Introducing the Plants Used in the Design of Green Roofs in Iran

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Abstract
Green roof as one of the substrates of the implementation of sustainable architecture has got particular importance among designers and architects. Green roofs not only improve visual aesthetic of hosting environment, but also cause air purification, enhance health and minds of citizens, reduce heat and increase the life span for the residents of the target areas. Green roofs share the nature and industry on the one hand and with the benefit of advanced technologies, operational capabilities, and on the other hand, relying on the free land plants, and the environment to make the area sustainable. One of the most important elements in the design, implementation and optimal performance of green roofs is correct selection of plants. The moisture, sunshine average temperature and the climate of the place as well as the features of the plants make plant species for use in green roof clear. The results show that six species of plants are suitable for temperate and wet climate, seven species for cold and snowy climate, and nine species for hot and dry, and seven species are recommended for use in green roofs of warm and humid climate.

Keywords: sustainable architecture, green roofs, plant, Iran

Introduction
Today, the concept of sustainable architecture is very widespread among designers and developers that are trying to use local adapted materials to the environment, nature and human action. In recent years, numerous articles in the field of green architecture are written by various researchers around the world. One manifestation of green and sustainable architecture is green roof. Although the basic idea originates from the Hanging Gardens of Babylon, but today the application and development of advanced technology has made them easier to build (Defense. 1386). Most of these statements with a few differences encourage designers to conserve energy as well as considering local features of the building and surrounding communities (Moradi 0.1389). The green walls (vertical gardens) are also a kind of living coating systems with the benefits like green roofs, where the various plant species grow on the surface of the building. So by using strategies such as green roofs and walls we can design along with nature instead of against it, and consequently achieve the stability of both contemporary architecture and urban planning and development to help ensure the protection of the environment. Thus, the construction of green roofs and walls in the urban planning in most countries has become an executive order. But one of the most important elements in the design of green roofs is appropriate selection of plant type. It is worth noting, however, the climate is among the most influential factors in the selection of suitable plant species, but the form of plant, configuration flexibility, the greenness, durability, flowering and color are also very important. The crop water requirement over specific periods, the resistance to sunshine, altitude, cold and heat are among important parameters influencing the selection of plant species (fishing. 1391). This paper attempts to address all the main parameters as well as interviews with botanists to introduce suitable species for the climate of Iran.

Literature
As mentioned above, although the origin of main idea of green roofs is not clear but it is likely that the idea originated from the Hanging Gardens of Babylon. Or gardens that aren’t suspended in the air, but in fact they were located on rooftops and fluorescent lights. Green roof is a roof that plants grow on its surface. In a study carried out in 1998 by the International Society of Horticultural Sciences based on climate of eight major capitals of Europe and based on the height of the target buildings, a collection of plants have been introduced. According to the characteristics and parameters used in this study, the reference for selecting plants is obtained for other regions and climates. In another study conducted by Lambyran and colleagues in 2012 in the Netherlands, on the Atlantic climate and vegetation features, seventeen plants was proposed to be used in the design of gardens for the city of Amsterdam. In another study conducted in 2013 by Kraft reasons for the operation of plants in green roofs in Manhattan were studied. The results show that it is based on many factors should be considered; such as polutters and selection of plant resistance to harsh environments on the roof. Plant diversity that can range from a structure covered with artificial grass to garden with plants used in landscape design. The green roof will cover the plants that have been carefully selected for the harsh environment and the roof must resist against the conditions of water, freezing sea breeze and dry climate, (Vahabzadeh. 1390). Plants vary depending on the weather and climate conditions (Forouhar. 1388). Green roof or roof garden is the peak of combination of performance and environment. Implementation details such roofs are not much different from conventional roofs, including insulation, thermal, waterproofing coatings, sand and seal. Besides these cases, the materials and elements used to operate the plant maintenance, drainage and water supply provided in the building are the same. Green roofs in Iceland and Scandinavia are modern roofs. The construction materials has been limited for the formation of green roofs (grass) in cold climate areas, so that residents have on it for construction, as much as possible and bring those areas, including turf and canvas materials stone used. The roofs typically include a combination of two or three layers of sod on the layer of branches and short branches to guide rainwater. While the roofs were the simple, heat storage and insulation for buildings and green roofs today are inspiring. In the twentieth century some gardens were considered; the most influential roof is in London (Derry & Toms) a roof covered by six thousand square meters and CasinoPation in Bern, Switzerland that were planted
in the 1930s. Green roofs of layers have modern form, a relatively new phenomenon. These types of roofs in the 1960s developed in Germany and expanded in many European countries and the US (Ahmadi et al. 1393). Garden Green roofs are divided into four categories based on the operating system.
1. Extensive system
2. Intensive system
3. The modular system or planter boxes
4. Synthesis system

**Extensive system**
The word green roof is used for spread systems. The system is known for low cross with a less thickness. This type of roof includes only one or two types of plants and the planting environment is shallow. Typically, in these systems at least once weight is taken into account. In particular, only maintenance staffs have access to this type of roof. The roofs like Norwegian grass are built on flat and sloping roofs on the building. In this system, plants are used usually to a depth of 40 to 100 mm. A weight of 50 to 100 kg is on the roof. In most places on the roofs steep slope of 10 to 20 percent is recommended. The maximum slope of 30% is needed to use tools like anti-erosion drainage.

![Figure 1: Details of extensive system implementation](image1)

**Intensive system**
The term roof garden is used for intensive system. It is also known to cross deep or roof garden. These include various types of plants and green roof is designed like a park. Green roofs have a large number of trees and the need to strengthen the structure is essential, especially for roofs that have public access.

![Figure 2: Details of intensive system implementation](image2)

**Modular system or planter boxes**
In this system, the plant and environment for culture are held in a special box that covers all or most of the green roof. The modular system of the plant on green roof is a continuous layer. The modular system has a disconnected environment.
Synthetic system
This type of roof is a combination of both extensive system and intensive system having the benefits of them. In addition, it has a higher load capacity. At the same time the emergence of large lightweight panels takes place.

Other classification
One other method of classification is separation of the flat roofs and steep. Green slope roofs that are prominent characteristic of many of the buildings in Scandinavian design. It needs simpler design in comparison with flat roofs.

• The roof of the building, which needs to be strengthened structures for the green roofs.
• Garden roofops; that are a protective layer, and separates the roofing and insulation from layers of soil and plants.
• Soil and fertilizer and irrigation system; which must be in the right place.

Green roof components can be divided into 5 categories.
1. Vegetation layer; since green roofs are designed as light as possible, often consist of shallow soil and plants that can grow with little care and maintenance.
2. Culture environment; space the plants begin to grow and grow in. environment due to the specific requirements of instruments should have little weight, different from the typical soil. In this case, you should use the environment to grow as much as possible about 900 kg lighter and the weight per cubic meter in the wet.
3. Drainage layer; drainage layer consists of a complex set of additional layers is as follows:
   • filter layer; there is a filter between culture environment and the drainage layer that keeps moisture away from the roots and prevents roots from sepsis. This filter can be a tissue cloth. The filter can also be a layer of sand.
   • Root barrier layer; a layer that has good root penetration and prevents damage to insulation and roofing membrane.
   • Drainage plate; a plate with three layers that top layer operates like a filter and keeps excess water away from the roots. This layer also acts as a protective layer roots. The middle layer in the form of the cone-shaped bowls keeps excess water from their roots. The bottom layer is a filter cloth to prevent damage to the membrane and insulation.
4. Protective layer: This layer consists of the roof coverings and insulation systems prevent percolating water. This plate can be made of strip of concrete, insulation plates of sturdy, thick plastic sheets, copper sheets, or a combination of these, depending on the characteristics of the design and use of green roofs.
5. The structure of the ceiling, membrane roof or insulation layer prevents the leak and seep. (www.Modern Architecture.com)
Green roofs can answer the constant human need in a innovative way. The residential open spaces are a manifestation of the nature of collective life. This space while providing growth opportunities for creativity, social context, interaction and social conflict and applications such as relaxation, communication, and entertainment are very effective in reducing pollution and improving the living environment. Here are some of the impacts of green roofs.

1. Sedation of plants for humans and consequently a reduction in the psychological stress.
2. Creating spaces for rest and refreshment, especially for elderly people.
3. Moderating climate change
4. Reducing maintenance costs of roof by a protective coating
5. Providing habitat for wildlife
6. Contributing to the scenic beauty of the city and the surrounding residential units and providing happy and healthy recreation
7. Extending the life of the roof of the building through the protection agents natural or artificial destructives
8. Reducing the effect of urban heat islands and air exchange between regions
9. Improving the drainage system in the city and water balance outside the city
10. Insulating against sound and heat storage

Methodology

Based on the goals, this study and the study of qualitative descriptive methods have been used in the inductive process. In this regard, the use of written sources and through interviews with people knowledgeable in the first step, the necessary data is collected and then classified in a trend analysis based on isolated data, the results are presented.

Plants suitable for green roofs

At this point, plant species suitable for green roofs will be introduced along with images. Remarkably, the study of plants selected based on all necessary parameters in green roofs and climate of packaging that can be formed (forming, covering the floor and walls, resistance to sunlight, resistance to drought air, wind resistance, improved visibility and impact in the landscape, water consumption, ease of propagation and low cost of maintenance) (Moradi 0.1389). Therefore, these factors are selecting the plants and not merely a parameter decision-making body.

- **Wisteria sinensis**

  - **Specifications** Climber plants, deciduous height of 30 meters. The leaves are 11 leaflets, fragrant flowers in clusters of pale violet color and long hung on the wall.
  - **honeysuckle plant**
Figure 9: honeysuckle plant

- Specifications
  It is very common plant in old houses to cover the pergola, fence and wooden scaffolding. Evergreen and can be up to 10 meters high on the trees or walls.
  - Jacaranda

Figure 10: The plant jacaranda

- Specifications
  Progressive and evergreen plant with tubular orange flowers - red and shiny that bloom in summer and extend until late October. Usually planted beside the hedges, in the autumn colors are fascinating.
  - Clematis

Figure 11: Clematis

- Specifications
  Clematis is a climbing plant that attaches its leaves and branches to woody plants and grows up to 6 to 8 meters. Junction of the branches has corners and the stem has a thick coating of 1-3 mm depending on the length of the stump.
  - ivy

Figure 12: ivy plant
• Specifications
Ivy is a climbing and evergreen plant. Due to the ability to connect an aerial roots level, and the availability of support such as trees, walls, etc. can grow to 20-30 meters.

• witch-hazel

![Ivy plant](image)

Figure 13: The witch-hazel plant

• Specifications
Rising and falling like the grape leaves. Its leaves are extremely decorative, so that first red, then dark green and red again in the fall.

• Yellow jasmine

![Yellow jasmine plant](image)

Figure 14: Yellow jasmine plant

• Specifications
The plant is a shrub, deciduous with yellow flowers and nice. Pruning can be done after flowering and the flowers appear in March and April. Its foliage is purple in the fall.

• Scalloped Spirea

![Scalloped Spirea plant](image)

Figure 15: Plant Scalloped Spirea

• Specifications
It is a fast-growing shrub, small and mid-spring to early autumn where its flowers appear in summer. Its use as a plant or plant them in small spaces and margins.

• Winter Sweet

![Winter Sweet plant](image)

Figure 16: Plant winter sweet
• Specifications
Plant winter sweet is a species of deciduous shrubs. This yellow flower in winter has a fast-growing branches without any leaf but very fragrant.
• Summer Lilac

![Figure 17: The mouse's tail plant](image1)

• Specifications
A widespread deciduous shrub to 5 m tall, with dark green leaves and fragrant purple flowers that appears from mid-summer to fall in the form of a dense cluster inflorescences.
• Hollyhock

![Figure 18: hollyhock plant](image2)

• Specifications
Small and deciduous shrub with a height of 3-4 meters with a crown irregular and often resistant ductile and rather flowery summer flowers for a long time.
• Red maple

![Figure 19: plant red maple](image3)
Shrubs of hardwood, deciduous, slow growth and small height is usually 6-10 meters. Green and red fall leaves with red, yellow or lime come in. Its root system is shallow.

- **Kriya**

![Kriya plant](image)

**Figure 20: Kriya plant**

- **Specifications**

Flowers are yellow, grass green and usually the leaves the agony of April and May are flourishing. In some cultivars of lemon leaves are putting their agony.

- **Pyracantha**

![Pyracantha plant](image)

**Figure 21: Plant Pyracantha**

- **Specifications**

Pyracantha is an evergreen shrub with a maximum height of about 4 meters. White flowers appear in late spring.

- **Barberry**

![Barberry plant](image)

**Figure 22: Barberry plant**

- **Specifications**

Barberry shrub is 1 to 5 m in length; Stick it in red, brown or yellow. It blooms at end of spring and beginning of summer.

- **Boxwood**

![Boxwood plant](image)

**Figure 23: Boxwood plant**
• Specifications
It has dotted leaves, shiny and dark faces of the main hedge plant. Both types of the plant, and the Japanese Mint leaves can grow to high altitude, but they are often eaten on the sidelines of garden shears or hedge or separating different spaces are seen.

• Thistle

![Figure 24: The thistle plant](image)

• Specifications
Semi-evergreen tree or shrub to 6 meters long and extensive, has dark green leaves and white flowers branches are shape and its color appears in the summer followed by bright red spherical fruits are produced (Mousavi Nia.1381)

Data analysis
After reviewing the nature of the green roof and suitable types of plants, it is necessary up to the purpose of this article to determine plants of Green roofs. It is noteworthy that, according to climate and zoning of Iran, Ganji proposed four divisions that include:

• Humid temperate climate (southern coast of the Caspian Sea)
• Cold and snow climate (mountainous West Country)
• Hot and dry climate (arid and semi-arid central plateau consists of two parts)
• Warm and humid climate (southern Iran)

This is the basis for different plants in different regions in this article. The surveys conducted are following plants for temperate and humid areas include the provinces of Gilan, Mazandaran and Golestan, for cold regions such as Chaharmahal & Bakhtiari and Hamedan Vbrfy for hot and dry areas include the provinces of Isfahan, Tehran and Qom, as well as for hot and humid climates such as Hormozgan are presented in this paper (Gaemi et al.1391). According to four climatic Iran, the following table mentions 29 species of plants that are the best for green roofs. It is worth noting that the highest profiles of some plants which are adapted to each region of the 17 species are presented.

<table>
<thead>
<tr>
<th>Warm and humid climate</th>
<th>Hot and dry climate</th>
<th>Cold and snow climate</th>
<th>Humid temperate climate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspirated</td>
<td>Wisteria sinensis</td>
<td>Jacaranda</td>
<td>Grass snakes</td>
</tr>
<tr>
<td>Summer Lilac</td>
<td>Hollyhock</td>
<td>Witch-hazel</td>
<td>Ivy</td>
</tr>
<tr>
<td>Red maple</td>
<td>Kriya</td>
<td>Gelsemium sempervirens</td>
<td>Boxwood</td>
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<tr>
<td>Tea</td>
<td>Pyracanta</td>
<td>Winter Sweet</td>
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<tr>
<td>Olive</td>
<td>Barberry</td>
<td>Clematis</td>
<td>Lavender</td>
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<tr>
<td>Astypa</td>
<td>Cactus</td>
<td>Hedrahelix</td>
<td>Artiplex</td>
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<tr>
<td>Nut grass</td>
<td>Rosette</td>
<td>New Leaf</td>
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<td>-</td>
<td>Mord</td>
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<td>-</td>
<td>Tamarix</td>
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Source: authors

Summary and Conclusion
As mentioned, one of the indicators of sustainable architecture is use of environmental design based on the natural elements and regional climate. Green roofs are one of the substrates of particular importance in the implementation of sustainable architecture for designers and architects. Following the deliberations and interviews with experts in botany and on four continents Iran, in this article as seventeen species of plants suitable for application in the design and implementation of green roofs has been proposed. The plant collections are presented in addition to matching up with all four climate temperate and humid climate, cold snowy climate, warm and dry climate, and the hot and humid climate.
Low Water requirement is proportional to the set limits and keep costs low. Although other plants are also capable of using green roofs, but the plants ability to withstand radiation, cold, heat, pollution and other tensions are very significant. Green roofs not only improve visual beauties, but also they cause air purification, health and minds of citizens, reduce heat and increase the life span for the residents of the target areas. So researchers have set seventeen plants among as top choices for the construction of green roofs, especially in metropolises Iran. Six species of temperate climate and wet, cold climate and snow seven species, nine species to climate warm and humid climate is hot and dry, and seven species recommended for use in green roofs.

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