International Journal of
Geo-Information

MDPI

Article

The Seasonal Migrants Spatially Affect the Park Green Space Accessibility and Equity under Different Travel Modes: Evidence from Sanya, China

Wentong Yang, Yeqing Cheng, Chunru Xu and Jinping Zhang *

College of Geography and Environmental Sciences, Hainan Normal University, Haikou 571158, China; 20212070500016@hainnu.edu.cn (W.Y.); hschengyq@hainnu.edu.cn (Y.C.); 20212070500015@hainnu.edu.cn (C.X.)
* Correspondence: 110966@hainnu.edu.cn

Abstract: The influx of seasonal migrants has a significant impact on public services in destination places and may reshape the spatial accessibility and equity patterns of park green space (PGS). However, the two-step floating catchment area (2SFCA) method and its extended forms neglect discrepancies between the travel behaviors of seasonal migrants and native residents and thus fail to delineate variations in PGS accessibility and equity in areas with seasonal migrants. To avoid this issue, this study drew on the case of Sanya, a city with large numbers of *Houniao*, who are primarily retirees leading seasonal migration between the north and the south of China. A multi-group, multi-mode Gaussian-based 2SFCA method was also proposed to evaluate the PGS accessibility and equity before and after the *Houniao* influx. The method considered the changes in the COVID-19 restrictions from a refined perspective, with fine-scale residential areas being the research units and travel time requested from the web map application programming interface. The results showed that most residential areas were found to have relatively low PGS accessibility and equity levels, except for those in the south-central and southwestern urban areas of Sanya. Both the *Houniao* influx and lifted COVID-19 restrictions affected the spatial patterns of PGS accessibility and equity. PGS accessibility and equity were decreased by the *Houniao* influx, whereas walking and public transport within a few residential areas outside *Houniao* gathering spots improved. This study can serve as a basis for the reasonable planning of PGS and other public services in cities receiving seasonal migrants, such as Sanya.

Keywords: park green space; accessibility; equity; *Houniao*; multi-group multi-mode two step floating catchment area method; spatiotemporal analysis; COVID-19

Citation: Yang, W.; Cheng, Y.; Xu, C.; Zhang, J. The Seasonal Migrants Spatially Affect the Park Green Space Accessibility and Equity under Different Travel Modes: Evidence from Sanya, China. *ISPRS Int. J. Geo-Inf.* **2023**, *12*, 423. https://doi.org/10.3390/ijgi12100423

Academic Editor: Wolfgang Kainz

Received: 10 July 2023
Revised: 7 October 2023
Accepted: 12 October 2023
Published: 14 October 2023

1. Introduction

Seasonal migration, driven by the desire to experience a different culture, enjoy a milder climate, and benefit from a more affordable cost of living, has emerged as a widespread global phenomenon [1–3]. This trend has become an important research topic in the fields of public policy, sociology, and public health [4,5], owing to increased personal mobility and improved living standards. These seasonal migrants, who annually engage in pendulum-like mobility between their home and destination places, are also referred to as snowbirds [6]. In countries like the United States, Canada, and Japan, where the population of seasonal migrants has reached a significant scale, in-depth analyses have been conducted regarding the motives behind the seasonal migration [7], the challenges these migrants encounter in accessing healthcare services at their destination places [4,8], as well as the precarity and perceived well-being they receive [9]. Additionally, seasonal migrants can also exert substantial influence on the areas they relocate to, manifesting in shifts in the energy consumption behaviors of native residents [10], reshaping the spatial patterns of supply and demand for the public space [11], etc. Given the wide-ranging impacts of seasonal migrants on the economy, environment, population distribution, landscapes, and more in their destination places, researchers have called for the inclusion of considerations of seasonal migrants in sustainable planning and decision-making processes [12,13].

With the aging of the population and the standards of living of residents improving continuously in China, internal retired migrants, also called *Houniao*, are gradually becoming non-negligible. These *Houniao* generally move seasonally from the cold north to the south, where the climate and environment are more pleasant, for a short-term residence; they leave after northern climates warm up, bringing opportunities for the development of the economic, social, and tourism industries in their destination places [14–16]. Similar to the challenges faced by other cities receiving seasonal migrants, the seasonal influx of a large number of *Houniao* also exerts enormous pressure on the public services at their destination places, leading to issues such as traffic congestion and public space shortages [17]. However, there remains a notable gap in research concerning the variations in spatiotemporal distribution of population and the impact of these migrants on public space in destination places, while a series of studies focus on qualitative analyses from the perspective of seasonal migrants. This lack of investigation results in a lack of theoretical support for urban planning and the allocation of public service facilities in cities receiving seasonal migrants.

Promoting the residents' sense of well-being directly and indirectly, park green space (PGS), as the main component of public space, provides ecosystem services from both cultural and environmental perspectives, thereby improving the health of residents while inspiring them to connect with nature [18,19]. Nevertheless, as urbanization progresses, urban open space is becoming increasingly fragmented. PGS, which is an essential component of the open space, has been separated by urban development into fragments located in various areas. The fragmentation of open spaces can present challenges in their efficient utilization due to inconvenient transportation between these dispersed areas [20]. Consequently, this situation results in a mismatch between the distribution of population and PGS, making it more challenging for certain areas to access this sort of open space compared to others. Moreover, the phenomenon of unequal distribution of resources and opportunities among different regions is considered within the context of spatial equity issues, which sparked extensive discussion among researchers.

Research on spatial equity of PGS has been mainly carried out by analyzing variations in PGS accessibility among residents in various regions, with increasing attention being paid to variations in park accessibility regarding different groups of socioeconomic status, races, and ages [21–23]. Evaluation methods and indicators within various contexts are multidisciplinary, including the Lorenz curve and Gini coefficient, Theil index, location entropy, and others [24–26]. Among these studies, the assessment of spatial equity is mostly based on spatial accessibility. This is because spatial accessibility is generally regarded as an indicator of spatial equity [27]. PGS accessibility is interpreted as the resistance residents overcome while accessing PGS [28]; good PGS accessibility generally implies better access to PGS resources for residents and, thus, more health benefits gained from PGS [29]. Hence, it is an essential indicator for identifying underserved areas and evaluating the reasonableness of PGS planning. Studies on PGS accessibility are abundant across the continents and have uncovered more detailed insights with the development of measurement methods. In early studies, researchers defined accessibility as the potential opportunity to access a service, with a greater emphasis on the relationship between the size of the service and distance rather than on the service itself [30]. In this context, Hansen [31] proposed a gravity model based on the gravity model. With the evolution of geographic information systems (GIS), approaches for measuring spatial accessibility, which incorporate buffer analysis and network analysis in the accessibility calculation, have witnessed a growing surge in popularity [32,33]. Nonetheless, the buffer method is inadequate as it overlooks zigzagging routes of travel, resulting in an underestimated coverage area. Similarly, the GIS-based network analysis method, while capable of calculating the travel time on actual road networks for various modes, does not consider the supply and demand between the PGS and residents. Both approaches fall short of capturing the reliable spatial pattern of accessibility. Therefore, the two-step floating catchment area (2SFCA) method proposed by Luo and Wang [34] has been widely used because it can reliably measure PGS accessibility from a supply–demand perspective using road networks. Moreover, extended forms of this method, integrated with extensions of decay functions [35], catchment sizes [36], competition among demands, and multiple travel modes [37,38], have been developed to meet the requirements for accessibility in different situations. Recent studies incorporated emerging web map platforms into accessibility measurements, thereby bridging the gap caused by subjective speed settings of different travel modes, neglecting complex urban traffic in the conventional 2SFCA method [39,40], and eventually measuring the PGS accessibility more accurately.

Many studies have employed the 2SFCA method to assess PGS accessibility; however, the impact of seasonal migrants has seldom been illustrated. This method remains limited regarding measuring the PGS accessibility for seasonal migrants in cities. First, although the research unit has been narrowed down from the municipal districts and census tracts [41,42] to the traffic analysis zones and communities [43,44], the spatial distribution of the native population and seasonal migrants at a finer scale remains undetermined. Second, travel behaviors and PGS demands are assumed to be inconsistent among different groups of residents; however, the influence of travel mode preferences of different groups on PGS accessibility cannot be revealed by the existing 2SFCA methods. Third, the distance thresholds for the catchment size of seasonal migrants are assumed to be different from those of native residents; hence, conventional practices with empirical thresholds set by researchers [45] result in inaccurate PGS accessibility that fails to demonstrate the influence of seasonal migrants.

As a well-known tropical coastal resort in China, Sanya attracts many *Houniao*, who migrate there every winter, seeking healthier lifestyles [16]. With inconsistencies in gathering spots and travel mode preferences among native residents, *Houniao* leads to periodic fluctuations in the spatial distribution of the population, urban traffic conditions, and PGS demand, which may affect PGS accessibility and equity. This may exacerbate or alleviate the PGS supply–demand mismatch, resulting in unfair access to PGS. Therefore, it is of great importance to study the impact of seasonal migrants on PGS accessibility and equity in migrant destinations, using *Houniao* as an example.

Using fine-scale residential areas as research units, this study proposes a modified 2SFCA method for more reliable PGS accessibility and equity under different travel modes prior to and following seasonal migration. The objectives are to (1) scientifically assess the PGS accessibility under different travel modes using the proposed method, (2) analyze the impact of the *Houniao* influx on the PGS accessibility patterns under different travel modes, and (3) reveal discrepancies in the PGS equity before and after the *Houniao* influx and provide a transferable approach for conducting research on the PGS accessibility while considering seasonal migrants and multiple travel modes. This method is illustrated and validated using a case study of the central urban area of Sanya.

2. Study Area

Located at the southern tip of Hainan Island, covering a total land area of 1921 km^2 (Figure 1), Sanya is an international tourist city with tropical seaside sceneries. As of 2021, Sanya has a resident population of 1.03 million, of which the urban population accounts for 71.78%, with a per capita GDP of CNY 81,000, ranking 97th among 293 prefecture-level municipalities in China. Moreover, Sanya is not only the second largest city in Hainan Province but also the city with the most *Houniao* in China. Specifically, more than 200,000 *Houniao* arrive in Sanya to escape the cold during the winter and return to their home places the following year, accounting for about 21% of the native residents reported by the Sanya Tourism and Culture Broadcasting and Sports Bureau (STCBSB, http://lwj.sanya.gov.cn/wljsite/, accessed on 20 February 2023). These seasonal migrants have contributed to the development of Sanya's economy and tourism, but they have also placed significant pressure on public services, resulting in traffic congestion and PGS shortage. This issue has garnered considerable attention from both policymakers and researchers.

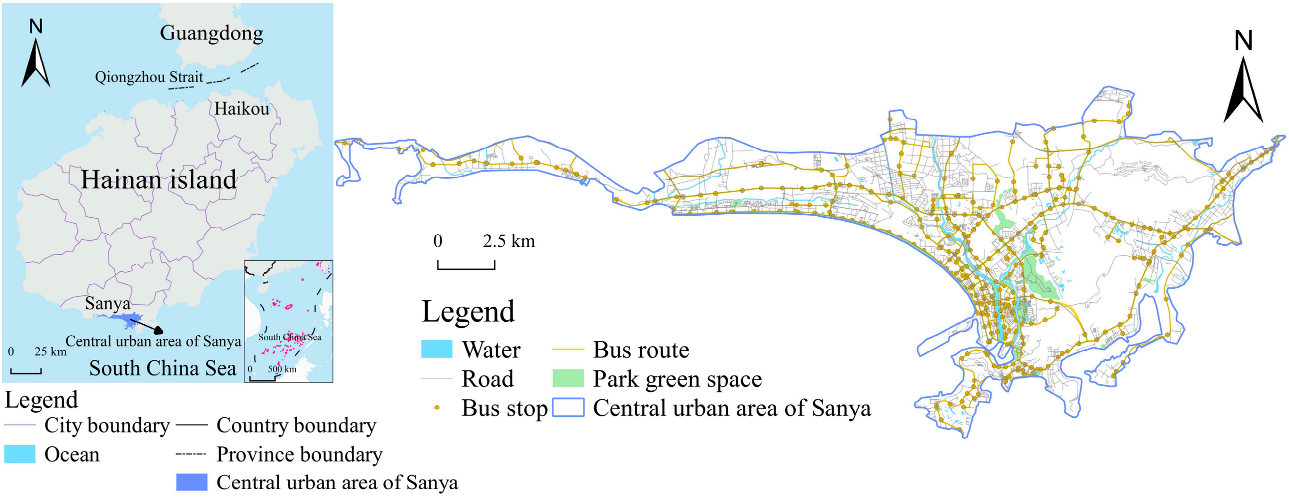

Figure 1. Study area and the spatial distribution of the bus stops.

Additionally, unevenness in the distribution of public transport (PT) resources is apparent in Sanya, with bus lines and stops in the central urban area being relatively dense, while PT services at the northern, eastern, and western ends are in short supply. With the construction of the Hainan Free Trade Port, Sanya was given a new position as the core destination of international tourism and consumption. However, the area of PGS per capita in Sanya was only 16.2 m^2 in 2021, i.e., relatively low compared with cities of similar population sizes in China. Moreover, the spatial layout and planning of PGS are unreasonable and cannot yet meet the basic requirements of full coverage in blocks every 500 m, and there is only limited discussion about the fair share of PGS construction results. Evidently, the huge gap between high-end city positioning and low-level PGS services, coupled with the seasonal fluctuations in PGS demand, make Sanya an ideal case for this study.

Because most native residents, *Houniao*, and bus stops are mainly located in the central urban area of Sanya, our study considered the central urban area of Sanya as the study area to investigate PGS accessibility and equity. Positioned in the south of Sanya, covering a land area of 160 km^2, the central urban area comprises 44 urban communities and 22 administrative villages, with a population of 756,700, accounting for 73.4% of the total population of Sanya.

3. Materials and Methods

3.1. Methodological Framework

As shown in Figure 2, the first component of the framework is data processing, as the data of the fine-scale population and PGS are key elements in this study, which served as the demand and supply, respectively. Since the reliability of spatial accessibility depends on the accuracy of the distribution of population and PGS, the online real estate platform (OREP) and the internet satellite images are utilized in the data processing. Moreover, the distribution of population and PGS also indicate the origins and destinations while residents accessing the PGS so that accurate travel time considering real-time traffic would be requested from the web map application programming interface (API) before and after the seasonal influx. The framework includes four travel modes, as revealed by the travel questionnaires issued by the Sanya Transportation Bureau, where 2479 out of 2513 respondents indicated a preference for modes of walking, riding, public transport, and driving. Following the data processing, a modified accessibility model proposed in this study would utilize these data to precisely calculate the accessibility under different travel modes before and after the seasonal migration. To achieve this goal, the travel mode preferences of different groups were collected through field surveys and incorporated into the model parameters. Subsequently, we delved into the variations in spatial accessibility before and after the seasonal influx under different modes. Next, the location entropy model was adopted to obtain the equity index based on the accessibility indicator. We then explored the discrepancies in spatial equity before and after the *Houniao* influx across different modes. This approach is adaptable and can be applied effectively in other urban settings.

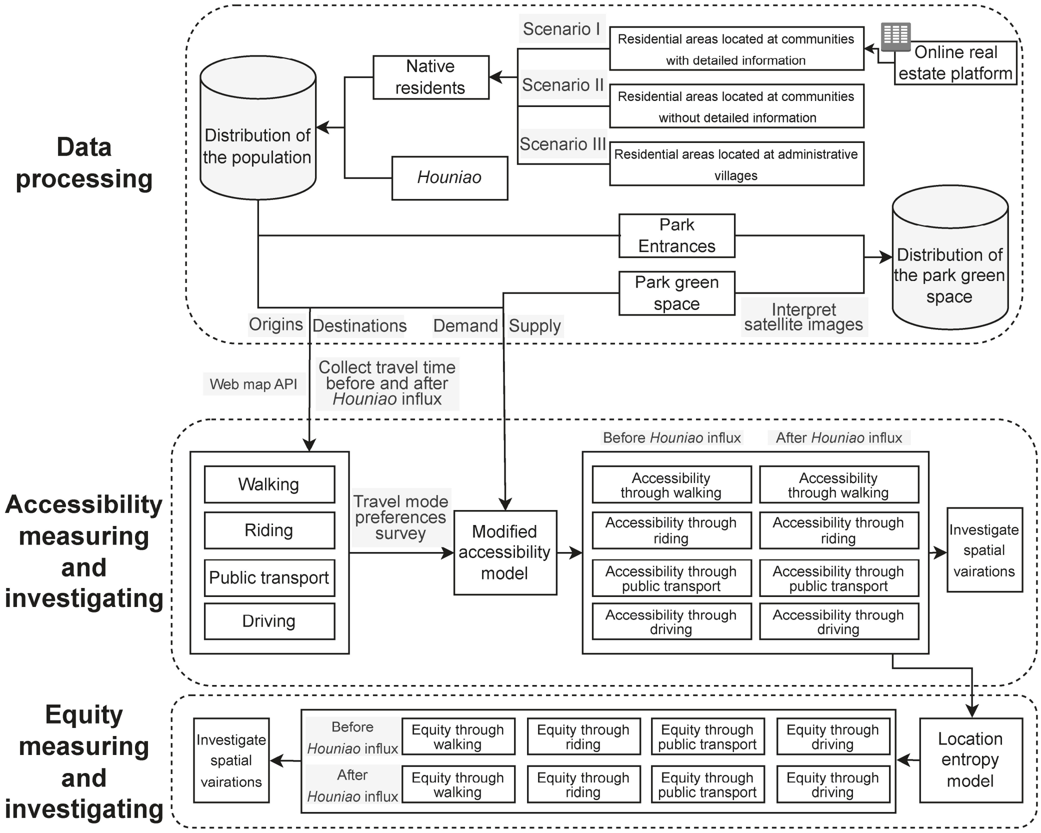

Figure 2. The methodological framework in this study.

3.2. Data Processing

3.2.1. Population

In PGS accessibility studies, the fineness of the population distribution determines the spatial scale. Considering that large demand patterns make it difficult to obtain reliable PGS accessibility [44,46], this study used a fine-scale residential area to accurately demonstrate the spatial distribution of seasonal migrants and native residents as the spatial unit. Specifically, according to the residential land outlined in the Regulatory Detailed Planning of Central Urban Area of Sanya (http://lr.hainan.gov.cn/, accessed on 15 October 2022), the population within each residential area was precisely estimated in three scenarios using the OREP Anjuke (https://anjuke.com/, accessed on 15 October 2022), Amap (https://amap.com/, accessed on 15 October 2022), Sanya Statistical Yearbook (http://tjj.sanya.gov.cn/, accessed on 11 February 2023), and Sanya Homestead Regulations (http://www.sanya.gov.cn/, accessed on 15 October 2022).

Scenario I: in terms of residential areas located in communities in which OREP recorded detailed information, residential outlines, numbers of housing units, and properties for rent and sale were obtained from Amap and OREP, respectively. Then, assuming only one household in each non-vacant unit, the population within such residential areas was estimated as follows:

$$P_{S1} = (T - RT - SL) \times HS \quad (1)$$

where P_{S1} is the estimated population in Scenario I. T is the number of total housing units according to OREP. RT and SL are the numbers of units for rent and sale, respectively. HS is the average number of people in each household, which is set to 2.93 according to the yearbook in this study.

Scenario II: in terms of residential areas located in communities in which OREP did not record detailed information, building outline and height data were derived from Amap, which were used to calculate the total floor area. Non-residential building outlines were excluded based on the non-residential area of interest. Then, populations within such residential areas were estimated by per capita housing floor area as the following equation:

$$P_{S2} = \sum_{i=1}^{n} (BS_i \times F_i)/HA \quad (2)$$

where P_{S2} is the estimated population in Scenario II. n is the number of total building outlines. BS_i is the area of the building outline i. F_i is the number of floors of the building outline i. HA is the housing floor area per capita. Due to missing statistics in Sanya, the housing floor area per capita of Hainan Province (34.56 m^2) was applied in our study.

Scenario III: in terms of residential areas located at administrative villages, OREP did not record detailed information. Usually found within central urban areas in China, these administrative villages are also known as urban villages, which have basically lost arable land within urban built-up areas under village self-governance and collective ownership of rural land. Since Land Administration Law of the People's Republic of China (http://www.npc.gov.cn/, accessed on 15 October 2022) stipulates rural homesteads and rural houses are not allowed to be freely traded, rural settlements were extracted as residential areas using satellite images, and then buildings inside settlements with an area more than 175 m^2 and total floor area more than 367 m^2, which are not supposed to be residential buildings according to Sanya Homestead Regulations, were screened out. The population within such residential areas was estimated as per household only owning one house.

Finally, 687 residential areas with a total population of 757,820, which was very close to the reported population of 756,700, were identified based on such three scenarios. Using fine-scale residential areas as basic research units is regarded as an effective way to reduce the error of population estimation. The data on *Houniao* were derived from the Survey of Gathering Spot of *Houniao* issued by STCBSB. Through address matching, we eventually identified 197,300 *Houniao* distributed in 124 residential areas in the central urban area (Figure 3).

3.2.2. Park Green Space

PGS is divided into comprehensive, community, theme, and pocket parks based on the Standard for Planning of Urban Green Space (GB/T 51346-2019) [47] and the Standard for Classification of Urban Green Space (CJJ/T 85-2017) [48] in China. By screening out PGS close to the public by field survey, we further identified 11 comprehensive parks, 6 community parks, 3 theme parks, and 13 pocket parks based on the interpretation of Google Satellite Images and the List of Parks in Sanya (http://dataopen1.sanya.gov.cn/, accessed on 11 February 2023) released by the Sanya Municipal Housing and Urban–Rural Development Bureau (Figure 3). Because reaching a PGS entrance is considered as accessing PGS services [23,27,49], it is essential to identify the exact PGS entrances to assess the PGS accessibility precisely. Specifically, park gates are identified as entrances if there are fences surrounding the PGS; otherwise, the intersections of the PGS outline with nearby roads are recognized as entrances. In our study, a total of 90 PGS entrances were identified.

3.2.3. Travel Time

Road networks from OpenStreetMap and self-designed speed limits have been frequently applied in previous studies, with the timeliness and fineness of road networks and the subjectivity of road network speed settings having significant impacts on the PGS accessibility results [23]. Despite setting road network speeds according to the road types to simulate real situations [50], biases were still present, with real-time traffic remaining undetected. Thus, in this study, reliable PGS accessibility was assessed using real-time travel costs requested from the Amap API.

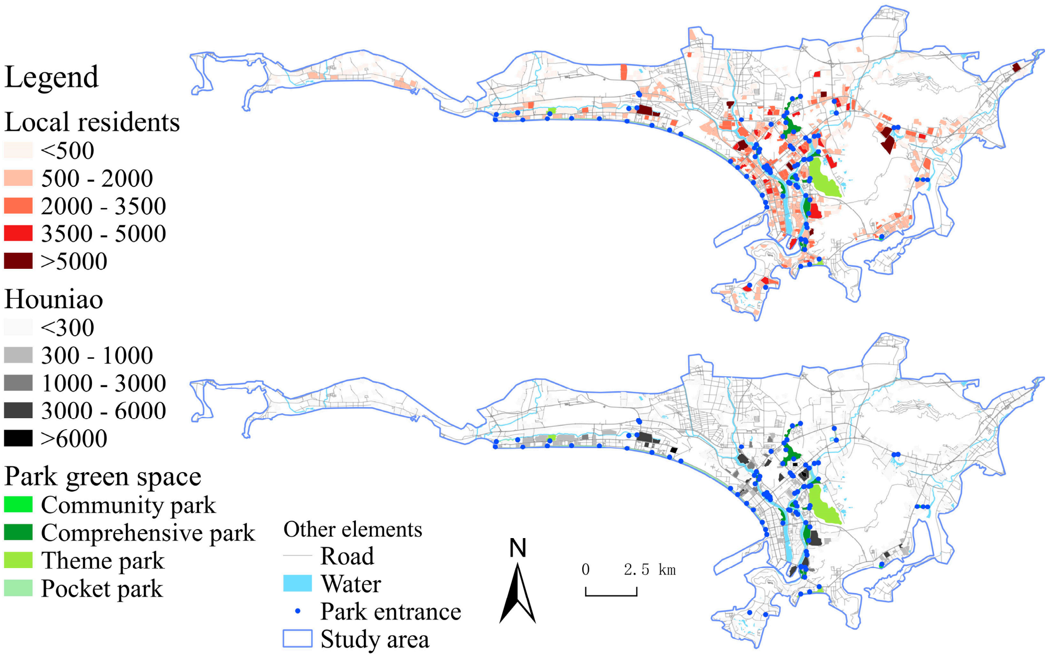

Figure 3. Spatial distribution of population and park green space (PGS) with entrances.

The travel time of walking, riding, PT, and driving to PGS was requested using the centroids of residential areas as origins and PGS entrances as destinations. The PT travel time refers to the total time spent using PT to get to PGS from residential areas, including the time spent walking from residential areas to bus stops and from bus stops to PGS entrances, waiting for the bus, and riding the bus. The study area was in the tropics, where most residents prefer to ride e-bikes instead of bicycles; therefore, in our study, residents were assumed to travel by riding e-bikes. Additionally, in the case of multiple PGS entrances, the shortest time was regarded as the travel time from the residential area to the PGS.

In December 2022, the coronavirus (COVID-19) lockdown was lifted in most areas of China; consequently, the number of *Houniao* in the study area increased. Moreover, considering that residents tend to visit PGS on the weekend, our study collected travel time data on 15, 16, 22, and 23 October 2022 and 11, 12, 18, and 19 February 2023 to investigate the discrepancies in PGS accessibility and equity due to changes in population and its distribution. These eight days were merely sunny and not holidays. The field study revealed that residents in the study area were more willing to visit PGS during 7:00–10:00, 14:30–17:30, and 18:00–20:00; hence, travel time data during these three periods under different travel modes were obtained and regarded as approximations of travel time to PGS in the morning, afternoon, and evening, respectively.

3.3. Methodology

3.3.1. Assessment of Spatial Accessibility of Park Green Space

Considering the different travel behaviors of residents, Mao and Nekorchuk [38] proposed the multi-mode 2SFCA (M2SFCA) method, which has been widely used for measuring PGS accessibility under multiple travel modes from a supply–demand perspective. The accessibility was calculated using the following two steps.

Step 1: Calculate the ratio of supply to demand.

$$R_j = \frac{S_j}{\sum_{m=1}^{n} \sum_{i \in \{D_m(ij) < d_m\}} p_m \times P_i} \tag{3}$$

where the supply–demand ratio R_j represents the potential area of PGS per capita. S_j is the area of PGS j. d_m is the catchment size of travel mode m. n is the number of travel modes. $D_m(ij)$ is the travel time from residential area i to PGS j. p_m is the proportion of residents accessing PGS by travel mode m. P_i is the population of the residential area i.

Step 2: Calculate weighted accessibility according to the proportions of different travel modes.

$$A_i = \frac{\sum_{m=1}^{n} p_m \times P_i \times \sum_{j \in \{D_m(ij) < d_m\}} R_j}{\sum_{m=1}^{n} p_m \times P_i} \tag{4}$$

where A_i is the weighted accessibility of residential area i calculated using the M2SFCA method. The remaining notations in this equation have the same meanings as in Equation (3).

This method assumes consistent catchment sizes and travel mode preferences. However, the distribution and travel behaviors of native residents and seasonal migrants in destination cities exhibit obvious differences. Since cultural gaps have been found between native residents and *Houniao*, surveys issued by the STCBSB show that *Houniao* mainly live in the southwestern and south-central residential areas of the study area, whereas native residents are dispersed (Figure 3). Non-commuter travel questionnaires from the Sanya Transportation Bureau (http://jt.sanya.gov.cn/, accessed on 15 October 2022) and *Houniao* travel questionnaires from a survey conducted in June 2022 provided the proportions of native residents walking (18.5%), riding (53.9%), taking PT (8.3%), and driving (19.3%) to PGS and *Houniao* walking (60.9%), riding (15.1%), taking PT (12.4%), and driving (11.6%) to PGS. Evidently, native residents mainly rode to PGS (followed by driving there), while *Houniao* mainly walked to PGS. Therefore, the M2SFCA method is not applicable to cases involving two groups of people with significantly different travel mode preferences, and it fails to delineate accessibility patterns under different travel modes [46,51].

To avoid these pitfalls, our study further modified the M2SFCA method to a multi-group, multi-mode Gaussian-based two-step floating catchment area (MMGa2SFCA) method to obtain more reliable accessibility patterns under each travel mode before and after *Houniao* crowding the study area. Specifically, the proportions of different travel modes of multiple groups were introduced in the first step of the M2SFCA method, whereas the conventional second step was deprecated. The detailed steps are as follows.

Step 1: Calculate the supply–demand ratio.

$$R_j = \frac{S_j}{\sum_{g=1}^{p} \sum_{m=1}^{n} \sum_{i \in \{D_m(ij) < d_{gm}\}} p_{gm} \times P_{gi} \times G(D_{gm}(ij))} \tag{5}$$

where d_{gm} is the catchment size of travel mode m of group g. p_{gm} is the proportion of group g accessing the PGS by travel mode m. P_{gi} is the population of group g of residential area i. $G(D_{gm}(ij))$ is a Gaussian distance decay function expressed in Equation (6):

$$G(D_{gm}(ij)) = \begin{cases} \frac{exp\left(-\frac{1}{2} \times \frac{D_m(ij)^2}{d_{gm}^2}\right) - exp\left(-\frac{1}{2}\right)}{1 - exp\left(-\frac{1}{2}\right)}, D_m(ij) \le d_{gm} \\ 0 \quad , D_m(ij) > d_{gm} \end{cases} \tag{6}$$

The time tolerance thresholds d_{gm} of native residents walking (30 min), riding (18 min), taking PT (20 min), and driving (15 min) to the PGS and *Houniao* walking (15 min), riding (5 min), PT (10 min), and driving (8 min) to the PGS were set according to household surveys [52] and *Houniao* travel questionnaires.

Step 2: Calculate the PGS accessibility under each travel mode.

$$A_{mi} = \sum_{g=1}^{p} \sum_{j \in \{D_m(ij) < d_{gm}\}} \frac{P_{gi}}{P_i} \times R_j \times G\left(D_{gm}(ij)\right) \tag{7}$$

where A_{mi} is the accessibility of residential area i under travel mode m. P_i is the total population of the residential area i.

3.3.2. Assessment of Spatial Equity of Park Green Space

Who benefits and why are important questions in the study of urban service delivery, as is the method of measuring equity [53]. Regarding accessing public services, spatial equity can be defined as the degree to which facilities are distributed in an equal way [54]. In this study, PGS equity refers to relative equality while considering the PGS demand of different groups of people with varying travel mode preferences and PGS distribution. As spatial PGS accessibility can evaluate the convenience of residents accessing PGS from their residences, it can further assess the spatial PGS equity by comparing it to the average. The PGS accessibility under each travel mode measured by the MMGa2SFCA was introduced into the location entropy model proposed by Rong et al. [26] to measure the spatial PGS equity, as shown in Equation (8):

$$E_{mi} = \frac{A_{mi}}{\sum_{i=1}^{q} A_{mi}/q} \tag{8}$$

where E_{mi} is the spatial equity index of residential area i under travel mode m, and q is the total number of demand points. The demand point is supplied with an above-average PGS within the research scope when $E_{mi} > 1$; otherwise, PGS is undersupplied for the demand point. Referring to the classification by Rong et al. [26], the spatial equity index was further divided into five levels to explore discrepancies in spatial PGS equity (Table 1). Among them, the relatively low and extremely low levels imply that the PGS accessibility for residents within these areas is below average.

Table 1. Spatial PGS equity classification and meanings.

Levels	E_i	Meaning
I	$E_{mi} \geq 10$	PGS equity of extremely high level
I	$10 > E_{mi} \geq 1.5$	PGS equity of relatively high level
III	$1.5 > E_{mi} \geq 1$	PGS equity of medium level
IV	$1 > E_{mi} \geq 0.5$	PGS equity of relatively low level
V	$0.5 > E_{mi} \geq 0$	PGS equity of extremely low level

4. Results

4.1. Travel Time under Different Modes

Figure 4 shows the average travel time of residents accessing PGS from residences under different travel modes in the morning, afternoon, and evening before (October 2022) and after (February 2023) the influx of *Houniao*. The impact of real-time traffic on weekend travel time was mainly reflected under the PT and driving modes, with the overall average travel time varying with the peak hours. In terms of the average travel time under the walking and riding modes, pedestrians and riders were hardly affected by real-time traffic, and the travel time under the walking and riding modes requested by Amap did not vary over time. By comparing the average time among different travel modes during each single period, the average travel time under the PT mode was found to be lower than that under the walking mode but much higher than those under the riding and driving modes. This was related to the poor PT services in Sanya: First, bus stops were unreasonably allocated, with a high density in the central urban area while being scarce in the northern, eastern, and western ends and far away from the residential areas and PGS entrances. This resulted in a significant increase in the time spent accessing the bus stop. Second, bus service was considered to have a low frequency, which resulted in a long waiting time.

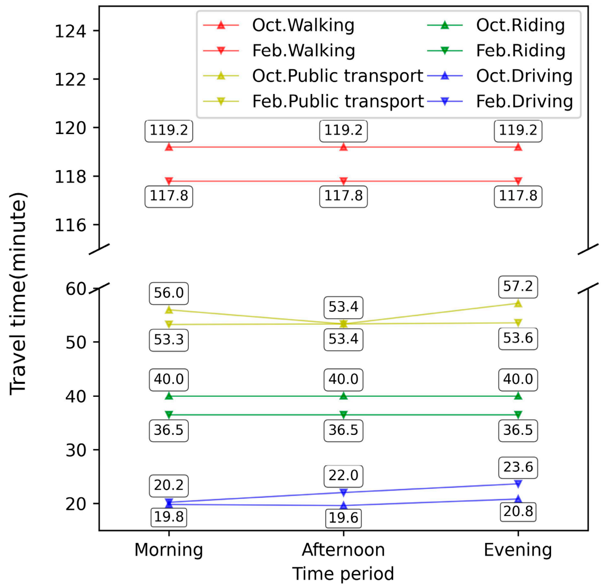

Figure 4. Statistics for the average travel time to all PGS under four travel modes during three periods requested from Amap Web Map Application Programming Interface (API) in October 2022 and February 2023.

Apparent discrepancies in the average travel time were found before and after the *Houniao* influx. Owing to the hot weather and intense sunlight, native residents preferred conducting recreational activities in the evening, leading to worse traffic conditions in the evening than in the morning and afternoon in October 2022, when nearly all residents were native. Thus, the average time consumption under the PT and driving modes were in descending order in the evening, morning, and afternoon. In February 2023, the average travel time of driving to PGS increased compared to October 2022, while those of walking, riding, and PT decreased. The population of the residential areas consisted of natives and *Houniao* during the tourist season, and weather conditions, such as temperature and sunlight, were more pleasant compared to those in October 2022. Residents were willing to conduct recreational activities during these three periods, leading to worsened traffic conditions and increased average travel time due to congestion. Moreover, as China lifted most COVID-19 restrictions in December 2022, roads and compounds were no longer closed. Residents could take advantage of shortcuts and the nearest gates of compounds to PGS, resulting in less average time spent walking and riding. Although traffic congestion worsened in February 2023, optimized bus lines and less time consumption in the walking phase led to a lower average travel time of PT.

4.2. Park Green Space Accessibility before and after the Houniao Influx

4.2.1. Discrepancy in the Average Park Green Space Accessibility

Figure 5 shows the discrepancies in the average PGS accessibility in the morning, afternoon, and evening before and after the *Houniao* influx. In terms of different travel modes in the study area, the PGS accessibility through driving was the best, followed by that through riding. Accessibility under four modes was from 6.540 to 8.954 and from 5.718 to 6.782 before and after the *Houniao* influx, respectively. PGS accessibility through PT was from 0.633 to 0.779; it was the worst, and only approximately one-third of that through walking. In terms of different stages, the *Houniao* influx led to a dramatic increase in PGS demand, resulting in an overall decline in the average PGS accessibility; however, the degrees of decline were not consistent across modes. Specifically, first, the average travel time under the driving mode increased significantly; thus, the driving mode had the greatest decrease in average PGS accessibility, which decreased by two units in the afternoon and evening. Second, since both groups of residents could barely access PGS through PT, the average PGS accessibility decreased slightly after the *Houniao* influx. Third, although the average travel time under the walking and riding modes decreased after lifting the COVID-19 lockdown, their PGS accessibility declined due to the surge in PGS demand caused by *Houniao*. In terms of different periods, the average PGS accessibility through driving was in descending order in the morning, afternoon, and evening before the *Houniao* influx and in the afternoon, morning, and evening after the *Houniao* influx, thereby reflecting the comprehensive impact of changes in population and traffic conditions on the PGS accessibility. In the evening, the PGS accessibility through walking and riding was the best; however, like PT, the average PGS accessibility changes within the three periods were not obvious.

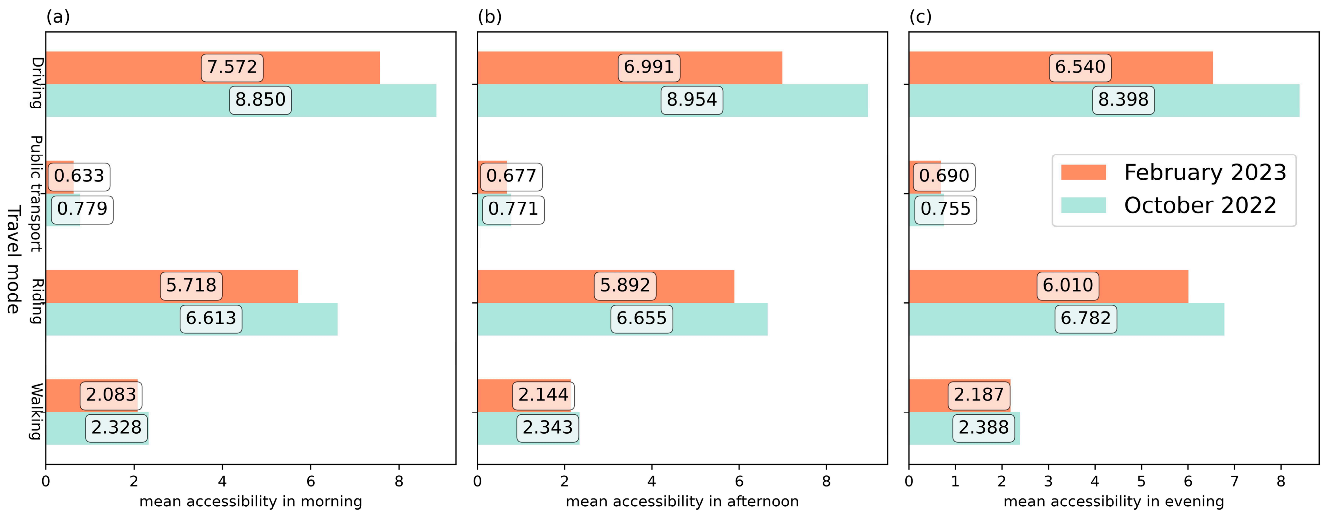

Figure 5. Average spatial PGS accessibility during each period of time under four modes in October 2022 and February 2023: (**a**) period morning; (**b**) period afternoon; (**c**) period evening.

4.2.2. Spatiotemporal Variation in Park Green Space Accessibility

Most residents within the study area were more willing to access PGS in the evening, while PGS accessibility did not vary much across the three periods except for driving. Hence, spatial accessibility patterns in the evening, which were the most representative, were analyzed to explore the spatiotemporal variations in PGS accessibility before and after the *Houniao* influx (Figure 6).

In terms of the different travel modes, residential areas with high PGS accessibility through walking, riding, and driving were mainly located in the south-central and south-western parts of the study area in October 2022, and the farther from these two areas a residential area was, the lower PGS accessibility it had. Regarding these two parts of the study area, the south-central part is regarded as the core area of the city, accommodating an abundant population with 21 parks providing sufficient PGS. The southwestern part is located in the well-known Sanya Bay National Tourism Resort Area, which has nine parks and a small population with a relatively sufficient PGS supply. In February 2023, the PGS accessibility in these two areas decreased by an average of 1.529 after the influx of *Houniao*. Because more *Houniao* crowded the southwestern part than the south-central part of the study area, while the former had a lower PGS supply than the latter, the average PGS accessibility in residential areas in the southwestern part decreased by 3.314, which was more than the decrease in residential areas in the south-central part. Specifically, in the southwestern area, out of 61 residential areas, there were 42 residential areas under the driving mode (69%), 38 residential areas under the riding mode (62%), and 25 residential areas under the walking mode (41%) with downgraded PGS accessibility levels after the

Houniao crowding the study area. In the south-central area, out of 139 residential areas, the numbers of residential areas that had lower accessibility levels after the influx of *Houniao* were 48, 24, and 13 under the driving mode (35%), the riding mode (17%), and the walking mode (9%), respectively. Although the PGS accessibility in most residential areas in other regions deteriorated, that in a few residential areas located at the edge of the central urban area and in the old communities of the southwestern part improved slightly because of slight decreases in the average travel time and the fact that they were not the main *Houniao* gathering spots.

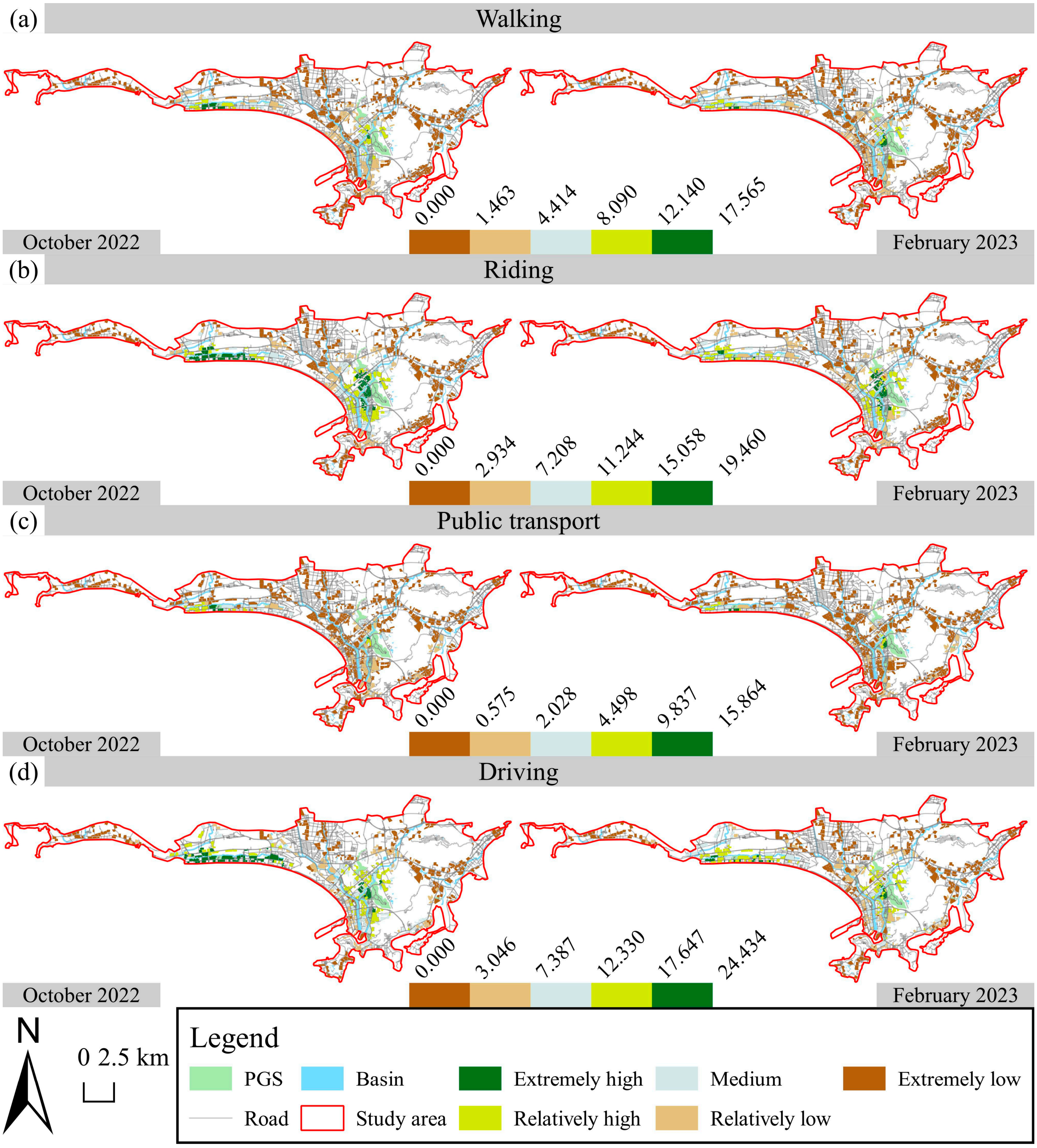

Figure 6. Comparison of the spatial distribution of PGS accessibility during the evening period under four modes in October 2022 and February 2023: (**a**) walking; (**b**) riding; (**c**) public transport; (**d**) driving.

In contrast to other travel modes, residential areas with high PGS accessibility were only located in the southwestern part in October 2022. In the aspect of the variation in

PGS accessibility level, 20 out of 61 residential areas and 19 out of 139 residential areas were found with lower levels in the southwestern part and the central-south part of the study area, respectively, after the *Houniao* influx. However, the PGS accessibility through PT improved in a few residential areas by February 2023. This was mainly because most COVID-19 restrictions were lifted, and residents could choose compound gates that were closer or more convenient for taking PT to the PGS, thereby reducing the travel time in the walking phases. Nevertheless, the long waiting time and distances from bus stops to park entrances made PT the worst travel mode in terms of PGS accessibility. In addition, owing to the lifting of most COVID-19 restrictions, the PGS accessibility through walking in residential areas located in the central part of the study area and not within the *Houniao* gathering spots improved, as residents could take more convenient routes to access PGS.

4.3. Park Green Space Equity before and after Influx of Houniao

4.3.1. Variation in Park Green Space Equity

Figure 7 illustrates the proportions of residents with different PGS equity levels under multiple travel modes in the evening at two different stages. More than 50% of the residents were at relatively low (IV) and extremely low (V) levels, with percentages ranging between 50.6% and 78.6% for all modes before the *Houniao* influx. The PGS equity under the driving, riding, and PT modes deteriorated after the *Houniao* influx, whereas the PGS equity under the walking mode improved slightly. The PGS equity under the PT mode was the worst, with the proportion of the level extremely low being much higher than those of the other modes. Little change was found after the *Houniao* influx, meaning that approximately 63% of residents had extremely difficult access to PGS through PT. Relatively low and extremely low levels accounted for approximately 65% of the walking mode. Specifically, 46.6% of residents under the walking mode were at extremely low PGS equity levels before the *Houniao* influx. The proportion decreased to 41.1% owing to convenience improvement by easing the COVID-19 restrictions, although the average PGS accessibility declined after the *Houniao* influx. Before the *Houniao* influx, the PGS equity under the driving mode was the best, followed by that under riding, with 32.6% and 36.1% of residents, respectively, being at an extremely low level. These proportions increased to 38.6% and 39.3% for the driving and riding modes, respectively, after *Houniao* crowded Sanya.

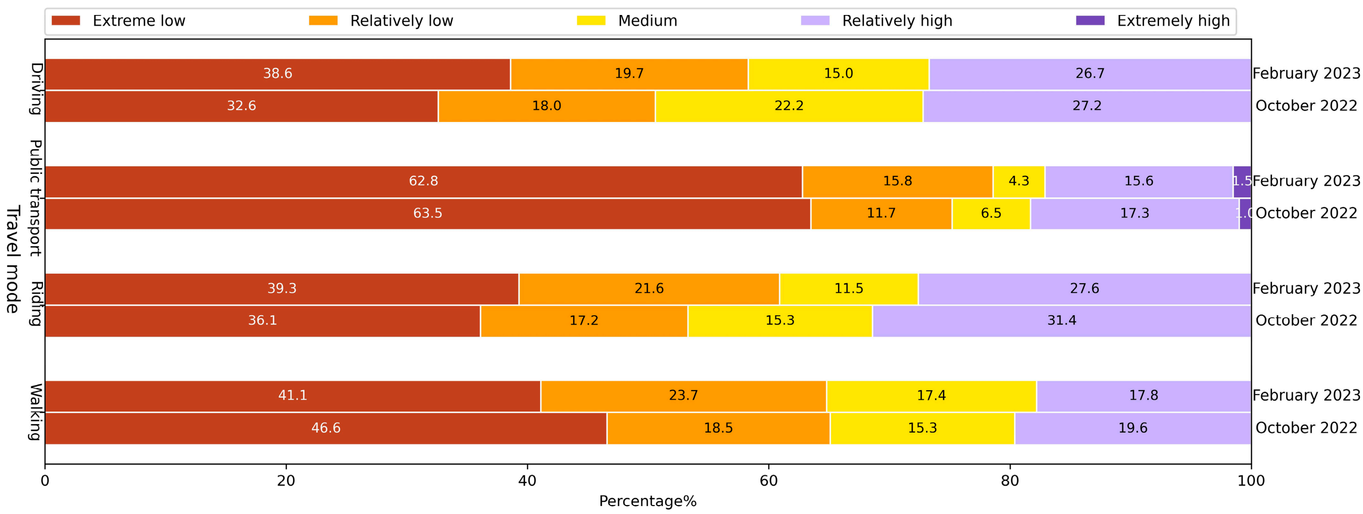

Figure 7. Proportion of residents with different levels of spatial PGS equity during the evening period under four travel modes before (October 2022) and after (February 2023) the *Houniao* influx.

In terms of the high levels of PGS equity, the shares of relatively high and extremely high levels declined to varying degrees after the *Houniao* influx. Extremely high levels of PGS equity only existed under the PT mode, and the proportion of extremely and relatively high levels accounted for 18%, which was similar to that under the walking mode but worse than those under the driving and riding modes. The results revealed that the PT convenience varied greatly across regions, leading to significant variations in the PGS equity under the PT mode. The proportion of extremely high levels of PGS equity under the riding mode significantly decreased from 31.4% to 27.6%, whereas only a slight decrease was found for that under the driving mode.

4.3.2. Spatiotemporal Variation in Park Green Space Equity

In terms of the spatial distribution of PGS equity (Figure 8), residential areas with better PGS equity levels were mainly located in the south-central and southwestern areas under the walking, riding, and driving modes, whereas those with worse equity levels were mostly located in other areas far from the above regions. Under the PT mode, residential areas with better PGS equity levels were mainly distributed in the southwestern area, whereas some were scattered in the south-central and eastern areas. PGS accessibility in residential areas with good PGS equity within these three regions was above average despite the fact that the average PGS accessibility through PT was the worst among the four modes.

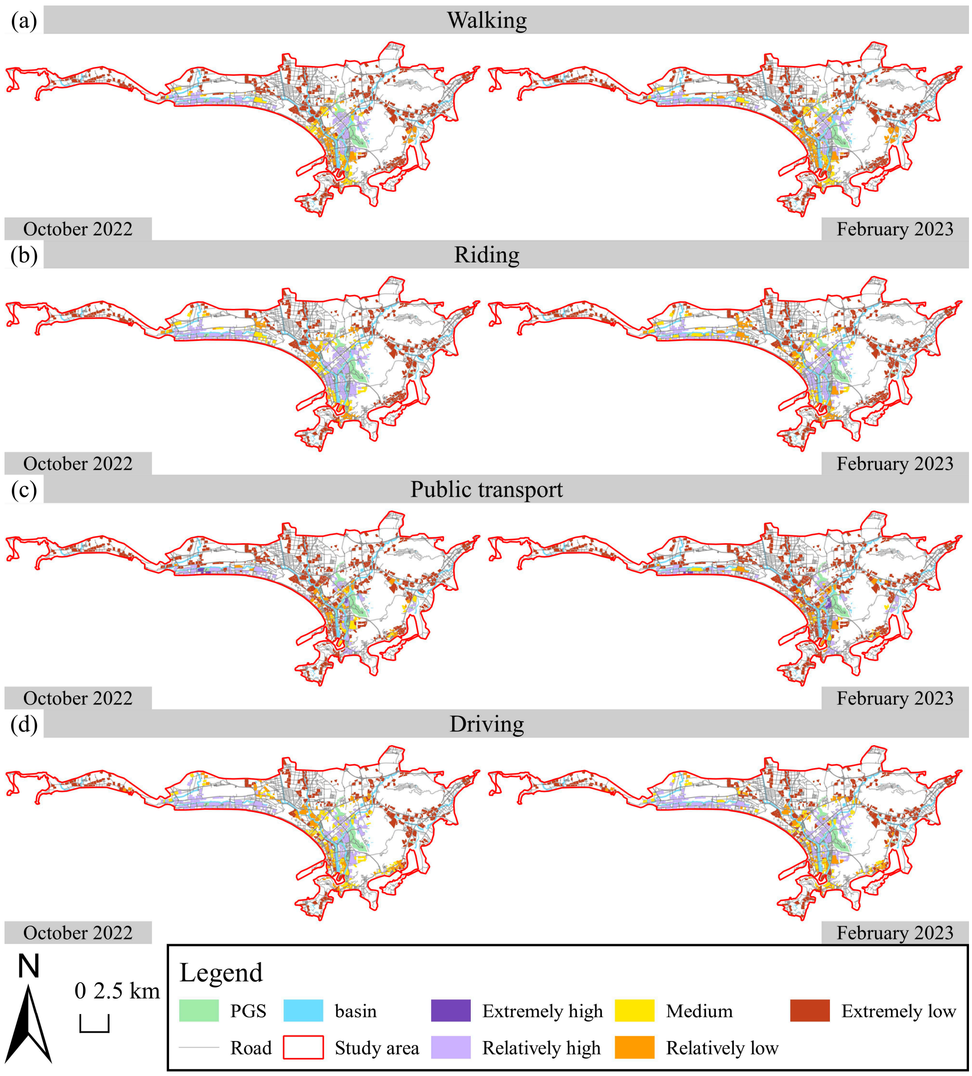

Figure 8. Comparison of the spatial distributions of different levels of spatial PGS equity during the evening period under four modes in October 2022 and February 2023: (**a**) walking; (**b**) riding; (**c**) public transport; (**d**) driving.

The exploration of spatial discrepancies in PGS equity between the two stages revealed a significant downgrade in the PGS equity level in residential areas with large numbers of *Houniao*, especially under the walking and riding modes, which were scattered in the southwestern, southcentral, and southeastern areas where *Houniao* gathered. This was mainly because the time tolerance thresholds of *Houniao* under all modes were lower than those of the native residents. Larger proportions of *Houniao* resulted in smaller weighted PGS accessibility in residential areas, leading to a downgrade in PGS equity. As the average PGS accessibility decreased, the PGS equity in a few residential areas, which had slightly increased PGS accessibility under the walking and PT modes and were located in the old communities of the southwestern areas and the edge of the central urban area with a small proportion of *Houniao*, significantly improved.

5. Discussion

Population distribution and travel mode choices are key factors affecting PGS accessibility. Regarding cities where populations vary seasonally, discrepancies in the composition and distribution of the population at different times and in the travel behaviors of the natives and seasonal migrants result in seasonal variations in PGS accessibility. However, the impacts of different resident groups on PGS accessibility and equity have not received much attention. Moreover, the accuracy of travel time, which changes significantly due to the influx of seasonal migrants, is crucial for reliable PGS accessibility measurements. Thus, fine-scale population distribution and travel mode preferences are essential for obtaining more reliable PGS accessibility via the web map API [39,55–57].

Discrepancies in travel mode preferences were found between the natives and *Houniao* within the research scope of the tropical resort of Sanya. In February 2023, road traffic conditions and population distribution had changed significantly compared to the case in October 2022, owing to the *Houniao* influx and the lifted COVID-19 restrictions. Therefore, the MMGa2SFCA method was proposed in this study to accurately assess changes in PGS accessibility and equity in cities receiving seasonal migrants, with fine-scale spatial units of residential areas presenting population distribution, real-time traffic from the web map API, and travel mode preferences from surveys and official statistics. The average travel time of PT and driving varied with the peak hours, which is in agreement with previous studies [55,56]. In line with the general characteristics of undeveloped areas without significant topographic relief, the order of the average travel time of each mode was driving, riding, PT, and walking, thereby corroborating the findings of a previous study [39]. The *Houniao* influx resulted in increased travel time of driving, while the travel time of walking, riding, and PT decreased significantly due to the lifting of the COVID-19 restrictions that reopened roads and side entrances of compounds. Assessing PGS accessibility with accurate travel time, which considered real-time traffic and the PT and travel mode behaviors of different groups of residents, outperformed offline network analysis, which ignored the travel behaviors of residents. This finding further substantiates the merits of web maps for PGS accessibility research.

The PGS accessibility in most residential areas decreased owing to the *Houniao* influx, whereas lifting the COVID-19 restrictions improved the PGS accessibility through walking and PT. This is another finding of our study indicating that COVID-19 restrictions apparently hindered the access to PGS by residents within the research scope. Since visiting parks was beneficial for both physical and mental health during the COVID-19 pandemic [58], minimizing restricted areas without causing significant inconvenience to residents accessing PGS is suggested for future public health policies.

Residential areas with higher PGS equity levels were concentrated in the south-central and southwestern parts of the study area, whereas those in suburban areas far from the core areas and lacking PGS and PT resources were characterized by difficulty in accessing PGS conveniently, which corroborated previous conclusions [27,59]. More than half of the population had relatively low PGS equity levels under each travel mode before and after the *Houniao* influx, indicating poor PGS equity in the study area. The influx of *Houniao* significantly downgraded the PGS equity levels in most residential areas. Moreover, the PGS equity levels in residential areas with large *Houniao* proportions were more likely to be downgraded, especially under the walking and riding modes. This new finding suggests that *Houniao* are the more vulnerable group between the two while accessing PGS due to their travel mode preferences.

Seasonal migrants are increasingly prevalent worldwide and confer benefits on the development of cities receiving them, particularly within the realms of the social, economic, and tourism sectors. Nevertheless, policymakers in such cities are supposed to be aware of the challenges resulting from the influx of seasonal migrants. We argue that more attention should be paid to the accurate assessment of periodic fluctuation in the spatial patterns of accessibility and equity of PGS under different travel modes. The policy and practice recommendations for Sanya and other cities that experience substantial influxes of seasonal migrants could be summarized based on the findings: policymakers need to consider the impact of the thousands of seasonal migrants on PGS accessibility and equity with regard to PT and PGS planning to improve the efficiency of residents while accessing PGS. Specifically, to address the issue of poor PGS accessibility and equity under the PT mode in Sanya, it is essential to expand the existing public transportation system by introducing additional routes, increasing frequency, and strategically adding more stops near the compound gates and PGS entrances for buses. This should be performed while concurrently implementing measures to alleviate traffic congestion. Such initiatives are instrumental in rectifying PGS inequity resulting from the uneven distribution of PT resources. While specific situations may vary from city to city, it is generally advisable to enhance the efficiency of public transportation. This is because public transportation is commonly one of the preferred modes of motorized travel for seasonal migrants in most cases. Regarding PGS's undersupply within the research scope, it is crucial to tackle the inequity stemming from the uneven distribution of PGS. This can be achieved by providing additional PGS in the northern and western regions of the study area, as well as the gathering places of *Houniao*. For other cities facing similar challenges, it is highly recommended to begin with accurate identification of spatial accessibility and equity patterns of PGS under different modes, implementing the methods outlined in this study as a transferable framework. Subsequently, efforts should be concentrated on the provision of PGS in places characterized by low accessibility and equity levels.

Our study has several limitations. First, socioeconomic characteristics were not included in the PGS equity analysis, as residents with different social characteristics may have different travel behaviors and time tolerance thresholds [60]. Second, this study did not consider the impact of PGS qualities, such as attractiveness, service quality, and levels of PGS, on PGS accessibility. In general, the better the attractiveness, service quality, and levels of PGS, the larger the service radius of the PGS, which could change the PGS accessibility patterns [46,51,57]. Third, while walk–transit–walk was considered by utilizing the web map API, there was a lack of research on other intermodal travel options, such as various combinations of cycling and transit [61]. This study investigated the impact of seasonal migrants with travel mode preferences different from those of native residents on PGS accessibility and equity under multiple travel modes. In future research, PGS equity under multiple travel modes will be further evaluated from the perspective of the socioeconomic characteristics of different people, the quality of PGS services, and intermodal travel.

6. Conclusions

Because the travel mode preferences of *Houniao* are different from those of native residents, our study implemented the MMGa2SFCA method proposed above to investigate the PGS accessibility and equity and their variations before and after the *Houniao* influx with fine-scale population distribution and accurate travel time requested from the OREP and web map API, respectively, using the central urban area of Sanya as a case study. The results highlight that the PGS accessibility of residents with different travel mode preferences and time tolerance thresholds could be accurately assessed under the travel modes of walking, riding, public transport, and driving, which could help policymakers improve PGS equity patterns. More than half of the residents in the study area had relatively low PGS accessibility and equity under each travel mode, especially under the walking and PT modes. In the context of the lifting of COVID-19 restrictions, the *Houniao* influx significantly decreased the PGS accessibility and equity of riding and driving, while the PGS accessibility and equity in a few residential areas located outside *Houniao* gathering areas improved under the walking and PT modes. This study presents a transferable framework that allows cities confronting similar challenges to attain precise assessments of spatial accessibility and equity of PGS. Additionally, it enables the investigation of their variations before and after the influx of seasonal migrants, offering valuable insights for policymakers to make informed and rational PGS planning decisions. Moreover, this study has important theoretical implications for cities like Sanya regarding responding reasonably to seasonal changes in the urban population, formulating sustainable public policy, and scientifically allocating PGS and PT resources, which is of great reference value for PGS planning in cities with seasonal migrants who have travel mode preferences different from those of the native residents.

Author Contributions: Conceptualization, Wentong Yang and Jinping Zhang; methodology, Wentong Yang and Jinping Zhang; software, Wentong Yang; validation, Wentong Yang, Yeqing Cheng, and Jinping Zhang; formal analysis, Wentong Yang; investigation, Wentong Yang and Yeqing Cheng; resources, Yeqing Cheng; data curation, Chunru Xu; writing—original draft preparation, Wentong Yang; writing—review and editing, Jinping Zhang; visualization, Wentong Yang and Chunru Xu; supervision, Jinping Zhang; funding acquisition, Jinping Zhang. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the National Natural Science Foundation of China (Grant No. 42261054) and the Hainan Provincial Natural Science Foundation of China (Grant No. 422RC663).

Data Availability Statement: The main text provides detailed explanations regarding various types of original data and their download links. Moreover, the aggregated and processed data utilized and analyzed in the present study could be derived from the corresponding author upon a reasonable request.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Repetti, M.; Phillipson, C.; Calasanti, T. Retirement migration in Europe: A choice for a better life? *Sociol. Res. Online* **2018**, *23*, 780–794. [CrossRef]
2. Wong, K.M.; Musa, G. Retirement motivation among 'Malaysia my second home'participants. *Tour. Manag.* **2014**, *40*, 141–154. [CrossRef]
3. Li, Y.; Alencar, A. A tale of two cities: Digital place-making and elderly Houniao migration in China. *J. Ethn. Migr. Stud.* **2023**, *49*, 1032–1049. [CrossRef]
4. Kohno, A.; Musa, G.; Nik Farid, N.D.; Abdul Aziz, N.; Nakayama, T.; Dahlui, M. Issues in healthcare services in Malaysia as experienced by Japanese retirees. *BMC Health Serv. Res.* **2016**, *16*, 167. [CrossRef]
5. Iorio, M. Italian retirement migration: Stories from Bulgaria. *Geoforum* **2020**, *111*, 198–207. [CrossRef]
6. Viallon, P. Retired snowbirds. *Ann. Tour. Res.* **2012**, *39*, 2073–2091. [CrossRef]
7. Repetti, M.; Lawrence, J.L. The cultural and structural motivations of cheap mobility: The case of retirement migrants in Spain and Costa Rica. *Geoforum* **2021**, *124*, 156–164. [CrossRef]
8. Pickering, J.; Crooks, V.A.; Snyder, J.; Milner, T. "If you have a pain, get on a plane": Qualitatively exploring how short-term Canadian international retirement migrants prepare to manage their health while abroad. *Trop. Dis. Travel Med. Vaccines* **2021**, *7*, 1–10. [CrossRef]
9. Tate, J.; Crooks, V.A.; Snyder, J. Altering consumer practices, facing uncertainties, and seeking stability: Canadian news media framings of international retirement migrants during the COVID-19 pandemic. *Can. Geogr./Le Géographe Canadien* **2022**, *66*, 65–75. [CrossRef]
10. Winkler, R.L.; Matarrita-Cascante, D. Exporting consumption: Lifestyle migration and energy use. *Glob. Environ. Chang.* **2020**, *61*, 102026. [CrossRef]
11. Jover, J.; Díaz-Parra, I. Who is the city for? Overtourism, lifestyle migration and social sustainability. *Tour. Geogr.* **2022**, *24*, 9–32. [CrossRef]
12. Zasada, I.; Alves, S.; Müller, F.C.; Piorr, A.; Berges, R.; Bell, S. International retirement migration in the Alicante region, Spain: Process, spatial pattern and environmental impacts. *J. Environ. Plan. Manag.* **2010**, *53*, 125–141. [CrossRef]

13. Crespo, M.; Follmann, A.; Butsch, C.; Dannenberg, P. International Retirement Migration: Mapping the spatio-temporal growth of foreign-owned properties in Cotacachi, Ecuador. *J. Maps* **2022**, *18*, 53–60. [CrossRef]
14. Ma, A.; Chow, N.W. Economic impact of elderly amenity mobility in Southern China. *J. Appl. Gerontol.* **2006**, *25*, 275–290. [CrossRef]
15. Chen, J. Displacement, emplacement and the lifestyles of Chinese 'snowbirds' and local residents in tropical Sanya. *Soc. Cult. Geogr.* **2020**, *21*, 629–650. [CrossRef]
16. Chen, J.; Chen, N.; Cai, F. Sanya, China: Tropical climate and the rise of a small city. *Cities* **2022**, *123*, 103589. [CrossRef]
17. Chen, J.; Wang, B. "Unattended" retirement: Lifestyle migration and precarity of the Houniao. *Popul. Space Place* **2020**, *26*, e2369. [CrossRef]
18. Wang, Y.; Shi, X.; Cheng, K.; Zhang, J.; Chang, Q. How do urban park features affect cultural ecosystem services: Quantified evidence for design practices. *Urban For. Urban Green.* **2022**, *76*, 127713. [CrossRef]
19. Gai, S.; Fu, J.; Rong, X.; Dai, L. Users' views on cultural ecosystem services of urban parks: An importance-performance analysis of a case in Beijing, China. *Anthropocene* **2022**, *37*, 100323. [CrossRef]
20. Yu, P.; Yung, E.H.K.; Chan, E.H.W.; Wang, S.; Chen, Y.; Chen, Y. Capturing open space fragmentation in high–density cities: Towards sustainable open space planning. *Appl. Geogr.* **2023**, *154*, 102927. [CrossRef]
21. Zhang, R.; Peng, S.; Sun, F.; Deng, L.; Che, Y. Assessing the social equity of urban parks: An improved index integrating multiple quality dimensions and service accessibility. *Cities* **2022**, *129*, 103839. [CrossRef]
22. Byrne, J.; Wolch, J. Nature, race, and parks: Past research and future directions for geographic research. *Prog. Hum. Geogr.* **2009**, *33*, 743–765. [CrossRef]
23. Xing, L.; Liu, Y.; Wang, B.; Wang, Y.; Liu, H. An environmental justice study on spatial access to parks for youth by using an improved 2SFCA method in Wuhan, China. *Cities* **2020**, *96*, 102405. [CrossRef]
24. Gu, Z.; Luo, X.; Tang, M.; Liu, X. Does the edge effect impact the healthcare equity? An examination of the equity in hospitals accessibility in the edge city in multi-scale. *J. Transp. Geogr.* **2023**, *106*, 103513. [CrossRef]
25. Yu, P.; Chan, E.H.W.; Yung, E.H.K.; Wong, M.S.; Chen, Y. Open space fragmentation in Hong Kong's built–up area: An integrated approach based on spatial horizontal and vertical equity lenses. *Environ. Impact Assess. Rev.* **2023**, *102*, 107174. [CrossRef]
26. Rong, P.; Zheng, Z.; Kwan, M.-P.; Qin, Y. Evaluation of the spatial equity of medical facilities based on improved potential model and map service API: A case study in Zhengzhou, China. *Appl. Geogr.* **2020**, *119*, 102192. [CrossRef]
27. Li, Z.; Fan, Z.; Song, Y.; Chai, Y. Assessing equity in park accessibility using a travel behavior-based G2SFCA method in Nanjing, China. *J. Transp. Geogr.* **2021**, *96*, 103179. [CrossRef]
28. Wang, M.; Mu, L. Spatial disparities of Uber accessibility: An exploratory analysis in Atlanta, USA. *Comput. Environ. Urban Syst.* **2018**, *67*, 169–175. [CrossRef]
29. Tian, M.; Yuan, L.; Guo, R.; Wu, Y.; Liu, X. Sustainable development: Investigating the correlations between park equality and mortality by multilevel model in Shenzhen, China. *Sustain. Cities Soc.* **2021**, *75*, 103385. [CrossRef]
30. Stewart, J.Q. Empirical mathematical rules concerning the distribution and equilibrium of population. *Geogr. Rev.* **1947**, *37*, 461–485. [CrossRef]
31. Hansen, W.G. How accessibility shapes land use. *J. Am. Inst. Plan.* **1959**, *25*, 73–76. [CrossRef]
32. Nicholls, S. Measuring the accessibility and equity of public parks: A case study using GIS. *Manag. Leis.* **2001**, *6*, 201–219. [CrossRef]
33. Oh, K.; Jeong, S. Assessing the spatial distribution of urban parks using GIS. *Landsc. Urban Plan.* **2007**, *82*, 25–32. [CrossRef]
34. Luo, W.; Wang, F. Measures of spatial accessibility to health care in a GIS environment: Synthesis and a case study in the Chicago region. *Environ. Plan. B Plan. Des.* **2003**, *30*, 865–884. [CrossRef] [PubMed]
35. Luo, W.; Qi, Y. An enhanced two-step floating catchment area (E2SFCA) method for measuring spatial accessibility to primary care physicians. *Health Place* **2009**, *15*, 1100–1107. [CrossRef] [PubMed]
36. McGrail, M.R.; Humphreys, J.S. Measuring spatial accessibility to primary health care services: Utilising dynamic catchment sizes. *Appl. Geogr.* **2014**, *54*, 182–188. [CrossRef]
37. Wan, N.; Zou, B.; Sternberg, T. A three-step floating catchment area method for analyzing spatial access to health services. *Int. J. Geogr. Inf. Sci.* **2012**, *26*, 1073–1089. [CrossRef]
38. Mao, L.; Nekorchuk, D. Measuring spatial accessibility to healthcare for populations with multiple transportation modes. *Health Place* **2013**, *24*, 115–122. [CrossRef]
39. Wang, H.; Wei, X.; Ao, W. Assessing Park Accessibility Based on a Dynamic Huff Two-Step Floating Catchment Area Method and Map Service API. *ISPRS Int. J. Geo-Inf.* **2022**, *11*, 394. [CrossRef]
40. Yang, L.; Zhang, S.; Guan, M.; Cao, J.; Zhang, B. An Assessment of the Accessibility of Multiple Public Service Facilities and Its Correlation with Housing Prices Using an Improved 2SFCA Method—A Case Study of Jinan City, China. *ISPRS Int. J. Geo-Inf.* **2022**, *11*, 414. [CrossRef]
41. Seifu, S.; Stellmacher, T. Accessibility of public recreational parks in Addis Ababa, Ethiopia: A GIS based analysis at sub-city level. *Urban For. Urban Green.* **2021**, *57*, 126916. [CrossRef]
42. Boisjoly, G.; Deboosere, R.; Wasfi, R.; Orpana, H.; Manaugh, K.; Buliung, R.; El-Geneidy, A. Measuring accessibility to hospitals by public transport: An assessment of eight Canadian metropolitan regions. *J. Transp. Health* **2020**, *18*, 100916. [CrossRef]

43. Liu, L.; Yu, H.; Zhao, J.; Wu, H.; Peng, Z.; Wang, R. Multiscale Effects of Multimodal Public Facilities Accessibility on Housing Prices Based on MGWR: A Case Study of Wuhan, China. *ISPRS Int. J. Geo-Inf.* **2022**, *11*, 57. [CrossRef]
44. Wu, W.; Zheng, T. Establishing a "dynamic two-step floating catchment area method" to assess the accessibility of urban green space in Shenyang based on dynamic population data and multiple modes of transportation. *Urban For. Urban Green.* **2023**, *82*, 127893. [CrossRef]
45. Xiao, W.; Wei, Y.D.; Wan, N. Modeling job accessibility using online map data: An extended two-step floating catchment area method with multiple travel modes. *J. Transp. Geogr.* **2021**, *93*, 103065. [CrossRef]
46. Zheng, Z.; Shen, W.; Li, Y.; Qin, Y.; Wang, L. Spatial equity of park green space using KD2SFCA and web map API: A case study of Zhengzhou, China. *Appl. Geogr.* **2020**, *123*, 102310. [CrossRef]
47. *GB/T 51346-2019*; Standard for Planning of Urban Green Space. Ministry of Housing and Urban-Rural Development of the People's Republic of China: Beijing, China, 2019.
48. *CJJ/T 85-2017*; Standard for Classification of Urban Green Space. Ministry of Housing and Urban-Rural Development of the People's Republic of China: Beijing, China, 2017.
49. Zhou, S.; Chen, F.; Xu, Z. Evaluating the accessibility of urban parks and waterfronts through online map services: A case study of Shaoxing, China. *Urban For. Urban Green.* **2022**, *77*, 127731. [CrossRef]
50. Jin, H.; Lu, Y. Multi-Mode Huff-Based 2SFCA: Examining Geographical Accessibility to Food Outlets in Austin, Texas. *ISPRS Int. J. Geo-Inf.* **2022**, *11*, 579. [CrossRef]
51. Hu, S.; Song, W.; Li, C.; Lu, J. A multi-mode Gaussian-based two-step floating catchment area method for measuring accessibility of urban parks. *Cities* **2020**, *105*, 102815. [CrossRef]
52. Xu, M.; Xin, J.; Su, S.; Weng, M.; Cai, Z. Social inequalities of park accessibility in Shenzhen, China: The role of park quality, transport modes, and hierarchical socioeconomic characteristics. *J. Transp. Geogr.* **2017**, *62*, 38–50. [CrossRef]
53. Talen, E.; Anselin, L. Assessing spatial equity: An evaluation of measures of accessibility to public playgrounds. *Environ. Plan. A* **1998**, *30*, 595–613. [CrossRef]
54. Omer, I. Evaluating accessibility using house-level data: A spatial equity perspective. *Comput. Environ. Urban Syst.* **2006**, *30*, 254–274. [CrossRef]
55. Zheng, Z.; Xia, H.; Ambinakudige, S.; Qin, Y.; Li, Y.; Xie, Z.; Zhang, L.; Gu, H. Spatial accessibility to hospitals based on web mapping API: An empirical study in Kaifeng, China. *Sustainability* **2019**, *11*, 1160. [CrossRef]
56. Wang, J.; Su, Y.; Chen, Z.; Tang, L.; Wang, G.; Wang, J. Assessing the Spatial Accessibility of Urban Medical Facilities in Multi-Level and Multi-Period Scales Based on Web Mapping API and an Improved Potential Model. *ISPRS Int. J. Geo-Inf.* **2022**, *11*, 545. [CrossRef]
57. Zhang, L.; Chen, P.; Hui, F. Refining the accessibility evaluation of urban green spaces with multiple sources of mobility data: A case study in Shenzhen, China. *Urban For. Urban Green.* **2022**, *70*, 127550. [CrossRef]
58. Liu, S.; Wang, X. Reexamine the value of urban pocket parks under the impact of the COVID-19. *Urban For. Urban Green.* **2021**, *64*, 127294. [CrossRef]
59. Xia, Y.; Chen, H.; Zuo, C.; Zhang, N. The impact of traffic on equality of urban healthcare service accessibility: A case study in Wuhan, China. *Sustain. Cities Soc.* **2022**, *86*, 104130. [CrossRef]
60. Zhang, W.; Gao, Y.; Li, S.; Liu, W.; Zeng, C.; Gao, L.; Li, M.; Peng, C. Accessibility measurements for urban parks considering age-grouped walkers' sectorial travel behavior and built environment. *Urban For. Urban Green.* **2022**, *76*, 127715. [CrossRef]
61. Pfertner, M.; Büttner, B.; Wulfhorst, G. An Open-Source Modelling Methodology for Multimodal and Intermodal Accessibility Analysis of Workplace Locations. *Sustainability* **2023**, *15*, 1947. [CrossRef]