Scientific Papers, Series B, Horticulture, Vol. LVI, 2012
ISSN Online 2286-1580, ISSN-L 2285-5653

GREEN ROOFS/ROOF GARDENS. RESEARCH ON ROOF/TERRACE VEGETALIZATION; VEGETALIZATION SYSTEMS

Elisabeta DOBRESCU

University of Agronomic Sciences and Veterinary Medicine Bucharest, 59 Mărăști, District 1, 011464, Bucharest, Romania, Faculty of Horticulture – Landscape architecture, Biodiversity and Ornamental Horticulture, phone number: +40 (21) 318 22 66, fax: +40 (21) 318 28 88,
e-mail: veradobrescu@yahoo.com

Corresponding author email: veradobrescu@yahoo.com

Abstract

The research analyses and studies of the posibility to extend the area of green space in urban areas. According to this analysis, surfaces can become green roofs, designed in various systems of vegetalization, determined by maximum permissible loads on the structure of resistance (intensive systems, extensive or mixed). In the present premises to reach by 2013 a minimum area of 26 sqm / inhabitant, (according to OUG nr. 114/2011), the paper aims to highlight ways in which vegetation surfaces can be on flat or sloping roofs of buildings. Also in the analysis of structures with high we can make a premise of separating the typology of "green roof / green terrace" to the concept of "roof garden".

Key words: *garden, system, roof, terrace, vegetalization.*

INTRODUCTION

Progressive decrease in the surface area covered by urban greenery is likely to make itself a domino effect. Thus less vegetation brings to lower the humidity level and a more difficult recovery of the poor oxygen levels in the air, which leads to progressive reduction of the remaining green areas, which lose their capacity for self-healing and disappear if no steps are taken to maintain and improve them through appropriate maintenance systems.

In the largest urban agglomeration in Romania, Bucharest, there are areas with high levels of pollution that often overlap with densely inhabited areas. Polluted areas are found mainly in pericentral ring of Bucharest but now, it appears that pollution extends outside of the ring. The main factor of air pollution is road traffic, which leads to the discharge into the atmosphere of large quantities of carbon monoxide, nitrogen oxides, lead, oil, dust and so on. Intense car traffic arteries across the city in all directions near the houses, which causes real discomfort to the population. This discomfort will lead in future to a high degree of ill residents of the capital, unless preventive measures are taken.

As in any large European city, increasing the intensity activities led to increased need for space and often this need was satisfied - justified or not - by giving up some green areas, especially through the transformation of entire blocks of houses with ground floor, ground and first floor at the most, with landscaped and maintained gardens, in areas of multi-storey buildings or business buildings, in which building coverage ratio increased significantly at the expense of green surface coefficient.

Maintaining the current situation implies the same high costs of energy used for cooling buildings, more rapid degradation of their roofs, poor soundproofing and reduced protection against electromagnetic radiation and ultraviolet rays.

Also, in terms of climate and environmental protection, it has no contribution to reduce pollution, CO_2 consumption, reduce humidity and temperature in the summer time.

Given the proven harmful effects of reduced surface of urban green space, but taking into account the current situation characterized by crowding and vertical development, which make for improper arrangement of green areas at ground level due to lack of space and lack of natural light is considered a worldwide

agreement that one of the solutions without adverse side effects (if properly implemented) is the solution green roofs or roof gardens.
A clear tie has to be done between "green roof" and "roof garden" concepts that often get confused.
A "green roof" is not covered with vegetation covers, "like a garden" [1], as circulated in treaties and projects on vegetalized roof. It's a subset that separates a building at the top and on which is provided, deliberately, by design, small vegetation [2], ranging from herbal plants that require very little culture substrate (3-10 cm.). Unlike green roof or green terrace, roof garden landscape is a more complex structure that integrates environmental functions, relaxation, recreation and short period leisure, sporting functions, games etc. In this case the culture substrate must ensure optimal development of a varied assortment of trees, shrubs, herbaceous plants and flowers (40-120 cm.)
The purpose of this paper is to define and differentiate in terms of scientific and technical concepts related to green roofs / green terraces and roof gardens. Another goal is to identify the different systems applicable to different types of vegetalization structures of existing roofs.

MATERIALS AND METHODS

The research refers to a comparative study between two major types of roofs vegetalization and their association with the terminology of "green roofs / terraces " or the "roof gardens" terminology.

The extensive vegetalization includes:

- Easy-load on structural strength (50-150kg./mp on saturation);
- Landscaping on any roof surface;
- Small and very small thickness of substrate vegetation (3-10 cm.);
- Very low or no-maintenance of all (the free, natural develompment);
- Ecological function of improving the microclimate.

Photo 1. Extensive vegetalization terrace [3]

The intensive vegetalization includes:

- Easy and immediate accessibility for residents and visitors;
- Large-load resistance structure (over 300kg./mp on saturation);
- Landscaping only on roofs that have deliberately set to have a heigh garden or on roofs which after a technical expertise were deemed to have a resistant structure to supports heavy loads.;
- Thick and very thick substrate and (40-120 cm.);
- Complex maintenance (irrigation, fertilization, maintenance);
- Complex functions, ecological and environmental, such as well landscaped gardens or parks on the ground (rest, relaxation, sport, play, promenade, etc.).

Photo 2. Intensive vegetalization terrace [4]

Scenario I – Vegetalization of roofs in an extensive system is a small investment, with significant benefits in terms of reduced operating costs of buildings, of prolonging their life by additional protection provided, with an important contribution to CO_2 consumption,

reducing pollution, and improve the comfort index of the population.
The minimum value of the investment basis for the green roof where scenario I is applied varies between 13 and 20 Euro/sqm, depending on the surface to be resolved.
General technical elements required to implement extensive system vegetalization on roofs:

- Minimum resistance structure to support the additional load;
- 2% slope to ensure drainage conditions;
- Performant waterproofing and thermoisolation system;
- Drainage and filtration system;
- Substrate of fertile soil with a small additional charge;
- Balanced distribution of mineral and vegetable loads all over the roof;
- The existence of a landscaping project;
- Choosing an assortment of shallow rooting species (Sedum, Sempervivum, Festuca etc.);
- Dendro-floricultural material selection based on resistance to climatic conditions of the region.

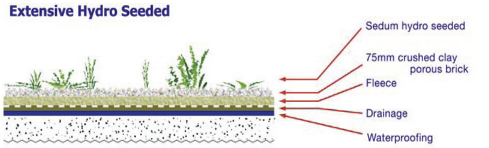

Fig. 1. Section view of an extensive hidro seeded [5]

<u>Scenario II – Vegetalization on roofs in an intensive system</u> is great investment option, obtaining maximum beneficial results both in terms of protection and insulation of buildings, improvement of regional pollution and the microclimate around buildings that the landscape is done.
Scenario II assumes a much thicker and looser layer of soil and may look like any other landscaped garden. The roof requires the same care as an ordinary garden and can only be achieved if the roof has a solid load bearing.
An intensive roof type can be compared to a plain garden or a park with no limit on the type of installed vegetation, including trees and shrubs. Also you can install the rest and promenade areas, sports and play areas, water areas, seating areas, cultural areas, etc.
Compared with extensive roof type, the intensive one needs operating costs considerably increased in addition to a greater investment value. The load bearings on the structures are considerable, and therefore, this type of roofing is suitable for newly constructed buildings, for which different structural elements supporting the roof are sized appropriately, taking into account these additional tasks. Installing an irrigation system is essential for this type of roof.
The minimum value of the investment to achieve green roofs where scenario II is applicable is between 55 and 80 Euro/sqm, depending on the surface to be resolved.
General technical elements needed to implement intensive system vegetalization roofs:

- Strong resistance structure to support the additional load in the garden;
- Minimum 2% slope to ensure drainage conditions;
- Performant waterproofing and thermoisolation system;
- Vapor barrier system and anti-root system;
- Drainage and filtration system;
- Advanced fertirigation system (automated);
- Substrate of fertile soil with a large additional load;
- Balanced distribution of mineral and vegetable loads all over the roof;
- The existence of a landscaping project.
- Ensure balanced proportions between compositional structures of landscaping (trees, shrubs, flowers, lawns, water, movement, light construction);
- Choosing the proper rooting assortment of species, depending on the thickness of the nutrient substrate available;
- Dendro-floricultural material selection, according to the volumetric register, color, seasonal decor, resistance to climatic conditions of the region.

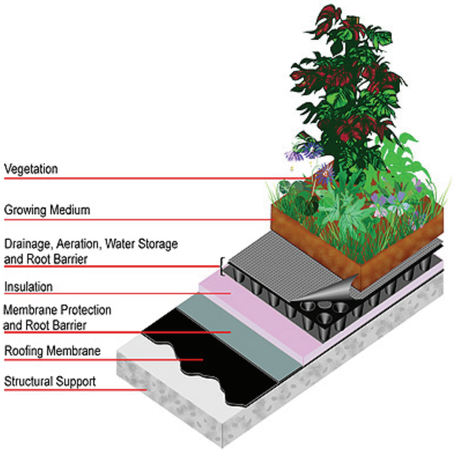

Photo 2. Layeres of an Intensive system [6]

To analyze the largest urban pole of Romania, Bucharest, most multi-floored residential buildings are in the category of old buildings, which were not originally scheduled to have a green roof project. For these types of buildings, considering the resistance structure analysis does not allow heavy loads, we used a multi-criteria analysis:

- Costs of design, weighting factor = 0.05;
- Investment cost, weighting factor = 0.10;
- Maintenance costs, weighting factor = 0.15;
- The duration of the investment, the weighting factor = 0.10;
- Isolation and protection, weighting factor = 0.05;
- Additional tasks in the structure of resistance, weighting factor = 0.15;
- Biodiversity species, weighting factor = 0.05;
- Risk on plantations to be replaced (inverse proportion to biodiversity species) weighting factor = 0.15;
- Quantity of materials needed for installation, weighting factor = 0.10;
- Diversity of functions, the weighting factor = 0.10.

Table 1. Comparative analysis of the to possible scenarios

Nr	CRITERIA	Weight factor	Scenario I		Scenario II	
			Abso-lute	Ponderate	Abso-lute	Ponderate
1	Design costs	0,05	10	0,5	8	0,8
2	Investment costs	0,10	10	2,50	3	0,75
3	Maintenance costs	0,15	10	1,50	6	0,90
4	Duration of the investment	0,10	10	1,00	5	0,50
5	Isolation and protection	0,05	8	0,40	10	0,50
6	Additional loads on the resistance structure	0,15	10	1,50	5	0,75
7	Species biodiversity	0,05	6	0,30	10	0,50
8	Risk regarding the need to replace plantations (inverse proportion to the species biodiversity)	0,15	10	1,50	6	0,90
9	Quantity of materials needed for installation	0,10	1	0,10	6	0,60
10	Function diversity	0,10	1	0,10	10	1
	TOTAL	**1**		**9,4**		**7,2**

As shown, the score obtained for Scenario I (extensive roof type) is more advantageous in relation to the criteria set, obtaining a score of 9.4 points out of a maximum total of 10 points. Scenario II with a score of 7.2 points out of a maximum total of 10 points, although it is less advantageous in terms of diversity functions offer greater advantages for maximum capacity and full use of facilities on the roof.

RESULTS AND DISCUSSIONS

Green roofs or roof gardens are a technology widely used in the fight against increasingly expanding wider urban heat islands. Their purpose is to provide shade roof, and reduce heat from the air through the process of evapotranspiration. These two mechanisms reduce the roof temperature and air nearby. A roof equipped with any type of vegetalization mentioned may have a temperature lower than ambient air, while a classic roof can record higher values up to 30 ° C. Roofs in extensive or intensive vegetalization can be installed on many types of buildings such as industrial, educational, commercial centers, office buildings and especially residential ones.

From the comparative study of the two major types of roofs a number of advantages can be drawn, but also accompanied by some disadvantages.

Scenario I has the following advantages:

- Improving the quality of urban life;
- Minimal additional loads on resistance to the existing structure;
- Can be installed on the buildings roof sloping up to 30˚ or more;
- Minimum quantities of materials for installation;
- Low maintenance with minimum prices, or no maintenance;
- Full implementation of the provisions of the legislation in force; [7]
- Small duration of achieving the project.

Disadvantages:

- Not a full appreciacion for the potential of the roof;
- Little isolation and protection of buildings;

Scenario II has the following advantages:

- Increase in the quality of urban life;
- Making the most of the roofs of buildings;
- Isolation and greater protection of buildings;
- Biodiversity plant composition;
- Full implementation of the provisions of the legislation in force; [8]
- Low economic disparities, environmental, and socio-cultural of our country and EU countries;
- Decrease the very large difference in level between urban built area per inhabitant and green area per inhabitant.

Disadvantages:

- Great additional loads to the building structure;
- Much higher investment cost;
- Long realization of project;
- Large amounts of material for installation;
- High costs of maintenance arrangement;
- Only roofs with a small slope degree can be installed.

Currently both the vegetalization scenarios are applied on an increasingly larger scale in the great cities of the world (and not only in cities). In Romania the concept of green roof / green or garden roof terrace is at a pioneering stage, needs of urban comfort enhancement by increasing the area of green space per inhabitant is very high and also even pressing at an European level. Given European policies to satisfy a healthy living environment, especially in urban areas, the largest urban agglomeration in our country, Bucharest, still does not meet the criterion of minimum green area per inhabitant imposed by the European Union (26 m/inhabitant)

Today, according to published statistics of the National Institute of Statistics [9] we have, in Bucharest, a factor of 23.21 sqm / inhabitant. Considering the built area of 159 km^2 recorded in 1992, [10] and assuming that only 5% of this area will be built by systems of roof vegetalization, we could reach a factor of 28 sqm / lociutor. This assumption may create alignment with European standards, which require a minimum of 26 sqm / inhabitant.

This solution expansion in urban green area is feasible and can be applied successfully in all cities deficient in green space. It aims to improve the microclimate around buildings that made the project both in terms of reducing temperature, humidity change during summer and reduce automobile pollution in adjacent areas. Planting on roofs meets the challenge of identifying urban solutions to counteract climate change (exacerbated by urban changes) which already causes increases in average temperatures of 2-4˚C during the summer months[11] in major urban agglomerations.

CONCLUSIONS

Considering the advantages and disadvantages of the two major types of vegetalization - extensive and intensive - we can draw the hypothesis that extensive vegetalization system can be applied to roofs of old buildings expertised to support maximum 250 kg./sqm and intensive system vegetalization can be implemented only on new buildings provided by the project to be vegetalizated, or old ones that after technical expertise are deemed to support loads higher than 300kg./m^2. The term "green roof" or "green terrace" may be associated only with roofs vegetalizated in extensive systems, with ecological and aesthetic functions, and the term "roof garden" can be associated only with intensive vegetalization system, which includes besides aesthetic and ecological functions the ambient and relaxing ones.

REFERENCES

[1] S.C. Blizzart Design S.R.L., 2011, Studiu de fezabilitate aferent obiectivului "Acoperisuri verzi", proiect nr. 1187, p. 6, Bucuresti.

[2] UAUIM Bucuresti in colaborare cu INCERC Bucuresti, 2010, Proiectarea si excutia acoperisurilor verzi la cladiri noi si existente, p. 2, nr. UAUIM-CCPEC 24/2009, redactare 1, Bucuresti.

[3] N. Gromicko, E. London, Green Roof Inspection, http://www.nachi.org/green-roof-inspection.htm.

[4] Kaiser Roof Garden, Lake Merritt area, 300 Lakeside Drive, http://www.kaisergarden.com/.

[5] Livingroofs.org & Ecology Consultancy Ltd, 2004, GREEN ROOFS Benefits and cost implications, p. 9, London.

[6] Vicky Hes, 2009, Green Roof Design and Function, http://www.decohot.com/2009/07/green-roof-design-and-function/.

[7],[8] O.U.G. nr. 195/2005 privind Protectia mediului, modificata si completata prin legea nr. 265/2006 si in conformitate cu prevederile din Legea nr. 24/2007 privind reglementarea si administrarea spatiilor verzi din intravilanul localitatilor.

[9] Institutul Naţional de Statistică, 2009, Cadastrului Verde al Municipiului Bucureşti – Registrul Spaţiilor Verzi, Primăria Municipiului Bucureşti, http://www.pmb.ro/pmb/comunicate/presa_com.php?msj=470.

[10] V. Negulescu, 2011, Dinamica spaţiilor verzi în MUNICIPIUL Bucureşti după anul 1800, Teza de Doctorat, coord. Prof. Univ. Dr. Braghina Cristian, p. 4, Universitatea din Bucureşti. Facultatea de Geografie, Şcoala Doctorală „Simion Mehedinţi".

[11] S.C. Blizzart Design S.R.L., 2011, Studiu de fezabilitate aferent obiectivului "Acoperisuri verzi", proiect nr. 1187, p. 5, Bucuresti.