

## Research Article

# Enhancing outdoor recreational experience: A methodology for assessing peri-urban greenway suitability based on hiker physical activity levels and motivations

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## ABSTRACT

This study presents an innovative methodology for assessing greenway suitability by integrating hiker profiles. The main objectives of the study are to design a method for calculating greenway suitability for different hiking profiles, based on physical activity levels and motivations, and to carry out a proof of concept on an official greenway. Applied to the 34 km Green Ring greenway in Tarragona, Spain, the approach categorises hikers into nine hypothetical profiles combining three activity levels (inactive, active, very active) and three motivations (nature appreciation, cultural heritage, physical activity). Using Geographic Information Systems (GIS) and fieldwork, the greenway was analysed through four key indicators (comfort, difficulty, naturalness, and culturalness) which were normalised into a unified scale. The Potential Suitability Value (PSV) metric was developed to measure greenway compatibility with different hiker profiles through custom algorithms prioritising profile-relevant indicators. Results highlighted marked variability in suitability, with the greenway being most favourable for inactive hikers motivated by nature, while those seeking physical challenges found lower compatibility due to limited greenway difficulty. The methodology demonstrates scalability, offering a framework for sustainable greenway management, personalised recommendations, and enhanced user satisfaction. Overall, the study bridges recreation and sustainable land management, promoting enhanced trail and greenway experiences, fostering better health outcomes, and encouraging deeper engagement with greenways.

## 1. Introduction

Practicing outdoor exercise in peri-urban and rural environments through multi-use trails or greenways offers significant benefits for both physical and emotional health (Breitenstein & Ewert, 1990; Kerr et al., 2012). Hiking, cycling, or running are common physical activities for multi-use trail users, further enhancing these benefits (Corning et al., 2012). Greenways, commonly featuring multi-use trails, are natural corridors or purposefully adapted pathways dedicated to non-motorised travel, designed to enhance physical activity, recreation, and sustainable transport (Akpınar, 2016; Senes et al., 2017). In urban and peri-urban environments, they are often integrated into existing natural corridors, public rights of way, repurposed railway lines, or canal networks (Senes

et al., 2017). Due to their accessibility and availability, they promote physical and sports activities, enabling users to meet the physical activity recommendations set by professionals (Brownson et al., 2000; Corning et al., 2012; Evenson et al., 2005; Neff et al., 2000; Schasberger et al., 2009; Wan Omar et al., 2012; G. Wang et al., 2004; Xie et al., 2022). Beyond the health benefits, users' motivation is not limited to fitness outcomes. In the case of hikers, various studies indicate that many also seek to enjoy the outdoors, relax, appreciate nature, and experience a greater sense of independence (Corning et al., 2012; Wan Omar et al., 2012; Watts & Bauer, 2022).

A satisfying hike largely depends on meeting the individual expectations of users. A pleasant environment or an attractive landscape are key aspects that influence the motivation to walk (Davies et al., 2012;

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Obradović & Tešin, 2022). These motivations vary among hikers, shaping their attitudes, perceptions, and satisfaction with the outdoor experience (Dorwart, 2015; Dorwart et al., 2010). Farías Torbidoni (2011), based on a study of motivations, classified hikers into three main groups: nature-minded, sporting and general-purpose hikers. Other studies have also shown that factors such as escaping the daily routine and connecting with nature are of great importance to greenway users (Keith et al., 2018; Mayer & Lukács, 2021). Therefore, hikers have diverse motivations, which can be sporting, ecological, naturalistic, or recreational-cultural (Vías et al., 2014, 2018). Understanding these motivations is crucial for greenway planners and managers, as it allows them to design and manage trails in ways that align better with the expectations and desires of users (Cordeiro & Alves, 2022; X. Wang et al., 2022; Zhang et al., 2019).

No single greenway is universally suitable for everyone, as the motivation to choose a particular route depends on multiple factors, particularly the individual profile of each user (Farías-Torbidoni et al., 2020; Vías et al., 2014, 2018; Vías & Ocaña, 2014). In addition to personal motivations, environmental and greenway characteristics, such as the attractiveness of the landscape, the quality of the terrain, and the presence of monuments or natural features, play a key role in the user experience (Molokáč et al., 2022). Variables like safety, accessibility, proper paving, panoramic views, and regular greenway maintenance influence hikers' behaviour and their level of physical activity (Farías Torbidoni et al., 2005; Farías-Torbidoni et al., 2020; Wan Omar et al., 2012). Elements such as rest areas, benches, and trees are crucial for those with physical limitations, enhancing walkability and promoting recreation in open spaces (Artigues et al., 2020; Zingmark et al., 2021). By considering the relationship between motivations and greenway characteristics, not only is user satisfaction improved, but the physical and emotional health benefits are also maximised (Farías Torbidoni et al., 2005; Vías et al., 2018).

Another relevant variable in greenway usage is the difficulty of the route, often used as an indicator in the technical descriptions of official trails. However, this is perceived subjectively, as it varies depending on the hiker's experience, physical condition, and other personal factors (Calbimonte et al., 2020). Efforts in the literature have sought to make greenway difficulty more objective through models that simplify its complexity. For instance, studies by Calbimonte et al. (2020) y Krevs et al. (2023) adopted the methodology of the French Hiking Federation, which classifies greenway difficulty based on three criteria: effort, technique, and risk. Effort refers to the physical demand of the route, technique evaluates the motor skills required, and risk measures the potential hazards hikers may encounter. Similarly, the *Método para la Información de Excursionistas* – MIDE (Method for Information for Hikers), supported by the Spanish Federation of Mountain Sports and Climbing – FEDME (FEDME, 2022), applies a 1-to-5 scale to classify greenways across four aspects: environmental severity (risk), orientation (technique), movement difficulty (technique), and required effort (effort). This system provides hikers with more precise information about greenway characteristics. Another notable methodology is SEN-DIF, developed by the Spanish Institute for the Development and Promotion of the High Pyrenees and Aran (IDAPA, 2022). This method evaluates greenway difficulty using two components: physical difficulty, measured by distance, elevation gain, and estimated time; and technical difficulty, which considers terrain obstacles and features that may challenge hikers. These models provide a more objective classification of greenways, offering valuable information for both experts and beginners.

Greenway evaluations, beyond their use in guides or technical sheets, are often implemented in online search engines or recommendation systems, making them accessible to a broader audience. One example is the FEDME search engine, available at FEDME Trail Finder (FEDME, 2022b). This search engine allows users to filter routes based on criteria such as location, type of trail (linear or circular), type of interest (historical, cultural, or geological), as well as parameters like

distance, elevation gain, and estimated time. Another notable case is the SanTour system (Calbimonte et al., 2018), which provides route recommendations tailored to the user's health profile. It considers factors such as physical condition, motor skills, and limitations like vertigo or balance issues. Similarly, the route recommendation system presented by Vías et al. (2018) utilises Geographic Information Systems (GIS), network analysis, and multicriteria methods to evaluate trail walkability. This includes characteristics such as surface type, width, slope, and obstacles. Additionally, it incorporates the scenic and natural interest of the surroundings, accounting for ecological, biological, and cultural or ethnographic elements.

Although these recommendation systems are known for their ability to assess greenway difficulty and provide valuable information, most of them primarily focus on physical or technical aspects, overlooking the personal motivations of users. This work specifically addresses this gap, proposing an approach that not only considers the physical conditions of hikers but also takes into account their individual motivations, such as interest in the landscape or the level of challenge sought. By combining these physical and motivational factors, the system offers a holistic solution, allowing users to select routes that are not only physically suitable but also emotionally fulfilling. This study has the potential to enhance hiking enjoyment and overall hiker satisfaction, providing a more personalised and complete experience.

In summary, the goal of this study is to design a methodology for calculating the potential suitability of greenways for different hiking profiles based on their level of physical activity and motivations. The main objectives of the study are: (1) to design a method that allows the calculation of greenway suitability for different hiking profiles and (2) to conduct a proof of concept of this method on an official local route. The study is applied to the Green Ring, a 34 km semicircular greenway in the peri-urban area of the city of Tarragona (Spain), selected for being one of the most used greenways in the region and for combining ecological components with historical and cultural elements, making it attractive to both hikers and tourists (Àvila Callau et al., 2023). The methodology begins with the creation of hypothetical hiker profiles, followed by the design of indicators and sub-indicators for the subsequent evaluation of the target greenway through fieldwork and GIS. The third step involves normalising the collected data. In the fourth step, algorithms are developed to identify the most suitable indicator values for each created profile. The final step consists of calculating the potential suitability value for each section of the greenway, tailored to each hiker profile. This methodology is designed to assess trail suitability specifically for hikers, rather than other users such as cyclists. Therefore, both the indicators and sub-indicators, as well as the motivations considered, are tailored to hikers and would need to be adapted for other types of users. For example, hikers engage with trails differently, often prioritising factors such as landscape appreciation, whereas cyclists may focus more on speed or ease of terrain (Farías-Torbidoni et al., 2023). Additionally, the selected greenway includes sections reserved exclusively for hikers, further reinforcing the relevance of applying the method specifically to them.

## 2. Method description

### 2.1. Selection and operativisation of the greenway

This phase is prior to and independent of the methodological proposal presented in the following section (2.2), as selecting a specific greenway is what enables the achievement of the second objective of this study. The selected greenway (Fig. 1), Green Ring (*Anella Verda*), connects the Francolí River and the Gaià River, two rivers that flow into the central area of the province of Tarragona (Catalonia, Spain), resulting in a long excursion that showcases a large part of the extensive historical-cultural heritage that the municipality holds. This can be done via its inland or coastal route, and its promoter is the Tarragona City Council (Ajuntament de Tarragona, 2019).

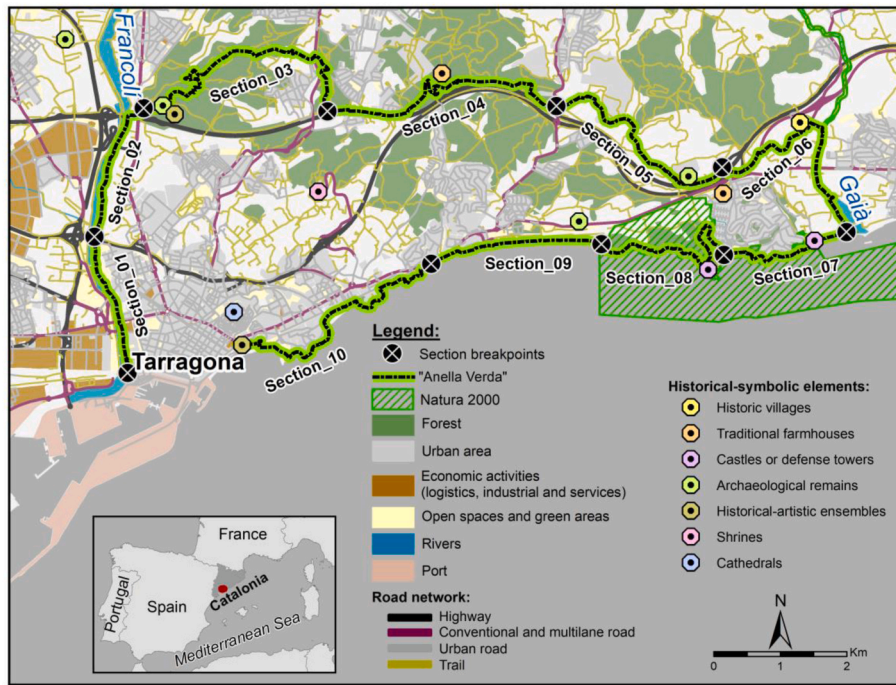


Fig. 1. Study area with the representation of the Green Ring (Anella Verda). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

The greenway follows ancient paths historically used by the local population and incorporates sections of officially recognised trails approved by hiking federations. It is partially multi-use, with only the inland section accessible to both pedestrians and cyclists, while the coastal section is exclusively for hikers, as it traverses beaches and rugged coastal areas unsuitable for cycling.

The route passes by a Roman aqueduct, medieval farmhouses, modernist buildings, defence towers, Roman quarries, orchards, river mouths, towns of interest, and coves of high natural value. The greenway is integrated into a traditional agricultural landscape that has

been deeply fragmented by the expansion of industrial, logistical, commercial, and recreational zones, as well as by a dense network of infrastructures. However, it has great potential for outdoor recreation due to its extensive network of trails (Àvila Callau et al., 2023). To operationalise data collection and subsequent calculations, the route is subdivided into 10 sections, averaging 4 km in length, using the same subdivisions as in the previous work of Àvila Callau et al. (2023).

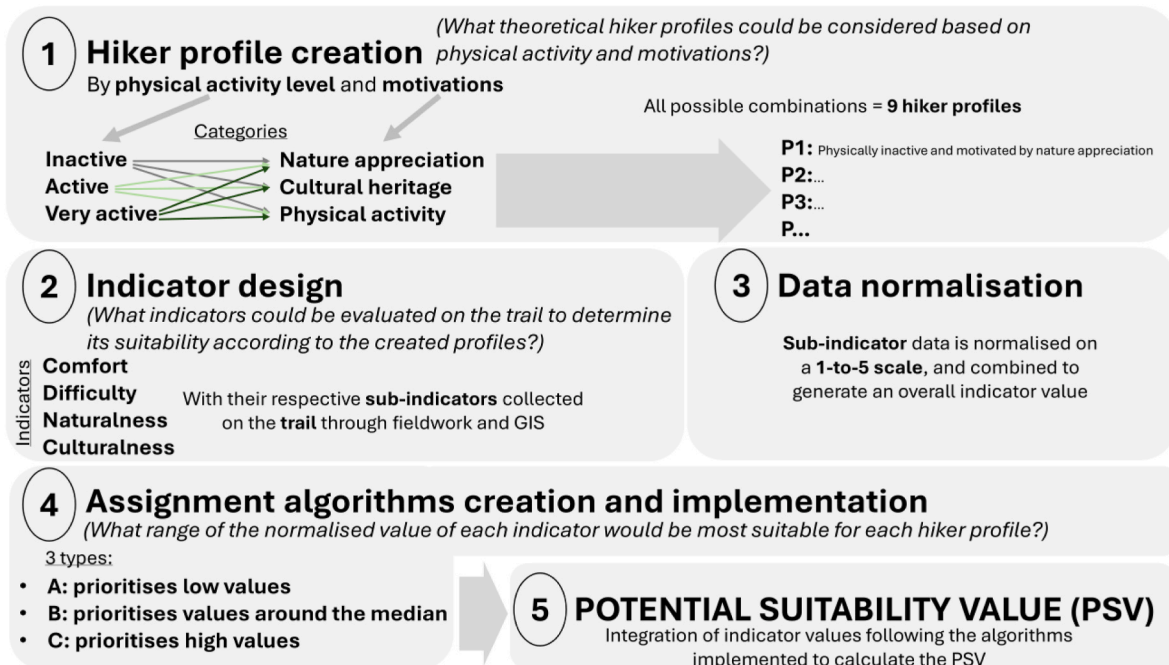


Fig. 2. Diagrammatic representation of the phases in the proposed methodology.

2.2. Methodological proposal

The methodological proposal presented in this article is structured into 5 phases (Fig. 2): (1) creation and design of hypothetical hiker profiles; (2) selection of indicators along with their sub-indicators to evaluate them on the selected greenway; (3) normalisation of the data collected on the sub-indicators and generation of a global value for each indicator; (4) design of the assignment algorithms to determine the value ranges of each indicator most suitable for each hiker profile; and (5) calculation of the Potential Suitability Value (PSV) for each profile and section of the analysed greenway.

2.2.1. Hiker profiles design

The first step involves creating hypothetical hiker profiles to assess the suitability of each section of the greenway according to the characteristics of each profile. Following the work of Di Felice (2014), two dimensions are applied to create the different profiles: one physiological and one motivational: (1) the level of physical activity of the hiker and (2) their motivation or interest. Each of these traits is associated with three typologies.

To determine the level of physical activity, three categories are used: (1) physically inactive, (2) physically active, and (3) physically very active. This classification is based on the WHO Guidelines on Physical Activity and Sedentary Behaviour (World Health Organization, 2020), which outlines the minimum physical activity (PA) that should be performed throughout a week to achieve health benefits and avoid harm due to inactivity. Recommendations are based on the certainty of evidence, and for adults, the inactivity threshold is defined as doing less than 150 min of moderate-intensity aerobic PA; or 75 min of vigorous-intensity aerobic PA; or an equivalent combination of moderate and vigorous-intensity activity throughout the week (physically inactive). Individuals who achieve these levels and even reach 300 min of moderate-intensity aerobic PA; or 150 min of vigorous-intensity aerobic PA; or an equivalent combination; or add muscle-strengthening activities 2 or more days a week are considered physically active. Adults who exceed 300 min of moderate-intensity aerobic PA; or more than 150 min of vigorous-intensity aerobic PA throughout the week will gain additional benefits (physically very active).

Although there are multiple motivations for hikers (Davies et al., 2012; Farias-Torbidoni et al., 2020, 2023; Keith et al., 2018; Li et al.,

2020), this study has focused on three key aspects: (1) the nature and appreciation of the landscape, (2) cultural heritage, and (3) physical-sporting activity. These three categories have been selected because, firstly, they relate to the characteristics of the greenway where the study is applied, as this route has significant natural and historical-cultural heritage. Secondly, in the study of Farias-Torbidoni et al. (2023) conducted in the same territorial area (Catalonia) as this one, motivations to experience nature, the landscape, or engage in physical activity are highlighted as some of the most relevant for both hikers and walkers. In contrast, other common social motivations, such as enjoying time with family or friends, have been excluded, as they are more typical of recreational walkers and not as relevant for hikers or other users (Farias-Torbidoni et al., 2023).

The combination of the six categories (3 from the level of physical activity and 3 from the motivations) results in nine hiker profiles (Table 1). It is important to clarify that the typologies for the “physical activity” trait are mutually exclusive. In other words, the hiker can be physically inactive, active, or very active, but they cannot select more than one typology at the same time. In contrast, for the “motivation” trait, the hiker could be interested in several typologies simultaneously. However, for operational reasons, the proposed model is based on the main motivation of each profile type.

2.2.2. Indicator design and data collection

To determine the suitability of the greenways for different hiker profiles, it is crucial to understand the specific characteristics of each greenway. This study applies a data collection process based on indicators and sub-indicators aligned with the previously created hiker profiles. For example, if the motivation is nature appreciation, the naturalness of the greenway must be evaluated by gathering relevant data to calculate its suitability.

A total of 16 sub-indicators and 4 indicators are applied (*comfort* with two sub-indicators; *difficulty* with four sub-indicators; *naturalness* with seven sub-indicators; and *culturalness* with three sub-indicators) (Table 2). This selection is primarily based on two references. First, the *Qualitätsweg Wanderbares* (Quality Hiking Trail) guide, promoted by the German Hiking Association (DWV, 2021). This guide details the requirements a trail must meet in Germany to be certified as a *Qualitätsweg Wanderbares Deutschland* (Quality Trail of *Wanderbares Deutschland*). It evaluates various greenway parameters (surface materials, location, enjoyability) and the development of the greenway as a

**Table 1**  
Types of hiker profiles created according to level of physical activity and motivation.

Hiker Profile	Hiker profile ID	Physical activity level			Motivation		
		Inactive	Active	Very active	Nature appreciation	Cultural heritage	Physical activity
Physically inactive and motivated by nature appreciation	P1	✓			✓		
Physically inactive and motivated by cultural heritage	P2	✓				✓	
Physically inactive and motivated by physical activity	P3	✓					✓
Physically active and motivated by nature appreciation	P4		✓		✓		
Physically active and motivated by cultural heritage	P5		✓			✓	
Physically active and motivated by physical activity	P6		✓				✓
Physically very active and motivated by nature appreciation	P7			✓	✓		
Physically very active and motivated by cultural heritage	P8			✓		✓	
Physically very active and motivated by physical activity	P9			✓			✓

**Table 2**  
Indicators and sub-indicators collected in every section of the analysed greenway.

Indicator label	Indicator description	Sub-indicator label	Sub-indicator description	Units
Comfort	Elements or conditions of the greenway dedicated to improving the comfort of its users.	Comfort elements	Benches, fountains, and rest areas.	Number of elements
		Green shade	Potential tree shade near the greenway.	Section length (%)
Difficulty	Technical and physical difficulty level of the greenway.	Displacement difficulty	Difficulty in movement measured based on the condition of the surface.	1-5 scale from the MIDE method
		Itinerary orientation	Ease of orientation on the itinerary from the perspective of the path definition, signage, and identification of landmarks.	1-5 scale from the MIDE method
		Environment severity	Severity of the natural environment measured by the number of risk factors present, such as obstacles, river crossings, rockfalls or exposure to cliffs.	1-5 scale from the MIDE method
Naturalness	Degree of naturalness of the greenway.	Positive slope	Positive slope of the route.	Meters
		Intensive use	Stopped construction projects, industrial areas, wastewater treatment plants, high-voltage power lines.	Number of elements
		Natural environment	Natural state, typical of the landscape or environment in which it is located.	1-5 scale where 1 represents a totally altered environment and 5 represents an original environment
		Noise pollution	Noise from machinery, road traffic, or railway traffic.	1-5 scale where 1 represents a silent environment and 5 represents an extremely noisy environment
		Natural landscapes	Large forested areas, exceptional biotypes or geotypes, rugged landscapes,	Number of elements

**Table 2 (continued)**

Indicator label	Indicator description	Sub-indicator label	Sub-indicator description	Units
Water bodies			landscaped areas.	Number of elements
			Springs, streams/creeks, rivers.	
Natural attractions			Gorges	Number of elements
			impressive peaks, ravines, caves, waterfalls, ancient trees, natural monuments.	
Asphalt			Asphalt paving of the greenway.	Section length (%)
			Streets of the historic centre with unique characteristics, representative urban planning, markets, tree-lined promenades and avenues, typical regional villages and town squares.	
Culturalness	Degree of cultural and heritage richness of the greenway.	Cultural interest points	Sanctuaries, chapels/hermitages, information centres, museums, castles, monasteries, archaeological remains.	Number of elements
		Heritage elements	Statues, monuments, commemorative plaques, sculptures.	

communication route (signage, landscape and natural surroundings, cultural aspects, and humanisation of the route, etc.). This guide is widely recognised and used by prestigious organisations in the field of outdoor recreation, such as the European Ramblers Association. Second, some sub-indicators were extracted from the MIDE method, designed to assess the difficulty of hiking routes. Within the *difficulty* indicator, sub-indicators are included to address technical difficulty (*displacement difficulty*, *itinerary orientation*, and *environment severity*), while the remaining sub-indicator (*positive slope*) is linked to physical difficulty. The length of the greenway section is not included as an indicator, as it is considered invalid due to the short sections (around 4 km). Other relevant sub-indicators, such as distance to cities or the accessibility of each section, have not been considered either. This is because the analysed greenway is a peri-urban route, almost entirely integrated within different urban areas. Moreover, the focus has been on measuring the elements that contribute to comfort once the hiker is already on the greenway and moving along its sections.

The data for the sub-indicators were collected using GIS and fieldwork. Three sub-indicators were measured using GIS: *green shade*, *positive slope*, and *asphalt*. Specifically, for the sub-indicators *green shade* and *asphalt*, length measurements were made through the photointerpretation of satellite images. In other words, the length of asphalt in each section and the adjacent green shade were measured and then the percentages were calculated based on the total length of each section. The estimation of green shade was not based on actual shadow projections, as these vary throughout the day and with atmospheric conditions.

Instead, the approach measured the length of adjacent evergreen tree lines along the trail, assuming they provide consistent shade coverage throughout the year. To determine which trees to include, a 50-m buffer from the trail centreline was applied. For the sub-indicator *positive slope*, the “calculate trail elevation statistics” module of QGIS 3 was used.

Regarding the sub-indicators collected through fieldwork, two techniques were employed. On one hand, for sub-indicators representing easily quantifiable elements, the total number of elements per section was counted: *comfort elements, intensive use, natural landscapes, natural attractions, water bodies, cultural interest points, heritage elements, and formal artistic elements*. On the other hand, for the remaining sub-indicators, Likert scales with five perception values (from 1 to 5) were used. Specifically, for the sub-indicators *natural environment and noise pollution*, a scale from 1 to 5 was applied according to the following criteria:

- **Natural environment:** (1) Totally altered: the natural environment has been completely transformed by human activities. The landscape may be dominated by artificial structures; (2) Very altered: the natural environment shows obvious signs of degradation. Vegetation exists but is sparse, and fauna is limited. There is a significant presence of human infrastructure; (3) Moderately altered: the natural environment retains some original features but shows signs of human impact. Human activities have a noticeable, but not dominant, impact; (4) Slightly altered: the natural environment maintains most of its original features. Vegetation is abundant, and fauna is diverse. Human activities have a limited and localised impact; (5) Original: the natural environment is in its original state, with no significant alterations. Vegetation is lush, and fauna is abundant and diverse. Human activities are minimal or non-existent.
- **Noise Pollution:** (1) Silent: artificial noise is practically non-existent, creating a peaceful and relaxing environment for walking; (2) Slightly noisy: artificial noise is minimal and causes no significant discomfort. Noise levels are low; (3) Moderately noisy: artificial noise is perceptible and may cause occasional discomfort during the walk. Noise levels are moderate; (4) Very noisy: artificial noise is frequent and bothersome, affecting the quality of the walk; (5) Extremely noisy: artificial noise is constant and deafening.

For the sub-indicators *displacement difficulty, itinerary orientation, and environment severity*, the same five-value scales from MIDE method were used, as detailed below:

- **Displacement difficulty:** (1) March on smooth surface; (2) Path with various surfaces; (3) March on stepped trails or uneven terrain; (4) Requires the use of hands or jumps over the terrain; (5) Requires the use of hands for progression.
- **Itinerary orientation:** (1) Well-defined paths and crossings; (2) Clear path trace and signage; (3) Requires identification of geographical features and cardinal points; (4) Requires navigation off the path; (5) There are obstacles that must be bypassed.
- **Environment severity:** (1) The environment is not risk-free; (2) More than one risk factor; (3) Several risk factors; (4) Many risk factors; (5) Numerous risk factors.

The fieldwork was carried out in July 2022 by three of the authors of this article. For the three sub-indicators derived from the MIDE system, the fieldwork team underwent a brief training process to ensure the most consistent evaluations possible. Specifically, during a preparatory session, the team reviewed and analysed the MIDE Procedural Manual (Montaña Segura, 2022). This manual provides additional guidance on determining, for instance, whether an environment contains several, many, or numerous risk factors. For example, category 4 (many risk factors) specifies that 7 to 10 risk factors from a predefined list in the manual are considered highly probable. The manual was also used as a reference tool during fieldwork sessions. For the remaining

sub-indicators, training was not deemed necessary, as they were either based on straightforward quantitative measurements or followed a well-defined 1-to-5 scale, as in the case of *natural environment* and *noise pollution*.

During data collection, the weather conditions were favourable, meaning there were no episodes of wind or rain. The data collected were entered into fieldwork forms in an analogue format by all operators independently. Subsequently, for the sub-indicators measured with Likert scales, the simple average of the ratings made by each operator was calculated.

### 2.2.3. Data normalisation

Once all the data for the sub-indicators have been collected, they are standardised on a scale from 1 to 5, where 1 represents the lowest level and 5 represents the highest quality level (Table 3). This standardisation allows the integration of the sub-indicators into their corresponding indicators. The values for some sub-indicators, such as *intensive use, noise pollution, and asphalt*, are inverted to maintain consistency with the others, as a higher value indicates lower greenway quality. The intervals used in the normalisation are specifically adjusted to the study sections, which are approximately 4 km long, following the *Qualitätsoffensive Wandern* guide. For example, according to the SENDIF, a 500-m positive elevation gain over a 4 km route represents a moderate level of difficulty (normalised value of 3). However, the same elevation gain on a 20 km route would represent a very challenging level (normalised value of 5). The same principle applies to the quantifiable sub-indicators. In other words, a total of 3 natural attractions on a 4 km greenway would not represent the same level of naturalness as the same number of attractions on a 20 km greenway.

Finally, to calculate the final value of each indicator, a weighting of the sub-indicators is carried out using the Analytic Hierarchy Process (AHP) method (Saaty, 1987), which is commonly used for multicriteria decision-making. In this case, the weights assigned to each sub-indicator come from the qualified opinions of a group of seven experts in the fields of geography, health, and physical activity. Independently, these experts evaluate and weigh the different sets of sub-indicators, and their contributions are then integrated through the calculation of an average. To obtain the final value of each indicator, a weighted sum of the sub-indicators is performed, using the weights previously assigned (Table 3).

### 2.2.4. Assignment algorithms design and implementation

Once the final quality values for the indicators and for each section of the greenway are calculated, the suitability of the greenway is determined according to different hiker profiles using what we refer to as the Potential Suitability Value (PSV). The PSV is obtained through pre-designed algorithms that assign specific scores to each indicator based on its real value and relevance to each hiker profile. For instance, the level of comfort may be irrelevant to highly active hikers. In this case, an algorithm that prioritises low values will be applied (algorithm A). Conversely, for hikers with low levels of physical activity, the presence of comfort elements will be essential, and thus an algorithm prioritising high values will be used (algorithm C).

Each algorithm weights the indicators differently, assigning higher scores to those that best match the profile. For example, if the hypothetical hiker prioritises naturalness, a high value of this indicator will receive a higher score. Additionally, the algorithms evaluate the normalised value of the indicator and assign one of four possible scores (0, 0.5, 1, 1.5), depending on how the value aligns with the specified hiker profile's preferences. The three algorithms (A, B, and C) with different prioritisation approaches are explained below, along with the R code used for each (Table 4):

- **Algorithm A** (prioritises low values): Normalised Value  $\leq 2$ : assigns 1.5 points. Normalised Value  $> 2$  and  $\leq 3$ : assigns 1 point.

**Table 3**  
Standardisation of sub-indicators (from 1 to 5) and assigned weighting values. Note: The description of the sub-indicators can be seen in Table 2.

Indicators	Sub-indicators	Standardisation scale					Weighting value (0–1)
		1	2	3	4	5	
		Original values					
Comfort	Comfort elements	0	1	2	3	>3	0.550
Difficulty	Green shade	[0–20] %	(20–40) %	(40–60) %	(60–80) %	(80–100) %	0.450
	Displacement difficulty	1 (March on smooth surface)	2	3	4	5 (Requires the use of hands for progression)	0.410
	Itinerary orientation	1 (Well-defined paths and crossings)	2	3	4	5 (There are obstacles)	0.160
	Environment severity	1 (The environment is not risk-free)	2	3	4	5 (Numerous risk factors)	0.350
	Positive slope	[0–50] m	(50–250] m	(250–500] m	(500–750] m	>750 m	0.080
Naturalness	Intensive use	>3	3	2	1	0	0.158
	Natural environment	1 (Totally altered)	2	3	4	5 (Original)	0.122
	Noise pollution	5 (Extremely noisy)	4	3	2	1 (Silent)	0.128
	Natural landscapes	0	1	2	3	>3	0.192
	Water bodies	0	1	2	3	>3	0.128
Culturalness	Natural attractions	0	1	2	3	>3	0.154
	Asphalt	(80–100) %	(60–80) %	(40–60) %	(20–40) %	[0–20] %	0.118
	Cultural interest points	0	1	2	3	>3	0.320
	Heritage elements	0	1	2	3	>3	0.550
	Formal artistic elements	0	1	2	3	>3	0.130

**Table 4**  
Types of assignment algorithms designed (A, B and C) and their implementation code in the R software. Note: “value” is the actual value obtained for each indicator on a scale of 1–5.

Type of assignment algorithm	R code
A	<code>ifelse(value ≤ 2, 1.5, ifelse(value &gt; 2 &amp; value ≤ 3, 1, ifelse(value &gt; 3 &amp; value ≤ 4, 0.5, ifelse(value &gt; 4, 0))))</code>
B	<code>ifelse(value ≤ 2, 0, ifelse(value &gt; 2 &amp; value ≤ 3, 1.5, ifelse(value &gt; 3 &amp; value ≤ 4, 1, ifelse(value &gt; 4, 0.5))))</code>
C	<code>ifelse(value ≤ 2, 0, ifelse(value &gt; 2 &amp; value ≤ 3, 0.5, ifelse(value &gt; 3 &amp; value ≤ 4, 1, ifelse(value &gt; 4, 1.5))))</code>

Normalised Value > 3 and ≤4: assigns 0.5 points. Normalised Value > 4: assigns 0 points.

- **Algorithm B** (prioritises values around the median): Normalised Value ≤ 2: assigns 0 points. Normalised Value > 2 and ≤3: assigns 1.5 points. Normalised Value > 3 and ≤4: assigns 1 point. Normalised Value > 4: assigns 0.5 points.
- **Algorithm C** (prioritises high values): Normalised Value ≤ 2: assigns 0 points. Normalised Value > 2 and ≤3: assigns 0.5 points. Normalised Value > 3 and ≤4: assigns 1 point. Normalised Value > 4: assigns 1.5 points.

In the process of assigning scores to each indicator for different hiker profiles, the choice of which algorithm to apply is based on the specific characteristics of each profile and the indicators. For example, for a hiker profile interested in cultural heritage, algorithm C will be used

when evaluating the *culturalness* indicator. This algorithm prioritises high values in the indicator, reflecting a greater affinity with the hiker’s motivations concerning cultural heritage. These decisions are based on detailed justifications provided in Fig. 3. It is important to note that not all indicators have a direct or significant influence on all traits of the hiker profiles. The justifications in Fig. 3 are derived from the consensus among experts who participated in the weighting of the sub-indicators.

In turn, these justifications allow for determining which algorithm should be used for each indicator and each type of hiker profile (Table 5). If it is considered that an indicator does not affect a particular hiker profile, the code N/A (not applicable) is assigned.

2.2.5. Potential suitability value calculation and mapping

The Potential Suitability Value (PSV) for each section and each hiker profile is calculated by summing all the scores assigned by the algorithms to each relevant indicator for that hiker profile. The resulting value is standardised on a scale from 0 to 5 using the following formula:

$$Potential\ Suitability\ Value = 5 \times \left( \frac{x - \min_x}{\max_x - \min_x} \right)$$

Where “x” is the original value for normalising, “min\_x” is the minimum value and “max\_x” is the maximum value of the original range of “x”.

Subsequently, the PSV is classified into five suitability categories: very low (from 0 to 1), low (greater than 1 to 2), moderate (greater than 2 to 3), high (greater than 3 to 4), and very high (greater than 4 to 5). Finally, these categories are used to generate comparable maps, and, ultimately, the percentage of the total length of the Green Ring that falls into each suitability category is calculated for each hiker profile.

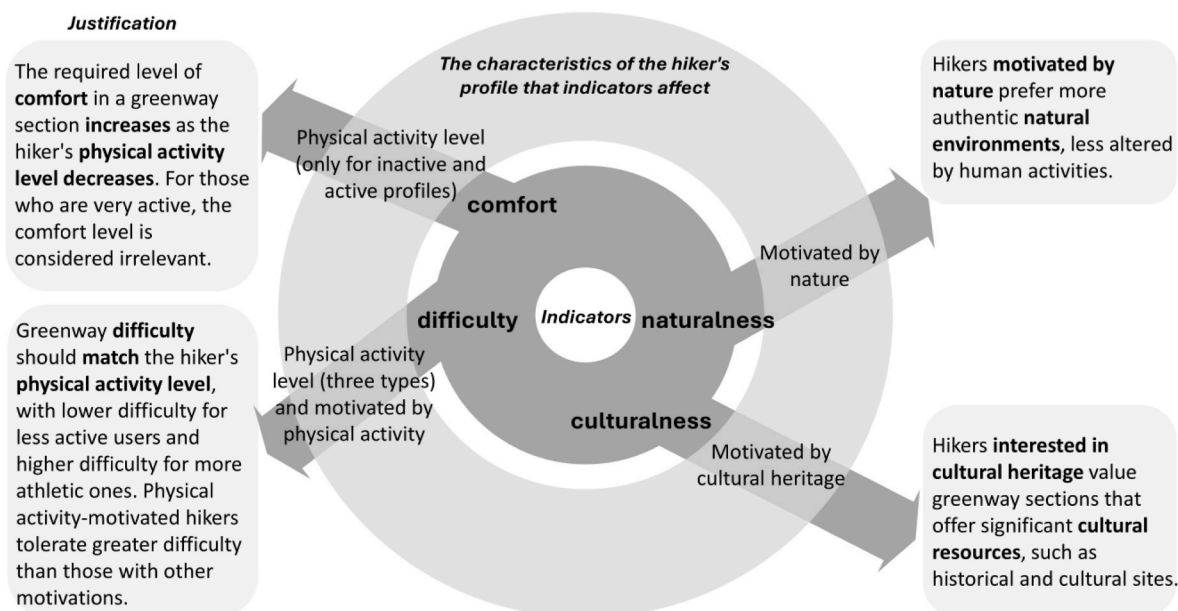


Fig. 3. Hiker profiles affected by the algorithms according to the different indicators and their justifications. Note: The justifications are based on the consensus among experts who conducted the weighting of sub-indicators.

### 3. Results

#### 3.1. Characteristics of the Green Ring sections

The analysis of the sections (Fig. 4. For the sections, see Fig. 1) shows very varied values for each of the indicators analysed: *comfort*, *difficulty*, *naturalness*, and *culturalness*. Sections 1 and 2, which run along the course of the Francolí River, and section 9, which runs entirely along a beach, have the lowest quality values. They are characterised by low values for difficulty and culturalness. At the other extreme are sections 3 and 8, which have similar quality, due to being very complete sections that combine the presence of natural, cultural, and comfort elements along with moderate difficulty.

Regarding the *comfort* indicator, sections 1, 6, 7, and 8 show the highest values (greater than 3), indicating that these areas of the greenway provide a more comfortable experience. Concerning the *difficulty* indicator, section 10 stands out with the highest difficulty value (4.36), suggesting it is the most physically demanding, while sections 1 and 9 have the lowest difficulty (value 1). For the *naturalness* indicator, sections 6, 7, and 8 stand out the most with values of 4 or higher, indicating these areas have a more natural environment. Regarding the last indicator, *culturalness*, section 3 has the highest cultural value (3.97), followed by section 6 (3.06), while the remaining sections generally have low values.

#### 3.2. Potential suitability values for each hiker profile

The analysis of the suitability of the sections in relation to each profile shows that the variation is very high (Fig. 5). There is no profile with all sections deemed suitable (Very high or High), and only one profile, P4 (Physically active and motivated by nature appreciation), is free of "Very low" values.

As shown in Fig. 6, in general, the suitability of the Green Ring is relatively low for all the analysed profiles, with some profiles (such as P1 and P4) being more likely to find suitable sections compared to others (such as P8 and P9), which face greater difficulty in finding high-suitability sections. The profile with the highest percentage of very high suitability is P1 (Physically inactive and motivated by nature appreciation), mainly due to the low difficulty of the sections and the presence of natural vegetation along the route. On the opposite end is

profile P9 (Physically very active and motivated by physical activity), which has a very high percentage of very low and low suitability, also due to the low physical demand of the Green Ring sections. It should be noted that physical exercise is the main motivation for this profile.

### 4. Discussion

#### 4.1. Methodological insights

The replicability and scalability of the proposed method is a central strength of this study. Similar to the work by Vías et al. (2018), the collection of key indicators, such as difficulty and naturalness, are easily applicable in different geographical areas and in projects with similar contexts. Additionally, the adaptability of the approach allows the routes to be evaluated both individually and comparatively, facilitating the expansion of the analysis to other routes within and outside the studied spatial context.

Although the profiles created in this study cover important aspects, they are not the only ones, nor necessarily the most valid, especially from the motivation perspective. There are other motivations not considered, such as emotional well-being, interest in photography, or social motivation, where group interaction is especially valued, and routes that facilitate participation in group activities (Davies et al., 2012; Farías-Torbidoni et al., 2020; Keith et al., 2018; Li et al., 2020). Including a broader range of motivations could improve the model's accuracy and its ability to offer personalised routes for a larger number of hikers, although the profiles proposed in this study address those considered as basic. Likewise, these motivations are well-suited to the selected greenway due to its high natural and historical-cultural value. Its diverse landscape enhances well-being and environmental awareness, while its heritage sites, such as a Roman aqueduct and medieval farmhouses, enrich cultural understanding.

Regarding the indicators and sub-indicators selected for this study, they cover key aspects for evaluating the suitability of the greenways, but the number is limited. There are other indicators that could enrich the analysis. For example, length, an indicator related to physical difficulty, has not been considered. For longer greenways, length would be a crucial sub-indicator as it directly affects the level of physical activity required by users and their overall experience along the route (Calbimonte et al., 2018; Krevs et al., 2023). The fact that section length

**Table 5**

Algorithms (A, B or C) implemented according to each hiker profile and each indicator. Note: N/A means that the algorithm does not apply to that indicator and hiker profile.

Hiker Profile	Profile ID	Comfort	Difficulty	Naturalness	Culturalness
Physically inactive and motivated by nature appreciation	P1	C	A	C	N/A
Physically inactive and motivated by cultural heritage	P2	C	A	N/A	C
Physically inactive and motivated by physical activity	P3	C	B	N/A	N/A
Physically active and motivated by nature appreciation	P4	B	B	C	N/A
Physically active and motivated by cultural heritage	P5	B	B	N/A	C
Physically active and motivated by physical activity	P6	B	C	N/A	N/A
Physically very active and motivated by nature appreciation	P7	N/A	C	C	N/A
Physically very active and motivated by cultural heritage	P8	N/A	C	N/A	C
Physically very active and motivated by physical activity	P9	N/A	C	N/A	N/A

was not included as an indicator does not affect the results, as the greenway was segmented into sections of approximately the same length (4 km). In this regard, the typical distance for health-oriented walking routes, designed for non-sporty profiles, is usually between 2 and 5 km (Mas-Alòs et al., 2021). Similarly, additional sub-indicators related to comfort, such as proximity to urban centres or accessibility by private and public transport (Caglayan et al., 2020), could have been included. However, due to the characteristics of the analysed greenway, which is highly integrated into the urban fabric, these factors were deemed less relevant for this specific case. For future studies applied to longer greenways that may be more remote in terms of accessibility from urban areas, these indicators would be crucial.

The algorithms designed to calculate the Potential Suitability Value (PSV) have a great ability to adapt to different profiles of hikers, enabling precise personalisation based on the motivations and needs of each type of user. These algorithms weight the indicators of each section of the greenway according to the actual values of these indicators and their relevance for each hiking profile. This facilitates the calculation of suitability scores that are more aligned with user expectations. Therefore, each of the algorithms (A, B, and C) offers a unique approach that addresses different needs. Algorithm A prioritises low values, which is

ideal for profiles that prefer more comfortable or less challenging conditions. Algorithm B weights values around the median, making it suitable for profiles with moderate levels of physical activity. Finally, Algorithm C focuses on high values, which is particularly useful for hikers looking for more intense experiences or challenges, such as those highly interested in cultural heritage, nature appreciation, or greenway difficulty.

Another fundamental aspect of these algorithms is their ability to assign scores based on the relevance of the indicators for each hiking profile. This approach, focused on individual motivations, can maximise hiker satisfaction by offering experiences that reflect their interests (Calbimonte et al., 2018; Dorwart et al., 2010; Farías Torbidoni et al., 2005; Zhang et al., 2020). Additionally, the algorithms use normalised values to make comparisons between different sections of the greenway. This ensures that the differences in the values of the indicators are fair and proportional, allowing the assigned scores to adequately reflect the characteristics of each greenway segment.

In contrast, other more simplified alternatives would not be as suitable. For example, using a single or universal algorithm for all profiles would be too general and would not capture the key differences between hikers. A physically inactive hiker prioritises comfort, while a highly active hiker seeks challenges, and comfort may be irrelevant to them (Farías-Torbidoni et al., 2018, 2020). A one-size-fits-all approach would not be able to reflect these differences, leading to irrelevant suitability assessments.

#### 4.2. Understanding the suitability results

Applying this method, the results obtained could show that, for example, a section with low difficulty may receive a low suitability score for the hiker profile P9 (physically very active and motivated by physical activity). This does not mean that the section is unsuitable for a hiker with this profile, but rather that, due to not providing enough physical exertion relative to their level of physical activity and motivation type, it falls below the metabolic equivalents (MET) they are capable of utilising. A metabolic equivalent (1 MET) is the amount of energy (oxygen) the body uses while at rest. Intensity can be described as a multiple of this value, meaning that the more the body works during physical activity, the higher the MET level achieved. According to the World Health Organisation, any activity requiring a consumption between 3 and 6 MET is considered moderate activity, which is the required consumption for most profiles using the trails studied (Herrmann et al., 2024). For users engaging in vigorous intensity activity (i.e., greater than 6 MET), such as jogging or mountain biking, or even for individuals with medical conditions who experience greater physiological demand from walking, health benefits can still be achieved by considering the exercise volume in relation to the duration of the activity and the time spent, measured in MET-minutes. In other words, health benefits can be obtained by practicing moderate intensity for longer periods, or vigorous intensity for shorter periods, even when using trails as the practice location (Farías-Torbidoni et al., 2018).

To strengthen the practical application of this method beyond health benefits, the suitability results can also guide decision-making for greenway managers and planners (Vías et al., 2018; Àvila Callau et al., 2023). For example, identifying sections with low suitability for certain hiker profiles can inform targeted improvements, such as modifying trail difficulty, enhancing accessibility, or providing additional infrastructure to better align with user needs. Additionally, researchers can use this approach to assess how different environmental and structural factors influence user experience, enabling more effective management strategies and sustainable trail planning (Farías Torbidoni, 2011). By integrating suitability analysis into greenway design and maintenance, both recreational value and ecological conservation efforts can be optimised.

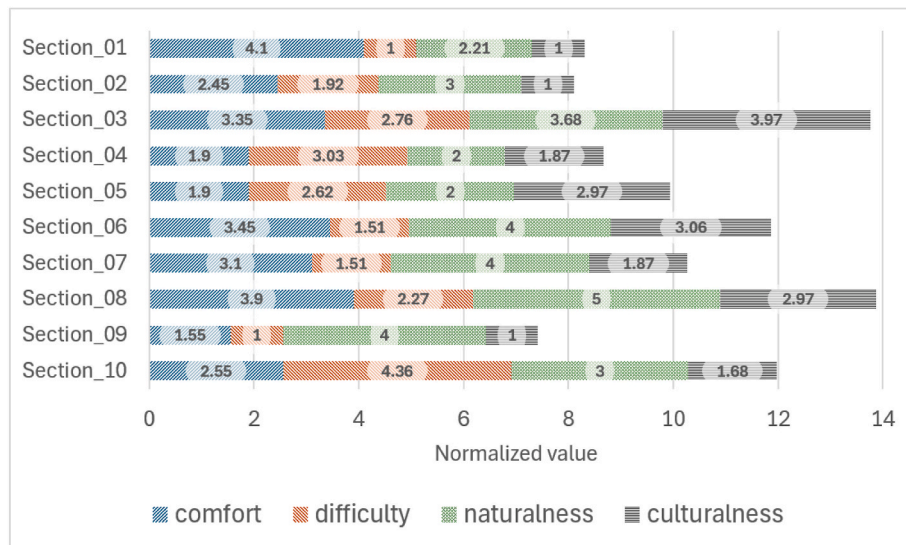


Fig. 4. Final values of the indicators (normalised from 1 to 5) for each section of the Green Ring. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

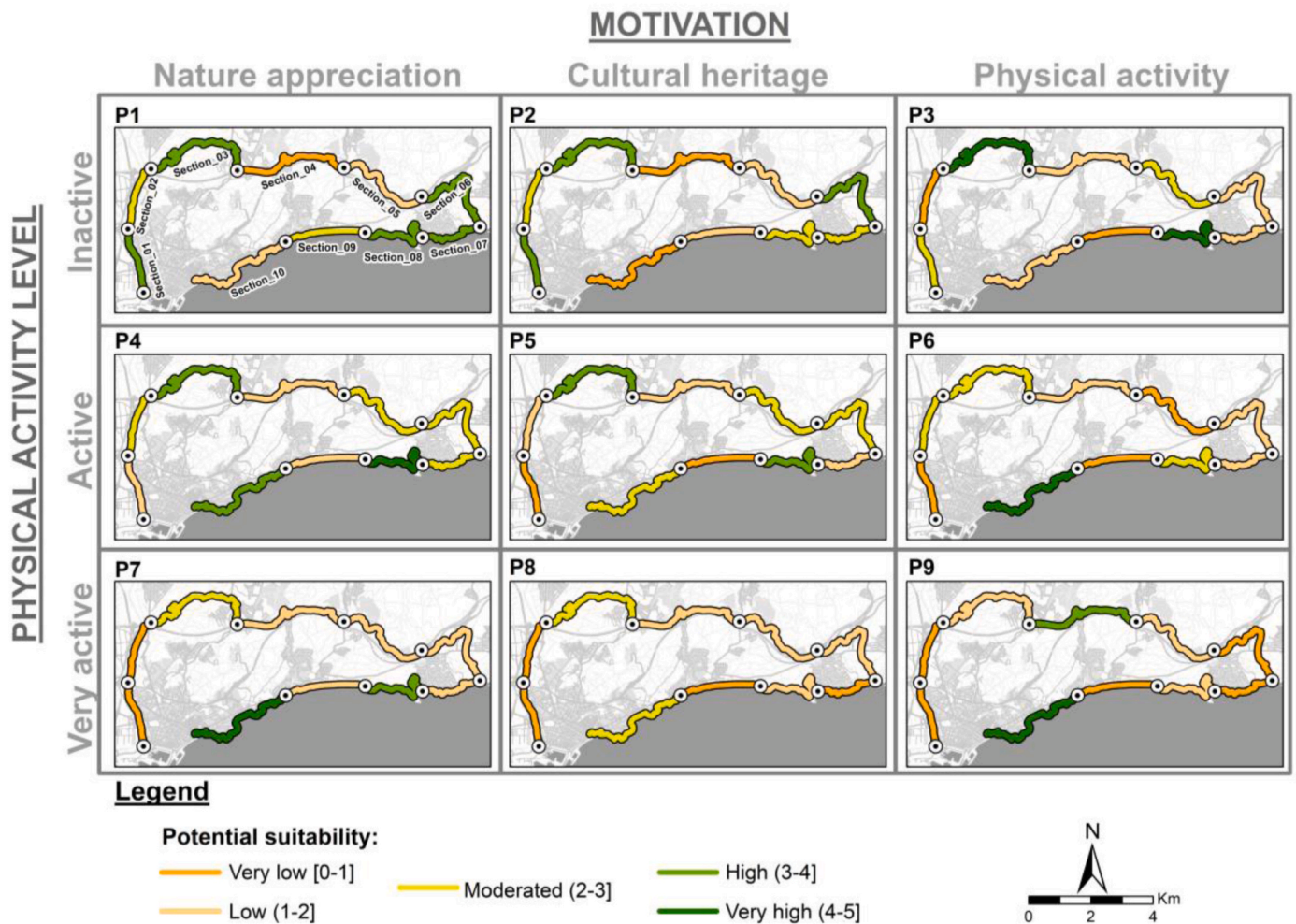
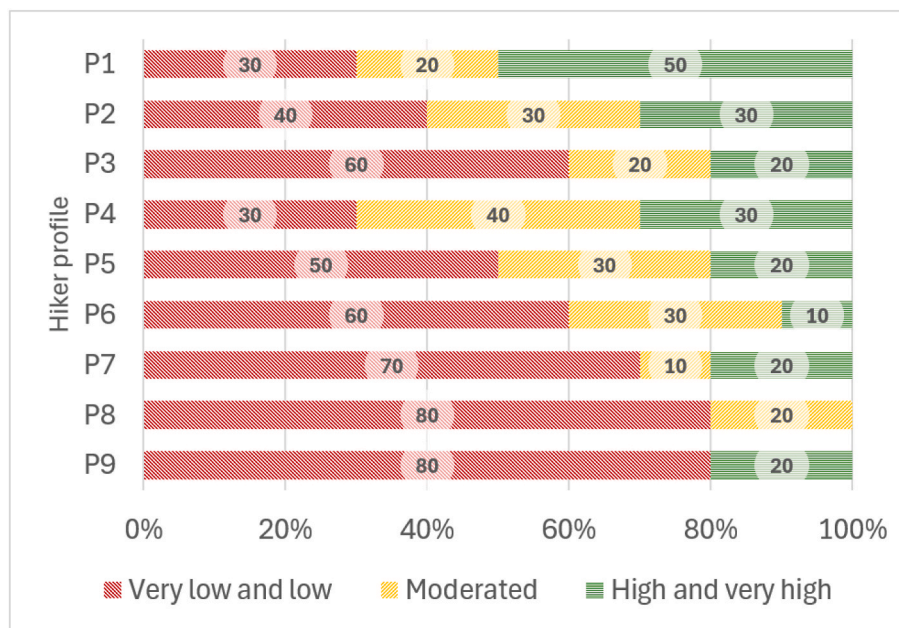


Fig. 5. Potential suitability of Green Ring sections for each hiker profile (from P1 to P9). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)



**Fig. 6.** Percentage of Green Ring sections according to their suitability for each hiker profile (from P1 to P9). Note: The description of the hiker profile IDs can be found in Table 1. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

#### 4.3. Limitations and practical applications

The limitations of this study are related to the need to narrow down the number of profiles and sub-indicators and indicators to include in the model. As mentioned earlier, there are other motivation profiles. A larger number of profiles would make the model much more complex and it is possible that there would be no significant differences, for example, between the profile that seeks emotional well-being and the one motivated by contact with nature. The same applies to the number of indicators: their quantity could be increased to obtain a more detailed characterisation of the sections, but the model would become more complex and, at the same time, less replicable due to its dependency on the availability of cartographic information.

Additionally, it is important to consider that some sub-indicators, such as *noise pollution*, are not only spatially but also temporally variable. This means that field evaluations conducted at different times could yield different results, highlighting the need to account for temporal fluctuations in the assessment. In addition, the data collection process presents inherent challenges. Despite efforts to standardise evaluations among field operators, such as prior training for sub-indicators that require it, variability persists due to differences in individual perception and interpretation (Àvila Callau et al., 2020). This underscores the need for rigorous and well-defined assessment protocols that minimise subjectivity.

Another key point is the need to assess user usability and satisfaction. While the model identifies suitable routes based on the designed profiles, it is crucial to validate these results through surveys or interviews with real users to assess whether the model's predictions align with their experiences and expectations. In this regard, collecting both qualitative and quantitative data from user experiences can help adjust and improve the model, making it more robust and adaptable. Usability analysis tools, such as those mentioned in Molokáč et al. (2022), can be useful for measuring user satisfaction and the emotional impact of the routes, ensuring that greenway design not only meets physical standards but also the motivational expectations of hikers.

As a future practical application of this work, it could be adapted into a route recommendation system that uses the results to generate personalised recommendations for hikers based on their physical activity level and interests. Previous studies in this area (Calbimonte et al., 2018;

Vías et al., 2018) suggest that recommendation systems can significantly increase user satisfaction by offering routes that align with both their physical capabilities and motivational preferences. The integration of data on the user's physical condition and motivations into a recommender system provides a more personalised experience, something that Davies et al. (2012) identify as a knowledge gap in the current scientific literature.

Finally, as guidance for future researchers or managers, this methodological approach could be applicable to any trail designed for hikers. However, it is likely to be more effective on peri-urban greenways, given their intrinsic natural and cultural characteristics, which are linked to the indicators and motivations used in the methodology. For urban trails, a more comprehensive adaptation of the indicators, sub-indicators, and hiker profiles would likely be necessary, although the remaining methodological steps would still be applicable. Similarly, for fully multi-use trails, it would be important to consider additional factors that could evolve the methodology, leading to the creation of new indicators or motivations. For example, the concept of recreational conflict, explored in other studies on outdoor recreation (Campelo & Nogueira Mendes, 2016; Corning et al., 2012; Dudney & Moghimehfar, 2024; Norman et al., 2019; Pickering & Rossi, 2016; Santos et al., 2016; Wolf et al., 2018), which involves conflicts between different types of trail users or landowners, overcrowding, among other issues.

#### 5. Conclusions

This study has developed a methodology that allows for the calculation of greenway suitability adjusted to the physical activity level and motivations of hikers. The application of this methodology to a heavily used greenway (Green Ring) allows for the conclusion that it is a robust and scalable methodology, offering a powerful tool for the design of personalised routes. Furthermore, the methodology is based on a multidimensional approach, combining physical and motivational criteria, and can easily be extended to other outdoor activities beyond hiking, such as cycling or running, by adjusting the criteria according to the type of physical activity and recreational or sports goals. The implementation of this methodology can significantly optimise the recreational experience and contribute to more sustainable and efficient management of cultural ecosystem services in peri-urban and rural

areas. Additionally, this approach also promotes the sustained use of greenways, which is essential for maximising their social and health benefits. However, the implementation of this approach should be complemented with practical validation through user experience. Collecting qualitative and quantitative data on satisfaction and preferences can refine the proposed models, improving their predictive capacity and practical utility.

### CRedit authorship contribution statement

**Aitor Àvila Callau:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Yolanda Pérez-Albert:** Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Project administration, Methodology, Funding acquisition, Formal analysis, Conceptualization. **Estela Inés Fariás-Torbidoni:** Writing – review & editing, Validation, Supervision, Resources, Methodology, Conceptualization. **Sebastià Mas-Alòs:** Writing – review & editing, Validation, Supervision, Resources, Methodology, Conceptualization. **Joan Alberich González:** Validation, Supervision, Resources, Methodology, Conceptualization. **Manel González Peris:** Validation, Conceptualization.

### Management implications

The proposed methodology has several key management implications. First, promoting health benefits is a central outcome, as encouraging greenway use aligned with individual fitness goals supports public health initiatives and enhances community well-being. Second, enhanced accessibility is made possible by identifying specific comfort and difficulty needs. This enables the development of inclusive trail improvements that accommodate users with varying physical capabilities, fostering equity in recreational opportunities. Third, personalised route planning empowers managers to adapt greenway recommendations to match diverse hiker profiles. By doing so, user satisfaction and engagement are significantly improved, catering to motivations such as fitness, cultural exploration, or nature appreciation. Finally, the methodology provides a scalable management framework. This allows for its application across different greenways, ensuring consistent and data-driven trail evaluation. Collectively, these implications promote sustainable and user-centered greenway management, enhancing recreational value.

### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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### Data availability

The authors do not have permission to share data.

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