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Advantages and Risks of Vertical Gardens

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Abstract

Urbanization which is one of the most serious problems in 21st Century, causes many environmental problems such as concrete areas and population increase. Although the decreasing urban green areas cause many environmental problems, it provides a basis for developing vertical garden. The vertical gardens are defined as gardens that cover façade walls with using various plant species by systems.

The vertical gardens not only increase urban green areas but also have some functions such as sound and heat isolation, energy productivity, air quality improvement, heat island reduction, aesthetics occurrence, and positive contribution to human psychology. Factors such as constant maintenance difficulties, high cost, lack of knowledge and consciousness in vertical gardens are preparing for the aesthetic purposes and preventing the spread of applications.

This study was carried out with the aim of determining the advantages of the vertical gardens and their risks. In this context, literature review was conducted and vertical garden's types and the advantages and risks of vertical garden were examined. As a result of the study, it has been revealed that the vertical gardens had an important place in urban areas especially for increasing energy efficiency and ensuring sustainable development.

Keywords: Vertical garden, advantages and risks, sustainable development

Dikey Bahçelerin Avantajları ve Riskleri

Öz

21. yüzyılın en büyük sorunlarından birisi olan kentleşme; yapı alanları ve nüfus artışı gibi olumsuzluklarla birlikte birçok çevre sorununa da neden olmaktadır. Kentsel yeşil alanların azalması birçok çevre sorununa neden olurken dikey bahçe kavramının da geliştirilmesine zemin hazırlamıştır. Dikey bahçeler, cephe duvarlarının çeşitli sistemler yardımı ile çeşitli bitki türleri kullanılarak kaplanması olarak tanımlanmaktadır.

Dikey bahçelerin kentlerde yeşil alan miktarını artırmanın yanı sıra ses ve ısı izolasyonu, enerji verimliliği, hava kalitesini iyileştirme, ısı adası etkisini azaltma, estetik görünümleri ile insan psikolojisine olumlu katkı yapmak gibi işlevlere sahiptir. Dikey bahçelerin sürekli bakım zorluğu, maliyet, bilgi ve bilinç eksikliği gibi faktörler sadece estetik amaçlı kullanılmasına zemin hazırlamakla birlikte uygulamaların yaygınlaşmasına engel olmaktadır.

Bu çalışma dikey bahçelerin sağladığı yararların ve neden olduğu olumsuz yanların belirlenmesi amacı ile gerçekleştirilmiştir. Bu kapsamda yurtiçi ve yurtdışında yapılan tüm çalışmalar incelenerek literatür taraması yapılmış ve dikey bahçe çeşitleri ile dikey bahçelerin olumlu ve olumsuz yönleri incelenmiştir. Çalışma sonucunda dikey bahçelerin kentsel alanlarda özellikle enerji verimliliğini artırmakta ve sürdürülebilir kalkınmanın sağlanmasında önemli bir yer tuttuğu ortaya konmuştur.

Anahtar Kelimeler: Dikey bahçe, avantaj ve riskler, sürdürülebilir kalkınma.

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1. Introduction

Urban population growth has caused by immigration from rural to urban areas posing many problems. The increasing pace of construction due to urbanization causes a lot of environmental problems and also it makes the city gray color. Green areas' contributions to the ecosystem and effects on people are very important. Therefore, necessity for green areas has recently been increasing.

Recent studies show that the amount of public green space (parks and gardens) has been decreasing. For example, the amount of green space in London was %38.4 in 2003 but it was %33 in 2013. In the same way, the amount of green space in Hong Kong was %41 in 2012 but after three years it was %40 (URL1, 2013; URL2, 2015). For this reason, seeking for the alternative green areas is increasing.

In line with this requirement, studies in order to integrate nature into construction are called as "vertical garden". The vertical gardens not only increase green areas at urban but also have some functions such as sound and heat isolation, energy productivity, air quality improvement, heat island reduction, location acquisition, creating agricultural area, aesthetics occurrence, and positive contribution to human psychology. However, there are some risks like constant maintenance difficulty, high cost and irrigation system problems (Erdoğan et al., 2008; Erdoğan et al., 2009; Ottelé, 2011; Mir, 2011; Kaynakçı Elinç et al., 2013a; Kaynakçı Elinç et al., 2013b; Yüksel 2013).

Vertical gardens can be both applied to outdoor and indoor. However, it is important to consider site selection criteria, as well as application and design principles. It should not be forgotten that vertical gardens can not be applied to all facades or surfaces.

In this study, it is aimed to analyze advantages and risks of vertical gardens. Initially, the term, vertical garden, was explained. Then, the appearance and types of vertical garden were expressed. After that, advantages and risks of vertical garden were revealed. In the light of this information necessity for vertical garden was discussed.

2. Materials and Methods

The main material of the study is vertical garden. To obtain data relating to vertical gardens, master and doctoral theses utilized, articles and papers which are about vertical greening system, urban development, green building certification systems and efficient use of energy were also referred. Besides, in particular, is the study focuses on the advantages and risks of vertical gardens. Within this scope, advantages and risks of vertical gardens were expressed so that we could answer the question whether the vertical garden was an important component of the urban ecosystem, or not.

3. Results and Discussion

The idea of using plants in structures has played an important role as the starting point of the vertical green systems. The Hanging Gardens of Babylon, one of the Seven Ancient Wonders of the World, are the first examples of vertical green system. The plants in these gardens had not been rooted in the ground because they were not able to grow in the harsh conditions in desert. So they had been rooted on the layered terraces. They have had a beautiful appearance (URL3, 2015). In the modern sense, the creator of the concept "Vertical Garden" is the French botanist Patrick Blanc. Patrick Blanc applied the first vertical garden experiment at the Science and Industry Museum in Paris in 1986. Patrick Blanc, however, has drawn attention with his practice at the 1994 Chaumont Garden Festival (URL4, 2015).

3.1. Vertical Garden

Vertical gardens can be defined the interior or exterior walls covered with the various plant species in two different ways; pre-vegetated in other words; "prefabricated modular panel" or in situ applied panels. Vertical gardens are categorized according to the material used in the system.
Vertical garden systems can be examined under four different headings as follows (Kanter, 2014);

- Modular system
- Foam based system
- Mineral wool based system
- Felt layer based system

3.1.1. Modular system

This type can be described as creating vertical gardens with panel or flowerpot in which plants placed inside (Mir, 2011). In both systems, there is a carrier profile at the bottom layer. Then, panels or flowerpots are mounted to the carrier profile. The plant material is inserted into the panel or pots. Drip irrigation is used in this type of vertical garden. Irrigation system also carries nutrient to the plants. A small amount of peat and soil can be used to avoid increasing weight of the system.

3.1.2. Foam based system

In this system, the foam based substrate which is made of aminoplast resin foam, is mounted to the above carrier profile. This media which hosts plants is very water efficient and robust for a wide range of plants and climate types. Panels which used in foam based vertical garden system has a standard size of 1000mm x 490mm x 140mm. Drip irrigation which conveys nutrient and water to the plants is used in this system (Mir, 2011).

3.1.3. Mineral wool based system

In this system, the panels which include of mineral wool are mounted above to the carrier profile. These panels have a standard size of 75mm x 600 x 1000mm. Each panels' weight is 15 kilograms and each panel have 16 areas for plants (Mir, 2011).

3.1.4. Felt layer based system

Felt material provides a base for plants such as soil. It allows water to diffuse homogeneously and it does not mold. Generally, nutrient and water are carried to the plants by using drip irrigation system in this type of vertical garden. In this system, an isolation material is used which is waterproof and it protects the facade from water and moisture damages. Excess water is accumulated in a dropper under the frame to reutilize (Örnek, 2011). Famous French botanist Patrick Blanc's technique grounds on this system.

3.2. Advantages of Vertical Garden

3.2.1. Providing biodiversity and habitat

Biodiversity is an important component of the ecosystem. Rapidly increasing urbanization and reduction of green spaces make preservation of biodiversity more difficult and there are changes in the link between human activities and biodiversity. Implementation of vertical garden systems in urban areas create habitat for fauna and flora. So they help to increase biodiversity (Ottelé, 2011). The more plant varieties are used in vertical gardens, the more biodiversity will be increased. However, it should be considered that different plant species require different habitat conditions. So plant species should be chosen carefully.

3.2.2. Sound isolation and barring bad images

As a result of intensive migration from rural areas to the cities, increasing urban population has brought with it the problem of noise pollution. Depending on the population, the increasing number of vehicles in the cities causes the increase of noise pollution and the decrease of people's quality of life. Vertical garden systems offer the best way to avoid the negative effects of noise pollution (Yeung, 2008). Because they can be used as a noise barrier. The growing media and plant species in vertical garden systems will contribute to a reduction of sound levels that transmit through or reflect from vertical garden system. Elements that influence noise reduction are as follows;

- The depth of the growing media,
- The materials used as structural components of the vertical garden system,
- The plant species used in vertical garden system (evergreen plant species are more effective).

Vertical garden systems can be used as an image barrier, too. By using these systems, green images can take the place of undesirable images like dump.

3.2.3. Increasing energy efficiency

Today, the reduction of energy sources and the increase of energy consumption have been under investigation of different disciplines dealing with these issues. Consequently, "Energy Efficient Building Design" concept has

emerged (Dikmen, 2011). One of the energy efficient building design's elements is vertical garden. Vertical garden systems can be used in the winter months for heating and in the summer months for cooling (Ottelé, 2011). These systems improve thermal insulation capacity through external temperature regulation. The main elements about energy efficiency can be listed as follow (Wong et al., 2009);

- The type of vertical garden system,
- Material for the application of vertical garden system,
- The insulation material used in the system,
- Used plant species and density of use.

3.2.4. Increasing amount of green space in the cities

The speed of construction is increasing due to urban population. Urban green spaces which offer recreational facilities to the people in urban areas are decreasing day by day. The destruction of green areas in the horizontal plane created the idea of invention of vertical gardens. So, urban areas could be gained green areas again.

3.2.5. Bringing rainwater to the ecological cycle

Drip irrigation system is usually used in vertical garden systems. This system transports the nutrient materials and water to the plants. The aim of irrigation system is to reach these materials to the root zone of the plants properly. By slowing the drainage of rainwater vertical garden systems prevent flood. Also vertical garden system allows rainwater to be used by plants. The plants filter the rainwater and bring it into the ecological cycle (Ottelé, 2011).

3.2.6. Protecting structures

Vertical garden systems protect structures from external effects. They can extend the life of the structure with two different functions as follows (Bjerre, 2011);

- Protect structures from temperature changes
- Protect structures from rain

High temperature changes may show expansion or contraction in the face of structures depending on the material used. Such movement can cause cracks in buildings. As a result, construction of the building would be damaged. Vertical garden systems will minimize expansion and contraction movements of minimizing the impact of temperature changes on the facades of buildings. So they protect structures from negative effects (Bjerre, 2011).
Rainwater can influence the life spans of structures. Acid rain can erode the surface of structure and excessive rainfall can cause deterioration of the structure. Well-developed vertical garden systems form an effective protection against driving rain, because they prevent that the rain will reach the surface of the facade. So, vertical garden systems reduce the amount of rain which affects to the facade and they protect structures from rainwaters' adverse effects (Bjerre, 2011).

3.2.7. Adding aesthetic and economic value to the structures

In our daily lives, we spend most of our time in the area were built with gray walls is quite far from the aesthetic concept. People's living spaces are increasingly graying, with a reduction of available green areas in the cities. Vertical garden systems are involved in the aesthetic value of the landscape to which they apply.

Today, people are looking for concept of green where they live. This situation is increasing prices of projects which have more green spaces.

3.2.8. Reducing urban heat island effect

Urban Heat Island (UHI) means that the urban temperature is higher than the surrounding countryside due to urbanization. During the day, facades of buildings and hard surfaces absorb the sun's ray. This causes an increase in the city's temperature especially at the night. This negative effect can be compensated by increasing the amount of green space in the city. Because they reflect the sun's rays (Mir, 2011). Vertical garden systems play an important role in reducing the urban heat island effect by increasing the evaporation surface and reflecting the sun's rays.

3.2.9. Air Quality Improvement

Vertical gardens are effective methods for improving the indoor and outdoor air quality. Population growth and increased industrialization in urban areas are the main causes of air pollution. Vertical garden systems provide an increase in the amount of green space in urban areas. Plants in the system can absorb exhaust gas, airborne dust and CO_2. The amount of absorption is related to plants' features. To reduce the air pollution especially in urban areas, vertical gardens are beneficial than the trees through the streets. Because they can circulate the pollution from the air better and sooner (Mir, 2011).

3.2.10. Contribution to the acquisition of green building certification

Experiences of National Green Building Councils in the world reveal that the most effective way to ensure widespread using of vertical garden is giving green label to the buildings. This label brings some standards to the buildings and also it provides a guide to architects and engineers (URL5, 2015).

Buildings and residential areas are responsible for %40 of CO_2 emissions, %12 of water utilization, %65 of waste and %71 of energy use. However, these figures can be reduced by using of green buildings (URL5, 2015).

Today, a lot of systems which evaluate environmental impacts of buildings are developed. The systems which are used most commonly as follows (URL5, 2015);

- LEED (Leadership in Energy and Environmental Design)
- BREEAM (Building Research Establishment Environmental Assessment Method)
- DGNB (German Sustainable Building Council)
- ÇEDBİK – Building Certification (Turkish Green Building Council)

In Table 1, it is given that the role of using vertical garden system in ÇEDBİK – Building Certification and how vertical garden affects this certification systems' method of scoring. ÇEDBİK - Building Certification system score is made out of 100 points and the total score is certificated such as (URL6, 2015);

- 45-65 points: approved
- 65-80 points: good
- 80-90 points: very good
- 90-100 points: excellent

Vertical gardens have an important place to get a ÇEDBİK – Building Certification with features such as integrated design, sound isolation, reduction of water usage, prevention of water loss, energy efficiency, environmentally conscious contractors, thermal comfort they provide, fresh air, control of pollutants, innovation. The points that can be taken under these benefits vary according to the design criteria score, but the highest score can be obtained from the energy efficiency criterion (1-15) (URL6, 2015).

Table 1. Points that the use of vertical green system in a building can earn in the ÇEDBİK - Building Certification system (URL6, 2015).

Scoring Criteria	Possible Scores
Integrated Design	1-2
Sound isolation	1
Reduction of water usage	1-6
Prevention of water loss	2
Energy Efficiency	1-15
Environmentally conscious contractors	2
Thermal comfort	3
Fresh Air	1
Control of Pollutants	2
Innovation	2

3.3. Risks of Vertical Garden

Vertical gardens have a few risks, as well as a lot of benefits. These risks can be examined under three main headings as follows (Ottelé, 2011; Mir, 2011);

- Maintenance frequency and difficulty
- High cost
- Irrigation systems problems

3.3.1. Maintenance frequency and difficulty

Vertical gardens need maintenance because they are living systems (Mir, 2011). Maintenance frequency depends on the type of vertical garden, climatic conditions and plant varieties. Carrier panels and isolation materials which are used for vertical gardens usually resist of environmental conditions. So maintenance is generally related to plant diversity and irrigation systems. But if there is a damaged carrier panel or isolation material they must be changed. As with all landscaping work the plants which convenient to environmental conditions must be used. However, there is still damaged or dead plant they must be altered. Also maintenance work required for the irrigation systems not to be affected by frost during the winter months. And it also should be realized that addition of plant food materials and regular pruning work for the desired effect (Mir, 2011).

It must be considered that maintenance which will be done in vertical surface is more difficult than in the horizontal surface. Furthermore, the maintenance and repairment works should not be ignored for the sustainability.

3.3.2. High cost

Expensive elements of the work which will be applied in a vertical surface are more than in a horizontal surface. Expensive elements in the vertical garden as follows (Perini et al., 2011);

- Carrier profile
- Isolation material
- Irrigation System Components
- Drainage System
- Plant Growth Media
- Plant Species
- Routine Maintenance Costs (Maintenance of irrigation system, drainage system and plant species)

3.3.3. Irrigation systems problems

Drip irrigation system which have automatic timing device is usually used on vertical gardens. Various failures in the irrigation system could cause troubles in terms of time and cost. So regular maintenance should be done with the controls of the irrigation system, and in particular, measures to be taken against frost may occur in irrigation systems in winter. It also should not be forgotten that the vertical garden which will be applied in the south façade need more water than in the north façade because of evaporation (Mir, 2011). Controlling the amount of nutrients during regular irrigation system maintenance is essential.

4. Conclusion

Increasing urban population also increases the rate of construction. With the increase of the structures, the green areas in the urban areas are disappearing, so various environmental problems arise. As a result of the studies of different professional disciplines trying to find a solution to this issue, the concept of "vertical garden" emerged. In these systems, the nature is integrated into the vertical plane and the urban areas that are becoming darker day by day are able to achieve the greenery that it misses.

As part of this study it is revealed that the vertical gardens not only have advantages but also have some risks. Considering the scope of vertical gardens' advantages it can be said that vertical gardens are vital for the urban areas and they especially contribute to the energy efficiency. So, vertical gardens are the key factor of sustainable development. When considering the risks of vertical gardening it is deduced that if there is enough time for regular maintenance work and adequate financial support many of these risks will be disappeared. It should be noted that the application area should be chosen at right place to obtain expected benefit from vertical gardens applications. For that reason, the place should be preferred where got maximum benefits from advantages of vertical garden.

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