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# DISTRIBUTION OF GREEN SPACES ACROSS SOCIO-ECONOMIC GROUPS: A STUDY OF BHUBANESWAR, INDIA

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**Abstract.** Urban green spaces (UGS) are linked with numerous health benefits. However, recent studies have highlighted an increased level of disparity in their distribution across different socio-economic groups. Adequate number of UGS and their size play an important role to achieve spatial equity. The purpose of this study is to analyze the availability of UGS across all socio-economic groups of Bhubaneswar, Orissa, India. Methods: The socio-economic groups are created by using the ward level socio-economic census data of Bhubaneswar and and PCA method of analysis. The UGS are identified using satellite images if they fulfil the criteria such as: named as a park or garden and has a definitive boundary in the year 2021. A one-way ANOVA is used for the analysis. Result: The study revealed a non-uniform distribution; 27 out of 67 wards do not have any form of parks in their vicinity. From the equity point of view, the UGS distribution is examined for parks and overall UGS. There is no major difference found in terms of availability of parks in different SES statistically. However, park area average is observed to be the higher in middle deprived communities (26738.32 $m^2$/neighborhood) followed by least deprived communities (22386.7378 $m^2$/neighborhood) but the average number of parks seem to be the lowest in the least deprived communities (1 park/neighborhood). The land allocation per capita for overall UGS came to be the highest for the most deprived neighborhoods (0.0146 $km^2$/1000 population). The bigger UGS are in the most deprived wards probably because there is availability of land and low population density.

**Keywords:** park equity, socio-economic status, principal component analysis, spatial distribution, neighborhoods, Bhubaneswar.

## Introduction

Social stratification is particularly important to urban planners and urban designers because it has spatial implications (Tan & Samsudin, 2017). While there is a great body of literature on western countries dealing with spatial segregation for different races, there are limited literature for developing countries such as India that are dealing with rising income inequality (Pawasarat & Stetzer, 1998; Stoll, 2005). Spatial segregation leads to uneven geographic clustering of socio-economic groups in the city. Studies on US have indicated that African American neighborhoods are usually concentrated around the downtown and older part of the city and are devoid of basic amenities and facilities (Shen, 2001). Recent studies on Southeast Asia such as China too have suggested that migrant population and low income population congregate in older settlements and dilapidated inner city neighborhoods (Xiao et al., 2017). However, studies on larger cities in India show a reverse pattern where the poorer neighborhoods are mostly located towards the periphery and vulnerable to flooding conditions (Mishra, 2018).

The stratification of neighborhoods play an important role in distribution of different facilities. There is a growing number of literatures on how socio-economic status (SES) of a neighborhood influence Urban green space (UGS) distribution. However, the studies show inconsistencies in their result (Tan & Samsudin, 2017). Evidences often suggest that UGS are not equally distributed among all groups of people and socially disadvantaged neighborhood contain significantly fewer parks and recreational resources than neighborhoods with higher SES (Crawford et al., 2008; Estabrooks et al., 2003; Moore et al., 2008; Tan & Samsudin, 2017; Vaughan et al., 2013; Wolch et al., 2005). In contrast, some other studies highlighted that park distribution is equal or better in low SES neighborhoods (Gilliland et al., 2006; Lee et al., 2007; Nicholls,

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2001; Xiao et al., 2017). Few studies highlighted greater number of parks in blocks or neighborhoods which has ethnically mixed population and middle- income groups (Abercrombie et al., 2008). Since UGS is a major environmental resource in most communities; its availability, size and quality are all important factors influencing its usage and impact on people's well-being. UGS generally offer diverse opportunities for physical activity and can thereby reach a large proportion of the population, especially disadvantaged groups who may not have access to other resources. However, researchers conclude that, there is significant amount of bias involved while distributing, developing or maintaining these UGS (Boone et al., 2009). Although regulations and policies justifiably advocate equal involvement of people, uniform UGS distribution is still an important element which is ignored in most of the urban planning processes (Sister et al., 2010).

India's rising income inequality is a key concern for its growth (Nissanke & Thorbecke, 2010). Abundant literatures have highlighted the ever-increasing wage inequality in service sectors (Pieters, 2010). Literatures also studied the plight of the socially disadvantaged group such as migrant workers or low-income households who usually live in dilapidated and informal settlements called "slums". Their poor living conditions and health inequality has been studied extensively in previous literatures (Chimankar, 2016; Islam et al., 2022; Taubenböck & Kraff, 2014). However, spatial inequality in terms of access to basic recreational infrastructures such as UGS is somewhat less explored. The present limited evidence has highlighted lack of accessible green spaces in megacities such as Mumbai and so far is the only study which linked green space distribution with SES (Sathyakumar et al., 2019). In addition, information regarding the census level, area based socio-economic status is very few in Indian cities. Socioeconomic indices (Income, education, employment). capture various aspects of poverty and unmet needs. Thus, the objective of this study is to analyze the distribution of UGS for the city of Bhubaneswar, India based on its SES. The distribution aims to look at the quantity and size as key parameters to understand whether inequality in UGS exist in the city of Bhubaneswar where 36% of population are slum population. Bhubaneswar is a mid-size city with a population of around 800,000 in comparison to mega cities such as Mumbai, Delhi, Bangalore, Kolkata or Chennai which have more than one million population. The novelty of the study lies with the size of the city and linking it with SES. It is assumed that wealth gap between the rich and the poor may not be that evident in mid-size cities such as Bhubaneswar. Thus, it will be interesting to find out if the distribution contains the same amount of biasedness as seen across all countries.

## 1. Literature review

Contact and access to nature is beneficial for people. Physical activity involves physical interaction with green spaces of different intensities such as walking a dog, strolling, hiking, running or cycling (Cortinovis et al., 2018). Public health professionals in recent years are actively promoting access to green spaces in the form of physical exercise to enhance physical and mental health of people (Stromberg et al., 2021). Access to green spaces and its distribution is important especially for disadvantaged populations because UGS is the cheapest form of resource for physical activity.

African Americans in USA had a long history of official neglect to the benefits of recreational needs because of the high degree of residential segregation. Few cities separated parks for different races and African Americans were most often forbidden to enter the parks of the advantaged. A study of parks on Baltimore, that has a larger percentage of black population (61%) reflects the complex interaction between race and planning and highlighted the social and institutional mechanism that generated inequality (Boone et al., 2009). Previous studies have used per capita park ratio as an indicator for planning, but soon realized that it alone cannot serve as a measure for park distribution. Thus, the other aspects such as quantity, size, and access are taken into account as important indicators for park distribution (Oh & Jeong, 2007). Research suggests that park distribution can be explained in three ways: park proximity, park density and park quality. While the distance of the park from each household is a measure for park proximity, park density quantifies the number of parks and the acreage in a geographic unit. Park quality explains the availability and maintenance of recreational features found inside the park for public use (Rigolon, 2016).

The study on Baltimore found out that African American and high-need populations have better walking access to parks but less access to park acreage per capita than whites and low-need populations increasing the park pressure. A similar study was conducted for a small midwestern city of U.S to determine whether the availability and accessibility of recreational resources varies for neighborhoods with different SES. Census tracts are used to represent neighborhoods and categorized in to low, middle, and high SES. The study found fewer physical activity resources in lower SES neighborhoods than the high SES neighborhood and, of the resources available, a lower proportion is free for use (Estabrooks et al., 2003). Built environments including commercial recreational activities too are studied based on their distribution in low-income neighborhoods. A study in United States considered four types of recreational facilities; sports and recreation clubs, dance studios and golf courses to determine their association with different SES neighborhoods by Zip codes. Like the findings of other research, this study finds significantly fewer numbers of all four types of facilities are present in neighborhoods with higher proportions of African American residents, residents classified in the "other minority" category, and Hispanic residents. Though this study does not talk about UGS as such but provides a good understanding on commercial recreational facilities and their distribution across US, a good indicator to analyze the pattern of physical activity in lower SES neighborhoods (Powell et al., 2006).

While studies on US focused on racial disparity, European studies mostly concentrated on park distribution among different religious groups. Europe has a strict policy on distribution of green spaces in the form of "Accessible Natural Greenspace Standard". The standard recommends at least 2 ha of green spaces for 1000 persons in 4 hierarchal level; within 300 m (2 ha), within 2 kms (20 ha), within 5 kms (100 ha) and within 10 kms (500 ha). A study on the park distribution of Leicester found more than 2 ha of green spaces per 1000 persons but disproportionate access to 2 ha and 20 ha green spaces among various ethnic and religious groups (Comber et al., 2008). Similar study in Berlin and Switzerland showed inequal distribution of green spaces for immigrants.

Singapore's park distribution focused on private and public housing showing residential estates primarily with private households have higher provision of parks on a per capita basis, low congestion and a greater number of units that are serviced by parks (Tan & Samsudin, 2017).

Developing countries such as China and India measured the discrepancy in respect to immigrant population. A study conducted for inequality in access to urban parks in Shanghai, China across all social groups concluded that Shanghai low-income social groups are not particularly disadvantaged. Marginalized groups such as migrants, unemployed individuals and residents of welfare housing are more likely to live in areas where there is better access to parks (Xiao et al., 2017). A similar study in Beijing too found a weak relationship between access to parks and SES (Tu et al., 2018). Distribution of urban green spaces in Mumbai showed that, while quantity of urban green spaces is not statistically associated with neighborhoods SES, the quality and accessibility aspects of urban green spaces share a statistically significant relation with SES. Further, it finds that the neighborhoods with higher SES in Mumbai have better access to green spaces, indicating spatial inequities in urban green spaces distribution in Mumbai. The quantity of UGS measured the percentage of UGS area in a census section and UGS area per inhabitant, quality of green spaces is influenced by their size and fragmentation (connected green patches are of better quality) and access assumed the disaggregated shape of the UGS patch and aggregation because of the unavailability of population data at block level (Sathyakumar et al., 2019).

From quality perspective, a study of distribution of parks in Phoenix, Arizona discussed on park facilities from a multi-cultural point of view. The study revealed that different social and cultural groups have different preferences for parks. While Latinos prefer more facilities and passive outdoor activities, African Americans prefer spaces for socialization and organized recreational activities and whites prefer solitary recreation. Thus, the neighborhood characteristics has to be studied first before allocating park facilities for a particular community (Ibes, 2015). In contrast, other researchers highlighted the mismatch in park facilities when designed for a specific community. The researcher stated that planning park facilities for a particular socio-economic group automatically marginalizes other socio-economic groups who are not considered as the main user of the park facility (Wang et al., 2015; Chandrasiri & Arifwidodo, 2017). Open space quality is also studied using various audits to analyze the quality of the environmental features in the parks (Badland et al., 2010). A study in Hongkong studied the inequality considering both quantity and quality of parks and found fewer number of parks with active facilities in neighborhoods which has higher percentage of ethnic minorities (Zhang et al., 2021).

Most of the above studies have used a combination of access and quantity for green space distribution. Green space access studies also have observed a surge in recent years using geospatial techniques. However, studies shared the difficulty in carrying it at Indian conditions. Since there are limited studies done in this area in Indian cities, a simplistic approach of quantity factor is considered for this research.

## 2. Study area

Bhubaneswar has been chosen as the study area because of its size. Bhubaneswar is the capital of Odisha state and located in the Eastern zone of India (Figure 1). Bhubaneswar Metropolitan Corporation (BMC) is the local urban governing body for Bhubaneswar and the principal provider of services to it. BMC has an area of 146.86 square kilometers and having a population of around 856,555 as per census, 2011. BMC has 67 census tracts or wards which are the smallest territorial entity for which census data are available (Bhubaneswar Municipal Corporation, n.d.). Designed by Otto Koenigsberger in the year 1948, the intention was to cater to housing not more than 40,000 people with administration being city's primary function. The city at that time was envisaged as a place for the common masses reducing the difference between the rich and the poor (Kalia, 1997). Koenigsberger planned a mixed neighborhood concept for different social classes; upper, middle, and lower

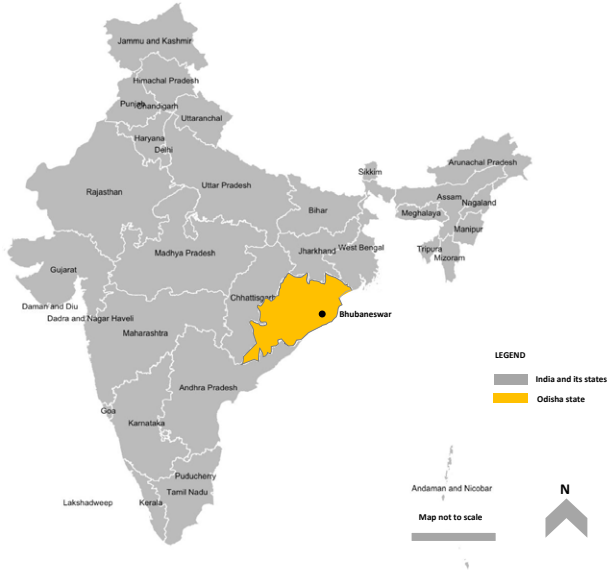


Figure 1. Location of Bhubaneswar in India (source: author)

with distinction in their types often depending on the land provided. Efforts were made to distribute the spaces more equitably among all income groups (Kalia, 1997). The city currently serves as the capital or Odisha and thus contains many government institutions. The residential accommodation provided to the government employees are located at the center of the city and thus allows very little flexibility for expansion there. The capital attracts many migrant workers due to increase in employment opportunities. The present transformed Bhubaneswar now contains 36% of migrant worker population taking 3.9 percent of the total municipal area (Anand & Deb, 2017). On an average 19.6% of houses do not have toilet facility and 21.4% do not have kitchen facilities (Census HH Amenities, 2011).

## 3. Methods

### 3.1. Geographic unit and data types for analysis

Availing data in developing nations is the biggest concern for researchers. Census provides area wise data for cities. The census tract or ward is the smallest statistical subdivision of a city consisting of socio-demographic data from census and thus maintain better homogeneity among population. Previous research also has linked wards to characterize neighborhoods in India (Adlakha et al., 2018; Bardhan et al., 2015; Sathyakumar et al., 2019). Literatures suggest the size of the census tract which usually has population between 1500–8000 vary from country to country (Vyas & Kumaranayake, 2006). For Bhubaneswar, each ward consists of on an average of 3500 households and around 10,000 population. There are 67 wards existing in Bhubaneswar Municipal Corporation. Area based socio-economic measure is used for deriving socio-economic status of wards. Census level data of 2011 has been used for this study. The ward level map is extracted from open street map (OSM) which is open sourced and available for public use for all most all countries.

### 3.2. Variables to measure socio-economic status

SES is an individual's position in a social structure which determines the person's available resources. The American Psychological Association (APA) defines socio-economic status as "the social standing or class of an individual or group" (American Psychological Association, 2018). Social class as described by Weber (1946) has three domains: 1) class which is determined by ownership and access to economic resources, 2) status is determined by prestige, social ranking and honor and 3) political power (Berkman & Macintyre, 1997). This tripartite definition has led many social scientists to develop multiple indicators for SES, the most important by Liberatos et al. (1988). Liberatos suggested three common indicators for SES: income, occupation and education. Income is closely related to Weber's idea of ownership and access to economic resources. Income facilitates access to better resources such as healthcare, quality food and better living conditions thus contributes to better SES. Similarly, occupation reflects Weber's definition of social status. Occupational status indicates how members of a community collectively evaluate the social standing of a job. As occupations vary, public perception of social prestige also varies accordingly (Berkman & Macintyre, 1997). Education highly influences social position and plays an important role in allocating certain levels of occupation to people (Sewell & Shah, 1967). Better education is associated with better occupation and subsequently leads to higher income. These three variables are commonly used in North American literature to depict SES.

Table 1. Variable selection criteria (source: author)

| Major domain | Variable reflecting major domain | Variables | Variables selected | Argument for selection |
|---|---|---|---|---|
| Income | Households availing banking facility | 02 | 01 | Higher income is linked with saving characteristics and thus increases the dependency on banking facilities |
| Access to transport | Car/jeep/van ownership | 03 | 01 | Public transport is efficient in Indian cities with various modes of transport such as buses, autos and cabs. The motorcycle is a cheaper mode of transportation. Ownership of cars reflects income characteristics |
| Housing stability | Home ownership | 03 | 01 | Reflects house stability, income characteristics and wealth |
| Education | Literacy | 03 | 01 | Literacy is used as the proxy for education Literacy is directly related to the occupation of a person |
| Employment | Female workers population | 03 | 01 | Reflects equality and empowerment for the submissive class which is represented through education |
| | Total workers population | | 01 | Income stability |
| Crowding | Family members per household | 07 | 01 | 9+ family members per household is considered for analysis. Larger family member means more people to feed on the income |
| Racial composition | Percentage of special class population | 04 | 01 | Underrepresented community |
| Total | | 25 | 08 | |

Socio-economic based data from census are being extracted to analyze the deprivation factor for this approach (Census PCA, 2011). However, this study considers seven indicators of socio-economic inequality as discussed in most of the literature: Income, employment, education, access to transport, housing stability, crowding and racial composition (Messer et al., 2006). Income data is not disclosed in census. As a result, number of households using banking facility is used as a proxy for income. Owning of durable assets such as car/jeep/van ownership is used as a proxy for access to transport. Family members of a household is used as an indicator for crowding. Occupational level data is not used in the analysis because of its unavailability in census database. The percentage of special class population substituted the racial composition indicator. Total workers population and female workers population indicated the employment status where female worker's population reflected the idea of gender equality and societal progression which usually comes through right education (Table 1).

### 3.3. Software used

Socio-economic data based measure has used principal component analysis (PCA) before (Filmer & Pritchett, 2001; McKenzie, 2005). Census data is downloaded in excel form and exported to SPSS for analysis purposes. SPSS 24 is primarily used for conducting the PCA to derive the deprivation score (Chuang et al., 2017).

### 3.4. Interpretation of results for PCA

PCA is a useful technique to transform large number of variables in a data set to smaller set of coherent and uncorrelated factors called principal components. While the first component comprises the largest possible variation of the original data sets, the second component carries the variation which is not considered in the first and so on (Krishnan, 2010). The output from the PCA is in the form of factor scores or weights for each variable. Conceptually, a variable with positive factor score is related to lower deprivation and a variable with negative factor score is related to higher deprivation. The final deprivation score is interpreted in such a way that the census tracts with better SES can lead to wealthier neighborhoods or higher scores. Conversely, lower scores lead to poorer census tracts.

Though all the of households of census are measured in percentage, standardized score (z-score) has been used for calculating the weighting factors of various indicators. The deprivation factor is measured be multiplying standardized score with factor scores or weight of each variable as shown in the below equation.

$$\text{Deprivation factor} = W_1 \cdot ZX_1 + W_2 \cdot ZX_2 \ldots\ldots + Wn \cdot ZXn, \quad (1)$$

where *Wn* is the weighting factor for each variable extracted from the first component of PCA and *ZXn* is the standardized score for those variables. The values are then clustered to arrive at quintiles from least deprived to most deprived neighborhoods. The lower two quintiles (Q1 and Q2) are combined to produce the most deprived communities or socially weaker neighborhoods (40%). The top 20% are for the wealthier census tracts or least deprived neighborhoods (Q5) and the remaining 40% is for the middle-income neighborhoods (Q3 and Q4). This classification is been used in several studies to expand the least and middle deprived communities (Filmer & Pritchett, 2001).

Researchers use factor analysis when there are chances of multicollinearity. In the present study, Kaiser-Meyer-Olkin (KMO) coefficient is used to detect multicollinearity so that the appropriateness of PCA can be carried out. KMO is a summary of how small the partial correlations are in respect to the sum of correlations. Partial correlation for each pair of variables is comprised of the correlation between those variables after removing the influence of other variables. If variables share common factors, then partial correlation is small. KMO can have maximum value of 1, with value of 0.9 being excellent and 0.5 as miserable (Krishnan, 2010).

### 3.5. Park distribution analysis-Data types and data interpretation

In this study, the UGS are defined as spaces which are accessible, used for physical activity and relaxation (Powell et al., 2006). Thus, only gardens and parks are considered for this study. Bhubaneswar also has plenty of water bodies which are mostly located at older part of the city and used for religious activities. Waterbodies since perform a separate function all together are excluded in the analysis but identified as potential recreational spaces. The UGS are identified using high spatial resolution satellite images (Google Earth) if they fulfill the criteria such as: named as a park or garden and has a definitive boundary. Corresponding images of the UGS are cross checked to confirm its existence and later substantiated from Bhubaneswar Administration's portal (https://bhubaneswarone.in/home/). UGS are digitized and their attributes are added as separate layers in the map format using QGIS keeping Open street map (OSM) as the base. QGIS is a free and open-sourced software specifically used for mapping purpose (https://www.qgis.org/en/site/). Based on the usage, the UGS are categorized as in Table 2. Per capita park area and coverage area later calculated with the following equation as mentioned by Fasihi and Parizadi (2020):

$$PCi = \sum SPi / Pi; \quad (2)$$

$$CRi = \sum SPi / Si, \quad (3)$$

where: PCi, per capita UGS area in quintile i (ha/1000population), CRi, coverage ratio in region i, SPi, total area occupied by UGS in the quintile i (Square Kilometers), Pi, population size in region i, Si, Land area of quintile i (Square Kilometers).

The park locations are overlapped with the area wise deprivation index to find out the neighborhoods which are deprived of any kind of green spaces and whether

Table 2. UGS typology of Bhubaneswar (source: URDPFI Guidelines, India)

| RGS typology | Access | Area | Remarks |
|---|---|---|---|
| Gardens | Restricted access but influential because of their size | Above 500000 $m^2$ | Recreation & Relaxation |
| Community parks | Public access | 50000 to 250000 $m^2$ | Exercise and physical activity |
| Neighborhood parks | Public access | Below 50000 $m^2$ | Exercise and physical activity |
| Waterbodies | Public access | 1000 to 10000 $m^2$ | Presently used for religious purposes but have potential for recreation |
| Privatized recreation | Restricted access but better facilities for recreation | Varies | Recreation and relaxation |
| Conserved forests & green spaces | Public access | Above 500000 $m^2$ | Recreation and relaxation |

there is any relationship between park distribution and deprivation index.

UGS availability for different SES quintiles is compared using descriptive and inferential statistics. A one-way ANOVA test has been performed to measure the park numbers, park area and park percentage to see if there is any significant difference between all the SES. P-value < 0.05 is considered significant.

## 4. Results

### 4.1. Status of UGS in Bhubaneswar

The total area of urban green spaces is 495.1 hectares (excluding the water bodies) consisting of 3.3% of total land area (Table 3). Indian standards recommend an area of 1.4–1.6 ha of land per 1000 population for recreational uses (Agarwal et al., 2021). Considering the population of Bhubaneswar, 0.57 hectares of UGS per 1000 population is available which is way below the NRPA (National Recreation and Park and Association) standard of 4 hectares per 1000 population (Veal, 2013).

### 4.2. Distribution of UGS

The indicators used in the current study for SES are moderately correlated with each other and thus all the three principal components are used for the study. Income, availing resources such as car/jeep/van and house came as the most important component of PCA accumulating to the total loading of 32.966%. Workers population came as the second important component adding up to 57.179% of the total loading and crowding and special population consisting of the third component holds up to 75.560% of the loading. The weightage of each component for the individual variables is shown in Table 4.

Table 3. Types of open spaces in Bhubaneswar Municipal Corporation (source: author, extracted from Open Street Map)

| Type of parks and water bodies | Count | Area ($m^2$) | Area (ha) |
|---|---|---|---|
| Gardens | 04 | 2,849,613 | 285 |
| Community parks | 06 | 491,724 | 49 |
| Neighborhood parks | 104 | 605,081 | 60.5 |
| Water bodies | 34 | 644,095 | 64.5 |
| Privatized recreation | 03 | 228,137 | 22.8 |
| Conserved forests and green spaces | 02 | 778,471 | 77.8 |
| Total | 153 | 5,597,121 | 559.6 |

Table 4. Factor scores of each variable (source: author)

| Major domain | Variable reflecting major domain | PCA1 | PCA2 | PCA3 |
|---|---|---|---|---|
| Income | Households availing banking facility | 0.867 | | |
| | Car/jeep/van ownership | 0.662 | | |
| Housing stability | Home ownership | –0.648 | | |
| Education | Literacy | 0.859 | | |
| Employment | Female workers population | | 0.931 | |
| | Total workers population | | 0.899 | |
| Crowding | Family members per household | | | 0.849 |
| Racial composition | Percentage of special class population | | | –0.674 |

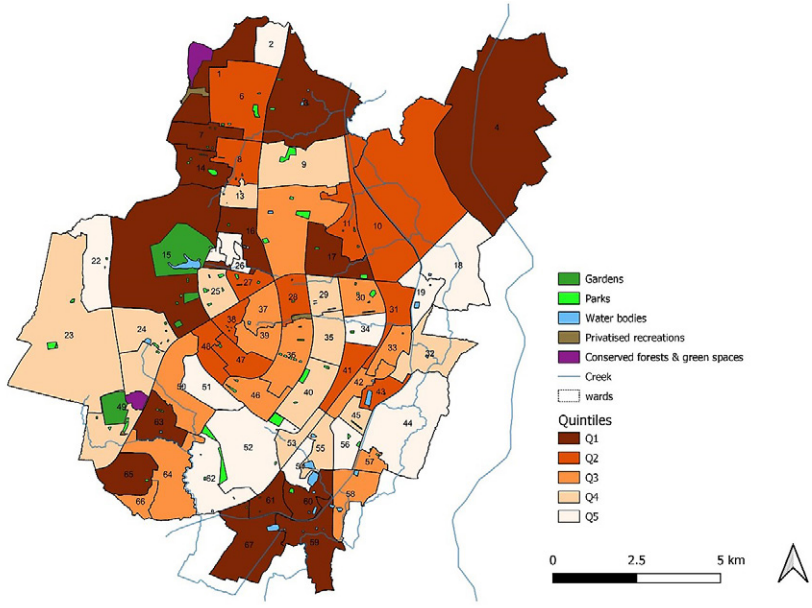


Figure 2. Distribution of green space as per deprivation quintiles (source: author)

Table 5. Urban green spaces and their proportion in different quintiles (source: author)

| Deprivation Quintiles | Gardens | Parks | Privatized recreation | Conserved forests | Area of UGS ($km^2$) | Proportion of UGS (%) | PCi ($km^2$/1000) | CRi (%) |
|---|---|---|---|---|---|---|---|---|
| Q1 | 03 | 23 | 01 | 01 | 3.0090 | 59.9308 | 0.0146 | 6.3375 |
| Q2 | 00 | 21 | 00 | 00 | 0.1098 | 2.1879 | 0.0006 | 0.4397 |
| Q3 | 00 | 20 | 01 | 00 | 0.3299 | 6.5716 | 0.0021 | 1.6003 |
| Q4 | 01 | 30 | 01 | 01 | 1.2585 | 25.0667 | 0.0076 | 4.2751 |
| Q5 | 00 | 16 | 00 | 00 | 0.3134 | 6.2430 | 0.0019 | 1.3191 |
| Total | 04 | 110 | 03 | 02 | 5.0208 | 100 | | |

KMO coefficient showed a moderate effect of 0.574 but adequate to run PCA analysis. While looking at the correlation matrix, literacy showed a strong relationship with the number of households availing banking facility (0.716). This substantiates the theory that education can lead to better income and thus the need to avail banking facilities. Car/jeep/van ownership also showed a moderate correlation with the number of households availing banking facilities (0.536) explaining how income facilitates access to resources. Surprisingly, home ownership showed a negative correlation with literacy (–0.455). Various government schemes are initiated in India recently to uplift the housing conditions of the poor such as PMAY or IAY. The schemes provide subsidized loans and houses for the poor who are not able to afford them. This might be the reason why the correlation showed a negative trend.

Figure 2 and Table 5 availability of UGS across all quintiles. The result indicates a non-uniform distribution of UGS across all neighborhoods. This is not a surprise for developing countries like India where unplanned growth is prevalent. Out of 67 neighborhoods, 27 neighborhoods are devoid of any kind of park facilities.

#### 4.2.1. Comparison of park availability

Parks are considered as a better indicator for UGS because of their availability across all neighborhoods. The study found the highest number of parks in Q4 and the lowest in Q5 (30 vs.16) as shown in Table 5. Statistically number of parks per neighborhood on an average came out to be 2.31 for Q4 and 1.00 for Q5 (Table 6). Only, 50% neighborhoods of Q5 (7 out of 14) and 64% neighborhoods of Q4 (9 out of 13) have parks. 78% of neighborhoods of Q1 has at least one park in their neighborhood. However, the park area average per neighborhood is found to be the highest for Q4 (26738.32 $m^2$) followed by Q5 (22386.7378 $m^2$) despite having the lowest number of parks in Q5. The park area percentage in respect to the ward land area too is observed to be the highest for Q4 (1.1953). The P-value seem to be statistically non-significant for all the three indicators: park numbers, park acre and park percentage stating no major difference in park availability across all quintiles ($p > 0.05$) as shown in Table 5.

Table 6. Comparison of park availability, with 95% confidence interval (source: author)

| Park indicators | Q1 | Q2 | Q3 | Q4 | Q5 | F-value | P-value |
|---|---|---|---|---|---|---|---|
| Park numbers | 1.64 | 1.61 | 1.54 | 2.31 | 1.00 | 0.977 | 0.427 |
| Park area avg ($m^2$) | 10135.9464 | 8451.9753 | 19373.6169 | 26738.32 | 22386.7378 | 0.739 | 0.568 |
| Park percentage | 0.5778 | 0.5207 | 1.1318 | 1.1953 | 0.8912 | 0.299 | 0.877 |

### 4.2.2. Comparison of overall UGS

The overall proportion of all types of UGS are observed to be the highest for Q1 (59.9308%) followed by Q4 (25.0667%). Thus, the least deprived community (Q1) has the maximum allocation of UGS and have the maximum square kilometers of UGS per 1000 persons (PCi = 0.0146) and green coverage ratio CRi (6.3375). Q4 has the highest number of parks (30 numbers) but comparatively less amount of PCi (0.0076) (Table 5).

## Conclusion and discussion

This study focusses on the capital city of Odisha; Bhubaneswar, India and evaluates the park distribution across all deprived communities, an environmental equity assessment. The study led to conclude that having a park in every neighborhood is still a luxury for Bhubaneswar. Due to very high density and unplanned development, open spaces have often been neglected in the city planning process. In Bhubaneswar, out of 67 neighborhoods, 27 neighborhoods do not have any form of parks in their vicinity. Indian standard Bhubaneswar's urban green space examined to be way below the Indian standards and much lower than the NRPA standard.

From the equity point of view, the park distribution examines park availability, and overall UGS allocation. There is no significant difference found in park availability among all SES statistically. However, the two quintiles signifying medium and least deprived communities have the highest park area. In contrast, the two quintiles signifying most deprived communities have the lowest park area average. Surprisingly, park numbers are the lowest for least deprived communities. This indicates that there are larger green spaces to engage in physical activity in least deprived communities. Despite having a greater number of parks on average, the park sizes are usually smaller for most deprived communities. This supports the earlier body of evidence which suggest that parks are smaller in deprived communities leading to more park pressure and congestion (Boone et al., 2009; Sister et al., 2010). The overall UGS allocation per capita came to be the highest for most deprived neighborhoods. These most deprived neighborhoods also have the lowest population density. Availability of gardens could be the reason for such a high percentage of UGS allocation. Gardens are observed in the most deprived neighborhoods probably because there is availability of land with a lower price, and they are located away from the city center where population density is comparatively low. Secondly these gardens are privately owned and maintained. The nominal entry fee is used for maintenance purposes thus reduces the burden on the government. The nominal fee restricts free access to the garden too. Future studies should look at the access of the gardens from the shape, location and aggregation point of view.

There could be several reasons why non-significant difference found for park distribution across neighborhoods. First, the heterogeneous nature of the neighborhoods could be one of the reasons for the mismatch. While looking at the spatial distribution, the most deprived communities seem to be located away from the center of the city. This confirms to the earlier studies of Kolkata and Mumbai in respect to poor neighborhood locations (Mishra, 2018). Another important element to consider for Bhubaneswar is the slum distribution. While the disadvantaged group are clustered at certain locations in western countries as well as mega cities such as Mumbai, Bhubaneswar sees a uniform distribution of slums. Slums are found in almost all neighborhoods (Anand & Deb, 2017) probably because there is a mutual dependability between the rich and the poor. The poor work as house maids or drivers and support the wealthy community and thus prefer to live closer to them (Gurtoo & Williams, 2009). So, the higher percentage of slums does not seem to be the characteristics of most deprived neighborhoods. Second, the house ownership is a profit-making business in Indian cities. People own multiple houses and rent them out to get profit in their investments. Usually, houses located in neighborhoods which attract commercial activities are prone to such conversion. Part of the houses get converted to other commercial activities. Renting houses bring in people of different socio-economic status to a particular neighborhood.

Third, education as a variable of socio-economic measure is another area of concern. Census data contains aggregated form of data for education without differentiating on level of education. The data explains the percentage of literate and non-literate only substantiating the previous argument that higher percentage of literate constitutes least deprived neighborhood whereas low percentage of literates constitutes most deprived neighborhoods. The level of education highly influences the occupation and subsequently the income of the population. While higher degrees such as STEM or MBA fetches better income, just a high school degree may not fetch income to that level. As a result, merely knowing whether a person is literate, or illiterate may not be sufficient to determine the hierarchy

of wealth or social status. The variable can just explain whether the population is deprived or non-deprived. Similar argument follows for employment too where the variables explain the workers and nonworkers population only without explaining their occupation.

Waterbodies are not considered as part of the UGS. Though they are presently used for religious purposes, they have a potential to convert into recreational and physical activities. Authorities should work towards identifying such water bodies to increase the green area percentage and dedicate them for physical activity since the eastern part of Bhubaneswar has limited amount of UGS.

This study can be considered as a starting point for park inequality research in mid-size Indian cities. The ward level study assumed that there is no meaningful difference in the residential patterns in respect to social and economic status. However, by looking at the heterogeneous nature of the neighborhoods, future studies should aim at examining park access and park quality on a smaller scale.

## Limitations

The study has several limitations. Like many studies pointed out, the ward-based SES measure does not seem to reflect the slums accurately. The ward extent is relatively large and usually consists of several neighborhoods including most deprived and least deprived neighborhoods together. A study specific to neighborhoods with smaller spatial scales can provide a clear picture on the pattern of available UGS (Tan & Samsudin, 2017). The quality of the park, its available facilities and amenity are significant determinants for park use too. Studies highlighted parks with more amenities, trees for shades and water features neighborhoods with higher SES (Crawford et al., 2008). Parks with lesser vandalism, litter or graffiti reported to have higher physical activity (Giles-Corti et al., 2005). The quality, maintenance and available facilities of parks is not covered in this study and require further research.

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