rather than a prescriptive mechanism, and to integrate spatial evidence with community consultation, environmental assessment, and strategic planning.

5. Research results and discussion

5.1. Analysis of regional planning and governance documents

Geodiversity Audit and Action Plan 2013 - 2016

Based on the Action Plan, the key development and revitalisation objectives of the NWHG focus on the sustainable management, conservation, and promotion of its unique geodiversity for education, research, and ecotourism. These aims are to be achieved through actions such as the ongoing maintenance of a comprehensive Geodiversity Audit, integration of geodiversity into local and regional planning strategies, stakeholder engagement, and public education initiatives (NWHG, 2013).

Conservation objectives in the Geopark centre on the legal protection and active management of sites of geological and geomorphological significance. The plan emphasises monitoring site condition, prioritising sites at risk (such as those vulnerable to over-visitation or environmental degradation), and deploying targeted interventions such as signage or visitor guidance.

The geotourism development strategy is one of the park management principles, as it calls for the creation of interpretive panels, geotrails, and guided walks, with an emphasis on providing varying levels of accessibility and information suitable for both specialists and the public. There is a clear need, stated in the plan, to use a spatial approach and GIS to manage a master database of sites, monitor changes in use or condition, and optimise the location of visitor infrastructure to balance access with protection (NWHG, 2013).

Review and update on NW2045 Vision: Call to Action 2025.

Stakeholders in the NW2045 project include community groups, local development trusts, statutory bodies, charities and trusts, local government, and landowners (both community, private, and NGO) active in Coigach and North West Sutherland (Peach, 2025). It also collaborates with the Scottish Government, including the Addressing Depopulation Fund.

The key development and revitalisation objectives are focused on reversing chronic depopulation, fostering sustainable economic growth, and ensuring resilient, thriving communities across Coigach and North West Sutherland. Achieving these goals rests on addressing systemic barriers, including housing affordability and availability, accessible services, and local economic diversification (Peach, 2025).

Conservation objectives in the NW2045 Vision are intertwined with the area's identity and future, emphasizing the stewardship of globally significant biodiversity, protected landscapes, and natural capital, such as peatlands and woodlands that contribute disproportionately to

Scotland's net zero and biodiversity targets (Peach, 2025). The plan highlights the need for community voice and benefit in renewable energy and nature-based projects, and for local heritage, including language, history, and culture to be preserved and integrated into development strategies.

Tourism is recognised as a double-edged sword, vital for the local economy but also a source of pressure on infrastructure, services, and the environment. The strategy advocates for sustainable, community-led tourism that leverages the area's globally important scenery, Geopark status, and cultural heritage, while investing in infrastructure and managing visitor numbers to mitigate negative impacts (Peach, 2025). Initiatives such as slow tourism, heritage interpretation (through museums and trails), and digital connectivity are encouraged to enhance accessibility and visitor experience.

The NW2045 Vision repeatedly highlights spatial questions related to the extremely low population density, uneven access to services, and the distribution of housing, economic activity, and infrastructure across a vast and remote geography. The report calls to action for national and regional policy to be informed by local knowledge, using spatial analysis to ensure that investment, services, and development are distributed equitably and in line with community priorities (Peach, 2025).

Rural and regional disadvantage in the highlands and islands

The stakeholders involved, span local, regional, and national levels and include Highlands and Islands Enterprise (the commissioning body), local authorities, the Scottish and UK Governments, community councils, development trusts and local businesses and social enterprises.

The Highlands and Islands region's development objectives focus on addressing structural disadvantages linked to peripherality, population sparsity, and poor accessibility, with an emphasis on enabling infrastructure (transport, digital, housing), green and blue economy opportunities, and community resilience (Indigo House, 2022). Achieving these goals relies on place-based policy, targeted funding, and improved data to capture rural realities, with explicit recommendations for nuanced, small-area indicators and better use of spatial analysis. However, the report also questions whether local, bottom-up initiatives can effectively deliver spatial justice.

While the report's main focus is socio-economic disadvantage, it repeatedly underscores the importance of conserving and leveraging the region's unique natural and cultural assets as the foundation for sustainable development, green recovery, and tourism. Conservation objectives thus include protecting high-value landscapes, ensuring biodiversity, and maintaining the attractiveness of rural and island communities for both residents and visitors (Indigo House, 2022).

Tourism is identified as both an economic strength and a source of pressure on local services, infrastructure, and housing. The strategy advocates for sustainable, year-round tourism that supports community wellbeing, maximises local benefits, and mitigates negative impacts such as housing affordability and service congestion. The report also highlights the opportunity for

digital and spatial technologies to enhance heritage interpretation and accessibility (Indigo House, 2022).

Critical spatial questions are raised on the distribution of disadvantage, access to services, and the location of economic and development opportunities. Key questions include: Where are the gaps in infrastructure and services, and how does population change, housing affordability, and access to employment vary spatially?

Highlands and Islands Regional Economic Partnership Regional Economic Strategy 2025-2035

The strategy is authored and published collectively on behalf of a broad and collaborative regional partnership of stakeholders. They include local authorities, Highlands and Islands Enterprise, the University of the Highlands and Islands, NatureScot, VisitScotland, and a range of business representatives and third sector organisations.

The key objectives for the Highlands and Islands are to create a dynamic, connected, resilient, and prosperous region with a balanced and growing population, embedding community wealth building, supporting Scotland's transition to net zero, and enhancing the natural environment (HIREP, 2024).

These aims will be achieved through collaborative regional action focused on six strategic goals: raising the region's profile to secure investment, delivering affordable housing, improving transport and digital infrastructure, building resilience through entrepreneurship and innovation.

Conservation objectives in the strategy are closely tied to safeguarding and enhancing the region's natural capital, including peatlands, woodlands, marine environments, and biodiversity, while supporting economic growth and climate resilience. The strategy recognises the pivotal role of environmental quality, landscape, and heritage assets in attracting investment, supporting sustainable tourism, and delivering on net zero ambitions (HIREP, 2024).

Sustainable tourism is a key opportunity, aiming for balanced growth that creates community and economic benefits while protecting the environment and heritage that underpin the visitor economy (HIREP, 2024). Success depends on investing in transport and digital connectivity, supporting innovation in hospitality, and enhancing the interpretation of cultural and natural heritage to attract high-value, year-round visitation. The strategy calls for place-based approaches, community involvement, and the leveraging of digital tools to manage visitor flows, improve accessibility, and ensure that tourism growth aligns with conservation and community wellbeing (HIREP, 2024).

Spatial questions concern regional disparities in population, housing, connectivity, service access, and economic opportunity, with particular emphasis on sparsity, remoteness, and the cost of delivering services across a large, dispersed geography (HIREP, 2024). Addressing these requires spatial data, mapping of infrastructure gaps, monitoring of service accessibility and housing availability, and targeted investment in areas of greatest need. The strategy

proposes the creation of a regional economic intelligence hub to support spatial analysis and evidence-based planning.

5.2 Discussion: establishing links between rural revitalization, conservation, and nature-based tourism

How do the regional documents reflect stakeholders' objectives and relate to literature?

Across the Geodiversity Audit, NW2045, the Rural and Regional Disadvantage Report, and the HIREP Strategy, stakeholders raise questions that closely mirror the concerns similarly raised in rural development and geotourism literature. Lane & Kastenholz (2015), Loras-Gimeno et al. (2025), and Ballesteros et al. (2021) emphasise that peripheral regions must mobilise their natural and cultural assets to support revitalisation, diversify rural economies, and strengthen governance structures. The documents echo these priorities: NW2045 calls for community-led tourism and improved interpretation; the Geodiversity Audit stresses monitoring site condition and managing visitor pressure; and HIREP highlights the need to leverage heritage and landscape assets to support sustainable growth.

These align with Cheer's (2024) argument that revitalisation depends on activating "countryside capital" through local agency and benefit-sharing. Likewise, the Geodiversity Audit's emphasis on spatially informed site management parallels Rodrigues et al. (2021) and Alcalá (2018), who show that geoparks must use spatial planning to distribute visitor flows, protect sensitive sites, and create coherent interpretive networks. In this sense, the regional documents and the literature converge around the same core challenge of organizing tourism in ways that reinforce community resilience and regional revitalisation rather than exacerbate structural vulnerabilities and territorial capacity.

To address that challenge and counter the vulnerability, stakeholders' management of the commons demands a transition toward a new model of open governance. Bichler (2021) argues that destination management has historically remained highly industry-centric, adhering to a prevailing discourse that prioritizes short-term market competitiveness and economic efficiency over long-term, localized societal interests. Consequently, while residents feel an innate responsibility for their destination and are deeply impacted by local conditions, their participation within existing governance mechanisms is frequently marginalized or reduced to tokenistic involvement that lacks any genuine redistribution of decision-making power.

A central issue across these regional planning documents is the stark gap between top-down institutional metrics, or what Moscardo (2011) terms "purported knowledge", and the realities of rural communities (Bichler, 2021). Relying on standardized national tracking indicators often masks extreme localized deprivation, transport poverty, and acute housing shortages. As previously established (Figure 6), successfully managing the Geopark territory requires a vertical and horizontal governance architecture capable of cross-coordinating hierarchic authority with local economic diversification and community retention needs.

Bichler (2021) validates presented policy synthesis, echoing the unified call from regional stakeholders across the *NW2045 Vision*, the *HIREP Strategy*, and the Indigo House report

(2022), for place-based investments to fight depopulation and infrastructure gaps. To bridge this operational divide, regional partnerships should function as administered knowledge networks to reduce information gaps and balance power asymmetries (Sanz-Ibanez and Anton Clave, 2019), and public bodies like Highlands and Islands Enterprise (HIE), the University of Highlands and Islands, and the broader HIREP partnership can serve as strategic intermediaries in this space. By launching regional intelligence hubs and commissioning targeted, place-based spatial research, these organizations gather decentralized local insights and convert them into empirical data. Aided with transparent, rigorous data, Geopark management and community trusts can directly challenge administrative decisions that fail to account for small-area indicators.

How do these synergies translate into the aims of the research?

The policy documents repeatedly highlight the need for spatially explicit evidence to guide investment, manage visitor numbers, and ensure that development aligns with conservation and community priorities. The Groundwork for Slow Tourism report identifies the absence of visitor-flow data as a major barrier to effective planning, while NW2045 calls for place-based decision-making informed by local knowledge and spatial analysis.

The GIS methods are designed to answer the very questions raised by stakeholders and anticipated in the literature. Lane & Kastenholz (2015) argue that rural tourism succeeds when assets are organised into coherent experiences; Ballesteros et al. (2021) show that heritage clusters can anchor revitalisation and the analysis operationalises these concepts by identifying where coherence between assets, access, and visitor flows already exists and where it is fragmented.

Taken together, the literature, policy documents, and spatial analysis form a framework that advances the thesis objectives. The literature provides the conceptual foundation, and the planning and policy documents articulate the practical agenda of stakeholders seeking community-led development and spatially informed decision-making. The spatial analysis delivers the missing evidence: it shows how landscape, heritage, and visitor flows are distributed across the Geopark and where opportunities for revitalisation exist.

5.3 Spatial Organization of Visitor Flows, Trail Networks, and Heritage Landscapes

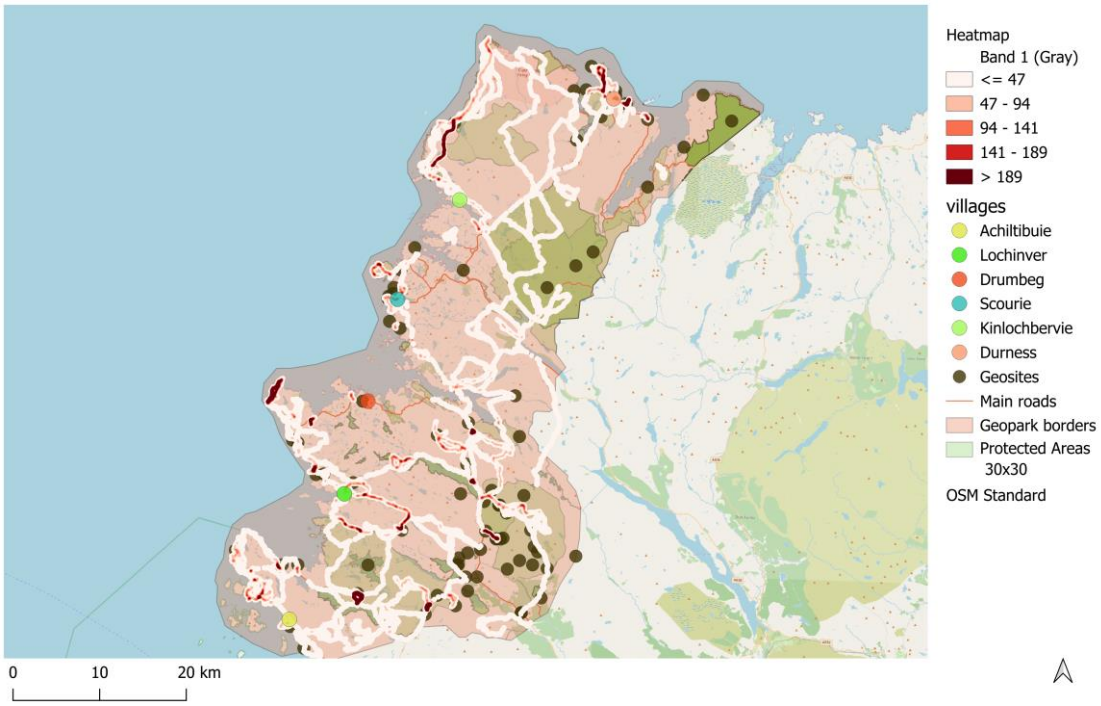

Figure 10. Kernel Density Estimation (KDE): relative index of spatial intensity of the visitor movement across the geopark

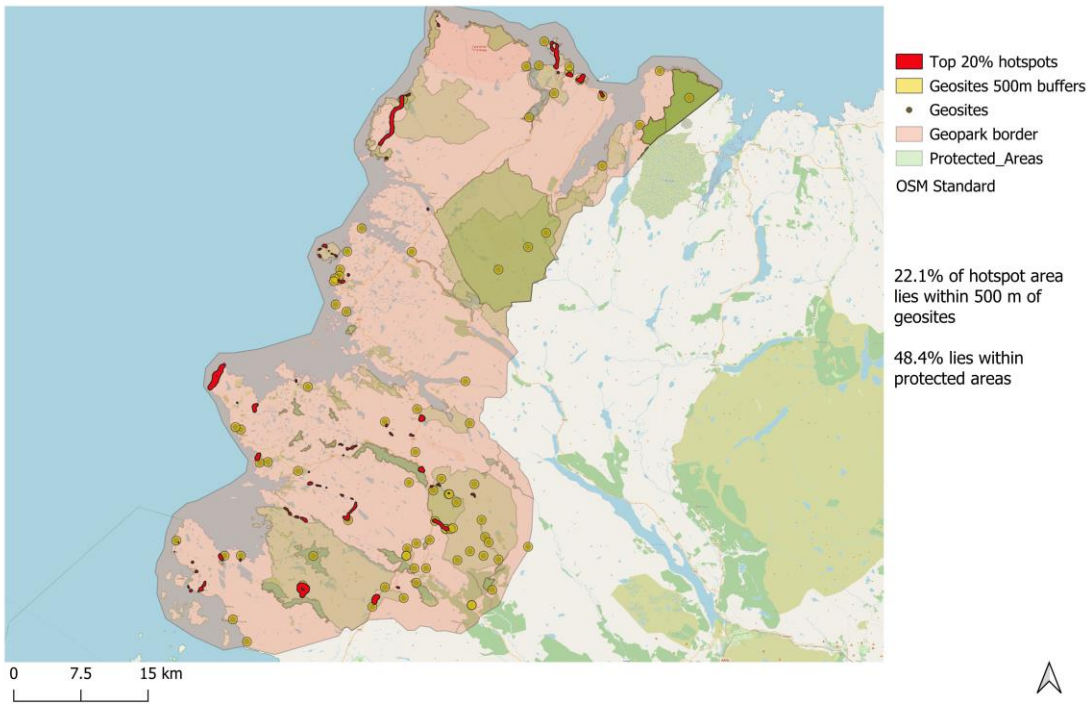

Figure 11. Top 20% Visitor Hotspots and Their Overlap with Geosite Buffers (500 m) and Protected Areas

KDE (Figure 10) highlights several concentrated hotspots. A kernel value represents the estimated density (or concentration) of features within a specific search radius around any given location. High Kernel values (> 189, dark red) represent severe spatial bottlenecks or "hotspots.", Mid-range values (47 to 189, light red) represent transition zones or standard travel corridors where the tracks do not concentrate, and low values indicate moderate movement. Well-known attractions and viewpoints often very accessible from car parks or villages such as: Stac Pollaidh, Knockan Crag, Old Man of Stoer, Sandwood Bay and Smoo Cave, and a network of linear corridors corresponding to frequently used approach routes. The findings confirm that visitor use is highly uneven: a small share of the landscape receives the majority of recorded movement. Several geosites and few larger areas received no visits based on the used data.

The 64 hotspot polygons (top 20% KDE) cover a total area of approximately 1,615 hectares (16.15 km²), representing about 0.8% of the total area of the NWHG (approximately 2,000 km²) (Figure 11). Geosites were buffered (500 m) and an Intersect operation was performed between hotspot polygons and geosite buffers. The area of overlapping polygons was summed and expressed as a percentage of total hotspot areas. A total of 356.89 ha of hotspot area intersects the 500 m geosite buffers, representing approximately 22.1% of all high-intensity visitor zones. Hotspot polygons were also intersected with protected area polygons. Overlapping area was calculated and expressed as a percentage of total hotspot area. A total of 781.69 ha of hotspot area overlaps with protected areas, representing approximately 48.4% of all high-intensity visitor zones within the Geopark.

What we can establish based on these findings is that visitor hotspots are strongly associated with designated conservation landscapes, but only a smaller subset is directly linked to geosite proximity.

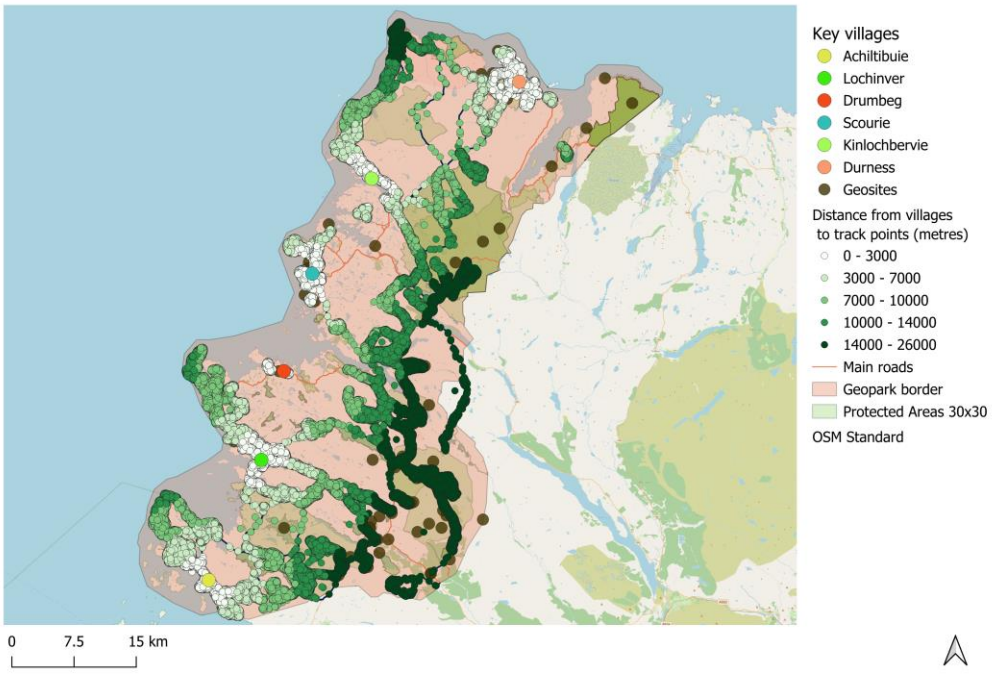

Figure 12. Local Accessibility: Distance from Villages to Nearest Track Point (Euclidean Distance)

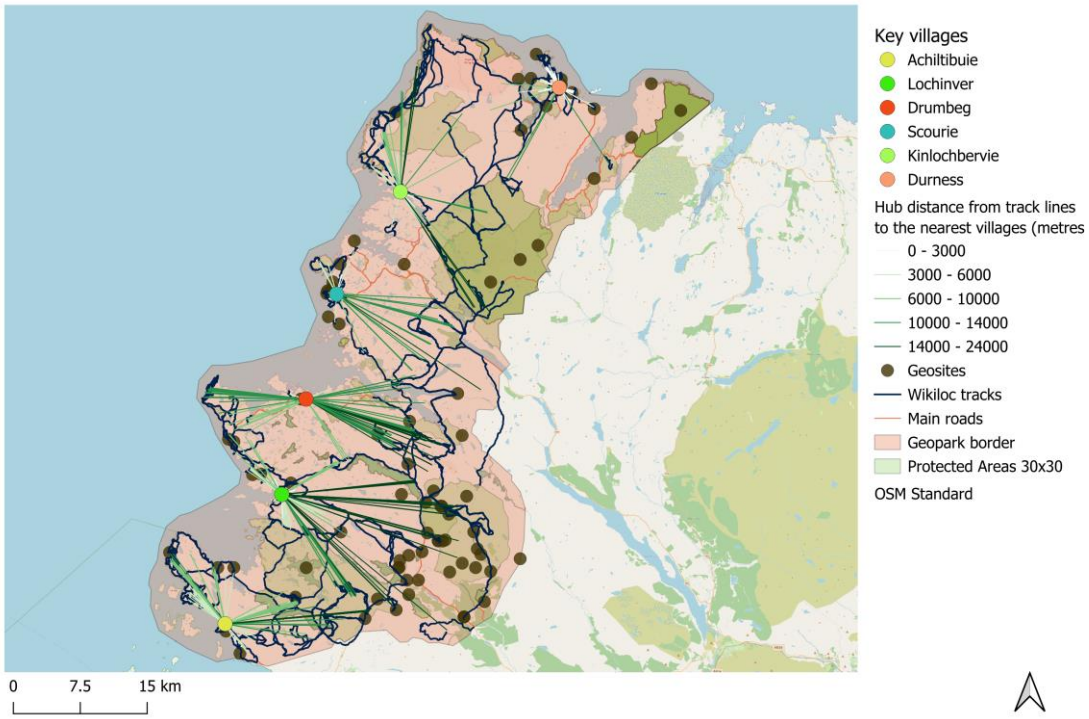

Figure 13. Local Connectivity Between Villages and the Walking Track Network (Euclidean Distance)

Local accessibility map (Figure 12) illustrates that Durness, Lochinver, Scourie and Achiltibuie have the shortest distances to track points (0-3000 m) and that they are structurally well-positioned for walking tourism. Local geography and road network determine limited opportunities for Kinlochbervie, and importantly, Drumbeg shows weak integration of close-by landscape value and clear need for trail development, interpretation, or infrastructure to unlock its landscape potential.

The hub lines (Figure 13) stretching into the central and eastern portions of the Geopark and predominantly falling into the 14,000 to 26,000 meters, confirm pattern observed across both maps: a coastal-inland divide and absence of settlement nodes to service in the interior track network.

Although the eastern part of the Geopark appears underserved and weakly connected in the village-track accessibility analysis, this pattern must be interpreted in the context. Visitor activity in this area is largely supported by the Geopark Visitor Centre in Unapool, which functions as a major access node independent of the surrounding villages. As a result, the apparent disconnection reflects settlement structure rather than an absence of visitor infrastructure there.

Accessibility and use of protected areas can be also evaluated from the map. Out of 141,218 Wikiloc track points, 58,087 fall within protected areas, representing 41.1% of all recorded visitor movements. This demonstrates that protected landscapes form a core part of the visitor experience within the Geopark.

Achiltibuie accounts for the largest share of all assigned track segments at 28.8% (Figure 14), followed by Lochinver with 22%, Drumbeg with 18.1%, Durness with 12.4%, Kinlochbervie with 11.7%, and Scourie with 7.09%, and this distribution is important because it shows how visitor movement is unevenly structured across the Geopark, revealing where revitalisation strategies are most likely to succeed.

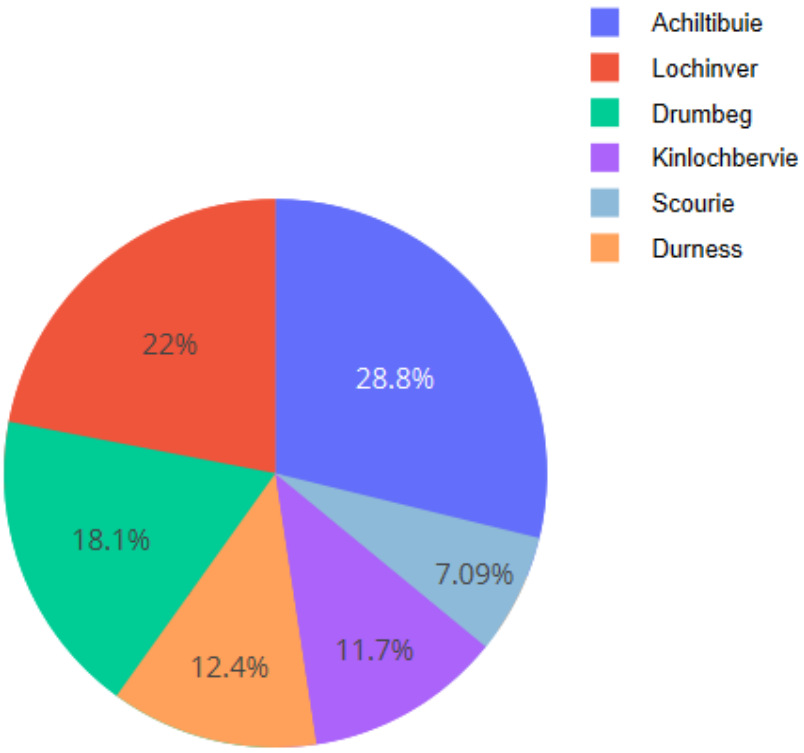

Figure 14. Percentage of track segments assigned to each village

Overall, the distribution implies two distinct operational zones. The coastal tracks likely experience higher footfall and are easier to manage or supply due to their proximity to village infrastructure and can readily support tourism and localized walking activities. Conversely, the inland tracks and Geositses demand a different management approach, as their high distances from villages pose significant barriers to access communities, emergency response, and infrastructure maintenance. This isolation, however, does not apply to the main road and NC500 and its own scattered infrastructure.

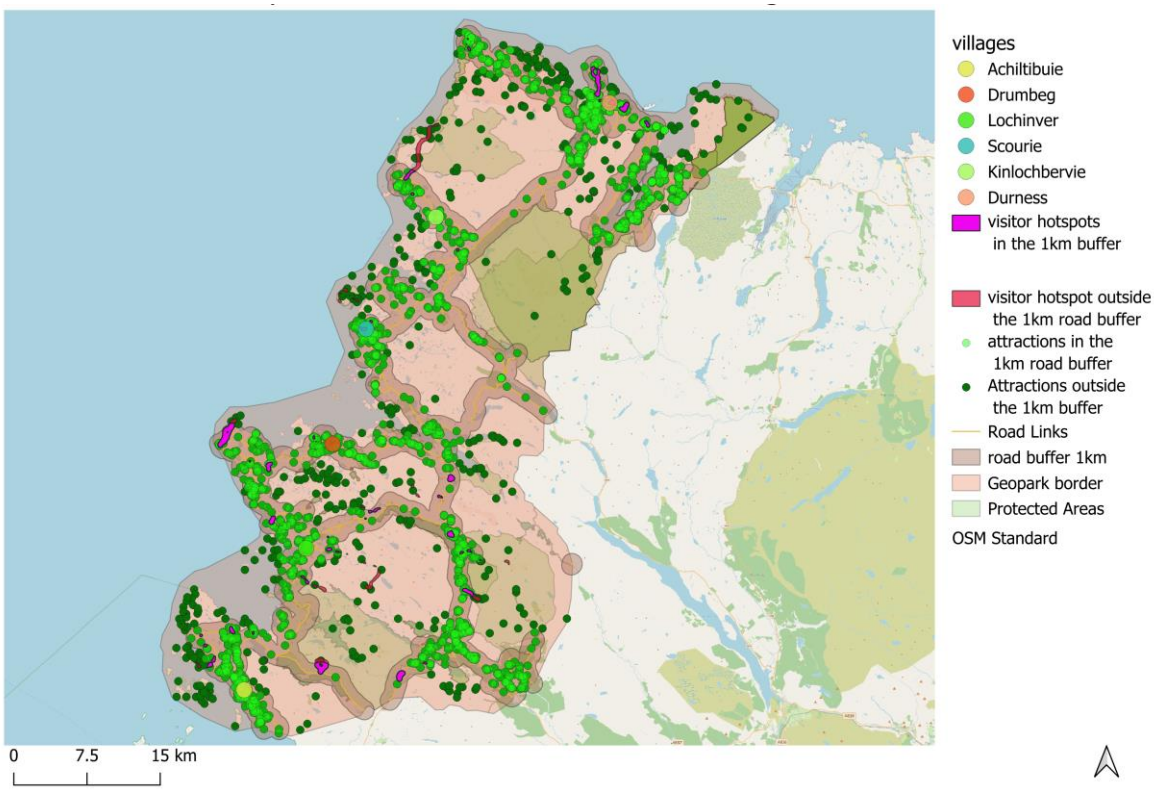

Figure 15. Road Accessibility Influence on Visitor Flows and Heritage Sites

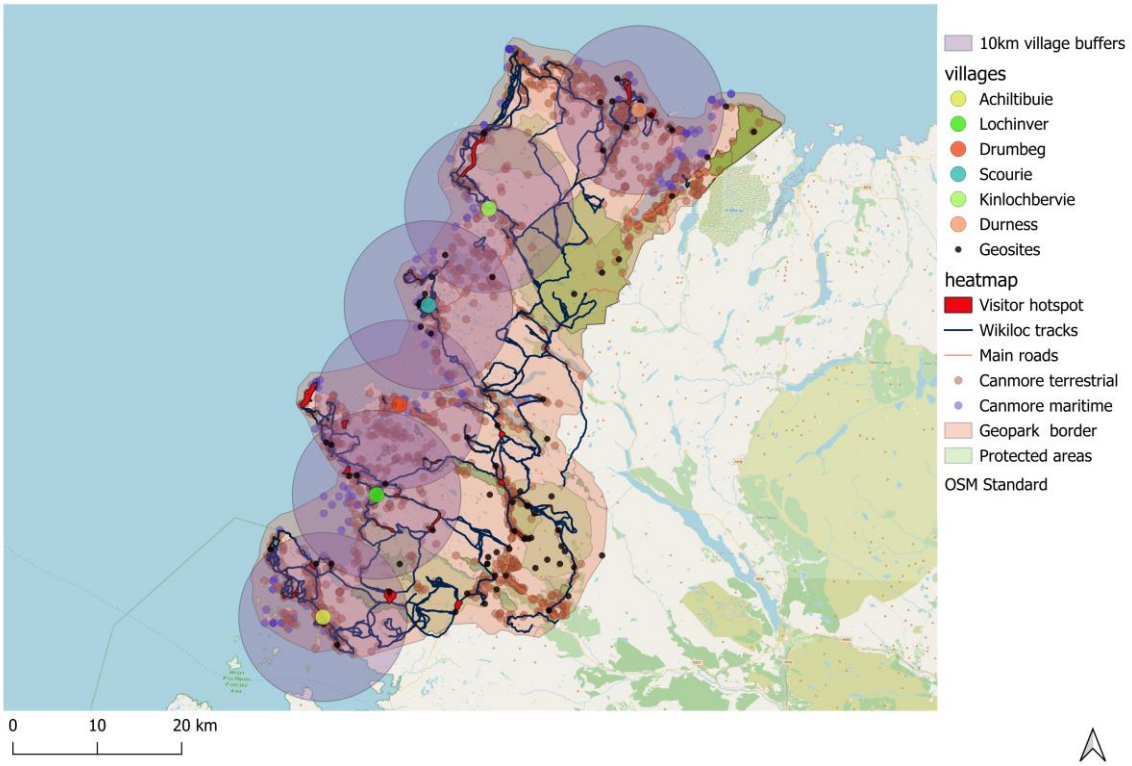

Figure 16. Village 10 km Influence Zones with Integrated Geosites, Heritage and Visitor Movement Data

Key findings from road accessibility and village buffer analysis (Figure 15 and 16) are that 3% of all merged attractions lie within 1 km of the road network. Moreover, 55.8% of all Wikiloc track points fall within the same 1 km buffer, and 67.2% of hotspots are fully or partially within 1 km of roads.

Across the datasets obtained from road buffer analysis (Figure 15), visitor engagement with the landscape shows a clear dependence on proximity to the road network. Out of 1,899 merged attractions, 1,375 fall within 1 km of the road buffer, meaning that 73% of all heritage assets are road-proximate. Similarly, 153,322 of 274,941 Wikiloc track points lie within 1 km of the road network, representing 55.8% of all recorded visitor movement. High-intensity use areas show the same pattern: 43 of 64 top-20% hotspots are fully or partially within the 1 km buffer, equivalent to 67.2%, indicating that hotspots are also strongly road-dependent.

Together, it demonstrates that visitor behaviour in the Geopark is fundamentally shaped by infrastructure, with both heritage engagement and movement patterns clustering around accessible corridors. This has direct implications for planning, and revitalisation strategies will likely benefit from infrastructure-linked visitor behaviour, recognising that proximity to villages and roads is a key determinant of use.

Buffering villages and roads therefore provides a method for identifying well-connected revitalisation zones, where landscape assets, visitor flows, and community nodes align.

Table 6. Village Buffer Summary Statistics Table

Village	***Maritime Records***	***Terrestrial Records***	***Geosites***	***Hotspots***	***Track Points***
Achiltibuie	*19*	*234*	*5*	*10*	*28,251*
Drumbeg	*25*	*241*	*8*	*12*	*10,595*
Durness	*49*	*324*	*10*	*5*	*15,434*
Kinlochbervie	*24*	*151*	*3*	*4*	*16,162*
Lochinver	*22*	*218*	*8*	*17*	*17,918*
Scourie	*23*	*161*	*10*	*8*	*6,066*

In addition, the role of Canmore sites capturing additional cultural, archaeological, and geomorphological value that enriches the interpretive potential of each village must be acknowledged (Table 6). This historical context and its processes produced the distinctive landscapes that continues to shape the region's land use, infrastructure, and development trajectories and are essential for interpreting the patterns in analysis, with dense clusters of terrestrial and maritime heritage. Villages such as Durness (49 maritime, 324 terrestrial) and Drumbeg (25 maritime, 241 terrestrial) contain dense clusters of cultural and archaeological sites that reflect long histories of settlement and economic restructuring in the Highlands. Even where individual features are small or isolated, their cumulative presence documents the legacy

of fishing, crofting, estate management, and demographic change, processes that shaped the region's land use, infrastructure, and spatial organisation.

These heritage patterns and areas with rich archaeological landscapes do not always correspond to areas of high visitor movement, revealing possible gaps in interpretation and accessibility. At the same time, villages with fewer heritage records but high track-point counts, such as Lochinver (17,918) or Kinlochbervie (16,162), demonstrate how mobility networks can overshadow deeper historical landscapes, but it can provide a powerful foundation for low-impact, high-quality interpretation that can support rural revitalisation.

5.4 Multi-criteria landscape suitability analysis

In the current buffer parameter and threshold setting (Figure 9), the presented model aims to identify precisely the kind of landscapes that escape visitors' attention due to infrastructure dependent mobility and cumulative effect of popular sites that generate hotspots of activity. Consequently, it can identify latent high-potential zones that could relieve pressure on overused sites (Figure 17) and translate the conceptual aims of the thesis and previous findings into a spatial decision-support tool.

Maritime heritage sites and their buffers were included in designing opportunity zones, even though many lie offshore or on small islands and require different access strategies, because they form an essential part of the wider coastal landscape of the Geopark. These features: wrecks, coastal structures, and underwater records, shape how visitors perceive the seascape, contribute to the region's cultural identity, and reflect long histories of fishing, navigation, and coastal settlement. Including them ensures that the suitability model captures the full character of the landscape and recognises the visual and interpretive importance of the sea. The underlaying premise and epistemic stance are that all knowledge is valid and can be useful in future interpretation planning.

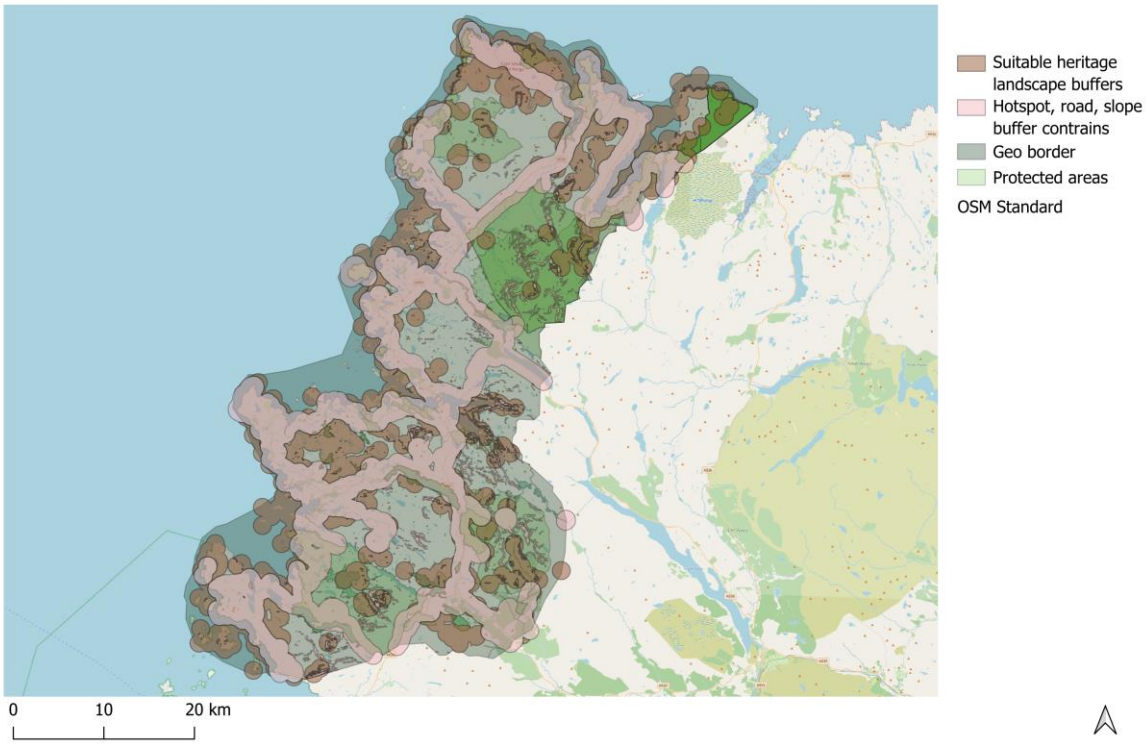

Figure 17. Regional Landscape Suitability Map

'Revitalisation opportunity zones' emerge where heritage value, walkable terrain, reasonable accessibility and community proximity coincide, often within or adjacent to protected areas (Figure 17). Approximately 527.6 km² or 24.8% of the Geopark's territory is classified as suitable for such development, with substantial overlap (23.9%) with the 30x30 protected-area network.

Unsuitable slopes (>30°) cover approximately 7,589.53 ha of the NWHG, representing around 3.6% of the total Geopark area (212,592.3 ha). Therefore. they do not represent major constraints on accessibility planning for identified landscapes.

The model is highly flexible and enables extensions, scenario-based planning, long-term adaptability, and wider methodological relevance. Because buffer distances, slope thresholds, and exclusion criteria can be adjusted, communities can explore different revitalisation strategies: for example, a slow-tourism scenario that reduces road influence and emphasises remote geosites, or a family-friendly scenario that lowers slope thresholds to prioritise accessible terrain. The workflow is also designed to incorporate new datasets as they become available, such as ecological surveys, or newly developed trails, allowing the model to evolve without structural redesign. Finally, the transparent, modular structure of the model makes it transferable to other geoparks, protected areas, or rural regions seeking to balance heritage, access, and conservation, demonstrating its broader applicability beyond the immediate case study.

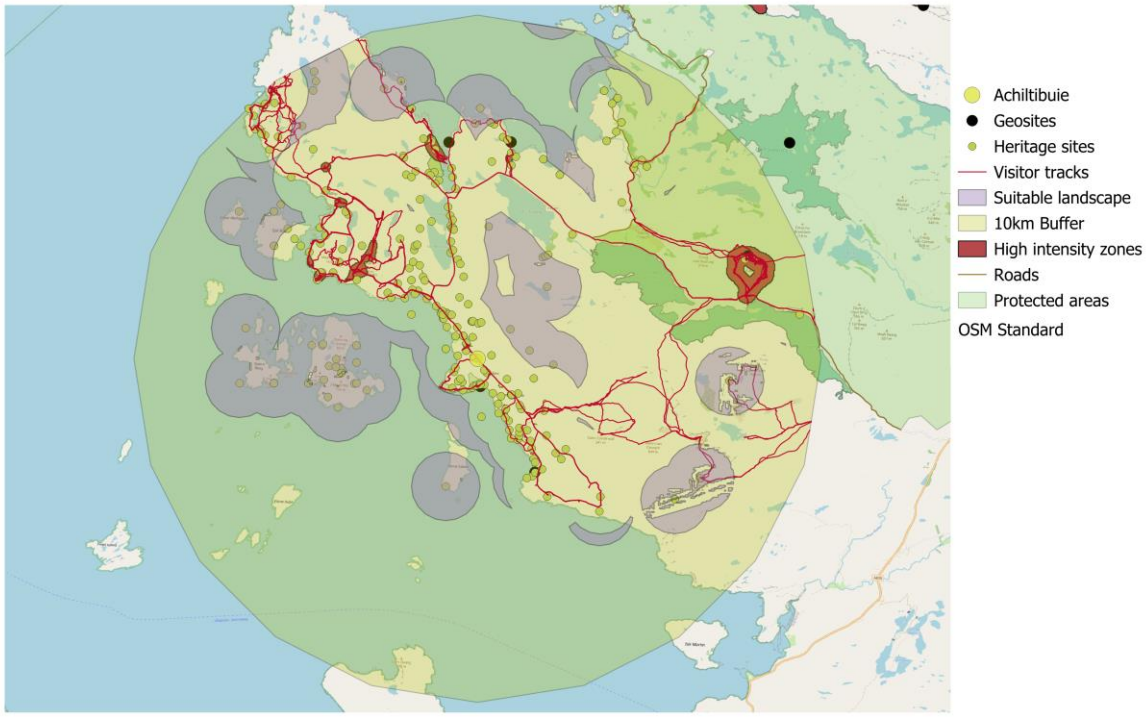

Figure 18. Landscape Suitability Around Achiltibuie (10 km Radius)

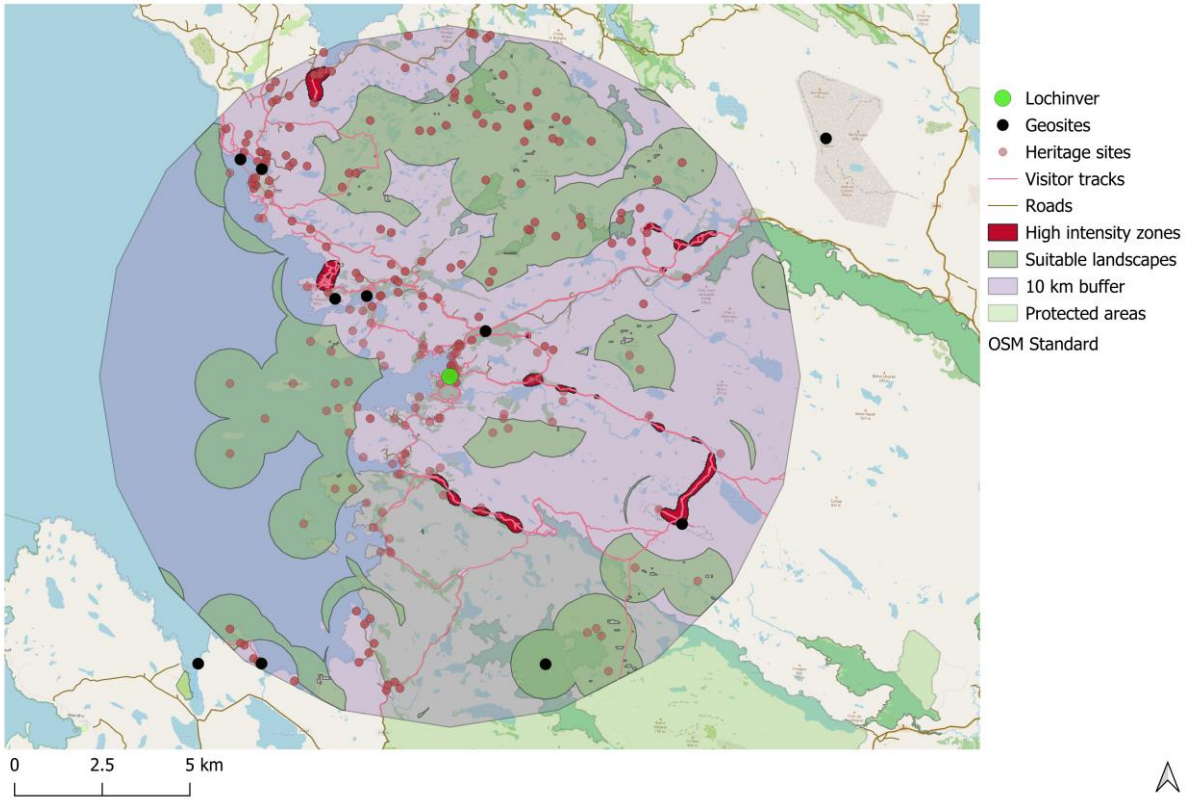

Figure 19. Landscape Suitability Around Lochinver (10 km Radius)

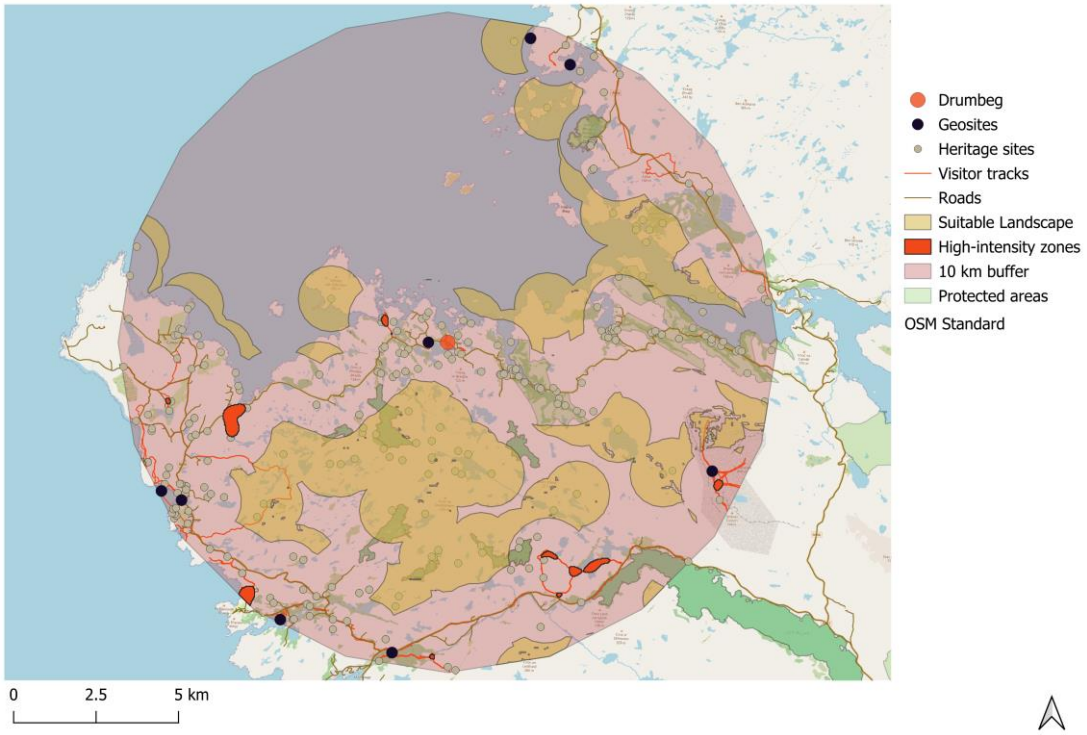

Figure 20. Landscape Suitability Around Drumbeg (10 km Radius)

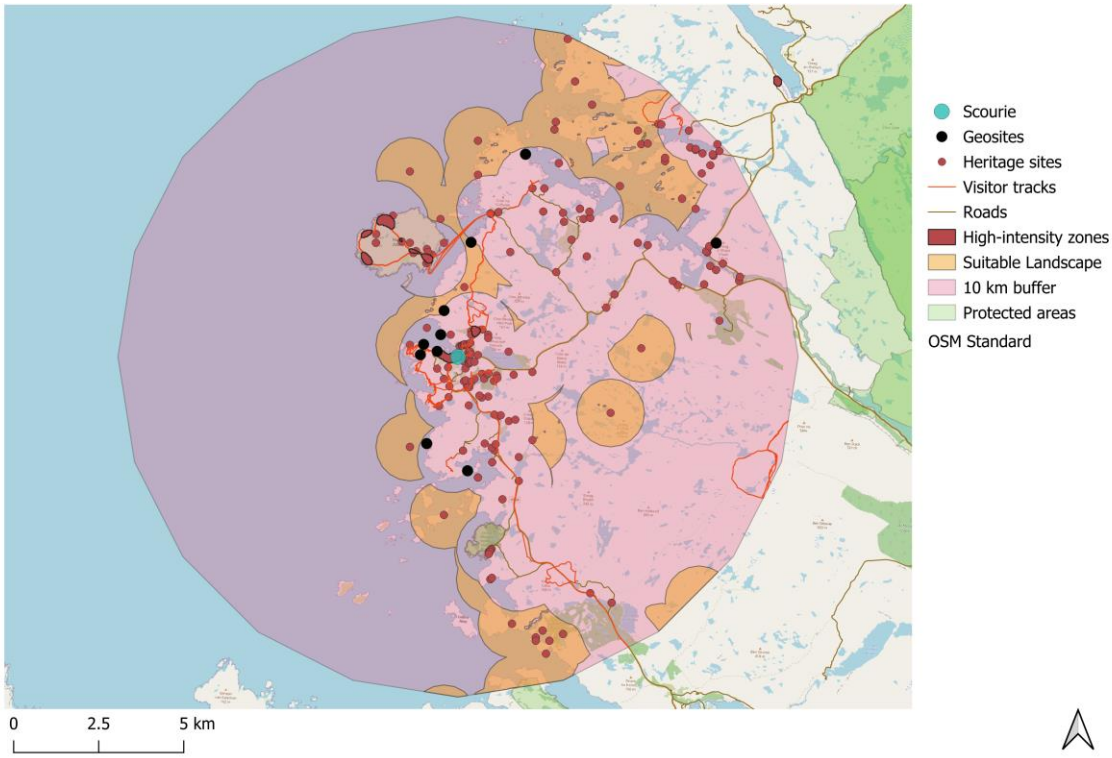

Figure 21. Landscape Suitability Around Scourie (10 km Radius)

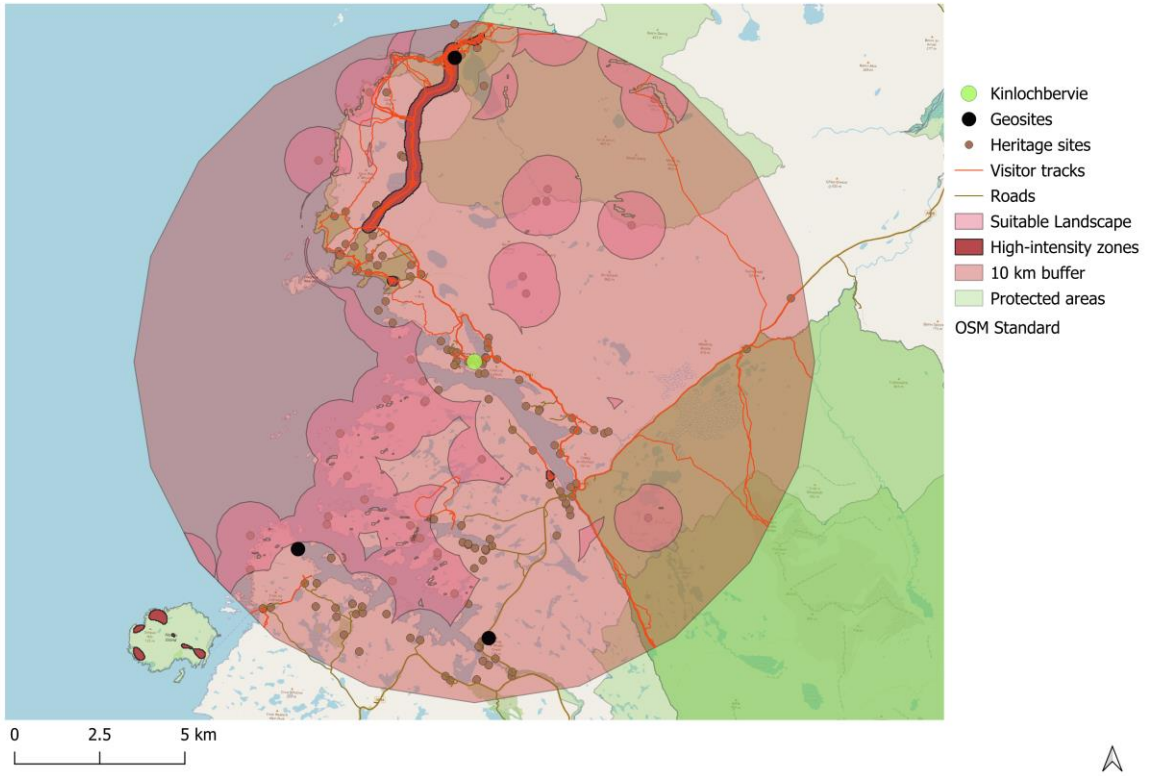

Figure 22. Landscape Suitability Around Kinlochbervie (10 km Radius)

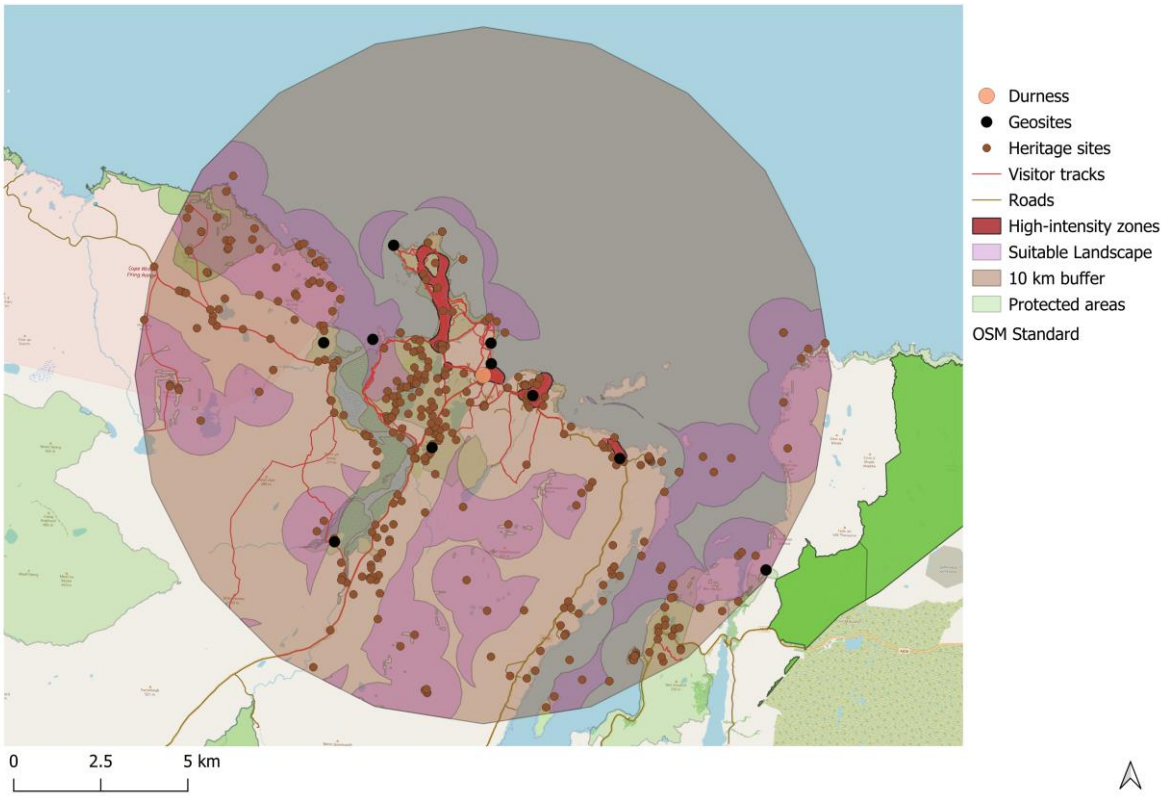

Figure 23. Landscape Suitability Around Durness (10 km Radius)

What the suitability maps highlight is where landscapes with unexplored heritage potential are (Figures 18-23). These landscapes are not easily accessible, not highly visited, and have good walking potential based on slope attractiveness. Importantly, they are linked to the history of the region, and their level of integration with protected areas can be assessed or expanded.

The Suitability Output (Table 7) shows that all six villages contain meaningful areas of revitalisation potential, often shared, though the scale and spatial configuration of these areas vary. Lochinver has the largest suitable area (86.19 km², 27.43% of its buffer), closely followed by Durness (82.34 km², 26.21%) and Drumbeg (71.50 km², 22.76%), while Achiltibuie, Kinlochbervie, and Scourie contain more moderate but still significant suitable extents.

As a result, combined potential of geo and bio-cultural heritage in the landscapes can be clearly communicated and investigated further with the assistance of community and regional planners. That could offer new opportunities for interpretation of regional history, employment, and a sense of place for the local community, important in its efforts to attract people to relocate and revitalize the region.

Additionally, the suitability study shows that 23.9% of all suitable areas overlap with the 30×30 protected-area network, but also 48.4% of hotspot area already falls within protected zones, indicating that visitors are naturally drawn to these conserved environments. The strongest opportunities lie in zones that coincide with protected natural areas, showing that conservation policies have effectively preserved high-value landscapes. These areas can offer high potential for sustainable tourism, which if carefully managed, can contribute financially to their continued protection. In geotourism research, similar patterns are observed: landscapes safeguarded through conservation designations tend to retain the geological, cultural, and scenic qualities that make them ideal for interpretation-based tourism (UNESCO, 2024).

Many identified areas are made up of small and scattered spaces and are of less significant value. However, where heritage points cluster, the likelihood of developing meaningful interpretation and experiences is higher. Interestingly, Durness (Figure 23) has 3 geosites that fall within the potential revitalisation landscape, and that finding suggests pathways for development. Most geosites in the buffering process were already excluded based on higher visitor activity, accessibility or far distance from villages (isolated northeastern sites prominently requiring further investigation). Because the study mainly explored additional landscape value that connects it to the central value of geosites, that observation particularly stands out.

A key aspect of buffering is that some suitability zones often belong to more than one settlement where village buffers overlap. For example, the largest suitable landscape appears in both Lochinver and Drumbeg's 10 km buffers (Figures 19 and 20), indicating a shared opportunity zone. Spatially, this makes sense: the area lies between the two villages and is accessible from both. However, the patterns of visitor movement differ sharply. Lochinver shows evenly distributed track networks, while Drumbeg shows limited visitor activity near the village. This contrast raises important spatial question: Why does a landscape close to Drumbeg remain under-visited, and if there are missing trails, interpretation gaps, or access barriers?

Could collaborative planning between the two villages unlock that shared potential? These questions cannot be answered by GIS alone, but the mapping provides a clear starting point for community participation, stakeholder workshops, and scenario exploration. The model therefore does not prescribe solutions but reveals where conversations should begin and addresses wider questions of regional inequalities and distributions of visitor flows and investments.

However, a few aspects of complexity in the development of these opportunities are omitted; seasonality being an important one. Despite that, the research acknowledges the role of facilities that could accompany heritage tourism, likely to perform multiply functions and benefit the local community. Visitor flows in the NWHG fluctuate sharply across the year, and these temporal dynamics influence both the feasibility and sustainability of new initiatives. As noted in rural tourism research, facilities that support geo and heritage-based tourism often serve multiple community functions, particularly in sparsely populated regions where infrastructure must be adaptable and resilient (Loras-Gimeno et al., 2025). Successful revitalisation depends not only on attracting visitors but on creating flexible, community-anchored assets that deliver value throughout the year (Rodrigues et al., 2021). In this sense, the model invites to enhance local services, reinforce place identity, and support long-term community wellbeing.

Table 7. Integrated Indicators Supporting Landscape-Based Revitalisation Assessment

Criterion	***Indicators***	***Achiltibuie***	***Drumbeg***	***Durness***	***Lochinver***	***Kinlochbervie***	***Scourie***
Accessibility	*Percentage of track segments assigned to each village*	*28.8%*	*18.1%*	*12.4%*	*22%*	*11.07%*	*7.09%*
Cultural Heritage Value	*Terrestrial Canmore sites*	*234*	*241*	*324*	*218*	*151*	*161*
	Maritime Canmore sites	*19*	*25*	*49*	*22*	*24*	*23*
Geoheritage Value	*Geosite count*	*5*	*8*	*10*	*8*	*3*	*10*
	Geosites inside suitable areas	*0*	*0*	*3*	*1*	*0*	*0*
Visitor Engagement	*Track point density*	*28,251*	*10,595*	*15,434*	*17,918*	*16,162*	*6,066*

	Hotspot count	*10*	*12*	*5*	*17*	*4*	*8*
Modelled Suitability Output	*Suitable area (km²)*	55.98 km²	71.50 km²	82.34 km²	86.19 km²	57.03 km²	46.88 km²
	% of buffer classified as suitable	17.82%	*22.76 %*	26.21%	*27.43 %*	18.15 *%*	14.93 *%*

5.5 Summary of research results for question 1

Table 8 synthesizes the spatial analysis to answer the first research question regarding the Geopark's spatial organisation and translates the GIS outputs into a consolidated framework of six conditions for landscape-based revitalisation.

Table 8: Geoparks spatial conditions for landscape-based revitalisation potential

Revitalisation Conditions	***Justification***
Substantial heritage value	*Dense clusters of geological, terrestrial, and maritime records create strong interpretive foundations, and the analysis shows that 73% of all heritage assets lie within 1 km of roads, making them accessible for low-impact development*
Visitor flows are present but not excessive	*KDE results show that only 0.8% of the landscape forms high-intensity hotspots, leaving extensive areas with moderate use that are ideal for sustainable tourism without adding pressure to carrying capacity and low-impact visitation (Newsome et al., 2013)*
Terrain is walkable	*With only 3.6% of the Geopark excluded due to steep slopes, most suitable areas offer favourable walking conditions, aligning with slow-tourism and geotourism principles*
Accessibility is reasonable	*The road-buffer analysis shows that 55.8% of all track points and 67.2% of hotspots fall within 1 km of roads, confirming that opportunities cluster around existing access corridors*
Conservation designations strengthen low-impact development	*The model shows 23.9% of suitable areas overlap with protected landscapes, supporting literature that emphasises the compatibility of conservation and nature-based tourism (UNESCO, 2024; Rodrigues et al., 2021)*
Communities are within reach	*Large number of suitable areas fall within 10 km village influence zones, when these buffers overlap, many opportunity zones are shared and reinforce collaborative planning*

5.6 Summary of research results for question 2

Building upon the spatial conditions presented in the previous section, table 9 addresses the second research question: how heritage interpretation and visitor planning can operationally support regional revitalisation. It synthesizes multi-criteria landscape suitability analysis into actionable planning strategies.

Table 9: Heritage interpretation and visitor planning actions supporting revitalisation

Planning Action	***Justification and evidence***
Activate under-visited heritage landscapes with innovative approaches	*The heritage density and track-point distribution within territory, highlight areas where interpretation can reveal overlooked cultural and geological value. Attention to biocultural landscapes and community-led heritage initiatives demonstrate how interpretation activate under-recognised heritage (Emmet & Nye, 2017; Represa-Pérez, 2025)*
Redistribute pressure away from over-visited hotspots	*With 48.4% of hotspot area inside protected zones, offering alternative routes in suitable landscapes can reduce ecological stress while enhancing visitor experience*
Strengthen village-based tourism economies	*As suitable areas were modelled within community influence zones, benefits from new trails, interpretation, or facilities naturally circulate back into local economies and there is evidence it can sustain local services and reinforce territorial cohesion (Price et al., 2025; Loras-Gimeno et al., 2025)*
Create coherent geotrails linking combined bio-cultural heritage clusters	*Spatial clustering of geosites and Canmore records naturally combine geological, cultural, and maritime narratives and can be integrated into coherent visitor experiences (Represa-Pérez, 2025; Hose, 2026)*
Support slow-tourism strategies aligned with NW2045	*Walkable terrain, heritage-rich landscapes stimulate low-impact, immersive, educational and place-based tourism.*
Enhance community resilience through place-based development	*Identifying landscapes where heritage, access, and community proximity converge, supports long-term resilience by reinforcing local identity and diversifying rural economies*

5.7 Summary of research results for question 3

The synthesis in Table 10 evaluates GIS and VGI approaches as meaningful tools for deconstructing landscape usage. Their effectiveness is contingent upon their integration into the wider governance framework of the Geopark, and greater inclusion, since this study relied on visitor data only. By encoding local knowledge and lived experiences directly into spatial

data, it can provide a decentralized tool that bridges horizontal peer networks to the formal hierarchic planning framework, forcing vertical planning to confront ground-level opportunities. With all limitations as well as challenges of implementation considered, the methodological evaluation in Table 10 confirms that the GIS and VGI framework can be an effective revitalisation tool and governance technology.

Table 10. Integrated advantages and challenges of GIS and VGI

Method + Application	***Advantages***	***Challenges***
Understanding visitor behaviour - using VGI to map flows, hotspots, and gaps	*VGI provides fine insight into how landscapes are used and experienced; aligns with citizen-science logic and distributed observation (Parker et al., 2013; Flanagin & Metzger, 2008)*	*Participation bias: Data collection for the study, as well as literature (Flanagin & Metzger, 2008) reveals that mainly experienced, tech-engaged hikers participate; other visitor types excluded*
Accessibility and movement patterns - using buffers, KDE, and trail overlays	*GIS integrates roads, trails, terrain, and village influence to reveal structural patterns of movement.*	*Buffer methods can simplify mobility and travel time*
Heritage distribution and biocultural value - mapping geosites and cultural clusters	*GIS reveals dense clusters of cultural, geological, and maritime heritage supporting interpretation planning*	*Heritage inventories treat all sites equally; intangible heritage and interpretive readiness are not captured*
Participatory and open governance & community knowledge - using VGI as citizen-science input	*VGI can enable visitors and residents to co-produce spatial knowledge; supports participatory governance and community-led stewardship (Elwood, 2008; Represa-Pérez, 2025)*	*Uneven digital access and uneven participation can reproduce inequalities in remote rural areas (Elwood, 2008)*
Suitability and revitalisation potential - using GIS to identify opportunity landscapes	*GIS produces transparent, replicable suitability zones aligned with heritage, access, and visitor flows; supports small-scale, community-led revitalisation*	*Assumes current patterns reflect future potential; It requires additional layers and field consultations*
Interpretation and geotrail planning - aligning spatial patterns with interpretive design	*Spatial patterns support design of geotrails and interpretive routes that reinforce relationships (Emmet & Nye, 2017; Newsome et al., 2013)*	*GIS alone cannot assess narrative quality, community meaning, or interpretive readiness of sites*
Transferability and strategic planning - GIS+ VGI	*Framework is adaptable to other protected landscapes; supports scenario planning and adaptive management*	*Requires integration with environmental assessment, and governance processes*

5.8 Bridging the gaps: space, participation, and interpretation

Against this backdrop, the framework offers a way to bridge gaps between spatial patterns, community knowledge, and heritage interpretation and it provides a shared platform for communities and Geopark managers to discuss opportunities grounded in existing patterns of use, rather than externally imposed visions, an important corrective given the region's history of top-down planning.

For that reason, the effectiveness of integrated GIS and VGI analysis in the North West Highlands must be understood within the region's long and complex economic history, as these legacies continue to shape tourism opportunities and vulnerabilities today, influencing how communities engage with development and how visitors experience the landscape (Lennon & Harris, 2020; White et al., 2024).

Ultimately, it's the communities that should shape and create their heritage and the interdependence of ecological and cultural values (Emmet & Nye, 2017; Bria & Casanova Vásquez, 2022), and this positions VGI as a citizen-science resource, offering insights that traditional monitoring systems in remote regions like the Highlands cannot easily capture. The same participatory logic that underpins community-led heritage stewardship also should apply to tourism: visitors and residents can contribute spatial knowledge that helps identify sensitive areas, under-used heritage landscapes, emerging pressures, and opportunities for revitalisation.

In this historic and relational perspective of heritage and landscape as a living resource and ongoing process of co-creating relationships between people and places, VGI can take an important role in contemporary nature-based tourism and landscape research. As Elwood (2008) argues, VGI incorporates the observations and experiential knowledge of new constituencies: including residents and visitors, into spatial decision-making and a diversity of understandings of the physical environment (Flanagin & Metzger, 2008). Taken together, such contributions are highly valuable in the revitalising and planning initiatives and can offer original insights for remote geoparks seeking low-impact infrastructure solutions and 'recycling 'of abandoned legacies (Hose, 2026).

There is strong evidence that interpretation strengthens the education-knowledge-awareness relationship (Newsome et al., 2013), and that under-recognised heritage can be activated through tourism (Represa-Pérez, 2025; Bria & Casanova Vásquez, 2022). VGI can support finding that heritage potential and with interpretive and participatory approaches, encourage local knowledge and narratives, both old and new, to produce new planning solutions to current regional challenges.

Figure 24. The ‘Bridge Between Two Continents’ Reykjanes peninsula, Iceland. The bridge joins the Eurasian and North American continental tectonic plates. Source: Dowling (2013)

6. Recommendations

6.1. Use spatial evidence for communication and strengthening of community planning of geo-tourism

This study can be used to aid the development of revitalisation zoning within NWHG, and shows that revitalisation potential is strong in areas adjust to where visitor flows and accessibility overlay and where heritage value remains unexplored, with the combined datasets revealing clear spatial patterns that communities can use to guide planning and interpretation.

Conceptual frameworks for interpretation often fail at implementation due to limited resources or expertise (Rosado-González et al., 2023), capacity building should therefore focus on helping local groups to translate presented in the thesis heritage clusters into accessible trail networks, and visible landscape features into coherent visitor experiences that reinforce conservation objectives and distribute flows more evenly across the Geopark.

6.2. Leverage spatial data for decision-support to develop regenerative infrastructure

Institutionalise the use of GIS and VGI in Geopark framework, for monitoring visitor flows and guiding facilities and infrastructure investment to areas with revitalisation potential. Regional strategies such as HIREP (2024) call for promotion of the region's assets to attract new investment, and spatial analysis and visitor management are clearly stated objectives of a range of stakeholders (NWHG, 2013; Peach, 2025; The Groundwork for Slow Tourism report, 2021). By maintaining a shared, open-access repository of GIS and VGI suitability models, horizontal peer networks can present an empirical "counter-narrative." allowing community groups to proactively challenge and explore new planning decisions and justify targeted funding bids.

6.3 Expand VGI and participatory approaches across all stakeholders

The value of VGI as a participatory tool in remote protected landscapes emerges as important factor in achieving thesis objectives. The Geopark should expand VGI and participatory approaches beyond visitor data to include residents, landowners, community groups, and other stakeholders, recognising VGI as both a monitoring tool and a form of inclusive governance aligned with UNESCO principles and offering a low-cost, scalable method particularly suited to remote regions with limited institutional capacity.

Digital connectivity remains a major weakness in remote rural areas (Indigo House, 2022), so participatory mapping and collaborative interpretation planning must complement digital tools. By embedding VGI and participatory methods into long-term governance, the Geopark can build a more resilient, inclusive, and spatially informed approach to heritage tourism and rural revitalisation.

7. Conclusions

7.1 Summary of the research

This thesis began by highlighting a paradox of the North West Highlands, in how it is losing population while simultaneously attracting increasing numbers of visitors. This contradiction raised fundamental questions about how communities can benefit from tourism in ways that support local wellbeing and protect fragile landscapes. Consequently, it set out to address three interconnected questions: how visitor flows, trail networks, and heritage sites are spatially organised within the North West Highlands Geopark; how heritage landscape planning can identify new opportunities for rural revitalisation; and how effective and transferable GIS and VGI approaches used in the thesis are in supporting communities and Geopark management.

The analysis demonstrates that visitor behaviour, heritage distribution, accessibility, and landscape character form a highly structured and uneven geography within the North West Highlands Geopark. Visitor activity is highly concentrated: the 64 hotspot polygons

representing the top 20% of KDE intensity, cover only 1,615 ha (16.15 km²), equivalent to 0.8% of the Geopark's territory. Despite their small footprint, these hotspots intersect substantially with areas of high heritage and conservation value. 356.89 ha (22.1%) of hotspot area lies within 500 m of geosites, while 781.69 ha (48.4%) overlaps with protected areas. This confirms that protected landscapes form the core of the visitor experience; a pattern reinforced by the fact that 58,087 of 141,218 Wikiloc track points (41.1%) fall within protected areas.

Visitor movement is also unevenly structured across settlements. Achiltibuie accounts for 28.8% of all assigned track segments, followed by Lochinver (22%), Drumbeg (18.1%), Durness (12.4%), Kinlochbervie (11.7%), and Scourie (7.09%). These figures show that a small number of villages capture most visitor flows, while others remain peripheral, shaping where revitalisation strategies are most likely to succeed.

Accessibility emerges as a dominant organising force. Across all datasets, visitor engagement shows a strong dependence on proximity to the road network. 73% of all merged attractions (1,375 of 1,899) lie within 1 km of roads, and 55.8% of all Wikiloc points (153,322 of 274,941) fall within the same buffer. High-intensity use areas follow the same pattern: 67.2% of hotspots (43 of 64) are fully or partially within 1 km of roads. These patterns confirm that road-proximate landscapes are the primary interface between visitors and the Geopark.

Terrain constraints are minimal. Slopes steeper than 30° cover 7,589.53 ha, only 3.6% of the Geopark, meaning that most landscapes are physically accessible for walking-based tourism. This supports the feasibility of low-impact, trail-based revitalisation across a wide range of settings.

These spatial relationships converge in the identification of revitalisation opportunity zones. The model classifies 527.6 km², or 24.8% of the Geopark, as suitable for landscape-based revitalisation. Notably, 23.9% of these zones overlap with the 30×30 protected-area network. These areas are not presented as fixed development sites, but flexible spaces inviting further investigation, where communities and Geopark managers can shape context-specific initiatives.

Furthermore, the findings directly address the theoretical friction between hierarchical and peer governance systems outlined in this study. State and public authorities, operating from centralized hubs, frequently rely on uniform metrics that fail to capture the nuanced realities of sparse peripheries. The study analyses visitors and proposes local communities as planning partners capable of demanding spatially explicit investments that align with their distinct carrying capacities and revitalization goals.

7.2 Relevance, transferability, future research

The approach developed in the thesis is transparent, adaptable, and transferable to other remote and protected regions.

The relevance of the research lies in directly addressing gaps identified in the literature, the case study, and strategic frameworks such as NW2045 and HIREP, all of which highlight the absence of spatial research in UNESCO sites, particularly within the NWHG and call for community participation and capacity building. The findings show that VGI and GIS can

strengthen local agency, support participatory planning, and contribute to wider debates on revitalisation and landscape management.

Second, the results are transferable by showing how by reorganising how visitors engage with the landscape, communities can activate heritage assets in ways that generate local benefit. This is particularly important in regions facing demographic decline and shrinking institutional capacity, where evidence-based planning helps villages identify their strengths and mobilise them creatively. The results also raise strategic questions about zoning within the Geoparks and are highly relevant for UNESCO Global Geoparks, Biosphere Reserves, and other protected areas, where visitor management, heritage assets, and community needs intersect. By adopting this approach, stakeholders can transform tourism and its processes into an active tool for conservation and local resilience.

Third, the current demographic dynamics and uncertainty about the future within the NWGH demand new approaches, synergies, and interpretations to revitalize the region and consequently attract residents to live and manage the ongoing change for their benefit, as well as visitors and wider territory. The revitalising potential of landscape and heritage presented in this thesis is both a product of past processes and a resource for future development. Building on this foundation, future research could expand this framework by incorporating stronger ecological component and a suite of nature-based solutions, as well as propose new physical interpretation site designs and their locations, aligning interventions with shifting demographic realities, and the people's changing relationship with landscape, identity and environment.

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