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Urban Physical Environments Promoting Active Leisure Travel: An Empirical Study Using Crowdsourced GPS Tracks and Geographic Big Data from Multiple Sources

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Abstract: Specific environmental characteristics can encourage active leisure travel and increase physical activity. However, existing environment-travel studies tend to ignore the differences in environmental characteristics associated with route choice and travel distance, of which the latter could be more important for health benefits, since longer trips are associated with increased exercise. Additionally, the most recent studies focus on leisure walking and leisure cycling, and activities such as hiking, climbing, and running are examined less frequently. This study, therefore, compares the similarities and differences of the environmental factors associated with route selection and travel distance through non-parametric tests and Cox proportional hazard models. The results show that two intersecting sets of environmental elements relate to both the route chosen and the distance traveled. Land use diversity and varied topography are appealing for both leisure trips and trip length. In addition, the differences in environmental characteristics among specific leisure travels may be attributed to variations in physical activity requirements, preferences for landscape viewing, and/or sensitivity to crowding. Therefore, conclusions drawn without considering the different types of leisure travel could be skewed. Whether particular surroundings may effectively increase physical activity remains uncertain. A more holistic perspective could be beneficial when studying the connection between the environment, active travel, and health.

Keywords: built and natural environment; active leisure travel; route selection; travel distance; Cox proportional hazard model

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1. Introduction

Sedentary lifestyles and a lack of daily physical exercise increase the risk of chronic diseases including obesity [1] and cardiovascular disease [2]. Given that walking or cycling are among the most common and accessible forms of exercise [3], experts are now interested in the potential health advantages of active leisure travel [4,5]. The term "active leisure travel" in the context of this article refers to a variety of travel modes for recreational purposes that can enhance physical activity levels, such as walking, cycling, running, hiking, and mountaineering, among others [4,6]. These activities typically occur in various settings, including urban streets, nearby green parks, or forest parks situated in suburban areas. There are at least three explanations for the considerable and growing research interest in active leisure travel: First, changing lifestyles associated with increasing socioeconomic status can lead to more time allotted to pursuing active leisure activities, which are associated with greater life satisfaction [7]. As a result, a growing number of people are engaging in experience-based leisure travel in their daily lives [8]. Second, active leisure travel, which may provide moderate-intensity activities that can be incorporated into daily life directly and decrease the share of motorized travel indirectly, has the potential to contribute to public health, energy efficiency, congestion reduction, and air pollution alleviation [1,9]. Third, compared with more utilitarian journeys that, in contrast to leisure travel, place a higher priority on efficiency, leisure travel is more likely to take place on safe, comfortable routes rather than on the quickest routes [10,11]. Urban planners seek to increase these "detours" to increase the exposure and duration to attractive and beneficial elements of the built and the natural environments [12].

The relationship between urban environmental characteristics and active leisure travel has been the subject of numerous prior studies [4,5,13,14], but the emphasis has primarily been on route selection. Some researchers have used several discrete choice statistical models (such as the Logit model, the multinomial Probit model, and the Path Size Logit model) to explore why people opt to take trip diversions and which environmental attributes appear to make routes more attractive [12,15,16]. Other research has uncovered which landscape elements are related to the environmental variations between the shortest path and the actual chosen route [10]. They find that people prefer leisurely walking in areas with high aesthetic value [10]), near parks and open spaces [4], and even on hilly terrain [17], whereas cyclists prefer routes with good bicycle amenities [18] and quiet routes [19].

Although these studies have significant implications for how to design attractive walkways or cycle lanes to promote active travel modes [20,21] less is known about how far individuals actually travel on their chosen routes. For individuals, a certain level of physical activity is required to produce health benefits [22]. Thus, while selecting an active mode of travel is crucial, the length and distance of the journey should also be considered. Encouragingly, the increase in travel distance resulting from detours appears to align more closely with the health-oriented policy objectives. However, it is worth noting that environmental factors that influence route choice and travel distance are not always consistent [23]. For example, some studies have confirmed that people prefer routes with density and a land use mix, which encourages active travel but shortens trips [24,25]. Therefore, health-oriented urban planning may benefit from integrating both route choice and distance traveled. This paper investigates how environmental elements relate to path selection and travel distance in an integrated manner using crowdsourced GPS travel trajectories in Beijing, China.

In addition to trip distance, the type of exercise and associated health benefits is important. On the one hand, various forms of leisure active travel, such as walking, cycling, and running, generate varying levels of physical activity [26]. On the other hand, these distinct types of leisure travel may also engender divergent environmental preferences [27]. However, most recent research [4,28,29] tends to focus on leisure walking and leisure cycling and less commonly considers other leisure activities such as hiking, climbing, and/or running. A few studies have looked at the route preferences of climbers and runners from the perspective of recreational specialization [27,30], and they found that people's desire for a specific physical activity level and self-challenge influence route choice. For example, cyclists with a high level of recreational specialization seem more likely than those with a low level to select longer, steeper routes [18]. However, the duration or distance of the excursion is not commonly evaluated in prior research. Hence, this paper explores how the environmental characteristics of different types of leisure travel activities vary.

The built environment has been the main focus of previous research, which has constructed a large corpus of travel environment metrics. For instance, the "5Ds" [31], which include population and employment density, land use diversity, street network and place design, destination accessibility, and distance to transit services, are strongly associated with travel behavior. High density may draw people to travel [32], and mixed land use, which offers a variety of services within close proximity, boosts the likelihood of active travel [33]. Alternatively, transportation-related characteristics that are related to accessibility, such as the number of public transportation stops and the intersection density, may promote cycling or walking [34,35]. However, for leisure travel, the natural landscape may have more influence than the aesthetic design of the developed area [12,28]. More green areas are associated with more frequent walking, and complex terrain encourages cycling [29,36,37]. The evaluation of natural landscapes cannot be disregarded, particularly when considering more leisure vacation activities such as hiking, climbing, and other outdoor sports.

To understand how environmental characteristics and various kinds of leisure trips vary, this paper mixes large data from multiple geographic sources with GPS track data collected via crowdsourced GPS tracks (Figure 1). First, by using non-parametric tests and Cox proportional risk models, the differences and similarities between environmental factors related to route choice and travel distance are compared. Second, the differences in environmental features for various types of leisure travel are examined with crowdsourced GPS track data.

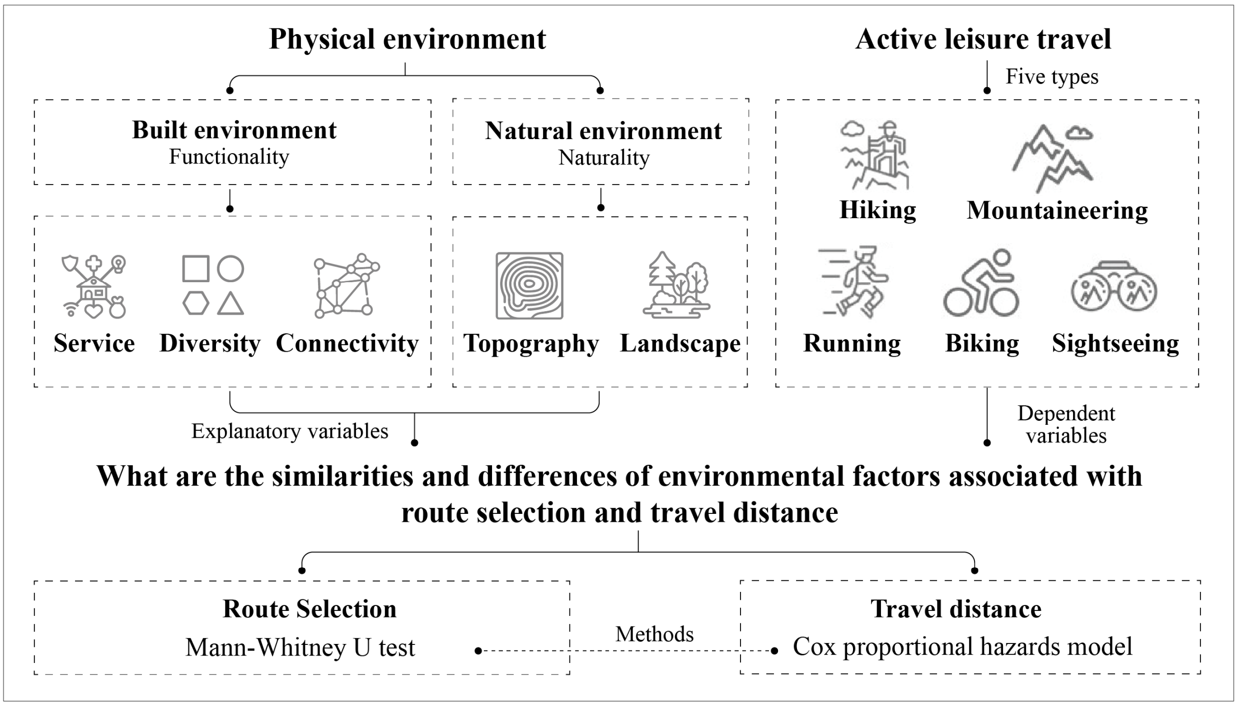

Figure 1. Research framework.

2. Data and Methods

2.1. Outdoor Active Leisure Travel Tracks

Beijing was selected as the focus of this investigation. The so-called "Forbidden City" is the centerpiece of Beijing's material cultural heritage and tourism infrastructure. When planning Beijing's urban development over the past 20 years, an ecological protection system was built based on mountain forests, a variety of wooded areas, and various forms of green spaces. As a result, Beijing provides ideal conditions for a wide range of outdoor recreational activities with public health benefits.

The sample of leisure travel data was collected from Foooooot (http://www.foooooot.com/, accessed on 2 May 2022), a popular outdoor travel app in China, which provides an online platform for users to record and share their tracks during outdoor leisure trips. Travel tracks and detailed data generated in Beijing between 2015 and 2021 were collected using network packet capture technology, which creates records including the location (latitude, longitude, and altitude), the speed and direction of GPS points, and the type, difficulty, time, distance, and departure time of the trip.

The original data consists of approximately 12.6 million GPS trajectories. The data cleaning procedure involved several steps: Firstly, trajectories that were entirely located within Beijing were extracted, while those spanning across provinces were excluded. Trajectories exhibiting distance errors exceeding 5% or displaying evident anomalies were removed. Subsequently, trajectories were filtered based on the mode of travel. Since the sample size for several activities (skiing, sailing, fishing, paragliding, and GPS painting) was very small, the primary active leisure travel included in this paper were hiking (43,343; 42.3% of trips), climbing (46,963; 45.8%), cycling (5239; 5.1%), running (5767; 5.6%), and sightseeing (1142; 1.1%), which together accounted for 102,454 individual trips (see examples of the five types of active leisure travel in Figure 2).

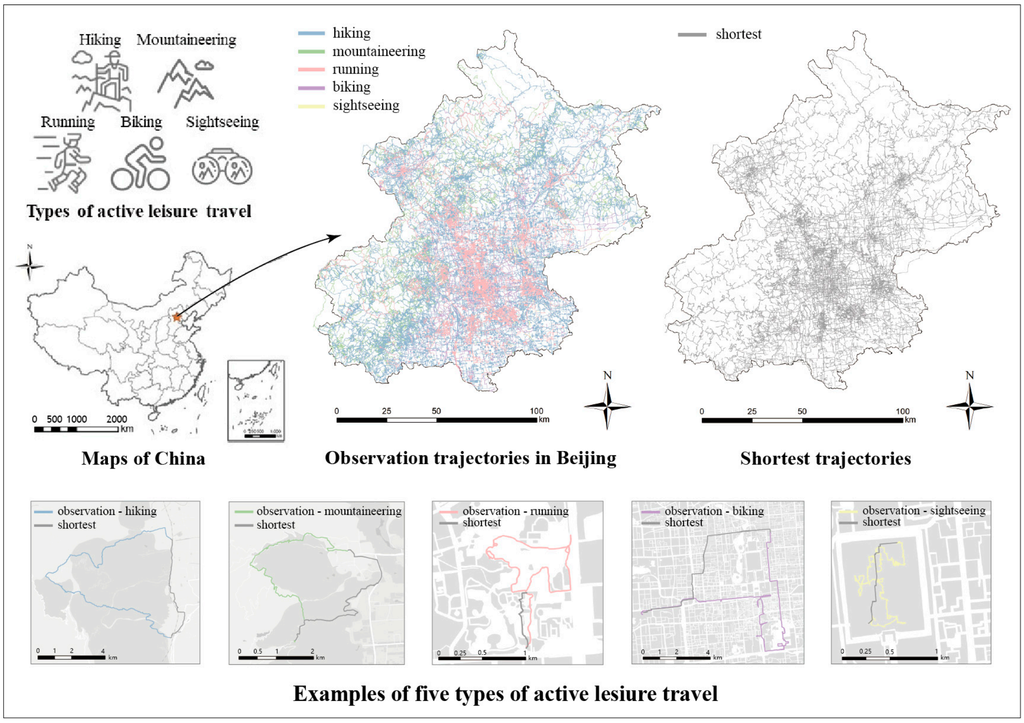

Figure 2. Study area, actual tracks, and shortest routes for active outdoor leisure travel.

The shortest possible travel path is a benchmark measure of what a utilitarian trip may have looked like and serves as a comparison to the observed trips. To replicate the shortest path, the mapping program for each actual observed journey track was launched. The route planning feature of the Amap open platform (https://lbs.amap.com/, accessed on 16 August 2022) was used, the Origin-Destination pair coordinates of the said travel track were entered, the appropriate mode of transportation was selected (the walking mode was selected for hiking, climbing, running, and sightseeing; the biking mode was chosen for biking), and then the simulated shortest path track and distance were calculated based on the road network.

2.2. Environmental Characteristics

This paper evaluates various factors of the built and natural environment within Beijing, China related to leisure travel. The environmental indicators can be divided into two categories: functionality and naturalness. The former uses the 5D approach (density, diversity, design, destination accessibility, and distance to transit services) described above to define the built environment's functional service diversity and density as well as transit accessibility. The latter describes the qualities of green spaces and observed topography changes while traveling. Several natural terrain types are also evaluated to investigate which natural landscapes are more alluring for leisure trips.

In this investigation, a hexagonal honeycomb grid with sides measuring 50 m was used to rasterize the study area. All environmental indicators were calculated in each honeycomb cell. The mean, standard deviation, and nonzero section ratio (the proportion of cells where a certain POI exists within all cells through which the path passes) of the environmental indicators in the honeycomb cells that the route traveled through were then totaled. The mean was used to describe the general characteristics of the travel environment, the standard deviation was used to reflect environmental variability, and the nonzero section ratio can be used to assess the balance of facility distribution. These selected indicators and specific measurements are shown in Table 1.

Table 1. Environmental Measurements.

Dimensionality		**Secondary Indicators**	**Description**	**Data Source**
Functionality	Density of services	Leisure and Entertainment Restaurants Shopping mall Toilet Banks Hotels Scenic attractions Park Square Cultural Venues Company Residential	Mean value: the mean value of the number of POIs within the hive cells through which the path passes. Proportion of nonzero sections: the proportion of cells where a certain POI exists within all hive cells through which the path passes	Amap
	Diversity	Number of service POI types	Types of service type POIs in all hive cells through which the path passes	Secondary calculation
		Land Use Mix Index	Calculation of the Land Use Shannon Diversity Index based on five POI ratios: residential, corporate, commercial (shopping, banks, restaurants, hotels), recreational, and leisure (scenic spots, parks and squares, cultural venues)	
	Accessibility	Density of population	Population Mean Value	LandScan
		Density of road intersections	Intersection mean, section ratio for intersection of three or more roads	Secondary calculation
		Subway Stations	Average number of POI at subway station entrances and exits, proportion of nonzero sections	Amap
		Bus stops	Average number of POI at bus stops, proportion of nonzero sections	
Naturality	Terrain	Elevation	Average elevation	ASTERGDEM
		Elevation fluctuation	Elevation standard deviation	Secondary calculation
		Slope	Average slope	
		Slope fluctuation	Standard deviation of slope	
	Landscape	Farmland Forests Shrubs Grassland Waters	Proportion of area of specific natural sites to the area of all hive units	CLCD
		Landscape Mix	Calculation of the Shannon Diversity Index based on five natural land area ratios: farmland, forest, shrub, grassland, and water	Secondary calculation
		NDVI	Average NDVI values	Landsat8

Amap, the LandScan Global Population dataset, the Advanced Spaceborne Thermal Emission and Reflection Radiometer Global Digital Elevation Model (ASTER GDEM) dataset, the CropLand Change Dection (CLCD) dataset, and Landsat 8 satellite images were the five original data sources. All of their points of interest (POI) sites and road network vector data, which cover the years from 2015 to 2020, were from Amap. The population raster data came from the LandScan Worldwide dataset 2015–2019 global population distribution with a precision of 1 km. The ASTER GDEM collection contains elevation data with a precision of 30 m. Data on natural land are from 30 m. China's yearly land cover product (CLCD) was produced by Landsat, 2015–2020 [38]. Landsat-derived remote sensing photos of Beijing from May 2015 to 2020 with a cloudiness rating of less than 5 were used to construct the Normalized Difference Vegetation Index (NDVI), a measure of vegetation cover and vigor, after the radiometric calibration and atmospheric correction. The distribution of data is shown in Figure 3.

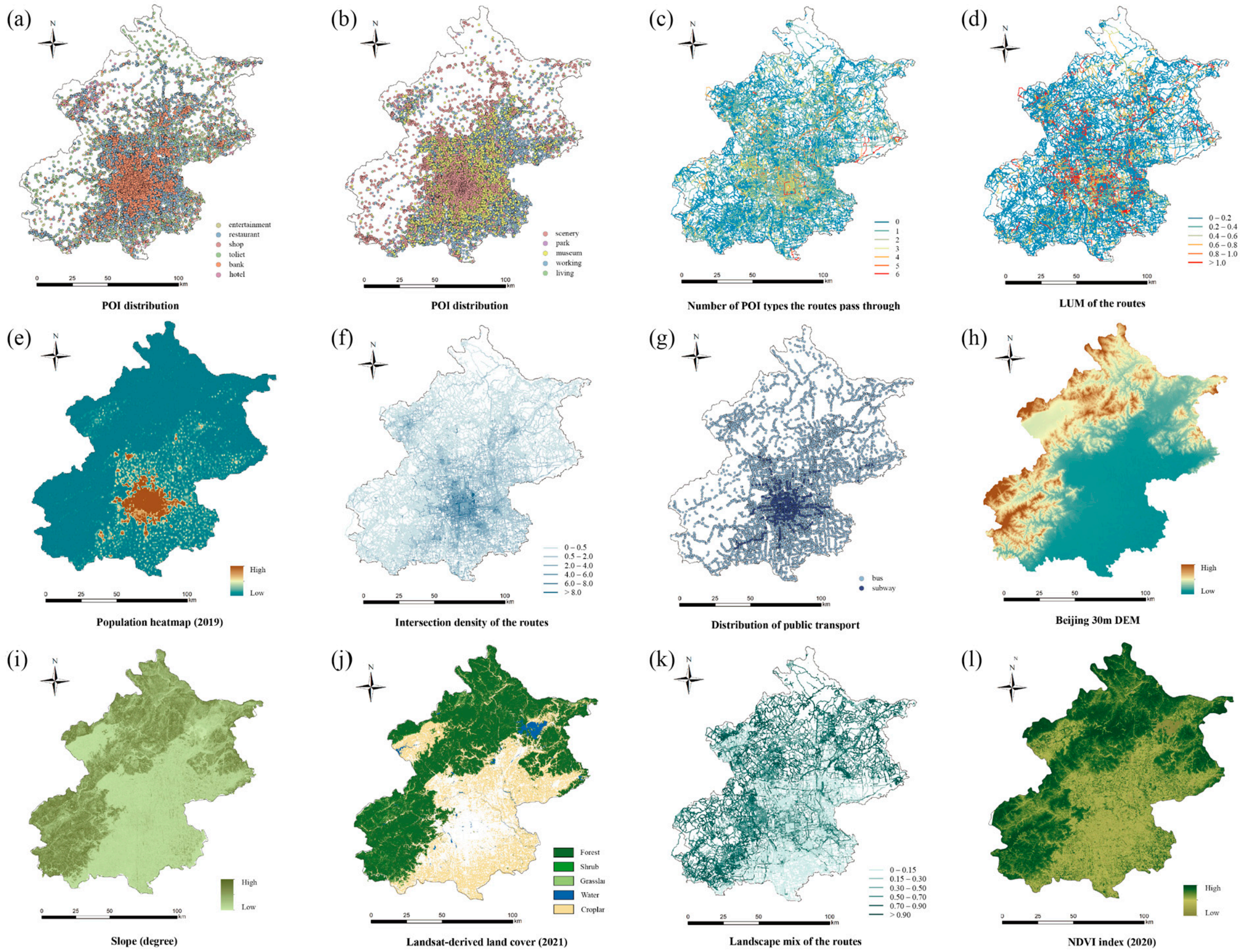

Figure 3. Data distribution of environmental factors: (**a**,**b**) depict the distribution of points of interest (POI) points, while (**c**) presents the number of POI types along each route; (**d**) represents the LUM index of the route, while (**e**) displays the population density map of Beijing in 2019; (**f**) shows the intersection density of each route, while (**g**) shows the distribution of public transport stations; (**h**,**i**) represent the elevation and slope of Beijing, respectively; (**j**) shows the type of land cover in 2021, and the landscape mix index of each route is shown in (**k**). Lastly, (**l**) illustrates the NDVI indicators for Beijing in 2020.

2.3. Methods

This paper discusses the environmental characteristics affecting route choice and travel distance separately. First, route choice was analyzed with non-parametric Mann–Whitney U tests to compare the environmental differences between the actual observed path and the shortest path. Second, to assess travel distance, Cox proportional risk models were applied to estimate the associations between the explanatory variables and the continuous travel distance.

2.3.1. Mann–Whitney U Test

The Mann–Whitney U test was used to assess the environmental differences between the real journey and the shortest path because the majority of the indicators were not normally distributed. The test was conducted on five different leisure travel modes, respectively. A total of 45 pairs had to be tested, and the mean of the number of POIs calculated by some indicators was tested separately from the proportion of nonzero paths. The results were Bonferroni corrected, which lowers the significance level for the actual test to 0.05/45 to avoid false positives from multiple tests.

2.3.2. Cox Proportional Hazard (PH) Model

The Cox PH model serves as a tool for analyzing the impact of various risk factors on the survival period. In this study, we define travel distance as the survival period and take the trip termination as the event. This model suits our analyses because each trip is a continuous increase in travel distance until the end of the trip [39], akin to the trajectory of lifespan. In other words, the probability of advancing additional distance units on the trip depends on the distance already traveled [40]. Therefore, a Cox PH model can be constructed with environmental factors such as explanatory variables, the travel year, and the minimum distance as control variables. The travel year is controlled for because of annual changes in the built environment. The model can be expressed as follows:

$$h(d) = h_0(d) \exp\left[\beta_{SD}\,\mathrm{SD} + \beta_{OL}\,\mathrm{OL} + \sum \beta_{year}\, year + \sum \beta_{BE}\, BE\right]$$

where the risk function *h(d)* represents the probability of the trip ending when the travel distance reaches d, $h_0(d)$ is the baseline risk function, SD is the corresponding shortest path distance (m), OL is the proportion of overlap with the shortest path, the year is the year dummy variable in which the trip occurs, and BE is the environmental variable, as shown in Table 1. β_{SD}, β_{OL}, β_{year}, and β_{BE} are the coefficients of the above variables. Comparing the relationships between the explanatory factors and outcomes is completed using the hazard ratio (HR). If the HR is significantly greater than 1, greater independent variable values are associated with a higher risk of the trip ending, which results in a shorter travel distance. If HR is less than 1, lower independent variable values are associated with a longer travel distance. The results of the coefficients for the dummy variables for the years are not included in the table.

In addition, for the POI class of environmental elements, the mean of the number of POIs and the proportion of nonzero road sections were distinguished, and two Cox proportional risk models (the rest of the indicators remain unchanged) were constructed to compare the overall characteristics of environmental elements with the degree of distribution balance on the travel distance.

3. Results

3.1. Descriptive Statistics

Table 2 displays the observed distance taken by the foooooot user, the shortest trajectory distance's mean and standard deviation as well as its mean detour index (shortest/observation) for each type of travel. Running is the most detour-prone mode of transportation, but it also has the shortest distance traveled. The next most detour-prone mode of transportation is hiking, which has an average shortest route length of 4.3 km but an average observed distance traveled of more than 10 km. Cycling provides around 2.8 times more travel on average than the shortest route, although mountaineering and cycling's shortest routes have similar distances and standard deviations, showing that the two activities have equal spatial spans. By contrast, the least detoured activities are mountaineering and sightseeing. Cycling is the sole form of transportation among many, and it has the longest average journey distance.

Table 2. Distances (unit: kilometers) and detour indices for various types of leisure travel.

	Observation (sd)	**Shortest (sd)**	**Detour**	**1/Detour**
hiking	10.218 (12.732)	4.319 (9.596)	0.315	3.175
mountaineering	12.425 (10.078)	6.213 (11.260)	0.508	1.969
running	8.251 (11.330)	1.074 (3.908)	0.108	9.259
biking	32.751 (34.432)	7.276 (12.831)	0.354	2.825
sightseeing	22.451 (36.412)	10.851 (18.799)	0.540	1.852
total	12.407 (14.933)	5.229 (10.612)	0.328	3.049

Note: Detour is equal to the shortest distance divided by the observed distance.

3.2. Mann–Whitney U Test

Table 3 displays the Mann–Whitney U test z values for each variable between the actual and shortest route, where colored grids indicate their Bonferroni-adjusted *p* values, which are significant given an alpha of 0.05 with a Bonferroni correction that reduces the threshold to 0.001 (0.05/45). Blue denotes results with negative z values, red denotes results with positive z values (using the shortest route as the baseline group for comparison), and darker colors denote higher absolute values of z values, which indicate some patterns. First, the observed paths for all five recreational travel modes are farther than the shortest routes (Table 3). Hiking and mountaineering routes had the most diversions (or greatest diversion from the shortest path benchmark), and sightseeing routes stray the least from the shortest routes.

In terms of the indicators of the built environment, the actual routes of the five modes of transportation have a larger density of services (aside from dining establishments, banks, homes, and tourist sites), a wider range of amenities, and a higher density of public transportation stops. As opposed to the shortest routes, these have lower population densities, intersection densities, and segment ratios. Sightseeing is the mode with the least environmental difference from the shortest path among the five types of recreational trips, while mountaineering reports the most substantial negative correlation. This finding is reasonable because mountaineering activities predominantly take place in natural environments further away from roadways, and while people still choose mountaineering routes with more infrastructure, including shops and restrooms, the fraction of trails with these amenities is smaller and the distribution is not uniform. With the exception of intersection density, the popular environments for cycling and running are comparatively constant. Runners are more likely to choose routes with greater intersection density, which denotes higher road connectivity, but cyclists avoid routes with more intersections.

The actual routes for all five recreational travel modes feature higher elevations, slopes, a greater variety of sceneries, more flora, more varied terrain, and a higher percentage of natural landscapes, according to measures related to the environment (except for farmland). The mountaineering paths among them are surrounded by thick forests but a somewhat smaller share of nearby water.

Table 3. Results of Mann–Whitney U test.

		Hiking	Mountaineering	Running	Biking	Sightseeing
Shortest route						
distance		156.105	160.186	83.591	64.251	18.503
Built environment: functionality						
entertainment	No.	32.47	5.973	25.982	19.467	0.636
	Pct.	31.488	4.63	25.602	21.094	0.281
restaurant	No.	−6.889	−4.831	−7.895	−7.222	12.131
	Pct.	−39.584	−57.37	−0.67	−11.14	−8.446
shop	No.	31.631	45.286	11.201	18.424	15.452
	Pct.	18.197	−26.116	20.565	12.71	−2.209
toilet	No.	29.828	30.425	13.397	24.803	20.282
	Pct.	23.246	−16.896	24.866	35.506	2.358
bank	No.	−3.873	−2.615	−2.323	−1.034	10.096
	Pct.	19.015	−24.743	20.309	17.169	−0.499
hotel	No.	30.916	37.461	10.094	18.044	13.949
	Pct.	15.268	−16.126	19.144	21.462	−0.24
scenery	No.	−49.81	−59.725	−8.617	−19.811	7.901
	Pct.	39.72	44.564	15.696	17.895	5.109
park	No.	31.288	−13.039	27.625	31.087	4.663
	Pct.	31.065	−13.27	27.469	30.97	4.657
museum	No.	63.939	55.766	30.582	47.042	11.546
	Pct.	20.352	−1.657	19.669	23.021	1.65
working	No.	30.011	32.106	7.751	20.163	16.352
	Pct.	17.877	−31.92	18.359	13.866	−2.358
living	No.	−49.422	−32.612	−19.862	−27.206	3.957
	Pct.	14.281	−21.726	14.65	8.261	−1.019
POI diversity		45.555	33.811	26.667	32.95	23.197
Land use mix		−5.744	−27.26	16.887	9.614	11.161
population		−10.995	−48.774	−0.457	−6.598	−4.891
intersection	No.	−16.617	−75.281	5.377	−11.607	−3.869
	Pct.	−25.43	−81.066	−1.185	−20.051	−6.358
bus	No.	28.48	27.77	11.636	23.273	18.82
	Pct.	5.598	−41.856	20.422	26.972	−3.237
subway	No.	13.442	4.99	8.776	16.173	8.68
	Pct.	14.942	−0.869	13.278	15.866	1.91
Natural environment						
DEM	Mean	69.036	106.439	51.441	52.57	13.193
	SD	162.243	165.235	85.521	82.069	26.906
Slope	Mean	102.819	173.505	53.466	57.191	19.373
	SD	141.46	180.532	72.856	73.439	23.393
NDVI	Mean	87.123	195.314	21.345	24.315	16.431
	Max	126.794	157.69	58.562	49.594	15.631
	SD	103.849	74.483	52.644	45.193	11.37
Cropland		−5.999	−112.72	27.289	40.716	−3.493
Forest		74.262	184.311	24.64	34.199	13.895
Shrub		53.256	97.215	6.968	7.375	10.585
Grassland		32.571	46.82	11.323	18.714	6.11
Water		44.154	−11.3	28.461	41.01	7.717

Table 3. *Cont.*

	Hiking	Mountaineering	Running	Biking	Sightseeing
Landscape mix	53.65	42.488	34.402	45.947	8.039

Note: The redder the background color of a cell, the larger the value; the bluer the color, the smaller the value.

3.3. Cox Proportional Risk Model Results

The trip distance is shown on the x axis, whereas the model-predicted survival rate—a measure of the likelihood that leisure travel will occur—is shown on the y axis (Figure 4). Running, mountaineering, and hiking, are the three most responsive forms of transportation, that is, as journey distance increases, the likelihood of continuing declines. Cycling and sightseeing have the highest likelihood of occurring when the distance traveled is greater than 50 km, whereas running, mountaineering, and hiking have a likelihood that is very near 0.

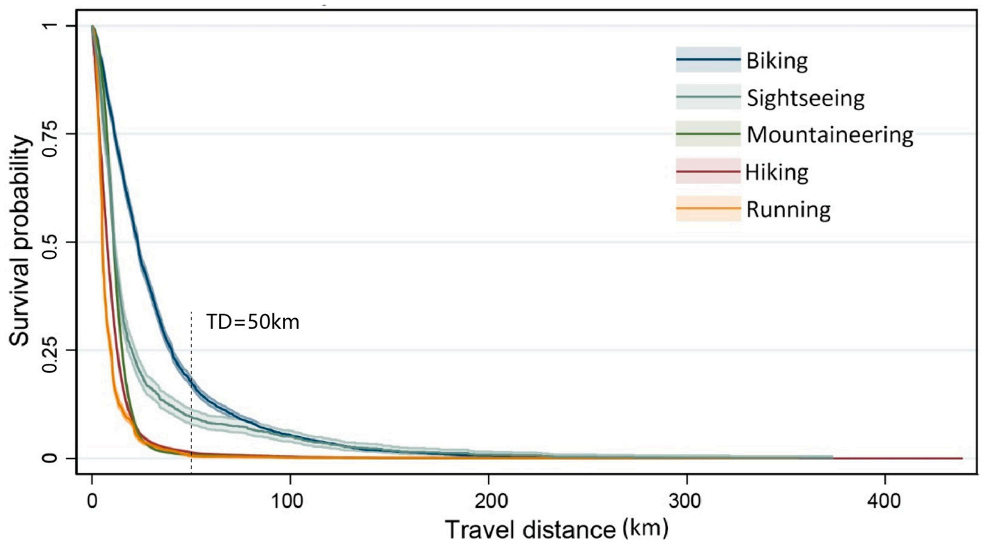

Figure 4. Kaplan–Meier survival curve for leisure travel distance (95% CI).

Tables 4 and 5 show the results of hazard ratios (HRs) from the Cox proportional hazards models with different ways to describe POI indicators. Table 4 uses the average number of POIs, and Table 5 uses the nonzero section ratios of POIs.

The average number of toilets and recreational facilities consistently and significantly exhibit high-risk outcomes in the models of the five leisure travel patterns (Table 4); that is, they do not support an increase in travel distance. By contrast, a lower risk of failure for all forms of leisure trips is influenced by facility diversity and population density. A larger number of stores near junctions is anticipated to result in longer trips for people who are bicycling and hiking. Additionally, lengthier rides are encouraged in areas with a high household density and a low corporate density. By contrast, a positive correlation exists between running distance and the average number of restaurants, parks, and museums. Additionally, the quantity of subway entrances merely increases the distance for cycling and running. The number of different types of amenities is negligible or negligibly positive for the journey distance for mountaineering and sightseeing patterns, but the greater the diversity of facilities, the longer the corresponding travel distance. Additionally, the influence of land use mix (LUM) is more nuanced, and a high LUM is negatively associated with longer hikes and runs and positively associated with longer mountaineering and bike rides.

Table 5 (nonzero section ratios) reveals that the section ratios for restrooms and recreational facilities continually maintain consistent, noticeably greater risk findings across the five recreational travel modes. The hazard ratios and 95% CI of two types of POI indicators are shown in Figure 5. Consistent with Table 4, the favorable effects of facility diversity and population density on travel distance also exist. For mountaineering activities, a balanced distribution of service facilities, such as shops, hotels, and museums, can greatly increase travel distances, whereas a large number of amenities is unfavorable to long-distance travel. Similarly, greater running or hiking distances are preferred given an equal distribution of businesses and dwellings. Although the average number of bus and subway stops was not related to the majority of leisure trip distances, their nonzero section ratios favor longer trips, underscoring the significance of a proper stop distribution. By contrast, a restaurant's nonzero section-to-quantity ratio makes evaluating the running distance difficult. The association between museums and hiking distance is different in a similar way.

Additionally, for the naturalness indicator, the results in Tables 4 and 5 are mutually reinforcing. Different leisure travel options have distinct advantages and disadvantages. People go on a longer hike or cycle further on lower elevation roadways, whereas mountaineering typically takes place in higher elevation areas. All four recreational travel modes—aside from biking—are anticipated to stay away from severe inclines. In general, places with diverse topographies are preferred for leisure travel, especially for mountaineering and riding. The maximum value rather than the average value can increase travel distance in the case of vegetation cover. All five categories, without exception, have a longer travel distance in areas with a high landscape mix. Hiking is typically expected to occur in areas with a high proportion of agriculture, forests, and shrubs, whereas mountaineering does not occur in places with a high proportion of natural landscape. For the remaining journeys, cycling occurs on farms, and running occurs in forests.

Table 4. Results of the Cox proportional risk model (described by the average number of POIs).

	Hiking	Mountaineering	Running	Biking	Sightseeing
Shortest route					
Overlap	**1.018** ***	**1.013** ***	**1.021** ***	**1.024** ***	**1.016** ***
shortest	**0.963** ***	**0.979** ***	**0.925** ***	**0.976** ***	**0.980** ***
Built environment: functionality					
entertainment	**1.009** ***	**1.034** ***	**1.009** ***	**1.023** ***	**1.028** ***
restaurant	**1.012** ***	1.020	**0.981** **	0.998	1.001
shop	**0.998** **	**1.043** ***	**1.016** ***	**0.983** **	1.000
toilet	**1.037** ***	**1.362** ***	**1.170** ***	1.060 *	**1.049** ***
bank	**0.979** ***	**1.130** **	**1.028** ***	1.078	0.968
hotel	**1.036** ***	**1.121** ***	**1.048** ***	1.079 *	0.977
scenery	1.003	**1.051** ***	0.994	**1.057** ***	1.013 *
park	1.005 *	**1.160** ***	**0.970** ***	**1.128** ***	**1.103** ***
museum	**0.989** ***	**1.066** ***	**0.978** ***	**1.056** ***	1.006
working	1.001	**1.011** ***	0.998	**1.040** ***	1.008
living	**1.000** ***	1.000	1.001	**0.998** **	1.000
POI diversity	**0.696** ***	**0.703** ***	**0.667** ***	**0.710** ***	**0.781** ***
Land use mix	1.043 *	**0.816** ***	**1.158** **	**0.761** ***	0.867
population	**0.993** **	**0.923** ***	**0.984** ***	**0.985** **	0.968 *
intersection	**0.999** ***	1.000 *	1.000	**0.999** ***	1.000
bus	**1.013** ***	1.008	1.002	1.004	1.003
subway	1.003	1.190	0.904 *	0.927 *	0.977
Natural environment: naturality					
DEM (Mean)	**1.126** ***	**0.796** ***	1.166	**5.856** ***	0.884
DEM (SD)	**0.229** ***	**0.030** ***	**0.531** ***	**0.033** ***	**0.120** ***
Slope (Mean)	**1.010** ***	**1.008** ***	**1.025** **	0.996	**1.060** ***
Slope (SD)	1.005	**0.959** ***	1.007	0.992	**0.891** ***
NDVI (Mean)	**1.011** ***	**1.007** ***	**1.006** ***	**1.007** **	**1.026** ***
NDVI (max)	**0.959** ***	**0.917** ***	**0.974** ***	**0.900** ***	**0.900** ***

Table 4. *Cont.*

	Hiking	Mountaineering	Running	Biking	Sightseeing
NDVI (SD)	**1.013** ***	**0.993** ***	**0.980** ***	0.999	**1.035** ***
Cropland	**0.992** ***	**1.020** ***	1.001	**0.994** ***	1.002
Forest	**0.994** ***	**1.018** ***	**0.987** ***	1.002	1.005 *
Shrub	**0.938** ***	**1.046** ***	0.800	0.912	0.876 *
Grassland	**1.014** ***	**1.040** ***	1.000	0.990	**1.031** ***
Water	**1.009** ***	**1.057** ***	1.005 *	**1.064** ***	1.019 *
Landscape Mix	**0.357** ***	**0.368** ***	**0.535** ***	**0.289** ***	**0.394** ***
−2LL	−406,063.9	−444,755.75	−42,414.65	−35,540.6	−6181.2014
N	43,343	46,963	5767	5239	1142

Note: ***, ** and * are statistically significant at 99%, 95%, and 90%, respectively. *p* values at 95% significance in regression are in bold. The results of dummy variables of travel year were excluded.

Table 5. Results of the Cox proportional risk model (depicted as a proportion of nonzero sections of the POI).

	Hiking	Mountaineering	Running	Biking	Sightseeing
Shortest route					
Overlap	**1.018** ***	**1.013** ***	**1.020** ***	**1.025** ***	**1.017** ***
shortest	**0.963** ***	**0.980** ***	**0.928** ***	**0.976** ***	**0.980** ***
Built environment: functionality					
entertainment	**1.027** ***	**1.056** ***	**1.007** **	**1.055** ***	**1.036** ***
restaurant	0.999	**0.957** ***	**1.017** ***	1.005	1.004
shop	1.001	**0.975** ***	**1.029** ***	1.009 *	0.987
toilet	**1.012** ***	**1.054** ***	0.998	1.002	**1.049** ***
bank	**0.992** ***	1.018	**1.016** **	**1.074** ***	0.972
hotel	**1.007** ***	**0.960** ***	**1.033** ***	**0.950** ***	0.981
scenery	**1.003** **	**1.031** ***	0.999	**1.037** ***	**1.019** ***
park	0.997	**1.077** ***	**0.960** ***	**1.152** ***	**1.129** ***
museum	**1.012** ***	**0.934** ***	**0.971** ***	**1.061** ***	0.996
working	**0.984** ***	1.011	**0.989** ***	**0.986** **	0.998
living	**0.997** **	**1.074** ***	**0.992** ***	1.010	**1.027** ***
POI diversity	**0.701** ***	**0.710** ***	**0.650** ***	**0.716** ***	**0.792** ***
Land use mix	1.033	**0.837** ***	**1.179** **	**0.708** ***	0.785 *
population	**0.993** ***	**0.925** ***	**0.987** ***	**0.979** **	0.976
intersection	**0.997** ***	**1.004** ***	1.000	**0.988** ***	**0.995** ***
bus	**0.963** ***	**0.947** ***	0.995	**0.929** ***	1.002
subway	0.988	**1.291** ***	**0.818** ***	**0.871** ***	0.987
Natural environment: naturality					
DEM (Mean)	**1.131** ***	**0.789** ***	1.050	**6.280** ***	0.841
DEM (SD)	**0.229** ***	**0.030** ***	**0.546** ***	**0.029** ***	**0.155** ***
Slope (Mean)	**1.008** ***	**1.015** ***	**1.038** ***	0.995	**1.048** **
Slope (SD)	1.004	**0.950** ***	0.993	1.001	**0.896** ***
NDVI (Mean)	**1.010** ***	**1.007** ***	**1.009** ***	**1.010** ***	**1.025** ***
NDVI (max)	**0.960** ***	**0.916** ***	**0.972** ***	**0.905** ***	**0.901** ***
NDVI (SD)	**1.012** ***	**0.992** ***	**0.984** ***	1.003	**1.035** ***
Cropland	**0.992** ***	**1.021** ***	1.000	**0.990** ***	1.003
Forest	**0.994** ***	**1.017** ***	**0.985** ***	0.997	**1.006** **
Shrub	**0.944** ***	**1.042** ***	0.740	0.902	0.881 *
Grassland	**1.014** ***	**1.041** ***	1.000	0.986 *	**1.032** ***
Water	**1.008** ***	**1.046** ***	1.004	**1.055** ***	**1.021** **
Landscape Mix	**0.343** ***	**0.362** ***	**0.510** ***	**0.266** ***	**0.384** ***
−2LL	−405,916.2	−444,487.22	−42,336.09	−35,471	−6164.7296
N	43,343	46,963	5767	5239	1142

Note: ***, **, and * are statistically significant at 99%, 95%, and 90%, respectively. *p* values at 95% significance in regression are in bold. The results of the dummy variables of the travel year were excluded.

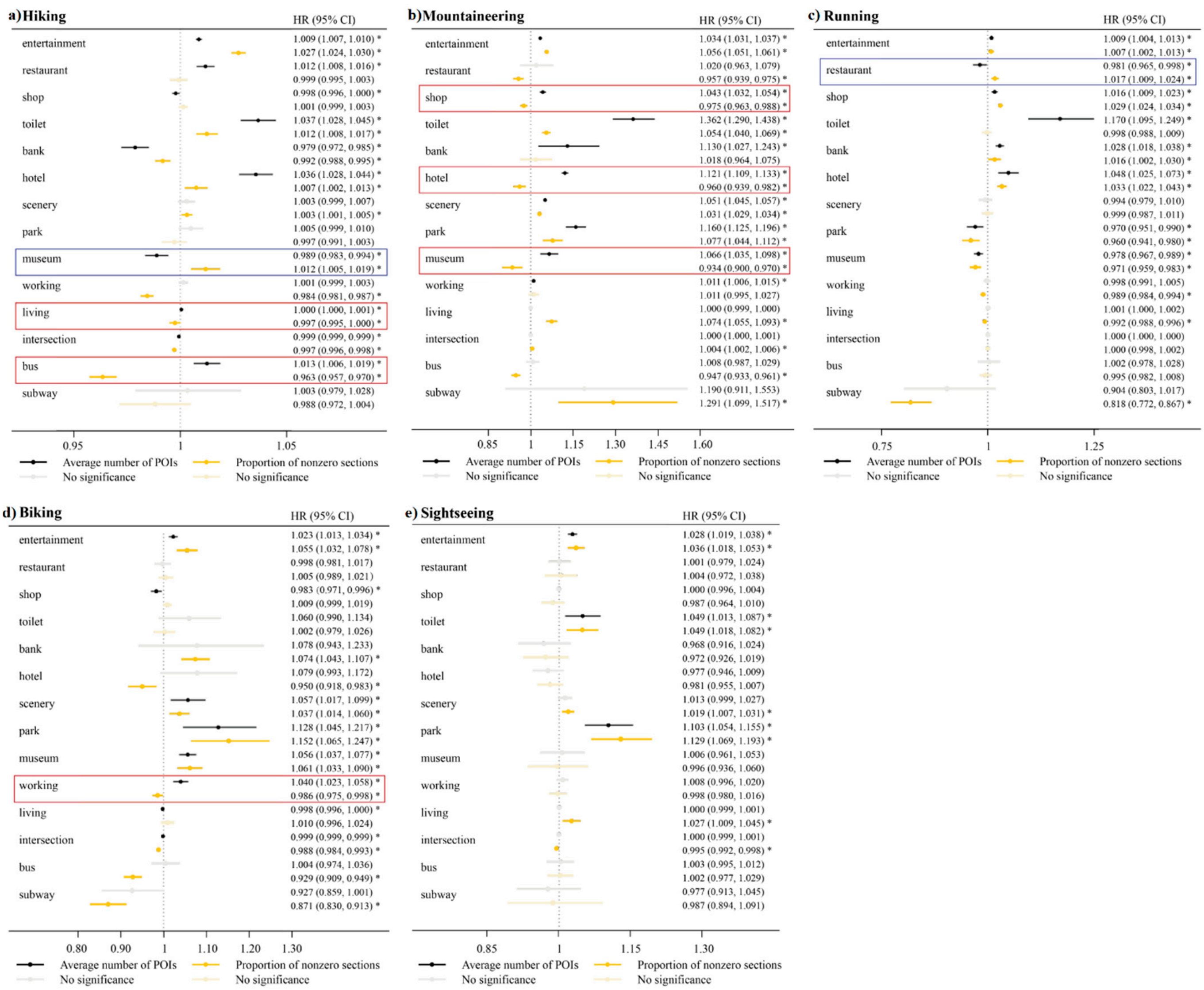

Figure 5. Hazard ratios and 95% CI of two POI indicators (the black refers to the average number of POIs, the yellow refers to the percentage of nonzero sections) for five leisure travel modes, namely, hiking (**a**), mountaineering (**b**), running (**c**), biking (**d**), and sightseeing (**e**). The gray and the light yellow, respectively, represent the non-significant factors. The red box marks the percentage of nonzero sections as a positive factor promoting long-distance travel, while the average number of POIs is a negative factor. And the blue box marks the opposite. Note: * means p value is less than 0.05.

4. Discussion

4.1. Differences in the Influence of Environmental Factors on Route Choice and Travel Distance

The results of route selection indicate that environmental factors correlate for certain types of leisure travel, whereas travel distance more accurately reflects the amount of physical activity involved in that journey. The findings show some overlap between surroundings that promote physical activity and appealing environments (Figure 6). Routes with high commercial diversity, land functional diversity (for hiking and mountaineering), high landscape mix, unique natural landscape proportions, and topographic diversity, for instance, are related to both leisure travel and are suitable for longer trips. By contrast, routes with low commercial diversity, land diversity (for hiking and mountaineering), and high landscape mix do not.

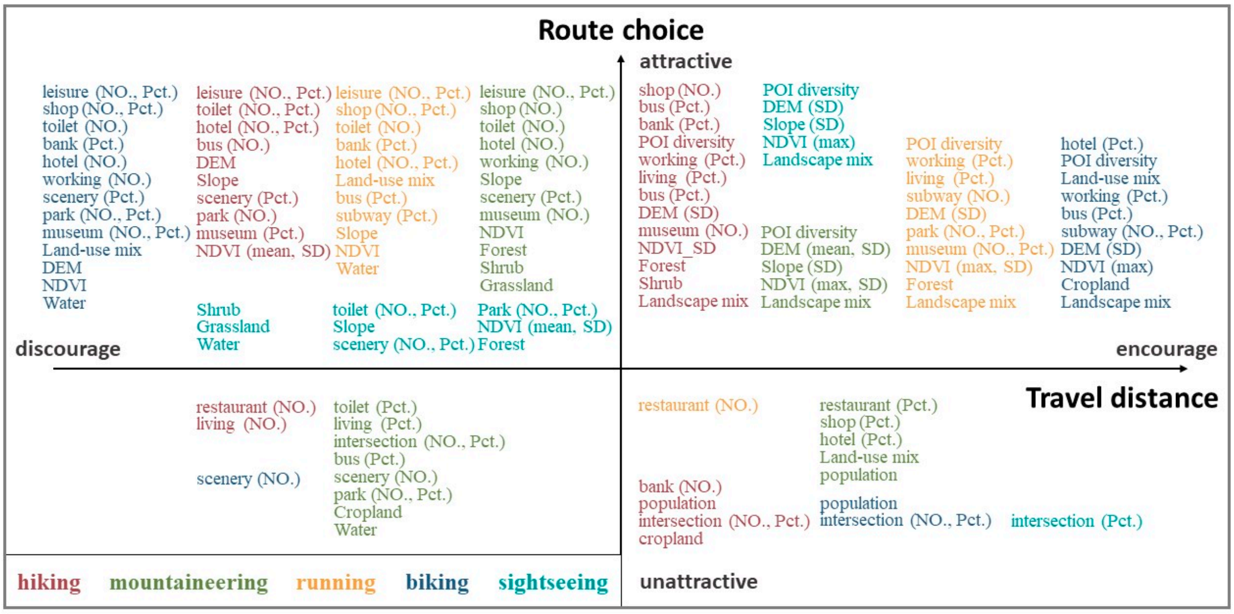

Figure 6. Quadrant of environmental preference for route choice and travel distance. NO. denotes the average number of POI indicators, Pct. denotes the nonzero section ratio of POI indicators, the mean is the mean value, and SD is the standard deviation.

Certain environmental elements vary with and predict route selection and trip time in various ways. While most services and transportation facilities are more densely or disproportionately distributed than the shortest route when used for leisure travel other than mountaineering, this does not automatically mean that they may encourage physical activity. The percentage of particular natural areas, including grasslands and watersheds, is comparable. Two potential reasons can explain this: On one hand, a functional and accessibility necessity for pleasure travel undoubtedly exists, but it is substantially less important than for travel that is strictly necessary [28,41]. High density may degrade the quality of travel along the route when the amount and variety of amenities, such as toilets or shops, are adequate [42]. However, streams and grasslands do have some attractive landscapes [43], and they are more likely to encourage frequent physical activity than long-distance travel [28,44]. A certain amount of "crowding" can also increase the distance traveled, even though leisure travel is favored on routes with low populations and residential density. Although crowding was once thought unfavorable for travel [45], researchers have gradually discovered that the presence of "good crowding" boosts the enjoyment of traveling [46]. Thus, the effect of crowding on leisure travel distance is complicated and reciprocal.

Furthermore, extending the distance of a component of leisure travel may be more advantageous than just increasing facility density if transit or other services are guaranteed to be available at regular intervals. This finding might be because leisure travel is more likely to be long-distance and leisurely than utilitarian travel [47,48], and reasonable facility locations are more suited to long-distance resupply than localized high densities.

4.2. Different Leisure Travel Environments

The different environments for different forms of travel vary significantly when leisure travel is broken down by activity type. Overall, the revealed preferences for varying amounts of physical activity, environmental observation, and crowd sensitivity give rise to these disparities in demand for different recreation environments.

Differences in demand for physical activity. Of the five leisure travel types included in this paper, sightseeing tends not to have exercise as its primary purpose, but it may be completed with the help of both walking and cycling. Hiking is typical of slow travel, whereas mountaineering, running, and biking typically have higher levels of physical activity [49]. In addition, the range and intensity of activity required for these types of leisure travel varies. As expected, mountaineering is more likely in an environment of higher elevations, whereas cycling is particularly less likely on high-elevation routes [43]; both are positively related to elevation change to the greatest extent, which may stem from the desire for self-challenge and the physical activity intensity for both activities [50,51]. Leisure travel similar to running, such as orienteering, GPS painting, and other leisure travel habits, circumnavigate small spans of space, and are better suited to dense forests or moderately undulating terrain environments, whereas urban parks tend to be favored sites [52,53], which may be due to the stronger stress-recovery effects of moderate-to-high intensity physical activity [54]. Although hiking is also encouraged to some extent by variable terrain, a preference still exists for flatter, lower-elevation environments, with increased physical activity mainly through detours. This preference reflects the nature of hiking as a soft adventure sport; that is, it is more focused on relaxation and discovery during the natural experience than on the pursuit of challenge and excitement [55].

Differences in environmental viewing. This paper found that the dominant environmental factor for leisure travel is the proportion of natural landscape and its balance. While a rich variety of facilities is equally beneficial for leisure travel [56], site mix has a much less positive effect than landscape mix. However, a specific proportion of natural landscapes does not always have a positive effect on travel distance, especially for hiking and sightseeing, where landscape diversity and balance are more important. This conclusion also applies to urban parks, where attractive urban green spaces may prioritize a variety of vegetation types rather than being designed as homogeneous entities [57]. The remaining types of leisure travel each have different environmental preferences; for example, hikers prefer environments with higher proportions of farmland, forest, and shrubs, and cyclists prefer traversing farmland [58] and routes with higher park density, and forest proportions produce longer running distances. Water proportions are reported beneficial in encouraging active travel and increasing the frequency of physical activity [28,44], but this paper found that water is not conducive to long-distance travel, especially for hiking, mountaineering, and cycling.

Differences in sensitivity to crowding. Leisure travel often avoids densely populated residential environments compared with the shortest routes, with mountaineering environments in particular being characterized by low-density suburban environments. On this basis, hiking, running, and biking allow for traveling farther on relatively crowded routes, compared with mountaineering and sightseeing, which are better suited to routes with more secluded sites. This difference may stem from dissimilarities in travel companionship and place. In contrast to Western single- or small-group forms of companionship [59], in recent years, organizing larger-scale urban hiking, running, or cycling through networks, festivals, communities, and units has become popular in China [60]. The former still predominantly occurs in sparsely populated suburban areas with beautiful natural landscapes over the latter [61,62]. Evidently, the social environment may have contributed to the difference in crowding sensitivity across travel and is reflected in the preference for the environment.

4.3. Limitations

This study was subject to some limitations. Firstly, the study delimited its focus to travel within Beijing, thereby excluding broader cross-city active leisure travel. Secondly, due to the lack of data, the models were unable to account for endogeneity problems between travel preferences, socioeconomic factors, route selection, and travel distance [63]. Consequently, identifying variations in travel environments related to individual factors was challenging. Thirdly, the sample pool was sourced exclusively from a singular application, potentially engendering user bias [64]. Notably, this approach omitted older outdoor enthusiasts, individuals accustomed to alternative social platforms, and foreign tourists from consideration.

The following challenges may continue to be addressed in future research: On the one hand, expanding the number and types of data sources offers a potential solution to the problem of inadequate samples. On the other hand, additional future research could analyze the mechanics of specific components of travel related to environmental features and the travel process, to address the paradox between sample size and the absence of socioeconomic features.

5. Conclusions

This paper examines the combined associations between urban built and natural environments on the route selection and travel distance of various types of active leisure travel. People frequently select routes with many amenities for leisure travel, but this is not always associated with longer trip times. By contrast, routes with a large proportion of land, a high proportion of different types of terrain, and a rich topography are appealing for both leisure travel and long-distance travel.

Additionally, compared with simply increasing facility density, the reasonable arrangement of facilities is more suitable for long-distance leisure travel.

In addition, we found that distinct leisure travel exhibits peculiar preferences for built versus natural surroundings, which may be related to variations in physical activity requirements, preferences for landscape viewing, and crowd-sensitive leisure travel. Out of the five leisure travel options, sightseeing is less focused on exercise, hiking is typical of slow travel, and biking, mountaineering, and running typically involve higher levels of physical activity. Different preferences for the landscape on different visits could result from these variances. The ratio of natural landscapes and their balance in relation to characteristics of the developed environment are additional dominant environmental factors for leisure travel. Each leisure travel pattern has a different predilection for the natural world. The social context may also affect how sensitive to crowding people are on different journeys and types of journeys, as evidenced by their preference for the environment. In contrast to mountaineering and sightseeing, which select routes with more quiet spots, hiking, running, and biking travel longer on rather congested routes.

Longer leisure travel promotes relaxation and physical activity and is more likely to withstand environmental changes. Therefore, conclusions drawn without considering the different types of leisure travel could be skewed. Furthermore, whether particular surroundings may effectively increase physical activity is debatable. While studying the connection between the environment, active transportation, and health, researchers may consider adopting a more holistic perspective. These policy ramifications are also brought about by this paper's findings.

On the one hand, the distance between leisure travel and urban tourism is eroding due to urbanization and improving living standards [65]. In addition to cycling in cities, hiking in suburban nature parks and even mountain climbing are now included in urban dwellers' everyday leisure activities that are no longer confined to simply walking around their homes. Aside from having a favorable effect on health and well-being, the increasing integration of these outdoor recreational activities with urban tourism can rejuvenate the industry as a whole [66]. As a result, urban planners should prioritize the attraction of natural environments for active leisure travel, develop urban ecotourism resources, and foster the high-quality advancement of urban ecotourism. This endeavor entails crafting eco-tourism policies underscored by green principles and minimal consumption, complemented by supporting infrastructures. Concurrently, improving the infrastructure for greenways, city parks, and natural reserves is imperative, which can encourage urban residents to partake in leisure activities within cities.

On the other hand, the setting that individuals typically pick for leisure travel is incompatible with the environmental factors that support lengthy travel distances. Long-distance leisure travel is generally more dependent on environmental diversity and balance. Therefore, practitioners need more empirical evidence to augment urban residents' engagement in leisure travel through comprehensive planning initiatives, bolstering the establishment of supportive and functional amenities within urban public spaces. To illustrate, advocating for the development of urban greenways is crucial, increasing the aesthetic diversity of the greenway by interlinking urban natural landscapes with human-centric features. Furthermore, ensuring the provision of transportation or service facilities at regular intervals along these routes is imperative to optimize convenience for residents and extend the distance of leisure travel.

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