

GREEN TERRACES – A PLANT BASED SOLUTION FOR GREENER CITIES

TERASE VERZI – O SOLUȚIE BAZATĂ PE PLANTE PENTRU ORAȘE MAI VERZI

PAȘCU Roxana¹, ZLATI Cristina^{1*}, VLADIMIR (ASIMINEI) Ina¹

*Corresponding author e-mail: cristina.zlati@iuls.ro

Abstract.

This research paper investigates the potential of green terraces as a sustainable, plant-based solution for mitigating urban environmental challenges and promoting greener cities. As urban populations continue to grow, cities face increasing pressures from climate change, air pollution, and the urban heat island effect, coupled with a significant loss of biodiversity. Green terraces, which include living roofs, rooftop gardens, and vertical green walls, offer a practical and scalable strategy to address these issues by integrating nature directly into the built environment. The study examines the multifaceted benefits of green terraces from several perspectives: environmental, economic, and social with focus on several on site examples. Through a review of existing literature, case studies, and quantitative data, this paper aims to provide a comprehensive overview of the design, implementation, and maintenance of green terraces. It also discusses policy frameworks and incentives that can encourage their widespread adoption. The findings demonstrate that green terraces are not merely aesthetic additions but are essential components of a resilient and sustainable urban infrastructure, offering a tangible pathway towards creating healthier, more livable, and truly greener cities..

Key words: green terraces, green city, sustainability, landscape.

Rezumat.

Această lucrare de cercetare investighează potențialul teraselor verzi ca soluție durabilă, bazată pe plante, pentru atenuarea provocărilor de mediu urban și promovarea unor orașe mai verzi. Pe măsură ce populațiile urbane continuă să crească, orașele se confruntă cu presiuni tot mai mari din partea schimbărilor climatice, a poluării aerului și a efectului de insulă termică urbană, împreună cu o pierdere semnificativă a biodiversității. Terasele verzi, care includ acoperișuri vii, grădini pe acoperișuri și pereți verzi verticali, oferă o strategie practică și scalabilă pentru a aborda aceste probleme prin integrarea directă a naturii în mediul construit. Studiul examinează beneficiile multiple ale teraselor

¹ “Ion Ionescu de la Brad” Iasi University of Life Sciences, Romania

verzi din mai multe perspective: de mediu, economice și sociale, concentrându-se pe câteva exemple la fața locului. Printr-o analiză a literaturii existente, a studiilor de caz și a datelor cantitative, această lucrare își propune să ofere o imagine de ansamblu cuprinzătoare asupra proiectării, implementării și întreținerii teraselor verzi. De asemenea, discută cadrele de politici și stimulentele care pot încuraja adoptarea lor pe scară largă. Concluziile demonstrează că terasele verzi nu sunt doar completări estetice, ci sunt componente esențiale ale unei infrastructuri urbane rezistente și durabile, oferind o cale tangibilă către crearea unor orașe mai sănătoase, mai locuibile și cu adevărat mai verzi

Cuvinte cheie: terase verzi, oraș verde, sustenabilitate, peisaj.

INTRODUCTION

Urban space is experiencing numerous social and ecological problems, linked to population migration that causes the accelerated expansion of cities, a phenomenon responsible in turn for an increasing urban densification, which culminates in the emergence of unprecedented ecological changes [Zlati and Pascu, 2021]. The observation of this continuous cyclical process has allowed the formulation of global projections that show that two-thirds of the global population will live in urban areas by 2050, putting even greater pressure on the infrastructure and resources in these areas [United Nations, 2025]. Specifically speaking, these pressures are manifested in the increase in air pollution levels, the expansion and worsening of the urban heat island phenomenon, the decrease in the capacity to manage urban waters and the accelerated decline in biodiversity [Grimm *et al.*, 2008; IPCC, 2022]. Overall, these processes not only affect environmental resilience, but also population health and quality of life in general [WHO, 2021].

The evolution of these challenges has generated the emergence of nature-based solutions (NbS) that have attracted increasing attention through the proposed approach. Namely, these solutions represent integrated strategies based on natural processes, arising in response to current environmental problems, bringing with them other related benefits [IPBES, 2019; Bernardis *et al.*, 2022].

In this context, green terraces - including green roofs, balcony gardens, green walls - all these components have emerged as promising solutions that incorporate vegetation into the built environment [Zlati *et al.*, 2022]. Compared to conventional green spaces, which occupy areas at ground level, green terraces occupy already built, otherwise unused areas, with the aim of increasing their ecological capacity without affecting the natural space [Oberndorfer *et al.*, 2007; Francis and Lorimer, 2011; Căpraru and Zlati, 2009; Draghia *et al.*, 2009].

From an ecological perspective, green terraces contribute to reducing surface and ambient temperatures, thus reducing the urban heat island effect [Santamouris, 2014; Zlati *et al.*, 2024]. At the same time, they also improve air quality, due to the absorption of pollutants and suspended particles [Currie and Bass, 2008]. And from a biodiversity perspective, they create habitats for pollinators, birds and insects,

favoring the creation of an ecological connection in dense urban areas [Köhler, 2008; Zlati *et al.*, 2019, Istrate *et al.*, 2025].

Also from a mental health perspective, green spaces are associated with increased levels of psychological well-being. And when designed for the community, they can serve to social cohesion between different categories of users, encouraging socialization and belonging [Guitart *et al.*, 2012].

MATERIAL AND METHOD

In this context, this paper aims to conduct an analysis of the potential for the creation and implementation of green terrace projects in the city of Iasi, as a long-term solution that could improve the effects of urban center congestion and support the transition to greener cities.

Following a synthesis of specialized literature and field investigations of existing green terrace models, plant compositions considered suitable for use on green terraces were proposed, based on which the most effective options for the design, implementation, and maintenance of a green terrace can be analyzed.

RESULTS AND DISCUSSIONS

Following the analyses carried out, the paper proposes four typologies of planting strategies:

1. Vegetative compositions organized around a major structural element
2. Mixed compositions of shrubs of various sizes
3. Compositions of decorative grasses or mixed with grasses and shrubs
4. Vertical systems with climbing plants

Instead of focusing on the individual performances of the species used, the study aims to analyze the contribution of vegetation ensembles.

1. Vegetative compositions organized around a major structural element

Compositions organized around a dominant dendrological element provide a vertical structure and impose a spatial hierarchy. Examples proposed for terraces include compositions such as: *Magnolia grandiflora* combined with spheres of *Prunus laurocerasus* and *Photinia x fraserii* at its base; *Acer palmatum* integrated with *Spiraea japonica*, *Euonymus fortunei* and *Cornus alba*; bamboo vegetable curtains (Figure 1). These are usually placed in large containers to provide a sufficient amount of substrate for root development. In all three examples, these groupings serve as a focal point, defining spatial boundaries, and the shrub vegetation at the base adds seasonal decoration through flowers or leaves, for a textural contrast.



Fig. 1. The illustration of the proposed compositions

From an ecological point of view, compositions organized around a dominant dendrological element represent the most complex plant structure, and the placement of vegetation on height levels resembles natural habitats, which helps to integrate into the natural urban network. The presence of dendrological specimens improves the degree of shading of built surfaces, reduces surface temperature, contributes to wind protection and increases the thermal comfort of terraces exposed to high solar radiation.

2. Mixed compositions of shrubs of various sizes

Compositions made up of a mix of shrub species offer a visual point at eye level, and combinations of deciduous and coniferous species bring interest and dynamism throughout the year. Typical examples used are: *Ligustrum*, *Photinia*, *Lavandula*, *Cotoneaster*, *Spiraea*, *Berberis*, as well as various varieties of *Juniperus* or *Pinus*. Shrubs that decorate with flowers bring strong seasonal accents, and conifers - in the winter months. A successful association with these is the use of bamboo - as an architectural element, providing vertical accent but without having the visual weight of a more massive tree (Figure 2).



Fig. 2. The illustration of the proposed species

Shrubbery groups represent a harmonious structural element from a compositional point of view, combining both ecological benefits and the feasibility

of their use on terraces. The height and moderate maintenance requirements offer more extensive possibilities for the use of shrub species on terraces.

From an ecological point of view, flowering species have an important role in supporting pollinators, and evergreen species provide habitat for insects and other small creatures.

From a design perspective, shrubs are more flexible in compositions, making it possible to choose species that correspond to the location, environmental factors, and user needs as accurately as possible. The low maintenance requirement combined with a high aesthetic performance leads to the favoring of this type of compositions, especially in residential or institutional spaces.

3. Compositions of decorative grasses or mixed with grasses and shrubs

In plant compositions made from decorative grasses or in mixed compositions that also include decorative grasses, species such as *Calamagrostis acutiflora*, *Pennisetum alopecuroides*, *Stipa tenuissima*, *Festuca glauca*, *Miscanthus sinensis* are used (Figure 3). These can be combined with each other or in a mix with shrubs.

This type of compositions shows a great adaptation to the conditions of a terrace, having a good resistance both to high temperatures and to other stress factors such as exposure to strong air currents. From an aesthetic point of view, it offers an ever-changing character throughout the year, also contributing through its form to the creation of a natural dynamism [Negrea and Zlati,2013].



Fig. 3. The use of decorative grasses

The compositions made of ornamental grasses align with the principles of nature-inspired design, especially with the concept of urban lawns. Ecologically speaking, these species are resistant to the thermal factor, require a lower amount of irrigation, while providing a sensory experience for the users of the space.

4. Vertical systems with climbing plants

Climbing species are especially used on various types of supports, being systems that offer a high degree of shade and protection without the need for a large amount of substrate or massive planters. From an ecological point of view, species such as *Hedera helix* or *Wisteria sinensis* are resistant to solar radiation, bringing comfort and elegance to the terrace (Figure 4).



Fig. 4. The use of vertical systems with climbing plants

From a social point of view, the space located under a pergola can be arranged for socializing, encouraging residents to spend time outside the rooms.

These observations and vegetation groupings demonstrate the need for clearly defined, context-appropriate design directions when implementing a green terrace design. This way, they can function not only as static design elements, but as components of highly resilient and biodiversity-rich urban infrastructure.

CONCLUSIONS

This study shows that it is necessary to change the perspective on green terraces, viewing them not only as decorative elements, but as multifunctional solutions based on nature. Regardless of the type of composition used, they contribute to a greater or lesser extent to improving environmental conditions.

Also, the structure of plant compositions has an influence not only on the ecological element of the environment, but also on the practical part of implementation, so special importance must be given to context-specific design strategies, and not to treating each site with a general approach.

Beyond the ecological benefits, a green terrace represents a place for informal socialization, encouraging interaction with the outdoor environment and representing a suitable example of urban sustainability.

For the large-scale inclusion of green terraces as an important element in a sustainable urban infrastructure, it is necessary to generate policies that stimulate future planning approaches of a built structure. In conclusion, it is necessary that future urban regeneration strategies prioritize green terraces, as scalable interventions at different sizes, capable of simultaneously improving both the ecological and social aspects of the environment.

REFERENCES

1. **Bernardis R., Dascălu M., Chelariu E.L., Zlati C., Pașcu R., Posta D., 2022** – *The analysis of some ornamental rose varieties grow in the green spaces from Iași*, *Scientific Papers Series B. Horticulture*, Vol. LXVI, nr. 1, pp. 638-643.
2. **Căpraru F., Zlati C., 2009** – *Observations regarding yield phenophases of some diseases genetic resistant apple cultivars, in the conditions of Bistrița region*, U.S.A.M.V. Iași, Vol. I (52) Seria Horticultură, pg. 539-544.
3. **Currie B.A., Bass B., 2008** – *Estimates of air pollution mitigation with green plants and green roofs using the UFORE model*. *Urban Ecosystems*, 11(4), 409–422.
4. **Draghia L., Chelariu E.L., Zlati C., Birescu L., 2009** – *Studies regarding the effect of some unconventional fertilizers used for ornamental plants cultivated in the field*. *Bulletin U.A.S.V.M. Cluj-Napoca, Horticulture* 66(1), pg. 510-515.
5. **Francis R.A., Lorimer J., 2011** – *Urban reconciliation ecology: The potential of living roofs and walls*. *Journal of Environmental Management*, 92(6), 1429–1437.
6. **Grimm N.B., Faeth S.H., Golubiewski N.E., Redman C.L., Wu J., Bai X., Briggs J.M., 2008** – *Global change and the ecology of cities*. *Science*, 319(5864), 756–760.
7. **Guitart D., Pickering C., Byrne J., 2012** – *Past results and future directions in urban community gardens research*. *Urban Forestry & Urban Greening*, 11(4), 364–373.
8. **Intergovernmental Panel on Climate Change, 2022** – *Climate change 2022: Impacts, adaptation and vulnerability* (Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change; H.-O. Pörtner et al., Eds.). Cambridge University Press.
9. **IPBES, 2019** – *Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. E. S. Brondizio, J. Settele, S. Díaz, and H. T. Ngo (editors). IPBES secretariat, Bonn, Germany. 1148 pages.
10. **Istrate M., Zlati C., Dascălu M., 2025** – *Pomicultură. Aplicații practice*, Editura “Ion Ionescu de la Brad” Iași, ISBN 978-973-147-586-8.
11. **Köhler M., 2008** – *Green facades—A view back and some visions*. *Urban Ecosystems*, 11(4), 423–436.
12. **Negrea R., Zlati C., 2011** – *Tree foliage, as main source of color in landscape composition*, U.S.A.M.V. Iași, Vol. I (54) Seria Horticultură, p. 531-536, ISSN 1454-7376.
13. **Oberndorfer E., Lundholm J., Bass B., Coffman R., Doshi H., Dunnett N., Gaffin S., Köhler M., Liu K., Rowe D.B., 2007** – *Green roofs as urban ecosystems: Ecological structures, functions, and services*. *BioScience*, 57(10), 823–833.
15. **Santamouris M., 2014**. *Cooling the cities – A review of reflective and green roof mitigation technologies to fight heat island and improve comfort in urban environments*. *Solar Energy*, 103, 682–703.
16. **United Nations, Department of Economic and Social Affairs, Population Division., 2025** – *World urbanization prospects 2025: Summary of results* (UN DESA/POP/2025/TR/No. 12). United Nations.
17. **World Health Organization, 2021** – *WHO global air quality guidelines: Particulate matter (PM_{2.5} and PM₁₀), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide*. World Health Organization.
18. **Zlati C., Istrate M., Pascu R., Bernardis R., 2024** – *An assessment of current status, future trends and opportunities for improving exotic and underutilized pome fruit species production in Romania*, *Scientific Papers Series B. Horticulture*, Vol. LXVIII, nr. 2, pp. 224-229.

19. **Zlati C., Istrate M., Pașcu R., Bernardis R., 2019** – *Sweet cherry cultivars evaluation in Romania*, Lucrări Științifice U.S.A.M.V. Iași, Seria Horticultură, vol. 62(2)/2019, pp. 69-74.
20. **Zlati C., Pașcu R., 2021** – *Urban farming - opportunity for fruit growing development in Romania*, Scientific Papers Series B. Horticulture, Vol. LXV, nr. 1, pp. 697-704 (717-724).
21. **Zlati C., Pașcu R., Bernardis R., 2022** – *Using fruit growing species for green roofs*, Scientific Papers Series B. Horticulture, Vol. LXVI, nr. 1, pp. 772-777.