



# Sustainable Urban Development by Green Systems

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**Abstract:** *A development that is not compatible with the environment, economy and society is not sustainable. Green roof and wall, as new approaches to architecture and urbanization, are based on the concepts of sustainable development to improve environmental quality, promote the economic and social conditions and, ultimately, sustainable urban development, because the implementation of green systems such as green roofs and walls, due to their environmental, economic and social features and functions, improves living conditions and realizes the goals of sustainable urban development; therefore, the establishment of green urban systems, due to their impact on urban life quality and sustainable development of the city, are worth exploring, and it is imperative that the green roof and wall issue is considered as one of the sustainable approaches to urban development. The purpose of this study is to examine how implementation of green systems impacts sustainable urban development. Hence, in the present study, the relationship between sustainable development pillars with green roof and green wall systems is investigated in cases such as flood management, reducing the effect of thermal islands, energy storage, filtering pollutants and reducing carbon dioxide, creating sound insulation, creating a natural ecosystem, food production, job creation, reducing exploitation costs against creating social interaction. The approach governing this applied research is qualitative. The research method is descriptive-analytic and collection of required information is based on theoretical concepts collected by the library method from books, articles and websites. Finally, considering the impact of green systems on sustainable urban development that is included in the findings of this study, executive suggestions for sustainable urban development are proposed by the environmental, economic and social functions of the green roof and wall.*

**Keywords:** *Sustainable Urban Development, Green Systems, Green Roof, Green Wall*

## INTRODUCTION

With an increase in the problems of the modern world, improving environmental, economic, and social conditions, which are the three main objectives of sustainable development, it became a top priority for the policies of developed countries. Developing countries like Iran are now seeking to implement these policies to resolve various cultural, social, and environmental issues with regard to economic consequences to reach a sustainable city (Keshtkar Ghalati et al., 2011:15). In order to implement these policies, green systems are one of the modern approaches of architecture and urbanization arising from the sustainable development concepts which can be used to increase the green space, promote environmental quality, improve economic conditions, and strengthen social conditions and thus, achieve sustainable urban development. The distribution of urban green

systems must be optimal and desirable to have environmental, economic, social, psychological, and psychological efficiency for citizens and create optimal ecological conditions for cities (Tehran gardens and green spaces Organization, 2010).

In the last few decades, spaces that have been used for cities were reduced, which has led to a troubling increase in the inappropriateness of air quality and temperature increase in cities. The deterioration of air quality in large cities is dependent on the diversity of population, increased industrialization, increased construction of fossil fuels, the problems caused by sewage systems, and the reduction of green space, which will lead to more energy requirement in summer and winter (Lazzarin, 2005). To solve these problems in the present era, the need for eco-friendly design alternatives have been increased, so that a sustainable global order is created. Cultivation of vegetables, shrubs, and even small trees on the roofs or walls can be useful in improving the climate of cities; in addition, it can also be very important for low power consumption, pollution reduction, and environmental warming reduction (Sayyadi and Madahi, 2011); hence the adverse effects of urban life, deterioration of air quality, and rising temperature can be reduced by increasing green systems in cities and buildings. On this basis, the search and investment in green roofs and walls is the most important approach that allows our cities to grow and develop reliable sustainable development.

The importance of this study is that, in case of not paying attention to three stable patterns in the city, the pattern of environmental, economic and social stability, inconsistencies will take over the whole city. An increase in the city's temperature and pollution, the end of fossil fuels, the destruction of the ecosystem and the city's facelessness following the inattention to sustainable development is not only for a specific region, but will also involve the whole city. Bringing the issue of designing the urban green systems is one of the requirements of the urban life, because, in addition to the environmental irreplaceable values, it has a direct effect in beautification of cities and citizens' comfort and vitality, and therefore, the deployment of urban green systems in order to affect the quality of life and achieve sustainable development of the city is essential. Furthermore, it is necessary that the issue of green roof and wall to be considered as one of the sustainable approaches in the city. The aim of this study is to investigate the effect of implementation of green systems on sustainable urban development. In this research, we first investigate the nature of green roofs and walls and the benefits of using these elements in sustainable urban development; finally, it has been concluded and solutions to the development of green systems usage in urban spaces have been discussed.

## **Research Method**

The nature of this study is to use qualitative data through analysis and description. This research aims to study some of the problems and improve the current status of society in relation to environmental, economic and social issues. The information required in the field of theoretical literature is documents which have been processed through coding after collecting information through books, domestic and foreign papers and sites. Finally, in the study, the effect of green systems on sustainable urban development is proposed and solutions for sustainable urban development are proposed by environmental, economic and social functions of green roof and wall.

## **Research background**

Sustainable urban development is prior to the industrial and technological revolution in Europe that human has not been able to create significant pollution due to the lack of scientific science and technology and the use of natural forces such as water, wind, sun, domestic animals, power of hands and simple industries (Firoozbakht et al., 2012: 216). In addition to the emphasis on the principles of

sustainable development in preparing the urban plans, the plan of healthy and green cities is one of the mentioned measures in the literature. The idea of sustainable city, in the eastern Mediterranean region for the first time, was proposed by Tehran municipality for the first time in a sustainable city symposium organized by the Tehran municipality in December 1992, and the green city plan is another plan proposed by Department of Environment of Iran through holding Green City Conference in September 1999. In this regard, the research design of providing quality assessment pattern of urban environment, which was implemented within the framework of the country's second development program by the environment department, tries to assess the urban sustainability by focusing on the biological- physiological basic needs of human being (environmental protection organization, 2008).

The idea of creating a garden on the roof and cultivation on it was created by the Iranians 2500 years ago and on the roof of Ziggurats, and the suspended green roofs were built by people of Babylon 600 BC. The floating gardens of Babylon were not gardens floating in the air; they were green spaces that lay on roofs and balconies of buildings. Also, with regard to historical history in Iranian architecture, moss and lichen covered the roofs of various regions of the country as insulation. Meanwhile, Vikings also guarded the walls and roofs of their houses with a layer of grass against wind and rain, and in some cases, they used seaweed to insulate the roof from seaweed (Ansari and Keshtkar, 2006: 62).

In the late 19th century, amongst the solutions which were proposed in relation to many settlement issues in the city, was the idea of creating garden-like cities. The idea was suggested by British Ebenezer Howard. His attention was more focused on getting rid of the harmful aspects of the industrial revolution and the elimination of crowded slums (Shiea, 2006). In the early 20th century, by considering the quality of urban environment in urban texture, environmental challenges of big cities, central regions of the city in particular, the emergence of the urban heat island and energy crisis, the new wave of green roofs approach in its modern concept was commenced from the Northern Europe. (Tehran gardens and green spaces Organization, 2010).

In their research entitled "the values and functions of green roofs in sustainable urban development", Yazdandad et al. concluded that green roofs are part of efforts to make cities more sustainable and one of the modern solutions to urban problems. In addition to the problems of employment and construction of plant units, this method is very efficient in many ways and can be an appropriate alternative to urban parks (Yazdandad et al., 2010). In his research entitled "how to conduct the green roof," Mirkuhi concluded that green roof technology could be considered as a technique to reduce environmental pollution. Indeed, the green roof is an organism and its main purpose is to improve the quality of the environment, and the recognition of the environmental and social variables effective in the increase of green roofs in the direction of macro investment requires the study of the interests and understanding of its types as well as the calculation of additional costs imposed on the structures for the maintenance of green roof (Mirkuhi, 2010). Refahi and Talkhabi investigated The effect of green roof in the internal temperature of building and energy consumption by the use of leaf-level index factors and soil layer in three climate regions of Iran; results show that the use of green roof in hot and humid climate of Bandar Abbas, arid and hot climate of Isfahan, arid and cold climate of Tabriz, results in a 5.8, 2.9, and 6.6% decrease respectively in energy consumption (Refahi & Talkhabi, 2015).

In China, considering green roofs are encouraged at the top of the buildings in Beijing. Fang Li In the paper entitled "the comprehensive planning of green city, based on the ecological principles," tries to answer the question of how to build a green city plan to achieve greater stability in the long-term sustainability, and in this regard, it suggests the development of green belts along the rivers, roads, parks, and the vertical green roofs spread over the built areas in the neighborhood scale (Li,

2005). In his study as "Urban Agriculture on the Green Roof for Urban Sustainability", Hoey argues that many urban areas in the world are trying to increase sustainability by improving urban green space and promoting urban agricultural development. The creation of green roof for agriculture provides an opportunity to achieve environmental, social and economic sustainability for urban buildings because it can help reduce environmental problems and promote community performance and develop urban food systems (Hui, 2011). Goussous et al. conducted a study based on thermal computing and computer stimulation to display thermal benefits of green roof on energy saving, suggesting that green roof technology is an approach to increasing annual energy productivity. (Goussous et al., 2014)

A study at the university of Canada revealed that the use of green wall reduces heating costs in the cold climate as Canada up to 23 %, and in the university of Maryland that the use of green wall in July reduces the temperature of the building's internal spaces from 3 to 11 degrees, and therefore, the cooling cost is saved up to 73%. (2008) this advantage is so important that 40 % of the green space of Germany and 7% of the green space of Canada and 20 % of the Japanese green space consist of a vertical green wall; because moderating the temperature of environment by green system, in addition to environmental advantages, causes economic benefits and thus, contributes to sustainable urban development (Mirzadeh, 2009: 10).

## **Research literature**

### **Sustainable development**

According to the interest of public opinion, especially people in the developed countries, about environmental issues, the introduction of developing countries to the dangers of environmental crises and the development of environmentally friendly technologies, that is to say green thinking, green industry and green culture in modern societies, the conscious sustainable development emerges increasingly among the communities (Aslani, 2001: 43). Sustainable development is the balance between development and the environment, society and economy, which is, in fact, an effort to achieve the best results in the plans of human and natural environment that is done for the current time and indefinitely for the future (Shiea, 2008). Sustainable development is a novel arena that simultaneously takes into account the politics and culture considering the economic and industrial prosperity and supports the environment and coexistence with nature as well as equality, and addresses the domestic and international issues of countries (Hosseinzadeh et al., 2017: 67). There are many definitions of sustainability, but the following two definitions clarify the nature of the word: (Hamideh & Mohammadpoor, 2007: 10)

1. Promoting the quality of life while considering the capacity of the environmental tolerance.
2. Accountability to the needs of the present generation without that the capability and possibilities of the future generations to be limited for supplying their future needs.

The world summit entitled "social development" has defined this term as a framework of efforts for achieving high quality of life for all people, in a way that economic development, social development, and environmental protection are intertwined, and mutually reinforcing constructive elements. Sometimes in the sustainability of the three environmental, social and economic systems, these foundations, are called the triple foundation line by which the persistence and success of development and design are evaluated. Ecological procedures and social and economic sustainability are committed separately because the responsibility of environmental guarantee means cultural sensitivity and social sustainability that should include ecological integrity; so, for cities without a combination of these three systems, there will be no durable and viable future. The global technological development has led to an increase in the rate of consumption, continuous urbanism and international growth of capitals and at the same time, the rapid growth of technology in

increasing environmental problems affects the global scale, which results in the rapid destruction of natural resources and species and increased levels of energy loss. Thus, it is understood that the built environment as a prominent indicator of energy and resources is strongly implicated in the dependent process of environmental, social and economic conditions (Cole & Richard, 2004).

The principles of sustainability are the use of nature solutions, adapt to the environment instead of the change of environment, coexistence with natural and artificial environment and unity in total and self-determination in components, non-renewable energy storage, recycling of buildings and building materials, respect to the context of the plan and employing the aforesaid design principles simultaneously; and three fundamental principles are as saving in the sources consumption, design based on the life circle and the human-based design principle. (Belali Oskouei, 2017).

### **Sustainable environment**

The basic condition in achieving environmental sustainability is to establish a dynamic equilibrium between different environment systems. This condition requires achievement of the ecological, social and economic systems from the practical perspective, and is defined as the establishment and continuity of the coexistence relationship among elements and basis of the environment from the ethical point of view. Accordingly, the sustainable environment can be defined as follows: (Hirmandi Niasar, 152: 2016)

- 1- **From the ecological point of view:** In the sustainable environment, the function of the main biological systems of the environment and their health is continued and improved. These basic functions for human activities include production of oxygen and carbon dioxide absorption, absorption of wastes and pollution, setting environmental conditions, producing renewable natural resources, providing comfort and psychological health.
- 2- **From the social point of view:** In the sustainable environment, the balanced coexistence between human society and natural environment has been established in order to social and economic benefits simultaneously. In such an environment, in order to achieve collective benefit, activities and developmental pathways are followed in which the cultural ecological capabilities of the development site were benefited.
- 3- **From the economic point of view:** In the sustainable environment, the economic development activities depend on the fair and balanced growth of biological and cultural community of the environment and thus, efficient and profitable use of them; therefore, systems and developmental processes enjoys flexibility, adaptability and variability, the ability to revive and reuse, productivity and diversity like a natural system (Hirmandi Niasar, 153. 2016).

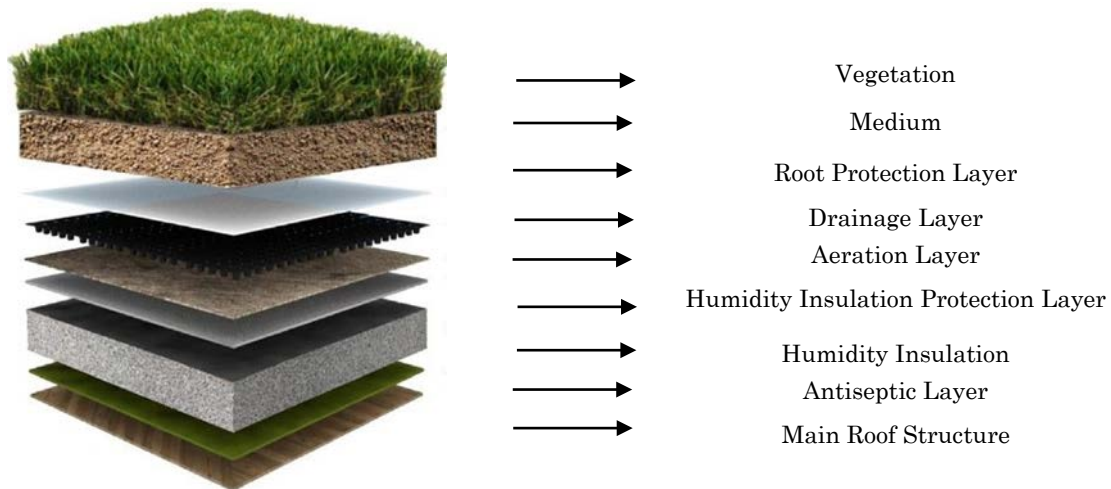
Achieving the sustainability of the man-made physical environment, as a part of the human environment and including the economic and social activities, depends on the establishment of a dynamic equilibrium between human physical space, pervasive environment, and space users. The dynamic of this balance depends on the way of responding of the physical environment to the needs and desires of users as well as the changing conditions of the environment. On this basis, Van Derain and Keterop concludes the "man-made sustainable environment" as: "a sustainable human physical environment induces the minimum psychological and physical problems to its residents over time. For example, the lack of proportion of the spaces to the needs, demands, or behavioral patterns of users, the need to repair, replace, or costly maintenance and the lack of providing desirable environmental conditions requires the minimum amount of renewable energy resources from its pervasive environment, thus causing the greatest damage to the environment " (Hirmandi Niasar, 153. 2016).

### The necessity of sustainable urban development

The city is a multi-dimensional phenomenon that the detailed foresight and planning for all its elements are not possible. In this view, rather than emphasis on the dimensions and shape of physical development, more attention is given to the long-term environmental, economic and social goals with the physical development goals. Sustainable urban development tries to restore the factors that have been faded in modern urbanism to the cities; therefore, it does not surrender to the present situation nor does look for ambitious targets, in fact, facilitate the evolution of the city's natural development towards equilibrium. Sustainable urban development is based on the rational use of natural resources as part of the sustainable development and also, should serve economic and social development. Looking for sustainable urban development theory developed to support environmental resources, the issue of saving resources for the present and future is posed by the optimal use of land and the least waste to non-renewable resources. The sustainable urban development theory introduces the subjects about the urban and regional pollution, reduction of production capacities of the regional and national environment, support of recycling, non-supporting the harmful developments, and eliminating the gap between rich and poor (UNESCO'S Message, 1992:16).

### Green roof system

The term green roof refers to a light system consisting of prefabricated layers together with the roof of the building constitutes a single system, allowing the growth of plants in a certain vegetative culture, in all or parts of the roof. The green roof layers are usually made from the top down of vegetation, root culture, planting layer, drainage layer, aeration layer, damp-proof layer, insulation, and antiseptic layer, respectively to protect the layers of roof structure; these layers are placed on the main structure of the roof. (Figure 1). In the green roof system, many of the applicable potentials are hidden and using this system in the cities reduces the cost of energy and adds to the effective efficiency of the environment. Furthermore, green roofs add up to the constructible area of a project and provide new sites for the intra-environment community (Razavian et al., 2010:139).



**Figure 1:** Green roof structure

Source: laminasytechos.com

Considering the types of green roofs, the authors are divided into two categories as extensive group and compact group while others have introduced another middle class group as semi-compact group which is a combination of the wide-spread and compact groups. (Raji, 2015: 616). Classification of

green roofs is divided in to two accessible and non-accessible groups in terms of accessibility, which in most cases, accessible roofs are consistent with compact roofs and non-accessible roofs are consistent with extensive roofs. Compact roofs, with more weight, more cost, the range of arable crops and more maintenance requirements are known as roof garden. The depth of the growing layer of these structures varies with respect to the type of trees and utilities in the range between 20 and 200 mm (Akbari et al., 2001: 300). Extensive green roofs were characterized by low weight and low maintenance cost, and the depth of the growing layer of these roofs varies between 50 and 150 mm. This type of green roof includes only one or two types of plants and the low-depth cultivation environment (Townshend, 2006).

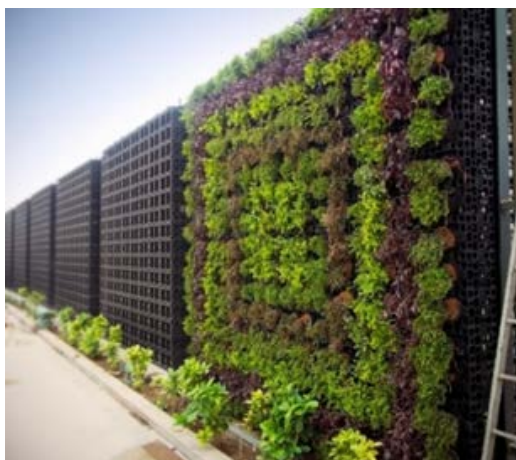
### **Green wall system**

The green wall is a new technology that today finds its place gradually in the contemporary and progressive cities of the world. The green wall is a wall as an independent structure or part of a building covered by vegetation (Saeid Mahdeloei, 2011: 17). Green walls are divided into two main categories:

**1. 1 Green views:** The green view is a green wall where a simple structure is connected to a wire mesh network (Fig. 2), cable (Fig. 3) or lattice panels (Fig. 4), and serves as a base for plants. Green views can rely on building facades, bars and columns, or can be constructed as an independent structure (Mahdeloei, 2011: 14).



**Figure 2.** Wire Grid Network System (Source: atlantiscorporation.com)



**Figure 3.** Green View Panel System (Source: atlantiscorporation.com)



**Figure 4.** Green View Cable System (Source: atlantiscorporation.com)

**2. Oxygen Concentrator walls:** These walls are divided into two types of active and passive systems:

**2.1. Active systems:** Active living walls are a combination of trees with pre - planted vegetation that are vertically installed to the façade in distance through a light system or are independent and self-static (Fig. 5). In this system, the air generated by plants is used in the building's air conditioning system. Foliage absorb monoxide and carbon dioxide and microscopic creatures of the root blot out the organic compounds and particulate matter in the air; hence, the natural process of plants produces fresh air that is drawn into the system through an air-vent and then spreads inside the building (Mahdeloei, 2010: 20).



**Figure 5:** Active Living Wall (ALW)  
Source: Mahdeloei, 2010: 20

**2.2. Passive green wall:** The passive green walls consist of square or rectangular walls that form the medium on the wall vertically and maintain the components of the plant. These modular panels are attached to the building wall by a light system. The effect of the passive system on air quality of the building is not scientifically clear, and this system practically does not have any role in air movement from the roots to the ventilation system. They are kept open to make relative recovery in



open air circulation. Some of the walls are protected behind the glass, so that the air flow is more predictable relative to what is going on in the passive layer (<http://www.greenroofs.org>).

### **The Relationship between the sustainable development columns and the green roof system**

The discussion of urban green systems and how the city has its impact on the city's sustainability makes this part of urban space important. In this chapter, considering the main objectives of sustainable development which is environmental development, economic development and social development in the city and society, the relationship between green roof functions and sustainable development is considered.

#### **1. The green roof's environmental functions**

- 1.1. Flood management:** the use of green roof reduces the cost of sewage channels. About 32% of the water of shallow channels irrigates plants and 32% of the rest is refined and goes into the deeper waterway, and nearly 42% is immediately goes into the atmosphere through the evaporation of plants; therefore, nothing leaves on the ground. In cities, 75-100% of the covers are impervious and only about 5% reaches the shallow and deep channels of the ground and 15% are evaporated via plants and 75% of the rest are floating on the ground. Studies conducted on the absorption of the flowing water in Portland city have concluded that if half of the buildings are in the center of the green roof, an amount of 66 million gallons of water are collected annually. This reduces the overflow of equivalent to 17 million gallons of sewage content (Beckman et al., 1977: 45).
- 1.2. The decrease in the effect of heat islands in cities:** large cities absorb the heat of the sun radiation because of having the extensive and hard surfaces and the lack of adequate vegetation, which is known as heat island. Heat islands can increase the temperature of the air by about 10 degrees Celsius. Roofs covered by plants make the weather conditions better due to the production of humidity and cool air. The green roof is very useful by modifying the effect of heat islands in terms of having healthy environment and providing human health. (Lazzarin, 2005)
- 1.3. Energy storage:** Low temperature in summer causes a reduction in demand for electricity, and during the winter the green roof can be an important insulation and provide a reduction in demand for thermal energy. In hot weather, when the temperature reaches 95 °F, the roof temperature reaches 175 °F, and this temperature has a direct effect inside and outside of the building. An increased outdoor temperature accelerates the chemical reaction that leads to the depletion of the ozone layer; furthermore, more ventilation is also used inside of the building in order to cool the building, which leads to more energy consumption. Plants convert the soil heat to humidity through evaporation, which leads to cooling the building and cooling of the inside of the building reduces the heat reflection. The results of computer simulations in American cities show that by adding a tree per housing unit, 12-24% of the energy to cool down can be saved in hot days and by adding three trees per housing unit, cooling energy per hot day can be reduced by 17-57% (Farshchi, 2009: 75).
- 1.4. Filtering the pollutants and reducing the level of carbon dioxide:** plants, absorb air pollutants through their pores and separate them with their leaves and are capable of breaking organic compounds in herbal tissues or in soil. In addition, they indirectly reduce air pollution by reducing the degree of heating and shading, so that the streets covered by trees have 15% less particulate matter than streets without trees. Assuming that the vegetation cover of the green roof is grass and the lawn has only 0.1% of the tree's function, 10 m<sup>2</sup> of the green roof vegetation can hold 2kg of particulates in itself per year. Reducing the level of CO<sub>2</sub> is another important function of the green space. Because it is one of the atmospheric gases that prevents thermal energy from moving close to the surface of the

earth, CO<sub>2</sub> as an interferer factor, increases the greenhouse effect and elevates the temperature. Green roofs are effective in reducing the level of CO<sub>2</sub> in the atmosphere via two different methods (Baker & Brooks, 1989: 115):

- 1) Carbon is the primary component of the plant structure and is naturally decomposed in plant tissues by photosynthesis and in soil beds by the shrubs and the plant root exudates.
- 2) Reducing energy through the insulation of the building and reducing the urban heat island (UHI) effect.

**1.5. Acoustic Insulation:** the discomfort caused by the noise in the streets is an important problem in urban areas. Green roofs, whose soil layer thickness is 12 cm, decrease the sound penetration up to 40 dB and the green roofs whose soil layer thickness is 20 cm, decrease the sound penetration by 46 dB (Taghavi, 2014: 26).

**1.6. Using recycled materials:** Some materials used to build green roofs are made of recycled sources. The use of building debris will save money on the cost of green roof construction and eliminate or reduce the cost of the landfill and reduce their transmission cost (Taghavi, 2014: 26).

**1.7. The creation of natural ecosystems for organisms:** By the establishment of green roofs, the habitats of the living creatures and plants that are victims of the construction development can be compensated and through this can, the amount of plant-free surfaces can be reduced and the development of wildlife which has been limited, can be expanded. ([www.livingroofs.org](http://www.livingroofs.org)).

## 2. Economic functions

**2.1. Food Production:** The green roof is an opportunity to develop agriculture on the roof that develops food production. Green roof products can have better quality and more natural production than market products due to the attention to the fertilization and pesticides. In addition, with the production of food in a residential unit, its rent price and land's value will increase (Keshtkar Ghalati et al., 2010: 21).

**2.2. Job employment:** The establishment of the green roof industry has had an enormous impact on the economy, among which are the creation of new enterprises in manufacturing, construction, design, installation and other green roof services (Keshtkar Ghalati et al., 2010: 21).

**2.3. Reduction of the Exploitation Costs vs. Commissioning Costs:** when a green roof is built, some expenditures are imposed on the employer in order to commissioning, but at the time of exploitation, these costs are returned by reducing energy and food costs and increasing the prices of rents and land (Keshtkar Ghalati et al., 2010: 21).

**2.4. Roof Shell Protection:** The typical rooftops life span is about 20 years while the green roof life span is estimated as 45 years or more, because the oil membrane is protected by soil and vegetation from ultraviolet rays and intense fluctuations in temperature between night and day (Bradley, 2011: 9).

## 3. Social functions

Another one of the most important features for achieving sustainable development, is obtaining the social sustainability as the main axis is sustainable development, human and human society, and development is meaningless without considering human beings. Green roofs, with a per capita increase in recreational space and conversation in a city can promote social interaction and reduce social tension in society. Other benefits of green roof can be referred to as an increase in the beauty

of the outer space of buildings, impact on urban psychology, and creation of a healthy place for residents (Tehran gardens and green spaces Organization, 2010).

Table 1 is regarded as a conceptual model for the way that the green roof system affects the city’s sustainability and finally in sustainable development, suggesting that the distribution of urban green systems must be optimal and desired to have environmental, economic, social, and psychological efficiency for citizens and provide a ground for optimal ecological conditions for the cities.

**Table 1:** The columns of sustainable development and its manifestation in the green roof system.

Sustainable development columns		The manifestation of the sustainable development in the green roof system	Conclusion		
1	Environmental sustainability	Flood and atmospheric precipitation management	High environmental quality	High quality of life	Sustainable urban development
		Reducing the heat island effect			
		Saving and reducing energy consumption			
		Carbon reduction, pollutants absorption and pollution reduction			
		Creating sound insulation			
		Using recycled materials in green roof construction			
		Creating a natural ecosystem for organisms			
2	Economic sustainability	Organic food production	High economic quality	High quality of life	Sustainable urban development
		Job employment			
		Reducing the exploitation costs vs. Commissioning Costs			
		Reducing the cost of fuel consumption and food production			
		The rise in land value			
		Increase in the useful life of the roof’s shell			
		Creating the acoustic, thermal, and humidity layer.			
3	Social sustainability	Expanding social and cultural interactions	High cultural quality	High quality of life	Sustainable urban development
		Increase in urban landscapes beauty			

Source: author

**The relationship between the sustainable development columns and the green wall system**

Green walls cover a wide range of environmental, economic, and social benefits. To cover the vertical profile with vegetation, in terms of environmental dimensions, causes 30% absorption of rain showers to store water and irrigate the green wall, modification of the heat island phenomenon, and reduction in energy consumption, decrease in carbon dioxide and air pollution, and in summary, it can lead to the improvement in environment’s quality. The green walls are also important for plant ecology and the absorption of living organisms and birds in terms of ecology and conservation of biodiversity. In terms of economic dimensions, the green walls increase the building’s value by increasing the green space area, the protection of the building’s structure and also, the environment’s beautification. The green walls also by providing thermal and sound insulation can cause the energy saving of heating and cooling in winter and summer as well as the reduction in the costs related to the thermal and sound insulation. On the other hand, irrigation system of green

walls and water swirling in the system leads to a green space with minimum water consumption (Mahdeloei, 2011: 17).

In terms of the social dimensions, the walls can cause the improvement and development of vitality in the houses and have contributed to the physical and psychological health of the citizens. Beautification of the urban landscape and improving the surrounding aspects of the building can be considered as other social benefits of this new technology. Recently, the urban farming and vegetable cultivation have recently become available in parts of the green wall, where urban farming itself has many social and economic benefits for citizens (Mahdeloei, 2011: 17). In this section, table 2 is presented as a conceptual model for how the green wall system affects the city's sustainability and finally, in sustainable development.

**Table 2:** The pillars of sustainable development in the green wall system.

Sustainable development pillars		The manifestation of the sustainable development in the green wall system	Conclusion		
1	Environmental sustainability	Precipitation and flood management	High environmental quality	High quality of life	Sustainable urban development
		Green wall irrigation by saved precipitation			
		Reducing the heat island effect			
		Saving and reducing energy consumption			
		Carbon reduction, pollutants absorption, and pollution reduction			
Creating a natural ecosystem for organisms					
2	Economic sustainability	Organic food production	High economic quality	High quality of life	Sustainable urban development
		Protecting the building structure			
		Increase in the building value			
		Creating the acoustic, thermal, and humidity layer.			
Reducing the costs of insulation and irrigation					
3	Social sustainability	Increase in urban landscapes beauty	High cultural quality	High quality of life	Sustainable urban development
		Citizens physical and mental health			

Source: author

## Conclusion

Sustainable development is a qualitative development considering the quality of life that aims to increase the quality of life for the present and future generation with regard to the environmental, economic and social factors. The main goal of sustainable development is to provide basic needs, improve the quality of life for everyone, maintain and manage the ecosystem and future better and a safer. In the context of environmental development and protection, building the needs of the current generation without compromising the resources needed for the next generation will be depended on the sustainable development. To achieve sustainable development goals, the creation of green systems such as green roofs and walls and using them is considered reasonable, since the characteristics and environmental, economic and social functions of green systems realize the three sustainable development goals, which are the promotion of the environmental, social and economic conditions.

In the implementation of green systems, it should be noted that the costs and difficulties of designing and implementation of a green system should not be compared with the operating conditions of a regular roof or wall; it must be compared with the diseases and mortality caused by the air and environment pollution, the staggering costs caused by this pollution, individual and social damages caused by the absence of green space in the environment. The problems caused by floods and

inundations and surface water control, development of the heat islands in cities, and being hot and polluted of the city's environment and air, the staggering costs of utilizing the waning fossil fuels, costs of repeated insulation and rehabilitation of traditional black roofs, and the deep psychological effects due to the inelegance of cities in people are all incompatible terms with sustainable urban development, which will be improved if green roofs and walls are exploited, and the ground for sustainable urban development will be provided.

Utilizing some policies in society promotes the use of green systems; for example, giving special support such as selection of the significant green system initiatives or encouraging environment-friendly associations and paving the way for designing and implementing multi-storey parking lots in high-density areas that face a lack of standard green space, can be part of this policy in society. In addition, by legislation in particular places where a green system is needed, this can be implemented.

The next step is to develop solutions for sustainable urban development using the function of roof and the green wall which is a part of the triple sustainable development goals.

**Proposed strategies for sustainable urban development by the environmental function of green roof and wall:**

1. Constructing green roofs in buildings whose land has already had green land use or has occupied ancient gardens.
2. Constructing green roof and wall in the hazardous and flood-prone areas within the watershed of the regions of the country.
3. Constructing green roof and wall in areas and regions that have a pollution crisis; such as central areas in the city.
4. Constructing green roofs in factories, workshops, and all buildings that are polluting the environment.
5. Constructing green roofs in all buildings and facilities which are related to the green space and environmental, and relevant organizations.
6. The use of green wall as the facade of buildings adjacent to airports, railway stations, and passenger terminals due to the insulation properties of the green wall against sound waves.

**Proposed strategies for sustainable urban development by the economic function of green roof and wall:**

1. Achieving a kind of self-sufficiency in producing healthy agricultural products among families on the green roofs and walls.
2. Planting vegetables on the green wall in kitchens.
3. Planting medicinal herbs on the green roof in the treatment centers and its related environments.
4. The propagation and promotion of the green roof and wall as the thermal, humidity, and sound insulation layer.

**Proposed strategies for sustainable urban development by the social function of green roof and wall:**

1. Making cultural attractions and improving urban landscape by green roof and walls.
2. Converting dry concrete walls on the margin of highways and passages to living surfaces with a relatively natural and striking facade by green walls.
3. Hiding the inelegance of the buildings by the green wall, including the chamber and equipment of the elevator, the chimney and equipment related to the heating and cooling systems due to poor and inelegant designs in the majority of the buildings.

4. The combination of the green system with urban furniture, such as the creation of a green roof in the roof of bus stations.
5. Making a place to relax and exercise, a place to spend hot summer nights, a visiting and meeting place in large apartments, a good place for celebrating festivals and rituals on green roofs.
6. Contributing to the process of the patients' treatment and improving their mood by the garden therapy with the establishment of green roof and wall in the inner and outer spaces of medical environments.
7. Help to improve the process of the individual's education and learning in educational and cultural environments by merging green roofs and walls with the atmosphere of the training classes.

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