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Urban Green Space Distribution Related to Land Values in Fast-Growing Megacities, Mumbai and Jakarta–Unexploited Opportunities to Increase Access to Greenery for the Poor

Yun Hye Hwang [1,*], Ivan Kurniawan Nasution [1], Deepika Amonkar [1] and Amy Hahs [2]

1 Department of Architecture, School of Design and Environment, National University of Singapore, Singapore 119077, Singapore; sdeivan@nus.edu.sg (I.K.N.); amonkar.deepika@gmail.com (D.A.)
2 School of Biosciences, Faculty of Science, University of Melbourne, Melbourne 3010, Australia; hahsa@unimelb.edu.au
* Correspondence: akiyhh@nus.edu.sg

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Abstract: Many studies on disparities in the distribution of urban green space (UGS) focus on the quantity and accessibility of designated open spaces. However, when all types of UGS, including unmanaged green areas, are accounted for, claims of green space distributive injustice become more complicated. We conducted a preliminary investigation questioning the common Global North assumption that the poor have less access to the benefits of green space, using the cities of Mumbai and Jakarta as case studies as, in their respective countries, wealth inequality has grown at a higher rate than in other Asian countries. We employed four sets of geospatial data to analyze green space distribution patterns and probe the relationship with UGS inequity in different land value districts. We found that the lower land value districts had more vegetation coverage with a higher vegetation density, mainly due to a large quantity of unmanaged greenery. The relationship between the status of urban development and the land values in a district is not necessarily reflective of the UGS distribution once unmanaged vegetation is considered. We conclude by discussing ways to optimize the use of unmanaged UGS as a socioecological asset for poorer districts, and we point to the practical consequences of incorporating the study's findings into policy and planning towards the creation of ecologically inclusive cities.

Keywords: green space distribution; UGS inequity; unmanaged greenery; fast-growing megacities; environmental equity

1. Introduction

Urban areas are home to more than half the world's population, with some predicting this will be closer to 68% by 2050 [1]. Over two thirds of this increase is expected to occur in the Global South, where there are particularly pronounced legacy issues of environmental inequity [2,3]. With cities so closely tied to the human experience, there is a growing recognition of the need for urban landscapes to provide equitable access to green spaces so that all can enjoy their multiple benefits.

1.1. Benefits of Dense Unmanaged UGS

Urban green space (UGS) plays an essential sociocultural role in improving the quality of life in cities [4–6] while also performing a wide range of ecological and biophysical functions [7,8]. The capacity to provide these various benefits is influenced by the UGS's usage, accessibility, associated facilities, size, species richness, density, and structure of vegetation [9–11]. In particular, areas of managed or unmanaged greenery that are larger and more natural, with denser vegetation coverage, such as woods, river corridors, natural meadows, and wetland forests, tend to have more functions. For example, larger patches typically support more flora and fauna community populations [12]; urban wilds protect native ecosystems and threatened species [13]; forest-like designs with more trees reduce emissions and maximize sequestration [14,15], mitigate air pollution [16], and mitigate heat island effects [17]; and urban forests maintain soil nutrients and prevent flood damage [18]. Finally, dense and large patches of urban woodlands have cultural heritage value, inspire aesthetic appreciation, offer educational and recreational spaces [19,20], and positively affect human health and well-being [21–23]. Accordingly, in our study, we paid attention to a range of urban green spaces, including unmanaged conservation areas and informal green spaces, in which the majority of the vegetation is naturally grown, without or with less regular maintenance, not just managed designated parks or gardens.

1.2. Measures of UGS Inequity

Given the manifold advantages of UGS, urban rejuvenation and new development should consider the areas, proportion, distribution, configuration, and types of existing and future green spaces in their standard planning processes [24]. While different researchers measure different items and use specific contexts [25,26], the equal spatial distribution of green space is of special interest to many [27,28]. Many studies on the distributional and proportional inequity of recreational green spaces and the urban tree canopy have noted the better accessibility of UGS to those of high socioeconomic status; for example, there is a positive relationship between green space area and neighborhood socioeconomic status in both US cities [29–32] and Chinese cities [33–35], and there is more tree cover in high income neighborhoods [36] and less accessibility to parks in poor ones [37]. Some authors also find that the quantity of UGS is dependent on socioeconomic variables including income, race/ethnicity, education level, and age [38,39]. As a single metric may not fully capture the various quantitative and qualitative interactions between the variables [40], recent studies have employed multiple measures, including quantity, quality, and proximity, for a more comprehensive understanding of social inequity and green space provision [41–44].

In many cases, landscape policy and the practical realities of UGS planning focus on “planned” and/or “protected” greenery [45], with less attention paid to “remnant” urban greenery [46]. Although a recent study on the relationship between green space and wealth in tropical cities in Southeast Asia considered the percentage cover of all types of green space [47], UGS characteristics and distributional patterns in lower socioeconomic districts are generally studied less often.

1.3. Equity Challenges in Fast-Growing Cities

Environmental inequity has become a crucial issue in the cities of developing countries with rapidly increasing poverty and larger wealth inequalities [3]. Poor people living in urban areas are frequently exposed to environmental hazards and higher levels of pollution, with a resulting negative effect on the health of the most vulnerable [48,49]. There are also large differences in educational access and economic opportunities for rich and poor, as shown by the Gini coefficients for these cities [50]. At the same time, ongoing dramatic environmental challenges and dynamic socioeconomic growth are threatening the provision of UGS [51], especially in poorer areas, and this trend is exacerbated by the governments’ lack of desire to protect it [52]. As urban density increases, ecosystem quality declines [53] and green space disappears [47]. At the same time, unequal income distribution has accelerated and is associated with spatial segregation in housing and reduced neighborhood environmental quality [54], with a concomitant reduction in UGS.

Land use planning and policies in cities are multifaceted and complex, and the absence of long-term plans for unintentional green spaces is compounded by limited planning efforts and/or inadequate environmental regulations and policies targeting low income communities [55]. Unfortunately, while remnant UGS may be relatively abundant, it is not always seen as beneficial [56] in fast-growing developing cities. For instance, in Jakarta, smaller yet dense remnant UGS patches stretching for 37 km along the Ciliwung watershed in some areas of urban kampongs are being replaced with concrete embankments in order to minimize the environmental risk of flooding.

To summarize, remnant vegetation is quickly disappearing in the world's most rapidly growing cities. Given the many benefits of UGS, and as the locations and types of green spaces have not yet been officially designated in most cities, we think this is an opportune time to argue for the inclusion of unmanaged UGS in policy and planning.

1.4. Aim and Objectives

The aim of this study was to identify the general patterns of UGS distribution equity in Mumbai and Jakarta. As we see it, the quantity and configuration of UGS should be able to ensure a uniform distribution of socioecological benefits across the landscape, irrespective of residents' socioeconomic status, and thus be equitable. We included unmanaged greenery (see Rigolon [44], seldom regarded as a major measurement target in environmental equity studies, and examined the disparities in UGS distribution patterns using multiple quantifiable measures. The specific objectives were as follows: (1) to describe the physical characteristics of UGS in Mumbai and Jakarta by measuring the quantity, types, areas, and density; (2) to examine the relationships between UGS distribution patterns and the distributive patterns of districts by land value as an indicator of social equity; (3) to discover common and different relationships in the cities, which might serve as a source of information for future urban planning. The study was intended to open a discourse on environmental equity in the context of rapidly growing cities in the Global South and to point to the urgent need for policy to treasure and retrofit urban nature in fast-growing cities.

2. Methodology

2.1. Study Area

Mumbai and Jakarta were selected as pilot cities because the unequal income distribution in their respective countries has developed faster than in other Asian countries [57,58]. In Mumbai, the housing politics of marginalized settlements are often obfuscated [59] and environmental vulnerability has increased in poorer areas [60]. Similarly, Jakarta has promoted inclusive partnerships in low income communities, but this social objective has limited effect given the high pressure on housing markets [61]. Given their size, rapid growth, and unequal income distribution, along with their present emphasis on the expansion of green space in planning and efforts to attenuate spatial disparities, Mumbai and Jakarta offer representative case studies to examine whether equity issues manifest spatially in quantified UGS in underprivileged communities.

Located on the western coast of India, bordering the Arabian Sea (18°58′30″ N latitude and 72°49′33″ E longitude), Mumbai is India's largest metropolis. The population has increased more than 12 times in the last century, and 20 million people now live in a space of 468 km^2 [62]. The rapid population growth and urbanization have understandably changed the land-use patterns—built-up land jumped from 55.2% to 70.9% of the total land mass over the past 25 years [63]. Within the built-up areas of the city, uncontrolled population growth and inadequate infrastructure have caused a huge loss of open space. Mumbai has an average 0.12 m^2 per person of green space, far below the average of 15–25 m^2 per person in the Asia–Pacific region more generally [64].

Situated on the northwest coast of Java Island (6°12′52.63″S latitude and 106°50′42.47″E longitude), Jakarta is the high-density capital city of Indonesia. Ten million people live in a land area of 661.52 km^2 [65]. Urbanization is only one the of many pressures on land availability in Jakarta. Another is that almost half of the city, especially the northern part, is below sea level [66]. Both conditions require the constant negotiation of land allocated for development and for natural landscape; built-up land represented 69.9% of the total in 2017 [67]. The ensuing conflict is apparent in the current land use planning map; the local government has only been able to deliver 7.61% of the total city area as green open space [68], but the land policy stipulates 30%. Even with investment, the average green space per person in Jakarta has only slightly increased, moving up from 2.21 m^2 per person in 2008 to 2.73 m^2 per person in 2014 [69].

Figure 1 shows the locations and boundaries of the two cities.

Figure 1. Locations and boundaries of study areas, Mumbai (**A**) and Jakarta (**B**).

2.2. Data Sources

To examine the associations between UGS provision and its distributional inequity, we employed three sets of geospatial data—urban green spaces by type, vegetation cover, and land value.

Firstly, our main sources of information on the types of urban green spaces in the two cities were geospatial databases: existing open space maps of Mumbai [62] and Jakarta [68] and open street maps (downloaded from Trimble Data Marketplace (https://data.trimble.com/), that discontinued its service on 25 June 2018. Open street map data from Mumbai and Jakarta were downloaded on 18 July 2017) for both cities. As our main sources of data might raise legitimate concerns about accuracy and reliability because the data refer to different years and different publicly editable sources, we cross-referenced the sources with satellite images (referenced from ArcGIS World Imagery in 2017), and independent researchers who were familiar with each city verified some of the major green patches that were missing. The consolidated green spaces were classified into managed and unmanaged vegetation based on Tan et al. [70], as these researchers covered almost all types of green spaces. In what follows, unmanaged green spaces refer to (protected or unprotected) nature reserves or informal green spaces where the majority of vegetation grows naturally with little human intervention. The managed green spaces that we examined included agriculture, sports fields, golf courses, urban parks, roadside greenery, and cemeteries.

Secondly, we obtained estimates of vegetation cover by processing Landsat satellite images using ArcMap 10.2.1. The recent satellite images for Jakarta and Mumbai (19 July 2017 and 20 April 2017, respectively) captured by a Landsat-8 Operational Land Imager (OLI) sensor and a Thermal Infrared Sensor (TIRS), were downloaded via USGS EarthExplorer. The sensors consisted of 11 spectral bands with spatial resolutions of 30 m [71]. The satellite images were later transformed into a map of the normalized difference vegetation index (NDVI), a commonly used technique to study vegetative land cover [72,73]. Numerous studies have found that higher NDVI values correlate with denser and healthier vegetation (see, e.g., [74–76]. NDVIs derived from Landsat-8 OLI were corrected to reflectance values that were consistent with those found by other instruments, such as Landsat-7 ETM+, MODIS, GOCI, and in-situ LED-derived NDVIs, with the same atmospheric conditions [77]. The flow to obtain vegetation cover using NDVI consisted of the following steps: computing cover using the reflectance value (ρ) in the red (R) and near-infrared (NIR) wavelengths [78], clustering coverage areas according to their spectral values [79], and calculating the mean NDVI values of these areas using the zonal statistic algorithm [80]. Due to the low pixel resolution (30 m $\times$ 30 m) of the Landsat data, we used the "green vegetation fraction" (Fg) concept [81] to estimate the amount of vegetation within each pixel (vegetation density). The vegetation coverage was classified into five groups based on the fractions calculated within a pixel. Figure 5 is the vegetation fraction map for the five classes of vegetation cover in the two cities.

Thirdly, we used property land values as proxies for social inequity, as other spatial data related to income or other socio-economic data were scarce in these two data-poor cities. Land value may be affected by many variables, such as land use, location, and amenity rent, and we admit that it doesn't always correlate directly with the levels of advantage or disadvantage. However, it does provide a coarse indicator of the socioeconomic status of the residents likely to live in the area and often correlates with other equity indicators [82–85]. The real estate land value maps that we used were produced by legal agencies and were consistently available across the full spatial extents of both cities, although the latest years were slightly different for the two cities. The property value information in Mumbai is open access; the Urban Design Research Institute has prepared a map showing the land value on the basis of ready reckoner rates in 2017 [86]. The ready reckoner rates are the prices of the land and the residential property per square meter for a given area; they are published and regulated by the state government [87]. Information on Jakarta came from the Indonesian National Land Agency's (BPN) online portal (http://peta.bpn.go.id/). The portal gives access to nationwide land information; it was set up to ensure transparency in land-related bureaucracy and to regulate land prices. The contents of the portal include land transactions, land value zones, and land ownership; these are updated as new information is obtained. The information on land values that was used in this study was extracted in March 2017. We derived shapefiles of the land values of both cities, overlaid georeferenced boundaries, exported these into polygons, and verified and adjusted them by comparing them to the respective city's land use plan. The managed and unmanaged green spaces were consolidated and visualized into maps and later classified into different sizes of green patches (from less than 1 hectare to more than 300 hectares) using ArcMap 10.2.1 for further analysis.

2.3. Analysis

UGS patches were extracted by the land value layers and processed individually by Fragstat 4.2 [88] in order to obtain the results for different landscape pattern metrics, including AREA_AM (area weighted mean patch size); ENN_MN (mean Euclidian nearest neighbor distance); LPI (largest patch index); LSI (largest shape index); NP (number of patches); PD (patch density); PR (patch richness); and TA (total area). See Table 1 for an explanation of the method used to calculate these indices. We also analyzed the correlations between the land value maps and the other two types of geospatial data (managed vs. unmanaged, vegetation fraction map).

To analyze the geospatial data, we used simple linear regression in Excel. The land value map served as a boundary and an independent variable to correlate land value with other variables obtained from ArcGIS and Fragstat. As the absolute area size varied across different land values, we mainly analyzed the proportional area size percentage within the same valued district. The analyses indicated the relationship between the distributive patterns of land value across the cities and the distribution of vegetation cover, the managed–unmanaged UGS, vegetation density, and spatial characteristics of patches, including size, shape, degree of isolation, diversity, richness, and numbers. We did not include comparative research on green space distribution across the two cities because of inconsistencies in the classification of types of green spaces and the ways of assessing land value.

Table 1. Landscape metrics used to quantify the spatial patterns of urban green space (UGS) in this study, in alphabetical order [88].

Landscape Metrics	Abbreviation	Description	Formula
Area-weighted mean patch area (hectare)	AREA_AM	The average area of all patches of a given type, weighted by the proportional abundance of the patch	$AM = \sum_{i=1}^{m}\sum_{j=1}^{n}\left[x_{ij}\left(\frac{a_{ij}}{\sum_{i=1}^{m}\sum_{j=1}^{n} a_{ij}}\right)\right]$
Area-weighted Euclidean nearest neighbor distance (meter)	ENN_MN	The shortest straight-line distance from patch to nearest neighboring patch, weighted by the relative area of patches	$MNN = \frac{\sum_{j=1}^{n'} h_{ij}}{n'_i}$
Largest patch index (%)	LPI	The area of the largest patch in the landscape divided by total landscape area. It is a percentage of dominant landscape.	$LPI = \frac{\max(a_{ij})}{A}(100)$
Landscape shape index (none)	LSI	Landscape shape index provides a standardized measure of total edge or edge density that adjusts for the size of the landscape.	$LSI = \frac{.25\ E^*}{\sqrt{A}}$
Number of patches (none)	NP	The number of patches in the landscape.	$NP = N$
Patch density (Number per 100 hectare)	PD	The number of patches on a per unit area basis that facilitates comparisons among landscapes of varying size.	$PD = \frac{n_i}{A}(10{,}000)(100)$
Patch richness (none)	PR	The number of different patch types present within the landscape boundary.	$PR = m$
Total area	TA	The metric defines the extent of the landscape	$TA = A\left(\frac{1}{10{,}000}\right)$

3. Results

Our results are presented by category. Firstly, we describe the quantity of UGS by different types (unmanaged vs. managed) in the study sites. Secondly, we compare eight indicators (total UGS; park provision; proportion of vegetation cover; total UGS; unmanaged UGS; managed UGS; vegetation density; LPI) across different district land values in each city. Thirdly, we present the spatial distribution of UGSs with respect to four characteristics (unmanaged vs. managed green spaces, patch size, vegetation density, land value). Finally, we report the common and different UGS distributive patterns by land value in both cities.

3.1. Quantity of UGS by Type

Figure 2 displays the proportion of the UGS area by type. The total UGS in Mumbai represents 26.6% (14,912 ha) of the total land area; the vast majority of this space is unmanaged greenery (22.3%, 12,535 ha). It is noteworthy that unprotected woods represent almost half of the total UGSs (12.3%). The remaining 4.3% (2380 ha) is managed greenery, notably parks (1.7%). In contrast, in Jakarta, protected or unprotected wood areas comprise very little of the total land area (0.7%), and the total UGS is slightly less than half (12.4%) that of Mumbai. Of this 12.4%, 9.7% is managed greenery, such as parks (2.8%), agricultural areas, roadside greenery, golf courses, and recreational grounds; many of the latter are not accessible to the public and require entrance fees.

3.2. Characteristics of UGSs by Land Value

Tables 2 and 3 shows that the vegetated area in the lowest land value districts comprises more than half of the vegetated area in Mumbai (66.5%) and half of the vegetated area in Jakarta (49.6%). The proportion of vegetated area generally decreases with increased land value in both cities (Mumbai, R = −0. 75; Jakarta, R = −0.74). The land value is negatively correlated with the proportion of total UGS in both cities (Mumbai, R = −0.55; Jakarta, R = −0.52). A similar pattern appears for the proportion of unmanaged UGS (Mumbai, R = −0.60; Jakarta, R = −0.59). There is a positive association between the proportion of high vegetation cover and the lowest district land value, albeit higher in Mumbai (63.5%)

than Jakarta (40.7%); this association decreases as we move to higher district land values (Mumbai, R = 0.59; Jakarta, R = 0.76).

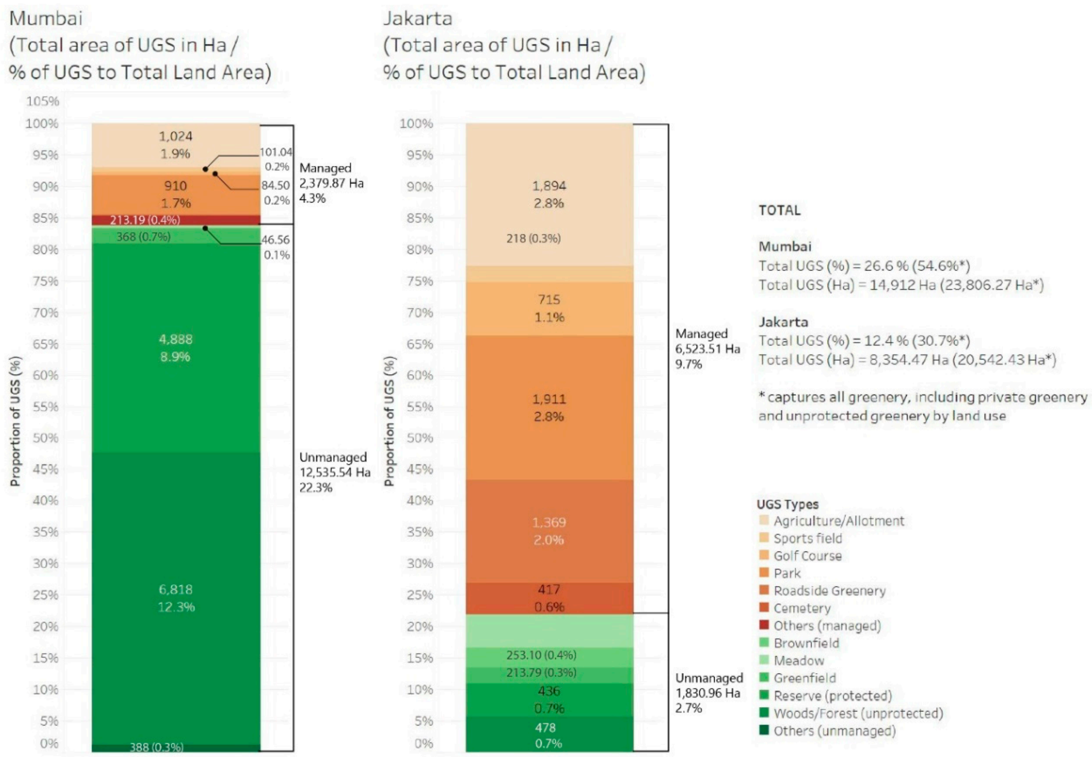

Figure 2. UGS percentages in Jakarta and Mumbai. Source: The "official" existing urban green space percentage, calculated from polygon data (approximate) of the filtered land use plan. Based on the sum, the estimated "official" existing canopy cover of Mumbai is 26.6% and of Jakarta is 12.4%. This only captures half of the value calculated from raster data.

Table 2. Relationship between district land value and 15 indicators (total UGS; park provision; proportion of vegetation cover; total UGS; unmanaged UGS; managed UGS; vegetation density; LPI; LSI; EMN_MN; PD; PR; and NP) in Mumbai

Indicator	620.5USD	1697.5USD	2881USD	4884USD	9960USD	R	*P*-Value
Total UGS (% of total city area)	22.1%	3.3%	1.6%	0.3%	0.2%	-0.601	0.2842
Park provision (% of total city area)	0.13%	0.56%	0.52%	0.35%	0.08%	-0.477	0.4168
Proportion* of vegetation cover	66.5%	52.5%	46.0%	46.7%	42.1%	-0.759	0.1368
Proportion* of UGS	43.3%	22.9%	11.1%	9.4%	11.9%	-0.635	0.2494
Proportion* of managed UGS	3.6%	4.2%	4.5%	7.9%	6.2%	0.651	0.2337
Proportion* of unmanaged UGS	39.8%	16.7%	6.5%	1.5%	5.7%	-0.651	0.2337
High vegetation cover**	63.5%	42.8%	35.2%	37.2%	35.4%	-0.639	0.2453
AREA_AM	0	0	46.0185	11.8295	17.8557	0.2323	0.7069
ENN_MN	0.0103	0.0089	506.385	423.0085	475.2216	0.6907	0.1966
LPI	53.33	24.05	39.87	30.48	36.32	-0.255	0.6791
LSI	11.7193	16.2463	20.0796	13.8867	9.9737	-0.4865	0.4060
NP	208	374	453	211	84	-0.6452	0.2397
PD	16,008,620,026	83,725,095,142	36.1185	63.8663	72.3979	-0.4629	0.4324
PR	8	8	7	5	4	-0.9454	0.0152
TA	0	0	1254.204	330.3776	116.0254	-0.0558	0.9290

The land value was originally indicated in Indian Rupees (1 USD ~ 65.4 INR); * Proportion within the same value district; ** Percentage of the two main values of green vegetation fraction.

Table 3. Relationship between district land value and 15 indicators in Jakarta.

Indicator	56.5USD	112.5USD	262.5USD	562.5USD	1125USD	1500USD	R	*P*-Value
Total UGS (% of total city area)	1.3%	0.8%	2.8%	1.8%	1.8%	2.5%	0.483	0.3320
Park provision (% of total city area)	0.04%	0.10%	0.37%	0.35%	0.52%	0.74%	0.943	0.0048
Proportion* of vegetation cover	49.6%	50.9%	32.3%	29.6%	29.2%	28.8%	-0.748	0.0873
Proportion* of UGS	57.6%	20.0%	12.4%	8.0%	7.2%	14.0%	-0.527	0.2831
Proportion* of managed UGS	53.7%	15.2%	8.3%	6.3%	6.1%	10.9%	-0.497	0.3160
Proportion* of unmanaged UGS	3.9%	4.8%	4.1%	1.8%	1.2%	3.2%	-0.597	0.2116
High vegetation cover**	40.7%	40.3%	22.0%	19.7%	16.5%	18.6%	-0.763	0.0776
AREA_AM	609.1124	17.7755	45.4973	23.7772	9.3833	51.0881	-0.4404	0.3821
ENN_MN	201.119	305.7434	154.1733	140.3546	126.6797	109.0829	-0.7256	0.1026
LPI	82.1	72.9	8.68	8.76	4.33	9.16	-0.689	0.129
LSI	7.913	20.5708	44.0504	49.8171	60.4489	51.6365	0.7749	0.0703
NP	105	361	2249	2654	3182	2668	0.7667	0.0753
PD	11.7673	72.9691	123.5477	217.0659	264.2616	159.9799	0.6896	0.1296
PR	5	6	7	7	6	6	0.0747	0.8882
TA	892.3	494.73	1820.35	1222.67	1204.11	1667.71	0.05028	0.3093

The land value was originally indicated in Indonesian Rupiah (1 USD ~ 13,300 IDR); * Proportion within the same value district; ** Percentage of the two main values of green vegetation fraction.

The park provision (Mumbai, R = −0. 47; Jakarta, R = 0.94) and proportion of managed UGS (Mumbai, R = 0.65; Jakarta, R = –0.49) show the opposite trend. However, the negative relationship between patch size (LPI) and land value is consistent across the two cities—Jakarta (R = −0.68) and Mumbai (R = −0.25). Patch types are more diverse in the lower land value areas of Mumbai (PR) (R = −0.94), whereas the high land value areas in Jakarta have uneven (LSI) (R = 0.77), scattered (NP) (R = 0.68), and less isolated patches (ENN) (R = −0.72).

3.3. Spatial Distribution of UGS by Land Value

In Jakarta, many unmanaged UGSs and the larger UGSs are scattered in the outskirts, and the smaller UGSs are dotted around the city; the highest population densities appear in the central district where the total UGS is limited (see Figures 3 and 4). The largest patches in Mumbai are more distinctive than those in Jakarta. Only the lowest land value districts host the largest patch sizes (>300Ha) (Figure 4 and Figure 6). These are located on the periphery of the city, especially in the northern inland area (Figure 3), and the majority of the greenery comprises protected and unprotected forested areas. Figure 6 demonstrates that lower land value areas are widely located in the northern part of Mumbai, while areas of high land value are smaller and more fragmented, located along the narrow coastline of the southern part of the city. Jakarta's high land value areas are relatively larger in size, and lower land value districts tend to be concentrated at the fringes of the city. While many managed UGSs are represented as small and broadly scattered patches, there is a trend whereby larger unmanaged patch agglomerations appear on the peripheries of both cities. These include mangrove and urban forests and meadow/nature reserves, all with relatively higher vegetation cover (Figures 3 and 5). For both, there is an overall correlation between larger UGSs and higher vegetation cover (Figures 4 and 5). Finally, the map of green vegetation fraction values (Figure 5) shows that the coverage is much higher in the lowest land value districts than in the highest (Figure 6).

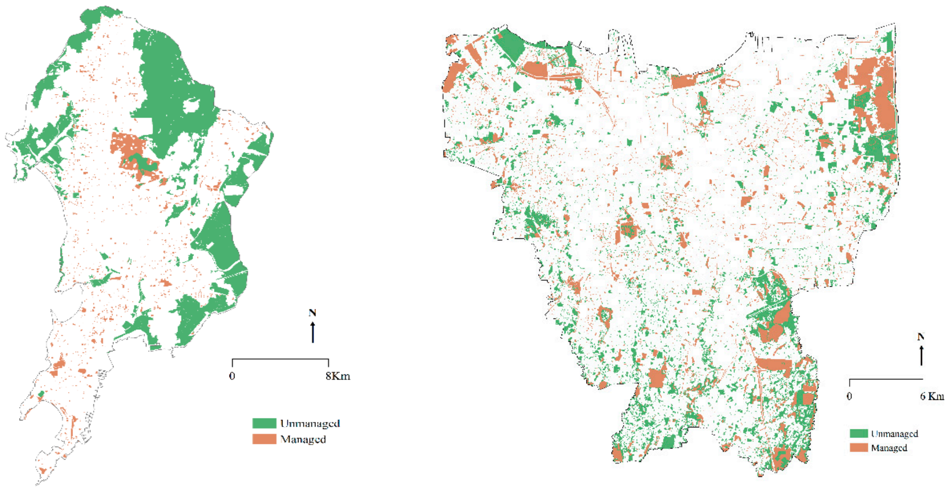

Figure 3. Unmanaged and managed UGS in Mumbai (**left**) and Jakarta (**right**).

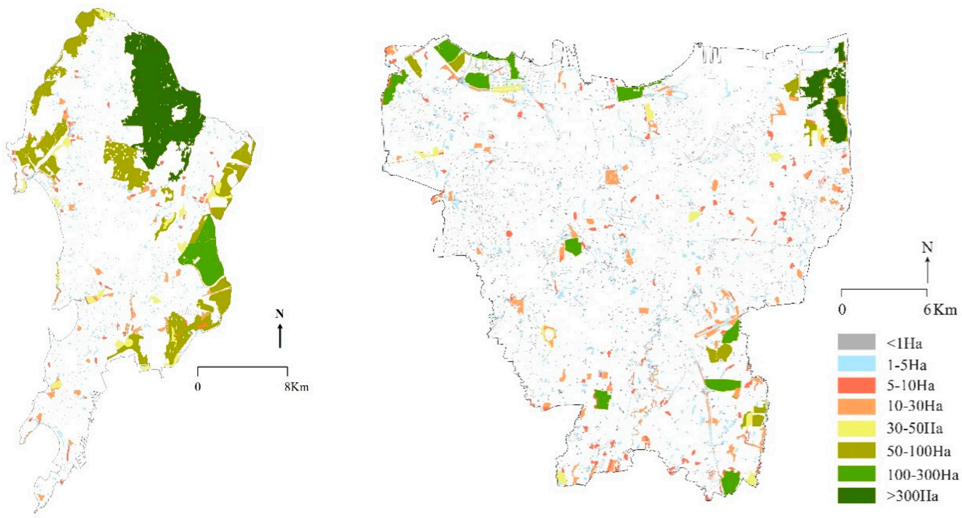

Figure 4. UGS map by patch size in Mumbai (**left**) and Jakarta (**right**).

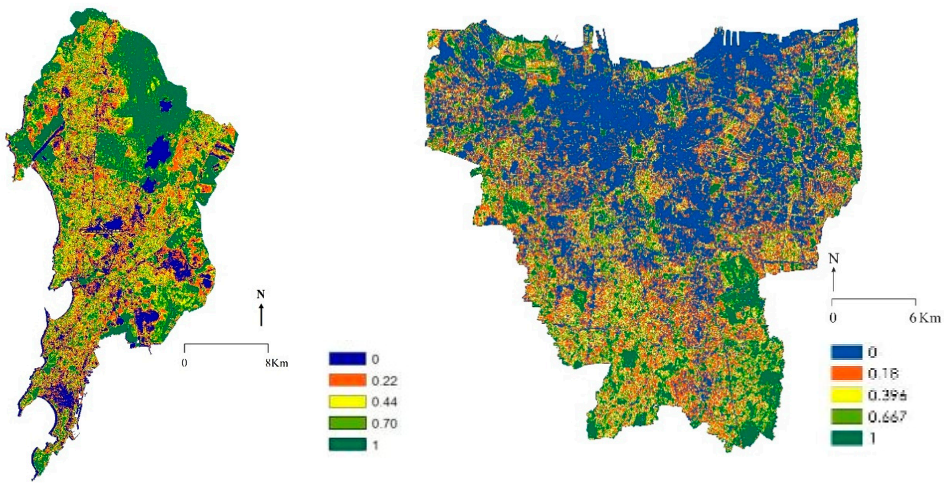

Figure 5. Vegetation fraction map of Mumbai (**left**) and Jakarta (**right**).

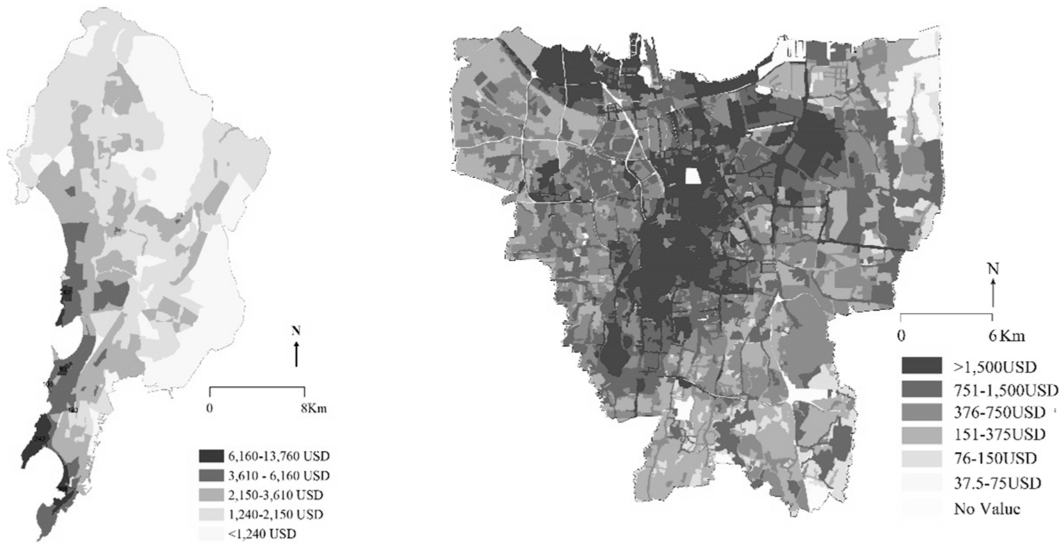

Figure 6. Land value (USD per m^2) map in Mumbai (**left**) and Jakarta (**right**).

In short, the key results are as follows:

- In Mumbai, the total UGS represents 26.6% of the total land area; of this, 22.3% is unmanaged green space.
- In Mumbai, only 1.7% of the total land area consists of urban parks, compared to 2.8% in Jakarta.
- In both cities, the lowest land value districts have a positive relationship with the patch size, vegetation density, and area of UGSs.
- In both cities, larger, denser, unmanaged UGSs tend to be concentrated at the fringes, where the residential property values are low and the population has the highest density.

4. Discussion

4.1. Significance of the Study Results

We offer four main takeaways. Firstly, the areas of unmanaged greenery are positively correlated with lower land value districts in both cities. This discovery differs from previous findings of a positive relationship between green space area and neighborhood socioeconomic status in many US cities [29,30] and in China [33–35]. Similarly, in a literature review of work on green space inequity in the cities of the Global South, Rigolon et al. [44] confirm the common understanding that those persons with high socioeconomic status (SES) have higher quantity, quality, and access to public open spaces, with few exceptions. Their different findings may reflect different geographic and cultural contexts and different administrative practices [44]. Alternatively, the quantity of green spaces may differ by city size, population density, and wealth [35,47,89]. The discrepancy might also be partially explained by a mismatch between the steady growth of trees as long-lived organisms and the rapid changes in social structures [90], combined with the dramatic economic growth in the context of developing megacities, where it is challenging to ensure consistent urban green space policies [91].

Secondly, our results show that unmanaged UGS has a positive relationship with larger patch sizes and denser vegetation, while managed areas tend to have smaller patch sizes and less complex vegetation structures. The latter might provide fewer socioecological benefits than remnant forests [92]. As cities become wealthier in the future, the total area of valuable unmanaged UGS might gradually increase [93], but it is likely to constitute newly constructed managed green space following a deliberate plan. Although the governance of unmanaged greenery might be complicated, particularly in developing countries [94], denser, larger, and unmanaged UGS represents a key opportunity to deliver a fuller suite of socioecological benefits to people living in lower land value districts [95], even if some are not physically utilized by the people living there. For example, they may bring indirect benefits such as cleaner air or cooling effects. In summary, the findings highlight the urgency of taking a pro-active approach to protecting remnant forests rather than trying to reintroduce their role and functionality at greater cost in the future.

Thirdly, the study shows that larger, denser, and unmanaged UGSs tend to be concentrated at the fringes of the two cities. Many are physically inaccessible, underutilized, and politically overlooked because they are considered "transitory" spaces awaiting development. This is not a surprising finding, but it raises interesting equity questions about which types of UGS to invest in in order to create more equitable cities; for example, designated urban parks may change the character of a neighborhood through gentrification. Ultimately, while full development may alter the patterns of and access to UGS in the near future, our results suggest poorer districts have the potential to achieve equity in UGS provision when all types of UGS, including unmanaged greenery, are taken into account.

Lastly, we found differences in the UGS patterns between the two cities. Mumbai has more diverse patch types in low land value districts while Jakarta contains scattered and less isolated patches in high land value districts. These differences may reflect the substantial amount of unprotected forested areas that remains around the fringe of Mumbai. In contrast, two decades of rapid urbanization in Jakarta has resulted in relatively less UGS in the peripheries of Jakarta, with those that do remain having been intentionally developed as designated recreational spaces. Mumbai may follow the same patterns as Jakarta in the future, as the pace of urbanization accelerates over the coming decades. According to Mumbai's land use plan [62], the city would face a rapid decline in the number of reserved and unprotected forested areas with more developments for affordable housings and denser commercial areas.

4.2. Planning and Policies to Promote UGS Equity

This study has confirmed the common distributional pattern of fast-growing cities whereby the city fringes have larger, denser, and less managed greenery alongside lower residential property values. Our findings remind us of the urgency of paying attention to such greenery. Accordingly, in the remainder of this paper, we suggest mechanisms that could protect, provide greater access to, and harness some of the opportunities offered by these unmanaged areas.

Firstly, capturing and protecting unmanaged UGS could be part of the greening policies of fast-growing developing cities, especially given the recent polices of many cities to increase the quantity of urban green space. For example, Jakarta plans to triple public green open space by 2030 [96], and Mumbai plans to restore/protect mangrove forests and wetlands along the city borders [97]. To achieve these goals, planners could carefully re-assess the ecological quality of UGS based on a number of measures/classifications (for example, the measures we used in our study) in order to maintain heterogeneity in ecosystems and ensure natural landscape diversity and social inclusiveness [98].

Secondly, our findings suggest the value of remnant UGSs as alternative green spaces which are able to provide socioecological benefits to underprivileged communities in the Global South. Although our study is the first attempt, to the best of our knowledge, to look at UGS through this lens, doing so is supported by Fuller's point of view that human—nature interactions are increasingly dependent on landscape quality outside formal green spaces as cities grow [9]. In the context of fast-growing developing cities, it is crucial to increase accessibility to unmanaged and informal green spaces in low income districts [37]. A realistic suggestion is to integrate unmanaged UGS into new urban developments and carefully plan the types of land use adjacent to these spaces. Simply allowing partial or "semi-open" access to privately-owned managed greenery in marginalized districts without the risk of trespassing may go a long way towards alleviating social inequity in public green spaces. Admittedly, however, remnant UGS is not always seen as beneficial by the public. Therefore, designers should make an effort to retrofit remnant/informal UGSs into spaces that could minimize associated disservices and make them more acceptable through selective management intervention [99].

Thirdly, as the majority of unmanaged UGSs in both Jakarta and Mumbai have unnamed or non-dedicated functions and no clear attachment to neighborhood communities, we recommend considering these green spaces as a "necessity", not something to be removed as cities expand. We propose devolving ownership of these spaces onto those directly benefiting from them; for example, they can supply sustenance or livelihood, educational resources, protection against pollution, and safety. Taking ownership requires active community engagement [100] and community integration/participatory planning [101]. While the notion of "just green enough" has critics [29], it has been effective in raising awareness of the need to anticipate the unintended consequences of urban landscape improvements, including in UGS. Ultimately, in their rejuvenation of existing areas, and considering the needs of residents, planners could retrofit critical areas of vegetation areas into more "usable" everyday green spaces by providing multiple ecosystems in order to achieve environmental equity.

4.3. Future Studies

Future studies could advance the methodology and focus of our work in a number of ways. Firstly, we simplified social inequity by using property value data available to the public, as this was the only dataset available for both cities. To overcome this limitation, multiple methods to identify social classes are needed, including the proportion of low-income residents, market trends, geographic context, sociocultural determinants, and the historic processes of urban growth, in order to reduce institutional biases and prevent socioecological exclusion.

Secondly, future studies should revisit and refine the relationships that we identified by collecting more detailed ground research data, such as the physical barriers affecting site access [102] or the threshold distance preferences of different social groups [103]. In addition, further study is needed to characterize UGS in terms of quality, beyond analyzing satellite images and GIS. Such work could include, for example, socio-environmental studies on population demands, cultural preferences for types of spaces, ownership, intensity of usage, spatial quality, and ecological quality.

Finally, although we sought out cities from different countries and with different development histories to move this research beyond a case study of a single city, we recognize the limitations of our work and have been careful to frame our research findings in a way that acknowledges that more cities must be studied before any general principles can be established. Additional research is also required in order to understand the different UGS distribution patterns in and between developed countries and the Global South.

5. Conclusions

With an ever-widening gap between the rich and the poor, there is growing concern that cities may not provide equal green spaces to all social strata. Despite the importance of this issue for environmental equity, little is known about dynamic UGS distributional patterns in fast-growing cities. Our study probed a unique combination of measures, counting all types of UGS and characteristics of UGSs related to land value, thus adding to the literature. More specifically, we questioned the common assumption that USG quantity tends to decline with district income and established a planning protocol for urban decision makers by exploring ways to secure, utilize, and optimize the available UGS in two megacities.

Our main conclusions are the following:

- The areas of unmanaged greenery are positively correlated with lower land value districts in Mumbai and Jakarta.
- Unmanaged UGS has a positive relationship with larger patch sizes and denser vegetation, while managed UGS has smaller patch sizes and less complex vegetation structures.
- Most unmanaged UGSs in lower land value districts are unprotected and underutilized.

Given their larger patch sizes and denser vegetation, unmanaged UGS should be considered an important asset that is able to promote UGS distribution equity, rendering other types of UGS investment, such as designated urban parks and private gardens, less important. Given our findings, we speculate that "more green for the poor" may be a transitory pattern in the context of fast-growing cities, where green spaces currently happen to exist but will be lost to rapid urban expansion in the absence of strategic planning. Large and densely vegetated patches of UGS in close proximity to lower land value districts might disappear after the completion of slum relocation and the maturation of the local property market. In any event, despite government efforts and policy initiatives to increase public parks and protect urban forests, the development of deliberate public green space is insufficient and lags behind the dramatic increase in population. Based on what we have seen in Mumbai and Jakarta, it is not too late to achieve environmental equity if policy makers prioritize the protection of denser and larger vegetated areas in low land value districts. To this end, we stress that urban planners need to pay attention to UGS protection, optimize its use, increase free public access, integrate ecological functions with human use, and support the multi-functionality of UGS towards the development of inclusive cities.

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