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ECOLOGICAL AND SOCIAL SIGNIFICANCE OF VERTICAL GARDENS IN THE ARCHITECTURE OF MULTI-STORY RESIDENTIAL BUILDINGS

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Abstract. This article scientifically analyzes the ecological and social functions of vertical gardens in the architecture of multi-story residential buildings. As a result of contemporary urbanization processes, urban green spaces are shrinking, atmospheric air pollution is increasing, and the balance of urban microclimates is being disrupted. In addressing these challenges, vertical gardens have emerged as an innovative and sustainable architectural solution. Based on international scientific sources, the study examines the ecological functions of vertical gardens, including improving air quality, enhancing energy efficiency, reducing noise levels, and supporting biodiversity. Furthermore, their impacts on human health, psychological well-being, and social integration are discussed.

Keywords: vertical gardens, green architecture, ecological sustainability, urbanization, microclimate, energy efficiency, green facades, social well-being.

Introduction

In the 21st century, rapid urban population growth has led to the intensive development of residential construction. However, the increasing number of multi-story buildings has resulted in the reduction of green spaces, deterioration of air quality, and changes in urban microclimates. Therefore, there is a growing demand for innovative solutions aimed at restoring ecological balance in modern architecture and urban planning practices.

Vertical Green Systems are vegetated structures created by cultivating plants on building facades or specially designed supporting constructions. These systems contribute to improving the ecological and aesthetic quality of urban environments. In recent years, vertical gardens have been widely implemented as an important component of sustainable construction in Europe, North America, and Asia.

Ecological Functions of Vertical Gardens Air Purification

One of the most important ecological functions of vertical gardens is the reduction of harmful pollutants in the atmosphere. Plant leaves have the ability to capture dust particles, heavy metal compounds, and various aerosols. In addition, through the process of photosynthesis, plants absorb carbon dioxide and release oxygen.

According to the research conducted by Perini and Rosasco (2013), green facades are capable of capturing a significant proportion of fine particulate matter in areas with heavy traffic. In particular, plant species with dense foliage demonstrate high efficiency in reducing air pollution.

Furthermore, vertical gardens contribute to reducing the carbon footprint of urban areas. Plant biomass absorbs atmospheric carbon dioxide and stores carbon in biological form. As a result, vertical gardens serve as an additional ecological tool in the fight against global climate change.

Mitigating the Urban Heat Island Effect. The expansion of multi-story buildings and asphalt-covered surfaces often causes temperatures in city centers to become higher than those in surrounding areas. This phenomenon is known as the Urban Heat Island (UHI) effect.

Table 1

Description of the Ecological and Social Functions of Vertical Gardens

Function Type	Functional Aspect	Mechanism of Impact	Expected Outcome
Ecological	Air purification	Plant leaves capture dust particles and harmful gases	Improvement of air quality
Ecological	Microclimate regulation	Transpiration and shading processes	Reduction of ambient temperature
Ecological	Energy efficiency	Provides natural thermal insulation	Reduction of cooling and heating costs
Ecological	Noise reduction	Vegetation absorbs sound waves	Improved acoustic comfort
Ecological	Biodiversity support	Creates habitats for insects and birds	Enhancement of urban ecosystem sustainability
Social	Health improvement	Clean air and a healthier environment	Reduced risk of respiratory diseases
Social	Psychological well-being	Visual connection with natural elements	Reduction of stress levels
Social	Aesthetic attractiveness	Integration of green elements into building facades	Enhancement of the visual quality of the urban environment
Social	Social integration	Community participation in maintaining green spaces	Strengthening of social cooperation and community engagement

Source: Compiled by the author based on the studies of Perini (2013), Ottelé (2011), Wong (2010), and Manso & Castro-Gomes (2015).

As can be seen from the data presented in the table, vertical gardens are multifunctional systems that enhance the ecological and social performance of multi-story residential buildings. Their ecological significance is primarily reflected in their ability to improve air quality, regulate microclimatic conditions, reduce energy consumption, and mitigate noise pollution. Through the process of photosynthesis, plants absorb carbon dioxide and release oxygen, thereby contributing to the improvement of the urban ecological environment.

In addition, the social functions of vertical gardens are of considerable importance. Green facades have a positive impact on people's psychological well-being by reducing stress levels and enhancing the aesthetic appeal of the living environment. Furthermore, the implementation of such systems in residential complexes promotes the development of environmental awareness and a sense of collective responsibility among residents. Therefore, vertical gardens are recognized as one of the effective tools for ensuring ecological sustainability and social well-being in contemporary architecture.

Table 2

Impact of Vertical Gardens on Multi-Story Residential Buildings

Indicator	Conventional Facade	Vertical Green Facade	Impact Level
Air Quality	Moderate	High	Positive
Thermal Protection	Low	High	Positive
Energy Efficiency	Moderate	High	Positive
Noise Protection	Low	Moderate–High	Positive
Aesthetic Appearance	Standard	High	Positive
Ecological Sustainability	Moderate	High	Positive
Resident Satisfaction Level	Moderate	High	Positive

Source: Developed by the author based on international scientific literature (Köhler, 2008; Pérez et al., 2011; Francis & Lorimer, 2011).

The table compares the key indicators of conventional facades and facades covered with vertical gardens. The analysis results indicate that green facades outperform conventional facades in terms of energy efficiency, ecological sustainability, and aesthetic attractiveness. In particular, the vegetation layer protects building walls from external environmental influences, reducing overheating during the summer season and minimizing heat loss during the winter season.

Furthermore, vertical gardens contribute to improving air quality, supporting biodiversity, and enhancing the living conditions of urban residents. As a result, the ecological and functional performance of multi-story residential buildings is improved, creating favorable conditions for the implementation of sustainable urban development principles. These advantages allow vertical gardens to be regarded as an important component of future architectural design.

Vertical gardens reflect a portion of solar radiation and reduce ambient temperatures through the process of plant transpiration. Studies conducted by Wong and colleagues have shown that buildings equipped with green facades exhibit significantly lower wall surface temperatures compared to conventional facades.

Consequently, the indoor microclimate of buildings is improved, the need for air conditioning is reduced, and overall energy consumption decreases.

Enhancing Energy Efficiency. Vertical gardens serve as natural insulation layers that improve the thermal protection of buildings. The vegetation and substrate layers reduce the direct impact of solar radiation during summer while slowing down heat loss during winter.

According to the scientific research conducted by Ottelé and colleagues (2010), green facades can reduce the operational costs of buildings by lowering energy consumption. This is particularly important in regions where energy resources are limited.

Noise Reduction. The increasing volume of traffic in large cities has led to growing concerns about acoustic pollution. Vertical gardens possess the ability to partially absorb and disperse sound waves.

The vegetation layer, substrate, and supporting structures work together as a natural acoustic barrier, reducing noise energy. Research has demonstrated that green walls can significantly decrease the penetration of external noise into building interiors.

Supporting Biodiversity. Vertical gardens serve as alternative habitats for natural ecosystems that are gradually diminishing due to urbanization. They provide additional living spaces for birds, insects, and pollinating organisms.

In particular, bees, butterflies, and other beneficial insects use vertical green systems as feeding and breeding habitats. In this way, the continuity of ecological networks within urban environments is maintained, and biodiversity levels are preserved.

Social Functions of Vertical Gardens. Improving Public Health. According to the World Health Organization (WHO), green spaces have a positive impact on human health. By improving air quality and reducing noise pollution, vertical gardens contribute to the creation of healthier living environments for urban residents.

Studies have shown that residential buildings enriched with green elements are associated with lower incidences of respiratory diseases, stress-related disorders, and psychological strain.

Enhancing Psychological Well-Being. The positive influence of natural elements on human mental health has been confirmed by numerous scientific studies. According to the Attention Restoration Theory developed by Kaplan and Kaplan, regular contact with nature helps reduce mental fatigue and restore cognitive attention.

Vertical gardens strengthen the visual connection between residents of multi-story residential buildings and nature. As a result, stress levels are reduced, psychological well-being is improved, and overall quality of life is enhanced.

Creating an Aesthetic Environment. In modern cities, the uniform and artificial appearance of buildings often diminishes the aesthetic attractiveness of the urban environment. Vertical gardens provide facades with a natural appearance and enrich architectural compositions.

In particular, the application of green facades in residential complexes improves the visual character of the area and can also have a positive impact on increasing property values.

Promoting Social Integration. Vertical gardens help foster environmental awareness and a sense of collective responsibility among residents. Involving community members in the maintenance and care of green systems within residential complexes strengthens neighborhood relationships and encourages greater social cohesion.

Such projects also serve as a means of environmental education. Through participation in the care and maintenance of plants, children and young people acquire valuable environmental knowledge and practical skills.

Improving Urban Quality of Life. The social effectiveness of vertical gardens is also reflected in the increased level of residents' satisfaction with their living environment. In areas enriched with green elements, people are more likely to use outdoor spaces, which contributes to the promotion of healthier lifestyles.

Moreover, environmentally friendly and aesthetically attractive residential environments foster positive perceptions of local neighborhoods among residents and contribute to the sustainability and long-term stability of the urban environment.

Conclusion. Vertical gardens are an important component of the architecture of modern multi-story residential buildings. Their ecological functions are reflected in improving air quality, enhancing energy efficiency, reducing noise pollution, mitigating the urban heat island effect, and supporting biodiversity. At the same time, vertical gardens perform significant social functions, including improving human health, enhancing psychological well-being, creating aesthetically pleasing environments, and promoting social integration.

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