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Vertical Greening System for Environment Responsive Architecture: The Case of Multistory Residential Buildings in Addis Ababa

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Abstract

Vertical Greening Systems can help mitigate the urban heat islands, increase the thermal efficiency of the buildings, save cooling energy and enhance air quality by using the vegetation's natural processes. However, since vertical greening schemes need materials and energy to be built, there are questions about whether they actually deserve to be adopted and how their environmental efficiency can be improved. The study aims to evaluate vertical greening systems' environmental efficiency and to study essential factors for efficient and sustainable building construction.

Keywords: Vertical greening system; System; Environment; Responsive architecture; Residential buildings; Urban agriculture

Introduction

Rapid urbanization is causing considerable ecological and environmental problems in our city, Addis Ababa. As the only large city in Ethiopia, vacant spaces are being taken by individuals and the government in order to meet the desperate need for shelter. Therefore, Vertical Greening Systems (VGS) allow vegetation to spread over a building facade or inside wall. VGS is considered a sustainable and green construction approach in the world. They will help reduce the urban heat island, enhance the thermal efficiency of buildings, save cooling resources and improve air quality by using natural processes of vegetation [1-3].This Journal aims to evaluate VGS' environmental efficiency and examine critical factors for efficient and sustainable construction design.

Vertical greening

Population growth and urbanization have put pressure on basic necessities such as food, water, and housing [4]. In the last five years, the worldwide urban population has increased by more than 50%. All of these are possible outcomes of unrestrained population growth. In response to these issues, peri-urban gardening has gained popularity as a means of providing green spaces, improving air quality, and reducing urban heat in urban areas.

A new concept in green infrastructure is vertical greenery, where plants are integrated into vertical surfaces. Numerous modern techniques have been created in recent years to grow a variety of plants vertically. Climbing plants with self-clinging roots grew directly on the building surfaces, twining plants grew on trellises and pergolas, and plants grew within the cracks of piled boulders.

Vertical greening has numerous significant benefits, including: Beauty abounds and adds visual drama, covers up views of plain or ugly walls and provides building protection. Live plants decrease stress levels; create peaceful ambiance, Increases value and salability of residence building. Reduces CO_2 levels and increases oxygen and improved air quality. Prevent from dust and harmful microorganisms, Plants are less accessible to diseases and pests.

Vertical Greening Systems (VGS)

Vertical Greening Systems (VGS) are structures that allow vegetation to spread over a building facade or interior wall. They can contribute to mitigating urban heat island, enhancing building's thermal performance, saving cooling energy and improving air quality. VGS are considered a sustainable/green building design approach and are becoming increasingly popular in the urban landscapes [3].

As the space available for greening is often very limited in urban cities, vertical greening can be an effective method applied to the exterior and interior surfaces of buildings to improve the city environment.

Vertical Greening Systems (VGS) is a system which allows vegetation to spread over a façade of a building. It will help to reduce the environment, increase thermal efficiency of the house, reduce cooling capacity and improve air quality. VGS is a safe and green approach to building architecture [3].

Applications of vertical greening systems

As responsive architecture:

1. Mitigating energy consumption.

According to studies, Ivy vine sunscreen, growing on a wall can effectively shade a west-facing wall, reducing heat absorption and lowering indoor temperatures [5]. Reduction of Urban Heat Island effect (UHI).

2. Elevate the thermal performance of buildings (lowering energy costs).

Plants, such as green roofs and walls, can reduce the air temperature around a structure in hotter weather, which not only reduces cooling costs but also reduces a building's UHI [6].

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3. The improvement of water-sensitive urban.

They are sometimes referred to as bio-walls. As indoor air is taken through the living wall, carbon dioxide (CO_2) and hazardous chemicals such as Volatile Organic Compounds are absorbed by the plants and planting media[7].

4. Improvement of Indoor Air Quality.

Plants and their planting media may be efficient sound barriers, as demonstrated on many motorways [5]. For the time being, the efficiency of green roofs for sound attenuation must be extrapolated from research on green roofs, and would be in densely populated cities, living wall systems can help reduce sound reflection from hard surfaces such as roads and buildings.

5. Noise pollution reduction.

Plants and their planting media may be good sound barriers, as observed on many roads. This helps for sound reflection from highways and buildings can be reduced by using living wall systems in cities that are becoming more congested [5].

6. Health and well-being improvement.

In one study on workers in the USA and Norway who worked in offices with indoor plants or window views reported better job satisfaction in recent polls [8]. Living walls are an emerging technology that can also be used to promote outdoor living and walkability in cities. Their added greenery can lower ambient temperature and moderate the harsh nature of many urban structures.

7. city-wide biodiversity and food.

As a consequence of green roof initiatives, there has been an increase in native flora and fauna species, and it is not unrealistic to assume comparable outcomes. Also, the potential for producing food on living walls has attracted attention throughout the world. In Ethiopia, many people who are currently living on vertical structures used to own their vegetable gardens while they were living on the ground. I will discuss it more briefly in the Edible City Solution section.

As edible city solution

Edible plants in vertical green systems boost the local environment and the urban ecosystem's harvestable products potential. The integration of facade technology into major cities of the world has been widely deployed and points out that their enhanced environmental performance and dramatic visual effect support a range of technical features that accommodate vertical urban farming, aesthetics, efficient thermal performance, daylight penetration, and interior environment control [9]. These systems can also improve the holistic approach to buildings by combining food, housing, and integrated ecological solutions, which is an increasing demand in today's world.

Materials and Methods

I have used these seven measurements on the application of vertical greenery system as an environmental responsive design. My research will examine different vertically greened as well as problematic buildings of Addis Ababa. I have used to the following criterion identify the problematic buildings to minimize my selection:

1. The buildings to be assessed are to be within the certain areas of Addis Ababa (i.e., around Bole, Piazza and National Theatre because those areas are a potential city centers of Addis Ababa and architecture experimental sites.

2. Buildings with high visual exposure, environmental value and vulnerability for main road.

3. Buildings with bare wall or space which is functionable in the installation process.

4. Their function must be mainly residential, (Apartments, row houses, Condominiums).

5. The building must have a potential trait which can be solved by vertical greening system.

I have chosen the two defected buildings by the above criterion. Further I have observed their interior and exterior through visual survey, mapping, interview and questionnaire.

After I have analyzed the buildings by categorizing in two groups:

1. With vertical green and

2. Without vertical green. After that I have established a comparative analysis, compared their outcome and drafted a recommendation.

Inspiration

During my survey, I have seen people trying to install greeneries in unhostile environments. In condominiums apartments, hotels, government offices and residentials with little space for greening (Figure 1). This implies that people are living in an environment which is away from nature by far, thus, they are desperately trying to be close to nature in any way as possible. During one of my interviews, a mother from one of Noah apartments implied that their apartment is the last place that she thought she would be raising her babies. She continued her concern about their future, her exact words were, and I might not wonder if my children thought a banana or an apple is a fabricated product. This her words trigged me that we as a community need to elevate our concern about nature and the modern way of living, we cannot be bound on the ground, to plant trees and plants. We have to think to grow vertically. Unless otherwise we will face difficulties. Population is growing and it will continue to grow. But the land/ earth will not. So, what is our plan for our children?

Figure 1. Ethiopia Addis Ababa, People planting in un hostile environment.

The comparison below compares 4 different buildings, with 4 different functions, with different types of greening system and different types of materials. But the above all have vertical greenery. And in the first analysis, I have chosen vertical greenery attempts in Addis Ababa and their achievement. To conclude also whether vertical greenery is applicable in any type of building as long as the appropriate system is installed.

Results and Discussion

Analysis

Buildings with vertical green: I have reviewed four buildings, Varnero Apartment, Peace Building, ICS middle school building and Hope University Library. Based on function, two of them are apartment buildings which one of them is partially commercial; containing a bank and shops function and the other two are a class room and a library (Table 1). Buildings without vertical green: The two buildings I, chose are Noah centrum real-estate apartment around Bole, Atlas and Bedilu building around Biherawi, Awash bank (Table 2). Finding and Comparative Analysis (Table 3).

		Varnero apartment	ICS, Middle school building	ICS, Middle school building	ICS, Middle school building
Stormwater management		ditch system, irrigation watering	Gutter, downpipes ditch system, underground pipes	Downward gutter to ditch	Ditch Flood occurred and installed concrete blocks
Green wall		Climbers, Potted plants	Climbers, Potted plants	Climbers, Potted plants	----------
Green roof		On parking	On parking	----------	Accessible dense green roof
Water efficiency		Alternative water source (groundwater)	Water-saving devices and Alternative water source (groundwater)	Water-saving accessories (double flush), Water-saving green plants	water saving device (double flush)
Energy consumption		Natural daylight	Natural daylight LED light bulbs RE-solar energy	Natural daylight LED light bulbs RE-solar energy	Natural daylight, fluorescent light bulbs, LED
Materials and Resources	Ceiling	stone steel roots	cement tiles, porcelain, Gypsum board, green roof	concrete slab	100% green roof
	Wall	HCB,	HCB, fine quartz, green wall	Ceramic, green façade	Grass, HCB, Glass, Bamboo
	Floor	Ceramic, tree parquet	Linoleum, ceramic	ceramic tiles	Plastic tiles
Waste management		disposal site	recyclers	Collected daily	Collected daily
Indoor environmental quality	Lighting	Windows, Balcony except toilets	Windows, except disabled bathrooms	Windows,	large windows, two opendowns, skylights
	Ventilation	natural ventilation, air conditioning	natural ventilation, air conditioning	natural ventilation, air conditioning	natural ventilation
	Thermal comfort	the back apartments have higher temperature	Cooler (orientation) Cladding materials (stone)	Balanced (orientation)	Cooler (green roofs, orientation)
	Acoustic and views	noise reduction materials	noise pollution Dumped by Acoustic panel fins	noise pollution Buffered by the vertical green	noise pollution at the back of the building
	Dampness and microbial growth	Leakage under the green roof, no microbial growth	Not yet observed	None	no dampness after maintenance

Table 1: Buildings with vertical green.

		Noah centrum apartment	Bedilu building
Storm water management		Gutter to Ditch	Gutter to Ditch
Green Wall		No	No
Green Roof		No (Except One Private Green)	No
Water Efficiency		Tap water system, water tankers	Only tap water system
Energy consumption		Natural daylight (Extreme), no renewable	Natural daylight (Extreme)
Materials and Resources	Ceiling	Galvanized metal	Concrete slab
	Wall	HCB, quartz paint	HCB, large glass windows
	Floor	Ceramic	Ceramic tiles, marbles and concrete
Waste management		chute system	NO
Indoor environmental quality	Lighting	Windows, extreme lighting	Windows, extreme lighting
	Ventilation	Natural ventilation and mechanical ventilation	natural ventilation
	Thermal comfort	Not vulnerable for heat, type of window	Vulnerable for heat
	Acoustic and views	There is noise pollution	There is noise pollution
	Dampness, microbial growth	No leakage, no microbial growth	leakage, there seems a microbial growth, no proper waste disposal place

Table 2: Buildings without vertical green.

	Varnero apartment	ICS, Middle school building	Peace building	Hope University library	Noah centrum apartment	Bedilu building
Energy consumption	No mechanism but good lighting	Good efficient	Good efficient	Good efficient	No mechanism	No mechanism
Thermal performance	Warmer	Cooler	Balanced	Cooler	Cooler	Hot, the case area side
Water-conserving urban	Irrigation Good	Flood preventing, fair	Poor	Irrigation Good	Poor	Poor
Indoor air quality	Fair	Good	Good	Good	Good	Poor
Noise pollution	Lessen	Lessen	Lessen	Exist	Exist	Exist
Health and wellbeing	Normal, good	Healthy	Healthy	Healthy	Healthy	Vulnerable
Biodiversity and food	Flora	Flora	Flora, insects	Flora, insects	None	None

Table 3: Finding and comparative analysis.

The purpose of this study was to explore to analyze the impact of vertical greenery system on environment responsive architecture. As it is shown in the table, buildings with vertical greenshave a better performance. As their environmental performance is analyzed. Edible plants in vertical green systems boost the local environment and the urban ecosystem's harvestable products potential. The integration of facade technology into major cities of the world has been widely deployed and points out that their enhanced environmental performance and dramatic visual effect support a range of technical features that accommodate vertical urban farming, aesthetics, efficient thermal performance, daylight penetration, and interior environment control. Relatively Noah Centrum Apartment has a better performance other than Bedelu building. The other fours' strength is directly related to the presence of the VGS.

Conclusion

As part of Hope University's thermal strength investigation, the slanted green roof's impact on water conservation was examined. The same goes for the Peace Building buffer zone. Biodiversity is lacking in the two buildings as well as a noise buffer and water efficiency. There is also a lack of proximity to nature and an edible plantation in addition to an unhealthy atmosphere. In the preceding sections, it was discussed that these problems might be simply fixed using the VGS method.

Building vertical greenery systems were the focus of the study. The VGS system was proven to be more efficient with passive energy utilization in harsh solar structures. In reality, vertical greening has emerged as a fundamental component of sustainable development, and it has the potential to become a major feature in urban cities in the coming years.

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