1. Brudermann & Sangakool

Green roofs are in general classified into two major cate- gories; intensive green roofs and extensive green roofs (Czemiel Berndtsson, 2010). Intensive green roofs are characterized by a rather high thickness of growing media; soil layers usually are thicker than 200 mm, with soil weights exceeding 300 kg/m2 (Berardi et al., 2014). Such deep soil allows for the growing of rel- atively large plants, and thus provides greater planting flexibility. Roof top gardens and roof gardens require intensive green roof- ing (Bianchini and Hewage, 2012b; Kosareo and Ries, 2007). Basic maintenance of such roofs includes weeding, fertilizing, and water- ing of the plants (Czemiel Berndtsson, 2010). Extensive green roofs, on the other hand, are limited to smaller plants such as sedums, small grasses, herbs, flowers and herbaceous plants (Berardi et al., 2014). The thickness of the growing medium is usually below 150 mm (Hakimdavar et al., 2014), with soil weights between 60 and 150 kg/m2 (Berardi et al., 2014). The construction of extensive green roofs is relatively simple; less effort is required in irrigation and maintenance (or may not be necessary at all). Due to their light weight and low level of maintenance, extensive green roofs are popular solutions in cities and are particularly appropri- ate for large scale rooftops (Hakimdavar et al., 2014; Jungels et al., 2013).

1. Besir & Cuce (2018)

Green roofs can be split into three categories (extensive, semi-intensive and intensive roofs) with respect to weight, substrate layer, maintenance, cost, plant community and irrigation as illustrated in Table 1 [28]. Intensive roofs are heavier and more expensive compared to other types. In addition, they require a higher level of maintenance. The extensive roofs do not have extra weight due to shallower growth substrate, and their maintenance cost is notably low [29]. Deeper growth substrates offer plenty of vegetation. Green roofs convert the impervious areas of a rooftop into multi- functional spaces using growing media and vegetation [33]. For this reason, green roofs are widely used for recreating space in urban areas [29,31]. By using local vegetation and growing medium, the require- ment of irrigation and maintenance costs can be reduced as a con- sequence of local climatic conditions [30].

1. Hossain, Shams, Amin, Reza & Chowdhury (2019).

Green roofs can be two types: intensive and extensive based on their characteristics such as purpose, structural requirements, internal comfort, installation cost, irrigation requirements, and accessibility [[5](https://www.mdpi.com/2075-5309/9/4/79/htm#B5-buildings-09-00079)]. Intensive green roofs are often accessible, consisting of large plants, shrubs, and trees, and can be used for recreational and leisure purposes ([Figure 1](https://www.mdpi.com/2075-5309/9/4/79/htm#fig_body_display_buildings-09-00079-f001)a). Intensive roofs are characterized by their greater weight (200–500 kg/m2), high capital cost ($540/m2), high irrigation requirements, fertigation, and maintenance requirement. On the other hand, extensive green roofs are often not accessible, consisting of low-growing plants such as succulents, herbs, and grasses ([Figure 1](https://www.mdpi.com/2075-5309/9/4/79/htm#fig_body_display_buildings-09-00079-f001)b), and are characterized by low weights (60–150 kg/m2), low capital costs (130–165 $/m2), low plant diversify, and minimal irrigation, nutrient, and maintenance requirement [[24](https://www.mdpi.com/2075-5309/9/4/79/htm#B24-buildings-09-00079),[25](https://www.mdpi.com/2075-5309/9/4/79/htm#B25-buildings-09-00079)].

1. Stefanoff, H. (2019).

Green roofs are generally categorized as intensive or extensive: intensive roofs generally have thicker soils supporting a broader array of plant types, whereas extensive roofs typically have thin soil and are limited in the types of plants they can support (van der Meulen, 2019). Typically, an intensive green roof has a depth of 15 or more cm, while an extensive green roof has a depth of less than 15 cm (Guo, Zhang, & Liu, 2014). Regardless of the roof category, roofs generally contain a drainage layer, substrate layer, and vegetative layer (Figure 1).

1. Coma, Pérez, Solé, Castell & Cabeza (2016).

Some authors divide these systems into two categories, “extensive” and “intensive” [5e8], while other authors introduce an intermediate category called “semi-intensive” green roofs, which are a combination of the extensive and intensive [9]. Generally, extensive green roofs have shallower substrates (<200 mm) that do not represent an excessive overweight for conventional roof structures (70e170 kg/m2) [8]. Some advantages are: no additional structural reinforcements, less investment in growing media and plants, and less maintenance. On the other hand, intensive green roofs systems, also called living roofs or roof gardens, implement more heavy vegetation, like trees and shrubs, which require deeper substrates (>200 mm). In addi- tion, roof gardens represent an overweight (290e970 kg/m2) and additional maintenance in plant care [8]. These systems are focused on landscape and aesthetic values to increase living and recreation spaces in densely populated urban areas [7].

1. Todorov, Driscoll & Todorova (2018).

Green roofs can be categorized as intensive, simple intensive, or extensive (Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau [FLL], [2002](https://onlinelibrary.wiley.com/doi/full/10.1002/hyp.13175?casa_token=tTxosgVWeUYAAAAA%3A1tpv12n3Xek8O75OHL6xulreRv31GvoUdxSi2G2GdXwE9MW62xx63MeEonY14bL6sFzxW67lL0OLtts#hyp13175-bib-0001)). Intensive green roofs exhibit a deeper growth medium capable of supporting a variety of vegetation, including bushes and trees. Simple intensive green roofs have lawn cover, whereas extensive green roofs typically utilize native, drought‐tolerant species, such as sedums. Berndtsson ([2010](https://onlinelibrary.wiley.com/doi/full/10.1002/hyp.13175?casa_token=tTxosgVWeUYAAAAA%3A1tpv12n3Xek8O75OHL6xulreRv31GvoUdxSi2G2GdXwE9MW62xx63MeEonY14bL6sFzxW67lL0OLtts#hyp13175-bib-0012)) reviewed different designs of green roofs, finding that growth mediums of less than 110 mm are typically classified as extensive, 110–150 mm depths can be classified as either intensive or extensive, and growth mediums greater than 150 mm are considered intensive roofs. Extensive is the most common design of green roofs, in part due to the lower capital (New York State Department of Environmental Conservation, [2015](https://onlinelibrary.wiley.com/doi/full/10.1002/hyp.13175?casa_token=tTxosgVWeUYAAAAA%3A1tpv12n3Xek8O75OHL6xulreRv31GvoUdxSi2G2GdXwE9MW62xx63MeEonY14bL6sFzxW67lL0OLtts#hyp13175-bib-0004)) and maintenance costs (Oberndorfer et al., [2007](https://onlinelibrary.wiley.com/doi/full/10.1002/hyp.13175?casa_token=tTxosgVWeUYAAAAA%3A1tpv12n3Xek8O75OHL6xulreRv31GvoUdxSi2G2GdXwE9MW62xx63MeEonY14bL6sFzxW67lL0OLtts#hyp13175-bib-0032)), as well as lower roof weight on the building structure compared with intensive roofs (FLL, [2015](https://onlinelibrary.wiley.com/doi/full/10.1002/hyp.13175?casa_token=tTxosgVWeUYAAAAA%3A1tpv12n3Xek8O75OHL6xulreRv31GvoUdxSi2G2GdXwE9MW62xx63MeEonY14bL6sFzxW67lL0OLtts#hyp13175-bib-0002)).

1. Nagase & Dunnett (2010)

Green roofs are mainly divided into two types: intensive and extensive. Intensive green roofs are characterised by a thick layer of growing medium or substrate (more than 200 mm), in which a wide range of plants and vegetation can be grown, particularly if irrigation is available. However, the relatively heavy weight of the substrate requires additional structural support on the building and therefore only a limited range of buildings can be used for installing an intensive green roof. On the contrary, extensive green roofs are characterised by a thinner layer of substrate (20–200 mm) and are relatively lightweight ([Johnston and Newton, 1993](https://www.sciencedirect.com/science/article/pii/S0169204610001519?casa_token=sNeVgp6zjx8AAAAA:w69pIXpJZZB4Yt66occkrX024oW28veGFY4K9dhjLvQA8CjUsmgbq14mYWa2gDnQNpsfmDx9CA" \l "bib0100)). As a result, a greater range of application is possible because little or no additional structural support is required on the building. This, combined with lower maintenance requirements, and a reduced need for irrigation has led to wider adoption of extensive green roofs, particularly where large areas of the roof surface are to be greened.

1. Williams, Rayner & Raynor (2010)

Two types of green roofs are widely recognised; intensive and extensive. Intensive green roofs can support complex vegetation communities including groundcovers, small trees and shrubs in substrate depths greater than 20 cm. They are often designed as roof gardens for human use and usually require irrigation, maintenance and additional structural reinforcement of the roof ([Oberndorfer et al., 2007](https://www.sciencedirect.com/science/article/pii/S1618866710000099?casa_token=s0B-0Z7U1uYAAAAA:03PYTYTZZkzmBRlHhq6V9ibzwydqUCX18lX5CaVxnHApBueEBwjUh79hNLtuUFiz4iHtijoMTA" \l "bib46)). Extensive green roofs, sometimes referred to as ecoroofs, have substrate depths less than 20 cm, require minimal or no irrigation and are generally planted with low growing succulents and stress tolerant herbaceous species ([Dunnett and Kingsbury, 2004a](https://www.sciencedirect.com/science/article/pii/S1618866710000099?casa_token=s0B-0Z7U1uYAAAAA:03PYTYTZZkzmBRlHhq6V9ibzwydqUCX18lX5CaVxnHApBueEBwjUh79hNLtuUFiz4iHtijoMTA" \l "bib20); [Oberndorfer et al., 2007](https://www.sciencedirect.com/science/article/pii/S1618866710000099?casa_token=s0B-0Z7U1uYAAAAA:03PYTYTZZkzmBRlHhq6V9ibzwydqUCX18lX5CaVxnHApBueEBwjUh79hNLtuUFiz4iHtijoMTA" \l "bib46)).

1. Coma, Pérez, Solé, Castell & Cabeza (2016).

 Some authors divide these systems into two categories, “extensive” and “intensive” [[5]](https://www.sciencedirect.com/science/article/pii/S0960148115301701?casa_token=QG6RnexzofYAAAAA:cd1pwWutU3YjVJBb5u02ZsWdOTpKRQJdMPqgKs-8Gr92Lm9Iyyuoi57Dk19hxxbW6yfv-Ca15g" \l "bib5), [[6]](https://www.sciencedirect.com/science/article/pii/S0960148115301701?casa_token=QG6RnexzofYAAAAA:cd1pwWutU3YjVJBb5u02ZsWdOTpKRQJdMPqgKs-8Gr92Lm9Iyyuoi57Dk19hxxbW6yfv-Ca15g" \l "bib6), [[7]](https://www.sciencedirect.com/science/article/pii/S0960148115301701?casa_token=QG6RnexzofYAAAAA:cd1pwWutU3YjVJBb5u02ZsWdOTpKRQJdMPqgKs-8Gr92Lm9Iyyuoi57Dk19hxxbW6yfv-Ca15g" \l "bib7), [[8]](https://www.sciencedirect.com/science/article/pii/S0960148115301701?casa_token=QG6RnexzofYAAAAA:cd1pwWutU3YjVJBb5u02ZsWdOTpKRQJdMPqgKs-8Gr92Lm9Iyyuoi57Dk19hxxbW6yfv-Ca15g" \l "bib8), while other authors introduce an intermediate category called “semi-intensive” green roofs, which are a combination of the extensive and intensive [[9]](https://www.sciencedirect.com/science/article/pii/S0960148115301701?casa_token=QG6RnexzofYAAAAA:cd1pwWutU3YjVJBb5u02ZsWdOTpKRQJdMPqgKs-8Gr92Lm9Iyyuoi57Dk19hxxbW6yfv-Ca15g" \l "bib9). Generally, extensive green roofs have shallower substrates (<200 mm) that do not represent an excessive overweight for conventional roof structures (70–170 kg/m2) [[8]](https://www.sciencedirect.com/science/article/pii/S0960148115301701?casa_token=QG6RnexzofYAAAAA:cd1pwWutU3YjVJBb5u02ZsWdOTpKRQJdMPqgKs-8Gr92Lm9Iyyuoi57Dk19hxxbW6yfv-Ca15g#bib8). Some advantages are: no additional structural reinforcements, less investment in growing media and plants, and less maintenance. On the other hand, intensive green roofs systems, also called living roofs or roof gardens, implement more heavy vegetation, like trees and shrubs, which require deeper substrates (>200 mm). In addition, roof gardens represent an overweight (290–970 kg/m2) and additional maintenance in plant care [[8]](https://www.sciencedirect.com/science/article/pii/S0960148115301701?casa_token=QG6RnexzofYAAAAA:cd1pwWutU3YjVJBb5u02ZsWdOTpKRQJdMPqgKs-8Gr92Lm9Iyyuoi57Dk19hxxbW6yfv-Ca15g#bib8). These systems are focused on landscape and aesthetic values to increase living and recreation spaces in densely populated urban areas [[7]](https://www.sciencedirect.com/science/article/pii/S0960148115301701?casa_token=QG6RnexzofYAAAAA:cd1pwWutU3YjVJBb5u02ZsWdOTpKRQJdMPqgKs-8Gr92Lm9Iyyuoi57Dk19hxxbW6yfv-Ca15g#bib7).

1. Bianchini & Hewage (2012).

Green roofs are classified as intensive and extensive according to their purpose and characteristics [[19]](https://www.sciencedirect.com/science/article/pii/S036013231200193X?casa_token=u9PZBBTSULQAAAAA:Io2DbY0QC4hIxmiq0uJntVp8Ir8h6l_hXTHhb04CuUOHXKK_Nfgy5G3nvcypXQfAv9Vfg61rEQ" \l "bib19), [[61]](https://www.sciencedirect.com/science/article/pii/S036013231200193X?casa_token=u9PZBBTSULQAAAAA:Io2DbY0QC4hIxmiq0uJntVp8Ir8h6l_hXTHhb04CuUOHXKK_Nfgy5G3nvcypXQfAv9Vfg61rEQ" \l "bib61). Intensive roofs are associated with roof gardens; need a reasonable depth of soil and require constant maintenance [[30]](https://www.sciencedirect.com/science/article/pii/S036013231200193X?casa_token=u9PZBBTSULQAAAAA:Io2DbY0QC4hIxmiq0uJntVp8Ir8h6l_hXTHhb04CuUOHXKK_Nfgy5G3nvcypXQfAv9Vfg61rEQ" \l "bib30). Extensive roofs have a relatively thin layer of soil, and are designed to be virtually self-sustaining, therefore require low maintenance [[30]](https://www.sciencedirect.com/science/article/pii/S036013231200193X?casa_token=u9PZBBTSULQAAAAA:Io2DbY0QC4hIxmiq0uJntVp8Ir8h6l_hXTHhb04CuUOHXKK_Nfgy5G3nvcypXQfAv9Vfg61rEQ#bib30). Environmental benefits of a green roof vary with the type of green roof; however, all types provide positive environmental benefits. Installation cost, maintenance, and construction time depend on the type of the green roof. Compared to the intensive type, extensive green roofs are lighter and require lower maintenance cost [[58]](https://www.sciencedirect.com/science/article/pii/S036013231200193X?casa_token=u9PZBBTSULQAAAAA:Io2DbY0QC4hIxmiq0uJntVp8Ir8h6l_hXTHhb04CuUOHXKK_Nfgy5G3nvcypXQfAv9Vfg61rEQ" \l "bib58). However, other benefits such as retention and delay of storm water, temperature control, and agricultural space effects can also be relatively lower.