

Revitalizing Urban Canyons Through Innovative Thermal Strategies

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Abstract

Urban canyons, environments very densely made up of tall buildings clustered on narrow streets, are treacherous when it comes to considerable heat retention and greatly increase wind speeds. The resulting conditions fuel the Urban Heat Island effect. That means urban canyons feel very hot and this of course harms both comfort and health of those who dwell in them. This research tackles the serious issue of discomfort due to heat in canyons by setting a set of design guidelines that reduce UHI effects and create a healthier microclimate. This study digs deep into a set of important thermal influences relating to urban canyons. Things like the sun give off heat, how surfaces reflect that heat were analyzed. This review leads to some principles to do a good design of buildings and landscapes that reduce heat build up. By presenting a review that uses solid evidence to reduce effects of Urban Heat Islands (UHIs), this contributes to urban design and landscape architecture and provide practical solutions to create urban spaces that are both thermal resilient and livable.

Keywords: Urban Canyons, Pedestrian Comfort, Urban Design, Pollutants Reduction, Street Design

INTRODUCTION

Addressing the impact of solar radiation in urban canyons involves a comprehensive consideration of various critical factors, such as Shade management, pedestrian comfort levels. These canyons trap air pollutants, elevate Urban Heat Island (UHI) values, and compromise resident health and comfort. Necessitating urgent intervention through landscape architecture to strategically design open spaces and selecting trees with adequate deposition rates [1] and further deducing comprehensive design principles tailored for the application in Northern American region.

Project Background and Review

As we know that now-a-days smart cities are rapidly growing and with this rapid growth something else which is growing parallel fast is the urban form with high sky-scrapers which creates the closed enclosures around the street and this enclosed street environments are called as Urban canyons. These canyons are everywhere around us and majority of them are in really in unhealthy conditions in terms of the user's and environment health. As these urban canyons traps the air pollutants within the streets and immensely increases the UHI values which ends up creating health and comfort issues for the users and majorly affects the ecosystem within the Urban boundary layer as well.

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Received Date: March 11, 2025
Accepted Date: April 14, 2025
Published Date: April 30, 2025

Citation: Rishabh Anand. Revitalizing Urban Canyons through Innovative Thermal Strategies. International Journal of Urban Design and Development. 2025; 3(2): 1–11p.

Project Overview

To effectively tackle this complex issue, it is imperative to establish a cohesive set of Design principles. These principles should be crafted to ensure a systematic and balanced approach, allowing future designers to create streets that are resilient against the negative effects of solar radiation in urban canyons.

LITERATURE REVIEW

The available sources will talk about, what is the canyon effect, and how it is increasing due to urbanization globally with some relevant case

studies of the countries like Australia and Canada and what these countries are currently doing to resolve these issues and what urban policies they are making for the near future. Along with this in what all aspects canyon effects are affecting the people and the environment how badly it is dangerous for the immediate users of such urban canyons. The selected content will also talk about the possible solutions that currently people are trying to find for urban canyons around the globe, like how green infrastructure can reduce the canyon effects, how currently municipalities are trying to deal with the temperature management in urban canyons.

Project Scope

This problem is spreading across the globe rapidly and we are not able to do anything about the already built Urban-forms which are creating these canyons. But the thing that we can do as Landscape Architects is to develop and strategies the involved open spaces in a way that all together the street design overcomes this issue of urban canyons.

Project Key Terms

High UHI intensity

Urban canyon contributes significantly to the temperature differential between urban and peri-urban areas. This has to do with how much radiation the canyon's surface has absorbed. Because of the temperature differential between the inside and outside of the buildings, heat can only enter the shadowed area through the conduction process. It is essential to comprehend how urban canyons raise UHI levels in order to properly design streets and put mitigation measures in place for the heat island effect,

Urban Heat Island (UHI) intensity is primarily caused by factors like dense constructions absorbing solar radiation, insufficient green spaces reducing evaporation, increased anthropogenic heat, limited air circulation in urban areas, and atmospheric pollutants. In essence, UHI intensity is driven by aspects of urban development, vegetation, heat emissions, air flow, and air quality.

Pedestrian comfort levels analysis

Due to problems mentioned above in the urban canyons, the Comfort levels on walkways gets highly dis-balanced for the users which further makes it even difficult to walk as well. Therefore, while dealing with the urban canyons it is necessary to take the comfort levels in account and provide high comfort levels to the users in the proposals, which can be analyzed by performing various simulations.

Urban boundary layer (UBL)

Urban canyons affect the urban boundary layer (UBL) by restricting air exchange and changing air flow patterns. They create micro-climates with temperature fluctuations, influence the distribution of solar radiation, and store heat. These effects influence pollutant dispersion, boundary layer height, and overall atmospheric stability in urban areas. Understanding these interactions is important for controlling urban air quality and thermal conditions.

There is an important potential of lowering urban temperatures when the building envelope is covered with vegetation.

Existing Scenario

There are many urban canyons around the globe where it is even difficult to walk and cities like Toronto and New York are majorly affected with such urban canyons.

The problems in the current solutions are that most of them are for the canyons which are not built yet or which are proposed but here the main concern is about the existing canyons which are affecting the health of their residents on daily basis.

Therefore there is a requirement of a framework or set of design principles which can take up the issue of high UHI and prepare guidelines which can reduce the impact of solar radiation in Urban Canyons.

Need of the Proposed Review

As mentioned above that there is big gap in the *review* field of urban canyons which needs to be filled in order to deduce a proper solution which can provide a healthy life to the residents. Therefore there is a need of a proper research which can study and analyse all factors of solar radiation in urban canyons which highly affects the environment of the street.

Research Questions

For this thesis project there are some important questions which we will be looking forward to answer through the research: -

1. How various landscape architectural strategies can reduce the impact of urban canyons on air quality and pedestrian comfort?
2. What all interventions can landscape architects apply to maintain the overall pedestrian comfort levels within the urban canyons?
3. How the environment within the urban canyons can highly affect the Urban Boundary Layer?

LITERATURE STUDY

Thermal Comfort

In order understand that what is Thermal comfort first we need to understand properly that what does thermal environment means and why it is necessary to manage while dealing with the urban spaces.

Thermal environment means the overall temperature conditions within a specific zone which gets affected by the aspects such as Humidity, Air movement, Temperature, Radiant Heat [2]. Now comes the point that why it is necessary to manage thermal environment while working in an urban space, it is because that fact that thermal environment of urban space gives a major impact on the quality of life of the users and they don't even realize it. For instance, an outdoor area designed without any consideration of the thermal environment will automatically be less socially active whereas on the other hand an open space designed with proper climate mitigation strategies will support and promote the social use-case of the area as people will not hesitate to use the space in warm or cold days as the space will remain Thermally comfortable. Therefore, it is highly important to understand and consider the thermal environment of the area so that we can manipulate the Micro-climate of the site by using various sustainable strategies which will eventually lead to a thermally comfortable design [3].

Now-a-days as a designer we cannot ignore the negative impact of the existing urban forms of the city to the thermal comfort level of the concerned site. Scenarios like increased radiation, wind pressures, reduced vegetation directly affects the comfort levels of the concerned area. That is the reason that open spaces in outdoors within a city needs to be designed according to the existing urban patterns. Hence, to create a thermally comfortable space a balance is highly required in between the urban form and the open areas which can be achieved by various strategies.

The thermal levels of such spaces are not only responsible for the social aspects of the area, here the micro-climate directly affects the energy demand of the contextual buildings as well, for instance the amount of sun lights hours a facade will have in a day will tell the cooling requirement of the indoor areas of that building. Similarly the amount of green buffers will tell the heating load of the adjacent building as trees prevents the infiltration possibilities for the building envelope. Therefore, managing thermal comfort of a proposed design brings lots of other benefits for not just humans but also for the environment.

There are numbers of ways by which a thermally comfortable design can be achieved and similarly there are numbers of aspects which all needs to be considered while making a space thermally comfortable [3] and all this analysis should begin right from knowing that what type of user group will be using the street or the site, what all activities that gonna be happening on the site and what time of the day. As we know that such urban outdoor areas are majorly used at the daytime along with the various types of movements like some users will be biking some will be walking or some will be driving all these user group will react to the thermal environment differently and all of them will have different thermal comfort requirements.

PET (physiological equivalent temperature)

When it comes to landscape design we create thermally comfortable environments for the users by using micro-climate and here an user can be called thermally comfortable when the energy he receives gets equals to the energy he loses in the environment.

As we discussed above about thermal comfort in urban areas for humans, but how one can analyze that the proposed design is giving sufficient amount of thermal comfort to the users? This is where PET comes in which is Physiological Equivalent Temperature which is a standard by which we can measure Thermal comfort levels of any proposed or existing space and see if that space is thermally comfortable or not [4]? So that required additions or subtractions can be done in the design in order to bring the correct PET value in place.

To understand the technical aspects of PET (Physiological Equivalent Temperature) calculations, it is essential to first grasp its key components. In any given landscape or environment, various energy sources—such as solar radiation, wind, and other environmental factors—contribute to heating the human body. This externally received energy is referred to as radiant energy. In contrast, the energy produced within the human body is known as metabolic energy. [5]. This was about addition of energy to the user's body now when the energy loses from the user's body due to natural phenomena like Evaporation, convection and radiation the final energy budget needs to be calculated so that later we can determine that if the user is thermally comfortable and which can only be possible when the energy gain will be equal to energy lost in environment. We can understand the whole calculation simply by the deduced equation;

$$PET = (\text{Total Energy gained}) - (\text{Total Energy Loss}) [5]$$

There are various PET standard available for different conditions as different user activities requires different thermal comfort levels. For instance, a cyclist will have different thermal comfort requirements than a person who is on his feet. Now after knowing all if and but of thermal comfort standards we can see that it is quite complicated to make a place completely comfortable that too for all kind of users that will be coming to site in future. But as designers, what we can do is to try to bring the place as much as near to thermally comfortable. The purpose of of site microclimate design is the thermal comfort of the majority of people in the majority of the time and once the big picture is resolved it is possible to deal with the specific cases.

There are various factors which affects the PET values, first of all it is important to understand that the proposed space will be used at what time of the year and not just the months the designer should even know that at what time of the day majority of the footfall will come to the site and what type of clothing insulation the users will be wearing on site, what will be the amount of sun light hours that the site will hold and what will be the wind direction and speed of the site. All these aspects are considered while analyzing the PET value of the site. [7]

As we saw above that PET standards can vary depending on the site location, number of users, climatic conditions but still there are some general guidelines and standards which are used in various urban planning and design applications as per the needs, like the UTCI (Universal Thermal Comfort Index).

UHI (urban heat island)

As we know that now-a-days urban cities are moving forward with a rapid growth which includes building a dense forest of urban forms which brings the unintentional creation of deep urban canyons. The hard and exposed surfaces of all these urban forest traps the direct and diffused radiation from the sun and further majorly affects the atmosphere of urban canyons and this phenomena is known as Urban Heat Island effect (UHI). Along with the benefits, Urban growth brings lots of disadvantages for the humans as well, like growth in various pollution levels, affect on the environment and biodiversity but in all this urban heat island in the most problematic and significant issue of the urban climate. UHI not only affects the thermal comfort of the users it also directly affects their physical and mental health and impacts of UHI are not only limited to urban canyons or its users it directly affects the Urban Boundary layer as well which is not healthy for the environment and also for the people living in the near by rural areas. [8]

UHI is one of the major problem in urban canyons because in canyons there are numbers of easy possibilities from which radiation can happen since canyons are like enclosures therefore when a sun ray enters in an urban canyon it reflects back from numbers of hard surfaces like road, building facades, footpaths, cycle tracks, seating surfaces and since all this happens in a small enclosure(urban canyon) the impact of UHI goes immensely on higher side which is really unsafe for the residents of such urban canyons. Such conditions of urban streets affects the social life of the area, as because of high UHI the over all thermal comfort levels of urban canyons decreases which reflects in the minimum social attractions of the area as people eventually stops coming out of the indoor areas which is quite obvious that no body will like open spaces if they will remain hot most of the time. They will rather like to sit inside air-conditioned rooms even in break times. That is the reason that urban life of people in such urban canyons are limited to indoors in most of the major cities.

This highly impacted condition of urban canyons not only affects the urban boundary layer or the environment they directly affects the energy demands of the buildings involved in such urban canyons, as high UHI levels in such streets warms the adjacent buildings as well which leads to increase in the cooling demand of the buildings and eventually energy demands increases. The only way by which all of these issues can be controlled is that designers needs to design the urban buildings in relation to the outdoor environment, for instance, promoting the idea of infiltration in the building so that ventilation can be maximized, using sustainable materials on the building's facade can help to balance both outdoor and indoor temperature in the urban canyons as overall amount of radiation will reduce and eventually the quality of stay for such streets in canyons will improve.

The only key to reduce the amount of UHI happening in an urban canyon is to reduce the amount radiation happening which can be done just by replacing or reducing the amount of hard surfaces inside the urban canyons [6]. Even if we can just replace the surface of a seating place on the street , that also can contribute to the overall heat reduction of the urban canyon. Its not just about the direct surfaces even the diffused surfaces contribute quite a lot towards the increased UHI of the canyons. [9]

Affect of Wind on UHI

Apart from the surface materials, wind also plays a major role in affecting the UHI of the street, therefore its not just about managing the type of materials inside the canyons. Therefore, Designers needs to take care about the wind circulation or ventilation happening inside the canyons because of the following reason:-

- i. *Dispersion of heat*: Inside a canyon various heat generates due to the activities by the users which needs to be dispersed from the canyon otherwise heat remains trapped inside.
- ii. *Ventilation*: While designing streets and placing trees in the case of urban canyons it is really important to cross-check the air ventilation possibilities as in order to reduce the UHI hot air should escape the canyons and cooler sir should enter from lower levels. This process of air getting flushed out of the canyons is necessary to reduce the intensity of UHI effect.

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- iii. *Enhanced evaporation*: Adequate amount of air movement inside an urban canyon helps to remove moisture from various surfaces and enhance evaporation which further helps to cool down the surfaces and reduce the amount of UHI effect.

Therefore, if all of the above points will not be kept in mind while planning a street in urban canyon, it might lead to more worse conditions of thermal comfort levels for the users due to the high UHI.

Urban Heat Island effect goes to its peak during night reason being that surfaces like concrete and asphalt absorbs heat during whole day and in night all these surfaces release heat in the atmosphere and not just hardscape material even trees and vegetation contribute absorbs heat and release it during night hours and this phenomena leads to make maximum temperature difference between urban areas and nearby rural areas.

Here, the UHI can be observed at two places, one at the surfaces which is known as SHI (Surface Heat Island) and other in the atmosphere above the city (Atmospheric Heat Island).

A surface heat island (SHI) forms when the temperature of urban surfaces is greater than that on the surrounding rural (natural) surfaces. This type of heat island is common where the city is surrounded by moist soil or by vegetated areas, which tend to be cooler than dry impervious surfaces of cities.

Factors of UHI Formation

1. *Urban form and density*: As we know that buildings hold the maximum amount of exposed surface area with hard materials, therefore urban form leads to become a primary factor behind the formation of UHI.
2. *Impervious surface*: Other than building envelopes there are other numbers of exposed surfaces inside the canyons such as roads, seating blocks, footpaths which all do not allow water to pass through pass which all contribute to the increase of UHI due to the low evaporation rates. [10]
3. *Anthropogenic heat (heat released by human activities)*: As mentioned above that in any urban canyon or a street users perform various types of activities and each activity react differently to the environment, the amount of released from the body depends on the type of activity that user is doing. Which further leads to different thermal comfort demands as mentioned above.
4. *Geographic location*: Apart from the fact that how many exposed hard surfaces are there in an urban canyon the formation of UHI also majorly depends on the geographic location, for instance a same site can have different UHI levels if places in two different corners of the world.
5. *Weather condition*: Climatic conditions also plays a major role in the formation of UHI and that is the reason that a same site will have different UHI intensities at different time of the year.

Factors That Reduce the Formation of UHI

1. *Landscape elements*: Such elements holds a power to majorly affect the micro-climate of any site or canyon, they can create both warmer or cooler environment in order to reduce the energy load of the adjacent buildings and with this outdoors will also remain pleasant for the users.
 2. *Vegetation coverage*: They can reduce the amount of solar radiation by acting as a barrier they block long wave radiations coming from the sky and at the same time vegetation coverage reduces the air speed and provides moisture through evaporation.
 3. *Water surface*: Water bodies in and around the cities cools the micro-climate due to the evaporation in the summer time but while using water bodies as solution towards UHI one thing planners needs to keep in mind is that water surfaces release heat during night time that they store in day times.
 4. *Surface permeability*: Permeable surfaces like grass pavers or soft-scapes have the tendency to let water pass through them which enhance the process of evaporation.
 5. *Shaded surfaces*: Shade pattern inside an urban canyon plays a major role in reducing the formation of UHI as the surfaces which hold more sunlight hours tends to generate more UHI intensity.
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Above mentioned points are some general aspects by which the UHI intensity can be reduced but there can be many other ways by which planners can manage to reduce the amount of UHI inside an urban canyon.

How Different Greens Affects UHI

As we know that there are numbers of trees and plants species available around the globe and each one of them react differently with Urban Heat Island effect in the streets, that is the reason that planners should be super careful while selecting the species during designing of streets. The landscape elements that have higher impact on solar radiation in a landscape are generally woody plants and solid structures. Not just the type of plants each and every part of the plants should be considered in such cases, like leaves, size, height every aspect matters and affects differently to the formation of UHI. Tree leaves have tendency to react differently to different conductance of heat some leaves allow radiation to transmitted through them (about 20%), absorb some radiation (about 50%) and reflect some radiation (about 30%).

Most scientist says that deciduous trees are best for urban canyons as they fall their leaves during winter season and allow maximum sunlight to both outdoor street spaces and indoor building spaces which further lead to reduce the overall building load as well. Whereas conifers are not that helpful during winter season since they block the large amount of sunlight hours falling on the streets but at the same time they provide year round shade to the streets. Therefore, both of the tree types are beneficial for UHI mitigation and it completely depends on the climate and UHI goals that which type of tree should be planted or the combination of both should be used.

The major aspect which should be taken in consideration while dealing with vegetation during the mitigation of UHI is the heat trapping. As we know that ground surfaces of urban canyons emit Terrestrial radiation which later gets trapped in the canopies of trees. Now what happens is that trees also doesn't like to keep the terrestrial radiation therefore they starts emitting it to the atmosphere and when the gust of wind hits the trees the air becomes warmer in the canyons.

Role of SVF (Sky View Factor) in UHI Effect

The very first thing which needs to understand is that what is SVF and why it is important to consider it during the process of UHI mitigation. SVF act as a measure in the field of urban climatology where it tells that how much sky is visible from a specific point (which can be anywhere on the site), this exposure of skies from specific points on the site is important to consider because SVF influence the amount of solar radiation received by the urban surfaces and how much sky is available for the convective heat exchange between atmosphere and the urban surfaces.

SVF can be rated in between 0 to 1 where 0 stands for no visibility and 1 stands for maximum visibility of the sky from the selected point. We can understand this in a better way by observing urban canyons as typical urban canyons holds mostly SVF values towards 0 due to the urban forms. Here due to lower SVF values in urban canyon or we can say less sky visibility the heat gets trapped in the atmosphere of urban canyon and due to limited solar access the process of radiative cooling stops which further leads to immensely dropping of Thermal comfort levels and increase in the UHI intensity of such canyons.

Whereas, streets with more open spaces or we can say higher SVF values tends to have lower UHI intensity due to adequate amount of solar access and radiative cooling. That is the reason that now-a-days planners are using SVF calculations for UHI mitigation and in order to increase the value of SVF they use strategies like building setbacks, Green belts, open spaces as all such strategies leads to reduce the UHI intensities in urban canyons.

Materials/albedo effect

The selection of materials is one of the most important factor when it comes to maintain the Thermal comfort levels of urban canyons. Materials holds numbers of properties which all varies from one

material to another but they all important to consider while selecting a material. In all of these properties the most important ones are Thermal properties as they directly influence the UHI intensity in the urban canyons due to the facts that how much amount of heat is being trapped or released during night hours. These properties not just affect the outdoor they majorly affect the indoors as well which further leads to increase or decrease the buildings energy demands.

Properties of Materials which are important to consider during the selection process : -

1. *Ability to absorb or reflect heat:* Different materials absorb or release amount of heat in the same atmosphere due the different albedo values. These different values impact indoors and outdoors of the buildings differently, here light colored materials like white absorbs less amount of heat and remains cooler whereas materials with dark color of shade like black gets heated easily due to high heat absorption rate.
2. *Insulation:* As we know that there are dedicated materials for insulating the building envelops like foam or gypsum boards, we such materials to insulate our indoors due to there high thermal resistance abilities. Such materials prevent heat transfers between indoor and outdoors therefore it is important to consider the insulation rate of materials while selecting them.
3. *Heat storage:* Most of the materials traps heat during day hours and release it during night hours but the amount of heat storage tendency differ from one material to another. These type of materials are known as Thermal mass materials for instance concrete or bricks. In order to balance the temperature difference in urban canyons it is important to keep in mind the amount of heat storage capacity of the material that we are selecting.
4. *Porosity of materials:* The numbers of voids present in a material defines porosity of materials. These voids can be cracks, holes or any other type of empty spaces within the materials. The porosity of materials can be beneficial in many ways. More voids in any material makes it lighter and enhance the insulation ability of the materials. Being porous also enhances the absorption ability of materials which further leads to water absorption as well which increases the evaporation rates and also adds up to the ground water recharge ability.

The Albedo Effect

The albedo effect is one of most important factors when it comes to UHI mitigation strategies, it is the ability of materials to reflect sunlight and absorb heat now what is important to take into consideration is that different materials comes with different albedo values, where high albedo materials absorbs less heat and holds high reflective properties, whereas low albedo materials absorbs more heat and reflect less sunlight which is not at all helpful towards UHI mitigation process.

There are dedicated Albedo ratings for each materials which makes it easier for the planners to select one from wide range of materials. The albedo ratings ranges from 0 to 1 where materials with 0 albedo ratings shows no reflection tendency and all of the heat gets trapped inside the material whereas materials with albedo ratings towards 1 shows the high reflection tendency where all of the heat gets reflected back and absorption of heat does not happens.

To understand the Albedo effect we will see some Albedo ratings of different materials, Asphalt - 0.1 to 0.3, as we studied above that darker shades gets easily hot due to high absorption ability and less reflective rate which makes asphalt a not a good option in UHI mitigation process.

Similarly, Light Roofing materials holds albedo ratings around 0.7 to 0.9 which makes such roof coatings a nice alternative to prevent heat gains and keeps the building envelop cooler.Planners and deigners can use albedo ratings to select the perfect materials for different kind of micro-climates and UHI goals in order to have favorable Thermal comfort levels and by this UHI effect can be easily mitigate and along with this we can easily reduce the overall energy demands of buildings within our urban canyons and improve thermal comfort not just for people in outdoors but also for the people inside the building envelopes.

Shadow patterns in urban canyons

As we are discussing about maintaining the Thermal comfort levels within urban canyons and how UHI intensity can be reduced. The basic solutions to all these issues are shadows and by using them smartly streets can be cooled down during daytime to reduce amount of solar radiation. There are numbers of ways by which we can manipulate the shadows according to our design proposal so that proposed spaces can have required numbers of sunlight hours.

But before initiating any strategy in urban canyons first we should analyse the existing shadow patterns of the built form or any other permanent element within the canyon. We can call this as Existing Shadow Pattern Analysis, which will only analyse shadows of all the existing buildings and elements only, which will include contextual buildings as well since they will also cast shadow on the site. After the Existing shadow pattern analysis we as planners can observe all the problematic areas in our urban canyon or the proposed site, we can point out the areas which will have sunlight hours of more than 6 to 8 hours a day and we can call such areas spaces with heat problems as due to such high numbers of sunlight hours these areas cannot will not be used by the users due to extreme heat conditions, whereas on the other hand we can observe the areas with less than 2 to 4 hours of sunlight in a day which is again problematic as sunlight is something which is not good if it is too much and it is also not good if it is too less therefore an adequate balance is required in the distribution of sunlight hours on the any proposed urban site.

Apart from spaces another element in urban canyons which requires proper consideration during existing shadow analysis is the building facades as they are also quite sensitive in this case , building facades should not be shaded whole day otherwise it will lead to uncomfortable conditions within indoors and increase the heating load during winters also. Therefore, building facades also requires at least 2 to 4 sunlight hours in a day in order to maintain adequate amount of thermal comfort levels. While placing trees planners should be very careful that where all tree shade will fall during whole day, that is why it is always advisable to analyse the trees possible shadow ranges at different intervals of time in a day before placing it in urban canyons.

Therefore, even if any facade is getting sunlight hours of more than 6 to 8 hours it should not be shaded by trees, all walls we can easily shade using green facades or climbers but windows should always remain exposed to sun to provide adequate amount of thermal comfort levels to the residents inside the building envelope.

Now after proper execution of Existing Shadow Range Analysis the next step is to take a closer look on the shading abilities of various elements that are proposed inside the urban canyons including the proposed trees and plantation. As mentioned above that each and every tree should be analyzed in order to decide their correct placement in the urban canyons not just placement by analyzing the shadow patterns of the proposed trees we can even find adequate distance between two trees as shadows should not overlap completely during any part of the day, that is why it is always suggested to analyze and see shadow patterns of trees at different intervals of time during a day in order to find correct place and distance from another tree in an urban canyon.

Apart from climatic aspects shadow patterns are important to analyze for some other important considerations which are described as follow -

1. *Street aesthetics*: Shadows add life to the urban canyons, as with shadows adds depth and visual appeal to the streets that is the reason that urban canyons which holds maximum sunlight hours due to poor urban forms are not very appealing and they face low footfall rates. Shadows are also important to manipulate as they enhance the quality of architectural elements present in the urban canyons.
2. *Public health*: Shades are required to allow users to come out of the buildings and enjoy the outdoor areas for performing recreational activities. Kids loves to play in outdoors but for them it is important that the play area should remain cool during the peak hours of day which can only happen by the adequate amount of shade falling on such areas. If all this doesn't happen residents does not like to step out of the buildings which directly affects their physical and mental health.

3. *Safety aspects*: Proper distribution of sunlight hours is also essential for urban living environment due to the safety aspects as well. As poor sunlight hours in an urban canyon brings dark streets which raise the safety issues for the residents for the evening hours, Therefore, designers and planners should analyse the shadow patterns and make sure that no space should remain dark during the late hours of the day.
4. *Seasonal considerations*: As we know that shadow patterns are not constant through out the year, different seasons brings different shadow patterns that is why it is important for the designers and planners to into consideration shadow patterns of all seasons of the site. So that proposed design doesn't fail during any season of the year.
5. *Balance in the biodiversity*: Proper sunlight is important for other habitats also as apart from humans other species needs adequate amount of sunlight hours to survive in any space. That is why a space filled with shadows does not allow various habitats to grow or develop within the urban canyons.

Human activities

As inside in urban canyons numbers of residents lives which includes various age groups of people. Each age group performs different types and numbers of activities in a day. Some of them just remain inside the buildings on the other hand some people like to stay out specially during weekends or holidays. As these age groups also includes senior citizens and they love to walk in morning or evenings while taking small breaks and performing social activities. Some people just step out to go to their offices or workplaces such people use urban canyons outdoors to just pass by they do not stay inside premises for much of the time. The point here is that there numbers of people in urban canyons who performs various activities and each of these activities require different thermal and micro-climatic conditions. That is why it is necessary for urban planners and designers to analyse before proceeding the design that what type of people are living and what are there daily schedule. So that they can know that at what time urban canyon footfall reaches to its peak levels and for this it is important to do an activity mapping for the concern site which will tell that what amount of people doing what type of activities at what time of the day so that accordingly UHI mitigation strategies can be made for the users to provide them the best possible Thermal comfort levels.

For instance, activities like jogging and running enhances the body heat production and metabolic heat changes for such users whereas activities like yoga, social gatherings does not brings in extra metabolic heat to the atmosphere but in this case both of the type of activities require different PET value to make users feel thermally comfortable and accordingly planners and designers can make alterations in design to provide shading and ventilation or any other possible additions to design.

Along with activity mapping another thing which is important to take into consideration is the clothing insulation that users of the concern urban canyon are wearing and during the whole year what all possible insulation layers that users wear is important to consider as clothing insulation is an important aspect to while calculating the PET value of any part of the site.

Other important aspect to consider while studying the human activities on a site is the zone on which specific activities will be performed as different zones on site at different places sometimes holds different types of micro-climatic conditions for example one end of the canyon can possibly remain hot during maximum part of the day due to the high sunlight hours whereas some other corner of canyon can have comparatively very less numbers of sunlight hours which will the space very cool as compared to the other end now in such case both of the zones hold different climatic levels therefore users performing activities in both zones requires different treatment in order to have adequate amount of thermal comfort levels.

One more aspect which influence the human activities on streets is the Cultural context of the place, many times cultural and social aspects brings in the types of activities that can happen on a street. For instance some places can have a culture to have outdoor gatherings at a fix day of every week at a fix time and such culture can attract lots of crowds and influence the thermal comfort dynamics.

Therefore, it is important to culture and history of a site as well in order to lead to a complete thermally comfortable environment.

CONCLUSION

This research explores strategies to lessen the effects of Urban Heat Islands (UHIs) inside canyons of our cities. There we see excessive accumulation of heat and very little movement of air leading to significant discomfort. Metrics like site analysis and simulations are used for a better understanding of this situation through research and these techniques are critical to making design guidelines we can use to improve temperature conditions and create city spaces that are more resilient. Results show that smart urban design is vital for reducing heat and introducing cooler and more comfortable spaces. Results are headed towards responsive urban planning to create livable and sustainable spaces that are truly healthier for people longterm.

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