

Understanding the Fundamental Purpose of Urban Green Spaces: Insights from Central Bengaluru, India

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Abstract

Bengaluru's open and green areas account for about 8.4% of the city, catering to the inhabitants and tourists.¹ However, the city inhabitants, who largely bear the costs of conservation of the major green area in the city receive only few benefits. Consequently, the microclimate declines and the quality of the habitats are being lost through impacts of the urban heat island effect, which in turn results in thermal discomfort in the core of the city. This study aims at understanding the major criterions of the open spaces, based on which the microclimate of the context can be enhanced. Hence, to understand the various issues related to the existing urban greens, a study was conducted in one of the planning districts, located in the central ring, to question the greenness of the open spaces in the same.

The study employed both qualitative and quantitative methods. In the qualitative analysis, the green spaces are inspected through repeated visits to understand the various activities they support. The observations are documented through photographs, drawings, and maps. The study investigated the relation between the different tones of shades and their impact on urbanism through sky view factors (SVFs) as a quantitative parameter.

Keywords: Urban heat island (UHI), Urban Green spaces, Microclimate, Masterplan, thermal comfort, public spaces, urban conservation.

Introduction

The larger the urban area, the greater the modification of its climate will be. The UN estimates that by 2025, 80% of the world's population will live in urban areas. It has been demonstrated that cities with variable landscapes and climates can exhibit temperatures several degrees higher than their rural surroundings (i.e. UHI effect), a phenomenon which if increases in the future, may result in a doubling of the urban to rural thermal ratio in the following decades. Hence, assessment of the UHI and strategies to implement its mitigation are becoming increasingly important for government agencies and researchers of many affected countries.

The rise in temperature in microclimate results from the changes to the form and composition of the land surface and the atmosphere. Land cover of large green spaces is

¹ T.V.Ramachandra, Bharath H Aithal, Gouri Kulkarni, Vinay S, 2017. Green Spaces in Bengaluru: Quantification through Geospatial Techniques. Indian Forester, 143(4) : 307-320, 2017

replaced with buildings and roads in urban areas. This alters the thermal, radiative, moisture, and aerodynamic properties of the surface of the atmosphere. Construction materials in urban environments have varying thermal (heat capacity and thermal conductivity) and radiative (reflectivity and emissivity) properties compared to surrounding rural areas. These result in most of the sun's energy being absorbed and stored in urban surfaces compared to the rural. In addition, the height of buildings and the ways in which they are arranged affects the rate of escape at night of the sun's energy absorbed during the day by building materials. The result is that urban areas cool at a much slower rate than the rural areas at night, thus maintaining comparatively higher air temperatures.

Urban areas also tend to be drier than their rural counterparts because of the lack of green spaces, a predominance of impervious surfaces and urban drainage systems, which quickly remove water from the urban surfaces. This combination of effects alters the energy balance of the urban environment. Consequently in urban areas compared to the rural, more of the sun's energy absorbed at the surface goes into heating the atmosphere and thus raise the air temperature than into evapotranspiration (water uptake and loss by plants), which is a cooling process.

Some of the major parameters influencing this are:

- Lack of Vegetation

Lack of vegetation, further increases the demand of shade and moisture in the urban community, which passively cools the environment and makes it more liveable.

- Urban Surfaces

The fundamental issue of change in land cover and further, the majority of them are being substituted by the modern materials that possess high thermal properties resulting in making it difficult for a city to achieve sustainability.

- Urban Geometry

Diversity in the urban design guidelines in terms of urban structure and form causing more variations in the street canyons fails in passive cooling of the environment, and to add to this the dimensions and the shape of the buildings also matter to the amount of heat dissipated in an urban setting.

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The rise in temperature in microclimate results from the changes to the form and composition of the land surface and the atmosphere. When a land cover of buildings and roads replaces green space, the thermal, radiative, moisture and aerodynamic properties of the surface and the atmosphere are altered. This is because urban construction materials have different thermal (heat capacity and thermal conductivity) and radiative (reflectivity and emissivity) properties compared to surrounding rural areas. These result in most of the sun's energy being absorbed and stored in urban surfaces compared to the rural. In addition, the height of buildings and the ways in which they are arranged affects the rate of escape at night of the sun's energy absorbed during the day by building materials. The result is that urban areas cool at a much slower rate than the rural areas at night, thus maintaining comparatively higher air temperatures.

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The Problem Statement

Today, cities are affected by the activities associated with land use and land cover changes based on urbanization. These in turn causes changes in atmospheric composition, in water and energy balances, and in the ecosystem. Therefore, studies are needed to evaluate the possible relation between urban growth and local and regional changes. Reduction of green areas, in the city core is a major impact for the deteriorating microclimate in the city. As mentioned earlier, the city's urban form is characterized by grid-iron plans with wide streets and lack of shade, besides the limited amount of green areas which affect the microclimate and thermal comfort of the city. Hence, the research problem is to look for the solution in decreasing the urban heat island effect in the core of the city, by identifying the most critical parameters for analyzing the site. This primarily is also addressed by understanding the role of green spaces amongst the various urban land uses in the core of the city.

Literature Review

Previous studies based on analysis showing relation between qualitative factors such as visual dimension and quantitative parameters such as sky view factors (SVF's) have demonstrated that there has been strong association between physical environments and physical activities.² In early stages, most of the research papers focused of what is an urban open space, and what are its uses to the city. Post late modernism, research on urban green spaces, also evolved to queer studies and how best they are used in public, some of it elaborating on women and children safety too³. Elaborate discussions have been made to progress in relating a qualitative parameter of a green space in an urban setting to a quantitative parameter such as; how safe an women feels to how shaded is the street⁴. In recent years, there are growing studies of validating environmental instruments which integrated the quality of urban design with physical activity in relation to healthy lifestyle.⁵ There have been conceptual models on which correlate the use pattern, the level of physical activity and environmental characteristics of a green spaces, such as safety, access.⁶ Most socially potential and relevant conceptual framework with physical indicators of green spaces such as functionality, safety, aesthetics, and

² McCormack, G., Giles-Corti, B., Lange, A., Smith, T., Martin, K. and Pikora, T.J. (2004) An update of recent evidence of the relationship between objective and self-report measures of the physical environment and physical activity behaviours. *Journal of Science and Medicine in Sport* 7: 81–92.

³ Ceccato, V. (2012). *The urban fabric of crime and fear*. New York, NY: Springer.

⁴ Ceccato, V. (2014). The nature of rape places. *Journal of Environmental Psychology*, 40, 97–107.

⁵ Bai, H., Wilhelm Stanis, S.A., Kaczynski, A.T. and Besenyi, G.M. (2013) Perceptions of neighborhood park quality: Associations with physical activity and body mass index. *Annals of Behavioral Medicine* 45: 39–48.

⁶ Bedimo-Rung, A.L., Mowen, A.J. and Cohen, D.A. (2005) The significance of parks to physical activity and public health: A conceptual model. *American Journal of Preventive Medicine* 28: 159–168

last-mile connectivity were also derived.⁷ However, most importantly, successful restorative urban settings included the issues of appropriate open space density that citizens could experience, and well connected with an accessible network of urban fabric.⁸

Previous studies have drawn attention to immediate green features and the user's behavior and perceptions. Although these studies have interpreted various capacities of variables or certain urban design parameters of open spaces, the impact on larger concern of design was less discussed in environmental evaluations and perceptions. This research, therefore, aims to draw the relation between the sky view factors and visual dimensions of various green spaces in the core of the city.

Methodology

Structure of measurement

The study is carried out in two stages:

1. The adequacy of open spaces in the CBD through land use is examined.
 - 1.1 The land use maps of the identified site, marking the specified zoned green areas in the masterplan, which further helps in questioning the type and justification of the same helps in calculating the open space around the planning district.
2. The quality of open spaces is then measured through visual photographs comparing the physical activities with the physical environment.
 - 2.1 Understating the green and grey relation around the open spaces and in the context of functional and social domains.

All above mentioned analysis is however; fundamentally understood through tools such as Figure ground maps, land use maps, and other activity mapping techniques. These maps are drafted to analyze and compare the immediate context and influence on the green spaces. Figure ground maps show the built around the green space, while, land use map obtained from the municipal corporation informs on the predominant urban land use and its' influence on the green space.

Based on the street canopy and Access Street for each green space, a planned set of locations are fixed and set to collect fish eye photographs for measuring sky view factors (SVFs). This shall qualify as a quantitative parameter and help in measuring the shading factor in and around the open space.

Bengaluru: the Case Study

The capital city of Karnataka, Bengaluru is situated in the southeast region of the Karnataka State in South India, at an average elevation of 920m above the mean sea level. Few parts of the city are rich in history such as Chamrajpet. Known after the Chamarajendra Wodeyar, who ruled in the late 18th century, it is said to be one of the first well planned extensions of the city to the Chamrajpet region. The extension being in close proximity to the central business district, Chamrajpet region is considered inside the first ring of planning districts, according to the Revised Masterplan 2015.

Hence, Chamrajpet, which is about 128 years old, is selected for the study, to understand, if apart from the roadside trees planted back then, any new green space help in heat island mitigation improving the thermal comfort.

⁷ Pikora, T.J., Bull, F.C.L., Jamrozik, K., Knuiman, M., GilesCorti, B. and Donovan, R.J. (2002) Developing a reliable audit instrument to measure the physical environment for physical activity. *American Journal of Preventive Medicine* 23: 187–194.

⁸ Thwaites, K., Helleur, E. and Simkins, I.M. (2005) Restorative urban open space: Exploring the spatial configuration of human emotional fulfilment in urban open space. *Landscape Research* 30: 525–547.



Fig. 1: Chamrajpet Planning District Map
Source: author

Chamrajpet, spanning about 3.9 Square Kilometers, acts as a threshold between the central business district and the residential area in the Southern region of Bengaluru. It is diverse in terms of land use, and other activities.

Observations and Findings

Open space percentage based on land use

In spite of the total area being around only 2.24 square kilometers, the population density is high with about forty thousand people per square kilometer, although a noticeable percentage of them could be a floating population. However, the green area is less with only 2.7 percent of the total area being green.

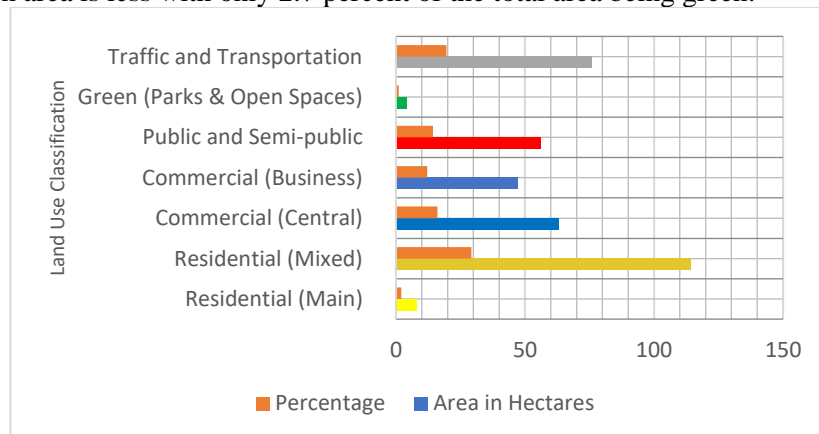
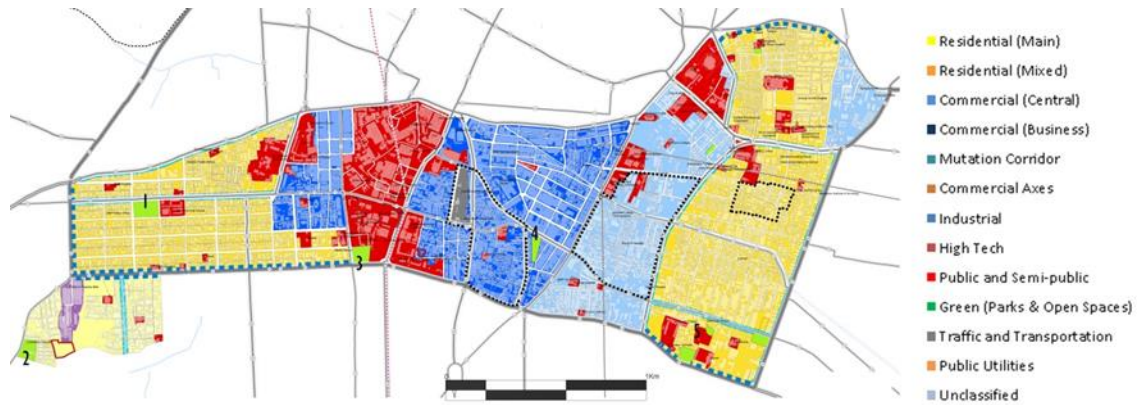


Fig. 2: Land Use Classification in Chamrajpet
Source: Author

The land use classification of the Chamrajpet planning district shows the undesirable variations among the different zones; specifically, the open spaces not reaching to 9.5 square meters of green area per person. However, the mixed residential use has diversity in terms of built typology, having considerations for trees planted in the streets.



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Fig. 3: Land Use map of Chamrajpet Planning District

Source: Revised Master plan 2015 BBMP

As shown in Figure 3, all the existing green areas as per the land use map were pilot surveyed and numbered based on the hierarchy of their area, and further audited.

Quality of open spaces

The audit for these green areas give an idea of what kind of the open areas, each of them are, further helping to categorize them in the larger picture. It also helps in understanding the multiple features of a single open space. In some areas, it helps in understanding the location of these open spaces much better through their proximity to the nearest landmark.

Table 1: Urban Audit for Green spaces in Chamrajpet

Source: Author

Planning District Name and Number	Green spaces	Function	Maintenance	Accessibi lity	Ownership	Land use around	Identity	Building Use	Access road width (in m)
Chamrajpet 1.07	1	• Barren Space • Playground • Presence of Wild flora	.5	1	Public	Institutional & Residential	Playground	Commercial & Residential	24
	2	• Cremation Ground	1	1	Private	Commercial & Residential	Cremation Ground	Commercial & Residential	12
	3	• Neighbourh ood Park	1	1	Public	Institutional & Residential	BBMP Park	Commercial & Residential	30
	4	• Neighbourh ood Park • Barren Space	.5	0	Public	Commercial	BBMP Park	Commercial & Residential	12
	5	• Playground		1	Private	Institutional & Residential	Playground	Institutional & Residential	30
		0-Neglected, 0.5-Average, 1- Maintained		0- Non-Accessible, 0.5-Average, 1- Accessible					

Findings

Stage one

Contextual visuals

In the central areas of city, most parts are shaded, either old institutional zones or older streets. In this stage of the research, photographs have been documented to understand the physical activities and physical environment in the open space. This stage is to also look for the scale of the open space in relation with immediate surrounding.

Green space 1



Fig. 4: Plan of the green space 1 with locations from where images were recorded.

Source: Author



Fig. 5: Visuals of the green space.

Source: Author

The open space although skewed in an urban setting, plays an important role for its functional dimension in an institutional setting it is in. This green space governed as a cremation ground, further is an activity node for the planning district Chamrajpet. The open space is surrounded predominantly by mixed use built, attracts density of people (5men/sqm) during the peak hours but is then deserted after 7pm. The open space does not have any sense of barricade helps it to achieve its maximum diversity of physical activities in the environment around it.

Green Space 2



Fig. 6: Plan of the green space 2 with locations from where the images were recorded.

Source: Author

**Figure 7:** Visuals of the green space 2

Source: Author

Surprisingly, cremation grounds although, classified as green spaces under the Urban and Regional Development Plans Formulation and Implementation (URDPFI) Guidelines, here have adequate green cover one to not able to recognize the crematorium from the google image. However in intensity of green is, the traffic doesn't let allow the calmness of the street to experience by the passer-by. This not only affects the density inside, but also impacts the density on the adjacent street towards the entrance of the gateway.

Green Space 3

**Fig. 8:** Plan of the green space 3 with locations from where the images were recorded.

Source: Author

**Fig. 9:** Visuals of the green space 3

Source: Author

The open space depicting itself as a neighborhood level park, not only serves its purpose for being a park for the predominant residential land use but also the institutional land use. It is surrounded by government institutions; it has untouched green on the approach street, making it shady on the outside. However, the canopies of the trees cover beyond the compound walls and shade the adjacent streets beyond the park. This notionally creates functional green spaces beyond the spatial organizations of what the city offers to people as its green.

Green Space 4

Fig. 10: Plan of the green space 4 with locations from where the images were recorded.

Source: Author



Fig. 11: Visuals of the green space 4

Source: Author

The small piece of land under the head of a neighborhood park is slowly deteriorating because there is a complete lack of access to this green in the city, both physically and visually. The green space is hidden amidst the concrete blocks with high FAR of the first development right of the city, which engulfs the green. Although there is adequate shade outside, the inaccessibility to this green space makes it inefficient in the core of the city.

Green Space 5

Fig. 12: Plan of the green space 5 with locations from where the images were recorded.

Source: Author



Fig. 13: Visuals of the green space 5

Source: Author

This green space categorized as the last green space certainly is unapproachable, as it lies inside a gated community of an institution space. Furthermore, unlike the neighborhood parks, the trees here also shade less on the adjacent streets, for two reasons, as the scale of the open space is large and there are also structures adjacent the street side from the compound wall. Lalbagh, which is the city's oldest garden, is located in close proximity to this green space. This helps in bringing down the temperature difference comparatively. However, this green space remains to be a private open space.

Green cover and sky view factors

Different from other open space research, which collected data of fish eye photographs of residential communities and photographs inside the green spaces, this research collected visuals and fish eye photographs both inside the green space and the access street, to measure how well or shaded the approach streets are. The buildings were anonymous in this article due to research ethics.

Green Space 1

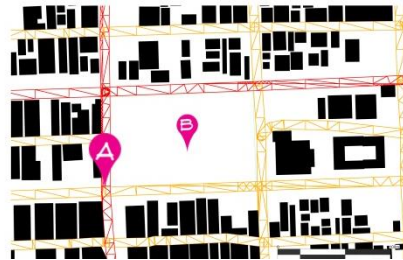


Fig. 14: Plan of the green space 1 with locations from where the Sky View Factors (SVFs') were recorded.

Source: Author

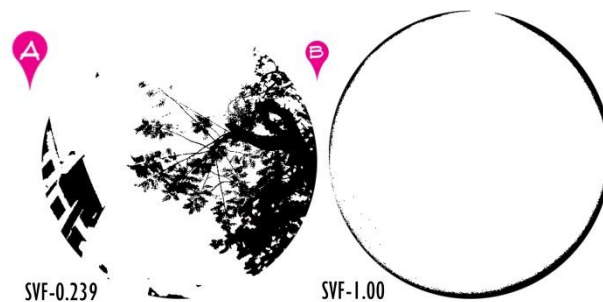


Fig. 15: Sky View Factors (SVFs') of the green space 1

Source: Author

This green space categorized under a playground, shows most of its sky view factors low, and shaded, creating urban friendly environments. However, the playground due to its' scale remains unshaded

Green Space 2

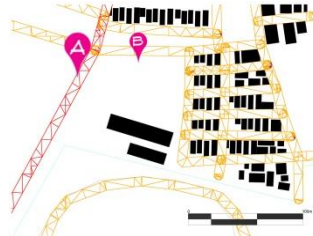


Fig. 16: Plan of the green space 2 with locations from where the Sky View Factors (SVFs') were recorded.

Source: Author



Fig. 17: Sky View Factors (SVFs') of the green space 2

Source: Author

Although, a cremation ground, the urban environment, invites diversity of physical activities with sky view factors not exceeding 1.38 on all sides of the approach streets.

Green Space 3

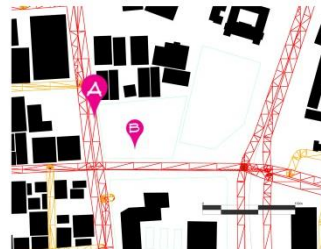


Fig. 18: Plan of the green space 3 with locations from where the Sky View Factors (SVFs') were recorded.

Source: Author

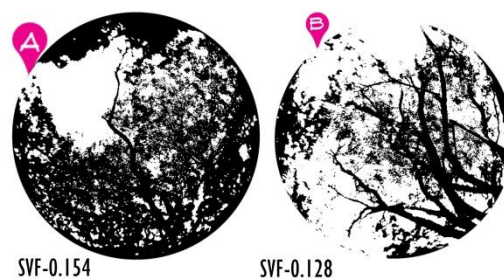


Fig. 19: Sky View Factors (SVFs') of the green space 3

Source: Author

Interestingly, although, the approach streets include 18 meters of Asphalt Street before the pedestrian zone, the results of the sky view factors show that they are well shaded, not exceeding a limit of 0.13 values creating a comfortable atmosphere.

Green Space 4

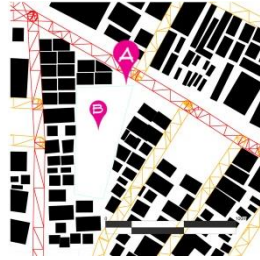


Fig. 20: Plan of the green space 4 with locations from where the Sky View Factors (SVFs') were recorded.

Source: Author



Fig. 21: Sky View Factors (SVFs') of the green space 4

Source: Author

The approach street of the green space remains unshaded with a sky a view factor of 0.631, while, the green space stays well shaded, with a relatively better SVF value of 0.368. However, it remains inaccessible to public.

Green Space 5



Fig. 22: Plan of the green space 5 with locations from where the Sky View Factors (SVFs') were recorded.

Source: Author

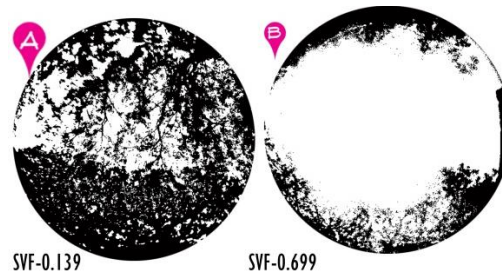


Fig. 23: Sky View Factors (SVFs') of the green space 5

Source: Author

This green space secluded inside an institution, has shaded approach Street showing a SVF value of 0.139 and the open span inside has a value of 0.699. This is due to the function of the space that it is designed for. The green space inside the institute is functions a playground, hence, has a SVF value not exceeding 0.75.

Discussion

In the primary studies, parameters taken into consideration are often both objective, and subjective. Parameters such as access road width, green space index, thermal comfort, explain the space objectively, while, the subjective matter of the space such as, nature of the space, physical activities, are discussed to elaborate to understand the growth pattern of such spaces. Although, the parameters mentioned in the preliminary urban audit mentioned in the beginning, categorizes all the authenticated green spaces in the Chamrajpet area, the detailed descriptive and normative criticism of the use of such public spaces gives a better picture in understanding the quality of each of these open spaces in particular. City's core being an interest example to study, various concerns of how parameters of thermal comfort's element such as a shade could play an important role in something to look upon. Chamrajpet is one classic example for the same.

All the green spaces serves its purpose for than what an ideal green space should serve as to a city, for open scape 3, which is a neighborhood level park maintained well by corporation(BBMP) being an exception. However, the reasons for to this are many. The approach street inaccessible is one major reason for the non-function of such a rich green space. This research, therefore, discovers that the difference between the use of open space in terms of physical activities and use experience between two or more different urban contexts and is strongly influenced with the immediate development models and their related urban planning, design and management. Exposure to direct solar radiation makes it uncomfortable on pedestrian streets or any urban environments and these effects on the personal perception of open spaces, creating aftermath on urban green environments. To overcome this, most often urban planners and urban designers try to design a planting design across the street, which often fails to be implemented due to larger spatial and technical constraints.

Hence, can it be inferred that the density of people the park caters to depends on the seamless accessibility it has and the last mile connectivity it has? The citizens of closer commercial zones use the immediate threshold spaces for public interaction since this green space is hardly accessible anytime during the day or night. Henceforth, to create comfortable microclimates for social uses in urban environments, sufficient shading facilities are a primary strategy.

Conclusions and Future work

Most previous research examines open space and associated users' activities in neighborhood environments through self-administrated questionnaires, while this research addresses this topic in urban settings where green space could generate therapeutic effects for the people of the core of the city, largely understanding the shade as a quantitative parameter.

Most importantly, this research fills the gap of understanding urban spaces and physical activities associated with them, in their physical environments. Furthermore, to understand the

purpose of an open space, each open space here in this research is looked at in a more qualitative way than a quantitative way, based on specific parameters mentioned in the beginning. Land use being a major parameter of concern for study to look at urban greens for its functionality, accessibility for these green spaces have given interesting results in understanding the kind the urban public spaces one needs to conserve in a city, fundamentally because they are well shaded.

The future scope of work for this research certainly starts from a basic literature such as Urban and Regional Development Plans Formulation and Implementation Guidelines URDPFI and question the limits of what is permissible and what is contextually more relevant in a green zone to be planned,. Since the green zone according to these guidelines, are more flexible and can deviate through the existing urban fabric, making it more a commodity for the land price the central core area has, and less an urban space the citizen can experience. Through various urban landscape strategies, one could also analyze the quantitative impact of how these urban open spaces contribute in mitigation the heat island while the streets that are covered with thick vegetation in the same planning district could be another interesting comparative study, certainly considering the density of traffic flow that streets have. However, the Sky view factors (SVF) of these streets have shown interesting results comparative to the green spaces itself.

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