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Short communication

Some European green roof norms and guidelines through the lens of biodiversity: Do ecoregions and plant traits also matter?

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ABSTRACT

Green infrastructure and in particular green roofs are crucial to meet the challenge of sustainable urbanisation fostered by the current European Research and Innovation agenda. Several documents were issued in the last decades in Europe for regulating the design, construction and up-keep of roof greening. In particular, the actual German guidelines have been widely adopted as a reference basis for green roof design and regulation worldwide, because of its exhaustiveness and proven building- and landscaping tradition. With the aim to assess the effectiveness of green roof guidelines and norms in supporting plant and soil biodiversity in different ecoregions, and particularly of the Mediterranean one, the German guidelines, the Swiss and Italian norms are screened and discussed in this paper. The German guidelines were chosen for their traditional referential role, the Swiss norm for its peculiar biodiversity approach, the Italian one for its application on a territory with remarkably heterogeneous environmental conditions, stretching from Alpine to Mediterranean ecosystems. Even if the three documents at comparison addressed to some extent biodiversity-related matters, none of them deepened the relationship between plant species selection (local ecotypes), growing medium composition (materials, granular size and thickness) and system build-ups (multi-layers and/or single-layer systems). This is a crucial point for countries, like Italy, encompassing very different climatic conditions. It was concluded that at the current knowledge a guideline/norm taking into account the peculiarities of green roof design in the Mediterranean ecoregion has to be widely refined.

1. Introduction

The current European Research and Innovation agenda fosters sustainable development and urbanisation by means of nature-based solutions with the aim to restore degraded ecosystems, to favour climate change adaptation and mitigation, and to improve risk management and resilience. Moreover, nature-based solutions provide at the same time *environmental, social and economic benefits* bringing nature and natural processes into the built environment (EU, 2015).

Green infrastructure is the network of natural and semi-natural areas, features and green spaces in rural and urban, and terrestrial, freshwater, coastal and marine areas (Naumann et al., 2011). In densely populated lands, the connection to this network ensures natural multiple ecosystem services including, water and air purification, landscape conservation, soil protection and space for recreation (Tzoulas et al., 2007). Constructed ecosystems such as green roofs are of utmost importance to ensure urban resilience in built environments (Ranalli and Lundholm, 2008; Gómez-Baggethun and Barton, 2013).

Green roofs can be synthetically defined as rooftops covered with growing medium, intentionally vegetated and/or spontaneously colonised (SIA 312-SN 564312, 2013). These surfaces represent novel urban habitats fulfilling several benefits and ecosystem services: they reduce storm-water runoff, slowly bring rain-water back to its moisture cycle via evapotranspiration, increase the roof waterproof membrane lifespan, reduce the energy consumption for heating and cooling, mitigate the urban heat island effect, and reduce air and sound pollution (Oberndorfer et al., 2007).

The recognition of green roof benefits has been inferred from the synergic work of technical universities, private companies and professionals over the last century in central Europe. The need to complement scientific interest and practical issues has led to the publication, in 1990, of the first guideline on green roofs design and construction by the German Landscaping and Landscape development Research Society (Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau E.V. – FLL).

The last FLL (2008) formalised a classification of green roof types

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according to the vegetation forms, use and maintenance as well as a standardised green roof system build-up.

1.1. Green roof types

Green roofs can be classified into the following three types:

1. *Intensive green roofs* can host trees, shrubs, perennials herbs and lawns on a 15–200 cm thick growing medium. They can be freely designed and developed on spatially connected areas on the same level and or at different quotes. The load bearing structure and the total costs represent the only constrains to the design and construction possibilities. The vast species selection palette confers to intensive green roofs a comparable recreation function to that of parks and gardens on the ground but it requires also similar maintenance effort in terms of irrigation, fertilization, pruning and weeding.
2. *Simple-intensive green roofs* can hosts shrubs, perennial herbs and lawns on a 12–100 cm thick growing medium. The spatial design and plant species selection are comparable to those of intensive green roofs but the execution, maintenance costs and total loads on the bearing structure are reduced.
3. *Extensive green roofs* are near-natural greened surfaces hosting mosses, succulents, forbs (including bulbs and tubers) and grasses on a 6–20 cm thick growing medium. The plant species should be local, stress tolerant, able to regenerate themselves and propagate easily. The maintenance regime is reduced to the minimum, unless of wanted pattern and specific design.

This traditional subdivision was implemented by the British code of best practice (GRO, 2011) with a fourth intermediate typology between simple-intensive and extensive green roofs:

4. *Biodiverse green roofs* aim to recreate habitats similar or even ameliorated compared to the one lost due to the construction. These roofs are sown or plug planted with autochthonous species that in turn attract specific fauna; are constructed with different substrate thickness and kinds such as sand and gravel; are supplied with specific structural elements for habitat provisioning such as trunks and boulders. This approach provides for the spontaneous development of the vegetation, the reduction of the maintenance effort to the minimum but also the creation of areas without vegetation to mimic brownfields (Kadas, 2006; GRO, 2011).

It is worth to mention that this typology was implemented for the first time in Switzerland over the last 20 years (Brenneisen, 2006; Dunnett, 2015).

1.2. Standardised green roof systems build-up

From the waterproof barrier upwards, the standard green roof system built up consists of the following functional or working layers (Fig. 1): anti-bonding layer, separation layer, root barrier, mechanical protection, drainage layer, filter layer, vegetation supporting layer (growing medium) and vegetation.

For each stratum and expected component of the roof, the FLL give definite requirements and functions (chapter 7). The anti-bonding layer has the function to prevent the adhesion of various materials and reduce the shear stress between different layers; the separation layer to divide chemically incompatible materials; the root barrier to protect the waterproofing layer and the structure against root penetration; the mechanical protection to defend the waterproofing layer from mechanical damages (it acts also as root barrier); the drainage layer to deliver the water in excess into the outlets for the prevention of waterlogging (also as protection of the membranes below it), but also to increase the available space for root development; the filter layer to prevent the drainage layer to be clogged by the fine soil and substrate particles of the vegetation-supporting layer (growing medium); finally, the growing medium to accommodate the roots of the plants.

Actually, the water storage is needed when the growing medium is not able to meet the water retention demand and it can be integrated into the vegetation-supporting layer and/or into the drainage layer and/or be a separate layer. An extra water supply and irrigation system is normally installed in intensive greening and may be required also on extensive greening to support the plants in case of extreme dry weather conditions.

The FLL have been used as a reference for green roof design but also for other national norms, standards and guidelines worldwide (Table 1) because of its exhaustiveness and proven building- and landscaping tradition (Doug et al., 2005; Dvorak, 2011; Abram, 2006). Among them, the Swiss norm (SIA 312-SN 564312, 2013) was the first to answer the engineers and architects need to have nature conservation guidance for green roof design after the Federal Act on the Protection of Nature and Cultural Heritage (Brenneisen, 2015).

The rationale of this study was to assess the effectiveness of some European green roof guidelines and standards in supporting plant and soil biodiversity, with particular reference to complex environmental variables and heterogeneous climatic contexts such as the Mediterranean ecoregion.

2. Materials and methods

The documents analysed are the German “Guidelines for the Planning, Construction and Upkeep of Green-roof sites” (FLL, 2008), later FLL; the Swiss “norm for roof greening” (SIA 312-SN 564312, 2013), later SIA; and the Italian “criteria for design, execution, testing and maintenance of roof garden” (UNI 11235, 2015), later UNI.

The FLL were chosen for their traditional referential role, the SIA for its peculiar biodiversity approach, the UNI for its application on a territory with remarkably heterogeneous environmental conditions, stretching from Alpine to fully Mediterranean ecosystems (Peel et al., 2007).

The first German guidelines were published in 1990 by the Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau e.V. – FLL (The Landscape development and Landscaping Research society) and since then further revised versions appeared in 1992, 1995, 2002 and 2008 (FLL, 2008). Actually, the FLL Research Society published the “principles of green roofing” in 1982 and revised them in 1984, prior to the publication of the first guidelines. The FLL consists of 16 chapters and 3 annexes regarding the planning, execution and upkeep of green roofs, roof terraces and other buildings with a growing medium up to 2 m thickness, while referred to other norms (e.g. DIN and EN standards) for specific technical topics (e.g. structural design loads and waterproofing materials).

The Swiss norm (SIA 312-SN 564312, 2013) was published by the Swiss Society of Engineers and Architects (SIA) in 2013. The norm refers to the SIA 318 “gardening and landscaping” and substituted the SIA 271/2, 1994 “roof greening” written in 1994 and refined in 2007. The SIA consists of five chapters and three annexes regarding the design and construction of roof greening while referring to other SN and SIA norms for specific technical details (e.g. draining features, top and down-soil parameters and other engineering related matters).

The Italian norm was issued for the first time by the Italian organisation for standardisation (UNI) in 2007 and it was revisited in 2015. The UNI consists of 11 chapters and three annexes regarding the design, the execution, the control and the maintenance of roof greening while referred to other UNI norms for specific technical details (e.g. waterproof membrane parameters, soil and substrate improvers)

This work considers exclusively the aspects included in the analysed documents affecting directly or indirectly the ecological value of green roofs. To do so, the chapters were grouped in one or more of the following competence domains (Table 2): 1) Design (Ds), 2) Requirements