VIRIdiVITA®

Saving water for life

Roof revitalisation - *the new generation*

*Translated from German to English with DeepL®

1. INTRODUCTION

Increasing urbanisation is causing various problems in cities.

To overcome these problems, nature must regain its place in the urban environment.

VIRIdiVITA, the new generation of roof revitalisation.

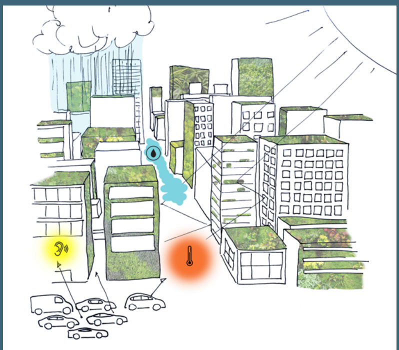
Since industrialisation, the urbanisation of our landscapes has continued to increase. This urbanisation has accelerated dramatically over the last few decades, at the same rate as population growth. Nature - the very basis of our existence - is visibly disappearing. We are now recognising the negative effects of this and beginning to address them.

Human needs in terms of spatiality seem to be at odds with those of nature. For too long, urban development has only taken into account the need for space, neglecting other needs essential to human life.

It is now necessary to bring the diversity of nature, and thus natural life, back into cities, but also into the minds of people, and to establish it there.

Promote biodiversity! This is the current and indispensable demand.

2. PROBLEM / MISSION



The problems of urbanisation :
- Soil sealing
- Urban heat islands
- Destruction of natural habitats
- Light pollution
- Air pollution
- Noise pollution
- Flooding
- Deterioration of quality of life

All these impacts affect our quality of life.

a) The problems of urbanisation

More than half of the world's population now lives in cities, and this figure is constantly rising. This population concentration has direct consequences for the environment:

- Soil sealing, leading to a greater volume of runoff water and therefore an increased risk of flooding
- Urban heat islands, due to the mineralisation of surfaces
- The destruction of natural habitats, leading to the decline of species
- Various sources of pollution (atmospheric, noise and light)

These problems lead to the disappearance of many plant and animal species and their functions. Indeed, each species plays an important role in the ecosystem, even if we humans cannot always see and/or understand it. The disturbance of a single species can, through cause and effect, disturb the entire ecosystem. Today, thousands of species are disturbed by human activities. We must not forget that all these species have well-defined functions, useful for the ecosystem of which we are a part. These consequences on the environment have repercussions on our quality of life. Whether it is from the point of view of our mental or physical health, these problems have an impact on our daily lives. By destroying the nature that surrounds us, we destroy ourselves at the same time.

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b) Possible solutions

The unification of human needs and nature is based above all on understanding. Knowledge and information about the interrelationships must be passed on. Without understanding, nature is not accepted. But what is nature? In this respect, we take the liberty of presenting our point of view, without claiming to be exhaustive or to have a correct definition. Nature is diverse, colourful, joyful, adaptable, it submits, perhaps for a time, to the human will, it is persistent, it is generous, it is the basis of life and much more.

Through this approach, holistic understanding and solutions can emerge and develop.

Our cities must become more alive. Alive in the sense of fullness. Plants and animals in all their diversity and uniqueness must be given living space. Planning teams must be interdisciplinary; the pure functionality of infrastructure must be extended to qualitative sustainability. All dimensions must be integrated into the planning.

In this essay, we focus below on the valuable revitalisation of roofs.

In the face of increasingly dense cities, the spaces available on the ground to reintroduce nature into the city are becoming increasingly rare.

However, many spaces in the city that are totally waterproofed and unused (roofs, facades, etc.) could be transformed to offer more pragmatic spaces.

With a surface area representing 30 to 50% of the city's surface area, roofs represent a significant potential for greening.
Green roofs are an ideal solution for combining ecology, economy and social issues.

3. HISTORY OF GREEN ROOFS

a) An ancestral technique

Contrary to what one might imagine, green roofs are not a 20th or 21st century invention. Their appearance dates back to the 6th century BC, with the famous «Hanging Gardens of Babylon», classified as one of the seven wonders of the world.

Since ancient times, especially in Rome and Athens, traditional flat roofs have been used for gardens. The Nordic countries, such as Norway, Sweden and Iceland, also have a long tradition of green roofs, which at the time used grass and peat. The principle is also known in some tropical countries such as Guatemala and Tanzania. At that time, these green roofs were essential to protect against climatic influences such as rain, wind, sun and heat.

b) Green roofs in the 20th century

The systems of more recent times have tried to solve this task with various technical demands and requirements - in a technically one-sided way. The overall understanding was and still is lacking. On the one hand, the roof should have as low a slope as possible, it should be waterproof and preferably always green. On the other hand, it must be light, water permeable, i.e. it must absorb as much water as possible and discharge it into the sewage system with a time delay - while remaining green.

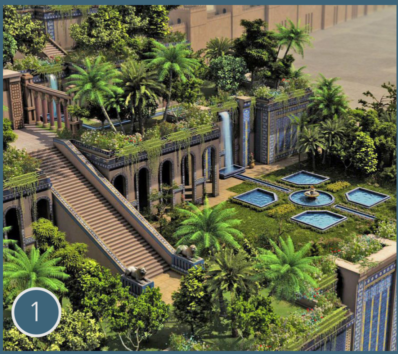
Most known systems work :
1. with water storage tanks, called drain plates, which collect water and release it slowly into the sewer system through small openings.
2. with a separation layer of cheap filter fabric
3. with light, artificial substrate
-> Technical situation before VIRIdiVITA

The supposed advantages are obvious
- easy to install
- allows for quick and initial greening
- cheap.

But the disadvantages are recognised in many places and, for lack of a better solution, are considered minor.
Associations hastily publish guidelines, which are supposed to confirm the accuracy of the systems.
-> Technical situation before VIRIdiVITA

The disadvantages - especially the durability - should not be underestimated. The ecological value should not be underestimated either.

Starting with the retention plate: this tank only serves to relieve the drainage systems. Water is not available for vegetation, as the plate is covered with a geotextile. If, against all odds, a plant root does manage to enter the reservoir, will the extensive, drought-loving plant become a water plant?



Green roofs were already present in the 6th century BC, as evidenced by the famous «Hanging Gardens of Babylon».

Green roofs also have a long tradition in the Nordic countries, where a mixture of turf and peat was used.

Long forgotten, this type of roofing has been making a comeback since the late 1980s. However, conventional green roofs have certain limitations, particularly in terms of water management.

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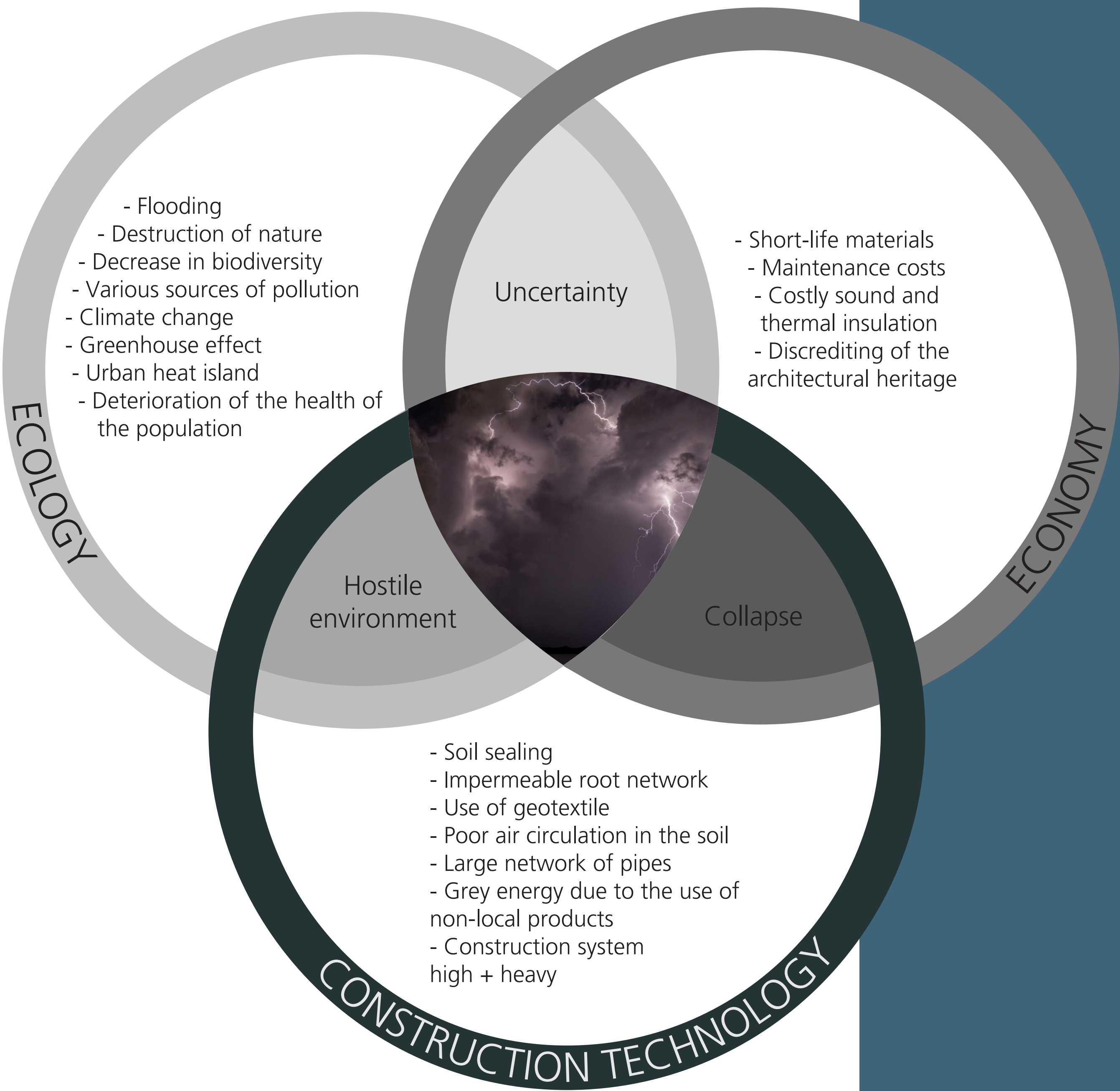
In addition, fine materials clog and obstruct the drainage system. This results in waterlogging and the water flow becomes obsolete. The second weak point is the geotextile. Geotextiles have not been used in gardening and landscaping since the 1980s, due to the knowledge that geotextiles clog.

Photo 3 shows water already standing on a new system. It doesn't take much imagination to see that the durability is not there. Of course, the system survives the usual 10-year warranty period.

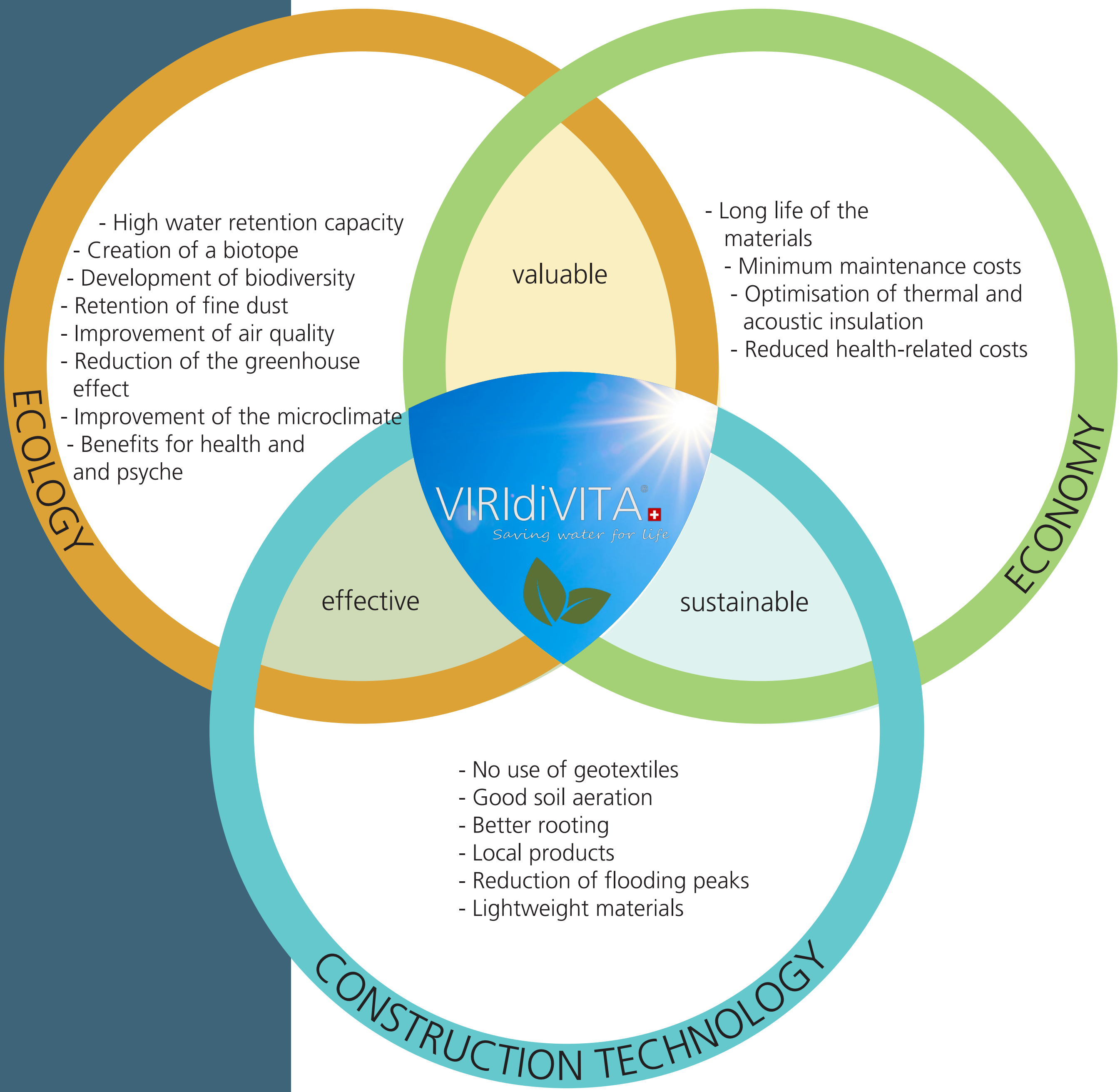
Finally, the artificial substrate: it is neither local nor natural. Because of its lightness, it is subject to wind erosion. After the decomposition of the mixed organic matter, vegetation often regresses, i.e. the area becomes bare. This seems, and is, unnatural. The ecological value of these substrates is extremely low, even counterproductive.



c) Rooftop revitalisation today

Fortunately, there is now an innovative solution to all these problems. However, it is important to be aware that each problem should not be treated individually, but that a holistic approach should be adopted. In this sense, VIRIdiVITA takes into account all aspects and current problems to offer a unique and adapted solution to each problem in order to face these universal difficulties in their entirety.

"Responsible action is taken by those who value ecology, construction technology and economy equally".



In the 21st century, we prefer to talk about rooftop revitalisation rather than rooftop greening. Biodiversity must be promoted, which does not mean simply being «green».

VIRIdiVITA is revolutionising the systems known until now - just like TESLA, which is turning the mainstream car industry upside down.

VIRIdiVITA is a new generation of roof revitalisation. The system has been developed by a team of experts in the field over many years and has been tested and improved under real conditions. It combines so many factors and needs like no other product.

The basis of the system is VIRIdiVITA premium roof, a 7 cm thick drainage/retention layer. Directly above this is a natural, local substrate. If you want to act ecologically and promote biodiversity, you can do without foreign substrate altogether. The structure of the VIRIdiVITA system combines the naturalness of the surface with the water reservoir in the subsoil - just as nature has taught us.

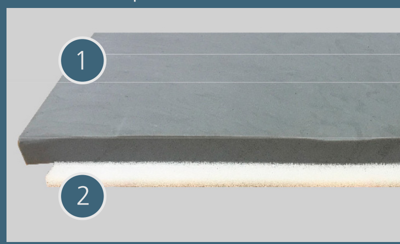
The combination and optimisation of ecological, constructional and economic factors is a prerequisite for a balanced and holistic product. Geotextiles, which have not been used in gardening and landscaping for decades for reasons of sustainability, are completely eliminated. Valuable water is retained and is available for vegetation and/or evaporation. Both forms of water consumption help to cool the roof and the surrounding area. Despite the high water retention capacity, the product flows at such a rate that the storage mat alone absorbs three (3) decadal rain events - and one (1) vicennial rain event in only 4 days (which is very unrealistic), thus buffering the water runoff, i.e. relieving the sewage systems.

With a construction thickness of only 12-13 cm and a unique water runoff coefficient of 0.05-0.06, VIRIdiVITA is a pioneer and industry leader. You can find more products for active roof revitalisation on the homepage: www.viridivita.ch.

The next generation of roof revitalization is well underway with VIRIdiVITA.

A new technology for revitalising roofs, which dispenses with geotextiles in favour of sustainability.

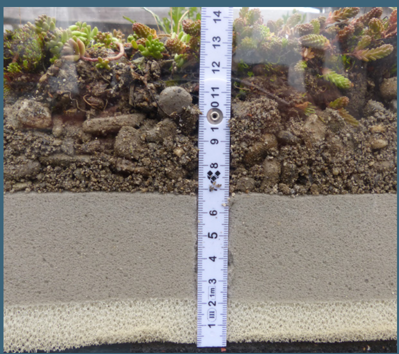
VIRIdiVITA premium roof®



1. Retention layer with storage support (50 mm)
2. Drainage layer as filter material (20 mm)

Water, a precious and vital resource, remains in its natural cycle.

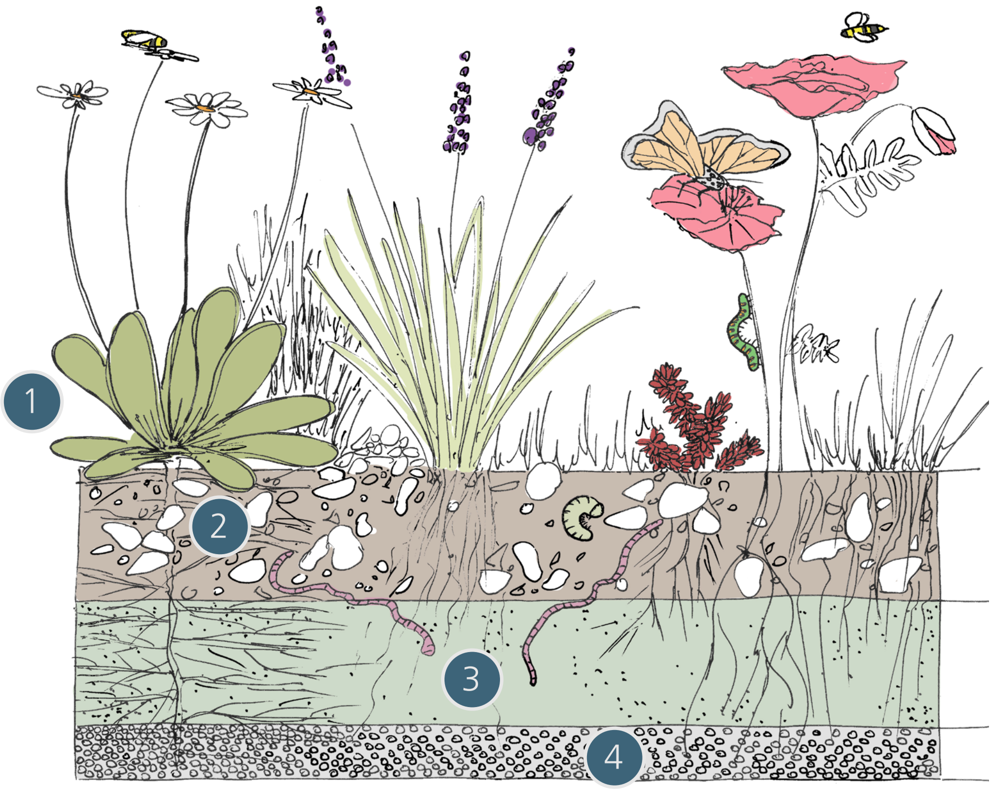
A system designed and developed entirely in Switzerland, which allows optimal water storage while promoting biodiversity.



VIRIdiVITA is innovation.

The VIRIdiVITA system is designed, developed and produced entirely in Switzerland. The collaboration between VIRIdiVITA and Recticel creates synergies that guarantee the highest quality of products installed on your green roofs. Thanks to the knowledge and experience of the VIRIdiVITA team in the field of nature and plants on the one hand, and the scientific implementation on the raw material side on the other, this partnership has enabled us to develop innovative foams specifically adapted to the needs of plants.

These polyurethane foams have many advantages, both from an economic and ecological point of view and in their application. Their lightness and adaptability to different needs allow for easy and efficient installation. Their compressive strength allows them to be installed in areas subject to stress. The optimal balance between pore structure and water retention capacity allows for sustainable and environmentally valuable habitats. Their durability and good recyclability make them ecologically interesting materials.



1 Life

2 Substrate

3 Retention layer

4 Drainage layer

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VIRIdiVITA meets a major ecological challenge by addressing the lack of vegetation in urban areas. This revolutionary green roof system differs from traditional systems in its reliable, reality-based technical expertise and its versatility of application. Simple roofs can thus be turned into ecologically sensible compensation areas. In addition, the wide range of applications of VIRIdiVITA allows the networking of different biotopes to counteract the problems of urbanisation. Today, more than ever, innovation in the service of nature will allow us to envisage a better future, where Man and Nature can live together in harmony. A close complementarity between ecology, economy and construction technology allows VIRIdiVITA to contribute to the general improvement of the urban climate.

Our vision is to let precipitation water flow back into its natural cycle at the point of origin and return it to nature - for the benefit of people, flora and fauna.

ECOLOGY

CONSTRUCTION TECHNOLOGY

ECONOMY

VIRIdiVITA®
Saving water for life

ROOF REVITALISATION, A COST-EFFECTIVE SOLUTION

ROOF REVITALISATION

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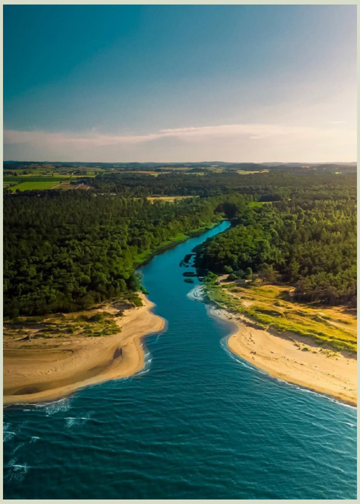
SUMMARY

1. INTRODUCTION

Population growth and urban densification leave little room for nature in cities. However, the decline in green spaces is making cities increasingly hostile to life.

Solutions are possible to make cities more welcoming and pleasant by giving a place to natural cycles.



One of the best known natural cycles is that of water. Water plays an important role in our lives and in the lives of all living organisms. It therefore deserves special attention.

The reduction of green spaces, and their impoverishment, only increases the hostility of the cities in which we live. While these green spaces have an undeniable beneficial role for the fauna and flora, they also play a preponderant role in our lives. Indeed, these little corners of nature offer us peace and enchantment, and in this way contribute to a better quality of life. Wherever we are, we find ourselves interacting with natural cycles.

We are familiar with many of these cycles, including that of water. Water flows from the source, through lakes and rivers, to the sea. There, it evaporates under the action of the sun, forming clouds, which are carried away by the wind and cool down. The water condenses into droplets, falls to earth as rain, seeps down and returns to the source: the cycle begins again. This natural cycle has been going on forever, perpetually, and without any human intervention. However, in recent decades it has been severely disrupted by human activities, which modify the natural circulation of water. The sealing of soils favours surface water runoff, to the detriment of infiltration into the soil. Dams, dykes and general human activity are all factors that lead to the modification of watercourses, which causes a multitude of problems. Some activities even lead to the total depletion of certain water resources (on a human scale), for example groundwater.

Water, the source of life, is an essential resource for mankind and for all the species, both plant and animal, that inhabit the planet, which must be preserved. It is therefore in the interest of all of us to reduce these interventions to a minimum, and to bring them into harmony with the requirements of sustainable land use.

However, some of these human activities are essential and cannot be stopped or even reduced, especially on a planet with a population of over 7 billion. This is the case, for example, of many infrastructures, which are essential for housing, work, transport and other activities. Nevertheless, it is possible to rethink these infrastructures, to optimise them, in order to reconcile them with environmental needs.

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But how can we reconcile urban planning and ecology in our densely populated cities?

Other solutions are possible, solutions that are economically, ecologically and socially viable. Buildings account for the majority of land use in cities. Unfortunately, this land use is not always compatible with environmental issues, and leaves less and less room for the creation of ecological compensation areas. What if the solution came from the buildings themselves? Every building has a roof, often unused and neglected, that just needs to be used to bring a little life back into the city.

Thus, the greening of roofs represents a considerable challenge:
to find harmony between nature and human activities, by ensuring an exemplary cohabitation.

Rooftops are a large part of cities. Often unused, they have great potential for redevelopment.

Green roofs make it possible to reconcile nature and human activities and thus solve many urban problems.

2. GREEN ROOFS - OR BETTER - REVITALIZED

Green roofs are an essential means of restoring nature to its rightful place in cities.

Plant dynamics are an integral part of this type of development.

Green roofs allow spaces that are not actively used by humans to be returned to nature. Each roof surface can thus have an important ecological meaning, provided that each parameter is carefully studied. Indeed, there is no "miracle recipe" that can be adapted to each roof. Each roof has its own specificities that deserve special attention, not only at the design stage, but throughout the entire project process. This is why everyone involved has a role to play in the design of these roofs: architects, town planners, builders, site managers, etc. Not just landscape architects, but all the trades involved in the project. This coordination allows for the creation of efficient and rational roofs that last over time.

Taking into account all the factors influencing the site also makes it possible to propose particularly suitable vegetation and to recreate a natural, autonomous and sustainable cycle. The vegetation can thus develop under the best conditions and play its essential role in the ecosystem.

Thus, green roofs must give free rein to plant dynamics. Plants must take root, develop and evolve. The roof is a place that fluctuates with the seasons and environmental influences. The diversity of species, the density of the vegetation, the speed of development, etc., are all parameters that vary and adapt constantly, depending on the characteristics of a given moment.

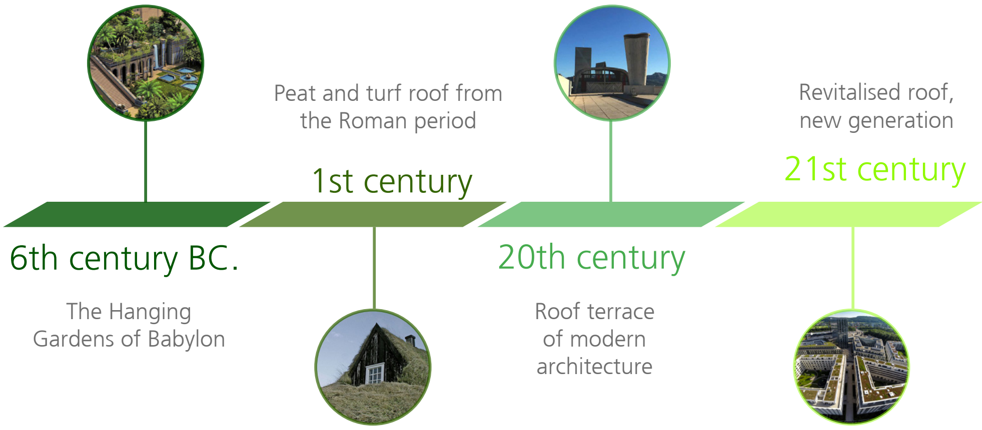
3. ORIGIN AND EVOLUTION

Contrary to what one might think, green roofs are not a 20th or 21st century invention. As the famous "Hanging Gardens of Babylon" prove, roof gardens were already in use in the 6th century B.C. They can also be found in ancient Athens and Rome, where the traditional flat roofs were already laid out as gardens. This tradition is also present in many parts of the world, especially in the Nordic countries, such as Norway, Sweden and Iceland. There, roofs are covered with a mixture of peat and turf in a method that dates back to Viking times, giving the houses very good strength and insulation. Similar techniques are also used in tropical countries such as Guatemala and Tanzania.

These ancient techniques have accompanied people through the generations and around the world to protect them from the vagaries of the weather. The versatility of these roofs allowed them to protect against rain, cold and wind, as well as sun and heat.

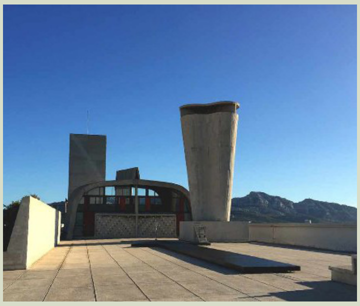
Long forgotten, green roofs resurfaced at the beginning of the 20th century. The famous Swiss architect Le Corbusier asked himself at the time: "Is it not contrary to logic that the entire surface of a city should remain unused and reserved for dialogue with the stars? ". As a precursor of modern architecture, Le Corbusier drew up "Les Cinq points d'une architecture nouvelle", in which the second essential point is the roof terrace. This is how green roofs came to make sense again at that time and found a place in the planning of cities.

However, it is only recently that these roofs have really taken off. Studies have shown the many benefits of this type of construction, from an ecological, economic and even social point of view. These benefits make green roofs an essential ally in solving urban challenges.




The Hanging Gardens of Babylon.


A revegetation technique using a mixture of peat and turf, a tradition dating back to Roman times and known in many parts of the world.


The roof terrace of modern architecture.


The revitalisation of roofs in the 20th century.

4. VARIOUS ROOF SHAPES

Green roofs include various forms of vegetation:
- intensive vegetation
- extensive vegetation

Green roofs, also known as the fifth facade, characterise all surfaces on the upper part of buildings with little or no connection to the ground. These surfaces can be greened in different ways. We distinguish two types of greening: intensive and extensive greening.

4.1. Intensive vegetation

Intensive green roofs, which are often feasible, cannot be implemented on all types of roofs. They require a significant financial commitment and maintenance effort.

Intensive green roofs are a roof design that is more like a garden. Multifunctional and practicable, this type of roof is a real living space. This implies a few constraints that should be established from the start. As a rule, more demanding plants are used, which require a differentiated soil structure, adequate drainage and irrigation, and regular maintenance. This type of roofing offers greater design possibilities, with many different types of plants and the installation of elements for recreational use. However, it is important to be aware that these elements require a significant financial commitment. Indeed, the term ‘intensive’ is also intended to reflect the generally high level of effort involved, both in terms of construction criteria, but also in terms of the thickness of the substrate layers, the choice of plants and their size, and the ongoing care and maintenance that this type of design requires.

Within intensive roofs, we can distinguish between two types of vegetation: simple vegetation and elaborate vegetation.

Simple intensive roofs have a substrate thickness that allows the establishment of woody plants, perennials and grasses.

a/ Simple intensive vegetation

Simple intensive roofs are usually composed of grasses, perennials and woody plants. The plants used are less demanding in terms of layer structure and water and nutrient supply. Simple intensive plantings need a substrate thickness of 20-30 cm.

Intensive roofs can even be planted with trees and thus become real gardens.

b/ Elaborate intensive vegetation

Elaborate intensive roofs also include grasses, perennials, woody plants, and sometimes even lawns and trees. The vegetation requires special attention and maintenance to develop in good conditions. It also requires a quality substrate with a minimum thickness of 30 cm. These roofs add significant weight to the building structure and therefore require complex systems and careful expertise to ensure the reliability of the project.

4.2 Extensive vegetation

In contrast, extensive green roofs are site-adapted, quasi-natural forms of vegetation that can grow and self-maintain on thin layers of substrate. We can distinguish between extensive spontaneous green roofs and extensive vegetated green roofs.

a/ Extensive spontaneous roofs

Roofs are a potential habitat for vegetation, as we can see on certain types of roofs, especially flat roofs. Indeed, even in the absence of human intervention, we can witness a spontaneous plant colonisation of the environment. These plants will be able to spread and establish themselves thanks to the action of birds and insects, as well as the wind. Over time, a more or less stable equilibrium is established, according to the progressive "trial and error" method, where vegetation particularly adapted to the local conditions of the roof will be able to establish itself and grow. This spontaneous colonisation takes time, and requires several stages of development, which will follow one another and cause the environmental conditions to evolve. However, these different forms of vegetation, such as moss/sedum or grass/grass, constitute an essential knowledge base for the use of suitable vegetation for extensive roofs. Also, natural environments with comparable characteristics to roofs, such as rock outcrops or dry grasslands, are fundamental sources of inspiration for the design of such roofs.

b/ Extensive vegetation

Extensive green roofs are based on observations made in natural environments and during spontaneous colonisation. However, man has implemented a series of targeted interventions to accelerate the vegetation process, but also to enrich and diversify it. Thus, the supply of water and nutrients is left to natural cycles, and maintenance is limited. The vegetation is also subjected to various development processes, in order to guarantee a sustainable establishment. The design of this type of roof also aims to establish relatively stable plant associations, while reducing implementation and maintenance costs.

The choice of plant species is mainly based on species that are not subject to strong growth and therefore do not have high nutrient requirements. Thus, plants that produce a massive amount of leaves do not meet the selection criteria for the local conditions of roofs and their extensive nature.

Roofs are particularly subject to climatic hazards. Thus, the regeneration capacity of plant species is an essential criterion in this type of design. Plants can reseed themselves and revitalise an environment by following their own dynamics. Thanks to the stocks of spores and seeds, which germinate as soon as the right humidity is available, the plant cover can easily close again.

Extensive green roofs are a quasi-natural form of vegetation.

Spontaneous vegetation is created by the action of the wind and birds, which spread the seeds indiscriminately. Species that are particularly adapted to the environment can thus establish themselves and multiply.

Extensive green roofs are very rich from an ecological point of view, both for fauna and flora.

By linking several green roofs, real ecological corridors can be created in the urban environment, allowing the connection of different ecosystems.

The Zurich waterworks in Wollishofen is a good example of the diversity that can be found on these roofs. More than 175 plant species have been recorded on this roof.

The *Orchis Morio* orchid is an example of the importance of these roofs for the preservation of biodiversity. The species, which is considered extinct in the Zurich region, has taken up residence on this roof and now has more than 6,000 specimens gathered on the factory roof.

a/ Habitat recovery and networking

Soil is increasingly threatened by human activities. Population growth, urban concentration, waterproofing, etc., are all factors contributing to the precariousness of the soil. Green roofs thus represent a substitute for all these areas of land used for buildings.

In addition to the environmental advantages of these roofs on an urban scale, they also make it possible to create real ecological corridors on a larger scale. These corridors ensure a connection between different ecosystems in order to allow the dispersion and migration of numerous animal and plant species, which are necessary for their survival. These corridors come up against numerous artificial obstacles, particularly in urban areas, which fragment the habitat of many species and lead to the disruption of ecological continuity. In this sense, green roofs contribute to the creation of diversified environments and allow the re-establishment of these corridors. They present a great diversity that provides essential habitats and refuges for many species, more or less rare.

This is shown by the example of the green roof of the Zurich waterworks in Wollishofen. The roof was planted in 1914, and 90 years later, surveys have identified more than 175 plant species and various spider species on the 3 ha of roofing. Among these species, some are classified as "endangered" or have become very rare. This is the case of the orchid *Orchis Morio*, which was considered to have disappeared from the Zurich region years ago, but which had spontaneously established itself on this roof when it was planted. Considered to be the richest population in the region with more than 6000 specimens, this orchid has found an invaluable refuge on the roof of the factory, which has allowed it to survive despite the evolution of our society. This site is therefore an authentic witness reflecting the ecological richness of the surrounding agricultural areas at the beginning of the 20th century. Furthermore, an in-depth study of the spider fauna on this roof showed that the spider population was significantly higher on the roof (27 species) than on the ground (19 species). This difference can be explained in particular by the disturbance to the grassland environment during mowing, which takes place several times a year. This example thus shows the interest and the predominant role that these roofs can play in preserving biodiversity, and the ecological richness that they can demonstrate.

b/ Enhancement of the architectural heritage

While these roofs represent a major interest from an ecological point of view, they also have benefits in many other areas. This is the case, for example, for the enhancement of the built heritage. The installation of green roofs contributes greatly to increasing the residential and recreational value of cities. It enhances the value of the building in question, but also of the surrounding environment. Green roofs thus contribute to the creation of a quality urban landscape and allow the harmonious integration of buildings with their environment. Combined with the possibility of use by the inhabitants, these spaces constitute real biotopes where man and nature cohabit in all simplicity. Furthermore, in combination with other greening measures, green roofs can break up monotonous layouts and unify heterogeneous building structures.

In terms of soil protection, the installation of green roofs can therefore be seen as one of many soil shaping and thus soil conservation measures that promote responsible, careful and recreational soil use.

The economic aspect is also very interesting. For example, in cities, the taxable factor for calculating the green area can be increased. This translates into a better use of the plot area. Ecologically revitalised roof surfaces contribute - in the context of condensed construction - to creating valuable living and working space.

c/ Regulation of the water balance

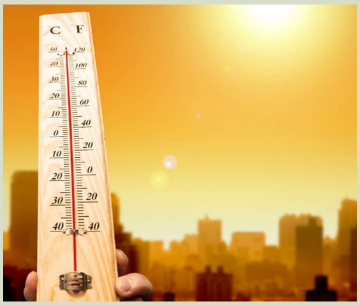
From a hydric point of view, these roofs have a crucial role. Their capacity to retain rainwater helps to relieve sewage systems and reduce the risk of flooding by reducing the amount of impervious surface in urban areas.

Rainwater is stored in the different layers of a green roof structure and some of it is used by plants, while the rest returns to the natural cycle through evaporation. The retention capacity of an extensive green roof is on average 70%. In the summer, this capacity can reach 100%, while in the winter it is more likely to be between 40 and 50%. The considerable reduction in water runoff values can result in significant savings in drainage facilities and costs for large properties.

Green roofs can also enhance the value of built heritage and ensure better integration into the environment.

The sealing of a large part of the urban territory leads to important problems, such as floods, which are becoming more and more regular and important.

Thanks to their high rainwater retention capacity, roofs can relieve sewage systems and reduce flooding.



The temperature on conventional roofs can sometimes exceed 80°C in hot weather. This contributes to the general temperature increase in urban areas.

Green roofs can reduce the temperature considerably (up to 70°C), which also has an effect on the urban climate. The dew that forms on the leaves also helps to humidify the air.

Green roofs can also significantly improve air quality. Their ability to capture fine particles and produce oxygen makes them important allies in air purification.

d/ Improving the climate

The presence of vegetation and water on roofs also contributes to the improvement of the urban climate. On roofs, water will return to the atmosphere through the phenomenon of evapotranspiration: through evaporation from the ground or through the transpiration of plants. This phenomenon contributes to the cooling of the air and its humidification, making the ambient temperature milder. Some studies have shown that a flat black roof can double its temperature in hot weather, while a flat green roof will halve it. Similarly, a roof membrane exposed to the sun can reach a surface temperature of 80-90°C, while the same membrane covered with vegetation remains at a temperature of 20-25°C. If you multiply these effects on one roof by the number of roofs that could be greened in the city, the results are surprising. The action of greening roofs alone could reduce the temperature in cities by several degrees, and also reduce the associated risk of urban pollution peaks.

e/ Air quality improvement

These roofs also have a real impact on air quality. Cities are home to various sources of pollution, including carbon emissions, greenhouse gas emissions and the release of fine particles. These pollutants pose significant health risks, including respiratory difficulties and serious lung diseases. But green roofs can make a significant contribution to reducing all these sources of pollution. Vegetation can fix carbon and CO_2, and produce oxygen, through the process of photosynthesis. In addition, the process of evapotranspiration causes the formation of fine water droplets. These droplets are able to pick up pollen and fine particles, loaded with heavy metals, and carry them into the substrate. There, they are fixed and degraded by the many inhabitants of the substrate: plants, insects, fungi and bacteria.

Roofs also reduce air pollution indirectly through their insulating properties. Indeed, this characteristic makes it possible to reduce energy consumption, which at the same time implies a reduction in greenhouse gas emissions and atmospheric pollutants.

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f/ Thermal insulation

The heat insulation capacity of this type of roof is well known. As mentioned above, a concrete roof can reach summer temperatures of up to 80-90°C, while a green roof never exceeds 20-25°C. This is a real advantage, especially in a world where heat waves are getting higher and higher, and more and more regular. It also reduces heat exchange through the roof: less heat enters the building during the day and less heat escapes at night. These energy savings have a real positive impact both from an economic and environmental point of view.

In winter, heat loss is also reduced, allowing buildings to maintain a comfortable temperature without excessive energy consumption.

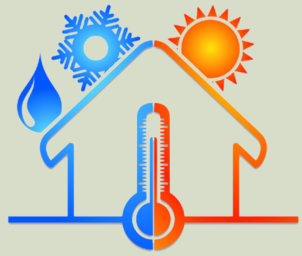
g/ Sound insulation

Green roofs are not only a good thermal insulator, they are also an excellent sound insulator. In the city, noise is very present and can come from various sources, both airborne and ground-based. Green roofs are able to cut noise pollution at least in half. This extra layer on the roof forms a real noise barrier. The plants are able to absorb high frequencies, while the soil absorbs mainly low frequencies. The combined action of these two layers drastically reduces the ambient noise inside buildings. With a substrate thickness of only 12 cm, an insulation effect of up to 40 dB is possible. This improves the quality of life of the inhabitants.

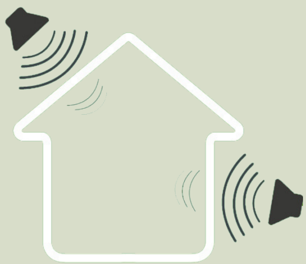
h/ Extending the life of roofs

This additional layer on the roofs also provides mechanical protection to the roof waterproofing. As explained above, the insulating nature of the vegetation reduces the thermal amplitude by 60-70°C. This reduction considerably limits the degradation of the elastomeric bitumen used to waterproof the roof. In addition, the vegetation system protects the membranes from ultraviolet radiation, which is largely responsible for their ageing. In this way, green roofing contributes to the sustainability of the built heritage and reduces maintenance costs.

Green roofing also prevents damage caused by mechanical injuries, for example from people walking on the roof. This is because the substrate distributes the weight evenly over the roof, thus reducing point loads.



Thanks to green roofs, the heat exchange with the outside world is reduced. A very important energy saving, both from an ecological and economic point of view.



Sound insulation is also greatly improved. A 12 cm substrate is sufficient to reduce noise by 40 dB.

Green roofs also have a much longer lifespan than conventional roofs. Green roofs protect waterproofing membranes and make buildings more durable.

i/ Green roofs and solar panels

Solar panels are fully compatible with the installation of a green roof. Their performance is even improved in the presence of vegetation.

Contrary to what one might think, the installation of a green roof is perfectly compatible with the installation of solar panels. This combination can even have interesting benefits. Scientific studies have shown that the yield of solar panels is optimal at outside temperatures of around twenty degrees maximum. As we have already seen, this is the temperature recorded on green roofs, even during the driest periods, when conventional roofs reach 90°C. Thus this combination would increase the yield of solar panels by about 4-5%. The panels can also have a real benefit for biodiversity. They will provide areas of shade, and therefore coolness, which will fluctuate according to the season and the time of day. This multiplicity of climatic conditions will encourage the development of new plants, which would not have been able to develop on a fully sunny roof, and will therefore increase biodiversity.

The vegetation also benefits from the shading provided by the solar panels at different times of the day.

However, the combination of these two systems requires good coordination and planning to ensure that the two systems work in harmony and are not incompatible. For example, it is essential to choose low-growing vegetation so that the plants do not compete with the solar panels by shading them. The choice of substrate is also crucial: a substrate with a high mineral content and low thickness limits the height of the plants, prevents the panels from being covered and thus ensures the optimal functioning of the solar modules. But it is also important to choose plants that are adapted to the site conditions, and in particular to the conditions that the solar panels will create, by providing shade in places.

Nevertheless, this type of combination requires good coordination to avoid risks. Unsuitable vegetation can invade the solar modules and prevent them from functioning.

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6. SPECIAL CONDITIONS

6.1 Notes on differentiation

One of the limiting factors for vegetation on roof surfaces is the lack of deeper rooting soil layers. This results in :

- limited root space at depth
- increased competition between roots
- no infiltration of precipitation water
- no upwelling of water by capillary action from subsoil layers
- reduced dew formation
- no exchange of mineral matter from the vegetation layer to the subsoil
- the immediate effects of waterlogging on roofs without slopes as a potential risk
- increased heating of the vegetation layer
- increased evaporation of water from the soil
- altered conditions for humus formation, mineralisation and nutrient release

The interaction between constant or relatively constant site factors due to the structure and, on the other hand, extremely variable external influences is often not easy to analyse in specific cases.

Just like plants that grow on rocks, plants on roofs do not benefit from soils that allow deep rooting.

6.2 Climatic factors

The formation of a micro-climate due to the topographical situation of a building, as well as the exposure of the roof surfaces and the structure of the building determine the qualities of the site. It is important to assess the particular extremes of conditions that may be present:

- long and regular dry periods
- seasonal rainfall distribution
- periods of frost without snow cover in winter
- the direction and strength of the main wind

On the roof, plants can be exposed to extreme weather conditions.

It is essential to assess the particular conditions to which the plants will be exposed in order to propose vegetation adapted to these extreme conditions.

6.3 Location factors related to the building

Buildings can create microclimates that enhance or mitigate local climatic conditions. Knowledge of these microclimates is essential for understanding site-specific conditions.

Changing climatic influences

The building, as an individual building or in connection with others, increases or decreases the climatic factors, so that, in connection with the local climatic conditions, a special building-related microclimate is created. The following individual factors for climatic characteristics in gardens can occur:

- Dynamic pressure conditions
- Creation of air corridors, changing in speed and direction
- Changing light and shade zones, the spatial extent of which varies during the day and year.
- Well-defined light and shadow zones
- High heat transfer and heat accumulation
- Irregular distribution of precipitation
- Precipitation-free zones

It is necessary to use plants that can withstand the emissions from buildings.

Building-related emissions

Building-related emissions that may affect vegetation include
- Gases
- Dust
- Hot air
- Cold air
- Thermal radiation

Architectural and constructional conditions

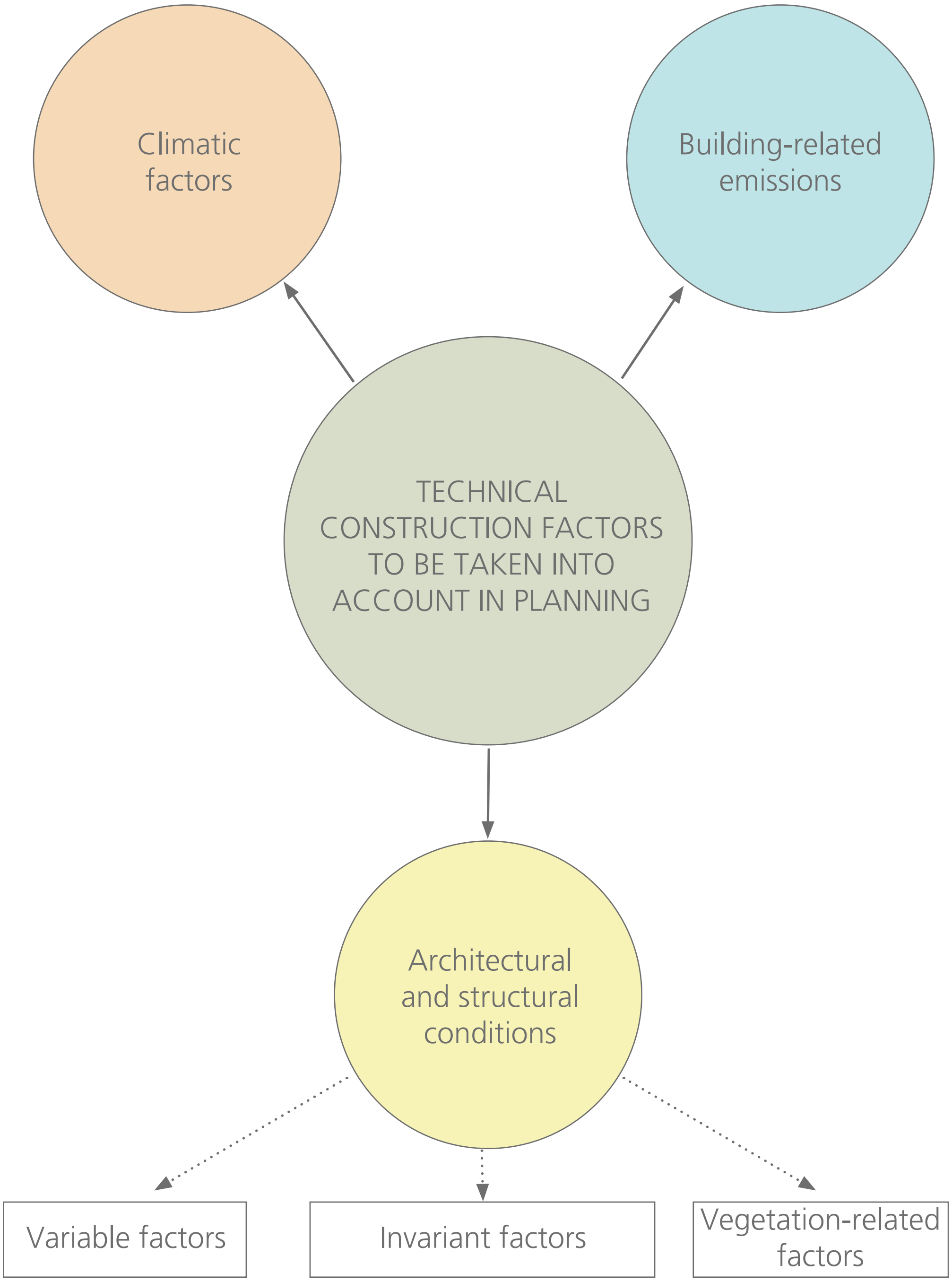
<u>Site factors that cannot be changed:</u>
- Carrying capacity for vegetation
- The height of the greening levels
- Slope conditions for sloping and flat roofs
- Shading from elevation or neighbouring building elements
- Cooling effect from below in the case of uninsulated ceilings below.
- Reflection from the façade
- Increased wind strength due to the building
- Pollution
- Type of façade design

<u>Variable site factors:</u>
- Loading capacity for vegetation
- Slope conditions for flat roofs
- Increased water accumulation by watering the façade
- Specific wind force
- Reduced space for roots
- Sensitivity of the roof structure to point loads

With regard to the variable site factors, the possibility of influencing the vegetation in a targeted and respectful manner decreases as the landscape planning progresses. For example, the additional load on the building's statics caused by the subsequent vegetation of the roof can already be taken into account in the statics when planning the house.

Site factors related to vegetation :

With the acceptance or modification of architectural and constructional specifications for the placement of vegetation on buildings, the design of the biological habitat for plants now begins. This is done with vegetation techniques and actions for root horizon production. Of particular importance is the supply of water and the regulation of the water balance.



Some site-related factors cannot be changed, such as the roof pitch.

However, flat roofs must have a greater or lesser roof pitch: this factor is variable at the time of planning.

7. RIGOROUS PLANNING

The installation of a green roof requires careful planning. Particular attention must be paid to the prevention of damage that may occur during the installation of this type of roof. This ensures the durability and reliability of the roof, and therefore the building.

The protection of the roof structure against root damage is therefore an indispensable part of the basic technical requirement. Constantly searching for water and nutrients, the root system explores every nook and cranny to satisfy the plant’s needs. This exploration is the cause of the damage that can occur on a green roof.

The waterproofing layer of the roof and the root protection layer must be adequately protected against mechanical damage. The means and measures are to be determined in each individual case according to the type of stress and use, according to the construction and greening aspects, and to be coordinated during the construction process.

In addition, all roof edges, connections to roof entrances, ventilation openings, dormer domes, construction joints, etc. are particularly sensitive to mechanical damage and weather influences. As a rule, a greening-free spacer strip is required at all edges, upright elements, roof eaves and structural joints. A minimum width of 50 cm must be kept free of vegetation, usually a gravel strip. However, this gravel strip can be perfectly integrated into the roof design, for example by varying the type and size of gravel, to create an ecologically valuable shelter for small wildlife.

All roof drains should also be kept free of vegetation in an area of at least 75 cm in diameter, to ensure that they function properly and are easily accessible for cleaning.

Good coordination and careful planning are essential to ensure a durable and reliable roof.

Particular attention must be paid to the waterproofing layer of the roof to avoid mechanical damage.

The gravel strip can become a real refuge for small fauna and an integral part of the project.

8. PLANT SELECTION

8.1 Basic principles

A thorough understanding of plant ecology and sociology is essential for the establishment of suitable vegetation on green roofs. For a basic understanding and assessment of the quality of biotopes that can be realised on green roofs, the "basic biocenotic principles" according to Thienemann (1956) must be considered, interpreted and applied.

<u>First fundamental biocenotic principle</u>

"The more variable the living conditions of a habitat, the greater the number of species in the associated community."

<u>Second fundamental biocenotic principle</u>

"The more the living conditions of a biotope deviate from normal and, for most organisms, from optimal, the more species-poor the biocenosis becomes, the more characteristic it becomes and the greater the abundance of individuals in which the different species are found."

For extensive green roofs, this means that increasing the thickness of the rooting layer, i.e. the substrate and drainage layer, can also increase the number of plant species. In reality, a stronger profiling of the "relief", i.e. the surface of the substrate layer, is often very limited in practice, due to strict static loads.

The associations of individual plant species under varying and fluctuating equilibrium conditions are extremely complex, which makes them unpredictable and at best estimable. These associations allow us to assess the behaviour of a species when it is in competition with other species. There is no point in knowing the growth performance of a species when it is in optimal conditions, with an adequate supply of water and nutrients. However, it is essential to know how a species might behave under pressure from other species and under actual site conditions. This knowledge allows us to associate species that have similar ecological requirements and that have tolerant or even mutually supportive relationships that allow them to coexist. These coherent associations of plant species lead to the creation of exemplary and sustainable green roofs.

The thickness of the substrate determines the number and type of plant species that can establish in these conditions.

Green roofs are based on a coherent combination of plant species inspired by the natural environment.

Depending on the environment, different types of plant associations can be formed.

a/ Differentiation of extensive green roof forms

On the basis of natural and anthropogenic plant communities, various potentially suitable Central European plant species associations can be considered. The differentiation of the vegetation forms, usually introduced in the meantime, used for extensive revegetation and mentioned below, is based on their climatic stages as an ideal state. From a practical point of view, a simplified distinction is made:

- Moss-Sedum vegetation
- Moss-Sedum-Herb vegetation
- Sedum-grass-herb vegetation
- Grass-Herb vegetation

Plant formations are developed in relation to a characteristic inventory of individual life forms that reflect the site conditions. A common mistake is to assume that certain roof surfaces can be used as models for planned vegetation forms. Even if this objective is pursued with the design of the vegetation, different vegetation forms or transitional forms will usually establish themselves later on depending on the small and micro-scale site conditions. However, the planned formation form should predominate and thus confirm the design objective.

b/ Moss-Sedum vegetation (MS)

Moss-Sedum vegetation is a very undemanding plant combination that can cope with the most difficult conditions.

Moss-Sedum vegetation is the expression of almost absolute boundary conditions. It is extraordinarily resistant to drought and can be placed on layers between 2 and 6 cm thick. The herbaceous vegetation is limited to small, spontaneously occurring annual and biannual species. Moss-Sedum vegetation often has surprisingly rich floral displays. During the cool, wet seasons, interesting reddish, brownish or yellowish blooms appear through the spore capsules of the mosses. In spring, there are interesting colour contrasts and a soothing beauty, for example in the light green stands of the spore capsules and the reddish-brown cushions of the Sedum album.

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c/ Moss-Sedum-Herb vegetation (MSH)

Moss-Sedum-Herb vegetation is often found in the vicinity of Moss-Sedum vegetation and also within Sedum-Grass-Herb vegetation. It represents a relatively difficult to delimit form of vegetation, which can appear as an alternation of vegetation between the two previously mentioned forms of vegetation. In the course of successive processes, especially on sites with a predominantly shady character, it can change into Moss-Sedum vegetation. The thickness of the substrate or the height of the rooting space is between 6 and 10 cm as a shallow layered structure and thus corresponds to the frequent loading assumption of about 1 kN per m2 as a replacement for roof gravel. An established and perennial sedum stand, although with changing surface colonisation, reaches approximately 50-70 percent surface cover. Moss-Sedum-Herb vegetation is very popular because of the very impressive colourful flowering of the sedum in June and July.

Moss-Sedum-Herb vegetation. The spectacular flowering of sedum in summer makes this plant community very popular.

d/ Sedum-Grass-Herb vegetation (SGH)

Sedum-Grass-Herb vegetation is characterised by grassy and sedum aspects, forming stands. Herbaceous stands are generally limited to short-lived, spontaneous species with low xeromorphism. This type of vegetation can be considered on thin to medium layers, i.e. 6-10 cm and 10-15 cm, depending on the climatic conditions, the slope of the roof and the exposure of the areas. On flat roofs, as the substrate thickness increases, grasses and herbs replace sedum, which moves into roof edges and other extreme areas.

Sedum-Grass-Herb vegetation. As the substrate thickness increases, sedum species are gradually replaced by herbaceous species.

e/ Grass-Herb vegetation (GH)

In the Grass-Herb vegetation, the grasses form a large main stand. However, this is rarely "meadow-like", but remains localised in varying thicknesses. On sheltered flat roofs, grass and herb vegetation can be established from a height of about 10 cm of available rooting space. However, this already means a limited location, combined with the risk of absence of taller grasses and herbs, which require more rooting space. Grass-herb vegetation can be achieved more reliably from a layer thickness of 15 cm or more (with no upper limit).

Grass-herb vegetation. The dominance of grasses and flowering plants is characteristic of this environment.

8.3 Selection criteria

Extensive green roofs can be combined with functionality by dividing the areas into two parts: one for vegetation and one used by people.

a/ Functional aspects

The use of extensive vegetation on roofs, i.e. walking on it all the time, is only possible to a very limited extent due to the sensitivity to trampling of some plants, such as succulents. The regeneration capacity of grass-herb vegetation is extremely low due to slow growth and drought-induced dormancy periods. In addition, mosses and sedums have low surface shear strength, so that palm-sized pieces of vegetation can easily break off, especially during drought conditions. Occasional foot traffic, for example during maintenance work, is not a problem, nor is more frequent foot traffic. In the latter case, however, it is to be expected that the vegetation will be restructured into a trampling plant community.

b/ Aesthetic aspects

However, there are a few parameters that need to be taken into account and clearly presented to clients. It is important to keep in mind that a green roof is a living space. Unlike impervious surfaces, which vary very little over time, green roofs are constantly changing. Depending on the environmental conditions, green roofs are constantly adapting and can take on many different forms.

The diversity of species, the density of vegetation, the speed of development, the composition of the species, etc. are all parameters that fluctuate in the aesthetic diversity of the same roof, over time.

It is therefore necessary to be aware and accept that a green roof does not look like an English lawn, and this is precisely what makes it so rich. The heterogeneity of our green roofs contributes to the establishment of a great diversity of fauna, thus creating a real ecosystem in the heart of an urban environment.

These permanent changes are, in fact, a real boon from a landscape point of view. The impression of having a new roof, a new landscape, which evolves with the seasons, with the passing years. Monotony, boredom and weariness are replaced by fantasy, satisfaction and enthusiasm.

Development of vegetation over time.

In winter, the waterlogged mosses form green masses, contrasting with the yellow-brown colours around them. Snow can sometimes cover the plants with a thick cottony blanket. Time seems to stand still for a moment. The song of the robin breaks the silence of the cold winter. The ladybirds hibernate comfortably in a scrupulously chosen cavity. A pile of branches, a pile of stones, bark or even mosses are all shelters that provide a cosy nest for a large number of insects during the winter season.

Then the flowers appear, signalling the beginning of spring. The first smells spread. The bees, coming out of a long rest, become active and make their grand return. Butterflies leave their cocoons to wander through the tall grass. Birds begin their nesting season. The vegetation turns a soft, intense green, bringing the garden back to life. The days grow longer and the weather warms up, allowing us to enjoy this wonderful sight for longer.

The vegetation reaches its peak during the summer season. The colours, the smells, the buzzing, or more simply life, is in full swing. The chicks break their shells, discovering their new environment. The summer drought challenges all these living things. Plants struggle, drying out, losing their green colour. The fauna searches for water, shade and coolness, waiting for autumn.

Then the days get shorter, the pace slows down: autumn is here. The colours blaze in a warm gradation of tones. A few plants illuminate the roof with their late bloom. The grasses adorn themselves with their brilliant colours, swaying in the wind. The abundant rainfall favours the emergence of mushrooms. Birds begin their migration to spend the winter in warmth. Insects unable to overcome the harshness of winter, reproduce to ensure that their offspring will take over next spring. Plants also prepare themselves for another winter.

And the cycle of seasons begins again, for a new year, unique, different, under the influence of the surrounding conditions. The moods will continue to change, year after year.

Sedums trapped in the ice try to brave the winter.

A bee comes to feast on the delicious sweet nectar offered by this blueberry in spring.

The Carthusian carnation delicately colours the roof during the summer season.

The sedums set the roof alight with their bright colours, characteristic of the autumn season.

Green roofs need time to develop. Plants must settle, acclimatise and grow at their own pace to ensure the sustainability of the landscape.

The use of native plants adapted to local conditions contributes to the preservation of local biodiversity.

c/ Temporal aspect

This type of roofing also requires patience and letting go. You have to be able to trust nature, accept the unexpected, and the fact that you cannot control everything. As a rule, vegetation takes time to develop. In our societies, where efficiency and profitability are increasingly important, the relationship with time is totally different: time escapes us, it is seen as an adversary that must be fought, slowed down or even stopped. The new technologies lead us to a desire for "everything, right away", in search of ever more immediate, instantaneous satisfaction.

But with nature, our relationship with time must be totally rethought. Nature is not based on the same time scale. The human life expectancy is about 80 years, while the life expectancy of a tree can reach more than 1000 years, which is also valid for simple lichens for example. Patience is therefore the watchword. Plants must be given time to settle, acclimatise, develop and evolve. This takes time and may be perceived as an inconvenience, but sometimes you have to see things differently, accept them as they are, and know how to benefit from them. This experience can help us in our daily lives to understand time differently. Giving nature time means allowing it to develop and take root in the best possible way, so that it is sustainable.

d/ Ecological aspects

Native plants should be used exclusively, to the detriment of exotic plants, which are of lesser interest for biodiversity and can sometimes even threaten it. Indeed, although certain exotic plants may appear attractive from an aesthetic point of view and may acclimatise particularly well to the conditions of the environment, they are nonetheless a scourge for biodiversity. These highly competitive species create imbalances and cause considerable, often irreversible, damage to the environment in which they settle. They are thus responsible for ecological, social and economic problems.

Native plants, on the other hand, are particularly well adapted to local conditions and offer real advantages to the surrounding flora and fauna. For example, the growth and survival of many pollinating insects, including wild bees and butterflies, are directly linked to native plants. The choice of native species is therefore essential to enhance and preserve local biodiversity.

9.1 Definition and distinction

a/ Finishing maintenance

The aim of finish maintenance is to achieve a condition that allows the development of subsequent maintenance measures. It includes all the services necessary to achieve the condition required for the acceptance of the work.

b/ Development maintenance

Development maintenance should be used to achieve a "functional state". Insofar as this applies to green roofs, decisions must be made on a case-by-case basis. Specific ecological objectives for extensive green roofs fall under developmental maintenance, e.g. the promotion of certain low-growing plant species through certain maintenance measures.

c/ Maintenance care

Maintenance is used to maintain the functional state. For the quasi-natural vegetation forms of extensive roofs, it is certainly not necessary to place too much emphasis on the functional aspect. For example, the species composition of the vegetation cover is subject to constant change, which makes maintenance interventions necessary only in exceptional cases. Extensive maintenance of green roofs is never of a permanent nature, but is limited to individual measures over longer periods, which result from the development of the vegetation.

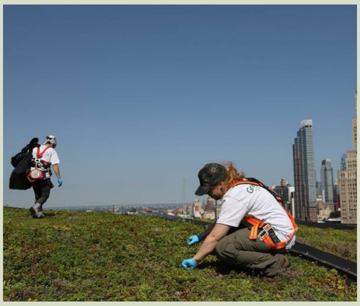
Maintenance of the roof in a safe manner.

Renovation of the waterproofing of a flat roof.

Maintenance of green roofs.

9.2 Care and maintenance

A thorough preliminary observation is necessary before any intervention.



Maintenance work should be limited to checking and, if necessary, removing alien plants that have taken root.

Quasi-natural forms of vegetation are subject to constant, more or less strong and successive processes of change. Individual plant species develop dynamics in association with each other, which depend not only on the site and meteorological influences, but also on the age of development. In addition, spontaneous plant colonisation from the inventory of species in the surrounding areas can trigger changes under certain conditions. The question therefore arises as to the extent to which it is necessary to intervene in a controlled manner as part of finishing, development and maintenance. Newly established spontaneous vegetation rarely causes problems during the relatively short period of completion. However, if large quantities of individual grasses of the ruderal or seed flora are sown as a seed mixture or are already present in the substrate, these species which are not adapted to the site can considerably hamper the establishment of the target vegetation due to competition for light and water. The objectives of the finish maintenance should be described as precisely as possible in relation to the acceptable condition. The aspects of the vegetation that are appropriate to the site should be used as a model. This means that the dynamics of the vegetation, as a response of the plants to the mosaic of the most varied site conditions on a small scale, is taken into account. From a vegetation engineering point of view, it is wrong to forcefully impose the ideal of an area-wide vegetation pattern, such as a grass cover, with all means of maintenance until it disappears.

10. SUMMARY

Our interest in and commitment to the environment lead us to find concrete and relevant solutions that allow us to give nature its rightful place. And when it comes to the environment, the city is where all the urgencies are concentrated, hence the need to give nature a place in the urban environment. Rooftops that are not actively used by humans are an essential means for nature to regain its place in highly urbanised areas where it has practically disappeared. Extensive vegetation on these roofs allows the development of quasi-natural vegetation zones, adapted to the conditions of the site. These forms of vegetation are self-sufficient and can also be established on thin layers of substrate. In order for the vegetation of a building to be ecologically sound, it is necessary to recognise and assess all the factors influencing the site in order to adapt the vegetation design to it. One-sided technical solutions should be avoided. Only in this way can the dynamics of plant and vegetation development be given sufficient scope to create a vital and sustainable greening.

The aim is not to create any kind of green roof, but to create an authentic environment, based on the observation of nature, in order to obtain a real biocenosis where fauna and flora are in constant interaction. Maintenance will be reduced, leaving room for a natural, stable and sustainable dynamic.

The greening of roofs is part of an ecological and environmental approach. For this project to be truly meaningful, it is therefore necessary to be attentive and demanding in the choice of materials, their quality and their origin. It is important not to be satisfied with a "natural looking" result, but to have a real line of conduct from the planning stage, through to implementation and maintenance.

Change and permanent adaptation are the only things that last in an eternal cycle.

Green roofs are an essential means of protection against urban problems.

They are a real biotope for the indigenous fauna and flora.

The natural dynamics of extensive green roofs offer permanent change.

KEY FIGURES

ECOLOGY

86 %
of plant species are **indigenous**, on extensive roofs

17 %
of known **beetle** species have also been found on **green roofs** in Switzerland

50
bird species use green roofs for **breeding** and **other activities**

+ 6 %
concentration rate at the sight of a green roof

1 m²
of **green roofs** can capture...

0.2 kg
of **suspended particles** per day

90%
of compounds, such as **carbon monoxide** and **butane**, are **degraded** by green roofs

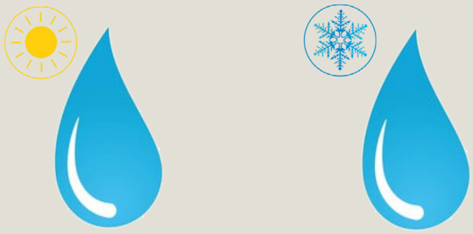
In the city, **greening** of
15 %
of roofs, would **reduce the temperature** of
3,3 °C

1,8 Millions m²
of **new green roofs** per year in Switzerland

KEY FIGURES

ECONOMY

Water **retention capacity** in summer and winter

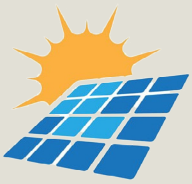


70-100% 40-50%

- 40 dB
of **noise** reduction

60.-/m²
electrical energy savings compared to a gravel roof

+ 4-5 %
of **efficiency** for **solar panels** in the presence of vegetation



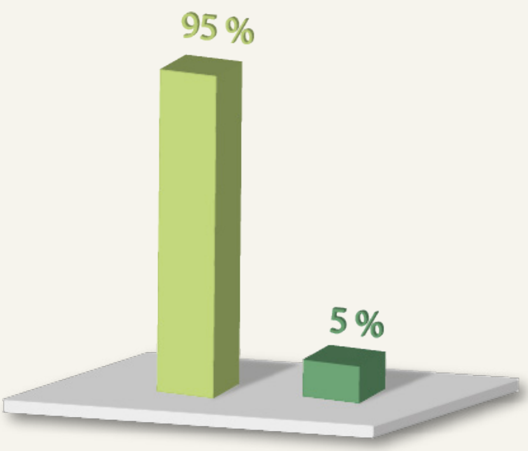
CONSTRUCTION TECHNOLOGY

x 2 **Lifetime** of a **green** roof compared to a **conventional** roof

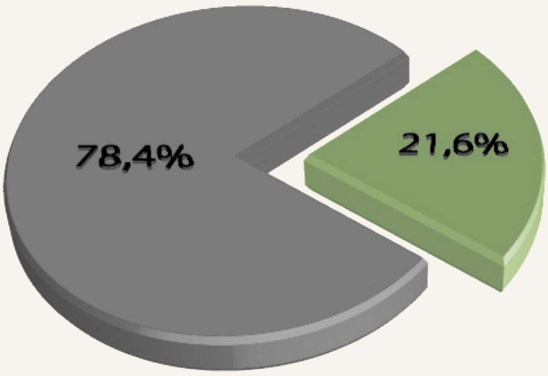
- 60°C **Surface temperature :**

Conventional roof | Green roof

80-90°C 20-25°C



In Switzerland, **95%** of green roofs are **extensive**



In the city of **Zurich**, only **21,6%** of roofs are **green**