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Aesthetical and Ecological Functions of Green Interfaces in Spatial Design

Selma ÇELİKYAY[1]*, Fulden GİZLİ[2]

[1] Department of Landscape Architecture, Bartin University, Bartin, Turkey
[2] Graduate School of Natural and Applied Science, Bartin University, Bartin, Turkey

*Corresponding Author: scelikyay@bartin.edu.tr
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ABSTRACT

Spatial interfaces are the elements that establish and link relationships between spaces. Interfaces, which can be either indoors or outdoors, but also between indoor and outdoor, have an important role in the relationship of the building with the city and the citizen. The interface represents the area formed between the building and the urban space and has a volumetric characteristic besides being planar. One of the innovative design applications to increase human-nature interaction in urban space is green interfaces. Green interfaces have both aesthetic and ecological functions as perceived elements in the transition between spaces. Green interfaces have a variety of names such as vertical garden, green surface, living wall, green wall, bio-surfaced wall, green pier, landscape wall. In addition to the positive effects of the green interfaces on the visual perception of space, there are also positive ecological effects in terms of reducing urban heat island effect, improving indoor air quality, increasing energy efficiency, increasing biodiversity and reducing noise. Green interfaces as important components of sustainable built environment have positive functions in terms of urban ecology, building ecology and human ecology and thus, improve the quality of life in the built environment. In this paper, the aesthetic and ecological functions of the green interfaces, which have become an important element in spatial design, have been presented in detail.

Keywords: Green Interfaces, Spatial Design, Human Ecology, Building Ecology, Urban Ecology.

INTRODUCTION

The concept of space has developed over time and has reached great dimensions with its different types and sub-titles. Therefore, there are many definitions of space in the literature. When it is examined with its general definition, space is the environment which is constructed and arranged on human actions. In other words, spaces are daily scenes of life in the city. In their study, İsmailoğlu and Öztürk (2017) called the interior space as a result of the closure of a part of the physical space with walls and ceiling planes, and the volume remaining outside it as outer space [1]. It is mentioned here that there are two different spaces, the space limited by certain elements and the space outside the limited space. Spatial life, which is the essence of architecture, starts in the interiors of buildings and continues in the city, streets, squares, playgrounds, gardens, and in every volume created by human beings [2]. In this context, the relationship between indoor and outdoor space in terms of space classifications comes to the agenda with both public and private sphere. According to Aytaç (2013), the elements that determine the outer space and the inner space and provide the transition between the two spaces should not alienate these two spaces to each other [3]. The user in the interior needs to feel where he is and wants to know his position in the environment. Inner-outer association is a permeable interface with the effect of creating contrast and transparency, both intellectually and physically. Permeability of internal-external relationship; types of space, function, psychological effects, perception, structural details can be discussed in many areas that can be reproduced [1]. Landscape elements such as glass, air, water, and plant design add diversity and richness to the transitions between the buildings and the outdoor spaces at varying levels. Therefore, these contributions increase the aesthetics of the city and provide users with more livable cities.

When structural interface designs are combined with plant designs in architecture, ecological contributions as well as aesthetic contributions come to the agenda. Green interface applications have been preferred since ancient times. The French botanist Patrick Blanc is the grandfather of green walls [4]. He is accredited for inventing the first hydroponic system and for introducing green walls to the public realm over twenty years ago. He looked to nature for inspiration and realized that many plants can grow without soil. Patrick Blanc, for the first time, introduced the application of what he called the city's living walls. Today, his vertical gardens can be seen all over the world, some covering buildings up to 10 stories high. He made positive contributions to both urban aesthetics and urban ecology.

The green interfaces used between the interior spaces and the urban outdoor spaces have both a distinctive and binding role. Green interfaces enhance spatial, visual and functional ties between buildings and the urban environment, reinforcing the interaction and continuity between the two spaces, increasing the use and viability of the urban space [5].

GREEN INTERFACES

A new approach to modern architecture, green interfaces have allowed nature and green to be incorporated into buildings and the city. Due to the increasing urban population, urban structure and technological developments, natural green areas are being damaged and the number of urban parks and gardens is decreasing day by day. The green interfaces developed against this problem are the solutions of the citizens' desire to give more space to the green spaces, the desire to integrate with nature, the protection of natural resources and aesthetic and ecological needs.

Green interface types

Green interfaces with aesthetic and ecological benefits have been studied many times in the recent past. Jaafar, Said & Rasidi (2011) collected the definitions of green interface varieties from the literature study and combined them into a common denominator.

Vertical gardens

Vertical garden is a complementary term that expresses all forms that cover the surface of walls with plant compositions. Vertical gardens are used to highlight plants, buildings or building facades [6].

Horizontal green systems

These systems are where plants are placed on the floor, balcony or above the building. But they are mostly hydroponic systems that are formed horizontally as part of a window shade or as a balcony garden [6].

Green facades

Green surfaces are a green wall system using climbing plants or ground cover plants, which include specially designed supporting structures. Green plants may be rooted at the base of structures, soil, intermediate planters or roofs. It takes about 3-5 years to fully cover these surfaces [6].

Living walls

Living walls consist of pre-arranged panels, vertical modules, and installations fixed vertically to a structural wall or frame. These panels can be made of plastic, expanded polystyrene, synthetic fabric, clay, metal and concrete [6].
Bio-surface walls

Bio-surface walls support the green facades. It refers to the vegetation created by directing plants to climb wires or cables in the structure [6].

Green pier

It applies mainly to eco-reinforcement. It covers the outer perimeter of existing buildings as a light structure to benefit from all climatic and ecological functions of plants for water and air cleaning [6].

Green field walls

These are the green spaces created by using new developing techniques on the outer walls or on the walls that are used for both purposes as interior-exterior. These walls create a wide range of synergistic uses, such as clean energy, air, water, food, land and social space [6].

AESTHETICAL FUNCTIONS OF GREEN INTERFACES

The word "aesthetics", which examines the beautiful part of the emotional field, contains meanings such as senses, perception, and perception with feelings [7]. As it has been studied in many different fields, "aesthetic" approach types have been examined at building and urban scale. In this context, aesthetic features are evaluated according to color, texture, shape, design etc. properties. Defined spatial relations, fluidity of spaces and well-structured spatial transitions determine visual landscape quality. In order to provide these features, material choices in urban design, urban furniture, lighting elements, floor coverings, facade decorations, plant designs are utilized [8].

The aesthetic values of buildings and urban scales were examined in terms of plant designs, and the effects of landscape designs were also examined in addition to natural green environmental components. Eroğlu & Başaran (2017) defined visual landscape quality as the relative aesthetic perfection of a landscape, and emphasized that the quality of landscape can be measured through the appreciation of the observer [9]. According to the human being, which is sensitive to aesthetics and nature, green interface designs are also effective elements of building and urban scale. In summary, green interfaces are used to correct negative awareness, improve the profile of a building and improve the visual perception of a city.

Aesthetic effects of green interfaces on building scale

According to Yazgan et al. (2009), moving natural landscapes to the interior spaces is the main objective in the integration of landscape with space. Planting designs, which are used extensively in the interiors and between the interiors and the interiors, define these areas and help create spatial identity [10]. One of the aims of plant elements used in interior design is aesthetic concern. Tzortzi, Georgi & Sophocleous (2018), investigated the effects of interfaces created with vertical gardens. They argued that the vertical garden immediately stands out because human eye is not accustomed to seeing a garden vertically and makes every place more aesthetic and more attractive where the green interfaces are placed [11].

For example, Figure 1 shows the headquarters of a company that is a lighting manufacturer in Shanghai (China). On the façade facing the road, groove floors are designed in a horizontal plane with green plants. Since the steel gutters create a mirror effect, a more intense plant cluster is perceived. The entrance door leads visitors to the four-storey high courtyard [12]. Thus, in the courtyard behind the hectic world outside, an atmosphere was created to lead to calm thinking.

Fig. 1. A company building in Shanghai [12].

Fig. 2. A company building in San Francisco [URL1].

The contribution of the green interfaces to the aesthetics of the building can also be examined at another company building in San Francisco (Figure 2). The lobby of this building, named Foundry Square III, is open to the public, with two adjoining living walls and two floor-to-ceiling glass walls creating a sumptuous interface. Passers-by can see the vertical gardens inside. One of the inner walls consists of 1426 square meters of monochrome foliage, the other wall contains 23 different plant species in an area of 1027 square meters [URL1]. In addition, the moisture sensors in the wall can only save water by irrigating when necessary. This application demonstrates the ecological functions of the green interfaces on the building scale as well as the aesthetic effect.

The aesthetic applications of green interfaces also affect the people in their environment in a psychological sense. By moving nature to places, it is ensured that people are intertwined with nature in daily life, so that physiological or psychological issues / problems can be alleviated by a physical and spiritual connection with nature [13]. Living walls as green interfaces created indoors have positive effect on individuals in a great extent. Some researches show that individuals living in buildings with plant applications were more careful, more productive, and less stressful than others [14].

Aesthetic effects of green interfaces on urban scale

Some parts of cities are surrounded by buildings that are repulsive, dull and have no aesthetic value. Worn building surfaces, dirty gray facades and soulless designed structures adversely affect urban aesthetics [15]. This aesthetically undesirable effect can be solved by green interface applications on building surfaces. Deformed, in need of renewal, in which life does not continue, building surfaces not to have aesthetically valuable features can be covered with plants and thus, urban image is renewed and urban aesthetics gain value.

The contribution of green interfaces to urban aesthetics can be seen at the electrical substation in Barcelona (Spain) (Figure 3).

The facade of the building in the form of a concrete mass is surrounded by a stainless steel cable mesh system. The roof of the building is considered as the fifth facade and all the facades of the building are covered with vegetation. Within a few years after the application was completed, all building facades were covered with green [12]. Built as a concrete mass, this building has been transformed into a green interface that adds value to urban aesthetics with simple application methods.

Fig. 3. Transformer substation in Barcelona [12].

Fig. 4. Green hall in Zürih [12].

Another example is a building in Zurich (Switzerland) that was built by a factory of an engineering company that is not actively used in the city (Figure 4). This structure is located within the city's residential and business centers. Consisting of a four-storey open frame, the building is 100 meters long, 34 meters wide and 18 meters high. It consists of two layers of steel profiles and there are hanging stairs between the layers, gallery spaces and balconies. The building called “green hall”, which is adorned with numerous climber plant species, hosts cultural events [12]. The structure that forms a green interface within the city with its mass presence also contributes to the aesthetics of the city.

ECOLOGICAL FUNCTIONS OF GREEN INTERFACES

With the increase of urbanization in the world, the concepts of “environmental carrying capacity” and “livability of cities” have been brought to the agenda. Therefore, ecological approaches such as conservation of existing landscape capacity, limited intervention in natural development, preservation of natural appearance, protection and restoration of existing habitats have started to be adopted. In today's conditions, impermeable hard surfaces such as concrete asphalt increase the heat island effect

which is a rapidly increasing problem in urban areas. In addition, dry walls, roofs and streets act as reflectors, absorbing some of the energy and reflecting some of them from hard surfaces [16].
After the sun sets, the heat absorbed by the hard surfaces during the day is released and forms dome-shaped heat islands covering the city. This formation in the city results in the formation of hot spots in other cold sections of rural areas. In order to find solutions to these problems, renewable energy sources are used in landscape design and management and sustainable ecological management policies are followed, for this purpose, local and recyclable, low cost local plant species are preferred with regulations to reduce energy consumption [16].

The indoor air quality is as important as the outdoor air quality. Synthetic building materials are preferred for better quality, insulated and comfortable buildings with developing construction technology. However, synthetic materials used indoors cause health problems for users who are constantly breathing in the indoor air. In addition, especially in winter, the thermal insulation is in the forefront, so that buildings cannot be adequately ventilated and health problems caused by poor quality materials are increasing (Sick Building Syndrome) [16]. Sick Building Syndrome is a collection of nonspecific systems such as eye, nose, skin and throat irritations, headache, fatigue and skin rashes [15].

Effects of green interfaces on human ecology

The change of the environment by natural or artificial interventions affects all living things in that environment at the same rate. The change in the natural environment during glacial periods has led to a decrease in climate and plant groups suitable for the climate on the one hand or the disappearance of some species. Mankind managed to defend itself, but technological developments that started after the industrial revolution and reached to the present day increased the dominance of human beings against nature.

Karaca (2008) argued that all environmental problems on the natural environment are caused by human-centered approaches. Human-centered approaches that are supposed to emerge under the influence of Western culture are based on the view of man as the master of nature [17]. However, this approach is the biggest harm that human beings suffer in the long run. Mankind should look at his relationship with his environment with a more holistic approach and understand what the nature of his life means for him [17].

Green interfaces contribute to urban ecology with urgent environmental developments by reducing waste in polluted cities. Plants act as bio-filters and purifiers, which have a striking effect on improving air quality in cities by eliminating or reducing pollutants in the air. Researches have shown that there is significantly less toxin in the air surrounding a vertical garden thanks to the leaves function as an air filter by cleaning dirty air. It is also stated that clean air increases the concentration and helps employees to be healthier, especially in work areas. This improvement in air quality was measured as cough up to 30% and reduction in dryness of the throat up to 20% [18]. This is of great importance for human ecology.

When the impact of the urban environment is examined theoretically, it is stated that if a living wall is placed in each of 50 houses in a row, it is equivalent to planting 50 trees in the street. Plants that act as purifiers replace CO2 with oxygen, which means that the breathing air is fresher and healthier [16].

Fig. 5. A shopping center in Basel [12].

The shopping center built between the residential area and the industrial area in Basel (Switzerland) serves as a green interface designed as both a green façade and a green roof. On the southern façade, flowerpots are arranged on each floor and many climbers are used, such as the evergreen wild vine (Fig.5). The damage to human ecology caused by many negative factors such as excessive lighting, magnetic fluctuations and noise pollution in the shopping centers has been reduced with the plant design created on the façade [12].

Effects of green interfaces on building ecology

Green interfaces play an active role in air conditioning. Green interfaces on the facades provide passive air conditioning and increase the energy saving of buildings [19]. For example, the vines that grow naturally on the facades of the building serve as cooling during the hot seasons. In a study conducted in Japan, temperature differences up to 10 degrees were recorded on plant and non-plant wall surfaces [19].

Plants that contribute to the building ecology by shading in the summer months shed leaves during the winter months, allowing the building facade to benefit from daylight. In summary, it is known that the heat gains and losses caused by the air movements on the façades are reduced by the green interfaces and energy efficiency is increased. Başdoğan & Çığ (2016) reported that the vertical garden, which is used as a green interface in a building, can function as a bio-filter and oxygen generator in addition to air conditioning. They emphasized that 27 grams of oxygen can be produced from 25 m2 leaf surfaces in one hour and thus the amount of annual oxygen required for human beings can be obtained from the surface of 150 m2 leaf [15]. In addition, they mentioned that a 60 m2 vertical garden can filter 40 tons of harmful gases and 15 kg of heavy metal [15].

Fig. 6. A company building in Rimini [12].

As seen in Figure 6, a company building on the banks of a busy road was formed by joining two symmetrical five-storey buildings at the intersection points. Surrounding the corridors outside the floors with plants wrapped in steel frames has a positive effect on both human ecology and building ecology (Figure 6). The planting of the building facades contributes to air conditioning, creates curtains for the sun and improves the sound insulation throughout the year.

As in the example above, the green interfaces used in the areas associated with indoor spaces also absorb background noise and support the creation of more useful, quiet and relaxing spaces. For example, green interface designs near a work area serve as a noise buffer and can reduce noise up to 5 decibels [19].

Turkey first vertical garden in the building scale, applied on the facade of Siemens' corporate buildings in Istanbul (Figure 7). On a facade of a historic building, the vertical garden, which is formed on a surface of 90 m2, uses 4000 live plants, eight of which are different plant species [20].

Fig. 7. Siemens' company building [URL2]

Plants and seagull symbols, Siemens logo and nature theme are processed in the vertical garden, which has brought the company's environmental identity to the forefront on the building scale [URL2].

Effects of green interfaces on urban ecology

The science of urban ecology includes approaches and studies aiming to create environmentally sensitive cities that see the city as an ecological system. Environmental problems can be solved by using the products and systems of the urban process for the benefit of nature. However, the destruction of nature and natural processes disrupts the urban ecological order. In order for human beings to regain this balance, the beneficial contribution of green interfaces is needed. One of the most important benefits of green interfaces for urban ecology is the reduction of the urban heat island effect. Water losses caused by perspiration or evaporation in plants provide a reduction in the surrounding temperature [19].

The air temperatures in the areas where buildings with green interfaces are located in the city are measured to be more livable than other areas. Alexandri (2008), pointed out that the greening of the facades and roofs of 10 meters high and 15 meters wide buildings in a valley within the urban area in Hong Kong would reduce the temperature of this valley by 8 to 9 degrees [21]. In addition, a study conducted at the Institute of Physics in Berlin found that the daily cooling value of 56 potted plants in a 4-storey building was 157 kWh [22]. Green interfaces in the city also contribute to biodiversity. Damaged wildlife as a negative return of artificial environments and rapidly growing urbanization is of concern to ecology. Green interfaces contribute to urban ecology and can also restore natural habitats. According to Örnek (2011), the careful selection and application of plants in green interfaces can create suitable habitats for endangered animals. When ideal conditions are created, bees, birds or butterflies can provide their basic needs such as water, food, protection and housing through green interfaces [19].

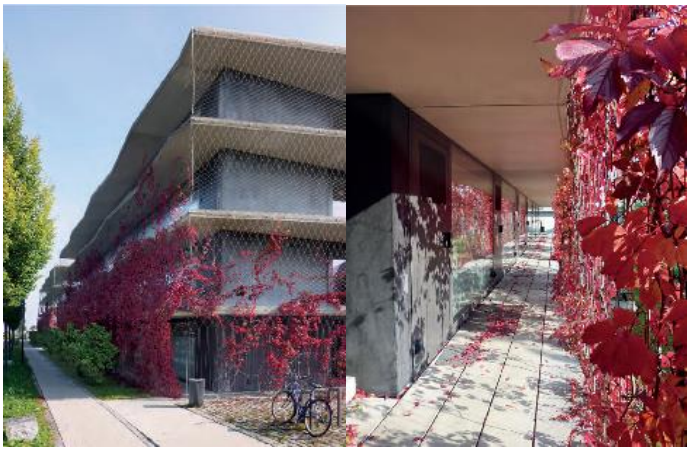

Fig. 8. Student residences in Garching [12].

Student residences on the campus of the Munich Technical University in Garching (Germany) are surrounded by corridors providing access to apartments on each floor. Outward-facing facades of these corridors were covered with steel cable network instead of railing and planting design was applied (Figure 8). The cable network is functionally designed dense up to the railing level and sparse after the railing level [12]. Year-round color variations of the Virginia creeper add aesthetic value to the structure. Deciduous plants in winter help to air-conditioning as mentioned above, while it is a noise curtain for students staying in residences [12].

The 25 Verde projects, designed in Turin, Italy, consist of 63 residential units (Figure 9). The plan U shaped architectural plan is formed around a courtyard. The steel structure that surrounds the façade is transformed into a vertical garden with large pots of trees. The housing units facing the green façade, which also became a public space, aimed to create a green filter between the interior and the facade. Planting on the façade has an absorption power of about 200,000 liters of carbon dioxide in one hour, thus helping to create the microclimate of the building itself. Geothermal energy is used in heating and cooling, rain water accumulated in water use, and natural ventilation brought by architectural fiction is used in air conditioning [URL3].

Fig. 9. House project in Basel [URL3]

This project is exemplary with its ecological approaches and contributions to aesthetic values both in building scale and in urban scale.

Urban agriculture is also an important application and production area that contributes to urban ecology. Rapid urbanization, rapid population growth and the decrease of rural areas have negative effects on agricultural areas. Therefore, in terms of land economy, new food production techniques have started to be tried in cities. Due to the decrease in horizontal urban areas, green interfaces create a suitable environment for vertical agriculture. Agricultural activities on green interfaces contribute to the production of fresher and more reliable foods and more sustainable urban ecology [23]. At the same time, vertical urban farming practices, like other crop designs, improve water efficiency and organic recycling, increase energy efficiency in buildings, reduce emissions in transport and improve

microclimate [23]. In the system where soilless plants are used in green interfaces, collected rain water is used. Thus, no extra water is used for irrigation and the amount of waste water is reduced.

SCOPE AND METHOD

In this study, the aesthetic and ecological functions of green interfaces, which give a new dimension to spatial design both indoors and outdoors, have been investigated and presented through examples. Green interfaces as important components of sustainable built environment have positive functions in terms of urban ecology, building ecology and human ecology.

In the study, the importance of green interfaces in theoretical framework is emphasized with the information obtained from the literature. By means of the literature research and also some best practices in the world and in turkey, aesthetic and ecological functions of green interfaces have been revealed.

CONCLUSION

The concept of quality of life, which has been frequently expressed for many years, is linked not only to today's needs but also to the needs of future generations. Greening systems have been used for this purpose for many years but in today's conditions it becomes more important in our cities due to lack of aesthetic value and ecological protection requirements. Planting designs in the spaces that we describe as interfaces, which reinforce the relations between outdoor and indoor spaces, are a suitable option to meet these requirements. When many problems such as social, environmental, aesthetic, ecological and health are taken into consideration, planting designs and green interfaces are also needed in terms of human ecology, building ecology and urban ecology in order to sustain the life cycle in the long term and to bring back the natural vegetation that is damaged by human beings.

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