

Extensive Green Roofs

Subjects: [Plant Sciences](#)

Contributor: Amii Bellini , Flavia Bartoli , Giulia Caneva

Extensive Green Roofs (EGRs) are nature-based solutions that provide several environmental, health, social, and economic benefits. This synthesis of about 1430 scientific papers, based on the five Ws, *When*, *Where*, *Why*, *Who*, and *Which*, aims to understand how interest in these important green infrastructures originated and developed, as well as the nature of such academic research. Special attention was paid to the way researchers approached plant selection.

roof greening

urban ecology

biodiversity

urban planning

sustainable development

1. Introduction

The growth of urbanization in developed and developing countries is one of the most important social and economic phenomena in the overall development of different aspects of human life ^[1]. However, urban ecosystems are where interactions between anthropogenic activities and the natural environment are at their most intense ^{[2][3]}. Over the years, the expansion of cities has led not only to a reduction in green areas but also to greater environmental damage from the production of heat, waste, water, and air pollution and has generally had a negative impact on biodiversity ^{[4][5][6][7][8]}. There is an urgent need for integrative planning of green cities if we are to meet the growing environmental, social, and economic challenges posed by the negative effects of urban development ^[9]. Cities of the future should strive to be greener by designing and managing green infrastructure that can improve urban resilience and livability ^{[10][11]}. Even though urban forests and green open spaces in cities (tree-lined streets, gardens, parks, wetlands) are essential, there is often limited availability of ground-level spaces suitable for nature-based solutions.

Green roofs, typically consisting of vegetation planted above a series of layers that protect the roof substrate and improve the system's performance, can, therefore, represent an ideal supplementary space ^{[12][13][14]}. In particular, extensive green roofs (EGRs) require a shallower growing media and little maintenance compared to intensive green roofs (IGRs), which involve a thicker growing media and more intensive gardening ^[6].

Vegetated building roofing dates back to at least the Neolithic Era (8000–4000 BC), as they provided protection for buildings in harsh and climatically extreme environments ^[15]. For example, in the Arctic and the semi-arid continental lands of Central Asia, the scarcity of trees gave rise to a vernacular architecture where roofs were insulated with soil and living grasses from natural meadows (**Figure 1a,b**), known as “sod-roofs” ^[16]. The use of vegetation on buildings has also been recorded in the milder climates of medieval and modern Europe, particularly the beautiful, intensive green roofs built by aristocratic families and religious organizations ^[13]. These architectural

structures gained complexity over the years with the invention of reinforced concrete, which allowed the construction of multi-story buildings with wide flat roofs and, as a result, provided many more opportunities for creating ornamental gardens above ground level [16].



Figure 1. Old vegetated building roof (a) Traditional semi-subterranean sod house in Iceland (Photo credit Christian Bickel under Wikimedia Commons at “https://en.wikipedia.org/wiki/Sod_house”. Accessed on 8 December 2023). (b) Traditional log farmhouses with sod roofs in Glittersjaa Mountain, Norway (Photo credit Tina Stafrén and “visitnorway.com”. Accessed on 8 December 2023).

Studies carried out in Germany in the mid-twentieth century stimulated the birth of modern EGRs; thereafter, spontaneous vegetation growth was observed on flat roofs, demonstrating nature's ability to create green roofs on buildings [13]. Le Corbusier [17] was already talking about green roofs in 1927 and listed them among his 'Five Points of Modern Architecture', citing their functional benefits in protecting reinforced concrete from temperature changes, as well as their recreational value [18][19], while in 1936 the roof gardens created in South America by Roberto Burle Marx became famous [20].

Extensive green roofs have been the subject of several review papers and research papers, although these tended to focus on individual aspects [21][22][23]. Such studies have shown how EGRs help mitigate the urban heat island (UHI) effect, reduce temperature through evapotranspiration [12][14][24], and stormwater run-off by retaining water [12][14][25][26][27]. They absorb air pollution [14][28] and act as a sound barrier due to the thickness of the substrate and vegetation layers [29][30]. Green roofs also provide ecological benefits by supporting urban flora and fauna biodiversity and functioning as ecological corridors [6][31][32][33][34]. Finally, some revision work highlights how green roofs can affect different types of ecosystem services [35][36].

Although the historical and geographical background seems quite clear, interest in this topic has lacked consistency and homogeneity both in chronological and geographical terms. The same can be said for the themes chosen for study; although the spectrum of topics is very broad, interest in addressing them is not homogeneous. There is still a need for a more detailed analysis of 'where and when' interest in modern green roofs spread in the context of scientific research and 'why', i.e., with what goal such studies were made. Additionally, green roofs may be of interest to a wide range of disciplines, particularly engineering, architecture, agronomy, and botany. Another interesting question in need of clarification is 'who', i.e., the professional background of the study authors.

The botanical aspect of green roofs and their design, on the other hand, tends to be neglected, with little attention paid to plant selection. Although plant species play an important aesthetic role, which is a crucial architectural priority and important for psychological well-being [8][37], the plants selected are also fundamental to the functionality of green roofs. For this reason, care should be taken to select the most appropriate plant species [6][38], and attention must be paid to the influence that soil depth, local climates, water availability, and planting density have on roof-based plants [19][39][40][41].

2. Origin and Evolution

Although the principles of EGRs can be found in early twentieth-century modern architecture, one can say with certainty that their introduction and related research began some decades later. This probably happened, like with many other innovations, as a result of the complex socioeconomic and political conditions created by the two world wars. There is now a truly global interest in research into this subject driven by curiosity, fashion, and necessity.

With regard to the geographical origin of EGRs, the vast database confirmed the role of Germany and Switzerland in early implementation and scientific research, which then expanded worldwide [42][43]. There is a margin of error in the precise quantification of scientific papers in the field since the indexing of papers began later and was implemented differently in different countries. Recent and rapidly spreading interest in places like Southern Europe, China, and the United States may be associated with an increased awareness of environmental issues and economic benefits [44]. Indeed, over the past three decades, environmental degradation has become a source of collective concern, leading many national and international organizations to launch specific initiatives based on sustainability in order to counter the progress of climate change and environmental degradation [45][46].

However, despite the need to address these issues collectively, countermeasures are not taken in the same way and at the same time by all nations, and cultural, political, and economic factors can influence how nations approach these strategies. This divergence is also clear in the present study.

The challenges related to political decisions and the market are evident, even when considering countries that emerge as the most active in this context, such as the United States, China, and Europe, where green roofs have become a central theme. Despite the establishment of organizations like GRHC (Green Roofs for Healthy Cities) or EFB (European Federation Green Roof and Walls) with the aim of promoting and encouraging the adoption of green roofs and walls in their respective countries, it is observed that regulatory frameworks and political incentives remain insufficient. Additionally, there is a lack of in-depth analysis and research on the management of the green roof market. For instance, although China is recognized as a global leader in constructing new areas every year, it still lacks adequate regulations on green roofs to stimulate their development [47].

3. Aims and Approaches

From the earliest published papers, the researchers found that despite being a multidisciplinary field, the study of green roofs is too often treated in a monodisciplinary manner [43][48].

The only negative finding common to all the papers was related to costs. This confirms the conclusions of Chen et al. [49] and Dong et al. [44], who identified maintenance, design, and construction costs, poor provisions for EGR adoption, and lack of subsidies as the main disincentives to the implementation of EGRs.

A general evaluation of the various approaches suggests little consideration was given to ecological concerns. Usually, when engineer/architect teams specify the selection method for plants, their decisions are made mostly on a technical or practical basis by considering morphology, canopy capacity, aesthetics, easy availability, and low maintenance. The terminology used is another element that highlights the need for more emphasis on plant selection. Authors often refer to vegetation with generic and minimalist terms such as 'grass', 'grass-like', and 'Sedum-like'. This denotes how, in some cases, vegetation is seen superficially as purely aesthetic or as an accessory. Ecological and environmental factors have recently been receiving more interest due to the role of biodiversity in environmental management as a hot topic, even in urban contexts [43][50][51][52][53]. This can also be seen in national and international policy trends. One such policy is the recently adopted Biodiversity Strategy 2030 [54], which aims to "bring nature back into our lives", in line with the goals of the Green Deal [55].

4. Botanical View

In most countries, from the United Kingdom and Germany to America and China, *Sedum* species (Crassulaceae) are the plants most used. Their selection is justified by the belief that they are the most suitable species for this environment, and they are often recommended in guidelines. It is undeniable that species selection is a challenge, and selecting drought-resistant species such as *Sedum* sp. on extensive green roofs is easy for any professional figure to justify [44][50][56].

There is increasing awareness of the need to employ a wider range of *Sedum* species by considering biogeographical and bioclimatic factors, using native species [57][58], or considering physiological and ecological factors like prioritizing species able to tolerate water stress [59][60], possess specific photosynthetic qualities (e.g., CAM, C4) [60][61] or can adapt to pioneer conditions [62][63]. However, the progress of research is slow. For example, only about a hundred species appear in papers published in North America despite its extreme environmental complexity and wide range of climatic conditions [42]. From an ecological point of view, we should be aware that *Sedum* species are not native to some parts of the world, and research should also focus on considering the suitability of other plant species for green roofs [48]. *Sedum* could be replaced with other species suited to the green roof construction environment by using ecological species selection methods [6]. In this way, by considering the variety of functions performed by different plant forms, green roofs can be designed so as to promote conditions beneficial to plants and maximize benefits [54][64].

Species diversity in green roofs has often been seen as simply an aesthetic issue [65]. Time and again, plant diversity has been shown to play an important role in the functionality of these infrastructures. For example, it can improve substrate cooling [66], prevent invasive weeds [67], and conserve water [48][68]. Plants are also crucial to social, psychological, and sometimes even to ethnobotanical considerations [69][70][71][72]. In some cases, for example, green roofs are used to grow food and treat water [73][74][75][76].

References

1. Ouyang, X.; Tang, L.; Wei, X.; Li, Y. Spatial interaction between urbanization and ecosystem services in Chinese urban agglomerations. *Land Use Policy* 2021, 109, 105587.
2. Zhang, J.; Hu, X.; Li, Q.; Kopytov, C. Evaluation and comparison of the resource and environmental carrying capacity of the 10 main urban agglomerations in China. *Nat. Environ. Pollut. Technol.* 2015, 14, 573–578.
3. Zhao, J.; Chen, S.; Jiang, B.; Ren, Y.; Wang, H.; Vause, J.; Yu, H. Temporal trend of green space coverage in China and its relationship with urbanization over the last two decades. *Sci. Total Environ.* 2013, 442, 455–465.
4. Horbert, M.; Blume, H.P.; Elvers, H.; Sukopp, H. Ecological contributions to urban planning. In *Urban Ecology: The Second European Ecological Symposium*; Bornkamm, R., Lee, J.A., Seaward, M.R.D., Eds.; Blackwell Scientific Publications: Oxford, UK, 1982; pp. 255–275.
5. Biondi, E.; Casavecchia, S.; Pesaresi, S. Nitrophilous and ruderal species as indicators of climate change. Case study from the Italian Adriatic coast. *Plant Biosyst.* 2012, 146, 134–142.
6. Caneva, G.; Kumbaric, A.; Savo, V.; Casalini, R. Ecological approach in selecting extensive green roof plants: A data-set of Mediterranean plants. *Plant Biosyst.* 2015, 149, 374–383.
7. Salvati, L.; Quatrini, V.; Barbati, A.; Tomao, A.; Mavrakis, A.; Serra, P.; Sabbi, A.; Merlini, P.; Corona, P. Soil occupation efficiency and landscape conservation in four Mediterranean urban regions. *Urban For. Urban Green.* 2016, 20, 419–427.
8. Capotorti, G.; Bonacquisti, S.; Abis, L.; Aloisi, I.; Attorre, F.; Bacaro, G.; Balletto, G.; Banfi, E.; Barni, E.; Bartoli, F.; et al. More nature in the city. *Plant Biosyst.* 2020, 154, 1003–1006.
9. OECD. 2018 Rethinking Urban Sprawl: Moving towards Sustainable Cities; OECD Publishing: Paris, France, 2018.
10. Duinker, P.N.C.; Ordóñez, J.W.N.; Steenberg, K.H.; Miller, S.A.; Toni, S.A. Nitoslaws Trees in Canadian cities: Indispensable life form for urban sustainability. *Sustainability* 2015, 7, 7379–7396.
11. Nitoslawski, S.A.; Galle, N.J.; Van Den Bosch, C.K.; Steenberg, J.W. Smarter ecosystems for smarter cities? A review of trends, technologies, and turning points for smart urban forestry. *Sustain. Cities Soc.* 2019, 51, 101770.
12. Berardi, U.; Ghaffarian Hoseini, A.; Ghaffarian Hoseini, A. State-of-the-art analysis of the environmental benefits of green roofs. *Appl. Energy* 2014, 115, 411–428.

13. Jim, C.Y. An archaeological and historical exploration of the origins of green roofs. *Urban For. Urban Green*. 2017, 27, 32–42.
14. Manso, M.; Teotónio, I.; Silva, C.M.; Cruz, C.O. Green roof and green wall benefits and costs: A review of the quantitative evidence. *Renew. Sustain. Energy Rev.* 2021, 135, 110111.
15. Oberndorfer, E.; Lundholm, J.; Bass, B.; Coffman, R.R.; Doshi, H.; Dunnett, N.; Gaffin, S.; Köhler, M.; Liu, K.K.Y.; Rowe, B. Green roofs as urban ecosystems: Ecological structures, functions, and services. *Bioscience* 2007, 57, 823–833.
16. Jim, C.Y. Green roof evolution through exemplars: Germinal prototypes to modern variants. *Sustain. Cities Soc.* 2017, 35, 69–82.
17. Oechslin, W.; Wang, W. Les cinq points d'une architecture nouvelle. *Assemblage* 1987, 4, 83–93.
18. Eisenman, T. Raising the bar on green roof design. *Landsc. Archit.* 2006, 96, 22.
19. Vannucchi, F.; Buoncristiano, A.; Scatena, M.; Caudai, C.; Bretzel, F. Low productivity substrate leads to functional diversification of green roof plant assemblage. *Ecol. Eng.* 2022, 176, 106547.
20. Fraser, V. Cannibalizing Le Corbusier: The MES Gardens of Roberto Burle Marx. *J. Soc. Archit. Hist.* 2000, 59, 180–193.
21. Besir, A.B.; Cuce, E. Green Roofs and Facades: A Comprehensive Review. *Renew. Sustain. Energy Rev.* 2018, 82, 915–939.
22. Cascone, S. Green Roof Design: State of the Art on Technology and Materials. *Sustainability* 2019, 11, 3020.
23. Cook, L.M.; Larsen, T.A. Towards a Performance-Based Approach for Multifunctional Green Roofs: An Interdisciplinary Review. *Build. Environ.* 2020, 188, 107489.
24. Gill, S.E.; Handley, J.F.; Ennos, A.R.; Pauleit, S. Adapting cities for climate change: The role of green infrastructure. *Build. Environ.* 2007, 33, 115–133.
25. Bliss, D.J.; Neufeld, R.D.; Ries, R.J. Storm water runoff mitigation using a green roof. *Environ. Eng. Sci.* 2009, 26, 407–418.
26. Li, Y.; Babcock, R.W. Green Roof Hydrologic Performance and Modeling: A Review. *Water Sci. Technol.* 2014, 69, 727–738.
27. Akther, M.; He, J.; Chu, A.; Huang, J.; Van Duin, B. A review of green roof applications for managing urban stormwater in different climatic zones. *Sustainability* 2018, 10, 2864.
28. Viecco, M.; Jorquera, H.; Sharma, A.; Bustamante, W.; Fernando, H.J.; Vera, S. Green roofs and green walls layouts for improved urban air quality by mitigating particulate matter. *Build. Environ.* 2021, 204, 108120.

29. Galbrun, L.; Scerri, L. Sound insulation of lightweight extensive green roofs. *Build. Environ.* 2017, 116, 130–139.
30. Van Renterghem, T. Improving the noise reduction by green roofs due to solar panels and substrate shaping. *Build. Acoustic.* 2018, 25, 219–232.
31. Fernández Cañero, R.; González Redondo, P. Green roofs as a habitat for birds: A review. *J. Anim. Vet. Adv.* 2010, 9, 2041–2052.
32. Braaker, S.; Ghazoul, J.; Obrist, M.K.; Moretti, M. Habitat Connectivity Shapes Urban Arthropod Communities: The Key Role of Green Roofs. *Ecology* 2014, 95, 1010–1021.
33. Bretzel, F.; Vannucchi, F.; Romano, D.; Malorgio, F.; Benvenuti, S.; Pezzarossa, B. Wildflowers: From conserving biodiversity to urban greening—A review. *Urban for. Urban Green.* 2016, 20, 428–436.
34. Wooster, E.I.F.; Fleck, R.; Torpy, F.; Ramp, D.; Irga, P.J. Urban green roofs promote metropolitan biodiversity: A comparative case study. *Build. Environ.* 2022, 207, 108458.
35. Lundholm, J.T.; Williams, N.S.G. Effects of Vegetation on Green Roof Ecosystem Services. *Green Roof Ecosyst.* 2015, 223, 211–232.
36. Francis, L.F.M.; Jensen, M.B. Benefits of green roofs: A systematic review of the evidence for three ecosystem services. *Urban For. Urban Green.* 2017, 28, 167–176.
37. Liberalesso, T.; Mutevuie Júnior, R.; Oliveira Cruz, C.; Matos Silva, C.; Manso, M. Users' perceptions of green roofs and green walls: An analysis of youth hostels in Lisbon, Portugal. *Sustainability* 2020, 12, 10136.
38. Benvenuti, S.; Bacci, D. Initial agronomic performances of Mediterranean xerophytes in simulated dry green roofs. *Urban Ecosyst.* 2010, 13, 349–363.
39. Brown, C.; Lundholm, J. Microclimate and substrate depth influence green roof plant community dynamics. *Landsc. Urban Plan.* 2015, 143, 134–142.
40. Aprile, S.; Tuttolomondo, T.; Gennaro, M.C.; Leto, C.; La Bella, S.; Licata, M. Effects of plant density and cutting-type on rooting and growth of an extensive green roof of *Sedum sediforme* (Jacq.) Pau in a Mediterranean environment. *Sci. Hortic.* 2020, 262, 109091.
41. Shafique, M.; Kim, R.; Rafiq, M. Green roof benefits, opportunities and challenges—A review. *Renew. Sustain. Energy Rev.* 2018, 90, 757–773.
42. Dvorak, B.; Volder, A. Green roof vegetation for North American ecoregions: A literature review. *Landsc. Urban Plan.* 2010, 96, 197–213.
43. Blank, L.; Vasl, A.; Levy, S.; Grant, G.; Kadas, G.; Dafni, A.; Blaustein, L. Directions in green roof research: A bibliometric study. *Build. Environ.* 2013, 66, 23–28.

44. Dong, J.; Zuo, J.; Luo, J. Development of a management framework for applying green roof policy in urban China: A preliminary study. *Sustainability* 2020, 12, 10364.
45. Puertas, R.; Guaita-Martinez, J.M.; Carracedo, P.; Ribeiro-Soriano, D. Analysis of European environmental policies: Improving decision making through eco-efficiency. *Technol. Soc.* 2022, 70, 102053.
46. Smol, M. Is the green deal a global strategy? Revision of the green deal definitions, strategies and importance in post-COVID recovery plans in various regions of the world. *Energy Policy* 2022, 169, 113152.
47. Xiao, M.; Lin, Y.; Han, J.; Zhang, G. A review of green roof research and development in China. *Renew. Sustain. Energy Rev.* 2014, 40, 633–648.
48. Vijayaraghavan, K. Green roofs: A critical review on the role of components, benefits, limitations and trends. *Renew. Sustain. Energy Rev.* 2016, 57, 740–752.
49. Chen, X.; Shuai, C.Y.; Chen, Z.H.; Zhang, Y. What are the root causes hindering the implementation of green roofs in urban China? *Sci. Total Environ.* 2019, 654, 742–750.
50. Snodgrass, E.C.; Snodgrass, L.L. *Green Roof Plants: A Resource and Planting Guide*; Timber Press: Portland, OR, USA, 2006.
51. Gedge, D.; Kadas, G. Green roofs and biodiversity. *Biologist* 2005, 52, 161–169.
52. Hendriks, I.E.; Duarte, C.M. Allocation of effort and imbalances in biodiversity research. *J. Exp. Mar. Biol. Ecol.* 2008, 360, 15–20.
53. Lundholm, J.; Maclvor, J.S.; MacDougall, Z.; Ranalli, M. Plant species and functional group combinations affect green roof ecosystem functions. *PLoS ONE* 2010, 5, 9677.
54. European Commission. EU biodiversity strategy for 2030: Bringing nature back into our lives. In Communication for the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions; European Commission: Brussels, Belgium, 2020; p. 25.
55. Hermoso, V.; Carvalho, S.B.; Giakoumi, S.; Goldsborough, D.; Katsanevakis, S.; Leontiou, S.; Markantonatou, V.; Rumes, B.; Vogiatzakis, I.N.; Yates, K.L. The EU Biodiversity Strategy for 2030: Opportunities and challenges on the path towards biodiversity recovery. *Environ. Sci. Policy* 2022, 127, 263–271.
56. Mentens, J.; Raes, D.; Hermy, M. Green roofs as a tool for solving the rainwater runoff problem in the urbanized 21st century? *Landsc. Urban Plan.* 2006, 77, 217–226.
57. Fioretti, R.; Palla, A.; Lanza, L.G.; Principi, P. Green roof energy and water related performance in the Mediterranean climate. *Build. Environ.* 2010, 45, 1890–1904.

58. Pirouz, B.; Palermo, S.A.; Maiolo, M.; Arcuri, N.; Piro, P. Decreasing water footprint of electricity and heat by extensive green roofs: Case of southern Italy. *Sustainability* 2020, 12, 10178.
59. Schweitzer, O.; Erell, E. Evaluation of the energy performance and irrigation requirements of extensive green roofs in a water-scarce Mediterranean climate. *Energy Build.* 2014, 68, 25–32.
60. Liu, J.; Garg, A.; Wang, H.; Huang, S.; Mei, G. Moisture management in biochar-amended green roofs planted with *Ophiopogon japonicus* under different irrigation schemes: An integrated experimental and modeling approach. *Acta Geophys.* 2022, 70, 373–384.
61. Cristiano, E.; Urru, S.; Farris, S.; Ruggiu, D.; Deidda, R.; Viola, F. Analysis of potential benefits on flood mitigation of a CAM green roof in Mediterranean urban areas. *Build. Environ.* 2020, 183, 107179.
62. Bevilacqua, P.; Mazzeo, D.; Bruno, R.; Arcuri, N. Surface temperature analysis of an extensive green roof for the mitigation of urban heat island in southern Mediterranean climate. *Energy Build.* 2017, 150, 318–327.
63. Fabian, D.; González, E.; Domínguez, M.V.S.; Salvo, A.; Fenoglio, M.S. Towards the design of biodiverse green roofs in Argentina: Assessing key elements for different functional groups of arthropods. *Urban For. Urban Green.* 2021, 61, 127107.
64. Butler, C.; Orians, C. Sedum facilitates the growth of neighboring plants on a green roof under water limited conditions. In *Proceedings of the Seventh Annual Greening Rooftops for Sustainable Communities Conference, Awards and Trade Show, Atlanta, GA, USA, 3–5 June 2009.*
65. Lee, K.E.; Williams, K.J.; Sargent, L.D.; Farrell, C.; Williams, N.S. Living roof preference is influenced by plant characteristics and diversity. *Landsc. Urban Plan.* 2014, 122, 152–159.
66. Heim, A.; Lundholm, J. Species interactions in green roof vegetation suggest complementary planting mixtures. *Landsc. Urban Plan.* 2014, 130, 125–133.
67. Levine, J.M. Species diversity and biological invasions: Relating local process to community pattern. *Science* 2000, 288, 852–854.
68. MacIvor, J.S.; Margolis, L.; Puncher, C.L.; Matthews, B.J.C. Decoupling factors affecting plant diversity and cover on extensive green roofs. *J. Environ. Manag.* 2013, 130, 297–305.
69. Brenneisen, S. *From Biodiversity Strategies to Agricultural Productivity; Canada, 2004.* Available online: <https://www.osti.gov/etdeweb/biblio/20861882> (accessed on 8 December 2023).
70. Mesimäki, M.; Hauru, K.; Kotze, D.J.; Lehvävirta, S. Neo-spaces for urban livability? Urbanites' versatile mental images of green roofs in the Helsinki metropolitan area, Finland. *Land Use Policy* 2017, 61, 587–600.
71. Manso, M.; Sousa, V.; Silva, C.M.; Cruz, C.O. The role of green roofs in post COVID-19 confinement: An analysis of willingness to pay. *J. Build. Eng.* 2021, 44, 103388.

72. Thapa, S.; Nainabasti, A.; Bharati, S. Assessment of the linkage of urban green roofs, nutritional supply, and diversity status in Nepal. *Cogent Food Agric.* 2021, 7, 1911908.
73. Banting, D.; Doshi, H.; Li, J.; Missios, P.; Au, A.; Currie, B.A.; Verrati, M. Report on the Environmental Benefits and Costs of Green Roof Technology for the City of Toronto; City of Toronto and Ontario Centers of Excellence—Earth and Environmental Technologies: Toronto, ON, Canada, 2005.
74. Chrisman, S. (Ed.) *Green Roofs Ecological Design and Construction*; Schiffer: Atglen, PA, USA, 2005.
75. Cantor, S. *Green Roofs in Sustainable Landscape Design*; Norton: New York, NY, USA, 2008.
76. FLL. *Richtlinie für die Planung, Ausführung und Pflege von Dachbegrünungen*; Forschungsgesellschaft Landschaftsentwicklung: Bonn, Germany, 2008.

Retrieved from <https://encyclopedia.pub/entry/history/show/124116>