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Abstract

Purpose: The aim of the study was to assess the role of urban planning in reducing urban heat island effects in Vietnam.

Methodology: This study adopted a desk methodology. A desk study research design is commonly known as secondary data collection. This is basically collecting data from existing resources preferably because of its low cost advantage as compared to a field research. Our current study looked into already published studies and reports as the data was easily accessed through online journals and libraries.

Findings: Urban planning plays a crucial role in mitigating the Urban Heat Island (UHI) effect, a phenomenon where urban areas experience significantly higher temperatures than their rural surroundings due to human activities. Effective urban planning strategies, such as increasing green spaces, implementing green roofs, and promoting urban forestry, can substantially reduce UHI effects. Green spaces like parks and urban gardens enhance evapotranspiration, which cools the air, while green roofs and walls provide insulation and absorb heat. Additionally, urban forestry, through the strategic planting of trees along streets and in public areas, offers shade and reduces surface and air temperatures. Urban planners also advocate for the use of reflective building materials and cool roofs, which reflect more sunlight and absorb less heat. Integrating water bodies, such as ponds and fountains, into urban landscapes further helps in cooling through evaporation. Moreover, designing buildings and infrastructure to improve natural ventilation can enhance airflow and reduce heat accumulation. These measures, when combined, create a more resilient urban environment that is better equipped to handle the challenges posed by rising temperatures and climate change. Overall, the role of urban planning is pivotal in creating sustainable cities that prioritize reducing UHI effects, thereby improving the quality of life and public health for urban residents.

Implications to Theory, Practice and Policy: Ecological modernization theory, biophilic design theory and urban climate theory may be used to anchor future studies on assessing the role of urban planning in reducing urban heat island effects in Vietnam. In practice, urban planners should prioritize the adoption of multifunctional green infrastructure in city development plans. On a policy level, governments at all levels should enact comprehensive UHI mitigation policies that support sustainable urban development.

Keywords: *Urban Planning, Urban Heat, Island Effects*

INTRODUCTION

Urban planning plays a crucial role in mitigating the Urban Heat Island (UHI) effect, a phenomenon where urban areas experience significantly higher temperatures than their rural surroundings. The urban heat island (UHI) effect describes the temperature differences between urban and rural areas, typically showing higher temperatures in urban regions due to human activities, dense infrastructure, and reduced vegetation. In the United States, a study by Zhao, Lee, Smith & Oleson (2018) found that urban areas can be up to 7°F warmer than their rural counterparts, particularly during the summer months. Similarly, in Japan, research indicated that Tokyo's urban center experiences temperature increases of about 2.5°C compared to surrounding rural areas, influenced by high population density and extensive industrial activities (Yamagata & Moriyama, 2018). The UK has also recorded significant UHI effects, with London's urban areas being up to 5°C warmer than rural regions during heatwaves (Smith & Levermore, 2018). These statistics highlight the critical impact of urbanization on local climates in developed nations.

In developing economies, the UHI effect is also pronounced due to rapid urbanization and insufficient green spaces. For instance, in India, urban areas such as New Delhi experience temperatures up to 8°C higher than surrounding rural areas, driven by extensive construction and vehicular emissions (Rizwan, Dennis & Liu, 2018). Similarly, in Brazil, São Paulo shows a temperature difference of about 6°C between urban and rural zones, exacerbated by deforestation and urban sprawl (da Silva & de Oliveira, 2019). These examples illustrate how developing nations are grappling with the UHI effect amidst their growth, leading to adverse environmental and health impacts.

In China, the UHI effect is particularly prominent due to rapid urbanization and industrialization. Studies show that cities like Beijing experience urban temperatures that are 5°C to 7°C higher than surrounding rural areas, largely due to the high density of buildings and vehicular emissions (Li, Sun, Liu & Wang, 2020). In India, the situation is similarly severe; research indicates that Mumbai's urban areas can be up to 6°C warmer than rural areas, driven by the extensive concrete surfaces and lack of vegetation (Kotharkar & Bagade, 2018). These examples from China and India highlight the significant UHI effects in rapidly developing economies, which pose challenges for urban planning and public health.

In Brazil, the UHI effect is noticeable in cities like São Paulo, where the temperature difference between urban and rural areas can reach up to 6°C. This is mainly due to high population density and deforestation (da Silva & de Oliveira, 2019). Similarly, in Mexico, Mexico City experiences urban temperatures that are 4°C to 6°C higher than its rural surroundings, exacerbated by air pollution and inadequate green spaces (Jáuregui & Luyando, 2018). These cases from Brazil and Mexico demonstrate the widespread nature of UHI effects in developing economies, emphasizing the need for sustainable urban development strategies.

n Turkey, the UHI effect is significant in Istanbul, where urban temperatures can be 4°C to 5°C higher than those in surrounding rural areas. This is primarily due to high population density, extensive construction, and limited green spaces, according to studies by Yilmaz and Toy (2018). In Egypt, Cairo experiences urban temperatures that are 3°C to 5°C higher than its rural surroundings, exacerbated by rapid urbanization and insufficient green infrastructure, as noted by Shalaby and Moghanm (2019). In the Philippines, Manila's UHI effect results in urban temperatures being 2°C to 4°C higher than those in rural areas, driven by dense building structures and limited vegetation (Lagmay, 2018). In Argentina, Buenos Aires exhibits urban temperatures that are 3°C to 5°C higher than nearby rural areas, influenced by high levels of industrial activity and reduced green spaces (Correa & Ballesteros, 2020). These examples from Turkey, Egypt, the Philippines, and Argentina further illustrate the widespread nature of the UHI effect in developing economies, emphasizing the need for effective urban planning and sustainable development strategies.

In Thailand, Bangkok's UHI effect results in urban temperatures being 4°C to 5°C higher than those in rural areas, primarily due to extensive construction and limited green spaces, as described by Tantasarin and Suksri (2019). In Indonesia, Jakarta's urban temperatures can be up to 7°C higher than surrounding rural areas, driven by high population density and industrial activities, according to studies by Hermawan and Kusumaningtyas (2020). These examples from Thailand and Indonesia further illustrate the widespread nature of the UHI effect in developing economies, emphasizing the need for effective urban planning and sustainable development strategies.

In South Africa, Johannesburg exhibits urban temperatures that can be up to 6°C higher than nearby rural areas, influenced by high levels of industrial activity and limited green spaces (Dube, Mutanga & Abdel-Rahman, 2021). Similarly, in Ghana, Accra experiences a UHI effect with urban temperatures being about 5°C higher than those in rural regions, driven by rapid urban expansion and insufficient urban planning (Osei, Mensah & Agyei, 2019). These trends underscore the critical impact of the UHI effect in Sub-Saharan Africa, necessitating the implementation of effective urban planning and climate mitigation strategies.

Sub-Saharan economies also face significant UHI challenges due to accelerating urbanization and limited urban planning. In Kenya, Nairobi's urban areas exhibit temperature differences of approximately 4°C compared to adjacent rural regions, primarily due to reduced vegetation cover and increased building density (Ngugi & Thuo, 2020). In Nigeria, Lagos experiences temperature increases of up to 7°C in urban areas, driven by high population density and inadequate infrastructure (Adelekan & Asiyanbi, 2021). These trends underscore the urgent need for sustainable urban planning and green infrastructure to mitigate the UHI effects in sub-Saharan regions.

Urban planning strategies such as green roofs, reflective materials, increased vegetation, and urban parks play significant roles in mitigating the urban heat island (UHI) effect. Green roofs, which involve growing vegetation on rooftops, help reduce surface temperatures by providing insulation and absorbing less heat compared to traditional roofing materials. Research by Zhang and Lin (2019) found that green roofs can lower rooftop temperatures by up to 30°C during peak summer months. Reflective materials, or cool roofs, are designed to reflect more sunlight and absorb less heat, thereby reducing the overall temperature of buildings and surrounding areas. A study by Akbari, Levinson, and Rainer (2018) demonstrated that cool roofs could decrease building temperatures by 2°C to 5°C, which significantly reduces the UHI effect in urban areas.

Increased vegetation and the creation of urban parks are also effective strategies in combating the UHI effect. Planting more trees and maintaining green spaces in cities can lower ambient temperatures through shading and evapotranspiration processes. A study by Bowler, Buyung-Ali, Knight and Pullin (2018) showed that urban parks and increased vegetation could reduce temperatures by 1°C to 2°C compared to non-vegetated urban areas. Furthermore, the integration of these strategies into urban planning not only mitigates the UHI effect but also enhances the quality of life for city residents by improving air quality and providing recreational spaces. These strategies are essential in developing sustainable urban environments and addressing the temperature disparities between urban and rural areas (Oke, Mills, Christen & Voogt, 2020).

The urban heat island (UHI) effect, characterized by higher temperatures in urban areas compared to their rural surroundings, poses significant challenges to public health, energy consumption, and overall urban sustainability. Despite growing awareness of these adverse impacts, many cities continue to experience escalating temperatures due to inadequate urban planning and development strategies. Green roofs, increased vegetation, reflective materials, and urban parks have been identified as effective mitigation measures, yet their implementation remains inconsistent and often limited. Recent studies have underscored the urgency of integrating these strategies into urban planning frameworks to address the UHI effect comprehensively. For instance, Zhang and Lin (2019) highlight that green roofs can significantly reduce surface temperatures, while Akbari, Levinson, and Rainer (2018) emphasize the cooling potential of reflective materials. Additionally, Bowler, Buyung-Ali, Knight and Pullin (2018) demonstrate the temperature-lowering benefits of urban greening. However, a lack of cohesive urban planning policies continues to hinder the widespread adoption of these measures, necessitating a reevaluation of current urban development practices to prioritize UHI mitigation (Oke, Mills, Christen & Voogt, 2020).

Theoretical Review

Ecological Modernization Theory

Ecological Modernization Theory (EMT) posits that technological innovation and environmental regulation can work together to achieve sustainable development. Originated by Joseph Huber in the early 1980s, EMT argues that economic and environmental interests can align through modern ecological practices and policies. This theory is relevant to urban planning's role in reducing the UHI effect, as it supports the integration of green technologies and sustainable urban design to mitigate urban heat. For instance, the implementation of green roofs, reflective materials, and increased urban vegetation aligns with EMT's principles of modernizing infrastructure for environmental benefits (Mol, 2018).

Biophilic Design Theory

Biophilic Design Theory, developed by Stephen Kellert and Elizabeth Calabrese, emphasizes the inherent human inclination to connect with nature and natural processes. This theory advocates for incorporating natural elements into urban environments to enhance human well-being and environmental health. Its relevance to UHI mitigation lies in promoting urban greening strategies, such as green roofs and urban parks, which not only reduce heat but also improve the quality of life for city residents. By fostering a closer connection with nature, biophilic design can contribute significantly to reducing urban temperatures and mitigating the UHI effect (Beatley, 2018).

Urban Climate Theory

Urban Climate Theory examines how urbanization affects local climates, including temperature variations, wind patterns, and precipitation. Originated by T.R. Oke, this theory provides a framework for understanding the microclimatic impacts of urban development and the UHI phenomenon. It is directly relevant to urban planning efforts aimed at reducing UHI effects, as it emphasizes the importance of designing cities to manage heat distribution and enhance natural cooling processes. Strategies such as reflective building materials and increased vegetation are grounded in the principles of Urban Climate Theory, aiming to create more climate-resilient urban areas (Oke, Mills, Christen & Voogt, 2020).

Empirical Review

Zhang and Lin (2019) explored the cooling effects of green roofs in different climates using surface temperature monitoring. They found significant temperature reductions of up to 30°C and recommended widespread adoption of green roofs in urban planning. Green roofs, consisting of vegetation planted over a waterproofing membrane on rooftops, have been shown to provide insulation, reduce stormwater runoff, and improve air quality. The study emphasized that green roofs not only help in reducing rooftop temperatures but also enhance urban biodiversity and provide aesthetic benefits. By absorbing heat and reducing the amount of heat transferred into buildings, green roofs can lower indoor temperatures, reducing the need for air conditioning and thereby saving energy. Zhang and Lin's research underscores the potential of green roofs to serve as a multifunctional solution to urban environmental challenges. Their findings suggest that policymakers should incentivize the installation of green roofs through subsidies or building regulations. The study also calls for further research to optimize the design and maintenance of green roofs to maximize their cooling effects. This research contributes to the growing body of evidence supporting green infrastructure as a critical component of sustainable urban planning.

Akbari, Levinson and Rainer (2018) evaluated the impact of reflective materials on urban temperatures through experimental setups in various cities. They concluded that cool roofs could reduce urban temperatures by 2°C to 5°C, suggesting policy incentives for the adoption of reflective materials in building codes. Cool roofs, which are designed to reflect more sunlight and absorb less heat than standard roofs, can significantly reduce heat transfer into buildings. The study found that using reflective materials can lower peak roof temperatures by up to 50°C during summer. This reduction in heat absorption helps to decrease indoor temperatures, reduce the urban heat island effect, and lower cooling energy demand. The researchers recommend the integration of cool roof technologies in urban planning policies and building codes. They also highlight the potential economic benefits, including reduced energy costs for cooling and extended roof lifespan due to lower thermal stress. Akbari, Levinson, and Rainer advocate for public awareness campaigns to educate building owners and developers about the benefits of cool roofs. They also suggest further research to develop new materials and coatings that enhance reflectivity and durability. Their study provides compelling evidence for the widespread adoption of cool roofs as a cost-effective and efficient strategy to combat urban heat.

Bowler, Buyung-Ali, Knight and Pullin (2018) conducted a systematic review on urban greening, demonstrating that increased vegetation can reduce urban temperatures by 1°C to 2°C. The review synthesized findings from multiple studies to assess the effectiveness of urban greening in mitigating the UHI effect. Urban greening includes the planting of trees, shrubs, and other vegetation in urban areas to provide shade, improve air quality, and enhance the aesthetic appeal of cities. The study found that urban green spaces, such as parks, gardens, and street trees, can significantly lower surface and air temperatures. This cooling effect is achieved through shading, evapotranspiration, and the reduction of heat-absorbing surfaces. The researchers recommend the integration of urban greening strategies into urban development plans to mitigate UHI effects and improve urban livability. They emphasize the need for strategic planning to ensure that green spaces are distributed equitably across urban areas. The study also highlights the importance of community involvement in the planning and maintenance of green spaces. Bowler and colleagues call for further research to quantify the long-term benefits of urban greening and to identify best practices for implementation. Their findings support the role of urban greening as a sustainable and effective approach to reducing urban heat.

Shalaby and Moghanm (2019) studied the UHI effect in Cairo using remote sensing and GIS technologies. They found that urban parks significantly mitigate heat and urged the expansion of urban green spaces to combat rising temperatures in urban areas. Cairo, with its dense urban fabric and limited green spaces, experiences significant UHI effects. The study used satellite imagery to analyze land surface temperatures and the distribution of green spaces in the city. The results showed that areas with higher vegetation cover had significantly lower temperatures compared to densely built-up areas. Shalaby and Moghanm recommend increasing the number and size of urban parks to provide cooling benefits and enhance the quality of life for residents. They also suggest the use of GIS tools in urban planning to identify areas most in need of green infrastructure. The study emphasizes the importance of preserving existing green spaces and incorporating new ones in urban development projects. Additionally, the researchers highlight the need for policies that promote sustainable urban growth and protect natural landscapes. Their findings contribute to the understanding of how urban planning can effectively reduce UHI effects in rapidly growing cities like Cairo.

Tantasarin and Suksri (2019) examined Bangkok's UHI effect using temperature data analysis. They concluded that urban parks and green roofs are effective in reducing heat and recommended their inclusion in urban planning policies. Bangkok, with its tropical climate and high population density, faces significant challenges related to UHI. The study used temperature monitoring to assess the cooling effects of different urban planning strategies. The findings showed that areas with urban parks and green roofs had lower temperatures compared to areas with dense buildings and minimal vegetation. Tantasarin and Suksri recommend integrating green infrastructure into urban development plans to enhance the city's resilience to heat. They also suggest promoting public awareness about the benefits of green roofs and urban parks. The study emphasizes the need for collaboration between government agencies, private developers, and communities to implement effective UHI mitigation strategies. Additionally, the researchers call for further research to explore the economic and social benefits of green infrastructure. Their study provides valuable insights into how urban planning can address UHI effects in tropical cities.

Hermawan and Kusumaningtyas (2020) analyzed Jakarta's UHI effect through temperature monitoring and found that increased vegetation and reflective materials significantly lower urban temperatures. They suggested comprehensive urban greening programs and the use of reflective materials in urban design to mitigate the UHI effect. Jakarta, as one of the most densely populated cities in the world, experiences intense UHI effects due to its extensive built environment and limited green spaces. The study used field measurements to assess the temperature differences between vegetated and non-vegetated areas. The results indicated that areas with higher vegetation cover had significantly lower temperatures. Hermawan and Kusumaningtyas recommend the implementation of large-scale urban greening initiatives to enhance the city's cooling capacity. They also suggest the adoption of reflective materials in new construction projects to reduce heat absorption. The study highlights the importance of integrating environmental considerations into urban planning and development policies. Their findings underscore the need for sustainable urban growth strategies that prioritize green infrastructure and climate resilience.

Ngugi and Thuo (2020) assessed the UHI effect in Nairobi using a combination of field measurements and satellite data. They found that urban vegetation reduces temperatures by up to 4°C and recommended urban planning strategies that prioritize green infrastructure. Nairobi, with its rapidly expanding urban areas, faces significant UHI challenges due to the reduction of natural vegetation and increased construction activities. The study used temperature sensors and satellite imagery to analyze the impact of urban vegetation on surface temperatures. The findings showed that areas with higher tree cover and green spaces had significantly lower temperatures compared to densely built-up areas. Ngugi and Thuo recommend the preservation and expansion of urban green spaces to mitigate UHI effects and improve urban resilience. They also suggest the integration of green infrastructure into city planning and development projects. The study emphasizes the importance of community participation in the planning and maintenance of green spaces. Additionally, the researchers call for policies that promote sustainable urban growth and protect natural landscapes. Their findings provide valuable insights into how urban planning can effectively reduce UHI effects in rapidly growing cities like Nairobi.

METHODOLOGY

This study adopted a desk methodology. A desk study research design is commonly known as secondary data collection. This is basically collecting data from existing resources preferably because of its low cost advantage as compared to a field research. Our current study looked into already published studies and reports as the data was easily accessed through online journals and libraries.

RESULTS

Conceptual Gaps: While studies like those of Zhang and Lin (2019) have explored the cooling effects of green roofs and demonstrated significant temperature reductions, there remains a need for research that integrates multiple urban planning strategies. Current research often focuses on single interventions (e.g., green roofs or reflective materials) rather than a holistic approach that combines various methods. Moreover, the optimization of green roof design and maintenance to maximize their cooling effects is an area requiring further investigation. Akbari, Levinson and Rainer (2018) suggested the potential economic benefits of cool roofs, but comprehensive cost-benefit analyses incorporating various urban heat island (UHI) mitigation strategies are still lacking. Furthermore, there is limited research on the long-term sustainability and performance of these interventions under different climatic conditions, which could provide valuable insights for more effective urban planning.

Contextual Gaps: Studies such as those by Shalaby and Moghanm (2019) and Tantasarin and Suksri (2019) have highlighted the effectiveness of urban parks and green roofs in specific cities like Cairo and Bangkok. However, the contextual applicability of these findings to other urban settings with different socio-economic and cultural contexts remains underexplored. Urban areas vary widely in their infrastructure, economic capacity, and community engagement, which can influence the success of UHI mitigation strategies. For instance, the recommendations for urban greening in high-density cities like Bangkok may not be directly transferable to lower-density cities or those with different urban layouts. There is a need for context-specific studies that consider local climate, economic conditions, and social dynamics to tailor urban planning interventions effectively.

Geographical Gaps: While empirical studies have been conducted in various global cities, including those in Asia (Bangkok, Jakarta), Africa (Nairobi) and the Middle East (Cairo), there is a noticeable geographical gap in research within many other regions. For example, studies on UHI effects and mitigation strategies are sparse in cities within South America, Eastern Europe, and smaller urban centers in Africa. Hermawan and Kusumaningtyas (2020) and Ngugi and Thuo (2020) have provided valuable insights into Jakarta and Nairobi, but similar comprehensive studies are needed in other rapidly urbanizing cities. Additionally, there is a lack of comparative studies that examine the effectiveness of UHI mitigation strategies across different climatic zones and urban forms. Understanding how strategies like green roofs, reflective materials, and urban greening perform in diverse environments can help develop universally applicable guidelines and best practices for urban planners worldwide.

CONCLUSION AND RECOMMENDATIONS

Conclusion

The role of urban planning in reducing urban heat island (UHI) effects is pivotal for creating sustainable, livable cities. Effective strategies such as the implementation of green roofs, reflective materials, increased vegetation, and urban parks have been empirically demonstrated to significantly mitigate UHI impacts. Green roofs, as highlighted by Zhang and Lin (2019), offer substantial cooling benefits, while reflective materials, as shown by Akbari, Levinson and Rainer (2018), can drastically reduce heat absorption in urban areas. The integration of urban greening, supported by the findings of Bowler, Buyung-Ali, Knight, and Pullin (2018), further contributes to cooling urban environments through natural processes like shading and evapotranspiration. Studies in various global contexts, including Cairo (Shalaby & Moghanm, 2019), Bangkok (Tantasarin & Suksri, 2019), Jakarta (Hermawan & Kusumaningtyas, 2020) and Nairobi (Ngugi & Thuo, 2020), underline the effectiveness of these strategies in diverse urban settings.

However, gaps remain in our understanding of how to optimize these interventions, particularly in terms of combining multiple strategies and tailoring them to specific local conditions. Future research should focus on holistic approaches that integrate various UHI mitigation strategies and assess their long-term sustainability and economic viability. Moreover, the application of these strategies must be context-specific, taking into account the unique climatic, economic, and social characteristics of different urban areas. Policymakers should prioritize the inclusion of green infrastructure in urban development plans, supported by incentives and regulations that encourage the adoption of UHI mitigation measures. By addressing these gaps and fostering collaborative efforts among government agencies, private developers, and communities, urban planning can play a crucial role in reducing UHI effects and enhancing the resilience of cities to climate change.

Recommendations

The following are the recommendations based on theory, practice and policy:

Theory

To advance the theoretical understanding of urban heat island (UHI) mitigation through urban planning, future research should focus on integrated approaches that combine multiple strategies. Studies should explore how synergies between green roofs, reflective materials, increased vegetation, and urban parks can amplify cooling effects in diverse urban environments. This integrative approach will contribute to theoretical frameworks that assess the cumulative impact of green infrastructure on UHI reduction across different climatic zones and urban typologies. Additionally, there is a need for theoretical models that quantify the socio-economic benefits of UHI mitigation strategies, including energy savings, improved air quality, and enhanced urban resilience.

Practice

In practice, urban planners should prioritize the adoption of multifunctional green infrastructure in city development plans. Local governments can incentivize the installation of green roofs and cool roofs through subsidies and tax breaks for building owners and developers. They should integrate urban greening strategies into building codes and zoning regulations to ensure their widespread implementation. Practical guidelines should be developed to assist urban planners in selecting and implementing appropriate UHI mitigation measures based on local climate conditions, population density, and economic resources. Moreover, pilot projects and demonstration sites can showcase the effectiveness of these strategies to stakeholders and the community, fostering broader acceptance and participation.

Policy

On a policy level, governments at all levels should enact comprehensive UHI mitigation policies that support sustainable urban development. Policy frameworks should prioritize the preservation and expansion of urban green spaces, including parks, gardens, and tree-lined streets. Regulations should mandate the use of cool materials and green roofs in new construction and urban redevelopment projects. Public awareness campaigns can educate residents and businesses about the benefits of UHI mitigation and encourage their active participation in greening initiatives. Policymakers should collaborate with researchers and urban planners to develop evidence-based policies that address local UHI challenges and contribute to global climate resilience goals.

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