*sustainability*

MDPI

*Article*

# Enclave-Reinforced Inequality during the COVID-19 Pandemic: Evidence from University Campus Lockdowns in Wuhan, China

**Cheng Sun [1,2,*], Yaxuan Xiong [2], Zhiqin Wu [3] and Jie Li [2]**

[1] Center of Hubei Cooperative Innovation for Emissions Trading System, Hubei University of Economics, Wuhan 430205, China
[2] School of Low Carbon Economics, Hubei University of Economics, Wuhan 430205, China; xiongyaxuan@mail.hbue.edu.cn (Y.X.); 18170049@mail.hbue.edu.cn (J.L.)
[3] School of Social Sciences, University of Manchester, Manchester M13 9PL, UK; zhiqin.wu@manchester.ac.uk
* Correspondence: suncheng@hbue.edu.cn

**Abstract:** The COVID-19 pandemic has impacted urban life and created spatial and social inequalities in cities. The impacts of lifting full lockdown restrictions once fast-spreading and community-acquired infection waves were under control are still not fully understood. This study aims to explore spatial inequality reinforced in the intervals between the waves of infection during the COVID-19 pandemic. Enclave-reinforced inequality resulting from enclave-based lockdown policies in Chinese cities was investigated through an analysis of the impacts of university campus enclave closures on the accessibility and crowdedness of urban green spaces. Using a modified two-step floating catchment area (2SFCA) and inversed 2SFCA (i2SFCA) method, accessibility and crowdedness were calculated and compared under two different scenarios. Additionally, the Lorenz curve, Gini coefficient, and Theil index were used to measure and compare intra-city global and local inequalities under each scenario. The results indicate that the lockdown of university campus enclaves decreased the supply of urban green spaces. Campus closures not only exacerbated the unequal distribution of urban green space, but also reduced the inequality of crowdedness in urban parks due to increased crowdedness in parks near the closed enclaves. Moreover, both accessibility and crowdedness worsened when the calculations were weighted for population size and the total supply of green space. Enclave-based lockdown in cities reinforced spatial inequality, and it is highly complex and has multidimensional impacts on urban inequalities and environmental injustice which should be considered by urban planners and decision-makers hoping to create healthy, inclusive, resilient, and sustainable cities in the "new normal" of the COVID-19 pandemic.

**Keywords:** enclave-reinforced inequality; COVID-19; urban enclaves; university campus; accessibility; Wuhan



**Citation:** Sun, C.; Xiong, Y.; Wu, Z.; Li, J. Enclave-Reinforced Inequality during the COVID-19 Pandemic: Evidence from University Campus Lockdowns in Wuhan, China. *Sustainability* **2021**, *13*, 13100. https://doi.org/10.3390/su132313100

Academic Editors: Jianquan Cheng and Jon Bannister

Received: 31 October 2021
Accepted: 23 November 2021
Published: 26 November 2021



## 1. Introduction

With the outbreak of COVID-19 in December 2019, lockdown, mobility restrictions, and border closure policies were adopted worldwide to control the spread of the virus [1]. Local lockdowns and restrictive policies, such as social distancing, border closures, and movement tracking, were implemented to control the situation and these produced a profound change in urban lifestyles [2,3]. The resultant spatial adaptability and resilience in cities can be described as "lockdown urbanism" [1]. The COVID-19 pandemic also disrupted daily movement [4]. Mobility-restricting and hard border policies introduced during the COVID-19 lockdown affected people's movement at different scales, from global travel between countries to local travel within cities [5]. The impacts included, but were not limited to, reduction and cessation of local public transport [6], modes of transport used [7], the distribution of accessible resources, and the operation of the urban social and economic system.

Changes that took root in the pandemic became embedded in urban daily life following the return to relative normality. Once fast-spreading and community-acquired infections were controlled, the focus turned to lifting restrictions in order to balance protective health measures with social and economic needs [8]. However, the pandemic has resulted in a shift in the long-term human paradigm; there has not been a return to the status quo in the post-COVID era, but rather a significantly different "new normal" has been established [9]. The exit strategy from full lockdown began by easing COVID-19 restrictions while mass testing, social distancing, and vaccinations took place, with the aim of ensuring a safe re-opening process that minimised the risks from new waves of coronavirus infections [10]. Certain vulnerable groups, such as those in education and healthcare facilities, were protected by maintaining partial lockdowns, and this approach is likely to continue as caution about future waves of COVID-19 remains high. Gaps still exist and the impacts of the releasing policies of full lockdown should be further assessed.

The impact of COVID-19 and local-scale lockdown responses have reinforced existing inequalities and created new ones [11]. A growing body of research has investigated inequalities in citizens' movement during the COVID-19 lockdown. For example, the pandemic may have long-term implications for health inequalities, leading to environmental justice issues, because gentrification and urban socio-economic transitions reinforced the uneven resources in urban green space to cope with coronavirus [12]. Lockdown social isolation policies also reduced accessible green spaces and "green mobility" and brought about further deprivation [13,14]. "Non-essential" activities could no longer take place in urban green spaces, which led to an increased demand for local green spaces [15]. Provision of access to green spaces for all is a key principle of goal 11 of the UN's Sustainable Development Goals (SGDs) to "make cities inclusive, safe, resilient and sustainable" [16]. To achieve this goal, COVID-19 response policies must also adhere to this principle [17,18], especially when full lockdowns were released and lifted after peak infections in the pandemic [19].

The pandemic is spatial in nature [20], so too are the responses to it, not only during lockdown but also in the lifting of restrictions. The change of movement has been the biggest impact in cities in the pandemic [21]. Studies of the spatial and temporal inequality of urban movement after restrictions have been lifted are still rare. This paper explored the spatial impact of partial lockdowns in urban enclaves on urban inequalities during the intervals between infection waves in China. In Section 2, we review the relevant literature and identify the research gap following the lifting of restrictions. Section 3 introduces the empirical research design to validate our conceptual framework and explains the spatial analytical methods used in this study. We selected Wuhan as the study area and university campuses as an example of multi-functional urban enclaves to analyse the change of green space supply within the study area before and after COVID-19 restrictions. Section 4 presents the results of changes to the supply of green space, crowdedness, and inequalities caused by urban enclaves during the pandemic. Section 5 identifies a new "enclave-reinforced inequality" in Chinese cities from the results and discusses the formation and implications of the findings for urban planners and local policymakers. Section 6 concludes this study and makes recommendations for further research.

## 2. Inequalities in Urban Enclave-Based Lockdowns

### *2.1. Urban Inequalities in the COVID-19 Full-Scale Lockdown*

Changes to human social and economic systems in response to the COVID-19 pandemic have reinforced existing structural inequalities; people of different races, ethnicities, occupations, classes, and genders have been unequally exposed to the risks [22,23]. The outbreak of COVID-19, which precipitated full lockdowns and other adaptive policies, has also raised new inequalities and injustices [12]. At the local scale, the biggest impact has been on movement in and between settlements [19]. To contain the fast spread of coronavirus, non-essential movement and access to public spaces, including urban green spaces, were strictly controlled [15], leading to local residents' unequal access to urban services and well-being spaces [24,25]. Social distancing and other movement restricting policies affected the use of public transport, which impacted population groups differently [26].

### 2.2. From Full-Scale to Enclave-Based Lockdown in Chinese Cities

Intra-city borders played an important role in Chinese cities during the COVID-19 pandemic [27]. Local lockdown policies focused on urban enclaves, such as gated communities and work unit compounds, which are common in Chinese cities [28]. Borders around gated communities were generally shut at the beginning of the pandemic when COVID-19 spread quickly [29]. Work unit housing neighbourhoods also closed their borders to contain the outbreak [30]. Unauthorised movement across these borders was strictly limited during the full lockdown to control the first wave of infections [1]. Urban enclaves are defined as self-contained entities which affect urban mobility and social connectivity by spatial order and boundaries [31]. The enclosure of urban enclaves in China may have delivered health benefits for enclave residents and reduced infection risks [32]. However, maintaining them in the post-lockdown era may be questioned on the grounds of segregation and inequality [33]. Therefore, researchers should provide more evidence of the advantages and disadvantages of enclaves to inform urban public policy and spatial governance during the ongoing pandemic.

### 2.3. The Linkage between University Campus Enclaves and Their Neighbourhoods

Most university campuses in Chinese cities are enclaved and occupy large-scale, self-organised walled and gated spatial units [34,35]. Unlike other urban enclaves in Chinese cities, crossing the border of university campus enclaves was not strictly prohibited by most higher education institutes in the pre-pandemic era. University campuses are considered to be gardens that form an integral part of urban greening designs [36–38]. The playgrounds, squares, lakes, woods, green belts, and other facilities within the campus serve local residents as well as students and faculty. A spatial linkage exists between universities and their host city to share facilities and green space within the campus.

Previous research has shown that residents in neighbouring communities use university campus green spaces for outdoor physical and recreational activities, such as running, walking, and cycling [39,40], and local children use the playground facilities [41], especially where campuses are located in densely populated areas of cities [42]. Most residential users walk to campus facilities [41]. To minimise health risks during the pandemic, university campuses were closed to the urban public and local community residents. Campus borders and controlled entry via gates were implemented (Figure A1 in Appendix A).

### 2.4. Inequality Reinforced in Enclave-Based Lockdowns

Greater understanding of the inequalities resulting from enclave-specific lockdowns policies is required so that policymakers and urban planners can ensure a safe and inclusive re-opening process that does not perpetuate social inequalities in the post-COVID "new normal" era. Enclave-based lockdown policies deeply impact the potential to engage in outdoor activities and may vary in different areas of a city. Enclave-based lockdowns are a new phenomenon introduced in the periods between the waves of infection during the COVID-19 pandemic; prior to the pandemic, resources and opportunities within enclaves were shared with the wider community.

However, urban inequality reinforced in enclave-lockdowns was overlooked in previous studies. To address this research gap, this study tried to conceptualise the inequality in this spatial-temporal process and quantitatively explore where and how the impacts are as the proof of concept. Accessibility is a concept to measure the relative ease with which destinations can be reached, and reflects the opportunities provided by destinations and costs and challenges experienced by those wishing to reach those destinations [43–45]. We designed an empirical study based on accessibility to validate our conceptualisation of inequality reinforced in enclave-based lockdowns and its impact on urban space in enclave-based lockdowns during the COVID-19 pandemic.

## 3. Materials and Methods

University campuses in Wuhan were identified as suitable enclaves with which to validate the conceptualisation of enclave-reinforced inequality as they provide multi-functional green services. As university campus enclaves have remained closed during the pandemic, the supply of accessible green spaces for local residents has decreased and residents have needed to find alternative urban green spaces in public parks. Consequently, the spatial distribution and quantity of available supply of public green spaces changed during the pandemic.

### 3.1. Study Area

Wuhan is a megacity with a population of 11.21 million [46]. It is the capital of Hubei Province, located in central China. It consists of three towns, Hankou, Hanyang, and Wuchang, and is divided by the Yangtze and Han Rivers (A, B, and C in Figure 1). Wuhan was chosen as the study area as COVID-19 first broke out in Hankou, one of the three towns in Wuhan. The city also contains numerous urban enclaves, the closure of which was essential to policies designed to control the spread of the virus [1]. Wuhan is also the centre for higher education in central China, with 83 universities and colleges located in Wuhan municipality and 132 university campuses within the wider built-up area. Together these provide a considerable volume of urban green space and recreational facilities to the local community. Lockdown restrictions significantly affected the availability of urban green space to citizens who reside off-campus.

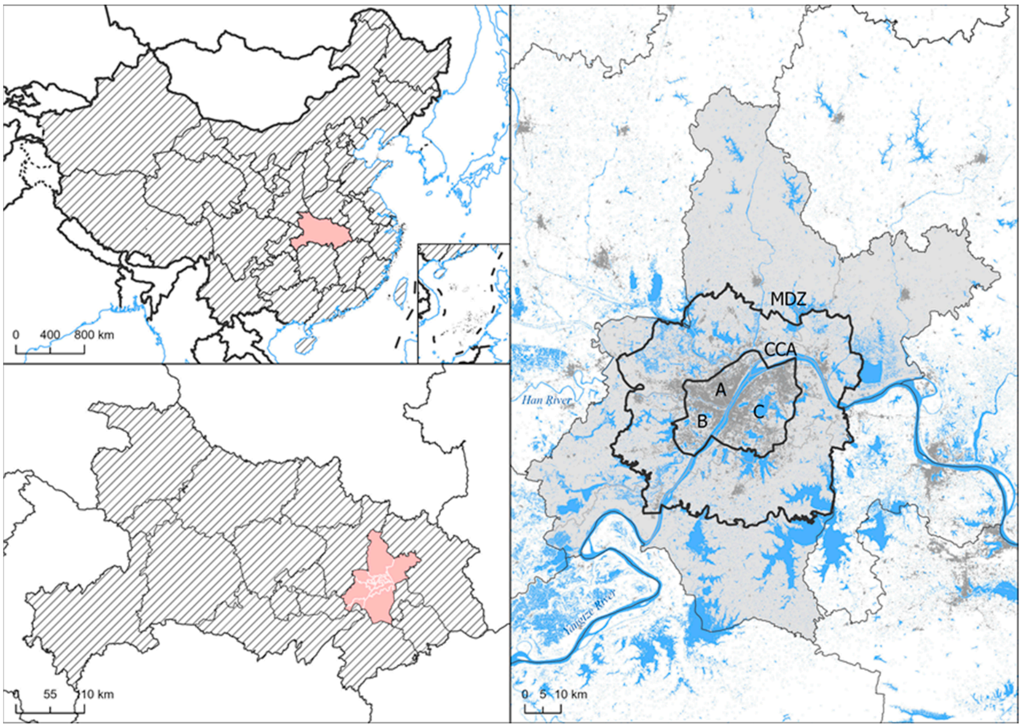


**Figure 1.** Study area (A: Hankou, B: Hanyang, C: Wuchang, CCA: central city area, MDZ: metropolitan development zone).

Data were collected within the metropolitan development zone [47] (the MDZ line with an area of 3261 km$^2$ in Figure 1) to avoid the impact of edge effect on the spatial analysis. Only results from the central city area (the CCA line with an area of 678 km$^2$ in Figure 1) are discussed.

### 3.2. Data

To explore and measure enclave-reinforced inequality at the local scale, data were collected between October 2020 and January 2021 and stored in a Geographical Information

System (GIS). Three datasets representing the demand, supply, and accessibility of urban green spaces were collected, as described in Sections 3.2.1–3.2.3 below. All data were processed, analysed, and mapped using ArcMap 10.8, ArcGIS Pro 2.6, QGIS 3.16, and Jupyther Notebook in Anaconda 3, and are shown in Figure 2.

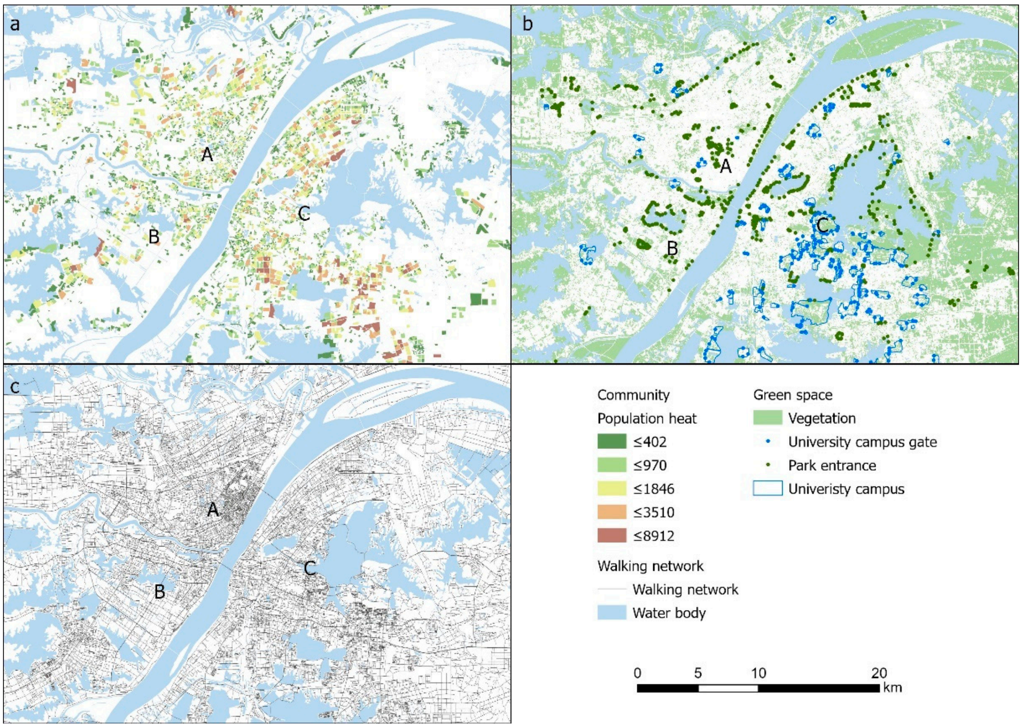


**Figure 2.** Research data (A: Hankou, B: Hanyang, C: Wuchang). (**a**) Community; (**b**) green space; (**c**) walking network.

### 3.2.1. Community and Population

Community borders, represented as residential area boundary in this case, and population data were collected to measure the demand for urban green space. Residential area boundaries were digitalised into vector feature data from the tiled map service provided by Tianditu Wuhan, a digital web map held by Wuhan Natural Resources and Planning Bureau. As census data are aggregated by district or sub-district, they are not suitable for analysing residential-scale patterns. Instead, population data were collected and processed from Baidu Heat Map [48]. We verified the linear relationship between the population heat and census data by comparing them at the district scale [49]. This process also revealed that the correlation between two datasets increased when only data from the study area were included (Figure 3). Baidu heat maps were collected at 10:00 a.m. and 11:00 p.m. on 11 December 2020 and 1:00 p.m. and 8:00 p.m. on 13 December 2020 to represent the typical daytime and night-time population on a weekday and weekend day. The average heat value from the four maps was used to estimate the population, and this was used to represent the demand for urban green space in each community.

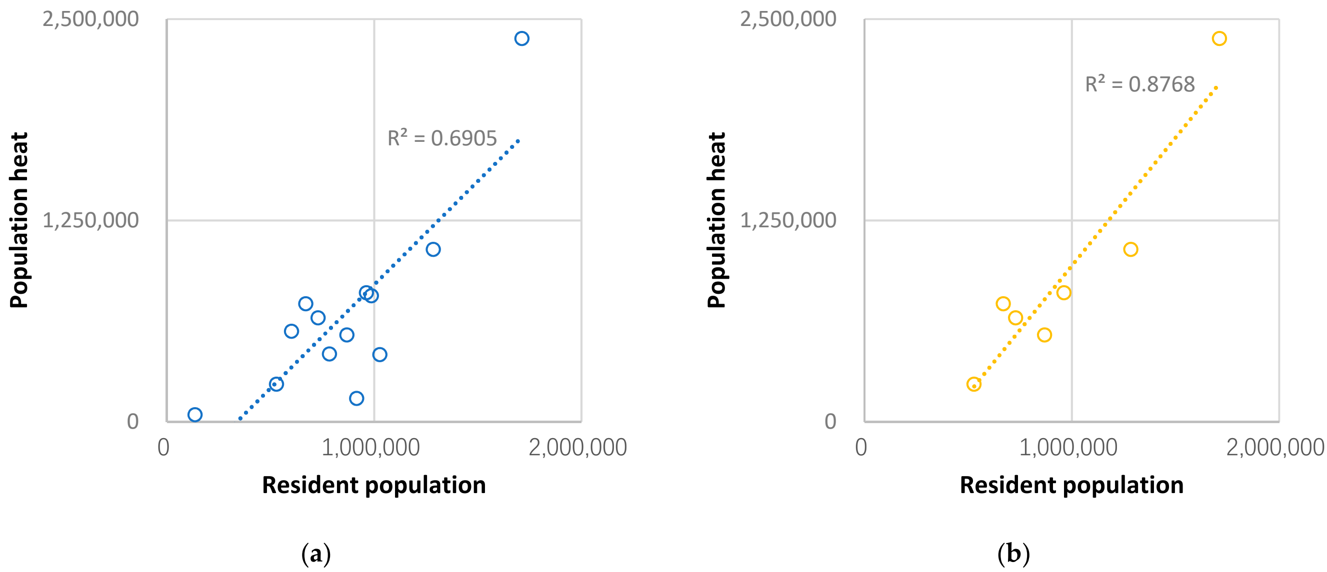


**Figure 3.** The linear relationship between population and heat value. (**a**) All districts; (**b**) urban districts.

#### 3.2.2. Green Spaces within University Campus Enclaves and Urban Parks

Park boundary, university campus boundary, and enclave gate location data were collected to present the supply of urban green space. The data were digitalised from the tiled map service provided by Tianditu Wuhan. Restrictions on movement and other lockdown conditions before and after the pandemic were confirmed by fieldwork conducted between October 2020 and January 2021. Because of the unique regulations governing military colleges, those campuses were excluded from this study. The area of green spaces in parks and university campuses was calculated from forest, grass, and shrub raster cells from Finer Resolution Observation and Monitoring—Global Land Cover (FROM-GLC), which was produced from 10-m resolution remotely sensed data [50]. The data indicated that 47.80% of the area in university campuses in Wuhan is green space. By comparison, only 45.96% of the area in parks in Wuhan is green space (Table 1). This shows how important university campuses are as providers of urban green space.

**Table 1.** Percentage of green space in each of the three land-use types in the study area (Unit: $km^2$).

| Data | Location | Count | Total Area | Mean Area | Total Area of Green Space | Percentage of Total Area Occupied by Green Space |
|---|---|---|---|---|---|---|
| Communities (residential area) | All | 4677 | 186.73 | 0.04 | 27.93 | 14.96% |
| | A | 1695 | 58.75 | 0.03 | 6.18 | 10.50% |
| | B | 587 | 28.39 | 0.05 | 5.23 | 18.42% |
| | C | 2431 | 99.60 | 0.04 | 16.52 | 16.59% |
| Parks | All | 144 | 78.91 | 0.55 | 36.27 | 45.96% |
| | A | 43 | 11.28 | 0.26 | 7.77 | 68.88% |
| | B | 20 | 9.02 | 0.45 | 3.74 | 41.46% |
| | C | 81 | 58.61 | 0.72 | 24.77 | 42.26% |
| University campuses | All | 132 | 48.70 | 0.37 | 23.28 | 47.80% |
| | A | 13 | 3.64 | 0.28 | 1.57 | 43.13% |
| | B | 7 | 2.97 | 0.42 | 1.36 | 45.79% |
| | C | 112 | 42.09 | 0.38 | 20.34 | 48.33% |

#### 3.2.3. Walking Network

A walking network dataset was extracted from a road network constructed from Google Satellite Maps. Motorways, ramps, overpasses, and other roads where pedestrians are banned from walking were excluded from the network. Topology and connectivity were calculated using ArcGIS 10.8 Network Analyst. A walking speed of 4.5 km/h, validated in a previous study [34], was used to calculate travel times.

### 3.3. Methods

To explore and quantify enclave-reinforced inequality, we designed a method to measure the potential accessibility and crowdedness, taking into account the location of urban enclave entrance gates. To assess the impact of enclave-based lockdowns, we compared the accessibility and crowdedness of green spaces before and during lockdowns.

#### 3.3.1. Accessibility and Crowdedness Analysis

Accessibility refers to the relative ease with which residents can access facilities and services [51]. It reflects the spatial distribution and spatial proximity of urban green spaces [52]. Accessibility measurement methods commonly include minimum cost weighted analysis, cumulative opportunities analysis, gravity-based analysis, utility-based analysis, space syntax, and two-step floating catchment area analysis (2SFCA) [53]. 2SFCA is widely used to explore the accessibility of healthcare facilities and green spaces. The 2SFCA method of measuring accessibility is based on the ratio of supply and demand within a cost-defined radius. The inversed two-step floating catchment area (i2SFCA) can be used to measure crowdedness, which is similar to 2SFCA, by inversely using the ratio of demand and supply [54]. However, 2SFCA and i2SFCA may not be suitable to measure the accessibility of resources located within enclaves, where the degree of access is limited by the number and location of gates. Therefore, this study presents a modified method of 2SFCA and i2SFCA which can be applied to urban enclaves with multiple gates and in which it is assumed that residents will choose one gate based on the criterion of minimum cost.

The original form of 2SFCA method is given in Equation (1). It was modified by calculating all the accessible gates within a 15-minute walk. If these gates belong to the same university campus or park, then select the one by a minimum distance. It is given in Equation (2) as follows:

$$A_G = \sum_{F=1}^{n} R_F = \sum_{F=1}^{n} \left[ \frac{S_F}{\sum_{g=1}^{m} D_g} \right] \quad (1)$$

$$\begin{cases} S_F = S_{F_i} \; i\epsilon min\left(Distance_{ig}\right) \\ R_F = R_{F_j} \; j\epsilon min\left(Distance_{jG}\right) \end{cases} \quad (2)$$

where $A_G$ is the quantity of green space accessible to residents within a 15-min walk, $S_F$ is the area of green space in the university campus enclaves or parks $F$, $D_g$ is the population of the community $g$'s centroid point, $i$ and $j$ are gates of the university campus enclaves or parks, and $R_F$ is the corresponding ratio of supply and demand.

A modified version of i2SFCA was used to measure and compare the potential crowdedness of parks when university campuses were closed to the public during enclave-based lockdowns. The modification was similar to the modified 2SFCA in this study, and the formula is set out in Equations (3) and (4):

$$C_F = \sum_{G=1}^{m} r_G = \sum_{G=1}^{m} \left[ \frac{D_G}{\sum_{f=1}^{n} S_f} \right] \quad (3)$$

$$\begin{cases} S_f = S_{f_u} \; u\epsilon min\left(Distance_{uf}\right) \\ r_G = r_{G_v} \; v\epsilon min\left(Distance_{vG}\right) \end{cases} \quad (4)$$

where $C_F$ is the crowdedness of park $F$. $D_G$ is the population of community $g$'s centroid point, $S_f$ is the capacity of park $f$ in the search area, $u$ and $v$ are park gates, and $r_G$ is the corresponding ratio of demand and supply.

3.3.2. Global and Local Measure of Inequality

The Gini coefficient and Lorenz curve were used to measure global inequality across the whole study area. To account for spatial heterogeneity of inequality within the study area, the Theil Index was used to measure local inequality in the three towns in Wuhan.

The Lorenz curve is often used to analyse income and wealth inequality in economics and transport geography [55]. It represents disparity visually, and the Gini coefficient, which is derived from the curve, quantifies the degree of inequality in the distribution. In this study, the Lorenz curve and Gini coefficient were used to measure the inequality of accessibility and crowdedness. The Gini coefficient was calculated as follows:

$$G_a = 1 - \sum_{k=1}^{n} (Y_{k-1} + Y_k)(X_k - X_{k-1}) \tag{5}$$

where $G_a$ is the Gini coefficient of the whole study area, $X_k$ is the cumulative proportion of the population from each community starting from the smallest, and $Y_k$ is the cumulative proportion of accessibility within the 15-min search area. When the coefficient is used to measure crowdedness, $X_k$ is the cumulative proportion of green space area in each park, starting with the smallest, and $Y_k$ is the cumulative proportion of crowdedness in each park.

The Theil index is a measurement of differences within and between different areas [56]. The bigger the index, the bigger the imbalance between different areas. The Theil index of accessibility and crowdedness was calculated for the whole of Wuhan to measure global inequality, and also in Hankou (A), Hanyang (B), and Wuchang (C) to measure local inequality using Equations (6)–(8) as follows:

$$T = T_b + T_w \tag{6}$$

$$T_b = \sum_{k=1}^{k} Y_k \ln\left(\frac{Y_k}{\frac{n_k}{n}}\right) \tag{7}$$

$$T_w = \sum_{k=1}^{k} Y_k \left(\sum_{i \in S_k}^{i} \frac{y_i}{Y_k} ln \frac{\frac{y_i}{Y_k}}{1/n_k}\right) \tag{8}$$

where $T$ is the overall inequality in accessibility or crowdedness within Wuhan. $T_b$ is the inequality in accessibility or crowdedness between a sub-area and the rest of the study area, and $T_w$ is the inequality in accessibility or crowdedness within a sub-area. $S_k$ is the count of the community. There were $k$ sub-areas in this study. Every sub-area has $n_k$ communities. $y_i$ is the proportion of $i$ in the whole accessibility or crowdedness. $Y_k$ is the proportion of accessibility or crowdedness contributed by $k$ sub-area. To assess whether inequality was affected by population size or the total supply of green space, measures of inequality were repeated, taking into account differences in land area, population size, and the quantity of green space in each sub-area.

3.3.3. Scenarios and Difference Analysis

The data were analysed under two scenarios. Scenario 1 is the normal pre-COVID situation in which parks and university campuses provide urban green space that is open to the public. Scenario 2 is enclave-based lockdown during the pandemic in which only parks provide urban green space that is open to the public. The standardised difference index of accessibility and crowdedness was used to measure the change in opportunities and the reinforcement of inequality. It was calculated as follows [57]:

$$D_A = (A_2 - A_1)/A_1 \tag{9}$$

where $D_A$ is the standardised difference index, $A_1$ is the accessibility or crowdedness under Scenario 1, and $A_2$ is the accessibility or crowdedness under Scenario 2.

## 4. Results

### *4.1. Residents' Accessibility to Green Spaces*

Accessibility was visualised and classified using the quintile method (Figure 4). Under Scenario 2, the second quintile of residential green space accessibility decreased by 0.87, the third quintile decreased by 5.46, and the fourth quintile decreased by 9.18. That is, accessibility to green space decreased under Scenario 2. The results indicate that the lockdown of university campus enclaves reduced local residents' accessibility to green space.

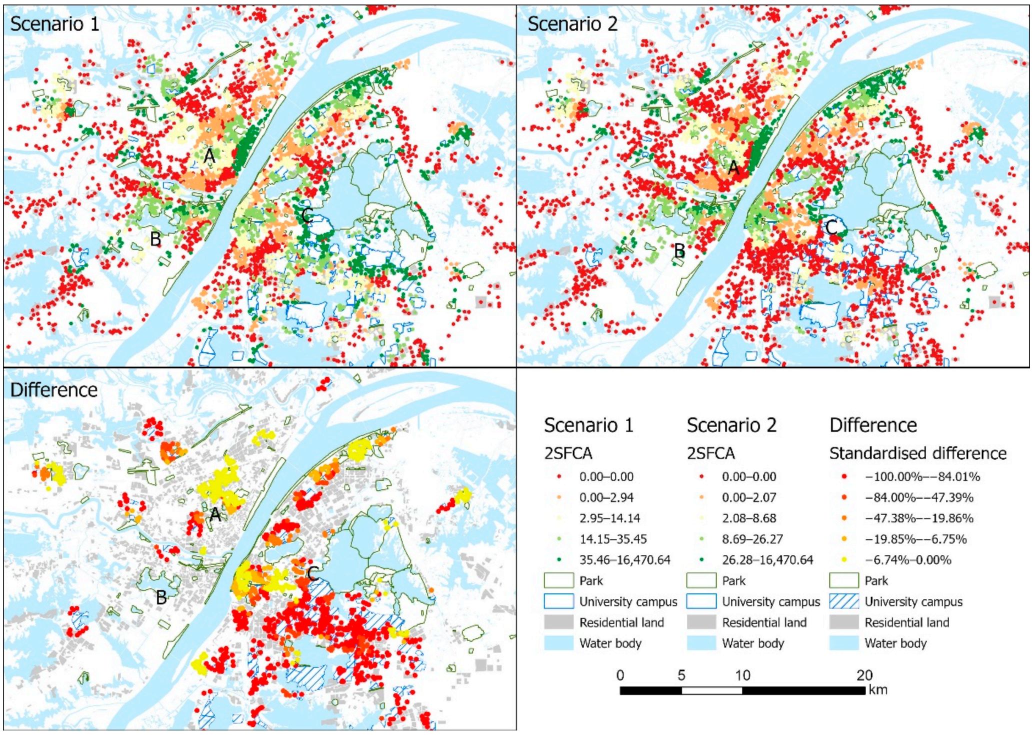


**Figure 4.** Residents' accessibility to green spaces pre-COVID (Scenario 1), during enclave-based lockdowns (Scenario 2), and how much this differed between the two.

The mean change in accessibility (Table 2) showed a decrease in accessible green space in Hankou (A), Hanyang (B), and Wuchang (C) in Scenario 2 even after population size has been accounted for. The average reduction in accessibility was significantly greater in Wuchang (C), indicating that university campus enclave-based lockdown policy had a disproportionate impact on Wuchang (C) residents. Average accessibility was much smaller in the population-weighted calculations.

**Table 2.** Mean accessibility to green spaces under each scenario.

| | | Wuhan | A | B | C |
|---|---|---|---|---|---|
| Spatial accessibility | Scenario 1 | 44.6168 | 14.4318 | 25.4597 | 69.8418 |
| | Scenario 2 | 33.0584 | 12.1199 | 22.6281 | 49.8661 |
| | Difference | −11.5584 | −2.3119 | −2.8317 | −19.9757 |
| | Standardised difference | −25.91% | −16.02% | −11.12% | −28.60% |
| Population-weighted accessibility | Scenario 1 | 22.2859 | 10.2910 | 15.9618 | 30.7514 |
| | Scenario 2 | 14.0451 | 9.0972 | 12.8342 | 17.2583 |
| | Difference | −8.2408 | −1.1938 | −3.1276 | −13.4931 |
| | Standardised difference | −36.98% | −11.60% | −19.59% | −43.88% |

### 4.2. Potential Crowdedness of Urban Parks

Potential crowdedness under the two scenarios was also visualised and classified using the quintile method. Figure 5 shows that under Scenario 2, the first quintile of park crowdedness increased by 0.01, the second quintile increased by 0.03, the third quintile increased by 0.14, the fourth quintile increased by 0.49, and the fifth quintile increased by 1.02. The standardised difference in crowdedness shows that overall park crowdedness in Scenario 2 was greater than in Scenario 1. This result suggests that the reduction in accessible green space resulting from the university campus lockdown policy increased crowdedness in urban parks.

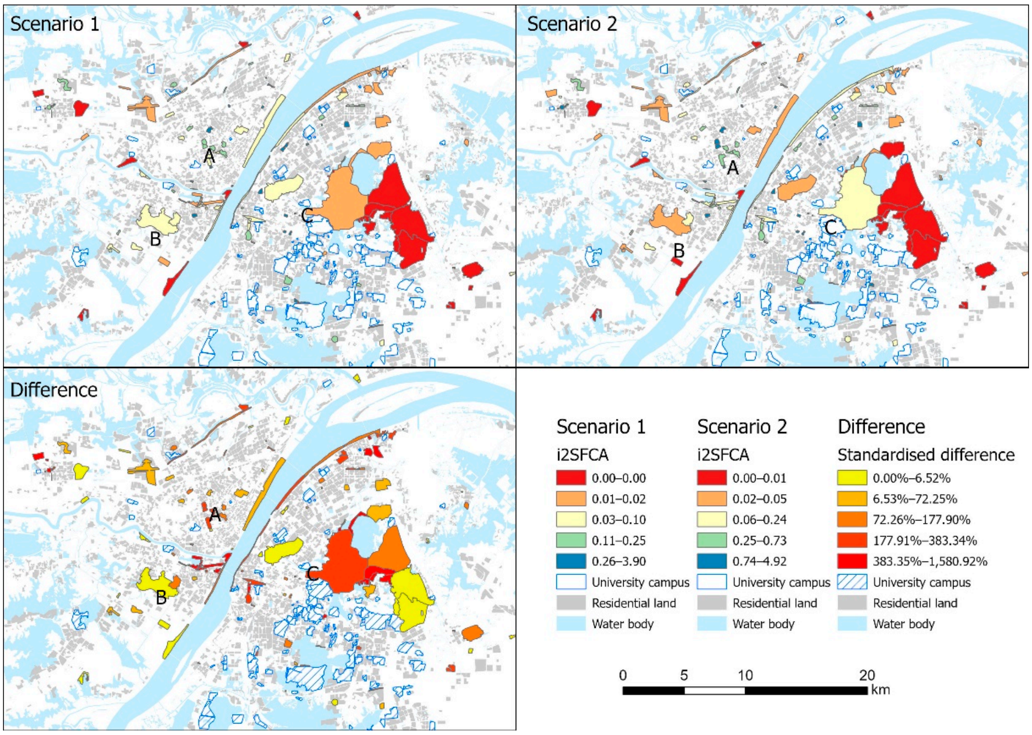


**Figure 5.** Crowdedness of urban parks under each scenario and the difference between the two.

Table 3 shows the change in the potential crowdedness of parks in Wuhan and its three constituent towns. The differences were all positive regardless of whether the overall park capacity was accounted for or not through weighting and showed that park crowdedness was higher in Scenario 2 than Scenario 1. Weighting significantly reduced the mean crowdedness in Wuhan and its three constituent towns in both scenarios, but crowdedness was twice as high in Scenario 2.

**Table 3.** Change in mean crowdedness under each scenario.

| | | Wuhan | A | B | C |
|---|---|---|---|---|---|
| Crowdedness | Scenario 1 | 0.2764 | 0.3963 | 0.1330 | 0.2520 |
| | Scenario 2 | 0.4633 | 0.6733 | 0.2232 | 0.4178 |
| | Difference | +0.1869 | +0.2770 | +0.0902 | +0.1658 |
| | Standardised difference | +67.62% | +69.90% | +67.82% | +65.79% |
| Capacity-weighted crowdedness | Scenario 1 | 0.0276 | 0.0553 | 0.0332 | 0.0185 |
| | Scenario 2 | 0.0586 | 0.1618 | 0.0697 | 0.0426 |
| | Difference | +0.0310 | +0.1065 | +0.0365 | +0.0241 |
| | Standardised difference | +112.32% | +192.59% | +109.94% | +130.27% |

### 4.3. Global Inequality

Figure 4 shows that residential communities located near the Yangtze River and major lakes had the highest level of accessibility to green spaces, probably due to river greening projects and ecological restoration of the lakes. Accessibility gradually decreased with distance from the river. This illustrates the inequality of green space accessibility for Wuhan residents. The Lorenz curve in Figure 6 shows that the changes in green space accessibility caused by enclave-based lockdown in the COVID-19 pandemic made it more curved. Moreover, the Gini coefficient in Wuhan City increased from 0.928 to 0.961 (Table 4). In other words, spatial inequality increased when university campus enclaves were closed to the public.

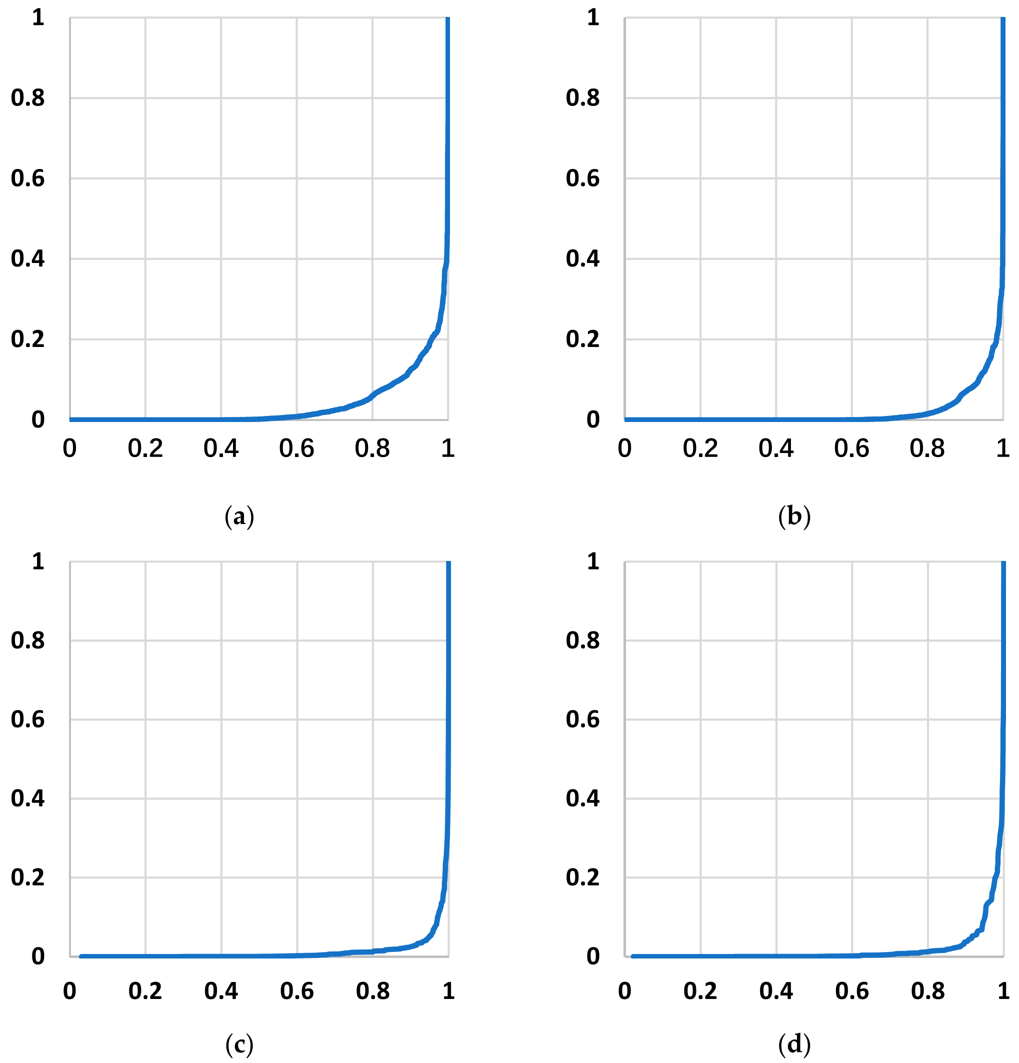


**Figure 6.** Lorenz curve of green space accessibility and crowdedness under each scenario. (**a**) Accessibility in Scenario 1; (**b**) accessibility in Scenario 2; (**c**) crowdedness in Scenario 1; (**d**) crowdedness in Scenario 2.

**Table 4.** Gini coefficient of green space accessibility and crowdedness in Wuhan.

| | Accessibility | Crowdedness |
|---|---|---|
| Scenario 1 | 0.9280 | 0.9746 |
| Scenario 2 | 0.9615 | 0.9643 |
| Variation | +0.0335 | −0.0103 |

In Scenario 2, the Gini coefficient decreased by 0.0103 (Table 4), indicating a slight reduction in spatial inequality of crowdedness in Wuhan's urban parks. This suggests the overall inequality of crowdedness in Wuhan decreased slightly when university campus enclaves were closed. However, the enclave-based lockdown policy led to an increase in crowdedness in urban parks. It should be noted that the decrease in inequality is a result of the decrease in the overall supply of green spaces, which reduces the difference in crowdedness between the green spaces still open to the public. As there was not a corresponding decrease in demand for green spaces, accessibility decreased and crowdedness increased.

### 4.4. Local Inequality

Owing to the spatial heterogeneity of population, land use patterns, road transport network, travel time, and service quality, it was expected that accessibility and crowdedness of green spaces would also vary spatially across Wuhan. The Theil index was used to measure the contribution of each area to the overall inequality of accessibility and crowdedness of green spaces in Wuhan. Under Scenario 2, the difference in accessibility within a sub-area ($T_w$) increased in Hankou (A), Hanyang (B), and Wuchang (C) (Table 5). This indicates that university campus enclave lockdowns increased the spatial inequality of green space accessibility within all three towns. Even after differences in population had been accounted for, inequality was higher under Scenario 2. Differences in green space accessibility in Wuchang (C) were much higher than in Hankou (A) and Hanyang (B) in both scenarios. $T_w$ decreased in Hanyang (B) and Wuchang (C) when differences in population size were accounted for.

**Table 5.** Theil index of green space accessibility.

| | | Scenario 1 | | | Scenario 2 | | | Percentage Difference | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | $T_b$ | $T_w$ | T | $T_b$ | $T_w$ | T | $T_b$ | $T_w$ | T |
| Spatial accessibility | Wuhan | | | 2.8311 | | | 3.4339 | | | +21% |
| | A | −0.1295 | 0.2290 | | −0.1305 | 0.2545 | | +1% | +11% | |
| | B | −0.0402 | 0.1608 | | −0.0326 | 0.2119 | | −19% | +32% | |
| | C | 0.3646 | 2.2464 | | 0.3223 | 2.8082 | | −12% | +25% | |
| Population-weighted accessibility | Wuhan | | | 2.2484 | | | 2.8062 | | | +25% |
| | A | −0.1285 | 0.3014 | | −0.1071 | 0.4402 | | −17% | +46% | |
| | B | −0.0364 | 0.1267 | | −0.0218 | 0.1691 | | −40% | +34% | |
| | C | 0.2978 | 1.6874 | | 0.1860 | 2.1396 | | −38% | +27% | |

Spatial variations in crowdedness within all three towns ($T_w$) decreased in Scenario 2 when only the difference in the size of each area was accounted for (Table 6). This confirms that the inequality of crowdedness in the three areas decreased when university campus enclaves were in lockdown. Crowdedness decreased by 38% in Hanyang (B), 24% in Wuchang (C), and 23% in Hankou (A). Taking the total area of green space to represent supply capacity, the capacity-weighted Theil index was calculated. The capacity-weighted inequality of crowdedness decreased in Hankou (A) and Hanyang (B) in Scenario 2 but increased in Wuchang (C). In addition, when the quantity of green space was accounted for, inequality of crowdedness decreased in both scenarios in all three towns.

**Table 6.** Theil index of crowdedness.

| | | Scenario 1 | | | Scenario 2 | | | Percentage Difference | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | $T_b$ | $T_w$ | T | $T_b$ | $T_w$ | T | $T_b$ | $T_w$ | T |
| Spatial crowdedness | Wuhan | | | 1.3077 | | | 0.9967 | | | −24% |
| | A | 0.1486 | 0.4476 | | 0.1563 | 0.3452 | | +5% | −23% | |
| | B | −0.0507 | 0.1100 | | −0.0506 | 0.0682 | | 0% | −38% | |
| | C | −0.0478 | 0.6999 | | −0.0530 | 0.5306 | | +11% | −24% | |
| Capacity-weighted crowdedness | Wuhan | | | 0.6375 | | | 0.6234 | | | −2% |
| | A | 0.1479 | 0.1999 | | 0.0979 | 0.1874 | | −34% | −6% | |
| | B | −0.0175 | 0.0881 | | −0.0186 | 0.0610 | | +6% | −31% | |
| | C | −0.0950 | 0.3141 | | −0.0621 | 0.3579 | | −35% | +14% | |

## 5. Discussions

### 5.1. Enclave-Reinforced Inequality and Its Formation

The results in this study have confirmed previous findings that the urban response to COVID-19 has changed the relationship between humans and nature [58] and that COVID-19-related lockdowns reinforced inequity issues [11]. By the results presented in this paper, enclave-reinforced inequality is defined as the unequal decrease in intra-city opportunities available in different locations and to different social groups under the constraints of urban enclave-based lockdowns, resulting in greater inequalities than pre-pandemic.

The enclave-reinforced inequality is temporal, and the definition builds under the background of the COVID-19 pandemic. Enclave-reinforced inequality from the perspective of outside users has been shaped by two phases in the COVID-19 pandemic (Figure 7). Phase one refers to the full lockdown and strict control of movement implemented by local governments, in which enclave gates were closed and citizens were not allowed to move across the enclave borders without permission. Changes in access to resources, services, and destinations located within their borders, and the inequality that ensued have been widely studied in this phase [3]. Phase two refers to the opening up stage in the intervals between COVID-19 waves, once the fast spread of the virus was controlled. In this phase, some urban enclaves, including gated communities, work unit compounds, and other residential estates, were re-opened, while others, such as schools, universities, and other gathering places, remained closed due to public safety concerns. Travel and movement remain constrained by enclave borders, resulting in changes to the supply of services and resources. Phase two represents the current "new normal" to prevent future COVID-19 waves in Chinese cities.

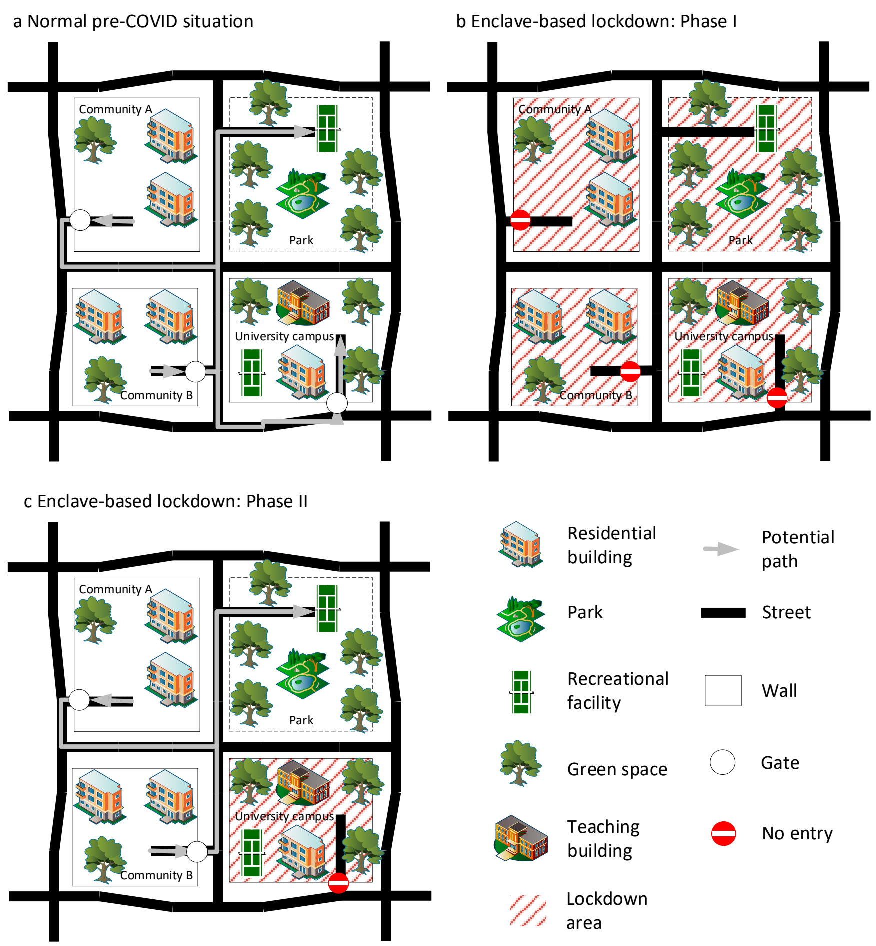


**Figure 7.** Two phases shape the new inequality during the pandemic.

The results suggest enclave-reinforced inequality was caused by interruptions to the linkage and relationship between university campus enclaves and local neighbourhood during the COVID-19 pandemic. Compared with cities in Western countries, urban enclaves with walls and controlled access are common in Chinese cities [28,59]. The potential impact of urban enclaves on social and spatial inequalities has been widely studied [33,60]. However, most research has focused on gated communities, urban villages, and state-owned enterprise work unit compounds. Public access to resources within urban enclaves, such as university campuses, should not be overlooked. In the pre-pandemic era, pedestrians were allowed to enter university campuses and use the green spaces, facilities, and amenities within them [37,39].

The Hubei University of Economics (HBUE) campus and its surrounding area are taken as an example (Figure 8 and the appendices). HBUE is a public university funded and governed by the Hubei Provincial government. The campus covers a 143.24 ha area, which includes a large-scale green space. Before the pandemic, citizens in surrounding communities (B, C, D in Figure 8) were able to access the HBUE campus with a 15-minute walk and could use its green spaces (Figure 8a). During the pandemic, the campus was closed to the public (Figure 8b). Local residents (B, C, D in Figure 8) were not permitted to enter the campus, and consequently, the availability of and accessibility to green spaces decreased.

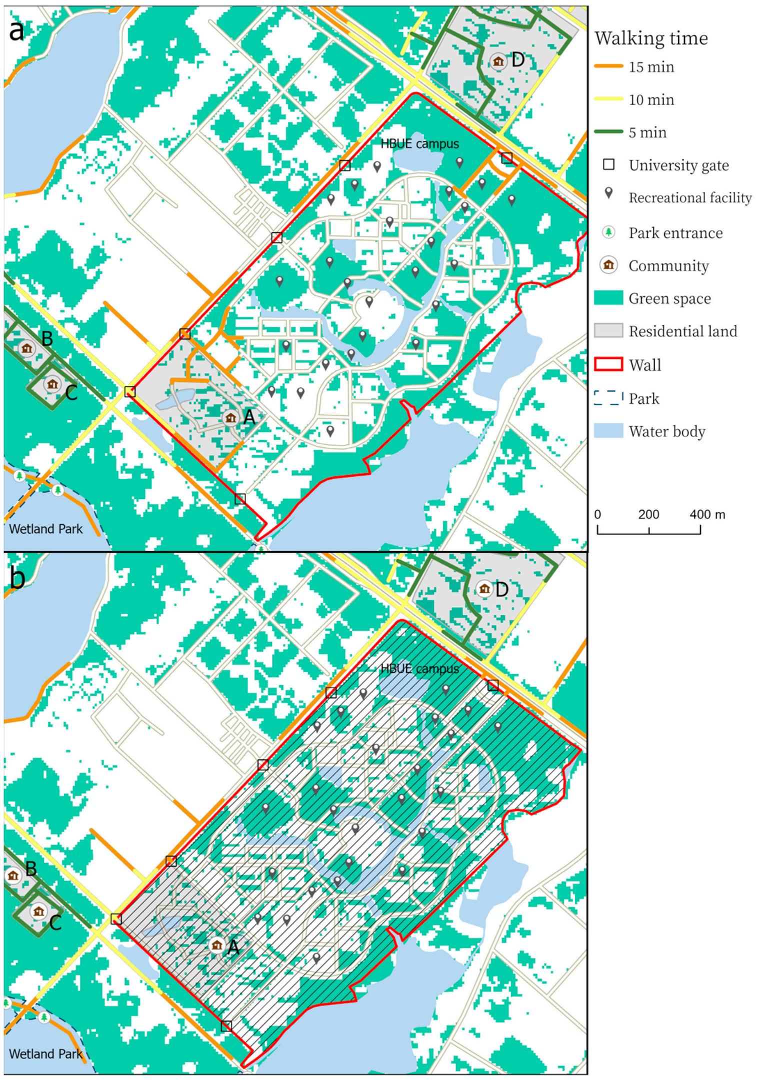


**Figure 8.** Green space accessibility in the HBUE campus. (**a**) Scenario 1; (**b**) Scenario 2.

The study also confirmed that enclave-reinforced inequality is in part created by the provision of recreational green spaces in university campus enclaves to local communities. In contrast, driven by the intention of equality, they were designed as a form of social welfare for their members in the era of pre-reform China while the surrounding area was not accounted for [61]. Enclave-based lockdowns during the COVID-19 pandemic exacerbated spatial inequalities by reducing the supply of green spaces and increasing crowdedness in public parks. Green spaces in university campuses provide welfare for the university population and local residents because the social and ecological functions of these green spaces are cross-border. On this basis, university campus enclaves can be considered as community parks, providing a multi-functional green infrastructure and forming a part of a multi-scale urban greening system with borders. The inequality of access to urban green space in parks funded by public investment leads to unequal health and sustainable benefits [52,62]. When the linkage and relationship between universities and local communities were halted during the pandemic, the impact of the loss of benefits was unevenly distributed across the city, and this has further implications for urban inequality.

### *5.2. Connecting Enclave-Reinforced Inequality with Urban Equalities*

Enclave-reinforced inequality resulted from the increase in unequal opportunities to access green space and the decrease in the supply of green space. Urban enclave-based lockdowns were implemented to address public health concerns during the COVID-19 pandemic. Essentially, the uneven distribution of opportunities is neither the result of insufficient resources nor socio-spatial segregation in cities. It resulted from the homogeneous governance of urban enclaves when they no longer shared their internal resources during the COVID-19 pandemic. It may not be the direct production of income, wealth, housing, or other disparities leading to the sorting of population or urban amenities [63]. Therefore, enclave-reinforced inequality is a highly complex and multidimensional issue at the intra-city scale, which derives from multiple intersecting policies [19] and the redistribution of accessibility [64]. Results presented in this study indicate that enclave-reinforced inequality can be deconstructed from the perspective of space, time, and spatial-temporal accumulation.

Spatially, the global and local inequalities presented in this study showed that enclave-based lockdowns and spatially heterogeneous reductions in the supply of green spaces, led to a new type of urban spatial inequality in the intervals between waves of COVID-19 infections, especially in Wuchang (C), where there is a large area of university campus enclaves. Temporally, the results of this study in two scenarios show how inequalities can arise from temporary policies and create temporal variations in urban inequality during the COVID-19 pandemic. Owing to its spatial-temporal accumulation feature, enclave-reinforced inequality is quite different from previous urban inequalities in the normal pre-COVID situation and other urban inequalities in the COVID-19 pandemic.

The spatial-temporal accumulation refers to the enhancement of spatial impacts during COVID-19 related lockdowns. It is hard to be optimistic that COVID-19 can be controlled globally in a short period of time. Therefore, the impacts reinforced from the inequality are institutional and will be harmful to urban sustainability if the enclave-based lockdown is not to be lifted by local governors under the pressure of disease control. Spatial-temporal accumulation of enclave-based lockdown will lead to health-related inequality. On the one hand, the restrictions of cross-border movement unevenly decrease the supply of green spaces and bring about disparities of accessible recreational space across the city. This will create unequal opportunities for physical activity and long-term health. On the other hand, the spatial-temporal constraint of urban green space increased the crowdedness of urban parks (Figure A2 in Appendix A). The increase in the number of local residents gathered in the park across the city will create unequal coronavirus infection risk in urban parks and along walking to urban parks.

*5.3. Implications for Well-Being and Urban Resilience*

The geographical process and potential impacts of enclave-reinforced inequality are summarised and shown in Figure 9. The uneven decrease of opportunities will lead to the unequal use of urban green spaces and disparities in physical activity, psychological benefits, and health at the intra-city level [52,62].

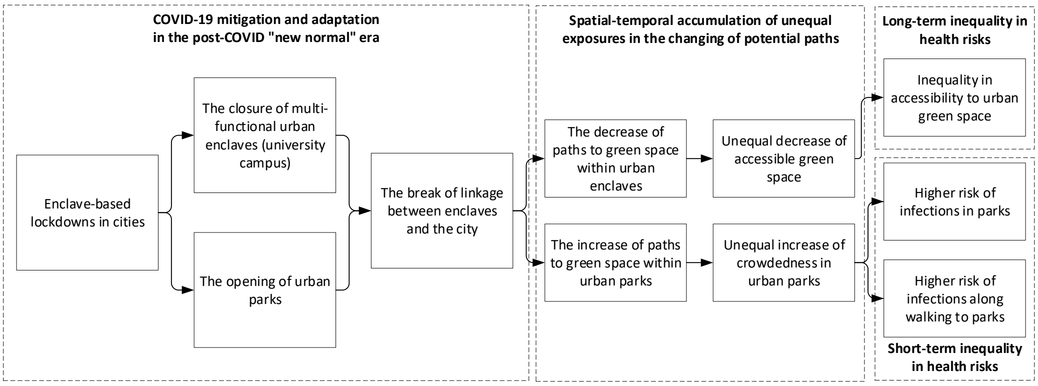


**Figure 9.** The geographical process and impacts of enclave-reinforced inequality.

The potential impacts of a spatially heterogenous decrease in urban green space during the pandemic include urban socio-ecological inequality, economic inequality, and the disparity of well-being. Well-being relies on being able to use resources to meet challenges [65]. To cope with the psychological, social, and physical challenges from the pandemic, urban green space plays an important role as a neighbourhood resource [12,58,66]. Urban green spaces support place-based coping and contribute to urban resilience against COVID-19 disturbances [67]. The long-term impacts of such disparities may be to decrease human capital and social exclusion, which may reinforce income and wealth inequalities [68], leading to unsustainable everyday life.

Unlike green space inequalities in Western countries, enclave-reinforced inequality in Chinese cities is derived from enclave-based lockdowns during peak infections, followed by the partial closure of urban enclaves in the intervals between infection waves. Resilient responses to disturbances should consider short-term and long-term adaptation [69]. Urban green spaces contribute to urban resilience by providing a place to respond to and cope with disturbance and risk [70]. The results of this study indicate that short-term closure of urban enclaves complements long-term strategies to address health concerns but leads to inequalities that adversely affect strategies to improve long-term resilience.

## 6. Conclusions

In this study, enclave-reinforced inequality was defined then measured before and during the COVID-19 pandemic. From the perspective of accessible urban green spaces and using evidence from the closure of university campus enclaves during lockdowns in Wuhan, it confirmed that enclave-based lockdowns reinforced inequalities. Urban governors, planners, and decision-makers should note and address these impacts if they wish to promote a healthy, inclusive, resilient, and sustainable city during the pandemic.

*6.1. Policy Implications*

Accessible green space decreased more in Wuchang where there is a large area of university campus enclaves, even after the population size had been taken into consideration. This indicates that the border and access status of such enclaves were not considered when urban green infrastructure and ecological networks were planned. To plan and construct an inclusive socio-ecological system, the connection between ecosystem services and the governance of urban enclaves needs to be understood in more detail.

To reduce inequality during the pandemic and avoid increasing spatial segregation and social exclusion, it is necessary to increase the provision of green space. Without this, increased crowdedness in public parks has the potential to conflict with social distancing measures and increase the risk of potential coronavirus infections. However, such ramifications cannot be alleviated solely by re-opening urban enclaves to the public, as this will inevitably increase the risk of infections within the enclaves. Therefore, to prevent and mitigate worsening urban inequalities, the homogeneous governance of enclave-based lockdown and "one size fits all" policy implemented by just closing the gates in the COVID-19 pandemic should be reflected on. Alternatively, heterogeneous governance of urban enclaves can be considered as the solution. Strategies include but are not limited to investigating green spaces in the surrounding area, setting certain levels of openness in a certain area within the enclave, and promoting visitor reservation and tracing systems based on digital technology.

### 6.2. Limitations and Recommendations for Future Works

There are several limitations in this study, which calls for further research. First, there will be two patterns of inequality reinforced in the second phase of enclave-based lockdown if the residents within university campus enclaves are considered. For example, enclave-based lockdown decreased the supply of green supply from the perspective of community B, C, D in Figure 8. In comparison, community A, where most residents are faculty members, staff, and students, was not affected by the closure of the HBUE campus. Therefore, it is necessary to explore and compare the derived impacts and unequal urban citizenship between different patterns of enclave-reinforced inequality. Second, enclave-reinforced inequality disproportionately affects residents in communities around university campus enclaves, as confirmed by the difference in green space accessibility and local inequality under the two scenarios. Disadvantaged groups and disparities in access to urban green space have been thoroughly studied under the banner of environmental justice [52,62,71], but the research has called for further investigation into whether disparities resulting from enclave-reinforced inequality are driven by socio-economic status or ethnic group. Third, the data were collected and analysed at the community level. The results will be more precise if the population data can be archived at the residential building level or a higher temporal resolution. Moreover, qualitative data and methods should be taken into account to create further debates. Considering the multi-dimensional impacts of urban enclaves, further analysis and discussions are needed to provide positive and negative evidence of the trade-offs between health, economic, social, and spatial factors in the post-COVID "new normal" era.

**Author Contributions:** Conceptualization, C.S. and Z.W.; methodology, C.S.; validation, Y.X. and J.L.; investigation, Y.X. and J.L.; writing—original draft preparation, C.S., Y.X. and J.L.; writing—review and editing, C.S. and Z.W.; visualization, C.S.; supervision, C.S.; project administration, Y.X.; funding acquisition, C.S. All authors have read and agreed to the published version of the manuscript.

**Funding:** UK–China Cooperation on Climate Change Risk Assessment (PF3051 CH-WS3HBUE YR1) and the Youth Project of Science Foundation of Ministry of Education of China (20YJC630149) jointly supported this study partially conducted in Wuhan, China.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** The data presented in this study are available on request from the corresponding author.

**Acknowledgments:** We would like to acknowledge Hanshi Qin, Longyue Xiao, Shiqi Zhong, and Jinsong Xu at Hubei University of Economics for their assistance in data processing and analysis. An early version of the manuscript was presented at the International Virtual Conference 2020 on Spatial Planning and Sustainable Development, and we would like to thank the discussant Suhong Zhou at Sun Yat-sen University for her comments.

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

## Appendix A

**Figure A1.** Hard border policy based on the gate of Hubei University of Economics campus (Photo taken on 25 March 2021).

**Figure A2.** Wetland Park near Hubei University of Economics campus (Photo taken on 14 November 2021).

## References


1. Jefferies, T.; Cheng, J.; Coucill, L. Lockdown urbanism: COVID-19 lifestyles and liveable futures opportunities in Wuhan and Manchester. *Cities Heal.* **2020**, 1–4. [CrossRef]
2. Kang, M.; Choi, Y.; Kim, J.; Lee, K.O.; Lee, S.; Park, I.K.; Park, J.; Seo, I. COVID-19 impact on city and region: What's next after lockdown? *Int. J. Urban Sci.* **2020**, *24*, 297–315. [CrossRef]
3. Brail, S. Patterns amidst the turmoil: COVID-19 and cities. *Environ. Plan. B Urban Anal. City Sci.* **2021**, *48*, 598–603. [CrossRef]
4. Jensen, O.B. Pandemic disruption, extended bodies, and elastic situations—Reflections on COVID-19 and Mobilities. *Mobilities* **2021**, *16*, 66–80. [CrossRef]
5. Goulias, K.G. Special issue on understanding the relationships between COVID-19 and transportation. *Transp. Lett.* **2021**, *13*, 327–330. [CrossRef]
6. Gkiotsalitis, K.; Cats, O. Public transport planning adaption under the COVID-19 pandemic crisis: Literature review of research needs and directions. *Transp. Rev.* **2020**, *41*, 374–392. [CrossRef]
7. Eisenmann, C.; Nobis, C.; Kolarova, V.; Lenz, B.; Winkler, C. Transport mode use during the COVID-19 lockdown period in Germany: The car became more important, public transport lost ground. *Transp. Policy* **2021**, *103*, 60–67. [CrossRef]
8. Han, E.; Tan, M.M.J.; Turk, E.; Sridhar, D.; Leung, G.M.; Shibuya, K.; Asgari, N.; Oh, J.; García-Basteiro, A.L.; Hanefeld, J.; et al. Lessons learnt from easing COVID-19 restrictions: An analysis of countries and regions in Asia Pacific and Europe. *Lancet* **2020**, *396*, 1525–1534. [CrossRef]
9. Kleinman, M. Policy challenges for the post-pandemic city. *Environ. Plan. B Urban Anal. City Sci.* **2020**, *47*, 1136–1139. [CrossRef]
10. Griffin, M.; Sohrabi, C.; Alsafi, Z.; Nicola, M.; Kerwan, A.; Mathew, G.; Agha, R. Preparing for COVID-19 exit strategies. *Ann. Med. Surg.* **2020**, *61*, 88–92. [CrossRef]
11. Cave, B.; Kim, J.; Viliani, F.; Harris, P. Applying an equity lens to urban policy measures for COVID-19 in four cities. *Cities Heal.* **2020**, 1–5. [CrossRef]
12. Cole, H.V.S.; Anguelovski, I.; Baró, F.; García-Lamarca, M.; Kotsila, P.; del Pulgar, C.P.; Shokry, G.; Triguero-Mas, M. The COVID-19 pandemic: Power and privilege, gentrification, and urban environmental justice in the global north. *Cities Heal.* **2020**, 1–5. [CrossRef]
13. Ugolini, F.; Massetti, L.; Pearlmutter, D.; Sanesi, G. Usage of urban green space and related feelings of deprivation during the COVID-19 lockdown: Lessons learned from an Italian case study. *Land Use Policy* **2021**, *105*, 105437. [CrossRef]
14. Tomasso, L.; Yin, J.; Laurent, J.C.; Chen, J.; Catalano, P.; Spengler, J. The Relationship between Nature Deprivation and Individual Wellbeing across Urban Gradients under COVID-19. *Int. J. Environ. Res. Public Heal.* **2021**, *18*, 1511. [CrossRef]
15. Ugolini, F.; Massetti, L.; Calaza-Martínez, P.; Cariñanos, P.; Dobbs, C.; Ostoić, S.K.; Marin, A.M.; Pearlmutter, D.; Saaroni, H.; Šaulienė, I.; et al. Effects of the COVID-19 pandemic on the use and perceptions of urban green space: An international exploratory study. *Urban for. Urban Green.* **2020**, *56*, 126888. [CrossRef] [PubMed]
16. United Nations. Goal 11. Make Cities and Human Settlements Inclusive, Safe, Resilient and Sustainable. Available online: https://sdgs.un.org/goals/goal11 (accessed on 16 October 2020).
17. Di Marco, M.; Baker, M.L.; Daszak, P.; De Barro, P.; Eskew, E.A.; Godde, C.M.; Harwood, T.D.; Herrero, M.; Hoskins, A.J.; Johnson, E.; et al. Opinion: Sustainable development must account for pandemic risk. *Proc. Natl. Acad. Sci. USA* **2020**, *117*, 3888–3892. [CrossRef]
18. Simon, D.; Arano, A.; Cammisa, M.; Perry, B.; Pettersson, S.; Riise, J.; Valencia, S.; Oloko, M.; Sharma, T.; Vora, Y.; et al. Cities coping with COVID-19. *City* **2021**, 1–42. [CrossRef]
19. Acuto, M.; Larcom, S.; Keil, R.; Ghojeh, M.; Lindsay, T.; Camponeschi, C.; Parnell, S. Seeing COVID-19 through an urban lens. *Nat. Sustain.* **2020**, *3*, 977–978. [CrossRef]
20. Poom, A.; Järv, O.; Zook, M.; Toivonen, T. COVID-19 is spatial: Ensuring that mobile Big Data is used for social good. *Big Data Soc.* **2020**, *7*. [CrossRef]
21. Batty, M. The Coronavirus crisis: What will the post-pandemic city look like? *Environ. Plan. B: Urban Anal. City Sci.* **2020**, *47*, 547–552. [CrossRef]
22. Bowleg, L. We're Not All in This Together: On COVID-19, Intersectionality, and Structural Inequality. *Am. J. Public Heal.* **2020**, *110*, 917. [CrossRef] [PubMed]
23. Sharifi, A.; Khavarian-Garmsir, A.R. The COVID-19 pandemic: Impacts on cities and major lessons for urban planning, design, and management. *Sci. Total. Environ.* **2020**, *749*, 142391. [CrossRef] [PubMed]
24. Salazar, N.B. Existential vs. essential mobilities: Insights from before, during and after a crisis. *Mobilities* **2021**, *16*, 20–34. [CrossRef]
25. Yang, Y.; Xiang, X. Examine the associations between perceived neighborhood conditions, physical activity, and mental health during the COVID-19 pandemic. *Heal. Place* **2021**, *67*, 102505. [CrossRef]
26. Bracarense, L.D.S.F.P.; de Oliveira, R.L.M. Access to urban activities during the Covid-19 pandemic and impacts on urban mobility: The Brazilian context. *Transp. Policy* **2021**, *110*, 98–111. [CrossRef]
27. Li, M.; Xie, J. Social and Spatial Governance: The History of Enclosed Neighborhoods in Urban China. *J. Urban Hist.* **2021**. [CrossRef]
28. Iossifova, D. Borderland urbanism: Seeing between enclaves. *Urban Geogr.* **2014**, *36*, 90–108. [CrossRef]

29. Liu, X.; Bennett, M.M. Viral borders: COVID-19's effects on securitization, surveillance, and identity in Mainland China and Hong Kong. *Dialog- Hum. Geogr.* **2020**, *10*, 158–163. [CrossRef]
30. Zhu, T.; Zhu, X.; Jin, J. Grid Governance in China under the COVID-19 Outbreak: Changing Neighborhood Governance. *Sustainability* **2021**, *13*, 7089. [CrossRef]
31. Liao, K.; Breitung, W.; Wehrhahn, R. Debordering and rebordering in the residential borderlands of suburban Guangzhou. *Urban Geogr.* **2018**, *39*, 1092–1112. [CrossRef]
32. Hamama, B.; Liu, J. What is beyond the edges? Gated communities and their role in China's desire for harmonious cities. *City, Territ. Arch.* **2020**, *7*, 1–12. [CrossRef]
33. Douglass, M.; Wissink, B.; Van Kempen, R. Enclave Urbanism In China: Consequences and Interpretations. *Urban Geogr.* **2012**, *33*, 167–182. [CrossRef]
34. Sun, C.; Cheng, J.; Lin, A.; Peng, M. Gated university campus and its implications for socio-spatial inequality: Evidence from students' accessibility to local public transport. *Habitat Int.* **2018**, *80*, 11–27. [CrossRef]
35. Gu, Y.; Zhao, J.; Herzog, T.; Mao, Q.; Latz, P. Exploring the space use mechanism of high-density campus in urban Beijing. *Habitat Int.* **2019**, *91*. [CrossRef]
36. Huang, Y.; Wu, S. A study on the development trend of campus planning and design in China. *City Plan. Rev.* **2014**, *38*, 85–91.
37. Li, X.; Ni, G.; Dewancker, B. Improving the attractiveness and accessibility of campus green space for developing a sustainable university environment. *Environ. Sci. Pollut. Res.* **2019**, *26*, 33399–33415. [CrossRef]
38. Wang, R.; Jiang, W.; Lu, T. Landscape characteristics of university campus in relation to aesthetic quality and recreational preference. *Urban For. Urban Green.* **2021**, *66*, 127389. [CrossRef]
39. Yu, Y.; Tang, X.; Lu, S. Healthy service functions and elements of universities: Taking Beijing as an example. *Landsc. Archit.* **2018**, 38–45. [CrossRef]
40. Liu, Z. Interactive Research on University and Community from the Perspective of Studentification: A Case Study of Wujing Town, Shanghai. Master's Thesis, East China Normal University, Shanghai, China, 2020. [CrossRef]
41. Lang, J. Research on the Post-Utilization Evaluation of University Campus Public Facilities Based on the Concept of Sharing: Taking Universities in Jinan as an Example. Master's Thesis, Shandong Jianzhu University, Jinan, China, 2020. [CrossRef]
42. Pan, H. Research on Campus Landscape Transformation Based on Public Behavior Characteristics: Taking the Guangdong Polytechnic of Science and Technology as An Example. Master's Thesis, South China University of Technology, Guangzhou, China, 2020. [CrossRef]
43. van Wee, B. Accessible accessibility research challenges. *J. Transp. Geogr.* **2016**, *51*, 9–16. [CrossRef]
44. Miller, E.J. Accessibility: Measurement and application in transportation planning. *Transp. Rev.* **2018**, *38*, 551–555. [CrossRef]
45. Hansen, W.G. How Accessibility Shapes Land Use. *J. Am. Inst. Plan.* **1959**, *25*, 73–76. [CrossRef]
46. *Wuhan Bureau of Statistics Wuhan Statistical Yearbook*; China Statistics Press: Beijing, China, 2019.
47. Wuhan City Government Wuhan's Urban Master Plan (2010–2020). Available online: http://www.wpl.gov.cn/pc-69-35849.html (accessed on 15 June 2015).
48. Fan, Z.; Duan, J.; Lu, Y.; Zou, W.; Lan, W. A geographical detector study on factors influencing urban park use in Nanjing, China. *Urban For. Urban Green.* **2021**, *59*, 126996. [CrossRef]
49. Hubei Provincial Bureau of Statistics. *Hubei Investigation Team of the National Bureau of Statistics Hubei Statistical Yearbook*; China Statistics Press: Beijing, China, 2020.
50. Gong, P.; Liu, H.; Zhang, M.; Li, C.; Wang, J.; Huang, H.; Clinton, N.; Ji, L.; Li, W.; Bai, Y.; et al. Stable classification with limited sample: Transferring a 30-m resolution sample set collected in 2015 to mapping 10-m resolution global land cover in 2017. *Sci. Bull.* **2019**, *64*, 370–373. [CrossRef]
51. Handy, S. Is accessibility an idea whose time has finally come? *Transp. Res. Part D Transp. Environ.* **2020**, *83*, 102319. [CrossRef]
52. Rigolon, A. A complex landscape of inequity in access to urban parks: A literature review. *Landsc. Urban Plan.* **2016**, *153*, 160–169. [CrossRef]
53. Wu, H.; Levinson, D. Unifying access. *Transp. Res. Part D Transp. Environ.* **2020**, *83*, 102355. [CrossRef]
54. Wang, F. From 2SFCA to i2SFCA: Integration, derivation and validation. *Int. J. Geogr. Inf. Sci.* **2020**, *35*, 628–638. [CrossRef]
55. Delbosc, A.; Currie, G. Using Lorenz curves to assess public transport equity. *J. Transp. Geogr.* **2011**, *19*, 1252–1259. [CrossRef]
56. Lope, D.; Dolgun, A. Measuring the inequality of accessible trams in Melbourne. *J. Transp. Geogr.* **2020**, *83*, 102657. [CrossRef]
57. Panagiotopoulos, G.; Kaliampakos, D. Location quotient-based travel costs for determining accessibility changes. *J. Transp. Geogr.* **2021**, *91*, 102951. [CrossRef]
58. Rotherham, I.D. Understanding and supporting the urban forest becomes increasingly important with urbanisation and now with COVID lockdowns. *Arboric. J.* **2020**, *42*, 187–189. [CrossRef]
59. Wissink, B.; Van Kempen, R.; Fang, Y.; Li, S.-M. Introduction—Living in Chinese Enclave Cities. *Urban Geogr.* **2012**, *33*, 161–166. [CrossRef]
60. He, S. Evolving enclave urbanism in China and its socio-spatial implications: The case of Guangzhou. *Soc. Cult. Geogr.* **2013**, *14*, 243–275. [CrossRef]
61. Chai, Y. From socialist danwei to new danwei: A daily-life-based framework for sustainable development in urban China. *Asian Geogr.* **2014**, *31*, 183–190. [CrossRef]

62. Wolch, J.R.; Byrne, J.; Newell, J. Urban green space, public health, and environmental justice: The challenge of making cities 'just green enough'. *Landsc. Urban Plan.* **2014**, *125*, 234–244. [CrossRef]
63. Tonkiss, F. City government and urban inequalities. *City* **2020**, *24*, 286–301. [CrossRef]
64. Zhang, M.; Zhao, P. Literature review on urban transport equity in transitional China: From empirical studies to universal knowledge. *J. Transp. Geogr.* **2021**, *96*, 103177. [CrossRef]
65. Dodge, R.; Daly, A.P.; Huyton, J.; Sanders, L.D. The challenge of defining wellbeing. *Int. J. Wellbeing* **2012**, *2*, 222–235. [CrossRef]
66. Uchiyama, Y.; Kohsaka, R. Access and Use of Green Areas during the COVID-19 Pandemic: Green Infrastructure Management in the "New Normal". *Sustainability* **2020**, *12*, 9842. [CrossRef]
67. Samuelsson, K.; Barthel, S.; Giusti, M.; Hartig, T. Visiting nearby natural settings supported wellbeing during Sweden's "soft-touch" pandemic restrictions. *Landsc. Urban Plan.* **2021**, *214*, 104176. [CrossRef]
68. Kabeer, N. Poverty, Social Exclusion and the MDGs: The Challenge of 'Durable Inequalities' in the Asian Context. *IDS Bull.* **2006**, *37*, 64–78. [CrossRef]
69. Pike, A.; Dawley, S.; Tomaney, J. Resilience, adaptation and adaptability. *Camb. J. Reg. Econ. Soc.* **2010**, *3*, 59–70. [CrossRef]
70. Meerow, S.; Newell, J.P.; Stults, M. Defining urban resilience: A review. *Landsc. Urban Plan.* **2016**, *147*, 38–49. [CrossRef]
71. Cook, I.; Swyngedouw, E. Cities, Social Cohesion and the Environment: Towards a Future Research Agenda. *Urban Stud.* **2012**, *49*, 1959–1979. [CrossRef]