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Integrating Urban Heat Island Mitigation into Green Building Rating Systems

RAGHAD ALMASHHOUR[1,*], JERRY KOLO [2], SALWA BEHEIRY [3]

[*1]: Department of Industrial Engineering, College of Engineering, American University of Sharjah, University City, *g00074611@alumni.aus.edu*, Sharjah P.O. Box 26666, United Arab Emirates

[2]: Department of Architecture, College of Architecture, Art and Design, American University of Sharjah, University City, *jkolo@aus.edu*, Sharjah P.O. Box 26666, United Arab Emirates

[3]: Department of Civil Engineering, College of Engineering, American University of Sharjah, University City, sbeheiry@aus.edu, Sharjah P.O. Box 26666, United Arab Emirates

*corresponding author:
e-mail:

Abstract. Amidst the climate crisis, cities remain the foremost cause and victims of the Urban Heat Island (UHI) effect. UHI is the higher temperature observed in a city compared to nearby rural environments. The built environment, in particular buildings, are known to be highly responsible for heating up or increasing the temperature of spaces in which they are built. Due to environmental and public interest concerns, how buildings are approved and constructed should be of concern in the fight against the UHI effect and climate change. Currently, municipalities use the Green Building Rating Systems (GBRS) to analyze the environmental performance of buildings. Reviews of the GBRS show that they primarily focus on energy consumption and carbon emissions in buildings. There is no evidence that GBRS assess how municipalities monitor or regulate the heat emitted by buildings. This research is designed to empirically ascertain from architecture, engineering, and construction (AEC) professionals how municipalities can directly, through their regulatory processes or indirectly though the GBRS, gauge the heat emitted by buildings, and prescribe pragmatic mitigation measures. The study was conducted through a questionnaire survey that will be administered online via snowball sampling. The outcomes of this research should provide practical insights into how UHI mitigation can be integrated into GBRS used by governments. Such integration will add value to the broader efforts of governments to combat climate change.

Keywords: Built environment; Urban Heat Island (UHI); Green Building Rating Systems (GBRSs)

1. Introduction

There is ample evidence that anthropogenic activities have, in recent years, exacerbated the earth's climate change crisis (IPCC, 2022). Cities have been identified as a key cause of the crisis because they are heat islands in a phenomenon known as urban heat island (UHI). This phenomenon results from cities as paved islands that trap and emit heat. UHI simply means that cities emit heat that warms the air and produces urban microclimates that, in turn, affect the macro or global climate. Existing studies show that urban areas are getting warmer than rural areas as a result of intensive anthropogenic activities. Of the activities, buildings and building construction have been pinpointed as major causes of greenhouse gas (GHG) emissions. To address the problem with buildings, cities worldwide have adopted a variety of measures and initiatives to improve the energy efficiency and reduce the carbon emission of buildings. One of such initiatives is the green building rating systems, varieties of which are currently in use by cities.

The World Green Building Council stated that a 'green' building is a one that, in its design, construction or operation, reduces or eliminates negative impacts, and can create positive impacts, on the climate and natural environment (Worldgbc, n.d.). The challenge addressed by green buildings is not only the need to reduce energy use but more fundamentally to provide a sustainable place for human habitation (Zhao et al., 2015). Hence, the green building methodology is a well-established and clearly defined strategy for achieving sustainable environmental impacts in various climates in response to worldwide energy and health problems.

A number of green building rating systems (GBRS) have been developed and are currently used by cities to make buildings more environmentally sustainable. Some of these GBRs require initiatives for buildings to mitigate urban heat. For instance, the LEED (US) suggests vegetated and high albedo roofs and at least 50 % of the parking spaces under the ground, deck, rooftop, or a building, or site hardscape with shading, high-reflectance paving materials, or open grid pavement systems (USGBC, n.d.). Other GBRs like BREEAM (UK), Green Globes (Canada, US), and DGNB (Germany) have also been concerned with UHI challenges (He, 2022), albeit through measures that this paper considers necessary but insufficient. In spite of the intent of extant GBRs to make buildings sustainable, reviews of the systems show that they primarily focus on energy consumption and carbon emissions in buildings (Awadh, 2017). Most of the GBRS were designed as, and still are, voluntary compliance systems. However, the urgency and severity of climate change has caused several governments, especially at the municipal level, to adopt the systems as part of the permitting and/or regulatory process(es) for buildings. Yet, in both the GBRS and the municipal processes, this paper contends that there is no evidence that UHI mitigation is treated as a single independent factor, neither is there a method for estimating the amount of heat emitted by building structures into the air. Therefore, one main research question was addressed in this study. Do any of the GBRS used by municipalities include any criterion/ factor to mitigate UHI? The GBRS covered in this paper are LEED, BREEAM, QSAS/GSAS Al Sa'fat, and Estidama.

Overview of Industry 4.0 Technologies

2. Methodology

To answer the research question and ascertain the paper's contention, this research inquired from architecture, engineering, and construction (AEC) professionals if and how existing GBRS address, factor or include the UHI on the built environment in their assessment criteria. The research was conducted through a structured questionnaire survey that that was administered online via purposive sampling technique, using Google Forms. The survey was conducted from April 5 to April 18. Due to the very technical nature of the research subject, the researchers used the purposive sampling technique to identify individual professionals known in the local region to have certification, experience and/or in any of the GBRs. The questionnaire was emailed to the purposive sample and recipients were requested to forward (snowball) the questionnaire to contacts in their professional circles. By the close of the survey date, a total of 12 experts answered the online questionnaire survey. Three main reasons explain this unexpectedly low response rate. One is the short timeframe of the survey, especially with what is often the busy schedule of the targeted survey group. Two is what a few who apologized to the researchers for not responding described as the overly technical nature of the information expected for the survey questions. The third is the well-known perennial obstacle of conducting policy and social research in the local region for reasons often attributed to confidentiality, proprietary information, etc. In spite of these constraints, the total of 12 respondents suffices for an expert panel for a study of this nature.

3. Results and Discussions

The demographics and background of survey respondents are presented in Table 1.

Table 1. Respondents' Demographic Information

No.	Demographic Characteristic	%	No.	Demographic Characteristic	%
1	*Gender*		4	*Educational Level*	
	Male	33		Bachelor	50
	Female	67		Masters	50
				PhD	0
2	*Years of Experience*		5	*Specialization*	
	1-2	10		Architecture	51
	3-5	42		Project Management	25
	>5	33		Consultancy	8
	None	15		Developer	8
				Urban Planning	8
3	*Organization Type*		6	*Types of Development of the Organization*	
	Public Sector	8		Residential	42
	Private Sector	84		Commercial	25
	Academia	8		Industrial	0
				Other: Mixed-Use	33

a. The use of GBRS in construction projects

This study showed that there is no dominant GBRS in use in the research region. The GBRSs used by the respondents are Estidama, by four of the 12 respondents; LEED, by three respondents; and Al-Safat, by only one respondent. This can be justified as compliance with all GBRS is voluntary, and in many cases, used as design checklists (Gowri, 2004; Mattoni et al., 2018). In an open-ended question that asked respondents to list any other GBRS they have used besides those on the survey, only Dubai municipality's "Green Building Codes" was added. Since then, Dubai required mandatory compliance with the code for design approval for all projects.

b. Urban Sustainability Issues and GBRS

Sustainability is often deemed to be the premier motive of GBRSs. The survey respondents were asked to identify which specific sustainability elements the GBRSs they use feature or include The elements listed were (Energy type, Water consumption and efficiency, Community culture, heritage, etc., Use of sustainable building materials, social equity/inclusivity, HVAC system of building, job creation in the local community, total heat emitted by building into the air, corporate social responsibility of firm, waste management system in building, impact of building on local climate, economic impacts of project on city, indoor environment quality, location and transportation, and land use and ecology). Most of the respondents were "unsure" for all of the issues. The high 'unsure' response rate was both intriguing and shocking for the researchers, because of the expectation or assumption that experts such as the survey respondents would be aware of the contents of the GBRSs. The survey did not probe the reasons for this knowledge gap and, barring speculations, finding the reasons would be a good subject for future research. According to the literature, this can be attributed to many factors, for example, one, as lack of awareness since building rating systems are still relatively new concepts, and some people may not have had the opportunity to learn about them. Two, the promotion of these systems may not have been extensive enough to reach a wider audience (Ding et al., 2018). Three, the limited exposure to GBRS prevalent in certain regions or industries, so professionals who are not directly involved in those areas may not have encountered them (Shareef & Altan, 2016). Finally, the lack of mandatory requirement plays a role, so developers or building owners may choose not to use them (Ade & Rehm, 2020).

c. GBRS, UHI, and Climate Change

In the following set of questions, the respondents were asked generic questions about GBRS, UHI, and Climate Change. 67% said that GBRSs are useful tools to help cities to fight climate change. However, this finding is inconsistent with previous studies where there is a serious debate about the inadequacies of GBRS in addressing climate change (Yudelson, 2016). According to Awadh, the GBRSs need serious improvement in areas such as climate change adaptability and the importance of sustainable communities (Awadh, 2017). 87% of the respondents agreed that cities are UHIs that worsen urban microclimate. This finding corroborates the findings of past research which contend urban planners and policymakers need to consider strategies to mitigate the effects of UHIs in cities and improve the urban microclimate for the health and well-being of humans (Alcoforado & Andrade, 2008; Kelbaugh, 2019; Marando et al., 2019).

It is noteworthy that 100% of the respondents confirmed that cities have a critical role to play in fighting climate change, which is consistent with the literature since cities are responsible for a significant portion of global GHG emissions (Gouldson et al., 2016; Satterthwaite, 2008). Asked specifically if they have used any particular regulatory tool by which cities estimate or measure the amount of heat that individual buildings emit into the air, all those who responded to the non-mandatory question categorically said “no”. This can be attributed to several factors including, one, lack of awareness as some building owners and managers may not be aware of the tools and methods available to measure building emissions or may not understand the importance of reducing building energy use and emissions (Ding et al., 2018). The second reason can be related to the complexity of these tools. Some of the methods used to measure building emissions can be complex and require specialized knowledge and skills. This can make it challenging for building owners and managers to comply with these requirements (Reddy, 2006). Overall, there are several barriers that can make these tools and methods less popular and more difficult to implement on a large scale. Addressing these barriers will require a concerted effort from building owners, managers, and policymakers to prioritize energy efficiency and emissions reduction.

d. Proliferation of GBRSs Worldwide

In the final section of the survey, the respondents were presented with a total of seven statements aimed at ascertaining their views on the proliferation of GBRSs around the world; the effectiveness of GBRSs on sustainability; and, if GBRSs reduce UHI. In summary, for five of the seven statements, the average answer was a total of 8 “Agree”, 1 “Disagree” and 3 “Not sure”. Asked if GBRSs are not effective for sustainable development beyond the building scale, 4 “Agreed”, 5 “Disagreed” and 3 were “Not sure”. This finding suggests a need to further investigate the effectiveness of GBRS on sustainable development beyond the building scale. On GBRSs and reducing the UHI impact of cities, all the respondents “Agreed” that GBRSs help to reduce UHI. This finding needs further investigation because it seems inconsistent with studies which claimed otherwise (Awadh, 2017).

4. Implications of findings

A foremost implication of the findings of this empirical study is that by incorporating strategies to mitigate the UHI effect into GBRSs, the rating systems can encourage developers and builders to consider the impact of their buildings on the environment. This can facilitate or enable more sustainable and resilient communities. Secondly, cities across the world should incorporate strategies to mitigate the UHI effect into GBRSs, to help address the negative impacts of UHI effect on people, the economies and quality of life in urban areas. By including UHI mitigation strategies in GBRSs, building owners and developers can be incentivized to implement these strategies, leading to the creation of more sustainable and resilient buildings. This can help reduce the energy consumption and environmental impact of buildings, improve the health and well-being of occupants, and contribute to the overall sustainability of urban areas. Another implication of the study is that it intensifies the search by scholars for specific, user-friendly and cost-effective tools or frameworks that cities can use, independent of the GBRSs, to estimate and mitigate the heat that building structures emit. The need for such preventive tools would curb the reactive posture that cities currently take to address CC challenges.

5. Conclusion

Cities are both causes and victims of UHI, which results from the intensive anthropogenic activities that occur in urban centers. As cities get warmer, so do microclimates, which then exacerbate global temperatures that progressively lead to CC. Building construction is a major activity in cities. From experimental to empirical studies, and in policy debates, there is evidence as well as conviction that how cities manage anthropogenic activities would go a long way in the fight against CC. This paper postulates that the feasible and cost-effective frameworks are needed for cities to actualize their good intentions and rhetoric to achieve sustainable development. Frameworks are needed that can enable cities to minimize, mitigate and even eliminate their negative impacts on the environment. CC epitomizes perhaps the worst and devastating impact of anthropogenic activities. The *political will to address CC must be accompanied by tools that are pragmatic in enabling governments to balance the need for growth and development on one hand, and safeguard the environment on the other. This study ascertained from AEC professionals and experts that the tool proposed in this paper is currently non-existent and is urgently needed if cities are to play the frontal role expected of them in the fight against CC.*

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