The Green Innovation Park as a research showcase and real-life lab for the SLU Alnarp campus

Kerstin Hofmann

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Supervisor:	**Åsa Ode Sang, Swedish University of Agricultural Sciences (SLU), Department of Landscape Architecture, Planning and Management**
Examiner:	Anders Folkesson, Swedish University of Agricultural Sciences (SLU), Department of Landscape Architecture, Planning and Management

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Abstract

The project site, which until recently hosted the Green Innovation Park, is located centrally on the SLU campus in Alnarp. In its current state the site reflects neither the curriculum of SLU nor the mission statement. In order to rectify this situation a research-based design approach is employed to transform the site into an exemplary piece of green infrastructure. A survey is carried out into the research conducted and education offered at SLU. Based on these results and a thorough analysis of the site, design modules are developed to supply the best possible design solution for every situation prevalent at the site. These content-based design modules are then added to an overlying structure which provides cohesion for the design. The result is a design which provides multiple ecosystem services and reflects the research conducted and education offered at SLU. It serves as a showcase for the research and a real-life lab and case study for the students, while at the same time being an attractive site inviting students and visitors alike to linger.

Keywords: green infrastructure, research-based design

Table of contents

List of tables

List of figures

Abbreviations

EC	European Commission
GI	Green Infrastructure
MA	Millenium Ecosystem Assessment
Pom	Programmet för odlad mångfald (The Programme for Diversity of Cultivated Plants)
SLU	Swedish University of Agricultural Sciences

1. Introduction

1.1 Green infrastructure

The European Commission (2024) defines green infrastructure as "a strategically planned network of natural and semi-natural areas with other environmental features, designed and managed to deliver a wide range of ecosystem services, while also enhancing biodiversity."

This very broad definition is reflected in the findings of various literature reviews on green infrastructure. Green infrastructure is used as a planning instrument and to provide ecosystem services such as stormwater management, climate change mitigation and biodiversity enhancement amongst other things (Matsler et al 2021, Ying et al 2021). The result are many ambiguous definitions of the term (Matsler et al 2021), very often formulated to fit the needs and aims of the respective project. A key element of GI, consistently appearing in the various definitions, is the concept of multifunctionality, allowing GI to provide multiple ecosystem services at the same time (Chatzimentor et al 2020, European Commission 2024, Wang & Banzhaf 2018).

Ecosystems and the services they provide have been thoroughly assessed in the Millenium Ecosystem Assessment (MA). The MA defines ecosystem services as "the benefits people obtain from ecosystems" (MA 2005) and proposes four categories of ecosystem services: provisioning, regulating, cultural and supporting (see also table 1).

Table 1: Categories of ecosystem services as proposed by the Millenium Ecosystem Assessment (MA 2005).

Ecosystem services			
provisioning	regulating	cultural	supporting
• Food • Water • Wood and fiber • Fuel • …	• Climate regulation • Flood regulation • Disease regulation • Water purification • …	• Aesthetic • Spiritual • Educational • Recreational • ...	• Nutrient cycling • Soil formation • Primary production • ...

The ambiguity of the definition of GI also translates to the question of what actually constitutes (a piece of) green infrastructure. The answers range in scale from whole networks (Jerome et al 2019) to single pieces of urban green space like trees, green walls or green roofs (Zölch et al 2016). The EC provides various examples of what GI can be, spanning the whole scale, again keeping the definition broad. For the purpose of this project the following example given by the EC was adopted as the guiding definition of GI: "Well-designed urban green spaces, (parks, gardens, green roofs, allotments…) … protecting biodiversity, while helping to tackle climate change, keeping cities cool, reducing flood risks and enhancing the health and well-being of urban residents" (European Commission 2024).

1.2 The project site

The site selected for this project consists of the building which until recently hosted the Alnarp branch of the Green Innovation Park and the surrounding free space. This selection was made for multiple reasons.

Firstly, the site is situated prominently on the Alnarp campus. Any transformation will be noticed accordingly by students and visitors alike and have a high impact.

Secondly, the site is very diverse. It offers various situations allowing for a multi-faceted design showcasing multiple solutions to implement green infrastructure.

Thirdly, in its current state the site does not reflect what is being taught in the various programs and courses at SLU in accordance with SLUs brand promise and mission statement "Science and Education for Sustainable Life". The site represents a stark contrast to these values, implying a "do as I say, not as I do" attitude. Transforming this site into an exemplary piece of GI would lend a lot of credibility to the SLU message.

1.3 Objective

The objective of this project is to provide a design proposal that will transform the project site into a multifunctional exemplary piece of green infrastructure as described in section 1.1.

By using the SLU curriculum and research activities as a starting point for a research-based design approach the proposal will provide the best possible design solution for each part of this site, resulting in a maximum of potential ecosystem services provided at the same time. Using cohesion factors to pull the various design elements together will also ensure that the transformed site is not only useful in terms of the ecosystem services provided, but also an attractive space to visit and a valuable addition to the SLU Alnarp campus.

In addition, by showcasing working solutions for the sustainable use of resources, the conservation and increase of biodiversity and the mitigation of climate change the site will represent the research conducted at SLU and can be used as a case study and real-life lab to educate students and the public alike.

1.4 Method

Since the space available in an urban context is limited, urban GI has to be created as a multifunctional space to provide as many ecosystem services per square meter as possible. This in turn makes a contend-based approach a necessity, based on the latest scientific findings in order to ensure the best possible use of the valuable space. To this end the design will be developed using a research-based approach as described by Milbrun & Brown (2003). Following the systematic model, each part of the site will be evaluated, and a design solution will be proposed reflecting the research and education carried out at SLU as well as the current state of science and technology.

In order to achieve this, the first step is to identify areas with similar conditions – zones – and define them. In the next step, modules will be developed for each zone providing the best possible solution. Following this, a framework will be created to contain the developed modules. And in a final step the modules will be added to the framework and additional cohesion factors will be applied, resulting in one cohesive design.

2. Analysis

2.1 GI-related SLU research and education

2.1.1 Research

Given the fact that SLU has an exclusively ”green” curriculum, most of the research conducted can be in one way or another connected to green infrastructure as defined by the European Commission. Even using the more specific example of the green urban space providing ecosystem services the list of research projects pertaining to green infrastructure is extensive. A comprehensive review of all research conducted in this field would be a project of its own and is not feasible within the context of this project.

Therefore, an exemplary overview of research conducted at SLU will be provided with a special focus of projects from the Urban Vegetation Group. In order to obtain this overview, informal short interviews were conducted in January 2024 with people from the Urban Vegetation Group as well as the POM project. In these interviews people were asked about their field of research and also, what they would like to see represented at the project site.

Frida Andreasson

Frida Andreassons focus is on soil science and plant-soil systems. This includes artificial substrates and their degeneration process and long-term stability as well as the very current and important topic of peat-free substrates. One of her current projects, “Substrate effects on tree development”, commenced in 2022. It looks into the effects of different substrates on the development of street trees and the change of properties of the different substrates over time. Another project, “Establishment watering of trees - A material sport?”, which started in 2024 will determine the effects of watering bags for irrigation of street trees during the establishment phase.

Since the street trees for the substrate project are planted in large troughs with a volume of ca. 1 m^3 and therefore easily transplanted and/or replicated, this is something Frida would like to see represented at the project site. Another topic she would like to showcase is the behaviour of artificial substrates over time.

Ishi Buffam

Ishi Buffam has a background in aquatic chemistry and biogeochemistry. His research mainly revolves around the ecosystem services provided by green roofs. He looks into the quantification of these ecosystem services, as well as possible disservices. A project on this topic, which started in 2024 is "How green should green roofs be? Ecosystem services trade-offs and synergies from nitrogen fertilization of green roofs as they age". Another point of interest is on the aging of green roofs and the impact this process has on the ecosystem services provided. This was the focus of a project finished in 2023, "In it for the long-term: How does the provision of ecosystem services from green roofs change as the ecosystems age?". His recent publications look into weedy species for green roofs (Heim et al 2024) and nutrient retention on green roofs (Goldschmidt & Buffam 2023).

At the project site Ishis interest obviously is in the flat roof on the north side of the building. He would like to see it turned into a green roof, which is then left to develop and age, reflecting the research he is conducting.

Tobias Emilsson

Tobias Emilsson has a strong interest in the technical aspects of green infrastructure. His research history on the establishment of green roofs goes back to 2001. He has a clear focus on applied research and briding the gap between the academic and commercial environment. He has been actively involved in the Scandinavian green roof institute (www.greenroofs.se) as well as the development of the Swedish handbook and guidelines for green roof installation, released in 2017. His research interests extend to the technical aspects of green walls as well, and to the efficient maintenance of green spaces. The latter is reflected in the ongoing projects "Innovative electrical and autonomous vegetation management in utility scale solar parks" and "Omvandling av slåttermaterial från vägkanter till biogas". He also has a focus on drought and flood tolerance of plant with reference to their suitability for urban green infrastructure, as reflected by some of his recent publications (Lausen et al 2020, Wiström et al 2023).

Tobias, like Ishi, has a strong interest in the flat roof on the north side of the building at the project site. He expressed interest in seeing different technical solutions installed, potentially in cooperation with commercial partners, to showcase available possibilities. He would like to see the same concept implemented for the walls of the building. Tobias is also responsible for the rainwater harvest troughs already installed at the south side of the building and would like to see those integrated and possibly extended.

Helena Persson

Helena Persson is the national coordinator for Pom, the Programme for Diversity of Cultivated Plants, at SLU. The aim of this programme and the corresponding project "A national inventory of unique plant genetic resources" is to inventory, evaluate, and preserve unique Swedish genotypes of cultivated plants. If deemed still garden worthy, these varieties were and still are reintroduced into the market under the trademark "Grönt kulturarv®" which translates to green heritage.

Helena expressed great interest in seeing the green heritage varieties represented at the project site in order to increase visibility for these valuable varieties and the project as a whole.

Karin Svensson

Karin Svensson has a background in landscape architecture. Her main area of research as well as teaching are plant use and planting design. She has a special interest in natural planting design. Her current project "Low maintenance perennial mixes for tuff growing conditions" looks into the possibilities of perennial mixes for public green spaces with a focus on mixes for dry conditions in sun as well as shade.

Karin indicated that she would like to see the mixes from the project included at the project site. In her opinion it would be a great opportunity to educate the public as well as students on the possibilities of perennial mixes. This has been difficult so far, since the trial plots are not very accessible to the public.

Petra Thorpert

Petra Thorpert has a PhD in landscape architecture. Her research focuses on the human perception of and interaction with green spaces. Her PhD thesis was about colour perception in urban green spaces (Thorpert 2019). This research topic is also reflected in some of her recent publications (Thorpert et al 2023, Thorpert et al 2024). Her current project "Designed urban greenery for a healthy living environment" is looking into the development of urban green spaces. In another project, "Green Sponge Buildings in Scandinavia", also ongoing, she is researching the establishment of green walls with a focus on the options and choices of decision-makers.

Since Petras research is not directly concerned with the technical side of green infrastructure nor with the plants used, she had no specific wishes concerning the project site. Her interest is in seeing a very diverse site created which could then be used as a real-life lab and case study for her research to be used in courses and to educate the public.

2.1.2 Education

There are a number of programs available at SLU that are directly or indirectly connected to urban green infrastructure.

At the first cycle, four programs are available, resulting in a bachelor’s degree. Those four programs are landscape architecture, landscape engineering, horticultural engineer - design and horticultural engineer - production. As a whole, these programs provide all the knowledge that is required to create the multifunctional green spaces that make up the backbone of green infrastructure, from planning through production and construction. In return all these programs would benefit greatly from a real-life showcase on the Alnarp campus.

At the second cycle again four programs are available which are in one way or another connected to the creation and management of pieces of green infrastructure. These four programs are horticultural sciences, landscape architecture, landscape architecture for sustainable urbanization and outdoor environments for health and well-being, each resulting in a master’s degree. Again, all these programs, especially the latter three would benefit greatly from an on-site showcase as the creation of green infrastructure is a key part of the curriculum.

2.2 Site analysis

2.2.1 General aspects

The project site is located at a very prominent position of the SLU Alnarp campus. It sits at the intersection of Sundsvägen, the main road through campus an Slottsvägen, which is the direct connection between Alnarpsgården and the castle, two main locations for the landscape architecture and landscape engineering programs. Slottsvägen is also part of the route from the bus stop and the main parking lot to the castle, park and arboretum, meaning most visitors to the Alnarp campus will pass by this site.

The project site itself is a very diverse site. On the north and east side it is surrounded by open ground and mature lime trees. A defining feature on the north side is the flat roof of the basement protruding from the building with roughly 250 square meters. The south and west front of the building are characterized by sealed ground, neighbouring buildings and full exposure to the sun.

2.2.2 Climate conditions

In order to select plants which are suitable for the site, it is necessary to analyse the climate conditions on site. The climate at the project site and the Alnarp campus in general is maritime due to the influence of the nearby Öresund. The result are relatively mild winters and cool summers with extreme heat or cold being the rare exception.

The coldest month is January with an average maximum of 2°C and an average minimum of -2°C (see figure 1). The hottest months are July and August with an average maximum of 21°C and an average minimum of 13°C.

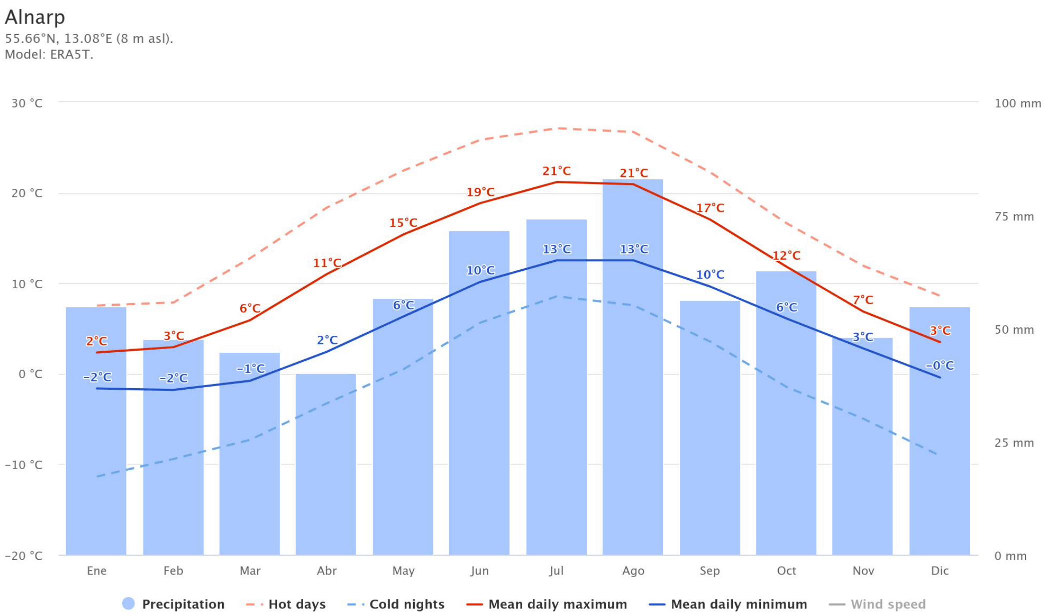

Figure 1: Average temperatures and precipitation in Alnarp (© by meteoblue.com/CC BY-NC)

Going by the total amount of precipitation April is the driest month with an average of 40 mm of rainfall, whereas August is the wettest month with an average of 83 mm of rainfall (see figure 1). The same is reflected in the number of precipitation days with 13.2 days in April and 18 days in August (see figure 2).

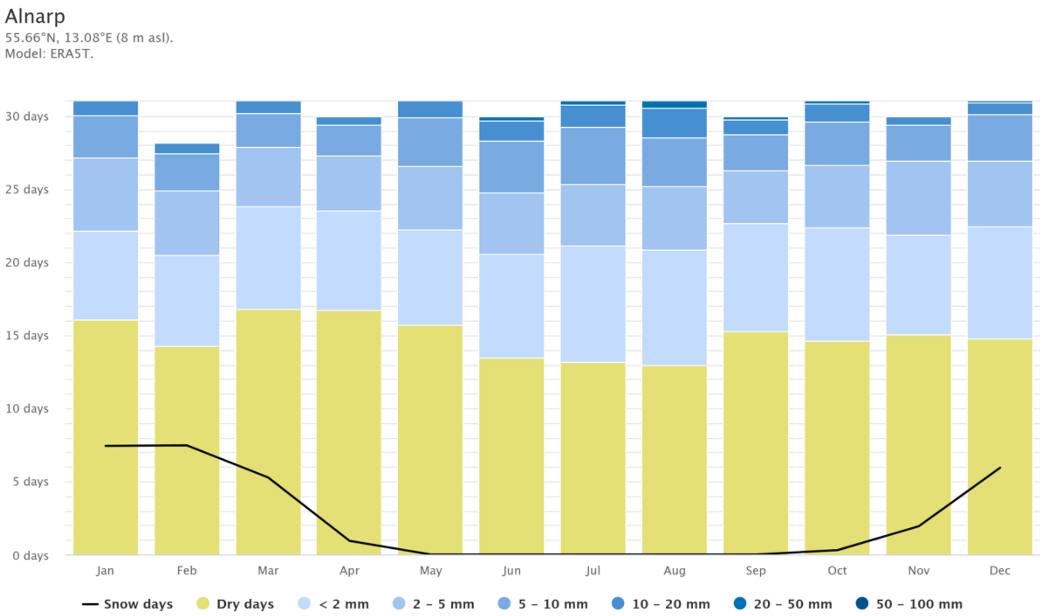

Figure 2: Precipitation amounts in Alnarp (© by meteoblue.com/CC BY-NC)

The maritime climate also results in a continuously high humidity ranging between 87% in December through February and 74% in April through June (source: https://www.weather-atlas.com/en/sweden/alnarp-climate#, accessed 18 December 2024).

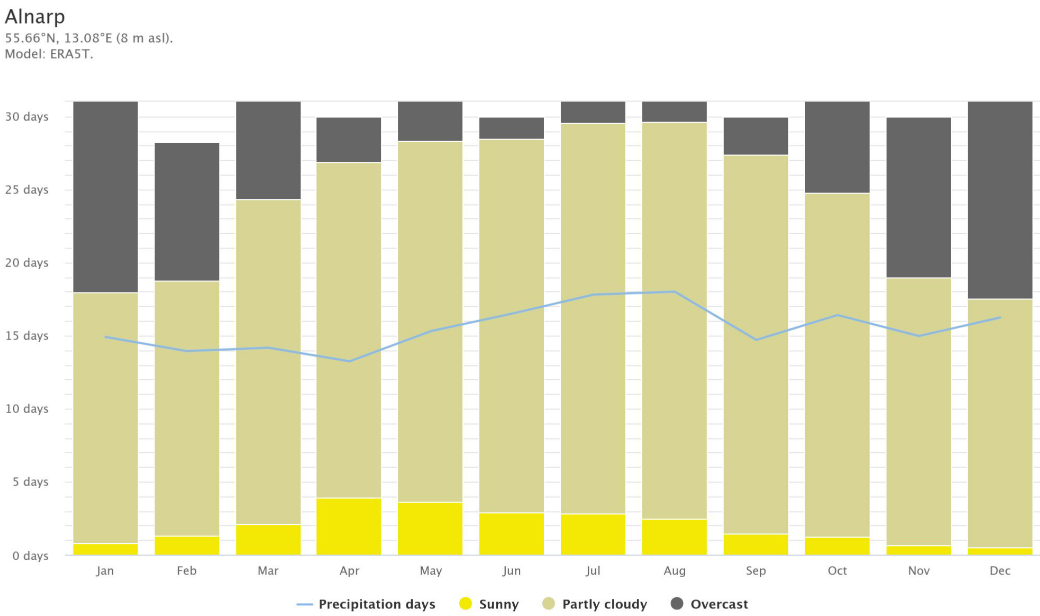

Figure 3: Cloudy, sunny, and precipitation days (© by meteoblue.com/CC BY-NC)

While the amount of fully sunny days in Alnarp is low throughout the year with a maximum of 3.9 days in April and a minimum of 0.5 days in January, the number of fully cloudy days is considerably lower during the summer month with only 1.4 overcast days in July and August as opposed to 13.5 overcast days in December (see figure 3).

2.2.3 Light exposure

Light exposure varies greatly at the project site. The North and East side of the site are characterized by shady conditions due to the shade cast by the building itself and the additional shade provided by the mature lime trees. The combination of the building and the trees result in different zones with shade intensity ranging from very light shade to deep shade.

The South and West side of the building are characterized by sunny conditions. While the west side of the building is in the shade for most of the morning, the south side can be considered as fully sunny for most of the day except early mornings and late afternoon in the summer.

The exposure to light at the project site is illustrated in figure 4.

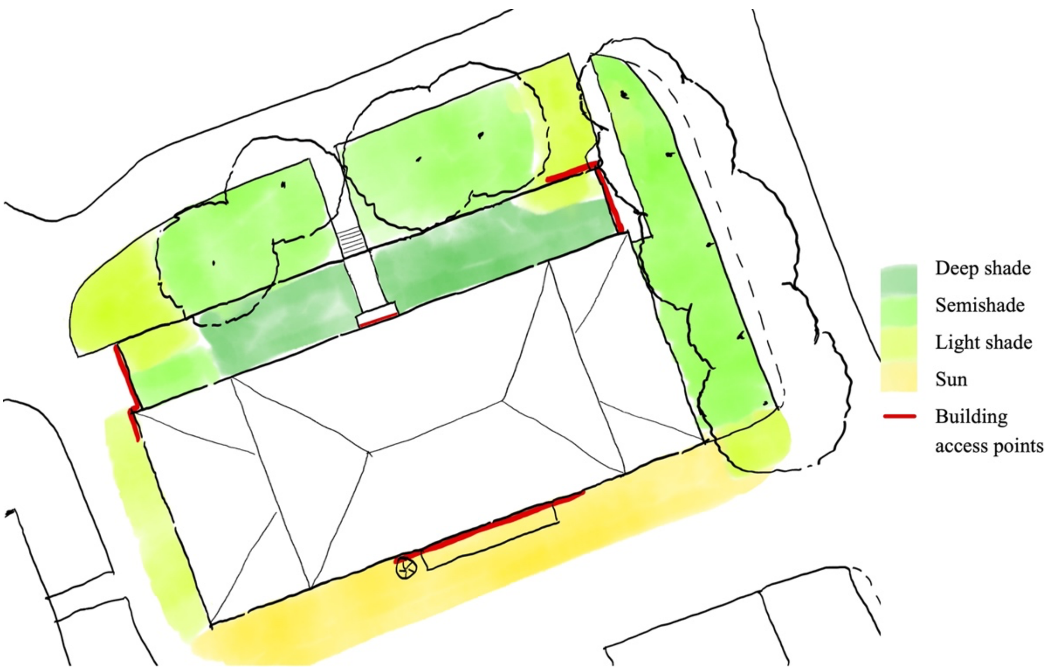

Figure 4: Light exposure around the project site building

2.2.4 Existing Vegetation

A key element to be considered at the project site are the nine mature lime trees planted at the north and east side of the building. These trees present a number of challenges when coming up with a design for the site.

Firstly, like most trees, *Tilia platyphyllos* does not like its core root area being covered with substrate or worse, plaster. This leaves little room for other plants to grow in.

Secondly, the trees also draw a large amount of moisture and nutrients from the surrounding soil. This presents considerable competition for other plants during the vegetation period.

Thirdly, the trees are mature and have a correspondingly large and dense root system. As a result, construction in this area is very difficult without damaging the roots.

3. Design

3.1 Zoning

As stated previously, the area around the project site building is a very diverse site. There are a number of factors to be considered in order to define the different zones for the design approach.

The first factor to be considered is the general type of situation. There are three main types of situations, ground, wall and roof. The ground can further be differentiated into open ground and sealed ground. The same is the case for the wall, since the walls at the north and east side of the building border on open ground whereas the south and west walls are adjacent to sealed ground. Figure 5 illustrates this further.

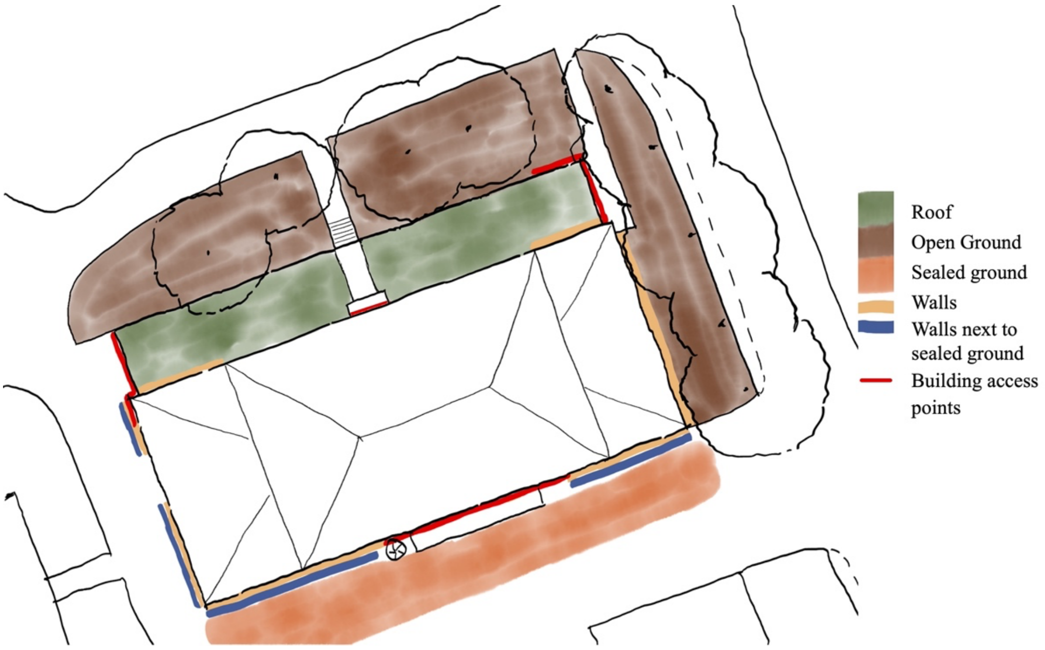

Figure 5: Types of situations around the project site building

A third factor which is only relevant for the open ground, are the mature lime trees. Part of the open ground is in the tree root area of these trees and must be treated differently from the rest of the space.

These three factors have an influence on the technical solution to be selected as well as the plant selection. A fourth factor, the light exposure, is only relevant for the plant selection. The light exposure is described in chapter 2.2.2 and illustrated in figure 4.

Applying these factors to the project site results in the following zones:

- Roof – shade
- Wall – open ground – shade
- Wall – sealed ground – shade
- Wall – sealed ground – sun
- Ground – open – shade – tree root area
- Ground – open – shade – no tree roots
- Ground – sealed – sun

3.2 Modules

3.2.1 Module 1: Roof – shade

The flat roof at the north side of the project site building is ca. 44 m long and 6 m wide. Allowing for the border and the access path to the back door this results in approx. 250 m^2 of available area. The existing border allows for a construction depth of ca. 20 cm.

The research conducted at SLU regarding green roofs is focused mainly on extensive green roofs. These roofs are usually simply constructed, with 10-15 cm of substrate, a filter membrane and a drainage layer. A green roof of this kind fits in with the existing structure at the project site, any additional construction would be unnecessary.

However, as there is a wish to showcase different technical solutions, an intensive green roof construction should be taken into consideration, including a deeper substrate layer and water retention elements. An intensive solution also allows for a greater variety of plants.

Taking these considerations into account, two different modules are proposed for the shady roof zone. Figure 6 illustrates how the projects site roof could look with extensive and intensive green roof areas.

Module 1a: Roof – shade – extensive

This module consists of an extensive green roof construction with a simple drainage layer, a filter membrane also acting as a root barrier and 10 cm of substrate. The following plant selection is proposed for this module:

- *Carex umbrosa*
- *Corydalis lutea*
- *Fragaria vesca* 'Norrlandsmultron' (Grönt kulturarv®)
- *Geranium nodosum* ‘Silverwood’
- *Hosta* ‘Halcyon’
- *Lamium orvala*
- *Luzula nivea*
- *Trachystemon orientalis*
- *Waldsteinia ternata*

All these cultivars are able to tolerate dry conditions as well as deep shade and are therefore suitable for an extensive green roof in the shade.

Module 1b: Roof – shade – intensive

This module requires some additional construction, namely some borders constructing a low raised bed to allow for the additional substrate depth and underlying construction. The intensive green roof consists of 20 cm of substrate a filter membrane and root barrier and water retention elements. The actual construction details would depend on the solution selected or provided by a commercial partner.

The proposed plant mix for this module is:

- *Bergenia cordifolia* 'Möja' (Grönt kulturarv®)
- *Carex umbrosa*

- *Geranium nodosum* 'Silverwood'
- *Helleborus foetidus*
- *Hosta* 'Halcyon'
- *Iris foetidissima*
- *Lamium orvala*
- *Luzula nivea*
- *Tellima grandiflora*

Again, these cultivars are shade and drought tolerant, though some of them require more root space than available in module 1a.

Figure 6: Illustration of how a green roof at the project site with extensive and intensive areas could look like.

3.2.2 Module 2: Wall – shade

The research conducted at SLU concerning green walls mainly focuses on wall bound systems. Soil-bound systems and the respective plants are not represented. Therefore, there will be no differentiation between zones 2 and 3 and one module will be proposed for both zones.

Wall-bound green wall systems vary greatly in terms of construction. Simple systems basically equal rows of pots or bags mounted on a wall, filled with substrate to hold the individual plants. More sophisticated systems include automated watering systems and/or the possibility to link the green wall to a rainwater harvest system. Some systems work substrate free using materials such as mineral wool instead.

Since the request was made to showcase different solutions here as well, there is no one definite solution proposed for this module, though it is strongly recommended to use a system which can be connected to a watering system. This would cater to the research going into rainwater management. The plant selection is made to allow for the limited root space and the shady conditions, assuming that an irrigation system is in place and therefore longer droughts will not be an issue.

- *Astrantia major* 'Lilla Mickelgårds' (Grönt kulturarv®)
- *Carex umbrosa*
- *Corydalis lutea*
- *Geranium nodosum* 'Silverwood'
- *Heuchera sanguinea* 'Smedsberget' (Grönt kulturarv®)
- *Hosta* 'Halcyon'
- *Lamium orvala*
- *Luzula nivea*
- *Tellima grandiflora*

3.2.3 Module 3: Wall – sun

The assumptions and proposal for this module regarding the technical solution are the same as for module 2. The difference lies in the selection of plants. Again, the plants need to be able to tolerate a limited root space but also should tolerate heat and full sun. Seeing as the exposure to heat and sun increases transpiration, the plants should also have some tolerance to drought despite the assumed irrigation system. Plants suitable for this module are:

- *Aster amellus* 'Axel Tallner' (Grönt kulturarv®)
- *Carex montana*
- *Dianthus plumerius* 'Marieberg' (Grönt kulturarv®)
- *Geranium himalayense* 'Sörmjöle' (Grönt kulturarv®)
- *Hylotelephium spectabile* 'Granlunda' (Grönt kulturarv®)

- *Nepeta racemosa* 'Linghem' (Grönt kulturarv®)
- *Primula x pubescens* 'Krusenstiernska' (Grönt kulturarv®)
- *Saponaria officinalis* 'Kvinnsgröta' (Grönt kulturarv®)
- *Stipa tenuissima*

Figure 7 illustrates how the project site building might look with green walls.

Figure 7: Illustration of how the project site building with installed green wall modules could look like.

3.2.4 Module 4: Open ground – shade – tree root area

The tree root area around the mature lime trees is a challenging situation. The tree roots leave little room for other plants to grow in, in addition draw a lot of the moisture from the soil and during the vegetation period cast considerable shade. One option to make use of this space is to use plants which will be able to tolerate these conditions, albeit needing intensive maintenance during the establishment phase. Plants suitable for this situation include:

- *Corydalis lutea*
- *Fragaria vesca* 'Norrlandsmultron' (Grönt kulturarv®)

- *Geranium nodosum* ‘Silverwood’
- *Luzula nivea*
- *Trachystemon orientalis*
- *Waldsteinia ternata*

3.2.5 Module 5: Open ground – shade – no tree roots

The area between trees is considerably less challenging than the immediate tree root area. Plants can be planted directly into the ground without disturbing too many tree roots and have space to develop. Nevertheless, the effect of the trees on the moisture in the soil remains, and there are still some tree roots to be expected. There are two ways to address these issues and therefore two modules proposed for this zone:

Module 5a: Open ground – shade – no tree roots – direct planting

Plants planted directly into the existing ground should be drought tolerant and able to tolerate some limitations to their root space. Suitable plants are:

- *Bergenia cordifolia* 'Möja' (Grönt kulturarv®)
- *Carex umbrosa*
- *Corydalis lutea*
- *Fragaria vesca* 'Norrlandsmultron' (Grönt kulturarv®)
- *Geranium nodosum* ‘Silverwood’
- *Helleborus foetidus*
- *Hosta* ‘Halcyon’
- *Iris foetidissima*
- *Lamium orvala*
- *Luzula nivea*
- *Tellima grandiflora*
- *Trachystemon orientalis*
- *Waldsteinia ternata*

Module 5b: Open ground – shade – no tree roots – raised beds

While raised beds are not possible in the immediate root tree area, they are a viable option for the spaces in between. A raised bed of est. 20 cm provides additional root space and eliminates the competition with the lime trees for water and nutrients. It opens up a much broader selection of plants to be used in this zone. In addition, raised beds would provide an opportunity to showcase different artificial substrates and compare their effect on plant development.

The proposed plant mix for this zone is:

- *Anemone tomentosa* 'Föraldrahemmet' (Grönt kulturarv®)
- *Astrantia major* 'Lilla Mickelgårds' (Grönt kulturarv®)
- *Bergenia cordifolia* 'Möja' (Grönt kulturarv®)
- *Carex umbrosa*
- *Geranium nodosum* ‘Silverwood’
- *Helleborus foetidus*
- *Heuchera sanguinea* 'Smedsberget' (Grönt kulturarv®)
- *Hosta* ‘Halcyon’
- *Iris foetidissima*
- *Luzula nivea*
- *Primula vulgaris* 'Rut' (Grönt kulturarv®)
- *Tellima grandiflora*

Figure 8 illustrates how the combination of modules 4, 5a and 5b combined with generic infrastructure elements could look like.

Figure 8: Illustration of how the open space at the project site could look like using modules 4, 5a and 5b.

3.2.6 Module 6: Sealed ground – sun

This zone, which consist of the thoroughfare at the west side of the building and the larger open space at the south side, is characterized by full sun. Due to the sealed ground, neighboring building and lack of shade it is also a potential heat island. In order to make the best possible use of the thoroughfare, turn the larger open space into an inviting area and cater to the various research projects and subsequent wishes for this space, two different modules are proposed.

Module 6a: Sealed ground – sun – wall-adjacent

Since the area to the west side of the building is a throughfare available space on the ground is limited. A viable solution are troughs along the length of the building with a limited depth of ca. 50 cm. These troughs should be connected to the roof drainage and the green wall modules in a rainwater harvest system. The troughs are another opportunity to showcase different substrates and their effects.

The plant mix for these troughs is similar to the one for the sunny green wall module, but allows for species needing a little more root space:

- *Aster amellus* 'Axel Tallner' (Grönt kulturarv®)
- *Bergenia cordifolia* 'Möja' (Grönt kulturarv®)
- *Calamagrostis x acutiflora* ‘Karl Foerster’
- *Dianthus plumerius* 'Marieberg' (Grönt kulturarv®)
- *Geranium himalayense* 'Sörmjöle’ (Grönt kulturarv®)
- *Hemerocallis* 'Esbjörn' (Grönt kulturarv®)
- *Hylotelephium spectabile* 'Granlunda' (Grönt kulturarv®)
- *Nepeta racemosa* 'Linghem' (Grönt kulturarv®)
- *Primula x pubescens* 'Krusenstiernska' (Grönt kulturarv®)
- *Saponaria officinalis* 'Kvinnsgröta' (Grönt kulturarv®)
- *Stipa tenuissima*

Module 6b: Sealed ground – sun – free-standing

The larger open space south of the building allows for larger, freestanding troughs. Since there is still traffic to be considered and allowing for emergencies, these troughs should still be constructed as portable with larger machinery. Since some shade would significantly increase the livability of the space, the proposed design element for this module are replicas of the street tree experiment conducted at SLU.

Figure 9 illustrates how the south side of the building could look like with modules 3, 6a and 6b.

Figure 9: Illustration of how the south side of the project site building with green walls and additional troughs could look like.

3.3 Cohesive factors

3.3.1 Plants

While the plants proposed for each module are selected first and foremost to suit the respective site and growing conditions, another focus has been to use plant with a wide amplitude regarding the growing conditions, allowing for repetition in the different modules.

There are species and cultivars which are tolerant to shade as well as sun, or which will grow on an extensive green roof just as well as in the open ground. By using these plants, a repeating design element has been created, automatically adding cohesion to the overall design.

Another cohesive factor regarding plants is the consistent use of green heritage varieties throughout the design.

Table 1 illustrates how species and cultivars are repeated throughout the design.

Table 2: List of plants used throughout the design and their distribution across the modules.

		Module								Grönt
Species	**Cultivar**	**1a**	**1b**	**2**	**3**	**4**	**5a**	**5b**	**6a**	**kulturarv®**
Anemone tomentosa	'Föraldrahemmet'							x		x
Aster amellus	'Axel Tallner'				x				x	x
Astrantia major	'Lilla Mickelgårds'			x				x		x
Bergenia cordifolia[2]	'Möja'		x				x	x	x	x
Calamagrostis x acutiflora	'Karl Foerster'								x	
Carex montana					x					
Carex umbrosa		x	x	x			x	x		
Corydalis lutea		x		x		x	x			
Dianthus plumerius	'Marieberg'				x				x	x
Fragaria vesca	'Norrlandsmultron'	x				x	x			x
Geranium himalayense	'Sörmjöle'			x	x				x	x
Geranium nodosum[1]	'Silverwood'	x	x			x	x	x		
Helleborus foetidus[1]			x				x	x		
Hemerocallis	'Esbjörn'								x	x
Heuchera sanguinea	'Smedsberget'			x				x		x
Hosta	'Halcyon'	x	x	x			x	x		
Hylotelephium spectabile	'Granlunda'				x				x	x
Iris foetidissima[1]			x				x	x		
Lamium orvala[1]		x	x	x			x			
Luzula nivea		x	x	x		x	x	x		
Nepeta racemosa	'Linghem'				x				x	x
Primula vulgaris	'Rut'							x		x
Primula x pubescens	'Krusenstiernska'				x				x	x
Saponaria officinalis	'Kvinnsgröta'				x				x	x
Stipa tenuissima					x				x	
Tellima grandiflora[1]			x	x			x	x		
Trachystemon orientalis[1]		x				x	x			
Waldsteinia ternata		x				x	x			

[1]These species/cultivars are includes in the dry shade plant mixes tested in the project "Low maintenance perennial mixes for tuff growing conditions" (K. Svensson, vbl. comm.).

[2]This species is includes in the dry shade plant mixes tested in the project "Low maintenance perennial mixes for tuff growing conditions" (K. Svensson, vbl. comm.), but the variety was replaced with a green heritage variety.

3.3.2 Materials

A very simple way to achieve cohesion throughout a design is the repetitive use of the same material(s). By using the same material, e.g. Corten steel for troughs, or the same wood for all platforms and benches, a repetitive element is created that pulls the whole design together into one unit.

3.3.3 Infrastructure

By using the same elements for the infrastructure of a design again and again cohesion is achieved with little effort. Using generic elements like wooden platforms for seating areas or wooden walkways for accessibility at various places in the design creates the repetition that in turn provides cohesion in the design.

3.3.4 Structure

Another possibility to achieve cohesion is to create an overall frame for the design elements which visibly holds these elements together. A simple way to do this is to orient all elements at the same axis or reference point, or to arrange everything at an angle.

3.4 Design proposal

Combining the previously described modules and cohesive factors, a design proposal was created for the project site.

The first step was to create a structure, or frame, for the modules and necessary infrastructure to fit into. Since the building is oriented on a west-south-west to east-north-east axis, a simple grid with a strict north-south orientation was laid over the site (see figure 10). The grid lines were positioned in reference to the lime trees, so that elements can be fitted into the grid and around the tree trunks without danger of damaging the trees.

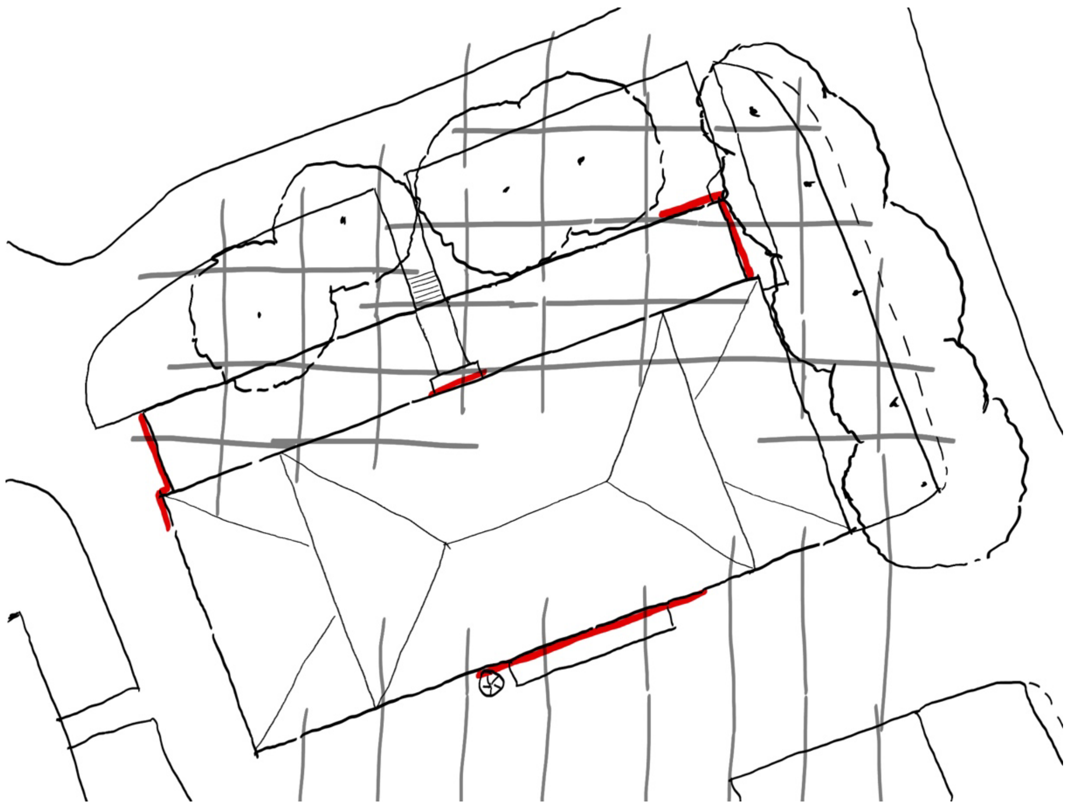

Figure 10: Step 1 of the design process - the project site with an overlying grid.

In a second step, infrastructure was placed on the grid. Seating areas were designated as well as walkways across the open ground and green roof (see figure 11). Both platforms and walkways on the open ground should be constructed to rest on point foundations. This ensures that the tree root systems are disturbed as little as possible while still making the site accessible.

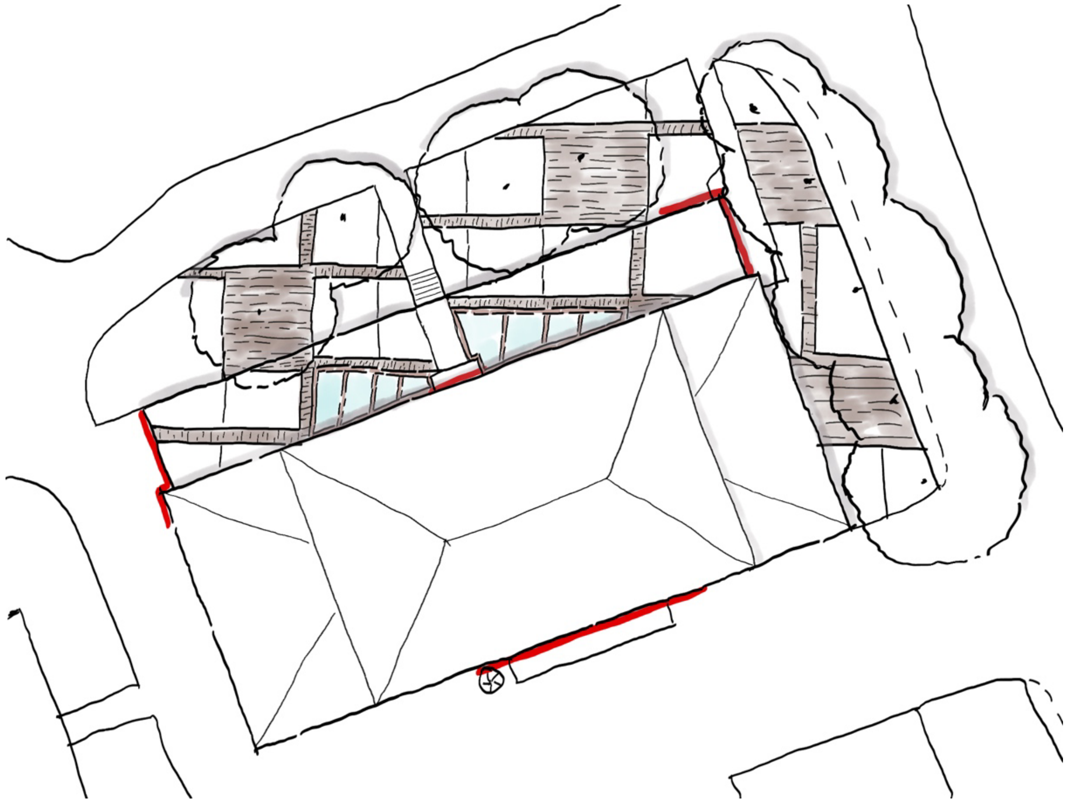

Figure 11: Step 2 of the design process - adding the infrastructure.

Another piece of infrastructure are the greenhouses situated on the roof on the north side of the building (see figure 12). These greenhouses were included to increase usability of the space. While the seating platforms provide space to work and relax in the created space, these spaces are weather dependant, and their usability therefore limited. The greenhouses provide all-year weather-independent "outdoor" workspaces, which increase the attractiveness of the space considerably.

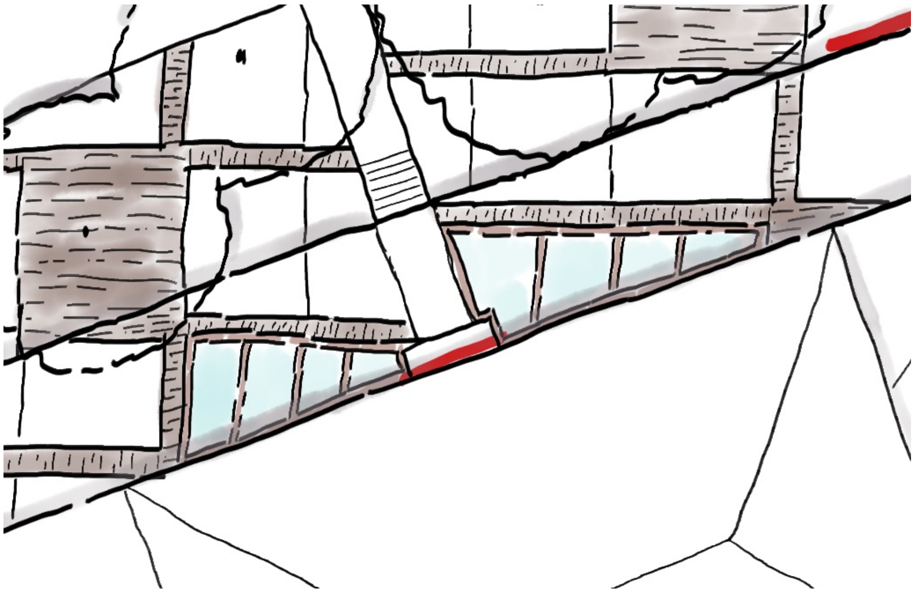

Figure 12: All-year outdoor work spaces - the greenhouses on the roof of the project site building.

Thirdly, to add another cohesive factor, materials were assigned to the different structures. All horizontal surfaces, namely seating platforms, walkways and benches, should be constructed from the same locally sourced wood. Vertical surfaces, including the borders of raised beds as well as all troughs, should be constructed from Corten steel.

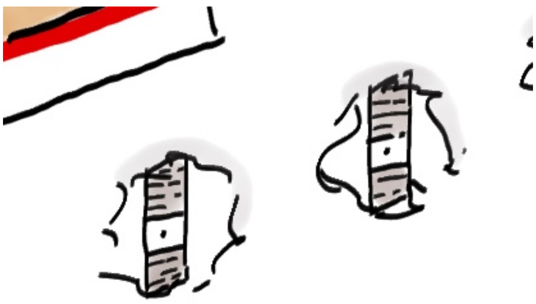

Figure 13: Detail of the street tree troughs with added wooden seating.

The final step was to place the developed modules in the previously created frame. Plant combinations and raised beds, if applicable, (modules 1a, 1b, 4, 5a and 5b) have been placed in the grid. Green wall elements with shade loving plants (module 2) were designated to every available space on the north and east facing walls, whereas elements with sun loving plants (module 3) were placed on all free spaces on the west and south facing walls. Rainwater harvest troughs (module 6a) have been lined up on all free spaces along the west and south facing walls, and street tree troughs (module 6b) have been placed on the north-south grid lines and parallel to the south facing wall. These troughs have been supplemented with wooden seating to better fit into the structural grid (see figure 13). An additional positive effect it the increased usability of the space. Figure 14 illustrates the final design proposal.

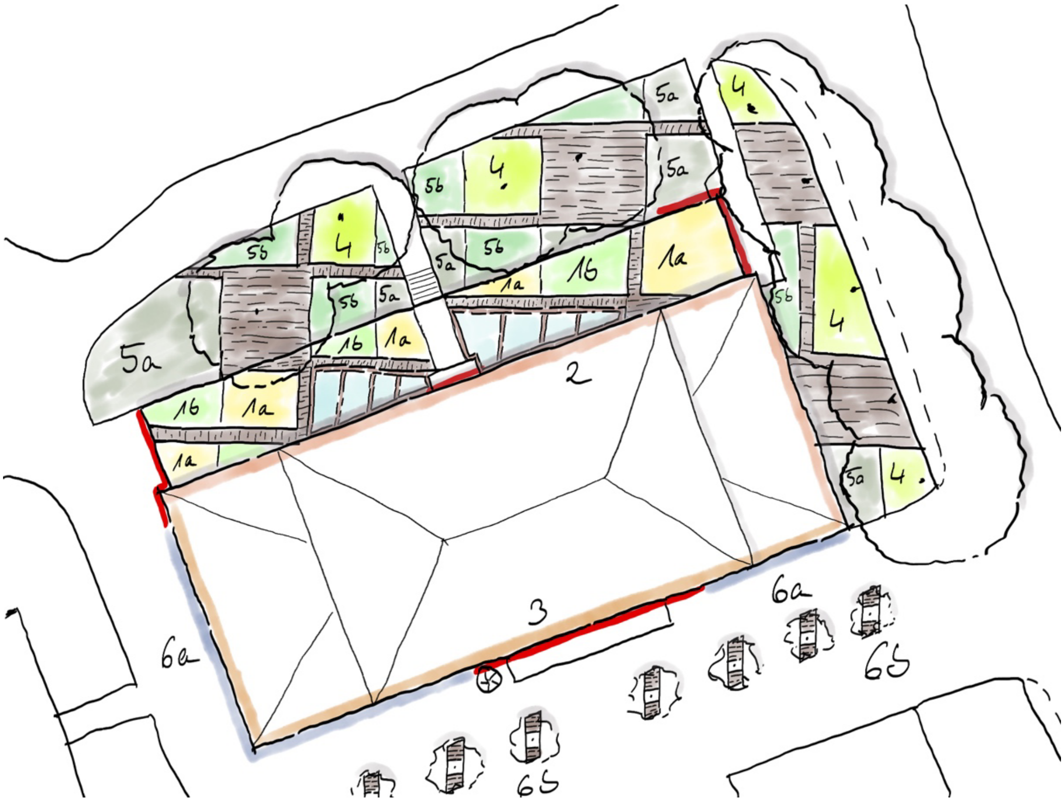

Figure 14: Last step of the design process - adding the modules to the frame.

4. Discussion

4.1 The design as a research showcase

One major objective of this project was to create a showcase for the research conducted at SLU. Since using the whole of SLU as a reference, the scope of the project was limited to the Urban Vegetation Theme Group at the Department of Landscape Architecture Planning and Management as well as the Pom project. In order to achieve this, interviews were conducted among the Urban Vegetation Group to get an overview of the research focuses in that group.

One of the main points of interest among the group are green roofs. The research covers the long-term development of these roofs, the provided ecosystem services and the technical aspects of green roofs. Including this research as a design reference was a given, since the project side includes a flat roof of est. 250 m^2.

A lot of the research in this area is directed at extensive green roofs. These roof types are characterized by a very simple construction. This simple construction makes it difficult to showcase a greater variety of technical solutions. Therefore, in order to also cater to the research into the technical aspects of green roofs, two modules were developed for the green roof situation. One module is for an extensive green roof, representing the very extensive research in this area. The other module is for an intensive green roof. The technical construction was left open on purpose to leave room to showcase different solutions, possibly in cooperation with commercial partner.

As a result, not only is the topic of green roofs well represented in the design, but by including two modules in the design the overall biodiversity is increased, as is the aesthetic value of the roof part of the design.

Another research topic, green walls, was easy to include into the design as there is sufficient unused wall space on all sides of the building. The decision was made to leave the technical solution undefined, merely suggesting a system that can be connected to the roof drainage and therefore be part of a rainwater harvest system.

This again, as in the case of the intensive green roof, leaves room to showcase different solutions, possibly in cooperation with commercial partner. By simply providing plant mixes suitable for green walls in shade and sun respectively, a lot of flexibility is maintained while still ensuring the green walls fit in with the rest of the design.

The subject of substrates their influence on plant development is represented throughout the design. This was ensured by creating the raised bed modules for the roof and open ground situations, and by including not only rainwater troughs but also the street tree experiment into the design.

A major topic represented throughout the design is that of plant use and planting design. A conscious decision was made not to use the plant mixes from the project "Low maintenance perennial mixes for tuff growing conditions", although they would have been suitable for three of the modules for shady conditions. One reason was the number of different mixes in that project. There are six mixes for dry shade in that research project (K. Svensson, vbl. comm.) and including all of them would have resulted in very small plots. Another reason was the aim to use the same plants across the different modules to achieve cohesion in the design. Therefore, the design mixes were created with that goal in mind. A third reason was the wish to include as many green heritage varieties from the Pom project as possible. But an effort was made to include some of the research project species and varieties in the design. 20% of the perennials used in the design are also included in the research project plant mixes. And, since the design plant mixes were created with the guideline "Right plant, right place" (Beth Chatto) in mind, the intentions of the research project and the general principles of good planting design are still represented.

The Pom project itself is well represented. The very diverse site allowed for 14 green heritage varieties to be included in the design. This constitutes almost 50% of the overall number of different perennials used.

4.2 The design as a case study and real-life lab for educational purposes

Another objective of the project was to provide a case study and hands-on learning opportunity to be used in the programmes and courses taught at SLU.

SLU offers degree programmes in the fields of landscape architecture, landscape engineering, horticultural science and environmental psychology. The design was created with these programmes in mind. Since all these programmes are in one way or another concerned with creating green infrastructure, the goal to provide a GI case study was complimentary to the design process itself and the goal to represent the research conducted at SLU.

There are many aspects of the created design, which can be utilized in the programmes taught at SLU. The design itself can be used as a case study for future landscape architects. The technical solutions will be of interest for students in landscape architecture, landscape engineering and horticultural engineering. The planting design is another case study which can be used to train the next generation of landscape architects, while the plants themselves, their use and requirements are of interest to future horticultural engineers. And the acceptance of the site among the students and the reactions of visitors can be an interesting research project for landscape architecture students as well as those working towards a degree in environmental psychology.

Overall, the design provides a great number of possibilities to be included in the various courses taught at SLU.

4.3 The design in the SLU context

The mission statement of SLU is “Science and Education for Sustainable Life“. So far, the project site, situated in the centre of the SLU Alnarp campus, does not live up to that statement. The site is characterized by blank walls, empty spaces, little biodiversity and no accessibility. Despite the thoroughly green curriculum of SLU, the project site is a rather bad example of green infrastructure. Instead of it being a case of “practice what you preach”, one is confronted with a case of “do as I say, not as I do”, lending little credibility to the goals claimed by SLU.

The proposed design rectifies this situation by turning the project site into an exemplary piece of green infrastructure. By implementing what is taught and researched at SLU and making it visible and tangible for students and the public alike, the site is transformed into a hub of sustainability and biodiversity in accordance with the SLU mission statement.

4.4 Transferability

Although the project site, due to its geographic location, deserves some special attention when it comes to its design and use, the rest of the Alnarp campus deserves some consideration as well.

There are many places on campus which, just like the project site, do not fulfil the expectations raised by SLUs mission statement and curriculum. Instead of reinventing the wheel for each of these places, the design for the project site can be evaluated for transferability.

The design of the project site is composed of modules which are designed for a combination of factors that in turn are not specific to the project site. Any site on campus can be zoned as was done for this design proposal. Then the modules developed for this design can be used as is or adapted if the target site shows conditions which are not present at the project site.

Since there are a number of modules for various shady situations, any target site in the shade should be covered by the available modules and adaptions should not be necessary. The same goes for any wall on campus.

As the modules for sunny ground situations are both trough-based, they are also directly transferable. In addition, the plant combination suggested for module 6a would also work in a sunny open ground situation.

On the whole, by using the modular approach, the design proposal created is highly transferable and adaptable.

4.5 Method reflection

One major aim of the design was to reflect the research and education SLU has to offer. The design was therefore created using a contend-based approach. An initial survey into research-based design methods suggested, that the systematic model according to Milburn and Brown (2003) was potentially the best method to use. In this model, the content (i.e. the research) is the determining factor, and the design process a “problem solving exercise” (Milburn & Brown 2003), aiming at applying the content to the specific requirements of the site.

Starting with a survey into the research conducted and education offered at SLU, the content for the design was defined as a first step. After summarizing the results of this survey, it became clear, that not all research was directly applicable to the site, and the large number and great diversity of research projects resulted in conflicting interests for the site.

The research was therefore transposed to the site, and the design modules were created to reflect the research actually conducted as much as possible under the given conditions. As a result, the design process followed in actual fact the analytical model, which “recognizes that research may not be applicable to the site in its traditional form” (Milburn & Brown 2003).

While the starting point of design process as a whole was the content, the actual creative process was still conducted working from big to small. But while the first thing to be created was the overall structure, it was created with the content in mind (form follows function), limiting the creative flexibility of the process.

On the whole, creating the design was a very structured process requiring little creativity. The result nevertheless is a design for a highly attractive multifunctional site providing a number of ecosystem services while still keeping the well-being of its users in mind.

5. Conclusion

The objective of this project was to create a design proposal for the project site located centrally on the SLU Alnarp campus. The design is supposed to transform the project site into a multifunctional piece of green infrastructure. The transformed site is supposed to provide various ecosystem services such as increasing biodiversity, mitigating climate change effect and promoting the well-being of its users. In addition, the site should function as a showcase for the research conducted at SLU as well as the programmes and courses taught there, making the curriculum of SLU and its mission statement visible and tangible.

The developed design proposal addresses all the above points. Due to the content-based design approach the research conducted at SLU, specifically in the Urban Vegetation Group, is reflected in every element of the design. Since research and education go hand in hand, the design also provides multiple opportunities to educated students and use the site as a case study and real-life lab.

Due to the fact that the research included in the design approach revolves around green infrastructure, the result is also the multifunctional piece of green infrastructure that was aimed at. By using the content-based approach to develop the best possible solution for each part of the site, a maximum of ecosystem services will be provided. At the same time the design results in a highly attractive site, inviting students and visitors to relax or work.

As a consequence, the transformed site adds to the overall attractiveness of the SLU Alnarp campus. This shows that by using a research-based design method an attractive design can still be achieved. The content-based approach ensures that at the same time the design ensures, that the result will also provide the ecosystem services required of any piece of green infrastructure, a mandatory requirement considering the limited space available for green spaces in our cities.

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