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ORIGINAL

The Role of Green Spaces in Mitigating Urban Heat Island Effects and Promoting Community Health

El papel de los espacios verdes en la mitigación de los efectos de la isla de calor urbana y la promoción de la salud comunitaria

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ABSTRACT

Introduction: this study aimed to explore how green spaces contribute to reducing urban heat island effects and enhancing public health. The heat island effect is the tendency for urban areas to be warmer than rural areas, leading to environmental and health consequences. Green spaces, including parks, gardens, and trees, may counteract some of these effects by providing shade and cooling and by encouraging residents of cities to be physically active and to enjoy better mental health.
Method: a literature review was made to collect information on the advantages of green spaces in cities. Past researches which explored how green spaces help to reduce urban heat island effects and increase community health were obtained and examined. They also looked at case studies of cities that have implemented such initiatives, and examined their efficacy.
Results: the results of this study indicated that green spaces can be useful in reducing the urban heat island effect. Trees and other vegetation can lower surface temperatures in urban areas, provide shade, and enhance air quality. In addition, green spaces have been shown to contribute to community health by offering spaces for exercise, calming anxiety, and acting as a hub for socializing.
Conclusions: to sum up, the findings of the study provide evidence that green spaces are crucial in reducing the negative impacts of urban heat islands and enhance the well-being of communities. Vertical gardening, terrace gardening, etc. This highlights the need for urban planners and policymakers to prioritize the development and preservation of green spaces in cities to counteract the negative effects of urbanization and foster healthy, sustainable communities.

Keywords: Investigate; Mitigating; Phenomenon; Demonstrate; Prioritize.

RESUMEN

Introducción: este estudio pretendía explorar cómo contribuyen los espacios verdes a reducir los efectos de isla de calor urbano y a mejorar la salud pública. El efecto isla de calor es la tendencia de las zonas urbanas a ser más cálidas que las rurales, lo que tiene consecuencias para el medio ambiente y la salud. Los espacios verdes, incluidos parques, jardines y árboles, pueden contrarrestar algunos de estos efectos proporcionando sombra y refrigeración y animando a los residentes de las ciudades a ser físicamente activos y a disfrutar de una mejor salud mental.
Método: se realizó una revisión bibliográfica para recopilar información sobre las ventajas de los espacios verdes en las ciudades. Se obtuvieron y examinaron investigaciones anteriores que exploraban cómo los espacios verdes ayudan a reducir los efectos de la isla de calor urbana y a aumentar la salud de la comunidad. También se analizaron estudios de casos de ciudades que han puesto en marcha iniciativas de este tipo y se examinó su eficacia.

Resultados: los resultados de este estudio indicaron que los espacios verdes pueden ser útiles para reducir el efecto isla de calor urbano. Los árboles y otros tipos de vegetación pueden reducir las temperaturas superficiales en las zonas urbanas, proporcionar sombra y mejorar la calidad del aire. Además, se ha demostrado que los espacios verdes contribuyen a la salud de la comunidad al ofrecer espacios para hacer ejercicio, calmar la ansiedad y actuar como centro de socialización.
Conclusiones: en resumen, los resultados del estudio demuestran que los espacios verdes son cruciales para reducir los efectos negativos de las islas de calor urbanas y mejorar el bienestar de las comunidades. Jardinería vertical, jardinería en terrazas, etc. Esto pone de relieve la necesidad de que los planificadores urbanos y los responsables políticos den prioridad al desarrollo y la conservación de los espacios verdes en las ciudades para contrarrestar los efectos negativos de la urbanización y fomentar comunidades sanas y sostenibles.

Palabras clave: Investigar; Mitigar; Fenómeno; Demostrar; Priorizar.

INTRODUCTION

Green Places are a key component of any city and provide advantages for both people and climate. Urban Heat Island (UHI) effect – temperature differences phenomena induced by human activities and urban infrastructures is one of the actual urban central issues. The following rise in temperatures affects not only the environment but also endangers public health. Whereas the urban heat island (UHI) phenomenon can be mitigated through the use of green spaces in urban planning, helping to foster community health.[1] It occurs because there are no plants, and lots of concrete and asphalt, that absorb heat, as is the case in cities. These surfaces absorb heat, hold it and release heat, increasing the general heat of the whole city. Studies show UHI effects can result in urban areas experiencing temperatures 2-3 degrees Celsius warmer than surrounding rural areas. Such a significant temperature difference could not only affect the environment but also alter the daily lives of urban people.[2] Increasing the amount of green space, including parks, gardens, and urban forests, can help reduce UHI effect by providing shade, evaporative cooling, and reducing energy use. Trees absorb and sequester carbon dioxide—lessening air pollution—and act as natural air conditioners by releasing water vapor through transpiration. Urban green spaces can mitigate the heatisland effect by lowering air temperatures through shade and evapotranspiration.[3] In fact, a single tree can create the same cooling impact as 10 room-sized air conditioners. Thus, if we will have more and more green space in urban方面 we will combat that UHI effect by using less energy and decreasing the temperature. Alongside their capacity to alleviate UHI consequences, green spaces are central to advancing community health and well-being. Urban densities are often associated with poor air quality, poor diets, and sedentary lifestyles, leading to a myriad of health complications, including respiratory issues, obesity, and mental health disorders. Similarly, green environments offer the prospect of outdoor recreation, physical exercises, and stress relief, contributing to the well-being of the community as a whole.[4] They do age, but we find that the closer we are to green spaces, the better our mental health and the lower the level of stress. Urban parks are also serving as an escape from pollution, making the surrounding air more knife-friendly. Green spaces are very important as they enhance the overall quality of life in urban areas.[5] This provides a natural environment for biodiversity and ecological balance, with habitat and sustainability for wildlife. Green areas provide community meeting sites supporting social cohesion and sense of community. More evidence comes from studies that have found that areas with more green spaces have lower rates of crime because green spaces increase the buffer between residential areas and busy roads.[6] Moreover, parks and gardens raise property values surrounding them since they are considered pleasant and desired facilities among potential homeowners. In this sense, green spaces are not just nice to have, they create a better place to live and an economic asset for all. Along with making new green areas, it is also important to protect and maintain the already existing.[7] This involves preserving green spaces from development and making sure there is adequate funding for their upkeep. Helping community members feel a sense of ownership through involving them in planning and maintaining parks and green spaces is also key – as is instilling the idea of doing so as a matter of pride in the community. Internal issues with space, funding and competing priorities can make it difficult to integrate green spaces into urban environments. But many of these obstacles can be overcome[8] — with thoughtful planning and collaboration. This is done by integrating green space into already established structures—rooftops, walls, and vertical gardens—making ideal use of a scarce resource. Public-private partnerships, green infrastructure financing tools, etc. Urban planners may also collaborate with communities to ascertain their requirements and preferences and ensure the effective utilization and maintenance of green space.[9] The provision of green spaces is essential to reduce UHI impacts, improve community health, livability and economic value of urban areas. Integrating green spaces into urban development can help create not only sustainability, but also healthy cities for generations to come. Hence, the importance of green parts and measures to guarantee their conservation and growth in these settings must be

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understood.[10] The time to take action is now, we must observe that as our cities are expanding we also need to design the cities in a way where not only the cities could develop but also we maintain a proper balance between development and nature, this balance can be obtained through green spaces. The main contribution of the paper has the following:

- Urban Heat Island (UHI) effect is one of the major threats affecting urbanized regions and can be mitigated by Designated Green Spaces (DGS). Parks, tree-lined streets and rooftop gardens can add shade and cool the surrounding air through evapotranspiration. As a result, it helps bring down the overall temperature in urban areas, making them more comfortable for residents and cutting down energy usage on air conditioning.
- Also, green spaces help maintain the well-being of urban dwellers by providing a place for exercise and reducing air pollution and stress. Research has indicated that access to green spaces can reduce rates of obesity, heart disease and mental health illnesses. Provide peace away from the concrete jungle and a space for people to kick back, stay active and immerse themself into nature.
- Moreover, green spaces can contribute to biodiversity and ecosystem services in cities. These spaces can act as a habitat for insects, birds, and various other animals — which can promote overall health of local ecosystems. Moreover, parks play a key role in stormwater runoff management, air and noise pollution mitigation, and natural air conditioning and ventilation in buildings thus furthering development of green settlements.
- The remaining part of the research has the following chapters. Chapter 2 describes the recent works related to the research. Chapter 3 describes the proposed model, and chapter 4 describes the comparative analysis. Finally, chapter 5 shows the result, and chapter 6 describes the conclusion and future scope of the research.

METHOD

Table 1. Comparative Analysis of Existing Models

Author	Year	Advantage	Limitation
He, B. J.et,al.	2019	Reduced energy consumption and cost through the use of efficient thermal insulation materials and methods.	One limitation is the lack of standardized guidelines and regulations for implementing green building strategies in urban areas.
Degirmenci, K., et,al.	2021	The ability to implement targeted and effective solutions to reduce heat impact and improve urban livability.	Inadequate funding or resources may limit the effectiveness of policy and technology responses in mitigating urban heat islands.
Brown, H., et,al.	2018	Optimal use of space promotes physical activity and reduces air pollution, leading to better overall health and well-being.	Lack of accessibility for lower-income communities who may not have the resources to live in higher-density areas or maintain trees.
Leal Filho, W., et,al.	2021	Reducing energy costs and improving air quality by providing natural shade, cooling, and filtering of pollutants through green infrastructure.	Limited generalizability due to specific geographic and socioeconomic variations in urban areas around the world.
Houghton, A., et,al.	2019	Improved public health and wellbeing, as green building design can reduce the negative impacts of extreme heat on communities.	Limited availability of studies examining the relationship between green building design and community health resilience to extreme heat events.
Kondo, K., et,al.	2021	Improved resilience of cities to climate change impacts, leading to more sustainable and liveable urban environments for residents.	Difficulty in accurately predicting future climate change impacts and individual responses.
Wang, X., et,al.	2021	Trees provide greater cooling effects in urban areas with higher diversity, improving overall climatic conditions and quality of life.	Lack of consideration for non-tree vegetation and potential influence of other factors in urban heat island mitigation.
Ruiz-Aviles, V., et,al.	2020	Reduced energy consumption and cost for cooling buildings due to natural shading and cooling effects of green infrastructure.	Potential high cost and limited scalability of implementing green infrastructure projects may make it difficult to implement on a large scale.
Khare, V. R., et,al.	2021	Promotion of sustainable urban development and improvement of quality of life in cities while reducing energy consumption and emissions.	Lack of comprehensive data and research on the effectiveness of specific mitigation strategies in the Indian context.
Jamei, E., et,al.	2019	Decreased energy consumption and associated cost savings due to reduced urban heat island effect.	Limitation of WSUD: Lack of scalability and adaptability to different urban contexts and climates.

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A has discussed. Intelligent design and the use of climate-friendly materials and technologies will be foundational to the next generation of green buildings, which will focus on mitigating the urban heat island effect. This method will lead not only to new energy efficient buildings but also to cooling urban areas and improving living standards. Degirmenci, K., teal. covered such hot spots in urban heat islands, the areas of land which are significantly warmer than the areas surrounding them due to the activities of man and urbanization. 1 (Urban Heat Islands: At the lowest level, there are policy and technology responses aimed at combating urban heat islands. Brown H., et al. communities is discussed in Ref. as neighborhoods that encourage urban density, appropriate tree equity and public health. They aim to minimise urban heat island effect and for community green spaces to support physical and mental wellbeing. To mitigate this, such communities promote walkability and cycling to minimise air pollution and encourage a healthy and active lifestyle. Leal Filo, W., teal. Urban Heat Islands are areas that are significantly hotter than their rural surroundings due to human pursuits and disappearance of vegetation. The link between trees, green roofs, and other natural infrastructure patient on green infrastructure has been shown to reduce this effect in cities globally. Houghton, A., teal. have discussed. Many recent studies have further explored how climate change in the form of extreme heat events connects with built environment changes, with some showing that incorporating green building design strategies can promote community health resilience to extreme heat events. It reviews the body of evidence available to date and posits that green building practices may be a promising avenue to mitigate negative health impacts from extreme heat exposures at the community level.

Kondo, K., teal. note that urban dwellers adopt strategies to mitigate the conflicting effects of climate change and the urban heat island effect, including means of emission reduction, adaptation to the new climate and extreme heat. It involves balancing contradictory behaviors, like using air conditioning but also cutting down on energy use. Wang, X., teal. have discussed. Studies have demonstrated that the quantity and variety of tree species in urban greenspaces can radically influence the amelioration of urban heat island effect. The increasing species richness and diversity from greenspaces help increase their cooling effects on the surrounding area, contributing to vital urban climate and human health benefits. Ruiz-Aviles, V., teal. Urban heat island effects can be mitigated by providing shade, evaporative surface cooling, and lowering surface temperatures (pervious areas) through the use of Green infrastructure like constructed wetlands and neighborhood development . These designs can be beneficial to cities, as it can reduce the effects of urban heat islands and promote better quality in cities. Hare, V. R., teal. wrote about urban heat islands, or urbanized regions that are much hotter than their nonurban surroundings due to human agency. It is imperative that measures to counteract UHI adverse effects in India such as creating green cover, cool roofs, pavements, and energy-efficient buildings are considered first. Steps taken in this direction will help to lower temperatures and make Indian cities more livable. Jamie, E., teal. have explained WSUD (i.e., Water Sensitive Urban Design), a sustainable urban planning and design approach that promotes environmentally sound management of the urban water cycle. It can also help manage urban heat islands by means of green space, fantastic materials, and managing floor water runoff to manage temperatures.

DEVELOPMENT

Urban Heat Island Effect + Community Health Focus: The proposed development seeks to combat two major urban issues. Compared to the countryside, urban areas are hotter and this is primarily the influence of concrete and asphalt which is abundant in cities, where heat is stored. This can increase power usage and significantly affect health, including heat-related conditions. This development aims to address this problem within cities by minimising gentrification and facilitating access to inner-city green spaces. Parks, gardens, trees and other green spaces can absorb heat, provide shade and cool their surroundings. This helps mitigate the heat island effect found in dense urban areas and contributes to a more pleasant, human-friendly environment for a city's inhabitants. Green spaces have also been shown to benefit community health. What makes LP a place of urban green which contributes to sustainable and healthy environment in urban areas. They mean spaces in the city that are clothed with vegetation: gardens, parks, green facades, green roofs and urban forests. Urban gardens are small-scale plots of land planted by residents or community groups, often in backyards or on empty lots. Apart from the visual appeal, these gardens have multiple advantages. They filter out air pollutants, mitigate urban heat island effect, and promote community interaction. Figure 1 shows the Proposed Development Model.

Green facades are vertical vegetation patches fixed to the outer walls of buildings. These can range from straightforward trellises adorned with climbing plants to intricate living walls featuring a diverse array of plant species. But instead, green facades filter and purify the air, incorporating and minimizing air pollutants, insulating buildings and minimizing the need for heating and air conditioning. Another form of urban greenery is the green roof, where vegetation is planted on the roof (see for more details). Beyond aesthetic appeal that enhances the city's skyline, green roofs also aid in building insulation, energy efficiency, and stormwater management. Green roofs absorb and hold rainwater to help alleviate pressures on city stormwater systems. Abstract—Urban forests are defined as areas with higher density of trees and natural vegetation. These forests

offer vital ecosystem benefits, including air purification, carbon storage, and biodiversity conservation. They also provide the city's residents with spaces for recreation and help to mitigate the urban heat island effect. Local small parks are green areas, providing places for sports and community gatherings. They frequently include features like playgrounds, seating areas, and sports facilities. They create space for physical activity, increase air quality, and allow for social connections. Because areas of the city have more concrete and less greenery, the development makes a commitment to creating green spaces in these low-income, underserved communities. The development focuses on an environmentally friendly item where green space and green features are promoted and integrated into urban commerce. It will benefit both people and the environment, making cities more resilient and liveable in the face of climate change.

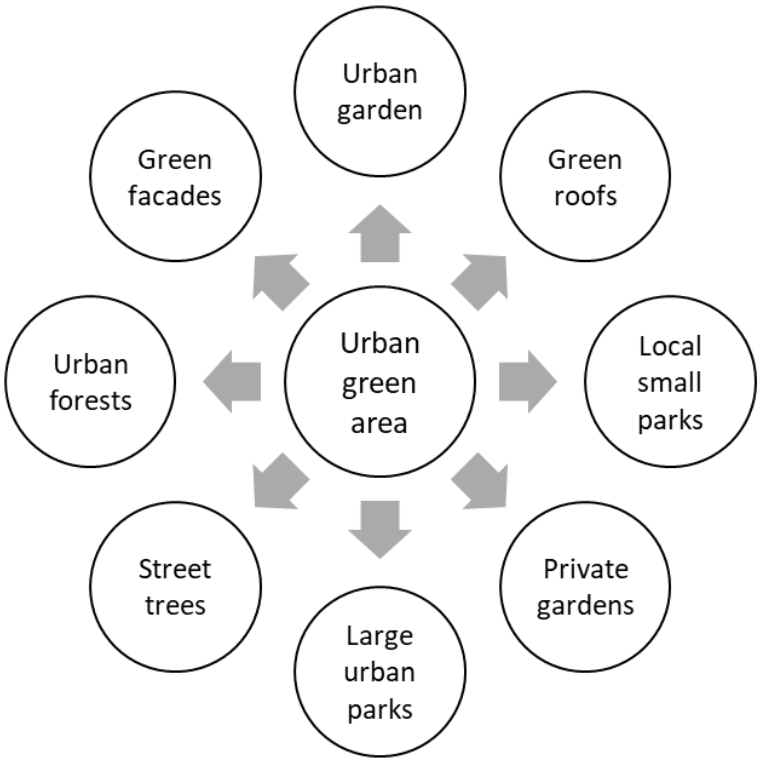

Figure 1. Proposed Development Model

RESULTS AND DISCUSSION

"This study shows that green spaces are a pivotal component in reducing the urban heat island effect and supporting community health. Green spaces (parks, gardens, trees) in urban areas lead to a reduction of the overall temperature due to shading and evaporative cooling. This can help mitigate the warming effect urban settings experience, caused in part by the reflective properties of concrete and asphalt. Additionally, the presence of green spaces has been associated with better air quality, decreased noise pollution, and higher rates of physical activity, which contribute to common health benefits in the community. The benefits include a reduced risk of respiratory illnesses, better mental health, and a greater chance for social contact. Discussion of these findings suggests that the integration of green spaces in urban planning and hosting can reduce the negative aspects of urbanization towards community health. It also stresses the importance of maintaining and increasing existing green spaces in cities for the health of citizens.

Ambient Temperature Reduction

Ambient Temperature Reduction is the lowering of the overall temperature of the environment in a city (or urban area) by means of implementing strategies and techniques.

This especially means green spaces — parks, gardens and green roofs, which suck up and dissipate excess heat, creating a cooling effect. The built environment can also help in reduction of ambient temperature through enhancing surface albedo, minimizing impervious surfaces and use of superb materials in construction. Figure 2 shows the computation of Ambient Temperature Reduction.

Table 2. Comparison of ambient temperature reduction

No. of Inputs	Comparison Models				
	SCS	IJER	WP	GBDS	Proposed Model
100	36,1	32,3	34	35,2	46,5
200	30,2	31,5	33,4	35,8	46,7
300	32,7	34,2	30,4	31,8	45
400	34,8	30,6	32,9	36,1	48,1
500	35,4	36,3	31	33,7	47,5

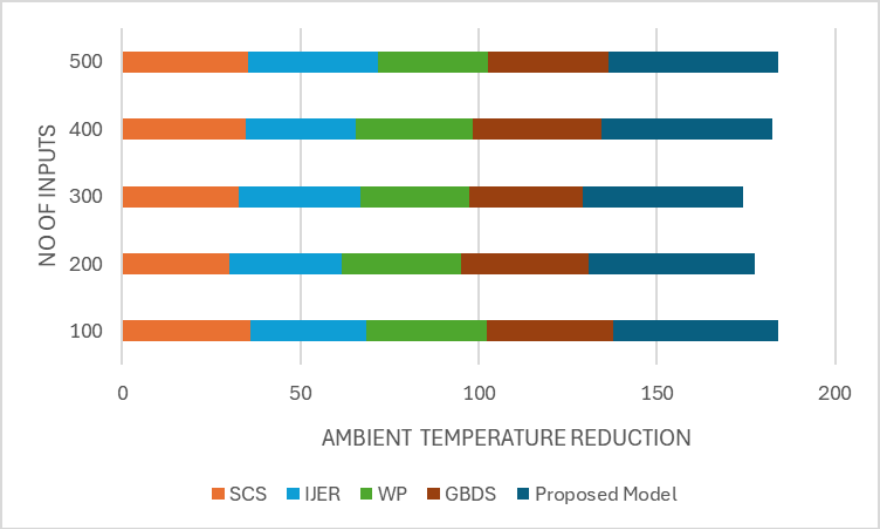

Figure 2. computation of Ambient Temperature Reduction

These approaches are critical for reducing the Urban Heat Island phenomenon, wherein urban regions are relatively hotter than outlying areas caused by human and lack of green space. Implementing these strategies can also positively impact community health by reducing heat-related illnesses that can occur when temperatures are elevated.

Air Quality Improvement

Green spaces (parks and gardens) help to improve the air quality in the urban area. They mitigate urban heat island effects, when cities become much hotter than rural areas around them because of all the heat-absorbing surfaces.

Table 3. Comparison of Air Quality Improvement

No. of Inputs	Comparison Models				
	SCS	IJER	WP	GBDS	Proposed Model
10	30,3	31,6	33	34,7	36,1
20	32	33,5	35	36,4	38,4
30	31,2	32,7	34,1	35,6	37,9
40	33,3	34,9	36,2	30,2	37,5
50	35,5	30,8	32,3	33,8	36

Green spaces can decrease the temperature of the surface layer of the atmosphere and air temperatures provide shade and cooling effects) that leads to reduction in formation of air pollutants and improves air quality for neighbouring communities. Figure 3 shows the computation of Air Quality Improvement.

These open spaces also encourage an active lifestyle and community connection, which are essential to both physical and mental well-being. This emphasizes the significance of establishing and sustaining green spaces within urban areas to enhance air quality and community wellness.

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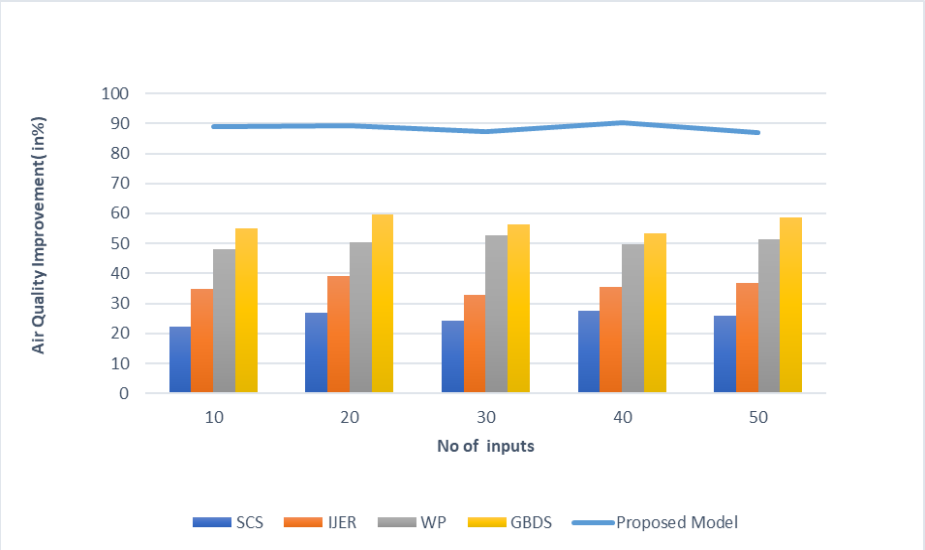

Figure 3. computation of Air Quality Improvement

Stormwater Management

Storm water management: The collection, treatment and disposal of all forms of runoff associated with precipitation events such as rain water, snow melt. This helps protect natural water systems from pollution, and it also lessens the risk of flooding and erosion.

Table 4. Comparison of storm water management

No. of Inputs	Comparison Models				
	SCS	IJER	WP	GBDS	Proposed Model
100	32,4	33,8	35,2	36,6	37,3
200	33	34,4	30,9	32,2	35,6
300	34,6	30,5	31,3	36,3	37,8
400	30,7	32,2	33,6	35	36,4
500	35,5	36,1	31,2	33,7	37,4

It is the use of various techniques and infrastructure including detention basins, rain gardens, green roofs, and permeable pavements to control and treat storm water prior to entering rivers, lakes and oceans. Figure 4 shows the computation of Storm water Management.

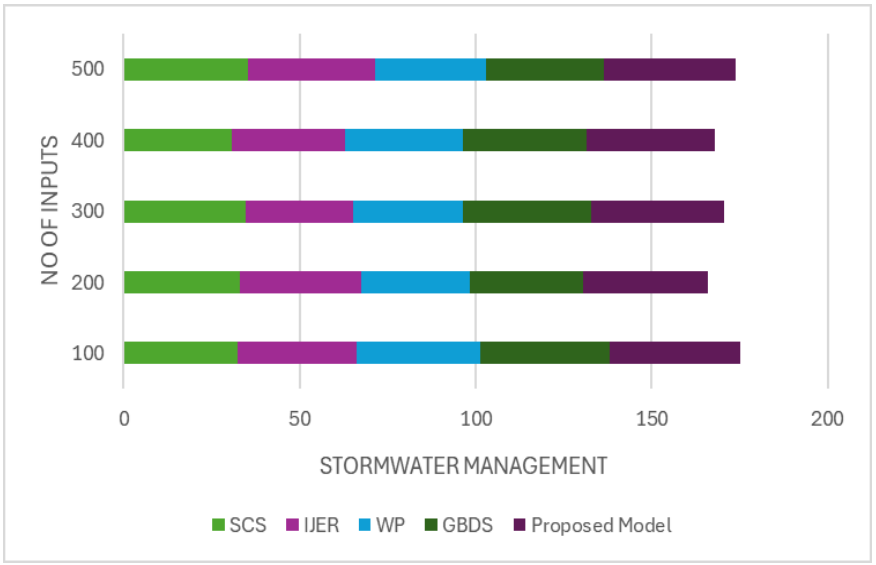

Figure 4. computation of Stormwater Management

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Parks, gardens, and trees are also forms of green space that help manage stormwater, absorbing and filtering runoff that would otherwise go into storm drains and sewers. In addition to reducing stormwater runoff, green areas can help reduce the urban heat island effect, which can help with community health by lowering temperatures and levels of air pollution.

CONCLUSIONS

Urban green space is valuable to mitigate the heat island phenomenon (UHI) and also a key to urban public health. Green spaces can significantly reduce surface temperatures through shading and evaporative cooling, therefore working against the UHI effect. That not only makes life better for the people who live in our urban spaces, but it has incredible environmental benefits. Urban green areas also provide health benefits to city dwellers both physically as well as mentally. And they offer physical activity opportunities in the form of walking, jogging, and outdoor play that can improve physical fitness and overall health. Spending time in green spaces has a likewise beneficial impact on mental health, lowering stress and encouraging relaxation. Plants and trees absorb the impurities and pollutants in the air thus contributing to the reduction of air pollution in urban spaces. For urban residents, this can help mitigate respiratory diseases and have a positive impact on respiration function. Urban green spaces promote both environmental sustainability and community/individual health. This means that when city planners, architects, and policymakers are designing and constructing urban environments, they must prioritize the creation and maintenance of green spaces. Not only will this create a healthier living environment, but it'll also improve the health and well being of the population as a whole.

BIBLIOGRAPHIC REFERENCES

1. He, B. J. (2019). Towards the next generation of green building for urban heat island mitigation: Zero UHI impact building. Sustainable Cities and Society, 50, 101647.

2. Degirmenci, K., Desouza, K. C., Fieuw, W., Watson, R. T., & Yigitcanlar, T. (2021). Understanding policy and technology responses in mitigating urban heat islands: A literature review and directions for future research. Sustainable Cities and Society, 70, 102873.

3. Brown, H., Proust, K., Newell, B., Spickett, J., Capon, T., & Bartholomew, L. (2018). Cool communities—Urban density, trees, and health. International journal of environmental research and public health, 15(7), 1547.

4. Leal Filho, W., Wolf, F., Castro-Díaz, R., Li, C., Ojeh, V. N., Gutiérrez, N., ... & Bönecke, J. (2021). Addressing the urban heat islands effect: A cross-country assessment of the role of green infrastructure. Sustainability, 13(2), 753.

5. Houghton, A., & Castillo-Salgado, C. (2019). Associations between green building design strategies and community health resilience to extreme heat events: a systematic review of the evidence. International journal of environmental research and public health, 16(4), 663.

6. Kondo, K., Mabon, L., Bi, Y., Chen, Y., & Hayabuchi, Y. (2021). Balancing conflicting mitigation and adaptation behaviours of urban residents under climate change and the urban heat island effect. Sustainable Cities and Society, 65, 102585.

7. Wang, X., Dallimer, M., Scott, C. E., Shi, W., & Gao, J. (2021). Tree species richness and diversity predicts the magnitude of urban heat island mitigation effects of greenspaces. Science of The Total Environment, 770, 145211.

8. Ruiz-Aviles, V., Brazel, A., Davis, J. M., & Pijawka, D. (2020). Mitigation of urban heat island effects through "green infrastructure": integrated design of constructed wetlands and neighborhood development. Urban Science, 4(4), 78.

9. Khare, V. R., Vajpai, A., & Gupta, D. (2021). A big picture of urban heat island mitigation strategies and recommendation for India. Urban Climate, 37, 100845.

10. Jamei, E., & Tapper, N. (2019). WSUD and urban heat island effect mitigation. In Approaches to water sensitive urban design (pp. 381-407). Woodhead Publishing.

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