Green façade at urban scale: Constructive and microclimate effects

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Introduction

Lack of vegetation in urban area ended up many damages like public health issues, urban run off, high urban temperature and finally UHI. The objective of this study is to figure out a sustainable and applicable solution to mitigate the high urban temperature caused by urbanization process in highly dense area in Ho Chi Minh city in Vietnam.

Reasearch questions:

- What are the aspects of urbanization that alter the urban temperature negatively?
- How the application of green façade can contribute to the thermal comfort?
- Up to what extend the green façade is able to alter the urban temperature?

Literature review

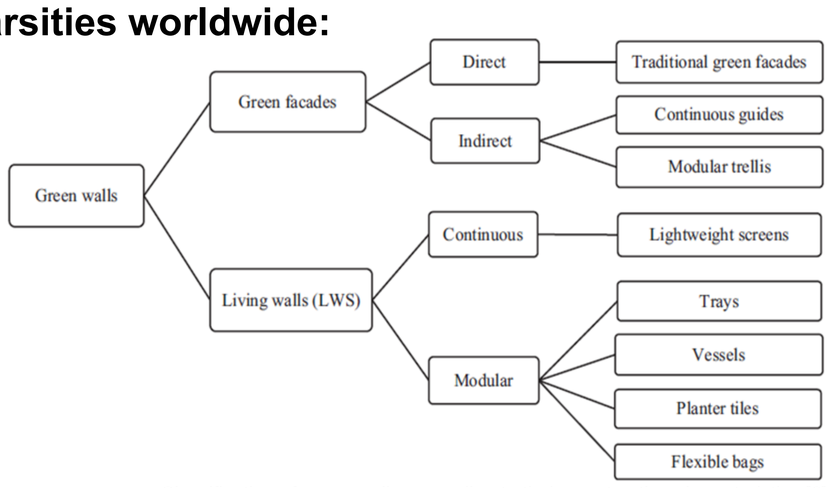
Urbanization and its consequences:

Rapid urbanization has caused changes to the urban temperature due to the increasing human activities, changes in wind pattern, dimnishing the vegetation and changes in landuse type, and so forth. Increasing urban temperature and rapid urbanization ended up to damages namely:

- Increasing pan evaporation in urban area [1]
- Increasing evaporation due to land cover changes[2]
- Urban runoff due to the changes in soil characteristics. [3]
- Higher energy demand for cooling [4]
- Public health issues and death due to heat stroke. [5]

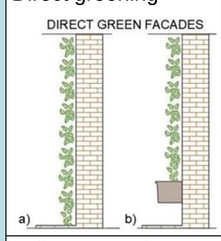
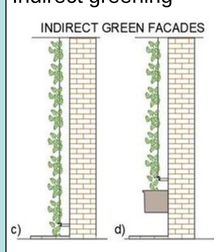
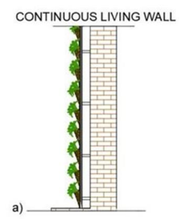
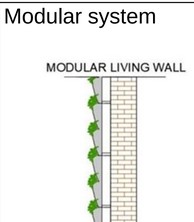
Green façade varsities worldwide:

The green façade is classified according the installation and vegetation growth pattern as the figure illustrates.



Classification of green walls, according to their construction characteristics.[6]

comparison of green wall systems.[6]

System	Category	Sub-category	Advantages	Disadvantages
Traditional green façade	Direct greening 	Traditional green façade	• No materials for irrigation, supporting… • Low cost • Low environmental burden	• Limited plant selection/climate adaptability • Spontaneous vegetation development • Scattered growth along surface
	Indirect greening 	Continuous guiders	• Vegetation development guidance • Low water consumption	• Limited plant development • Slow surface coverage • High environmental burden of some materials
		Modular trellis	• Lightweight support • Vegetation development guidance • Controlled irrigation/drainage • Easy to assemble and maintenance	• High installation cost • Limited plant selection • High environmental burden of some materials
Living walls	Continuous system 	Felt pockets vertical gardens	• Uniform growth • Flexible and lightweight • Increased variety of plants • Uniform water distribution	• Complex implementation • High water consumption • Frequent maintenance
	Modular system  [8]	Trays	• Easily disassembled for maintenance • Increased variety of plants • Controlled irrigation and drainage	• Limited space for root development • High installation costs • Complex implementation • Surface forms limited to trays dimensions
		Planter tiles	• Increased variety of plants • Attractive design of modules	• High installation costs • Complex implementation • Limited space for root development • Surface forms limited to tiles dimensions
		Flexible bags	• Increased variety of plants • Adaptive to sloped surfaces	• High installation costs • Heavier solution due to growing media/limited to building maximum load • Complex implementation

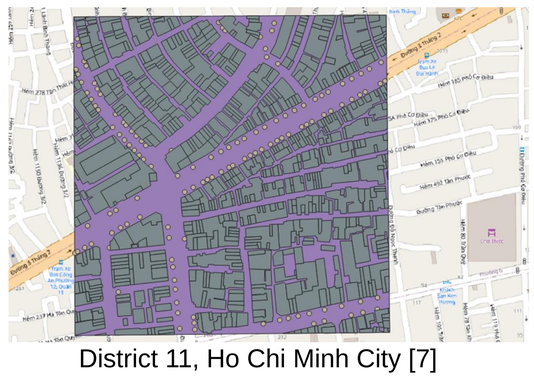
Methodology

The methodology of this study includes diverse steps beginning from reviewing literatures done around this topic and rising understanding and knowledges to apply, gathering spatial and metereological data required, and application of the gathered data on the QGIS software and finally the simulation of the mean radiant temperature and analyzing the results by the use of SOLWEIG tool and raster statistical analyze tool to figure out the temperature differnce by the implementation of greenery on the urban building surface.

Case study

The chosen case study for this research in located in highly dense area in Ho Chi Minh city in Vietnam, district 1 and 11, with tropical hot and humid weather condition. The case studies include narrow alley and dnesly built up area with a mix of residential and commercial building.

District 1, Ho Chi Minh City [7]



District 11, Ho Chi Minh City [7]

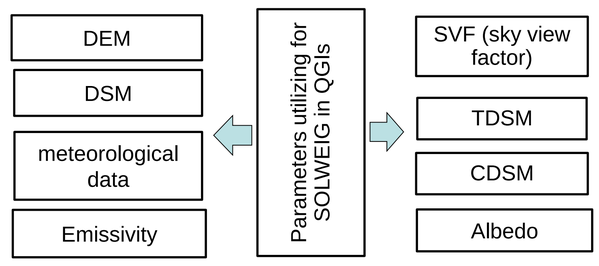
Findings

Scenario: Green facade in urban renewal in HCMC

Focusing on bringing back the vegetation to the urban area to improve urban sustainability considering:

- Environment
- Aesthetic view
- Urban temperature reduction
- Functional aspects of greenery in urban area
- New technologies of green system regarding the application and maintenance

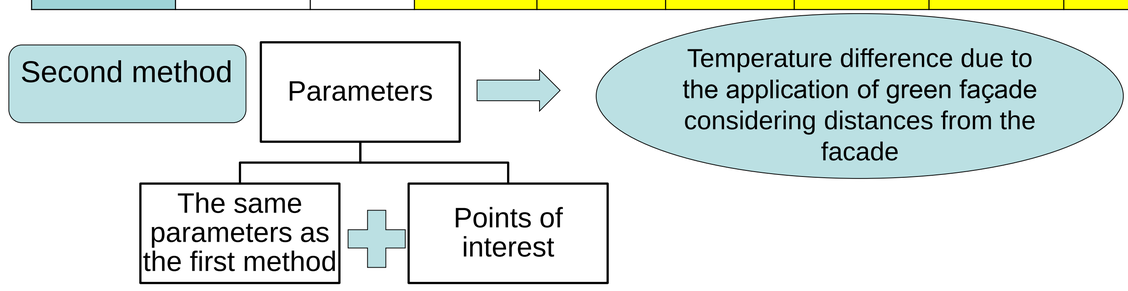
The results of Thermodynamic simulation:



First method

The results of first analytical method

Façade	Emissivity	Albedo	MRT District 1	MRT District 11	Maximum MRT District 1	Minimum MRT District 1	Maximum MRT District 11	Minimum MRT District 11
Existing façade	0.85	0.50	35,19	34,94	37,83	33,26	37,56	31,94
Green façade	0.95	0.3	32,53	32,67	34,54	29,18	35,23	28,46
MRT difference			2.66	2.77	3.29	4.08	2.33	3.48



The results of second analytical method, district11

Point	MRT for the existing façade	MRT for the green façade	MRT difference
1	34.75	33.24	1.51
2	34.48	32.12	2.36
3	34.27	31.32	2.95

The results of second analytical method, district1

Point	MRT for the existing façade	MRT for the green façade	MRT difference
1	35.08	33.12	1.96
2	34.88	32.43	2.45
3	34.80	32.09	2.71

1. De-Fang, F. *et al.* (2022) "Effect of urbanization on the long-term change in pan evaporation: A case study of the Nanpan River Basin in China," *Ecological Indicators*, 145, p. 109631. Available at: https://doi.org/10.1016/j.ecolind.2022.109631.
2. Ali, A.K.M. and Ramahi, F.K.M.A. (2020) "A study of the Effect of Urbanization on Annual Evaporation Rates in Baghdad City Using Remote Sensing," *Iraqi Journal of Science* [Preprint]. Available at: https://doi.org/10.24996/ijs.2020.61.8.29 .
3. Jiang, Y., Fu, P., & Weng, Q. (2015). Assessing the impacts of Urbanization-Associated Land Use/Cover change on land surface temperature and surface moisture: a case study in the Midwestern United States. *Remote Sensing*, *7*(4), 4880–4898. https://doi.org/10.3390/rs70404880
4. *Heat Island impacts | US EPA*. (2022, September 2). US EPA. https://www.epa.gov/heatislands/heat-island-impacts
5. Lee, Y. Y., Din, M. F. M., Ponraj, M., Noor, Z. Z., Iwao, K., & Chelliapan, S. (2017). OVERVIEW OF URBAN HEAT ISLAND (UHI) PHENOMENON TOWARDS HUMAN THERMAL COMFORT. *Environmental Engineering and Management Journal*, *16*(9), 2097–2111. https://doi.org/10.30638/eemj.2017.217
6. Manso, M., & Castro-Gomes, J. (2015). Green wall systems: A review of their characteristics. *Renewable & Sustainable Energy Reviews*, *41*, 863–871. https://doi.org/10.1016/j.rser.2014.07.203
7. KGBauko Institute, 2023
8. Palermo, S. A., & Turco, M. (2020). Green Wall systems: where do we stand? *IOP Conference Series: Earth and Environmental Science*, *410*(1), 012013. https://doi.org/10.1088/1755-1315/410/1/012013