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Research
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The Nature-Inclusive Redesign

The possibilities of nature-inclusive redesign in Dutch urban monumental buildings

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Preface

I am writing this research for my graduation research in the Heritage & Architecture graduation studio as a completion of my master's in architecture, urbanism and building sciences at Delft University of Technology.

The research forms the basis of my graduation project. Parallel to this, there is a design process, in which the research is tested. The research is intended for interested parties, such as designers and owners of Dutch urban monumental buildings.

The research is about the nature-inclusive redesign of monumental buildings. This subject stems from my interest in working with greenery, such as designing, creating and maintaining gardens. I also enjoy watching and caring for animals. In addition, I am fascinated by monumental buildings, they tell a story and possess many cultural, social, architectural, technical and environmental values. A large number of these buildings are not or hardly used. I see it as a challenge to make such buildings part of society and let visitors experience these values. Finally, I am concerned with the problem of biodiversity and see the opportunity, as a future designer, to contribute to its solution through this research.

Robin Simons
Amsterdam, 1 June 2022

CONTENT

Reading guide

The first chapter discusses the research plan. In the second chapter, the benefits of a nature-inclusive building for its users are outlined, which serves as a theoretical foundation for making a building more nature-inclusive. Then the case study of the Groenmarkt in Amsterdam serves as an example of a nature-inclusive building. Next, the fauna species on which the research will focus are discussed. The animal species that are dependent on the urban environment and like to live in or near buildings are studied in more detail. In the fifth chapter an overview is given of the nature-inclusive options to be addressed. Following this, these are discussed by category. Subsequently, decision trees are set up, in which by answering the questions it is determined which nature-inclusive options can be applied to a case. These decision trees are tested by the case study of the monumental Koudenhorn building in Haarlem. For this purpose, first several analyses are addressed and after that the decision trees are filled in, resulting in a list of suitable nature-inclusive options. Chapter 11 summarises the study and describes how the toolbox created can be used. Lastly, a recommendation is given on how to make a building more nature-inclusive.

1 The research plan

1.1 Introduction of and motivation for the topic

The Netherlands and many other countries in the world are facing major problems that threaten people and nature. Due to climate change, global temperatures are rising, and extreme weather conditions appear more frequent (Ipcc, 2020). Researchers Tadeo Rahola, Peter van Oppen, and Karel Mulder (2009) discuss the increase of long-lasting heat waves that cause major problems, especially in cities. Such as, thermal discomfort, heat stress, increased energy consumption and affected wildlife. On the other hand, heavy rain is becoming more frequent, causing considerable material and economic damage (Deltares, 2016). In addition, large quantities of carbon dioxide and particles are emitted, which in turn contribute to climate change and deteriorating air quality (Fenger, 1999). Furthermore, the biodiversity is under great pressure. It forms the basis of our food chain, maintains the quality of the soil, and filters the air (Wageningen University & Research, n.d.). Landscape coordinator Koen Helling (2020) concludes in his research that several fauna species depend on the buildings and vegetation in the city. The buildings and their outdoor spaces serve as accommodations, give shelter, and can also provide food. Helling, therefore recommends that buildings should be built as nature-inclusive as possible (Helling, 2020).

Nature-inclusive building contributes to solving the earlier described problems. Nature-inclusive buildings cool down the environment, thereby reducing heat stress. Designing with vegetation enables infiltration of the soil and water retention, thereby preventing water nuisance. It filters carbon dioxide and fine dust from the air, improving air quality and fighting climate change. In addition, biodiversity is greatly enhanced. (Berardi, Ghaffarian-Hoseini & GhaffarianHoseini, 2014)

Nature-inclusive building brings many other benefits, such as for the city and the users of a nature-inclusive building (Wageningen University & Research, 2018; Jenssen, Hvoslef-Eide & Oarga, 2014; Kabisch, Korn, Stadler & Bonn, 2018). The fact that nature-inclusive building contributes to solve major problems and has many benefits, creates a great research subject. Also, it is fascinating to integrate nature into the built environment to improve both the lives of people and nature. An example is shown in Figure 1.

Figure 1: BOOM Landscape. (n.d.). Nature-inclusive design in a new to be built tower in Brinckhorst

1.2 Problem statement

There is a wide range of nature-inclusive options that can be applied to make a building more nature-inclusive (Arcadis, 2018; Gemeente Amsterdam, 2018). The application of nature-inclusive aspects in the design of new buildings are easy to implement, and relatively inexpensive through minor adjustments, because of the blank canvas (Helling, 2020). However, the aspects are more difficult to integrate into existing buildings. Especially in monumental buildings, where multiple constraints have to be considered. Monumental buildings possess great values that must not be substantially affected. The adaptations must be structurally and spatially possible. In addition, there is an existing plot and building shape (form, height, and orientation). It also depends on the presence of certain building elements and the facade materialisation.

The pressure on biodiversity remains high where a large part of the same biodiversity depends on cities and vice versa (FLO Legal, 2021). The above shows that implementing nature-inclusive options in new buildings is easy. On the contrary, for monumental buildings it is currently unclear if and if possible what should be considered in order to make this group more nature-inclusive. The reason behind the choice of the target group and the scope is explained in the theoretical framework.

1.3 Goal of research

The purpose of this study is to gain insight into the possibilities for nature-inclusive design in monumental buildings by consulting literature and doing observations. Furthermore, to get a better perspective on what must be considered when applying this to a Dutch urban monumental building. To create a toolbox for designers and building owners of these buildings and to test it on a case study with the same selection criteria.

The goal is to use the toolbox to help designers and building owners of Dutch urban monumental buildings to make their buildings more nature-inclusive through a redesign. The implementation of nature-inclusive design will help nature and increase biodiversity.

1.4 Research question

The central research question is:

How can Dutch monumental buildings in an urban context be redesigned to be more nature-inclusive?

The sub-questions involved are:

1. What are the benefits of a nature-inclusive building for its users?
2. For which fauna species that occur in the Dutch urban environment should there be more nature-inclusive buildings?
3. What are the possibilities to make a nature-inclusive design and are they applicable to a Dutch monumental building?
4. Which nature-inclusive options could be applied to a redesign of a Dutch urban monumental building to make it more nature-inclusive, and what could be learned from this?

1 The research plan

1.5 Theoretical framework

To give a sense of the framework, the most relevant term will be defined first. The study focuses on nature-inclusive building. This means creating more space for flora and fauna in new buildings, renovations, or restructurings (IVN Natuureducatie, n.d.). This may involve adding vegetation, water, and accommodations for fauna, but it may also include aspects to reduce nuisance, like avoiding annoying light emissions. It concerns built objects, such as infrastructural objects, buildings, and art objects, but also the surrounding environment (IVN Natuureducatie, n.d.). Thus, the built environment is integrated with nature and people live in harmony with it. A synonym that is used for this is nature-inclusive design.

This research is about how Dutch monumental buildings in an urban context can be redesigned to make them more nature-inclusive. This is done for a Dutch urban context, because of location dependency. For example, the climate affects the choice of vegetation types, but also the kind of animal species that forage in the Dutch cities and for whom the design will be made. Besides, in cities the problems are more intense, because of increasing building density, used materials and lack of green-water structures (Deltares, 2016; Fenger, 1999). Monumental buildings are selected because using them and making them sustainable contributes to their preservation. This is supported by the Heritage & Architecture studio of the Technical University of Delft (Heritage & Architecture, 2021). In addition, heritage is an important factor in making a city culturally bustling, financially successful, socially inclusive, and sustainable (UNESCO World Heritage Centre, 2019). This research focuses on nature-inclusive aspects regarding both the exterior façades, and the immediate surroundings of a building. Vegetation, water, and fauna possibilities for birds, mammals and insects are investigated. The specific animal species will follow from the study in sub-question two.

1.6 Methodology and methods

The first question will examine the benefits of nature-inclusive building for its users. This concerns both humans and animals. This will be done by means of literature research in books, academic papers, reports, web articles and websites. Afterwards, a residential building by landscape architects Buro Harro located at the Groenmarkt in Amsterdam, still to be realised, will serve as a case study.

For the second question, a literature search will reveal for which fauna species the design will be made and on what this choice will be based.

Then, by means of literature and observation research in books, scientific articles, reports, internet articles and websites, an overview will be made of the possibilities to include nature. First, each possibility will be briefly described and visualised with a hand sketch. This will be followed by an explanation and then a description of what needs to be considered when applying them to a monumental building. Finally, a toolbox will be designed based on the applicability of the different possibilities to a monumental building.

In the last sub-question, a case study will be used. The earlier designed toolbox will be applied on a monumental building. The analyses concern building and location studies and a value assessment based on the matrix of Clarke, Kuipers and Stroux (2019). The green-water structure, sun orientation, plot, volume, façade layout, façade construction and materialisation are all aspects that will be addressed. Images and documents will be consulted for this purpose. The analyses will be visualised and make clear which nature-inclusive methods could be applied in a redesign. Lessons can then be learned from the results. The used case study is the Koudenhorn police building in Haarlem. This building is a national heritage site, built in 1768 as a deacon's house (Monumenten.nl, 2020).

Finally, the central research question will be answered by a summary with the toolbox and a recommendation.

1.7 Relevance

This study clearly lists a wide variety of nature-inclusive possibilities. In addition, this study analyses the applicability of these possibilities to Dutch monumental buildings in an urban context. The study of this specific group is an extension of the existing literature.

The involved group of Dutch urban monumental buildings is large, because it concerns three different types of built monuments: national, municipal, and provincial. In August 2021, there were 61,809 national monuments in the Netherlands, which are mainly houses and residential complexes (Rijksdienst voor het Cultureel Erfgoed, 2021). The number of municipal monuments was estimated at 55,801 (in 2015) and the amount of provincial monuments was 811 (in 2019) (Rijksdienst voor het Cultureel Erfgoed, 2020). A large proportion of these monuments are in an urban environment. This shows that the research is carried out for a relevant number of buildings.

This research is of practical relevance. The toolbox helps designers and owners of Dutch urban monumental buildings to make their buildings more nature-inclusive. The more far-reaching goal is to be socially relevant. Making these monuments more nature-inclusive will help nature and reduce the pressure on biodiversity. Not to forget, the research also contributes to solving other serious problems, which are already addressed in the introduction. Furthermore, it has a positive effect on the users of the city and the redesigned estates (Wageningen University & Research, 2018; Jenssen et al., 2014; Kabisch et al., 2018).

2 Benefits of a nature-inclusive building

The benefits of a nature-inclusive building for its human and animal users are first examined. Nature-inclusive building provides numerous benefits, including the enhancement of: activities, health, the immune system, the mental state, the quality of the living environment, social connections, biodiversity and can be food or produce food. It is important to note that there is much overlap between the various benefits. One advantage may be related to the other. In this way, the combined effect can be large. It should also be noted that the quality of the green space influences the various benefits. High-quality greenery has a more positive effect than low-quality vegetation (Wageningen University & Research, 2018).

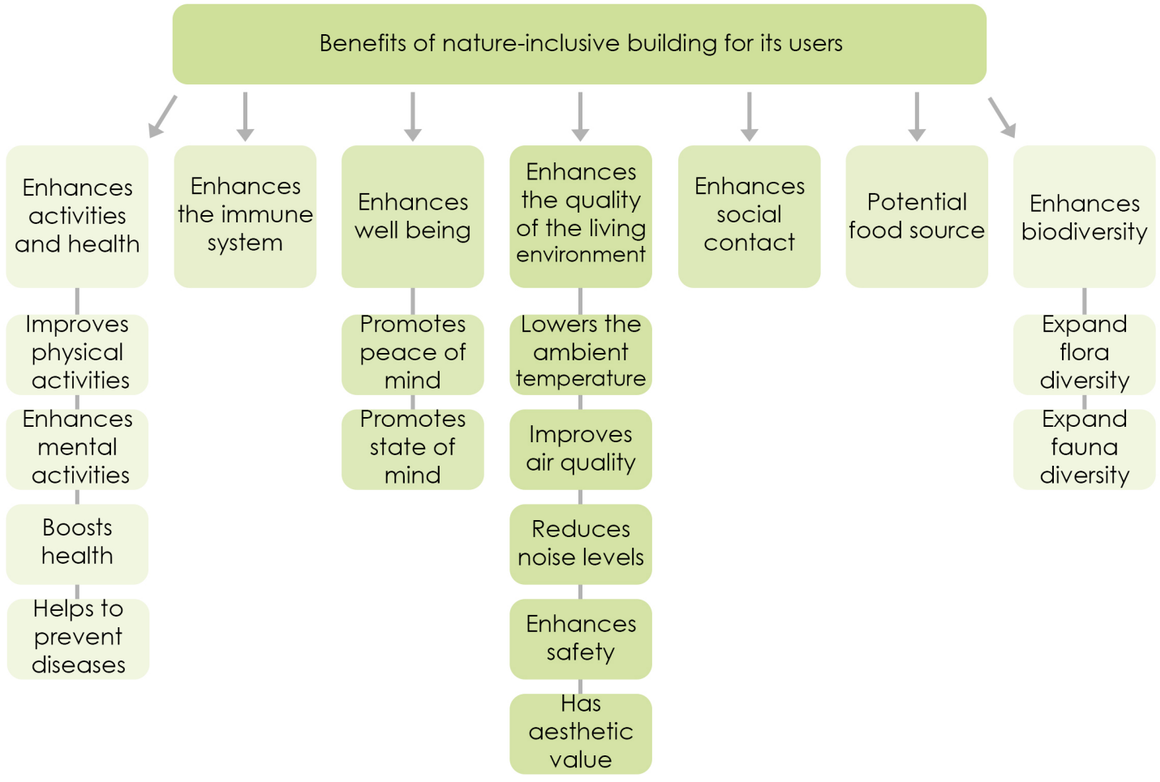

Figure 2: Diagram of the benefits of nature-inclusive building for its users

Enhances activities and health

Research also shows that nature improves physical and mental activity and health. Hartig et al. (2014) says that nature benefits physical activities by providing a suitable and attractive space. These include work activities (as studying and cleaning), transport activities (as cycling and walking) and leisure activities (as sleeping and swimming). Coombes et al. (2010) found from research that the availability of urban green spaces promotes physical activities. They surveyed 6821 respondents living in an English city. They looked at the availability and quality of green space in their immediate vicinity and what the relationship was with the respondents' physical activities and degree of obesity. Research also shows that the degree of greenery in a room or the view of it has a positive relationship with memory and concentration capacity (Hiemstra et al., 2019). This increases the performance, productivity, and creativity of observers (Dravingne et al., 2008; Wageningen University & Research, 2018).

Figure 3: [Enhances activities]. (2020, May 5)

Researcher Lisa Miles (2007) described physical activity as having diverse effects on the various body systems. For example, it improves energy balance, lowers the blood pressure at rest, increases blood flow, enhances bone and muscle strength, increases emotional wellbeing, raises self-esteem, and reduces anxiety. It also helps to prevent many diseases, including diabetes and cardiovascular disease. This is supported by research by professors Coutts et al. (2010). They conclude that population mortality rates decrease as more green space is found in the vicinity. They also state that life expectancy will increase as a result (Jonker et al., 2014).

Enhance the immune system

Improving the functioning of the body's immune system is another benefit of nature-inclusive building. Researcher Granon Rook (2013) described that a properly functioning immune system depends on the degree of exposure to other organisms. These organisms can be found in people, animals, and the living environment. He mentions that in an urban environment without greenery, exposure to organisms is severely limited, causing the build-up of the immune system to be weaker and allergies, asthma, and eczema to occur more often. Research by Professor Ming Kuo (2015) supports this. She describes that the micro-organisms present in nature, as well as the sight and sound of the natural environment, form an important basis for the immune system and health.

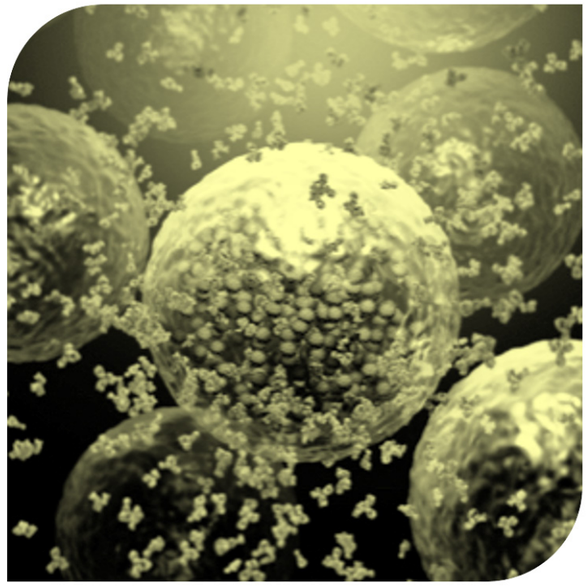

Figure 4: bioMérieux Connection. (2021, October 28). Enhances immune system

2 Benefits of a nature-inclusive building

Enhances mental peace and mind-set

First, nature-inclusive building improves mental peace and state of mind. Researchers Ulrich et al. (1991) found that seeing and hearing a natural environment has a positive effect on emotional states of mind. This follows from a study among 120 test subjects. They were shown a stressful film followed by the image and sound of a natural or urban environment. Both test scenarios were measured with different measurements and personal evaluations and then compared. Professor Stephen Kaplan (1995) mentions the great importance of nature in restoring the state of mind. This concerns both the recovery from short-term stress and long-term depression. Researchers Bratman et al (2015) showed by a test that walking in a natural environment reduced self-conscious complaining. Partly as the nerve activity in the subgenual prefrontal cortex, the brain part involved in emotional regulation. However, this was not the case when walking in an urban environment. This demonstrates the reduced presence of stress and depression symptoms when perceiving a natural environment.

Figure 5: Piceli, G. (n.d.). [Enhanced mental peace and mind-set]

Enhance the quality of the living environment

Nature-inclusive building also improves the quality of the living environment. This happens, as it lowers the ambient temperature, improves the air quality, reduces noise, increases safety, and has aesthetic value. The reduction in temperature takes place in several ways. Firstly, vegetation evaporates water, thereby extracting energy from its surroundings. This lowers the air temperature and the temperature of the objects in its immediate vicinity (Wageningen University & Research, 2018). Secondly, certain types of greenery such as trees, shrubs and plants block solar radiation. The resulting shade provides cooling (Wageningen University & Research, 2018). Thirdly, the use of greenery on façades has an insulating effect. In this way, summer hot air is kept outside and cool air inside the building (Damen & Brouwers, 2012).

Figure 6: [Enhance the quality of the living environment]. (2020, August 18)

The improvement of air quality is again achieved in several ways. First, greenery filters the air. Vegetation, especially trees, absorb air pollutants and particulates that are harmful to health. In addition, vegetation converts carbon dioxide, which is partly responsible for global warming, into fresh oxygen (Hiemstra et al., 2008). As a second feature, greenery can serve as a barrier. It blocks out polluting air and annoying air currents (J. Hiemstra, 2019). As a third, greenery humidifies the air, which is good for one's health (Hiemstra et al., 2008).

The reduction of annoying noise takes place because greenery blocks and absorbs the sounds from outside, but also from inside the building (Van Moorselaar et al., 2014). The degree of reduction depends on many factors, including the type of vegetation and its positioning. Research by Li et al. (2010) shows that people's noise acceptance is greater when they perceive more greenery. This follows from research among 688 participants in Hong Kong. The participants were asked about the extent to which they experience noise pollution. The results were then analysed in combination with their living situation. Nature also produces sounds, such as the rustling of leaves by the wind or the singing of birds, which are mainly experienced as positive (Van Moorselaar et al., 2014).

In addition, greenery increases safety. Research by Wolfe and Mennis (2012) shows that there is a relationship between the degree of greenery and the crime rate in that area. The feeling of safety also increases in a green environment.

Flora and fauna have an aesthetic value as well. An aesthetic value appreciated by an observer has a positive effect on his or her state of mind (Nasar, 1988). In research by Ulrich (1985), the aesthetic quality, together with the emotional experience, was cited as the most important benefit among observers of the natural environment.

Enhances social connections

Social connections between users are also enhanced. In green spaces, people and animals like to come together and build up a connection with each other. In addition, communicating increases the general mood (Stansfeld, 1999).

Figure 7: MStudioImages. (2018, November 20). [Enhances social connections]

2 Benefits of a nature-inclusive building

Potentially providing food

Another advantage of nature-inclusive building is that the vegetation can be or produce food at the same time. In addition, the insects, for which the nature inclusive building is partly intended, help with the pollination of the vegetation. (McGregor, 1971).

Enhance biodiversity

Nature-inclusive building is also good for biodiversity. On the one hand, it creates a wide variety of flora. On the other hand, under suitable living conditions, it will maintain or increase the diversity of fauna (Econsultancy, n.d.). A Nature-inclusive design is based on improving the living conditions for fauna by providing their three basic needs, namely housing, food, and protection (Vogelbescherming, 2019). They also mention the importance of diverse habitats.

Figure 8: Tucker, A. (2014). Enhance biodiversity [Picture]. New England

3 Case study Groenmarkt Amsterdam

Figure 9: Buro Harro. (n.d.). Façades and roof of the nature-inclusive building on the Groenmarkt in Amsterdam

Figure 10: Buro Harro. (n.d.). Perspective of the nature-inclusive building

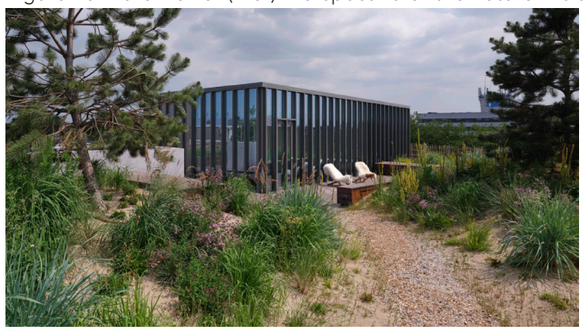

Figure 11: Buro Harro. (n.d.). Roof of the building

Figure 12: Buro Harro. (n.d.). Roof of the building

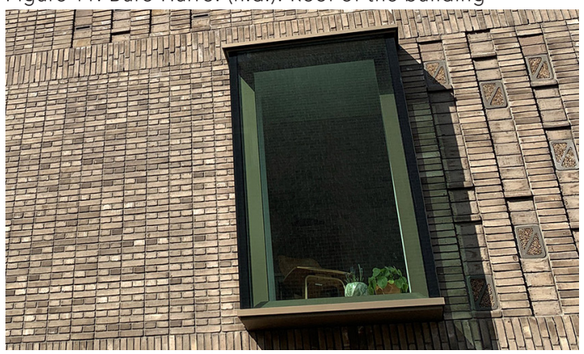

Figure 13: Buro Harro. (n.d.). Façade of the building

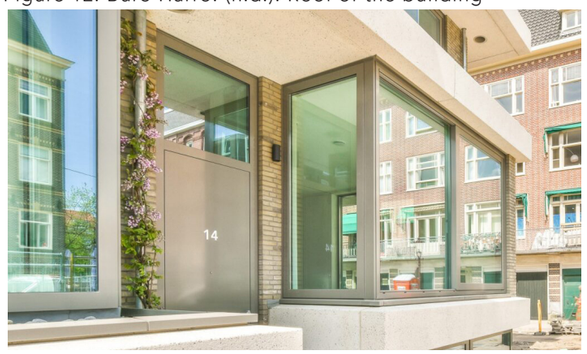

Figure 14: FRIS Woningmakelaars Amsterdam. (n.d.). The large windows in the building

The residential building on the Groenmarkt in Amsterdam, constructed in 2021 and designed by Buro Harro, is a good example of a nature-inclusive building. The building is a part of the city where man and nature come together. The residential building consists of 35 diverse apartments with a parking basement, which provides more space for the users. The brick facades fit well into the context. In addition, accommodations for bats, birds, and insects have been included, which appear like modern ornaments. Climbing plants grow on the façades right through the spacious balconies. The balconies, bay windows and large window panels provide a good view of the varied biodiversity. A generous roof landscape has been designed on top of the building. This landscape consists of hills of sea sand covered with flourishing native plants, between which meandering shell paths run. There are even pine trees growing there. On the roof, there is a large saltwater swimming pool, terrace, and beach pavilion. This roofscape is the ideal place for residents to gather, engage activities and enjoy nature. The natural environment improves health, the immune system and well being of the residents (Miles, 2007; Kuo, 2015; Ulrich et al., 1991). The building is connected to a small green park by a wide pavement, which invite use. The other side of the building is connected to the adjacent water by a stepped vegetated quay. (Buro Harro, 2021; Groenmarkt Ontwikkeling, 2021)

4 The aimed fauna species

This chapter will examine which fauna species foraging in the Dutch urban environment would benefit from more nature-inclusive buildings. Not all animal groups will be considered, but only birds, mammals, and insects (butterflies and bees).

4.1 Importance of the urban environment

Research by the Compendium voor de Leefomgeving (2018) shows that there are around 27,000 animal species in the Netherlands. Some of these species are highly dependent on the urban environment. Research by Lahr et al. (2014) shows, using a cross-section of the Dutch species register, that 1.6% of the animal species occurring in the Netherlands are entirely dependent on the urban environment and 8.7% are to a large extent reliant. They state that a large proportion of these are plants, insects, and small freshwater creatures, but birds, mammals, reptiles, and amphibians are also mentioned. This preference of certain animal species appears to result, partly, from the fact that it is warmer in cities than in the surrounding area, due to which water is less likely to freeze in winter (Compendium voor de Leefomgeving, 2020). In addition, animals house themselves in or on the façades of buildings, which are predominantly more dry and warmer than the surrounding area (Ottburg et al., n.d.). Additionally, there is a lot of food to be found in the city, such as human waste and numerous rodent species. The many artificial lights attract plenty of insects that are a source of food for bats and swallows, for example (Ottburg et al., n.d.).

Figures 15 and 16 show the trends of Dutch urban breeding birds and butterflies. These trends show that the populations of these animal groups have declined significantly in this environment in recent decades. Similar sounds could be heard from bee and mammal populations in recent years. However, these populations seem to be stabilizing, partly due to the improvement of the living environment (RTL Nieuws, 2021). This illustrates the importance of improving the living conditions for animals in the city.

Dutch urban breeding birds

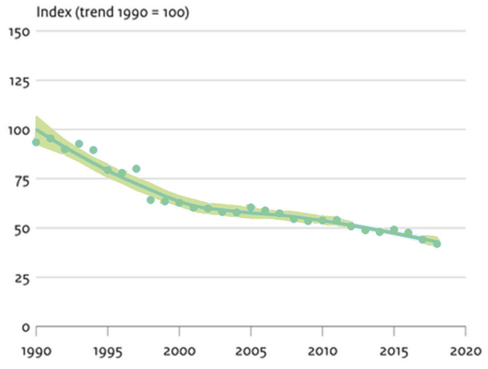

Figure 15: Sovon. (2018, December). [Population trend of Dutch urban breeding birds]

Dutch urban daytime butterflies

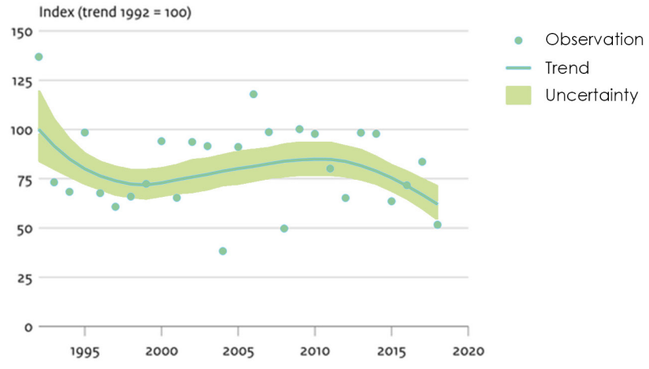

Figure 16: De Vlinderstichting. (2017, November 30). [Population trend of Dutch urban daytime butterflies]

4.2 Selected fauna species

Lahr et al. (2014) conducted a geographical analysis among a selected group of plant and animal

Birds

Species (Lahr et al., 2016)		Housebrooders (Kooijmans, 2014)	Holebrooders	Street green birds	Bushbirds	Treebirds	Parc- & gardenbirds	Water- & marshland birds	Pioneering birds	Fieldbirds	National distribution (Sovon, n.d.)
Urban											
Boomkruiper	- Treecreeper		○			●	○				Entire country
Ekster	- Magpie			○		●	○				Entire country
Gaai	- Jay					○	●				Entire country
Gierzwaluw	- Swift	●									Entire country
Groenling	- Greenfinch			○	○	○	●		○	○	Entire country
Heggenmus	- Hedge sparrow				●		○				Entire country
Houtduif	- Wood pigeon					●	○				Entire country
Huismus	- House sparrow	●	○		○		○		○	○	Entire country
Kauw	- Jackdaw	●	○				○		○	○	Entire country
Kokmeeuw	- Bl.-headed gull	○						○	●		Coastal regions & m.
Koolmees	- Great tit		●	○		○	○				Entire country
Meerkoet	- Common coot							●			M., N. & W. country
Merel	- Blackbird			○	○	○	●				Entire country
Pimpelmees	- Blue tit		●	○		○	○				Entire country
Roodborst	- Robin				○		●				Entire country
Spreeuw	- Starling	●	○			○	○				Entire country
tjiftjaf	- Chiffchaff			○	○	●	○				Entire country
Turkse tortel	- Turkish tutle dove					●					Entire country
Vink	- Chaffinch			○		●	○				Entire country
Wilde eend	- Mallard							●			M., N. & W. country
Winterkoning	- Wren				●		○				Entire country
Zanglijster	- Song thrush				○		●				Entire country
Zilvermeeuw	- Herring gull	○						○	●		Coastal regions
Zwarte kraai	- Carrion crow					●				○	Entire country
Zwartkop	- Blackcap				○	●	○				M., E. & S. country
Urban drift											
Blauwe reiger	- Grey heron					●		○			Entire country
Neutral											
Canadese gans	- Canadian goose							●			Entire country
Huiszwaluw	- House martin	●									Entire country
K. mantelmeeuw	- L. bl.-backed gull	○						○	●		Coastal regions
Waterhoen	- Moorhen							●			Entire country

Illustrations from (Vogelbescherming Nederland, n.d.)

Figure 17: Bird species dependent on Dutch cities

4 The aimed fauna species

species to gain quantitative and qualitative insight into the extent to which the selected species are dependent on the Dutch urban environment. For the selection, they included vascular plants, butterflies, dragonflies, amphibians, reptiles, birds, and mammals from all Dutch species. Then they looked at what part of these occurred on the Red Lists and the Habitats and Birds Directives. The species were then filtered on the basis of previous research and experts. Furthermore, the list was extended with birds, so all bird varieties would be analysed. The final list consisted of 347 species. A grid was then placed over the geographical map of the Netherlands and the degree of urbanisation was determined for each grid block. A GIS study of the selected 347 species was performed using observation data from the Nationale Databank Flora en Fauna (NDFF). From this, the degree of urbanisation was determined. (Lahr et al., 2014)

Figure 17 shows a list of bird species ranked by the degree of dependence on the city (urban, urban drift and neutral) based on the study by Lahr et al. (2014). In addition, the location of each species' preferred nesting sites (the green and white dots) is identified. Furthermore, the national distribution is described. The figure shows that the swift, house martin, house sparrow, starling, and jackdaw nest in or on the facades of Dutch urban buildings. For this reason, these species will be targeted in the nature-inclusive aspects of the exterior façade. For the nature-inclusive aspects concerning the immediate surrounding, the entire list will be addressed.

The list for mammals was drawn up in a similar way (Figure 20). For each species it is defined where they like to stay (the green and white dots). In addition, the national distribution is described. The common, nathusius and soprano pipistrelle, serotine bat, lesser horseshoe bat, and parti-coloured bat live in or on the façades of Dutch urban buildings. For this reason, these species will be targeted in the nature-inclusive aspects of the exterior façade. For the nature-inclusive aspects of the immediate surrounding, the entire list will be considered. Exceptions to this are the polecat, stoat, weasel, vole, and black rat, due to the great disturbance these species could potentially cause.

In addition, there are more than 2,400 species of butterflies in the Netherlands (De Vlinderstichting, n.d.). These are divided into 53 daytime butterfly species and the rest are nighttime butterflies. De Vlinderstichting states that there are plenty of opportunities for butterflies in the city if the design and management of green spaces is modified. Besides,

Figure 18: Emco Home. (n.d.). [Bees]

Figure 19: 123RF. (n.d.). [Butterfly]

Mammals

Species (Lahr et al., 2016)		Building inhabitant (Zoogdiervereniging, n.d.)	Hole inhabitant	Cave inhabitant	Tree inhabitant	Bush inhabitant	Lodge inhabitant	National distribution (NDFF, n.d.)
Urban								
Egel	- Hedgehog		○			●		Entire country
Gewone dwergvleermuis	- Common pipistrelle	●		○	○			Entire country
Konijn	- Rabbit		●					Entire country
Laatvlieger	- Seratine bat	●		○				Entire country
Urban drift								
Ruige dwergvleermuis	- Nathusius pipistrelle	●			○			Entire country
Neutral								
Bever	- Beaver		●				●	M., E. & S. country
Bunzing	- Polecat		●					Entire country
Grote bosmuis	- Wood mouse		●		○			E. & S. country
Hermelijn	- Ermine							Entire country
Kleine dwergvleermuis	- Soprano pipistrelle	●			○			Entire country
Kleine hoefijzerneus	- Lesser horseshoe bat	●		○				S. country
Ondergrondse woelmuis	- Field vole		●					E. & S. country
Otter	- Otter		●			○	○	M., N. & E. country
Rosse vleermuis	- Noctule bat	○			●			Entire country
Tweekleurige vleermuis	- Parti-coloured bat	●		○				Entire country
Waterspitsmuis	- Water shrew		●					Entire country
Wezel	- Weasel		●					Entire country
Woelrat	- Vole		●					S. country
Zwarte rat	- Black rat	●	○	○	○			Entire country

Figure 20: Mammal species dependent on Dutch cities

there are 358 bee species in the Netherlands (Groen Kennisnet, 2021). The Nederlandse Entomologische Vereniging (2021) states that more than 100 of these species could be found in cities. Because large groups of butterflies and bees are dependent on the city, both the nature-inclusive aspects regarding the exterior façade and the immediate surrounding will focus on these insect groups and no specific species will be mentioned.

4 The aimed fauna species

4.3 Fauna species on the red lists

The Ministerie van Landbouw, Natuur en Voedselkwaliteit (n.d.) also regularly publishes red lists of various groups of animal species. These lists are based on population trends and rarity and show which Dutch species are threatened or already extinct. The Ministry carries out actions to maintain the species on these red lists. Of the 196 Dutch breeding birds, as many as 94 are on the Red List (Ministerie van Landbouw, Natuur en Voedselkwaliteit, n.d.). Of the 87 Dutch mammals, 28 are on the same list (Ministerie van Landbouw, Natuur en Voedselkwaliteit, n.d.). Of these animal groups, those on the red lists are shown in red in Figures 17 and 20. Of the urban birds, only the house sparrow and house martin are on that list. A larger number of urban mammals are threatened, including the hedgehog, rabbit, and seratine bat. Butterflies and bees are equally in bad condition. There are 52 butterfly species and 219 bee species on the Red Lists (Ministerie van Landbouw, Natuur en Voedselkwaliteit, n.d.). Particularly the highly endangered and rare species would benefit from more nature-inclusive buildings in the urban environment.

4.4 Information about species

Swift

Recognition

The swift is a completely brown bird with a light throat patch. It has long sickle-shaped wings, a forked tail with a short bill and legs. It is 16.5 cm tall and spends much of its time flying. They sleep, mate, bathe, and drink in the air. Swifts can often be seen flying and shouting in groups. (König, 2001; Vogelbescherming Nederland, n.d.)

Figure 21: Vogelbescherming Nederland. (n.d.-f). [Urban housebrooders]

Distribution and number

The swift is found throughout the Netherlands. In 2018 to 2020, 45,000-70,000 breeding pairs were counted. The bird winters in Africa and stays in the Netherlands from mid-April until mid-August. The number of wintering swifts is unknown. (König, 2001; Sovon, n.d.)

Habitat and food

They like to forage in the vicinity of open greenery or water. This does not have to be present in the immediate vicinity. Their nesting place is preferably located in an area with little or no woodland. They hunt in the air in various habitats in cities and towns for flying insects, such as mosquitoes, hoverflies, day and night moths. For their young they make insect balls which they feed on. (König, 2001; Vogelbescherming Nederland, n.d.)

Breeding

The swift uses cavities in buildings for nesting. They use the nesting place year after year with the same partner. If enough nesting places are available, they like to breed in groups. The specific housing requirements are described in the chapter on nature-inclusive fauna possibilities. They brood in May and June, with a single clutch of 2 to 3 eggs. The breeding period is 18 to 22 days. (König, 2001; Vogelbescherming Nederland, n.d.)

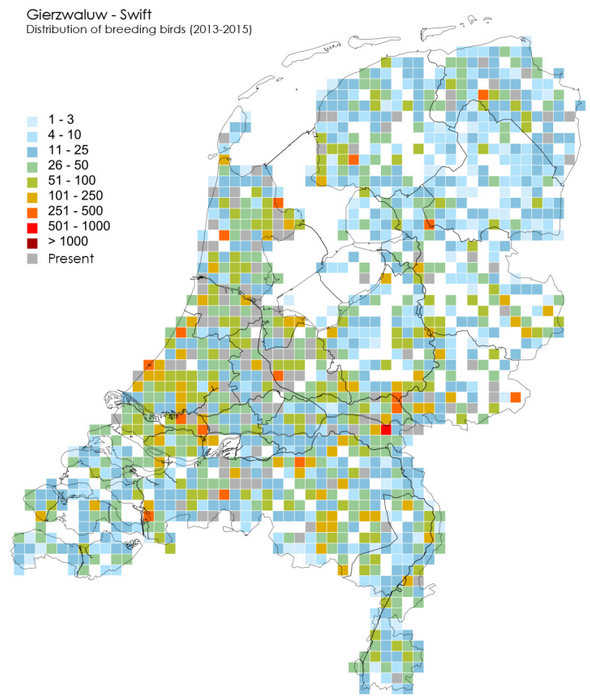

Figure 22: Sovon. (n.d.-j). [Distribution of breeding swifts]

4 The aimed fauna species

House martin

Recognition

The house martin has a black and blue upperpart with a white rump. The underside is completely white. They have a forked tail, short bill and legs. The bird measures 12.5 cm. (König, 2001; Vogelbescherming Nederland, n.d.)

Figure 23: Vogelbescherming Nederland. (n.d.-f). [Urban housebrooders]

Distribution and number

The house martin is found throughout the Netherlands. In 2018 until 2020, 85,000-120,000 breeding pairs were counted. The bird winters in Africa and is present in the Netherlands from mid-April to the end of October. Compared to the end of the 1960s, the number of house martins has declined by 75%. The decline was particularly noticeable in the large cities. Currently, a narrow recovery seems to be visible. (König, 2001; Sovon, n.d.)

Habitat and food

House martins live in open areas near buildings and bridges. They make their nests with clay and sand that they find near pools and ditches. They catch flying insects, such as mosquitoes, in the air above watery places. (König, 2001; Vogelbescherming Nederland, n.d.)

Breeding

The house martin makes bowls on buildings or breeds in nest boxes on buildings. The specific housing requirements are described in the chapter on nature-inclusive fauna possibilities. They like to breed in colonies from mid May till the beginning of August and have 2 to 3 clutches of 4 to 6 eggs. The breeding period is 13 to 16 days. (König, 2001; Vogelbescherming Nederland, n.d.)

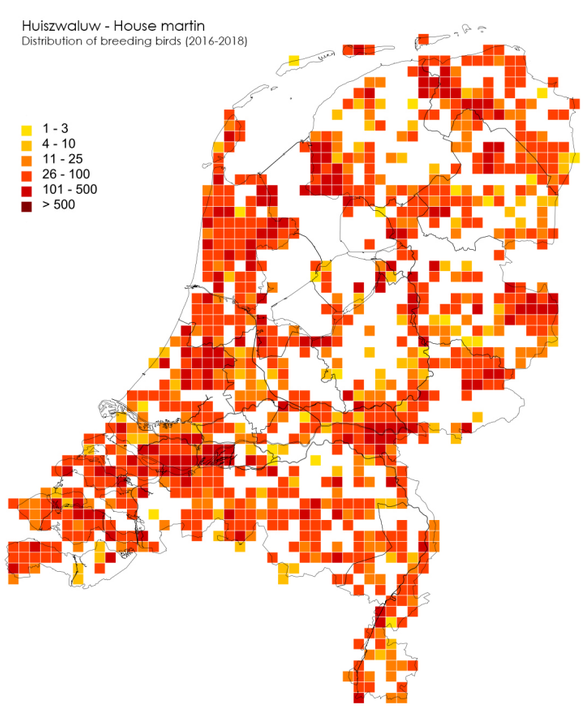

Figure 24: Sovon. (n.d.-a). Distribution of breeding house martins

House sparrow

Recognition

The male and female have a different appearance. The male has a brown striped top with a black breast, grey head, cheeks, and underside. It has a comparatively large grey bill and head with short pink legs. The female is lighter brown in colour and has a grey underside. The bill is yellow. The house sparrow has a size of 14.5 cm. (König, 2001; Vogelbescherming Nederland, n.d.)

Figure 25: Vogelbescherming Nederland. (n.d.-f). [Urban housebrooders]

Distribution and number

The house sparrow is found throughout the Netherlands. From 2018 to 2020, 600,000-1,000,000 breeding pairs were counted. This bird species is present throughout the year. Since the late 1980s, the number of breeding pairs has declined by 50%. Currently, the numbers seem to stabilize. (König, 2001; Sovon, n.d.)

Habitat and food

House sparrows like to live in a messy human environment, with shrubs, sheds, and meadows. They do not like environments with many tall trees. House sparrows like to take dust and water baths. House sparrows have a diverse diet consisting of seeds, grains, peanuts, berries, flower buds, fat balls, bread, and insects. (König, 2001; Vogelbescherming Nederland, n.d.)

Breeding

The house sparrow likes to nest in or on buildings in loose colonies. The specific housing requirements are described in the chapter on nature-inclusive fauna possibilities. They do this from the end of March until August and have 3 to 5 clutches of 4 to 6 eggs. The breeding period is 11 to 14 days. (König, 2001; Vogelbescherming Nederland, n.d.)

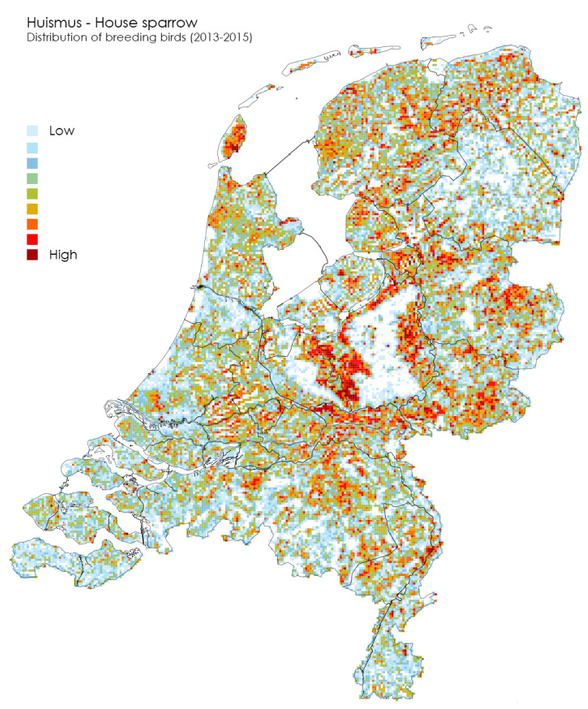

Figure 26: Sovon. (n.d.-b). Distribution of breeding house sparrows

4 The aimed fauna species

Starling

Recognition

In the winter months, the starling has a different plumage than during the breeding season. During the winter months, the starling has black plumage with purple-green highlights, white breast patches and a grey bill. During the breeding season, the starling has green, blue and purple stripes on its back and a yellow bill. The starling has a size of 22 cm. It is often seen in large groups parading through the air. (König, 2001; Vogelbescherming Nederland, n.d.)

Figure 27: Vogelbescherming Nederland. (n.d.-f). [Urban housebrooders]

Distribution and number

The starling is found throughout the Netherlands. From 2018 to 2020, 400,000-700,000 breeding pairs were counted. Part of the starlings migrate to neighbouring countries from November to March. In addition, starlings from Northern and Eastern Europe spend the winter in the Netherlands. Since the 1970s, the number of breeding pairs has declined (König, 2001; Sovon, n.d.).

Habitat and food

Starlings like to forage in cities and villages on lawns and wet and dry grasslands. Here they look for insects and their larvae. In winter they eat a lot of berries and fruit. (König, 2001; Vogelbescherming Nederland, n.d.)

Breeding

The starling likes to nest in or on buildings. It is not a colony breeder, but does like to breed near other starlings. The specific housing requirements are described in the chapter on nature-inclusive fauna possibilities. They do this from mid April to June and have 1 to 2 clutches of 5 to 7 eggs. The breeding period is 11 to 15 days. (König, 2001; Vogelbescherming Nederland, n.d.)

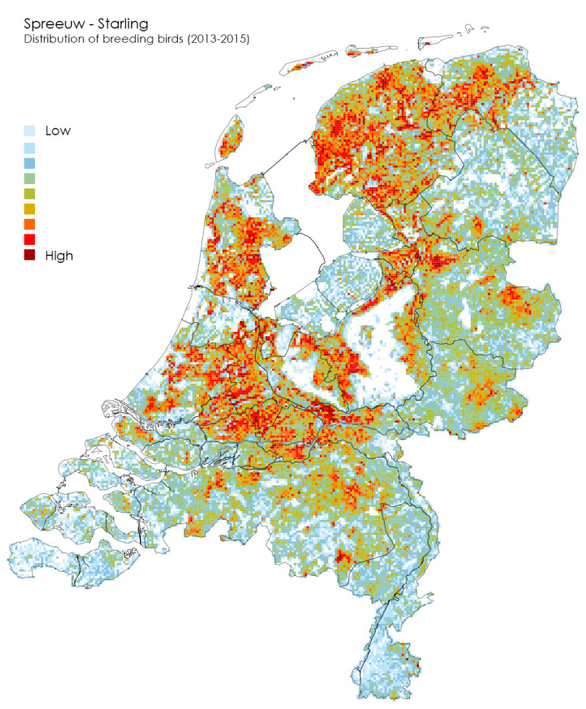

Figure 28: Sovon. (n.d.-c). Distribution of breeding starlings

Jackdaw

Recognition

The jackdaw has grey-black plumage with a grey neck and back of head. It has a black bill and legs and a relatively long tail. This 33cm smart bird likes to live in groups. (König, 2001; Vogelbescherming Nederland, n.d.)

Figure 29: Vogelbescherming Nederland. (n.d.-f). [Urban housebrooders]

Distribution and number

The jackdaw is found throughout the Netherlands. From 2018 to 2020, 100,000-150,000 breeding pairs are counted. Jackdaws from Northern and Eastern Europe also winter in the Netherlands from the end of October to the beginning of April. Since 1990, no major change in the population has been observed. The last decade the population seems to be increasing. (König, 2001; Sovon, n.d.).

Habitat and food

Jackdaws like to forage in built-up areas and are often found on lawns. They are true omnivores. They eat insects, snails, worms, buds, seeds, berries, and waste. The young and eggs of other species are also on the menu. For this reason, this bird species may not be desirable in combination with other animal species. (König, 2001; Vogelbescherming Nederland, n.d.)

Breeding

The jackdaw likes to nest in or near buildings. It is not a colony breeder, but does like to nest in the vicinity of other jackdaws. The specific housing requirements are described in the chapter on nature-inclusive fauna possibilities. They usually have the same partner for their entire life. They brood from April to June and usually have one clutch of 3 to 8 eggs. The breeding period is 17 to 19 days. (König, 2001; Vogelbescherming Nederland, n.d.)

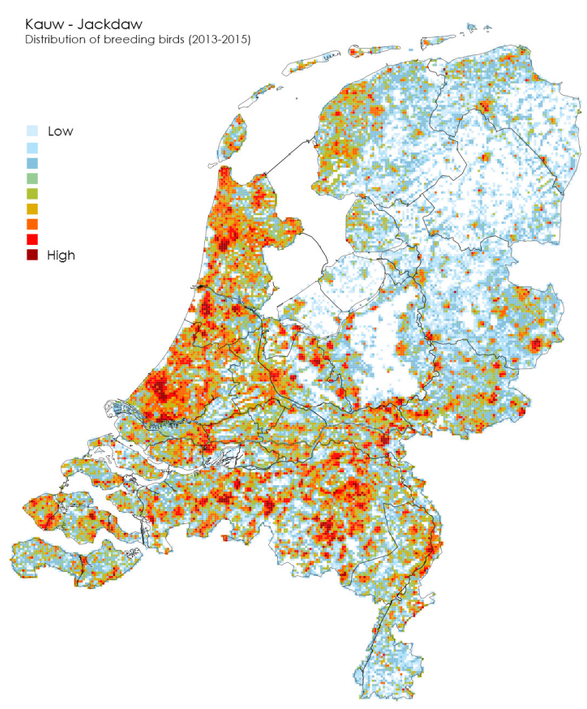

Figure 30: Sovon. (n.d.-k). [Distribution of breeding jackdaws]

4 The aimed fauna species

Common pipistrelle

Recognition

The common pipistrelle has reddish-brown to dark brown fur on its back and grey-brown fur on its belly. The bat has small brown-black ears, face, and wing membrane. The wings are long and narrow. This bat species is one of the smallest in Europe with a body length of 5.1 cm and a wingspan of 18-24 cm. The common pipistrelle is active in the evening and at night and hunts by means of high-pitched sounds. (Diversen, 2003; Zoogdiervereniging, n.d.)

Figure 31: Common pipistrelle

Distribution and number

The common pipistrelle is found throughout the Netherlands and winters here. This species currently has the status of not threatened, but is still on the red list. (Diversen, 2003; NDFF Verspreidingsatlas, n.d.)

Habitat and food

The common pipistrelle likes to forage in open and semi-open areas in green built-up areas near forest edges, tree-lined avenues, banks, waterways, ponds, puddles, and streetlights. The foraging area should be at a distance of 2 to 5 km from the accommodation. These bats mainly hunt insects, such as mosquitoes, moths, hoths, glass flies, and beetles. (Diversen, 2003; Zoogdiervereniging, n.d.)

Carrying

The common pipistrelle likes to live in or attached to the same buildings. The specific housing requirements are described in the chapter on nature-inclusive fauna possibilities. This bat species breeds in colonies of dozens to a few hundred females. The female has one or two pregnancies of 6 to 8 weeks per year, after which she gives birth to one or two young. (Diversen, 2003; Zoogdiervereniging, n.d.)

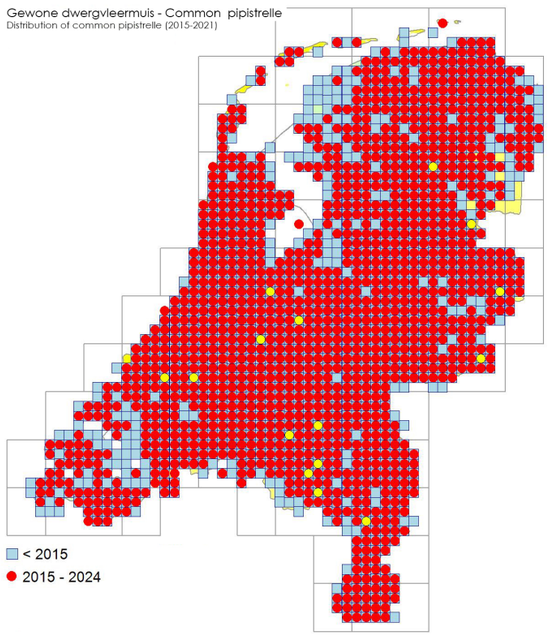

Figure 32: NDFF Verspreidingsatlas. (n.d.-h). [Distribution common pipistrelle]

Serotine bat

Recognition

The serotine bat has a dark brown fur on the back and a light brown fur on the belly. The hairs have grey tips. The bat has small brown-black ears, face, and wing membrane. This bat species is one of the largest species in the Netherlands with a body length of 8.2 cm and a wingspan of 32-38 cm. The serotine bat is active in the evening and at night and hunts by means of high-pitched sounds. (Diversen, 2003; Zoogdiervereniging, n.d.)

Figure 33: Seratine bat

Distribution and number

The serotine bat is found throughout the Netherlands and winters here. This species currently has the status of vulnerable and is on the red list. (Diversen, 2003; NDFF Verspreidingsatlas, n.d.)

Habitat and food

The serotine bat likes to forage in open and semi-open areas near woodland edges, tree-lined avenues, hedges, and damp grass fields, as well as over waterways, ponds, and puddles. The foraging area should be located at a distance of 1 to 5 km from the nest site. Bats hunt mainly insects, such as mosquitoes, moths, and beetles. (Diversen, 2003; Zoogdiervereniging, n.d.)

Carrying

The serotine bat likes to live in or near the exact same buildings. The specific housing requirements are described in the chapter on nature-inclusive fauna possibilities. This species of bat breeds in colonies of 50-100 females. The female has a single pregnancy of 6 to 8 weeks, after which she gives birth to a single young. (Diversen, 2003; Zoogdiervereniging, n.d.)

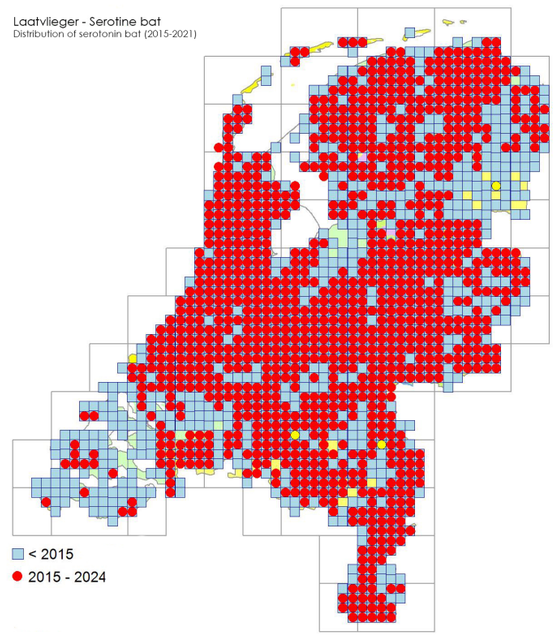

Figure 34: NDFF Verspreidingsatlas. (n.d.-f). [Distribution of serotonin bat]

4 The aimed fauna species

Nathusius pipistrelle

Recognition

The nathusius pipistrelle is very similar to the common pipistrelle. This species has reddish brown to dark brown fur on the back and greyish brown on the belly. Part of the tail and the wings are hairy. The bat has small brown-black ears, face, and wing membrane. The wings are long and narrow. This species of bat is quite small and has a body length of 5.5 cm and a wingspan of 23-25 cm. Nathusius pipistrelle is active in the evening and at night and hunts by means of high-pitched sounds. (Diversen, 2003; Zoogdiervereniging, n.d.)

Figure 35: Nathusius pipistrelle

Distribution and number

The nathusius pipistrelle is found throughout the Netherlands and winters here. Other animals of this species from central and Eastern Europe also hibernate in the Netherlands from September to spring. The nathusius pipistrelle is currently on the red List. (Diversen, 2003; NDFF Verspreidingsatlas, n.d.)

Habitat and food

The nathusius pipistrelle likes to forage in semi-open wooded areas near forest edges, tree-lined avenues, banks, watercourses, ponds, puddles, and streetlights. Buildings and open areas are less popular. The foraging area must be at a distance of 5 to 10 km from the roost. These bats mainly hunt insects such as mosquitoes. (Diversen, 2003; Zoogdiervereniging, n.d.)

Carrying

The nathusius pipistrelle also lives in or near the same buildings every year. The specific housing requirements are described in the chapter on nature-inclusive fauna possibilities. This bat species breeds in colonies of 50 to 150 females. The female has one or two pregnancies of 6 to 8 weeks per year, after which she gives birth to one or two young. (Diversen, 2003; Zoogdiervereniging, n.d.)

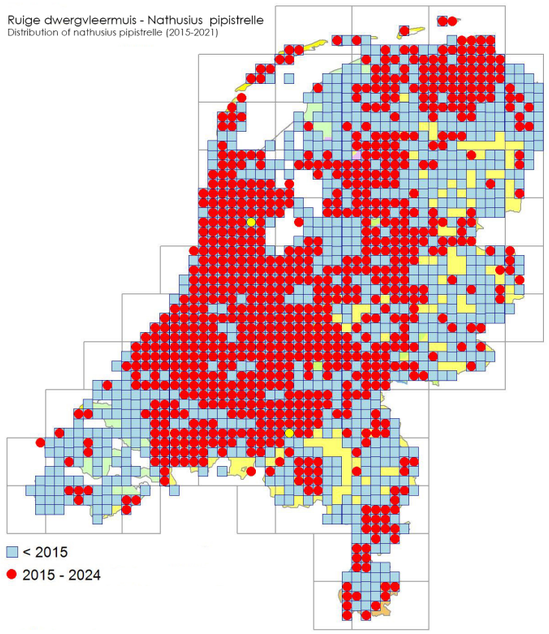

Figure 36: NDFF Verspreidingsatlas. (n.d.-g). [Distribution nathusius pipistrelle]

Soprano pipistrelle

Recognition

The soprano pipistrelle is very similar to the common pipistrelle. This species has reddish brown to dark brown fur on the back and greyish brown fur on the belly. The bat has small brown-black ears, face, and wing membrane. The nose, mouth and ears are lighter in colour. The wings are long and narrow. This bat species is one of the smallest species in Europe with a body length of 4.8 cm and a wingspan of 24 cm. The soprano pipistrelle is active in the evening and at night and hunts by means of high-pitched sounds. (Zoogdiervereniging, n.d.)

Figure 37: Soprano pipistrelle

Distribution and number

The soprano pipistrelle is found throughout the Netherlands. At the moment, it is unknown whether this species spends the winter here. The species is on the red list. (NDFF Verspreidingsatlas, n.d.)

Habitat and food

The soprano pipistrelle likes to forage in water- and tree-rich areas near forest edges, tree-lined avenues, gardens, banks, waterways, ponds, and streetlamps. These bats mainly hunt insects such as mosquitoes. (Zoogdiervereniging, n.d.)

Carrying

The soprano pipistrelle likes to live in or near buildings. The specific housing requirements are described in the chapter on nature-inclusive fauna possibilities. This bat species breeds in colonies of on average 200 females, but also colonies consisting of thousands of animals are known. The female has one or two pregnancies of 6 to 8 weeks per year, after which she gives birth to one or two young. (Zoogdiervereniging, n.d.)

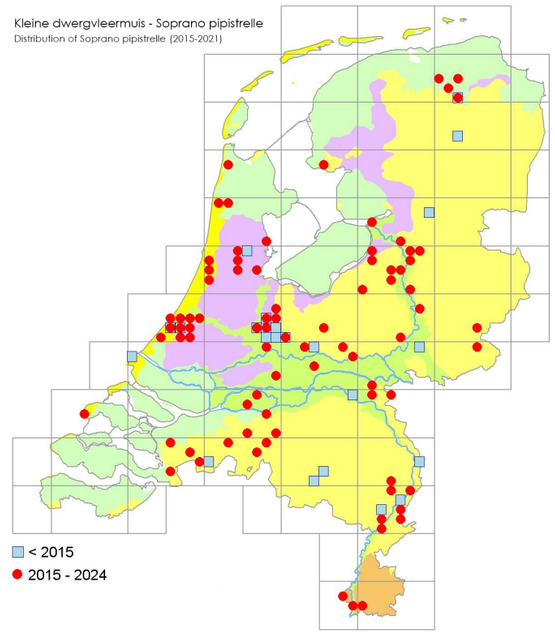

Figure 38: NDFF Verspreidingsatlas. (n.d.-h). [Distribution soprano pipistrelle]

4 The aimed fauna species

Lesser horseshoe bat

Recognition

The Lesser horseshoe bat has a brown fur on the back and white-grey fur on the belly. The bat has a greyish brown nose, ears, and broad wing membrane. On the nose it has a horseshoe-shaped skin seam. It is a small bat species with a body length of 4.5 cm and a wingspan of 25 cm. The Lesser horseshoe bat is active in the evening and at night and hunts by means of high-pitched sounds. (Diversen, 2003)

Figure 39: Lesser horseshoe bat

Distribution and number

The Lesser horseshoe bat is only found in the South of the Netherlands, where it also winters. The species is on the red list and has been assigned the status of disappeared. (NDFF Verspreidingsatlas, n.d.)

Habitat and food

The Lesser horseshoe bat likes to forage in open woodland, limestone areas and parks near bushes. These bats mainly hunt insects, such as mosquitoes, moths, beetles, and spiders. (Diversen, 2003)

Carrying

The Lesser horseshoe bat likes to live in damp buildings. The specific housing requirements are described in the chapter on nature-inclusive fauna possibilities. This bat species breeds in colonies of 50 to 500 females. The female has one pregnancy of 6 to 8 weeks per year, after which she gives birth to one young. (Diversen, 2003)

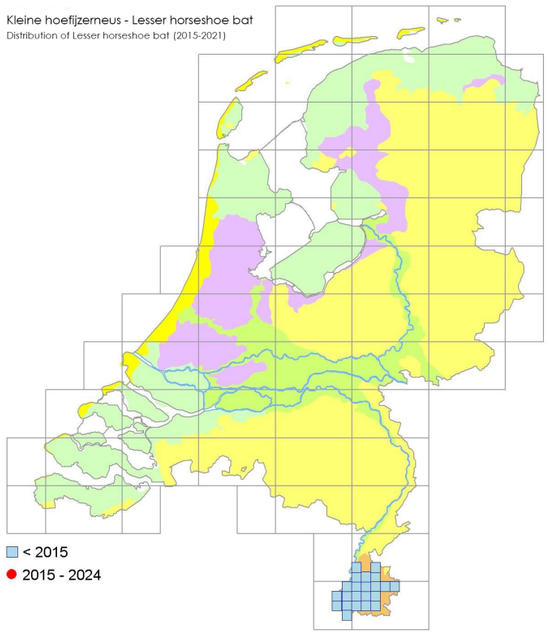

Figure 40: NDFF Verspreidingsatlas. (n.d.-i). [Distribution of lesser horseshoe bats]

Parti-coloured bat

Recognition

The parti-coloured bat has a black fur with light grey hair tips on its back and white-grey fur on its belly. The bat has small brownish black ears, face, and wing membrane. This bat species has a body length of 6.4 cm and a wingspan of 27-33 cm. The parti-coloured bat is active in the evening and at night and hunts by means of high-pitched sounds. (Diversen, 2003; Zoogdiervereniging, n.d.)

Figure 41: Parti-coloured bat

Distribution and number

The parti-coloured bat is found throughout the Netherlands. Some of these species come to the Netherlands to hibernate. This species currently has the status sensitive and is on the red list. (Diversen, 2003; NDFF Verspreidingsatlas, n.d.)

Habitat and food

The parti-coloured bat likes to forage in the urban environment, but can also be found in woody mountainous areas. They forage near the edge of woods, tree-lined avenues, hedgerows, and damp grassy areas, but also over watercourses, ponds, and pools. These bats mainly hunt flying insects. (Diversen, 2003; Zoogdiervereniging, n.d.)

Carrying

The parti-coloured bat likes to live in or near the same buildings. The specific housing requirements are described in the chapter on nature-inclusive fauna possibilities. This bat species breeds in colonies. The female has a single pregnancy of 6 to 8 weeks, after which she gives birth to one or two young. (Diversen, 2003; Zoogdiervereniging, n.d.)

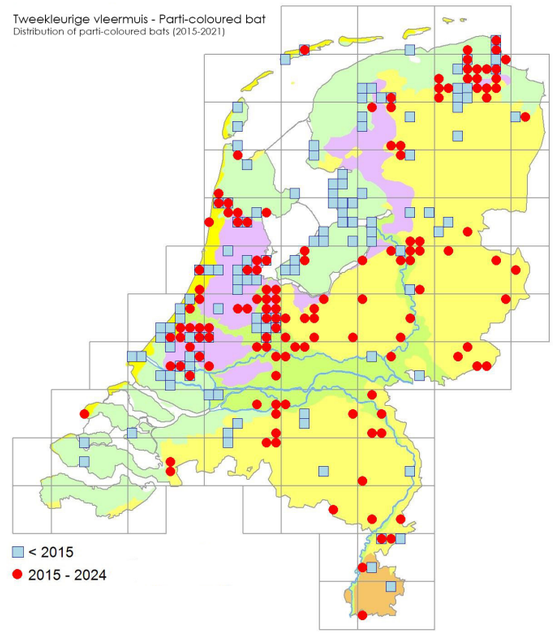

Figure 42: NDFF Verspreidingsatlas. (n.d.-j). [Distribution of parti-coloured bats]

4 The aimed fauna species

Wild bees

Recognition

Bees belong to the group of insects and can be divided into the honeybee and the wild bee. The honeybee is the only species that cannot survive without a beekeeper. For this reason, the focus is on the wild bees. Wild bees include bumblebees and solitary bees. Bumblebees are social bees that live together in groups of several tens to hundreds. Solitary bees, on the other hand, live alone. The different species can differ greatly from one another. In colour and hair, but also the size can vary from a few millimetres to a few centimetres. (IVN Natuureducatie, 2019)

Figure 43: Friends of the Earth. (n.d.). [White-tailed bumblebee].

Habitat and food

Wild bees like to forage in an environment with many different native flowering vegetation types. The nectar and pollen from this flowering vegetation is their food source. The food source should be located near the residence. The distance depends on the species, which can fly several tens to sometimes even several kilometres. (IVN Natuureducatie, 2019)

Oviparous

Some species of wild bees like to nest in or on buildings. The specific housing requirements are described in the chapter on nature-inclusive fauna possibilities. They do this by applying pollen in the nest cavity and then laying an egg on it. The nest cavity is then sealed with mud, plant remains or saliva. After a while, the egg hatches. The pollen serves as a source of food, after which the bee is ready for a new life. (IVN Natuureducatie, 2019)

Butterflies

Recognition

Based on the time of flight, butterflies can be divided into day and night butterflies. Butterflies are cold-blooded animals and are active at temperatures above 20 degrees. The different species of butterflies differ greatly in appearance and size. The smallest butterfly in the Netherlands is only a few millimetres large. The largest can reach 15 cm. The maximum age also varies from a few weeks to a year. (De Vlinderstichting, n.d.)

Figure 44: PNGitem. (n.d.). [Blue butterfly].

Winter period

Butterflies have different techniques to get through the winter from October to February. For example, some butterflies hibernate as an egg, caterpillar, pupa, or butterfly. Certain species migrate to warmer countries. (De Vlinderstichting, n.d.)

Habitat and food

Butterflies like to forage in a warm environment with a wide variety of native flowering vegetation. They use the nectar from flowering vegetation as a source of food. The food source must be located near the accommodation. The young butterflies, called caterpillars, eat from host plants. The desired vegetation types differ for each species. They also like to eat rotting fruit. (De Vlinderstichting, n.d.)

Oviparous

Some butterflies live in or near buildings, to hide, rest or hibernate. These accommodations are discussed in the chapter nature-inclusive fauna possibilities. The eggs are laid by the female butterfly on the host plant. The caterpillars then eat the host plant, after which they become a pupa and then a butterfly. (De Vlinderstichting, n.d.)

5 The nature-inclusive possibilities

In this chapter, the possibilities for a nature-inclusive design are examined. This covers the possibilities for flora, water, and fauna. For fauna, the focus is on the animal species identified in the previous chapter. It concerns the possibilities that apply to the façades and the immediate surroundings of a building. Furthermore, each possibility is described with what should be considered when applying it to a Dutch monumental building. Figure 45 lists the various possibilities. Several design options are described for the various possibilities. It should be mentioned that there are many other possible ways of applying the option. The creativity of the designer is therefore required.

The nature-inclusive possibilities

Flora	Water	Fauna
Green roof	Blue roof	Fauna residences
Extensive green roof	Natural pond	Bird accomodations
Semi-intensive green roof	Ecological puddle	Mammal accomodations
Intensive green roof	Natural wadi	Insect accommodations
Roof garden	Natural bank	Connecting ecological structurea
Brown roof	Floatland	Preventing window casualties
Façade greenery		Preventing annoying light emission
Green (quay) walls		
Trees		
Shrubs and hedges		
(Flowery) planting		
Natural pavement		
Stacked branches and tree trunks		

Figure 45: The nature-inclusive possibilities regarding flora, water, and fauna

6 The nature-inclusive flora possibilities

6.1 Green roof

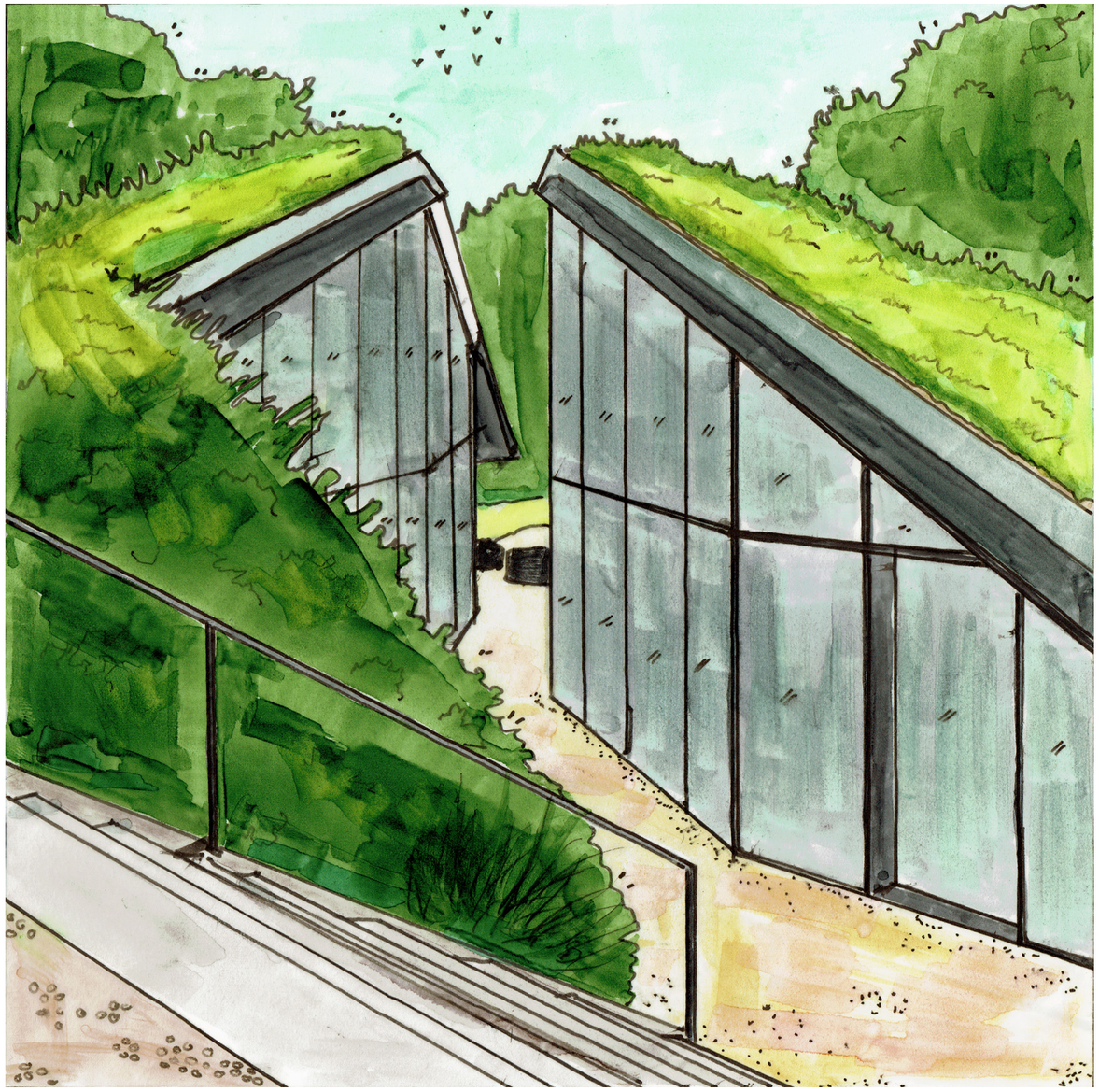

Figure 46: Nature-inclusive possibility: green roof

A green roof is a roof covered with vegetation. Besides having many advantages, which is discussed in chapter one, it is an important surface for both plants and animals. The species of animals that emerge are partly determined by the type of vegetation chosen (Atelier GROENBLAUW, n.d.). A green roof is good for biodiversity, because it acts as a source of food, a place to live and a safe place due to the absence of many types of predators and traffic. Three types of green roofs can be distinguished: extensive, semi-intensive and intensive green roofs. (Gemeente Amsterdam, 2018)

6.1.1 Extensive green roof

An extensive green roof is covered with mosses, sedums, grasses and/ or herbs. Underneath is a thin layer of substrate, a filter and drainage layer. The drainage layer retains water, which is used to water the greenery. Below this is a protection layer and water barrier. The total package has a thickness of 4 to 7 centimeters. On this type of roof, mainly insects can be found (Atelier GROENBLAUW, n.d.). By varying the height of the soil, the green roof becomes suitable for multiple fauna species. Compared to more intensive vegetation, this type of roof requires less maintenance and the costs are lower as well. (Gemeente Amsterdam, 2018)

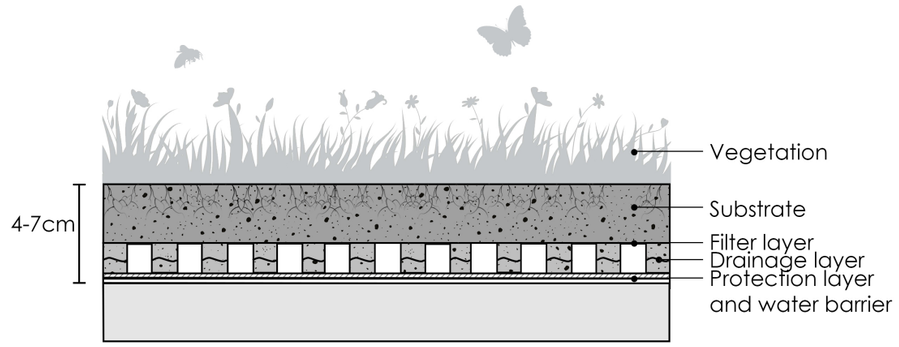

Figure 47: Build-up of an extensive green roof

Points of attention for the application of Dutch monumental buildings

An important point to consider is the monumental value of the roof. The value attributed and its argumentation may be documented in the description of the monument or must be determined based on a value assessment to be performed. If the roof has a high monumental value, it will have to be ascertained if the green roof will be detrimental to this value. On the roof must be enough available space due to installations for example. De Vogelbescherming (n.d.) describes that birds and insects can usually be found up to a height of 150 metres. This means that a green roof can be used functionally up to a great height. A green roof can be applied to many roof types, including flat, curved, and pitched roofs. However, there is a maximum pitch of 60°. Between 35° and 60° additional measures are required. The steeper the angle of inclination, the greater the risk of dehydration (Atelier GROENBLAUW, n.d.). A green roof is possible in all orientations, but the solar demands of the various types of flora must be taken into account. It is essential to check whether the supporting structure can cope with the increasing mass, by the weight of at least 54 kg/m^2 or more (Checklist groen bouwen, n.d.). In addition, exhaust gases can damage the vegetation.

6.1.2 Semi-intensive green roof

A semi-intensive green roof is covered with grasses, herbs and/ or shrubs. Underneath is a layer of substrate, a filter and drainage layer. The drainage layer retains water, which is used to water the greenery. Below this is a protection layer and water barrier. The total package has a thickness of 20 to 40 centimetres. On this type of roof, mainly insects and small birds can be found. By varying the height of the soil, the green roof becomes suitable for multiple fauna species. This type of roof requires maintenance. (Gemeente Amsterdam, 2018)

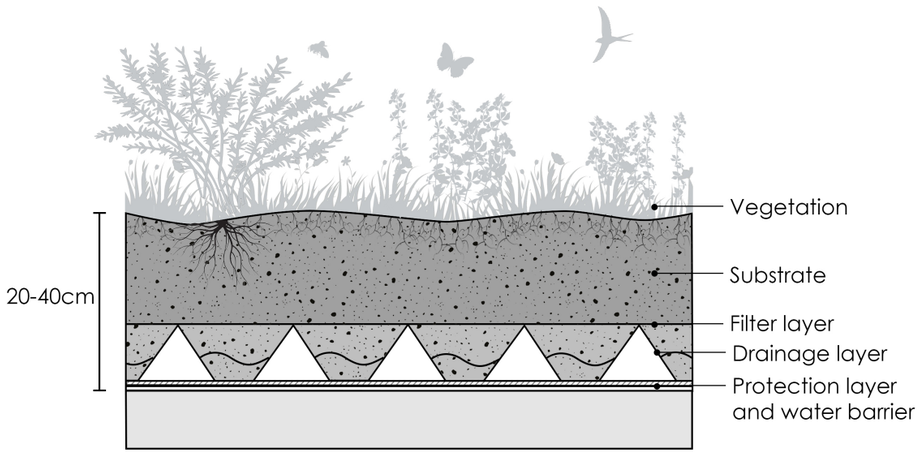

Figure 48: Build-up od an semi-extensive green roof

Points of attention for the application of Dutch monumental buildings

An important point to consider is the monumental value of the roof. The value attributed and its argumentation may be documented in the description of the monument or must be determined based on a value assessment to be performed. If the roof has a high monumental value, it will have to be ascertained if the green roof will be detrimental to this value. On the roof must be enough available space due to installations for example. De Vogelbescherming (n.d.) describes that birds and insects can usually be found up to a height of 150 metres. This means that a green roof can be used functionally up to a great height. A green roof can be applied to many roof types, including flat, curved, and pitched roofs. However, there is a maximum pitch of 45°. Between 35° and 45° additional measures are required. The steeper the angle of inclination, the greater the risk of dehydration (Atelier GROENBLAUW, n.d.). A green roof is possible in all orientations, but the solar demands of the various types of flora must be taken into account. It is essential to check whether the supporting structure can cope with the increasing mass, by the weight of at least 270 kg/m^2 or more. In addition, exhaust gases can damage the vegetation.

6.1.3 Intensive green roof

An intensive green roof is covered with grasses, herbs, shrubs and/ or trees. Underneath is a thick layer of substrate, a filter and drainage layer. The drainage layer retains water, which is used to water the greenery. Below this is a protection layer and water barrier. The total package has a thickness of 80 to 120 centimetres. On this roof, there is a great degree of biodiversity, such as insects and all sizes of birds. By varying the height of the soil, the green roof becomes suitable for multiple fauna species. Compared to extensive vegetation, this type of roof requires more maintenance and higher costs. (Gemeente Amsterdam, 2018)

Points of attention for the application of Dutch monumental buildings

An important point to consider is the monumental value of the roof. The value attributed and its argumentation may be documented in the description of the monument or must be determined

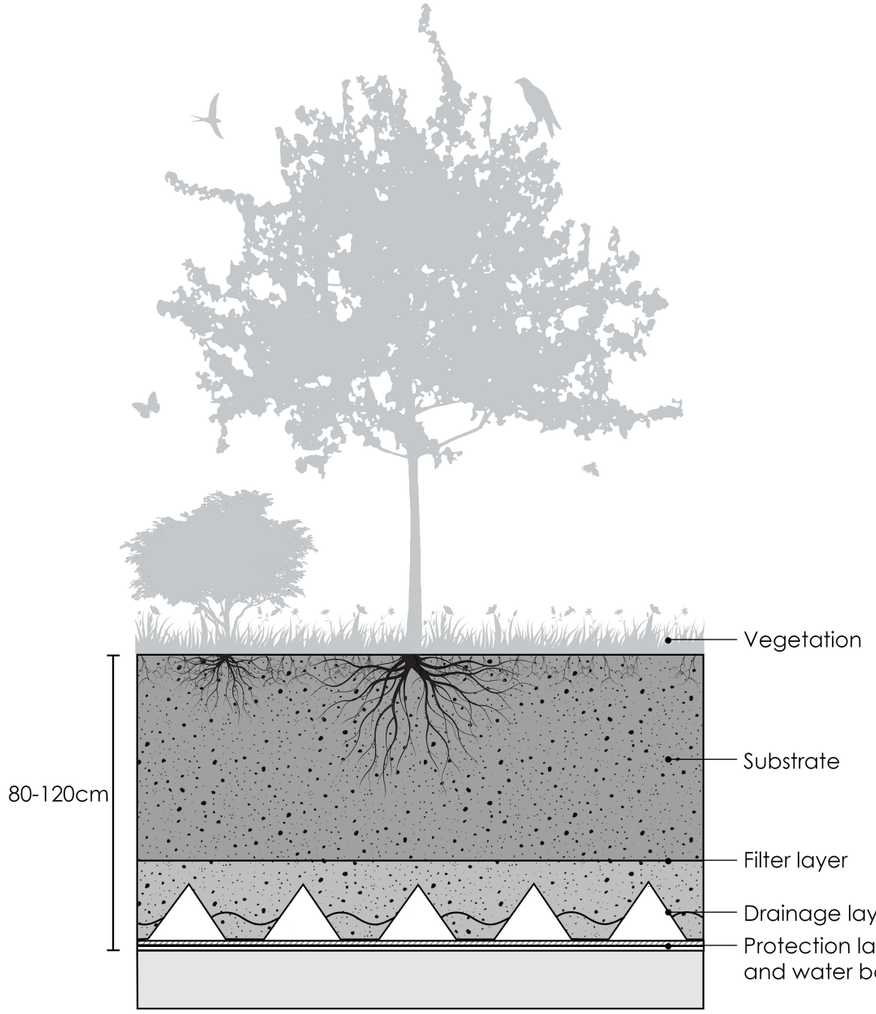

Figure 49: Build-up of an intensive green roof

based on a value assessment to be performed. If the roof has a high monumental value, it will have to be ascertained if the green roof will be detrimental to this value. On the roof must be enough available space due to installations for example. De Vogelbescherming (n.d.) describes that birds and insects can usually be found up to a height of 150 metres. This means that a green roof can be used functionally up to a great height. A green roof can be applied to many roof types, including flat, curved, and pitched roofs. However, there is a maximum pitch of 10°. The steeper the angle of inclination, the greater the risk of dehydration (Atelier GROENBLAUW, n.d.). A green roof is possible in all orientations, but the solar demands of the various types of flora must be taken into account. It is essential to check whether the supporting structure can cope with the increasing mass, by the weight of at least 1,080 kg/m^2 or more. The roof must be accessible for maintenance. In addition, exhaust gases can damage the vegetation.

6 The nature-inclusive flora possibilities

6.2 Roof garden

Figure 50: Nature-inclusive possibility: roof garden

A roof garden is a garden on the roof that is used by both people and animals. There are many variants depending on the use. For example, a vegetable garden, terrace, swimming pool, play or sports field can be located in combination with vegetation (and paving). The animal species that occur depend on the vegetation used. Extensive vegetation is mainly occupied by insects, while birds can be found in more intensive vegetation. Urban bird species like the hedge sparrow, wren, jay, greenfinch, blackbird, robin and song thrush like to nest here. More intensive vegetation ensures greater biodiversity. In addition, a roof garden requires maintenance and high costs. (Gemeente Amsterdam, 2018)

The vegetation can include grasses, herbs, shrubs, and trees. Underneath is substrate, a filter layer, and a drainage system. The last one retains water, so that it can later be used to water the vegetation.

Points of attention for the application of Dutch monumental buildings

An important point to consider is the monumental value of the roof. The value attributed and its argumentation may be documented in the description of the monument or must be determined based on a value assessment to be performed. If the roof has a high monumental value, it will have to be ascertained if the roof garden will be detrimental to this value. On the roof must be enough available space due to installations for example. De Vogelbescherming (n.d.) describes that birds and insects can usually be found up to a height of 150 metres. This means that a roof garden can be used functionally up to a great height. A green roof is best applied to a flat roof. Slightly curved or inclined roofs are also possible. The ability to use them must be taken into account. However, there is a maximum angle of 45°. Between 35° and 45° additional measures are required. The steeper the angle of inclination, the greater the risk of dehydration (Atelier GROENBLAUW, n.d.). A green roof is possible in all orientations, but the solar demands of the users and the various types of flora must be considered. It is essential to check whether the supporting structure can cope with the increasing mass. The roof must be accessible for its users. In addition, exhaust gases can damage the vegetation.

6 The nature-inclusive flora possibilities

6.3 Brown roof

Figure 51: Nature-inclusive possibility: brown roof

A brown roof is an ecological roof covering without a fixed soil composition. A brown roof provides food, shelter, and a safe environment. This is due to the absence of some types of predators and traffic. The roof is used by insects and birds. Urban bird species like the black-headed gull, herring gull and lesser black-backed gull like to nest here. Bees too nest in the soil. A brown roof requires little maintenance (BiodiverCity, 2011). (Gemeente Amsterdam, 2018)

The soil consists of sand, ground (excavated from the area), shell stones and recycled rubble. Stones and old tree wood can also be placed on top. Plants can be planted, but it is best to let them grow spontaneously. A protection layer and a water barrier have been applied under the soil. The total package has a minimum thickness of 10 centimetres. The composition and thickness of the soil influences the biodiversity (Checklist groen bouwen, n.d.).

Points of attention for the application of Dutch monumental buildings

An important point to consider is the monumental value of the roof. The value attributed and its argumentation may be documented in the description of the monument or must be determined based on a value assessment to be performed. If the roof has a high monumental value, it will have to be ascertained if the brown roof will be detrimental to this value. On the roof must be enough available space due to installations for example. De Vogelbescherming (n.d.) describes that birds and insects can usually be found up to a height of 150 metres. This means that a brown roof can be used functionally up to a great height. A brown roof can be applied to many roof types, including flat, curved, and pitched roofs. However, there is a maximum pitch of 10° (NHBC Standards, 2020). A brown roof is possible in all orientations, but the solar demands of the various types of flora must be taken into account. It is essential to check whether the supporting structure can cope with the increasing mass, by the weight of 180 kg/m^2 or more (Checklist groen bouwen, n.d.).

6.4 Facade greenery

Figure 52: Nature-inclusive possibility: facade greenery

In this nature-inclusive option, the façade is covered with vegetation. This option requires little horizontal space but can cover large vertical areas. The designer can play with greenery through the choice, positioning, and density of the vegetation. A green façade promotes biodiversity by providing food, shelter, and residence (Gemeente Amsterdam, 2018). Urban bird species like the hedge sparrow, wren, jay, greenfinch, blackbird, robin and song thrush like to nest here, and insects benefit as well. In addition, facade greenery requires maintenance and type 4 may involve high costs. (Atelier GROENBLAUW, n.d.)

There are four types of façade greenery: self-adhesive climbing plants, climbing plants with an escorting substructure, hanging and climbing greenery in containers and greenery in substrate attached to the façade. For the first two types, it is important to know how the plants grow to adjust the substructure to this. These types require at least 45 centimetres of space at ground level (Gemeente Amsterdam, 2018). For the third type, the containers can be placed at ground level, on balconies or on the roof. In types 3 and 4, an irrigation system can be of great added value.

Points of attention for the application of Dutch monumental buildings

An important point to consider is the monumental value of the façade. The value assigned and the reasoning behind it can be documented in the description of the monument or must be determined based on a value assessment to be conducted. If the façade has a high monumental value, it will have to be ascertained whether the greenery on the façade will negatively affect this value. In addition, a sensitive façade, such as a brick façade with soft mortar joints or a soft wood façade, can be affected by the façade greenery (Atelier GROENBLAUW, n.d.). There must be sufficient horizontal space as well as vertical space (due to the presence of façade openings and the like). For the growing of vegetation and for conducting maintenance. The vegetation must not cause any obstruction in front of facade openings. De Vogelbescherming (n.d.) describes that birds and insects can usually be found up to a height of 150 metres. This means that façade greenery can be used functionally up to a great height. However, the maximum growing height of the vegetation must be considered. Facade greenery can be applied to both flat and curved facades. A green façade is possible in all orientation directions, but the sunlight requirements of the various types of flora must be taken into consideration. The composition of the soil and the groundwater level influences the choice of vegetation species. It is essential to check whether the supporting structure can bear the increasing mass, for example type 4 weighs on average 80 kg/m^2 (Atelier GROENBLAUW, n.d.).

6 The nature-inclusive flora possibilities

6.5 Green (quay) walls

Figure 53: Nature-inclusive possibility: green (quay) walls

Green (quay) walls is the provision of space for vegetation in walls. The greenery is good for biodiversity and especially for insects, such as butterflies and bees (Gemeente Amsterdam, 2018). A green wall requires little maintenance. Only woody flora species need to be removed to prevent the wall from deteriorating (Copijn, 2019).

The creation of these walls can be done in many ways, including making openings in walls of flowerbeds, garden walls and providing these with substrate and plants. In addition, when renovating and restoring (quay) walls, the holes and new joints can be sealed with a deep mortar joint made of sand, chalk, and crushed peat stone (Checklist Green Building, n.d.). These joints can be covered with plants. Local holes can also be made in the wall and filled with this fertile mortar and possibly plants. Another possibility is an expensive and complicated intervention. In this case, an entirely new quay wall will be constructed. The quay wall consists of a concrete wall at a slight distance from a brick or basalt block wall (Copijn, 2019). The cavity will be filled with crates containing capillary sand, substrate for the planting and possibly another capillary layer of cloth. The recessed joints in the brick wall, which are at least 3 centimetres wide, are sealed with the fertile chalk mortar and planting (Copijn, 2019). The hydration of the greenery is important. A few species are suitable for planting. The wall can be planted or colonised in a natural, often long-term manner.

Points of attention for the application of Dutch monumental buildings

In case of a quay wall which is part of a water defence system, there are strict requirements to ensure its stability (Van Breukelen et al., 2003). If this is the case, it must be examined whether this nature-inclusive option is possible. An important point of attention is the monumental value of the wall. The value of the wall and the reasons for this value can be included in the description of the monument or must be determined by means of a value assessment. If the wall has a high monumental value, it will then have to be ascertained whether the greenery on the wall will adversely affect this value. In addition, soft mortar joints can be slightly affected by the greenery (Atelier GROENBLAUW, n.d.). Green (quay) walls concern both flat and curved walls. A green wall is possible with all orientation directions, but the sunlight requirements of the various types of flora must be considered. North-facing orientation is best for this. Watering is particularly important for the positioning. In addition, calcium mortar joints are less strong, which can lead to constructional problems.

6 The nature-inclusive flora possibilities

6.6 Trees

Figure 54: Nature-inclusive possibility: trees

Each tree forms its own ecosystem (Hoffman, 2010). It is recommended to use a cluster of various tree species. This is beneficial for many animal species and prevents large-scale loss of population due to diseases and pests (Vogelbescherming, 2020). In addition, trees are an ideal source of food, habitat, and shelter for many animal species (Hoffman, 2010). Urban mammals such as the noctule bat like to live in trees (Arcadis, 2018; Zoogdiervereniging, n.d.). Bats also use trees for foraging and orientation (Arcadis, 2018). Urban birds like the treecreeper, magpie, wood pigeon, chiffchaff, Turkisch turtle dove, chaffinch, carrion crow, blackcap and the grey heron make nests in trees (Kooijmans, 2014). Moreover, the fruits and nuts produced by certain tree species can be consumed by humans. Also, the wood from pruning can be used for numerous purposes. A free-standing tree needs little to no pruning. In contrast, to prevent damage to surrounding elements or to ensure safety, other trees need to be pruned annually. In addition, trees need water, nutrition, and minerals (Boomkwekeronline.nl, n.d.).

Points of attention for the application of Dutch monumental buildings

When positioning a tree, it should not be placed on an important water barrier. This is to ensure its stability. A tree can be placed on both flat and sloping surfaces. When positioning the tree, sufficient growing space must be kept free. This space applies both above and below ground. The root system of a tree can be larger than the tree crown. In addition, the tree should not block views or the desired daylight. The tree should also not form a barrier to the approach route to the habitats of swifts and bats. Strong winds can topple a tree with a full canopy and shallow root system. This can be prevented by positioning the tree in a sheltered spot or by placing an anchoring pole next to the tree during the first few years. When positioning, make sure that no damage can be caused to the surroundings and that safety is guaranteed. Think of roots destroying cables, pipes, paths, and ponds. It is also a legal requirement to place trees at a minimum distance of two metres from the property boundary to prevent nuisance on neighbouring plots (Tuinbase.nl, 2021). This may vary from one municipality to another. The zoning requirements of the tree are also important when it comes to placement. As well as the soil, including the ground composition and groundwater level. If necessary, the tree can be placed on a hill to increase the local groundwater level in relation to the surface level (Boomkwekeronline.nl, n.d.).

6 The nature-inclusive flora possibilities

6.7 Shrubs and hedges

Figure 55: Nature-inclusive possibility: shrubs and hedges

A shrub is a woody species of flora that branches and forms leaves directly above ground level. A hedge is several bushes planted side by side. These shrubs can be placed anywhere, but are often used as borders or site boundaries. It is ideal for the last-mentioned function, as it is a natural solution for creating privacy and blocking out people. It is a good replacement for unbridgeable barriers such as walls and fences (Natuurpunt, n.d.). A properly functioning hedge has a minimum width of 50 centimetres and a height of 80 centimetres (Gemeente Amsterdam, 2018). There are many different shrub species that can be used. A mix of different species increases biodiversity (Hoffman, 2010). Shrubs with dense vegetation, spines, nectar, and fruit are ideal for many fauna species, as they provide food, accommodation, and safety (Gemeente Amsterdam, 2018). Birds such as the hedge sparrow, wren, jay, greenfinch, blackbird, robin and song thrush like to nest in bushes, but mammals such as the hedgehog also prefer to make their accommodation there (Kooijmans, 2014; Zoogdiervereniging, n.d.). In addition, bats use line-shaped vegetation to orient and forage (Arcadis, 2018). If flowers or fruits grow on the shrub, bees and butterflies too benefit from it. Some fruits can also be consumed by humans. Depending on the species, a shrub needs to be cut once or twice a year and requires water and nutrition (Natuurpunt, n.d.).

Points of attention for the application of Dutch monumental buildings

Shrubs and hedges can be placed on both flat and sloping surfaces. When positioning, sufficient growing space must be kept free. This space applies both above and below ground. The zoning requirements of the shrub species must be considered when positioning them. Also, the positioning should not cause any nuisance, such as in front of windows. The composition of the soil and the groundwater level influences the choice of shrub species.

6 The nature-inclusive flora possibilities

6.8 (Flowery) Planting

Figure 56: Nature-inclusive possibility: (flowery) planting

Every square metre of additional green space is beneficial for people and animals. The arrangement of borders, façade gardens, tree terraces and the like with grasses, herbs, flowers, and plants is a nature-inclusive option. For this, it is recommended that different (flower-rich) types of planting are used (IVN Natuureducatie, 2019). In various forms, such as open and closed vegetation, and with various heights. Applying relief in the subsoil can help. The expected life span of the planting should also be accounted for. In the next chapter, research is conducted into suitable plant species. Besides improving the aesthetic quality of a space, planting is also good for biodiversity. The urban mammal like the hedgehow like to build his accommodation there. In particular, planting with nectar, pollen, seeds, and fruits is suitable (Gemeente Amsterdam, 2018). The flora provides certain types of herbs, flowers, seeds, and fruit that can be consumed by humans. The planting requires some maintenance, water, and nutrition. Ecological management is desirable for this (IVN Natuureducatie, 2019).

Points of attention for the application of Dutch monumental buildings

(Flowery) Planting can be placed on both flat and sloping surfaces. When positioning, sufficient growing space must be kept free. This space applies both above and below ground. The zoning requirements of the plant species must be considered when positioning them. The composition of the soil and the groundwater level influences the choice of plant species.

6 The nature-inclusive flora possibilities

6.9 Natural pavement

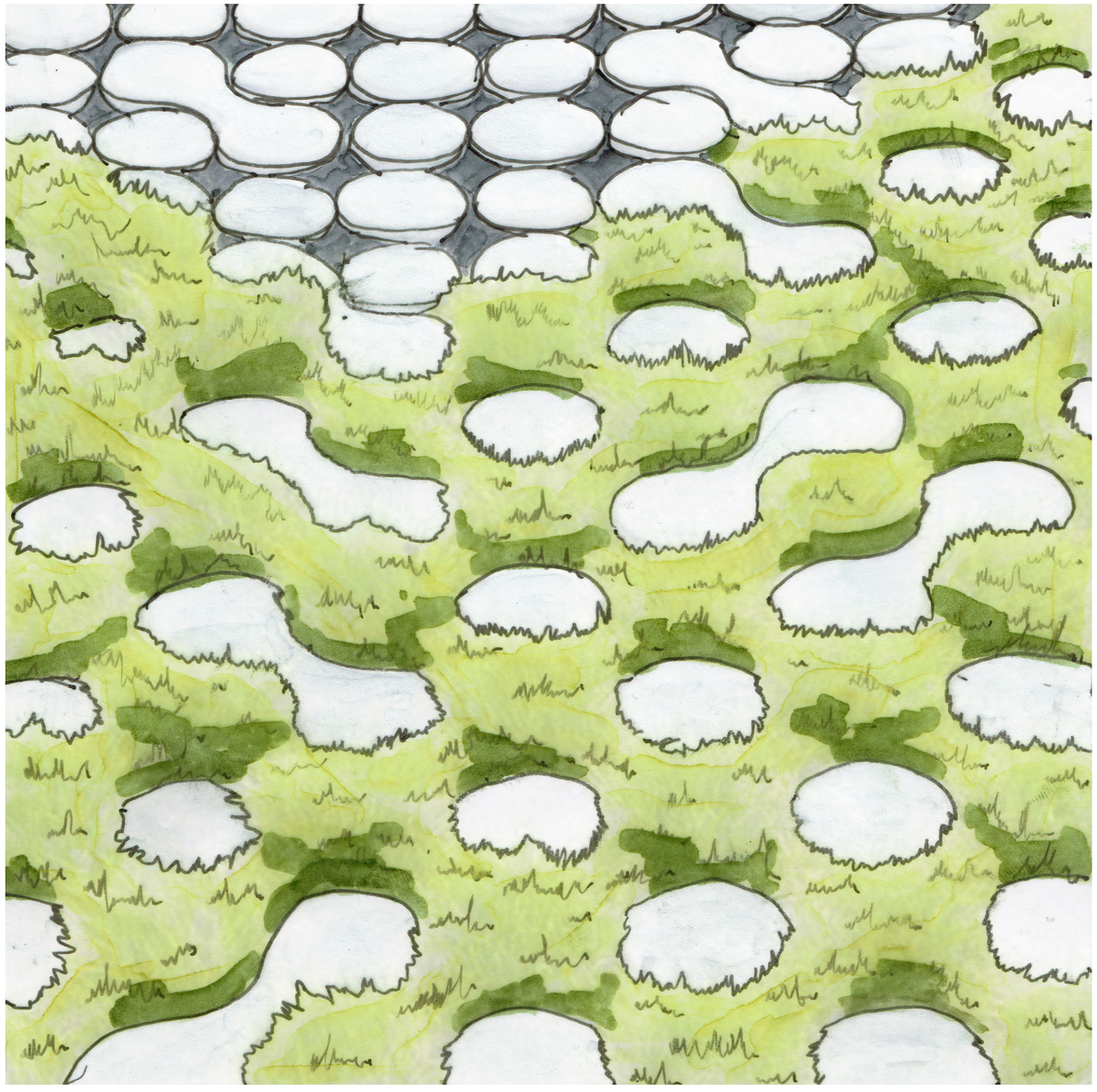

Figure 57: Nature-inclusive possibility: natural pavement

Natural pavement is paving that is good for biodiversity and an alternative to closed paving. There are several variants, including semi-paved surfaces (tree and wood chips, peach pits and cocoa shells), paving with open areas for vegetation and open paving elements with vegetation or steppingstones between vegetation. With natural paving, infiltration of the soil is possible, which prevents dehydration (Zandcompleet, n.d.). It is also beneficial to biodiversity. Semi-paved surfaces, as well as the vegetation in the other types, are a good habitat for various animal species, such as insects, small birds, and mammals. Bees like to nest in open sandy soil. Natural paving requires some maintenance. The vegetation needs to be maintained and the semi-paved surface gradually decomposes, therefore it must be renewed after a few years.

The paving can be laid on a sand bed and possibly on a root layer (De Tuinen van Appeltern, n.d.) The thickness of the sand bed depends on the subsoil and the load. The paving is then applied, possibly with planting that usually consists of grass or walkable ground cover plants (Zandcompleet, n.d.). The path can be enclosed with bands.

Points of attention for the application of Dutch monumental buildings

Natural pavements can be installed on flat, sloping, and curved surfaces. Accessibility for disabled people must be considered. Semi-paved surfaces and vegetation are difficult to access for this group of users. De Vogelbescherming (n.d.) describes that birds and insects can usually be found up to a height of 150 metres. This means that natural pavements can be used functionally (also because of their weight) on the roofs of high buildings. The sunlight requirements of the various types of flora must be taken into account, as well as the traffic that uses the paving. Semi-paved surfaces and steppingstones are not suitable for heavy traffic. However, the other two types are more suitable (Zandcompleet, n.d.). The soil composition and water level determines the build-up of the pavement.

6 The nature-inclusive flora possibilities

6.10 Stacked branches and tree trunks

Figure 58: Nature-inclusive possibility: stacked branches and tree trunks

Not only living flora can increase biodiversity. Dead wood also provides opportunities for many different life forms. Stacked branches, old tree trunks and stumps are examples of this. A stacked branches is a stacked wall of branches between poles or trees (Buitenleven, n.d.). For a well-functioning wall, it should not be too low and too narrow. A minimum height of 100 centimetres and a width of 50 centimetres are recommended (Buitenleven, n.d.). Sand or compost can be applied between the branches. Old tree trunks or stumps can be provided with extra holes. They can also be used multifunctionally as a bench or play object. The dead wood increases biodiversity. Flora species grow on the dead wood and it releases nutrients into the soil (Arcadis, 2018). For various fauna species, the dead wood provides food, habitats, and protection (Buitenleven, n.d.). Among others, the bee, butterfly, hedge sparrow, wren, greenfinch, blackbird, robin, song thrush and hedgehog may house here, but also reptiles and amphibians. Stacked branches and tree trunks have low costs and limited maintenance. Due to the decomposition of the wood, wood has to be applied every few years.

Points of attention for the application of Dutch monumental buildings

Stacked branches and tree trunks can be applied to flat and sloping surfaces. De Vogelbescherming (n.d.) describes that birds and insects can usually be found up to a height of 150 metres. This means that Stacked branches and tree trunks can be used functionally up to a great height. Also, the positioning should not cause any nuisance, such as in front of windows. The dead wood can be placed in all orientation directions. Placing the stacked branches from East to West creates a sun and shadow side which is favourable for many species.

7 The nature-inclusive water possibilities

7.1 Blue roof

Figure 59: Nature-inclusive possibility: blue roo

A blue roof is a roof on which water is retained and, if desired, vegetation is planted. This can include water plants and/or a helophyte filter, which filters the water. Possibly also the household greywater which discharges onto the roof (Gemeente Amsterdam, 2018). The filtered water can then be reused in the building, for instance for flushing the toilet. In addition to the advantages mentioned in chapter one, a blue roof reduces the burden on the sewer system by buffering water for a long time. In addition, the fire resistance of the roof is increased, and it has an aesthetic quality (NDA, 2014). A water roof is good for biodiversity. For example, for birds, bats, bees, butterflies, dragonflies, and damselflies (Gemeente Amsterdam, 2018). The urban bird as the mallard also like to nest there. Algae growth can occur on a blue roof. This can be reduced by gradually discharging water, by a filter system or by having fish swim in the water, which eat the algae and insect larvae. Stagnant water should be avoided, this can be done by using a pump (Hoekstra, 2016). In addition, the water can freeze in winter, which can cause damage. A blue roof needs some maintenance, such as keeping the vegetation in good shape, cleaning the water, and carrying out inspections (Hoekstra, 2016).

A watertight layer is applied to the underlying roof structure and roof ridge with a root-resistant layer on top. In the resulting tub, substrate is placed in the water with the desired relief, in which aquatic plants and/or a helophyte filter can grow. A static or dynamic drain is applied to the roof (Hoekstra, 2016). The static drain drains water slowly and the dynamic drain does this computer-controlled given the expected weather forecast. There is also an overflow on the roof, which drains the excess water to prevent leaks (Amsterdam Rainproof, n.d.). The roof edge must be high enough to prevent water from running over.

Points of attention for the application of Dutch monumental buildings

An important point to consider is the monumental value of the roof. The value attributed and its argumentation may be documented in the description of the monument or must be determined based on a value assessment to be performed. If the roof has a high monumental value, it will have to be ascertained if the blue roof will be detrimental to this value. A blue roof can only be used on flat roofs. On the roof must be enough available space due to installations for example. De Vogelbescherming (n.d.) describes that birds and insects can usually be found up to a height of 150 metres. This means that a blue roof can be used functionally up to a great height. A blue roof is possible in all orientations, but the solar demands of the various types of flora must be taken into account. It is essential to check whether the supporting structure can cope with the increasing mass, by the weight of at least 135 kg/m^2 or more. The roof must be accessible for maintenance. In addition, exhaust gases can damage the vegetation.

7 The nature-inclusive water possibilities

7.2 Natural pond

Figure 60: Nature-inclusive possibility: natural pond

A natural pond is a small body of water that is a paradise for life in and around the water (Gemeente Amsterdam, 2018). The pond can be a proper habitat for birds, mammals, reptiles, amphibians, fish, bees, butterflies, dragonflies, and damselflies, among others (Gemeente Amsterdam, 2018). Urban birds such as common coots, moorhens and mallards also like to nest there. However, the creation of a pond must consider the danger of drowning for both humans and animals. A pond requires some maintenance, such as cleaning and refilling the water and maintaining the vegetation (Milieu Centraal, n.d.).

The groundwater level determines the construction of the pond. If the groundwater level is high, sand is placed in the hole to stabilise it. On top of this a root canvas is applied with pond substrate and aquatic plants. The groundwater will flow through the root sheet. If the groundwater level is low, sand will be placed in the hole to stabilise it. A preformed plastic tub or pond foil is placed on top. When using pond foil, a protective root canvas is applied to both sides of the foil. Pond substrate is placed in the pond, in which water plants are planted. The pond is then filled with (tap) water. The pond must have a minimum width of 130 centimetres (Gemeente Amsterdam, 2018). The ideal depth is 100 to 150 centimetres. At this depth, fish and amphibians can also overwinter. The bank must be provided with a gentle slope so that the various animal species can get in and out of the water easily. Too much water movement should be avoided (Tuinkenner, n.d.). Water plants grow at different depths. Most water plants grow best at a maximum depth of 80 centimetres (Milieu Centraal, n.d.). By designing the pond in layers, it is suitable for many types of aquatic plants. These plants create a balance in the pond by filtering the water, producing oxygen, and limiting algae growth (Milieu Centraal, n.d.). This makes the use of pumps, filters, and chemicals unnecessary. For this, the pond must be large enough (Milieu Centraal, n.d.). With small ponds, of less than 1000 litres, it is difficult to achieve a natural balance (Tuinkenner, n.d.). By creating height differences with various types of aquatic plants, it is a suitable place for many animal species (Milieu Centraal, n.d.).

Points of attention for the application of Dutch monumental buildings

A pond should be placed on a flat surface. The presence of cables, pipes and tree roots in the ground must be considered. A pond can be applied to all orientations. However, the pond will degrade better if there is sufficient sunlight (Tuinkenner, n.d.). The zoning requirements of the plant species must be considered when positioning them. When choosing a pond, the groundwater level must be considered. At a high groundwater level a root sheet will be used, by low groundwater a plastic tub or pond foil will be sufficient.

7.3 Ecological puddle

Figure 61: Nature-inclusive possibility: ecological puddle

A puddle is a small, shallow, stagnant or weakly flowing body of water that is separated from other water (Ravon, n.d.). Animal species such as birds and mammals drink and bathe in the water. It is the ideal habitat for amphibians, reptiles, dragonflies, and damselflies (Gemeente Amsterdam, 2018). The urban birds as the common coot, mallard and the moorhen also like to nest there. The risk of drowning for humans and animals must be considered during the realisation. The puddle requires some maintenance (Ravon, n.d.).

The groundwater level determines the construction of the puddle. If the groundwater level is high, a pit is dug, in which sand is placed to stabilise it. On top of this, a root canvas is placed with pond substrate or sand. The groundwater will flow through the root sheet. If the groundwater level is low, a pit will be dug, in which sand will be applied for stabilisation. Pond foil is placed over this, with protective root canvas on both sides. Pond substrate or sand is placed in the puddle. The puddle is then filled with water. The banks, which are at least two metres wide, consist of bare sand or light vegetation (Gemeente Amsterdam, 2018). The sandy substrate warms up quickly and is popular with amphibians. The sunlit North bank is particularly important (Ravon, n.d.). The pool has a depth of 50 to 150 centimetres (Gemeente Amsterdam, 2018). This allows for rapid warming of the water and there is sufficient depth for a dry summer. Separate shelter stones can also be placed in the water or on the slope. The bank should be as gentle as possible with a maximum slope of 26 degrees (Ravon, n.d.). The pool is self-sustaining with rain or groundwater, it can be refilled if necessary. The water must not contain any large fish species and water pollution must be prevented (Ravon, n.d.). Aquatic plants can be added to the pool or be colonised by nature. The plants are necessary for egg deposition (Ravon, n.d.). The pool must not be overgrown with plants and must consist of at least 50% open water. Algae and plankton are suitable for the various animal species. A land habitat must be available in the vicinity of the pool.

Points of attention for the application of Dutch monumental buildings

A pond should be placed on a flat surface. The presence of cables, pipes and tree roots in the ground must be considered. A pool needs at least 50% of the day's sun. The zoning requirements of the plant species must be considered when positioning them. When choosing a pond, the groundwater level must be considered. At a high groundwater level a root sheet will be used, by low groundwater pond foil will be sufficient.

7 The nature-inclusive water possibilities

7.4 Natural wadi

Figure 62: Nature-inclusive possibility: natural wadi

A wadi is a vegetated artificial lowering of the landscape with an infiltrating and/ or buffering effect. A wadi is important for water management (Atelier GROENBLAUW, n.d.). The water from roofs, roads and the like can be led to the wadi, reducing the burden on the sewer system (Gemeente Amsterdam, 2018). In addition, it hydrates the soil in summer and drains in winter (Boogaard, 2020). A wadi is also good for biodiversity. It provides cover and food for birds, mammals, amphibians, and insects, among others (Gemeente Amsterdam, 2018). The urban birds as the common coot, mallard and the moorhen also like to nest there. When choosing a wadi, the risk of drowning must be considered. A wadi also requires maintenance, such as the upkeep of greenery and the removal of silt and dirt.

Infiltration, buffer, and mixed wadis are available in various variants depending on the soil conditions (Gids Duurzame Gebouwen, n.d.). The infiltration wadi is used when the soil is permeable (more than 20 mm/h) and the groundwater level is more than 100 centimetres below ground level. First, it is possible to dig a trench and place a permeable soil on top of it, followed by potting soil with vegetation (Gemeente Amsterdam, 2018). This variant can provide a lot of wetness over the entire trench. It is therefore possible to choose for a deeper channel in the middle made of drainage concrete or stones with infiltration sand underneath (Gids Duurzame Gebouwen, n.d.). Alternatively, a box filled with gravel, lava rock or clay granules wrapped in geotextile can be placed in the middle of the wadi (Amsterdam Rainproof, n.d.). The buffer wadi is used when the soil is poorly permeable (less than 1 mm/h) or when the groundwater level is high (Gids Duurzame Gebouwen, n.d.). In the former case, an extra channel or pipe is installed at the deepest point to drain off the water, or another infiltration box is installed with a drainage pipe in it. The mixed wadi is applied with an average soil permeability (1-20 mm/h) and a groundwater level of more than 100 centimetres below ground level (Gids Duurzame Gebouwen, n.d.). The latter variant is used for this purpose. In addition, it is possible to install sump heads, which in case of a large amount of water transport the water directly to the drainage pipe, surface water or sewer (Atelier GROENBLAUW, n.d.). Anything can be chosen for the vegetation, from grasses to trees. If they can withstand the fluctuating water level. Vegetation can increase water storage by up to 30% (Verkade, 2020). The dimensions of the wadi depend on the amount of water to be collected and the soil conditions. It is also possible to apply regulation mechanisms in the trench to retain the water for a longer period.

Points of attention for the application of Dutch monumental buildings

A wadi is best placed on a flat surface, but a slope is also possible as long as the water flows into the wadi. The presence of cables, pipes and tree roots in the ground must be considered. The sunlight requirements of the various types of flora must be considered as well. The implementation of the wadi depends on the soil conditions, such as the types of soil present and the groundwater level.

7.5 Natural bank

Figure 63: Nature-inclusive possibility: natural bank

A natural bank is an overgrown, gentle embankment that forms an ecological connection between water and land (Gemeente Amsterdam, 2018). A natural bank improves the water quality, protects the bank, and contributes greatly to biodiversity. It allows fauna to enter and exit the water easily and offers birds, mammals, amphibians, insects and fish food, shelter, and protection (Gemeente Amsterdam, 2018). Urban birds such as coots, moorhens, Cannadian goose and mallards like to nest here. Furthermore, the greenery requires some maintenance.

A bank can take many forms, such as a water berm, marsh berm or gentle embankment (Van Breukelen et al., 2003). A marshy bank is a bank with a horizontal surface below the water level. The horizontal surface of a marshy bank is almost equal to the water surface (Van Breukelen et al., 2003). A gentle embankment is one where the bank gradually slopes downwards and is most suitable for water levels that fluctuate by more than 30 centimetres for a prolonged period. A mixture is also possible. The slope should have a maximum gradient of 26 degrees and a minimum width of 100 centimetres (Van Breukelen et al., 2003). The bank should be covered with various types of flora, ranging from water plants to flowery grassland (Gemeente Amsterdam, 2018). To prevent the land from crumbling away, bank protection can be installed, such as block and fibre mats, a foreshore or shoring (Van Breukelen et al., 2003).

Points of attention for the application of Dutch monumental buildings

If the bank is part of a water defence system, there are strict requirements to ensure its stability (Van Breukelen et al., 2003). If this is the case, it must be examined whether this nature-inclusive option is possible. A bank is feasible in all directions, but the zoning requirements of flora must be considered. The possible presence of cables, pipes and tree roots in the subsoil should be considered as well. The soil composition, water level, water quality and the presence of waves also determines the shape and structure of the bank, as well as the suitable flora species.

7 The nature-inclusive water possibilities

7.6 Floatland

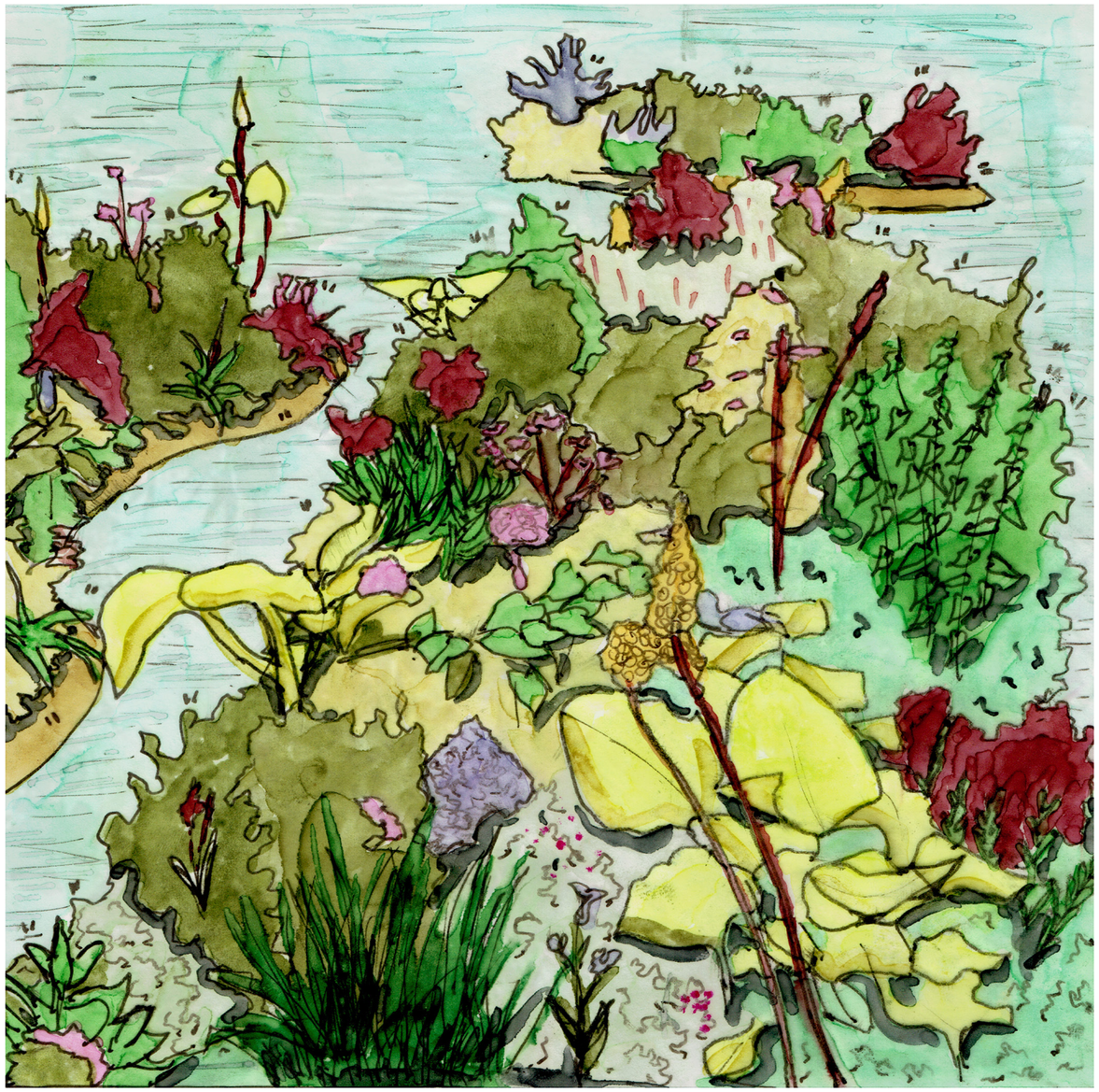

Figure 64: Nature-inclusive possibility: floatland

A floatland is a floating construction on the water, on which vegetation is placed. This ecological island improves the water quality, protects banks, and increases biodiversity (Ecoshape, n.d.). A floatland provides a gradual transition from the water to the land and is a suitable habitat for birds, mammals, insects, amphibians, and fish. Urban birds such as coots, moorhens, Cannadian goose and mallards like to nest here. A float land requires some maintenance, such as maintaining the greenery and removing washed-up rubbish.

A floatland can consist of various structures, including woven willow twigs, plastic modules or a mesh block filled with substrate and coconut fibres (De Vree, n.d.). The construction must have an open soil structure, in and through which roots can grow (Didderen & Paalvast, 2015). For the planting, bank vegetation is used, which grows well in a wet environment. The island must be anchored. This can be done using poles or a weight anchor to which the island is attached (Nautilus Eco-Solutions bv, 2020). The construction must be strong and have sufficient float capacity to support both the saturated construction and the vegetation (Didderen & Paalvast, 2015). In addition, the floatland must be easily accessible by fauna.

Points of attention for the application of Dutch monumental buildings

Here, the installation of a floatland must not impede the mobility and flow of the water. Floatlands can only be used in stagnant or slow-flowing water. Large waves and strong currents should be avoided. A floatland can be used with fluctuating water levels because the construction moves with the water level. However, the construction should not run dry. In addition, it is advisable to position the island at least 2 metres from the bank to prevent unwanted trespassing. The island can be placed in all directions, but the zoning requirements of the vegetation must be considered. Water quality and flow also applies to the type of vegetation to be used.

8 The nature-inclusive fauna possibilities

8.1 Fauna accommodations

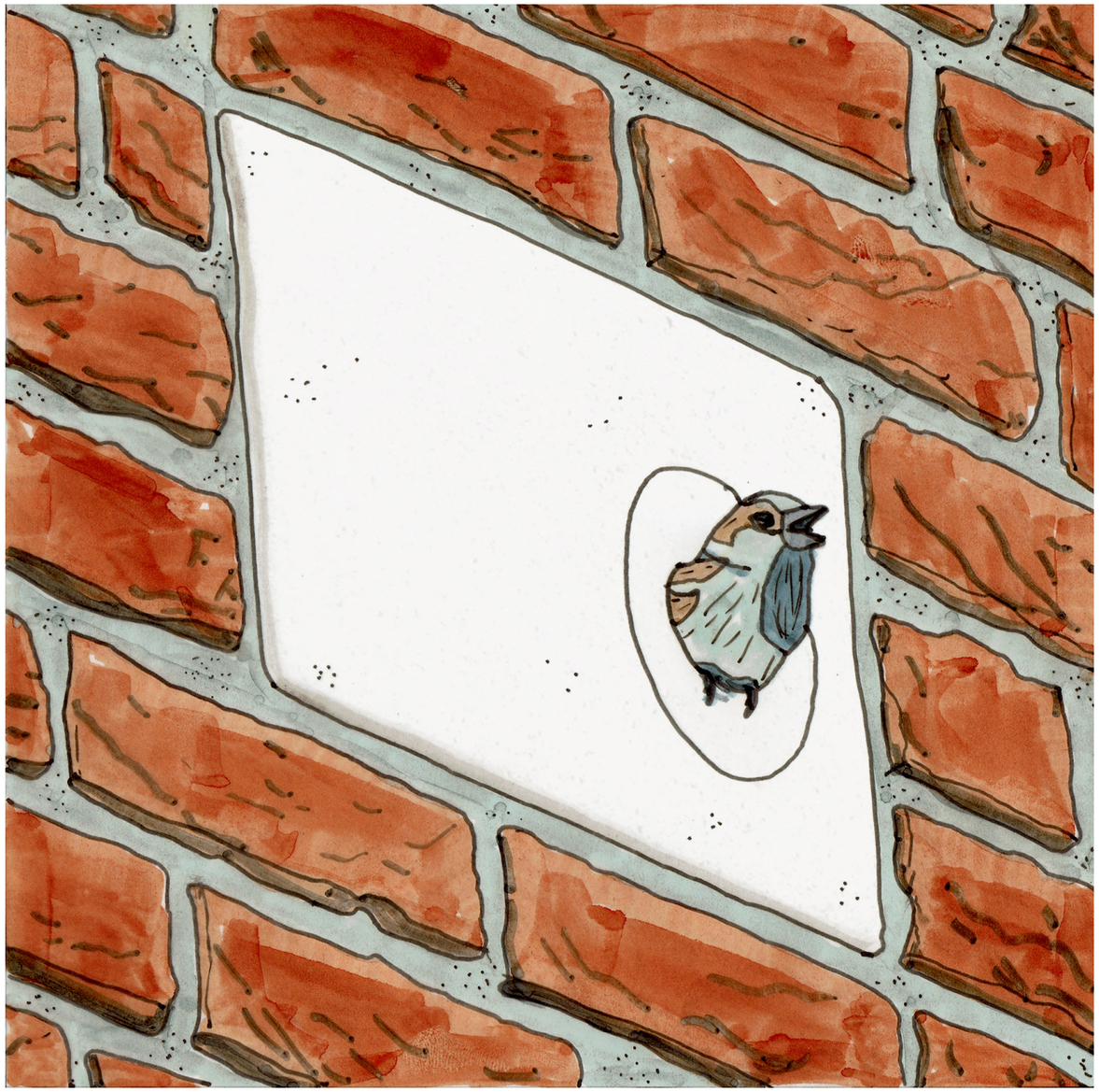

Figure 65: Nature-inclusive possibility: fauna accommodations

The following covers the fauna accommodations for the earlier described birds, mammals and insects.

8.1.1 Bird accommodations

There are several bird species that like to nest in the urban environment. Each species of bird has its own requirements for its nesting place. For this reason, there is no generic nesting place for all birds. In the following, as mentioned earlier, there will be a focus on urban bird species that are highly dependent on the city and breed in or on buildings, such as the swift, house martin, house sparrow, starling, and jackdaw. For birds, there are nesting stones and nesting boxes, bird shelters under roof tiles and fauna flats. These nesting places can be installed visibly or invisibly. A nesting stone is a wooden-concrete element that can be placed in various places in the masonry and serves as a bird's nesting place. The nesting stones are available in various designs for the various bird species. The possible formation of cold bridges must be considered when installing them. However, this is limited by the small dimensions of the stones (Bouwnatuurinclusief.nl, n.d.). Nesting boxes can be placed in many different positions, such as on the facade, in the eaves, chimney or on the plot. These nesting boxes can be made of wood-(concrete). The dimensions of the boxes for the various bird species are shown in Figure 66. However, different dimensions are mentioned in the literature. A bird vide can be installed on sloping roofs. This is a construction that is placed under the last row of tiles and in which birds can build nests. Fauna flats are freestanding towers, in which several wooden-(concrete) nesting sites are incorporated. This tower offers each bird its own nesting place. There are also specially developed nesting roof tiles. However, the use of these is

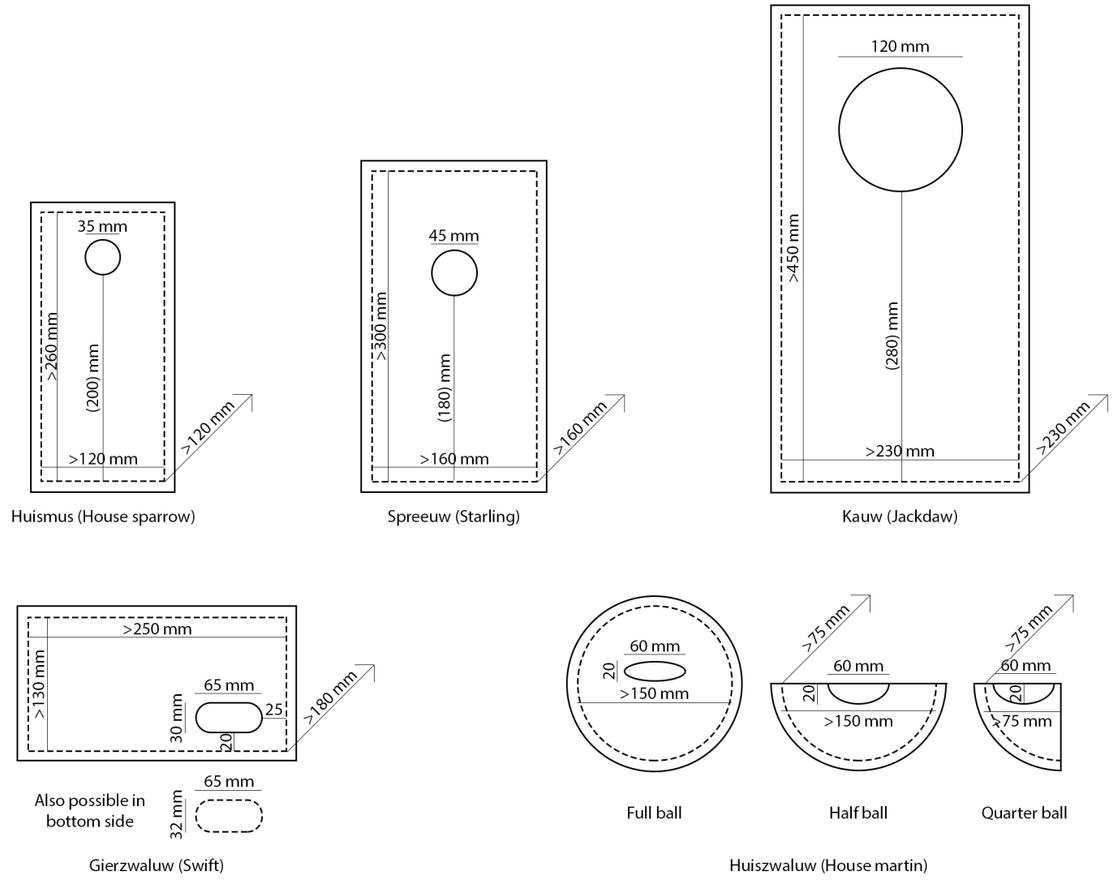

Figure 66: Dimensions bird accommodations

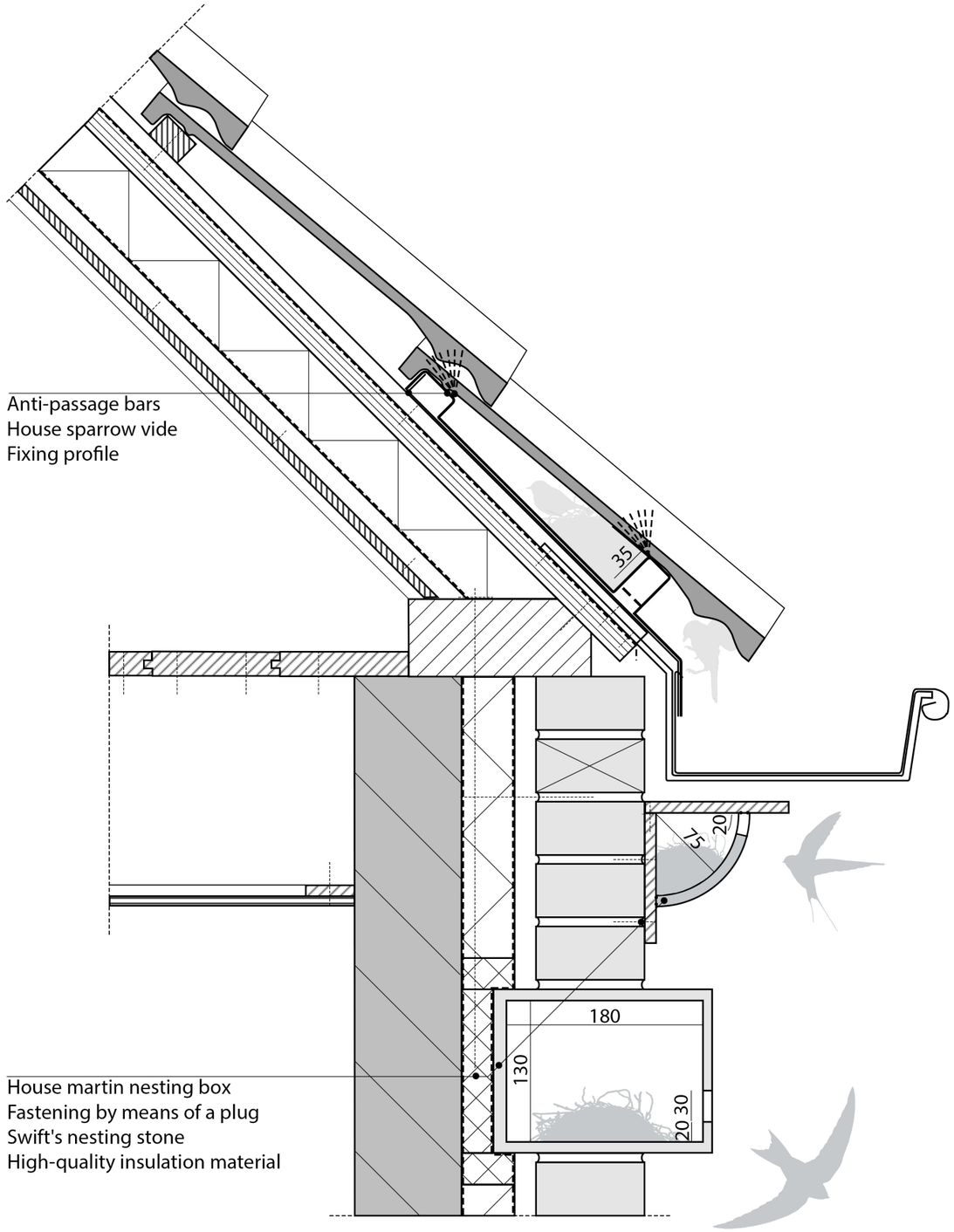

Figure 67: Detail bird accommodations

not recommended due to the high risk of overheating (Gierzwaluwbescherming Nederland, n.d.). The nesting boxes should be cleaned annually and possibly nesting material should be provided.

Points of attention for the application of Dutch monumental buildings

Important to consider is the monumental value of the building elements in which or to which the nesting sites are applied. The value assigned and the reasoning behind it can be documented in the description of the monument or must be determined based on a value assessment to be conducted. If the building element has a high monumental value, it will have to be ascertained whether the nesting sites will negatively affect this value. In addition, there should be sufficient space on the façade and no nuisance at façade openings. The accommodations must be accessible for maintenance. The bird species have requirements regarding the positioning of their nesting sites. These are partly determined by factors such as wind, precipitation, light & shade, heat & cooling, and height (Gemeente Amsterdam, 2018). The desired positioning of the various bird species is shown in Figure 68. The nesting sites can be applied on both flat and sloping surfaces. Consideration should be given to whether the facades can support the additional weight. However, the mass is limited. If nesting stones are applied, the force transmission should be taken into account.

Requirements nesting place

Species	Orientation (Gemeente Amsterdam, 2018)	Height (Gemeente Amsterdam, 2018)	Built-in (Gemeente Amsterdam, 2018)	Add on	Nesting stone	Nesting box	Bird shelter roof tiles	Fauna flats
Gierzwaluw (Swift)	North, East (West)	3-40 m	●	●	●	●		
Huiszwaluw (House martin)	North, East (West)	6-10 m		●		●		●
Huismus (House sparrow)	North, East (West)	3-15 m	●	●	●	●	●	●
Spreeuw (Staling)	North, East (West)	3-40 m	●	●	●	●	●	●
Kauw (Jackdaw)	North, East (West)	3-(20)m	●	●	●	●		

Side note

Gierzwaluw (Swift)	Required free flight path of 2 metres wide and 3 metres high. Preferably positioned under an overhang and not above windows. Ideally placed in a cluster with a minimum distance of 80 centimetres.
Huiszwaluw (House martin)	Required free approach route of 2 m wide and 3 m high. There must be water nearby and possibly clay. Preferably positioned under an overhang and not above windows. Ideally positioned in a cluster.
Huismus (House sparrow)	Positioning at a maximum distance of 5 metres from tall greenery. Preferably not above windows. Ideally placed in a cluster with a minimum distance of 50 centimetres.
Spreeuw (Staling)	Positioning at a maximum distance of 5 metres from tall greenery. Preferably not above windows. Ideally placed in a cluster.
Kauw (Jackdaw)	Preferable not to be placed above windows.

Figure 68: Requirements bird accommodations

8 The nature-inclusive fauna possibilities

8.1.2 Mammal accommodations

There are several bat species that like to roost in or on buildings, including the common, nathusius and soprano pipistrelle, the serotine bat, the lesser horseshoe bat, and the parti-coloured bat. They do this in bat boxes and bricks, behind eaves and wall panelling, under roof tiles, in cavity walls, chimneys, attics and basements. There are various types of accommodation, such as summer, pair, maternity, and winter quarters (Koster et al., 2011). These have different dimensions, partly depending on the species of bat (Figure 69). Not every nesting site is suitable for all types of roosts, this is related to the indoor temperature present (Koster et al., 2011). In Figure 71 is the suitability indicated. Also, the nesting sites can be installed both visible and invisible. Inside the nesting place and 20 cm around the entrance, the bats must have enough grip (Koster et al., 2011). For this reason, the surfaces to be held can be provided with a rough material, such as unsanded wood, wood-concrete, concrete, or brick. Horizontal slots of 2 mm deep can also be made every centimetre (Koster et al., 2011). In the cavity wall, the insulation material can be provided with a grippy layer or mesh. The bats do not damage the insulation material. Prevent disturbing lighting and cold bridges at their nesting sites. The latter is often not a problem due to the narrow nesting place (Checklist groen bouwen, n.d.). In addition, the nesting areas do not require any maintenance.

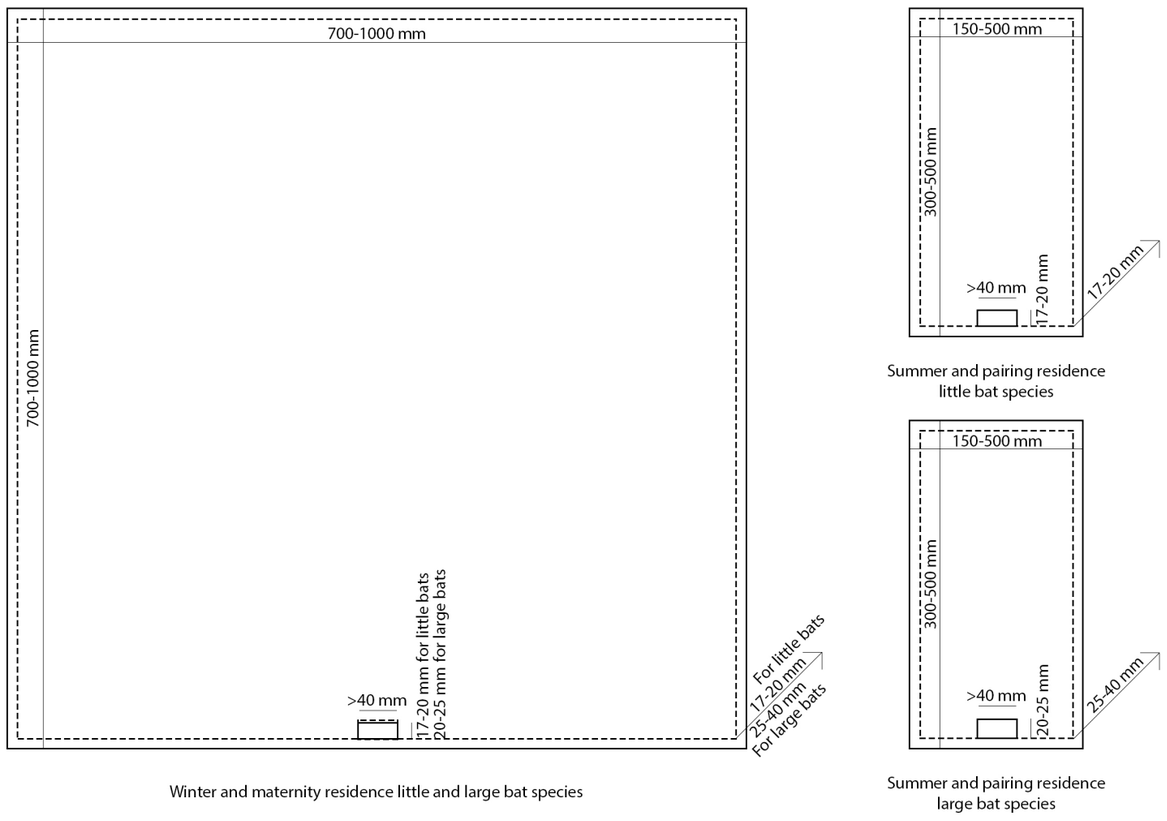

Figure 69: Dimensions mammal accommodations

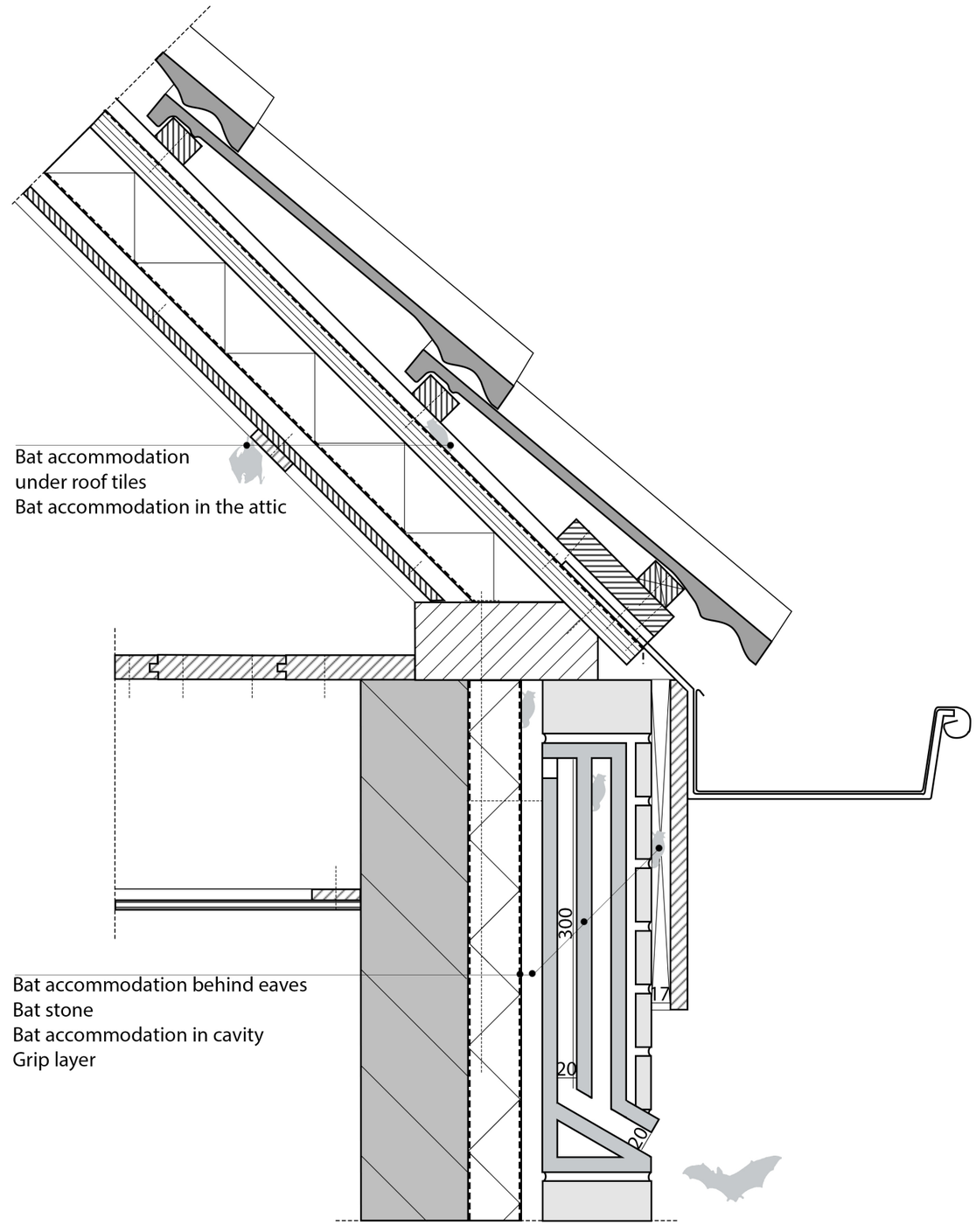

Figure 70: Detail mammal accommodations

8 The nature-inclusive fauna possibilities

Points of attention for the application of Dutch monumental buildings

An important point to consider is the monumental value of the building elements in which or to which the nesting sites are applied. The value assigned and the reasoning behind it can be documented in the description of the monument or must be determined based on a value assessment to be conducted. If the building element has a high monumental value, it will have to be ascertained whether the nesting sites will negatively affect this value. In addition, there should be sufficient space on the façade and no nuisance at façade openings. The bat species also have requirements regarding the positioning of their nesting sites. These are partly determined by factors such as wind, light & shade, heat & cooling, and height (Gemeente Amsterdam, 2018). The desired positioning of the various bat species is in Figure 71 visible. The nesting sites can be applied on both flat and sloping surfaces. Consideration should be given to whether the facades can support the additional weight. However, the mass is limited. If nesting stones are applied, the force transmission should be taken into account.

Requirements residence

Type of residence	Orientation (Gemeente Amsterdam, 2018)	Height (Gemeente Amsterdam, 2018)	Small bat box (Kosten et al., 2011)	Big bat box	Roof edges, panelling, etc.	Small built-in box	Big built-in box	Cavity wall & roof layer	Attic & cellar
Summer residence	All	3-50 m	○	○	○	○	○	○	○
Pairing residence	All	3-50 m	○	○	○	○	○	○	○
Maternity residence	South & West	3-50 m		○	○	○	○	○	○
Winter residence	North & East	3-50 m					○	○	○

Side note

All residences	Preferably not positioned above windows. Free entry and exit area of 2 metres high and wide.
Common pipistrelle	Small entrance opening and depth accomodation
Serotine bat	Large entrance opening and depth accomodation
Nathusius pipistrelle	Small entrance opening and depth accomodation
Soprano pipistrelle	Small entrance opening and depth accomodation
Lesser horseshoe bat	Small entrance opening and depth accomodation. Lives only in damp cellars and attics of buildings
Parti-coloured bat	Large entrance opening and depth accomodation. Must be positioned at a minimum hight of 30 m.

Figure 71: Requirements mammal accommodations

8.1.3 Insect accommodations

70% of all bees nest in sandy places underground, such as holes, hills, and sand barriers (IVN Natuureducatie, 2019). 20% Nests above ground in dead tree trunks, branch rills, dead plant stems, stacked stones, insect hotels, stones, and boxes. 10% Nest both above and below ground (IVN Natuureducatie, 2019). Eggs are laid in the wild bee nest sites, which contributes to improving the wild bee population. The butterfly uses leaves, shrubs, branch poles, sheds, insect hotels, stones, and boxes as shelter, resting or hibernation place (De Vlinderstichting, n.d.). The focus will be on insect bricks and boxes, because these are placed in or on the façade. Insect bricks are mortared into the façade and insect boxes can be attached to the façade. In Figure 72 the dimensions of the different accommodations are shown. The insect bricks and boxes for wild bees are usually made of wood(concrete) and filled with natural materials, such as wood, bamboo, reed, and peat (IVN Natuureducatie, 2019). The nest cavities should be smooth to avoid damage to the wings. The back of the tubes must be sealed. The insect stones and boxes for butterflies are also often made of wood(concrete) and possibly filled with leaves and twigs. Prevent cold bridges at their nesting sites. This is often not a problem due to the narrow nesting element (Checklist groen bouwen, n.d.). The amount of maintenance is low. The butterfly accommodations can be filled with leaves and twigs. In the case of bee accommodations, the nest cavities must be cleaned or replaced every few years.

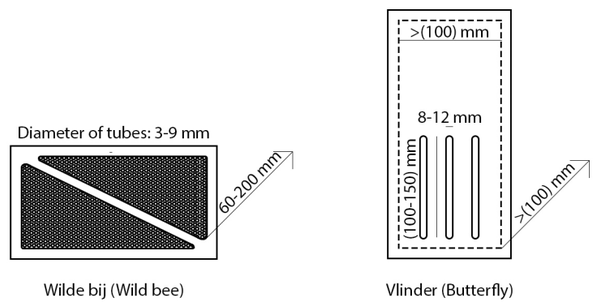

Figure 72: Dimensions insect accommodations

8 The nature-inclusive fauna possibilities

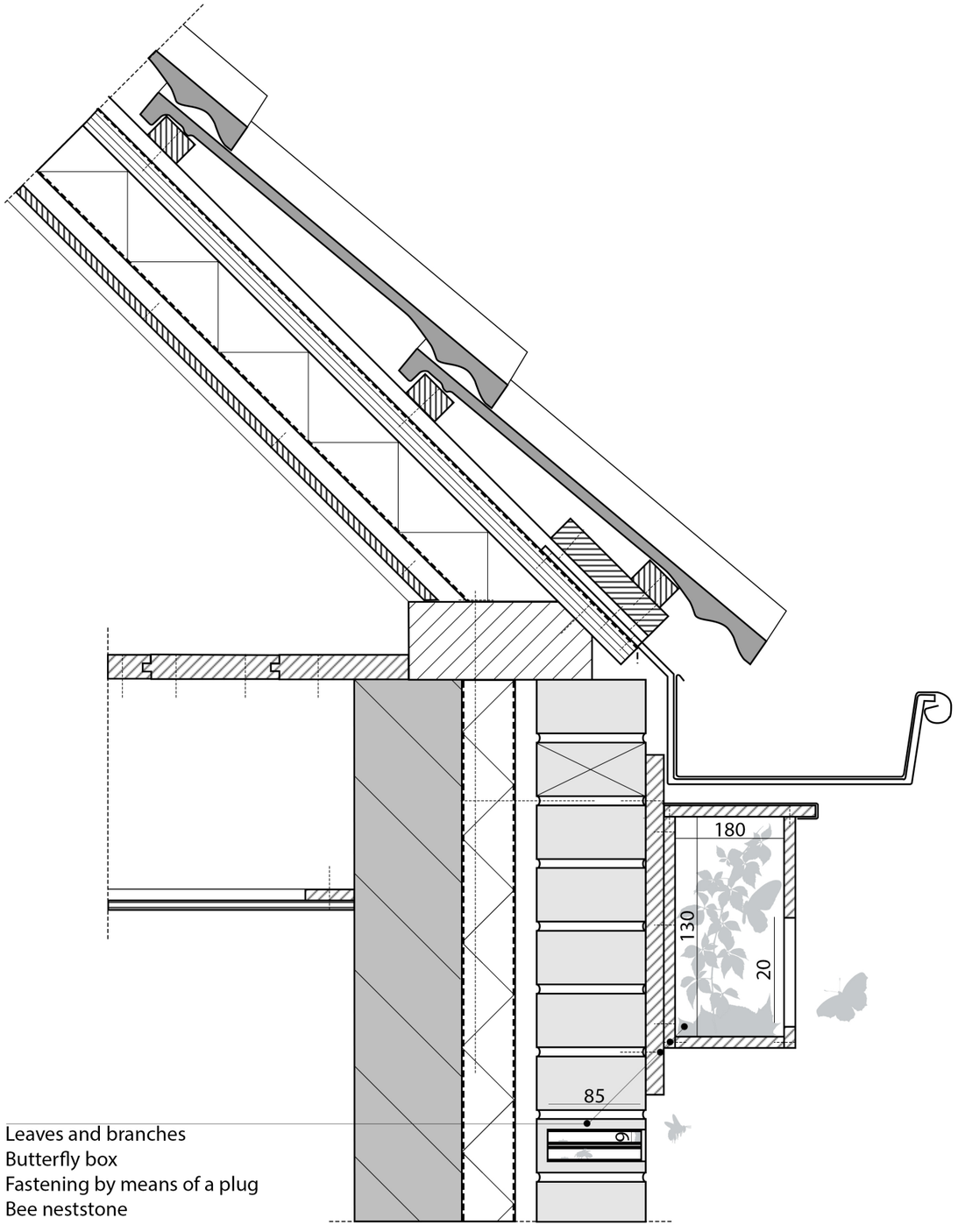

Figure 73: Detail insect accommodations

Points of attention for the application of Dutch monumental buildings

An important point to consider is the monumental value of the building elements in which or to which the nesting sites are applied. The value assigned and the reasoning behind it can be documented in the description of the monument or must be determined based on a value assessment to be conducted. If the building element has a high monumental value, it will have to be ascertained whether the nesting sites will negatively affect this value. In addition, there should be sufficient space on the façade and no nuisance at façade openings. The accommodations must be accessible for maintenance. The wild bees and butterflies also have requirements regarding the positioning of their nesting sites. The desired positioning of the various insect species is in Figure 74 visible. The nesting sites can be applied on both flat and sloping surfaces. Consideration should be given to whether the facades can support the additional weight. However, the mass is limited. If nesting stones are applied, the force transmission should be considered.

Requirements accommodations

Species	Orientation (IVN Natuureducatie, 2019)	Height (De Vlinderstichting, n.d.)	Built-in (IVN Natuureducatie, 2019)	Add on	Nesting stone	Nesting box	Insect hotel
Wilde bij (Wild bee)	South & West	(1-10) m	○	○	○	○	○
Vlinder (Butterfly)	All	(1-10) m	○	○	○	○	○

Side note

Wilde bij (Wild bee)	Prevent water ingress and strong winds. Avoid shade from vegetation and objects. Not too close to bird nesting boxes. In the vicinity of pollen-bearing vegetation. Can also be placed on the roof
Vlinder (Butterfly)	Prevent water ingress and strong winds. Not too close to bird nesting boxes. In the vicinity of nectar-bearing vegetation. Can also be placed on the roof

Figure 74: Requirements insect accommodations

8 The nature-inclusive fauna possibilities

8.2 Connecting ecological structures

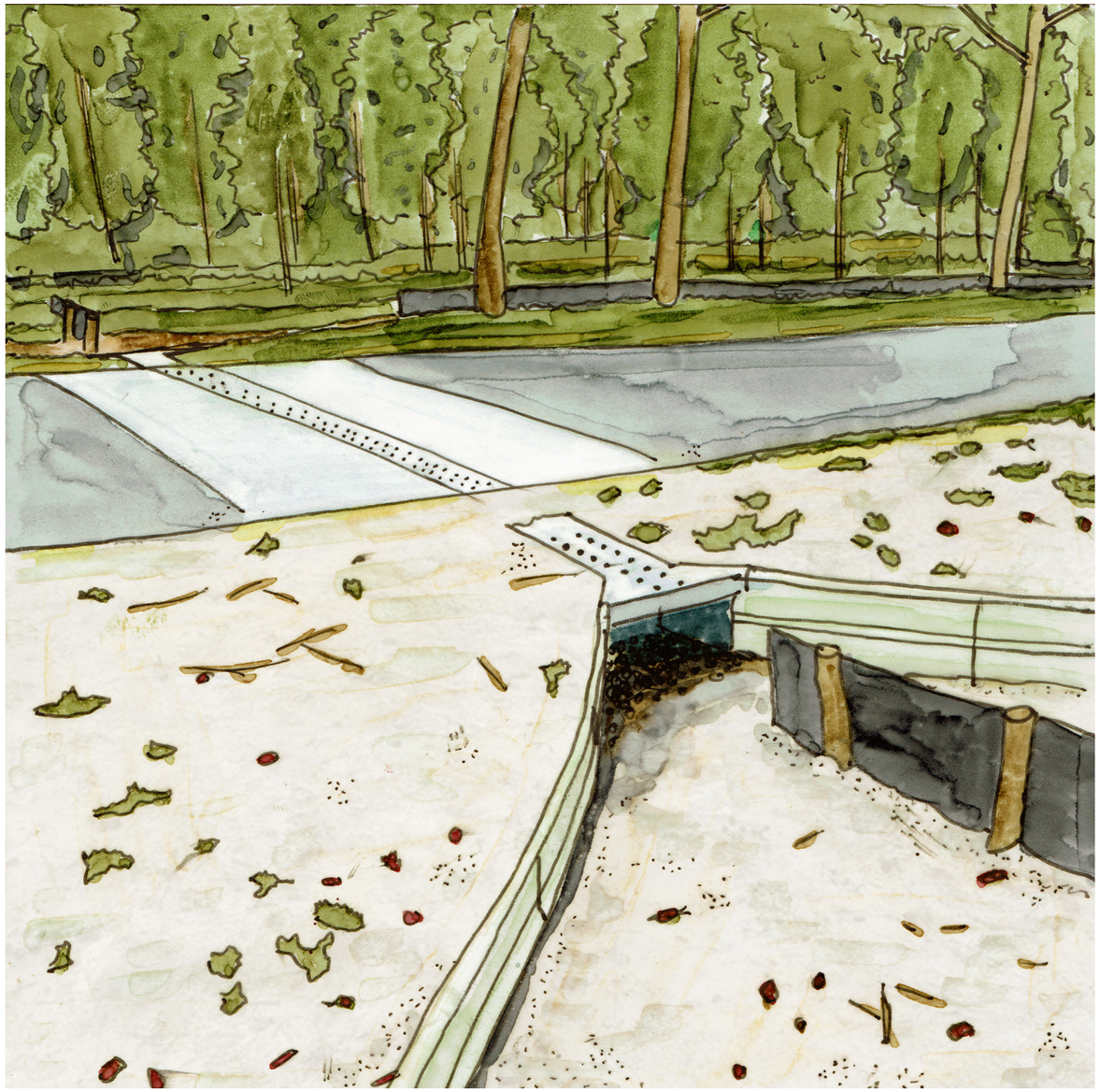

Figure 75: Nature-inclusive possibility: connecting ecological structures

It is important for all animal species that they can reach their habitats easily and safely. This requires the connection of ecological green and water structures and the removal of possible barriers, such as roads, quays, and fences. The connection can be made on one's own plot, but also on a larger scale. The removal of barriers can be done by installing fauna passages, fauna access points and fauna guidance walls.

Fauna passages include tubes under roads and paths to cross them safely. When designing these passages, it is best to choose a concrete square tube with perpendicular walls (MJPO, n.d.). The exit must be visible in the tube and light holes can be made in the top for certain fauna species (Ravon, n.d.). The tunnel can be equipped with a substrate of organic material. By installing fauna guiding walls at both ends, the fauna is guided into the tunnel which is at equal height (Ravon, n.d.). The tube has a minimum width of 30 cm and a height of 15 cm. A second passage is to make holes in fences and walls, through which animal species can pass. The minimum size of the hole must be 15 x 15 centimetres. Fauna access points include the previously described embankments, floadlands, and stairs. The latter is a minimum 15 centimetre wide plank with grooves or edges for extra grip. These stairs have a maximum gradient of 35 degrees and run parallel to the edge. Finally, there are fauna guidance walls, which keep the fauna away from dangerous roads and paths. These walls are closed and have a minimum height of 30 centimetres. The wall must be buried to prevent fauna from passing underneath.

Points of attention for the application of Dutch monumental buildings
If there is a break in the ecological structure, this can be improved by applying the nature-inclusive flora and water possibilities.

8.3 Preventing window casualties

Figure 76: Nature-inclusive possibility: preventing window casualties

When glass reflects the surroundings or windows seem to form a passageway, birds sometimes fly into the glass, which can be fatal. The options listed below require no additional maintenance.

There are several ways to prevent birds from flying into glass. Firstly, the glass can be covered with (white) stickers. At least one sticker with a diameter of 20 centimetres must be placed on every square metre of glass surface (Gemeente Amsterdam, 2018). Secondly, various figures can be sandblasted into the glass. As a third option, the glass can be provided with at least 2 centimetres wide vertical lines at a maximum distance of 10 centimetres from each other. The glass can also be given a tinted foil or replaced with anti-reflective, textured or bird-safety glass (Gemeente Amsterdam, 2018). The latter is glass with a UV coating, which is good visible for birds and less visible for humans. Also, the windows can be fitted with a rod division. This can be done by modifying the frame or choosing glass with an internal rod division. In all these ways, the reduced visibility and daylight entry must be considered.

Points of attention for the application of Dutch monumental buildings

An important point to consider is the monumental value of the windows. The value assigned and the reasoning behind it can be documented in the description of the monument or must be determined based on a value assessment to be conducted. If the windows have a high monumental value, it will have to be ascertained whether the method will negatively affect this value. The Vogelbescherming (n.d.) describes that birds can usually be found up to a height of 150 metres. This means that up to a great height, the prevention of window casualties is useful. In addition, the methods can be applied to both flat and curved glass surfaces.

8 The nature-inclusive fauna possibilities

8.4 Preventing annoying light emission

Figure 77: Nature-inclusive possibility: preventing annoying light emission

Almost all animals are disturbed by lighting (Gemeente Amsterdam, 2018). Annoying light has a negative effect on habitat quality, can disrupt biological rhythms, cause disorientation and exhaustion (Knol, 2011). Obstructive light emission must be avoided, particularly in the case of greenery and water structures.

Annoying light emission can be prevented by turning off non-functional light. Another option is to replace the luminaire or lamp bulb with a more bundled or softer light. In addition, test results show that the colour of the light also influences fauna (Knol, 2011). Light with a wavelength smaller than 492 nm (purple, blue, white and UV light) should be avoided. Light with a wavelength between 493-565 nm (green) and 596-621 nm (yellow-orange and orange) is considered as the least disturbing. Nowadays, light is available that can change throughout the day. This allows functional white light to be used during the day and orange light at night. It is also possible to fit windows with curtains, to prevent light from escaping the building.

Points of attention for the application of Dutch monumental buildings
However, the light can only be modified if its functionality is preserved. This is especially the case for light intended for traffic and social safety.

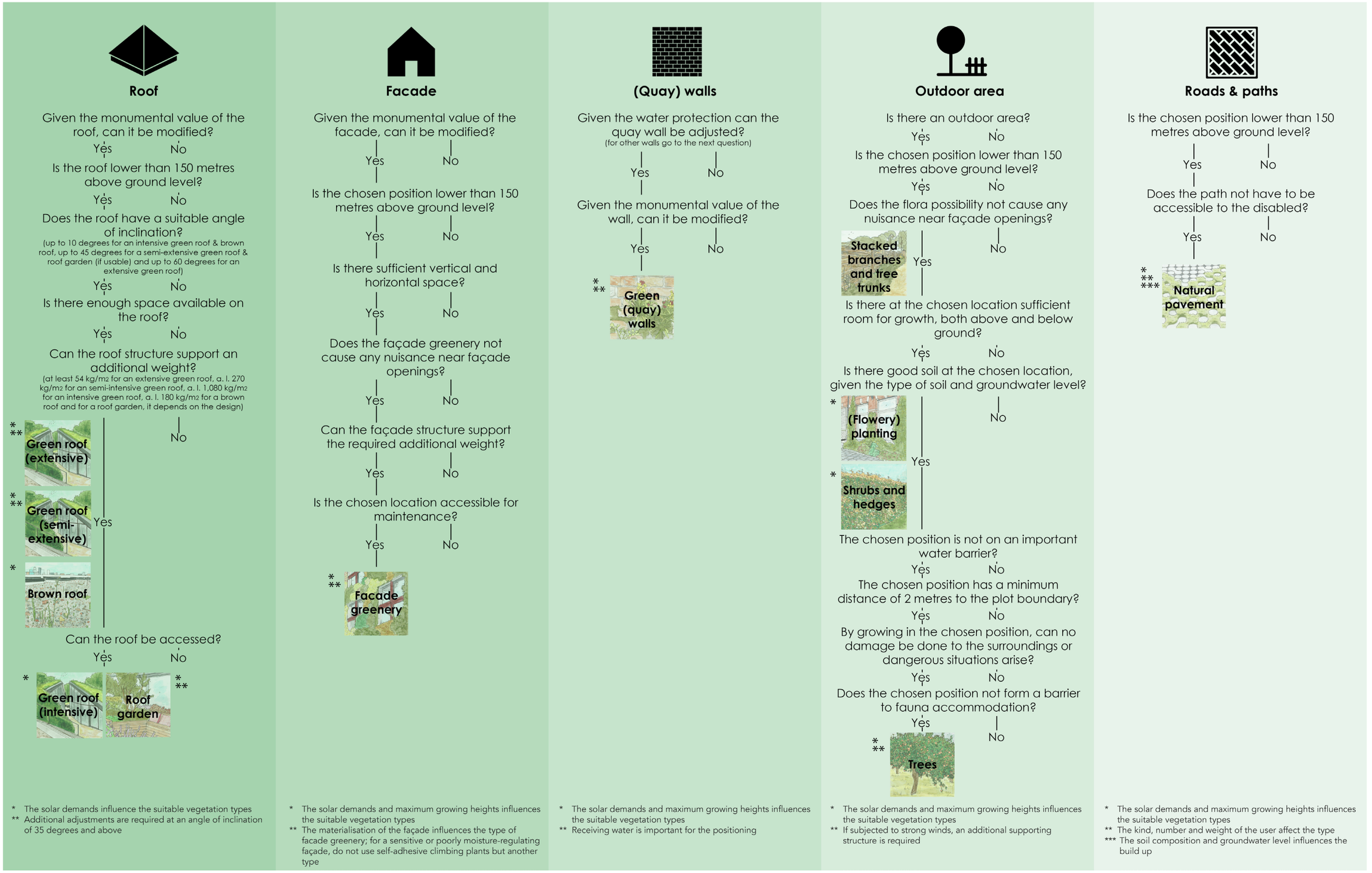

Figure 78: Decision tree of the nature-inclusive flora possibilities

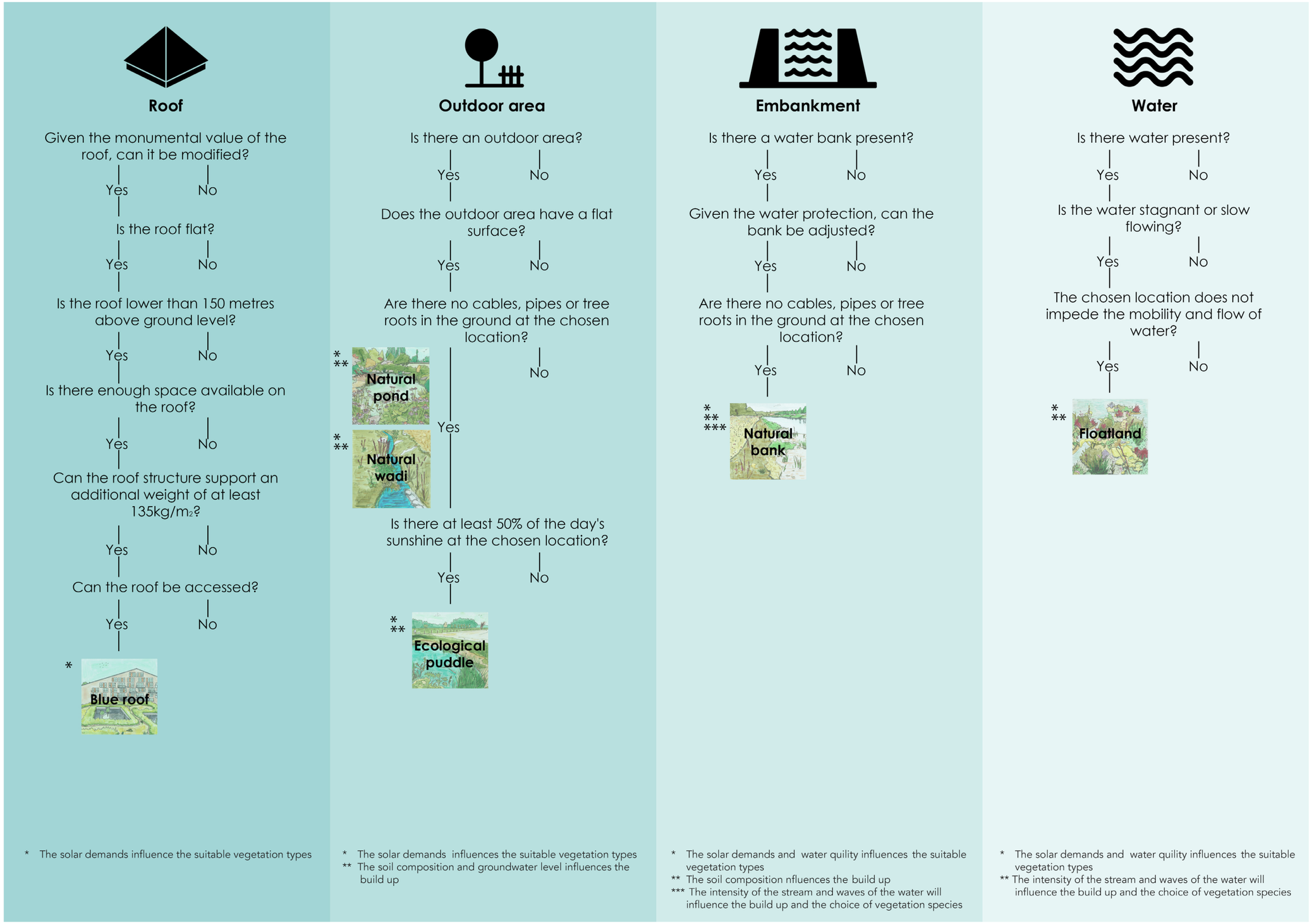

Figure 79: Decision tree of the nature-inclusive water possibilities

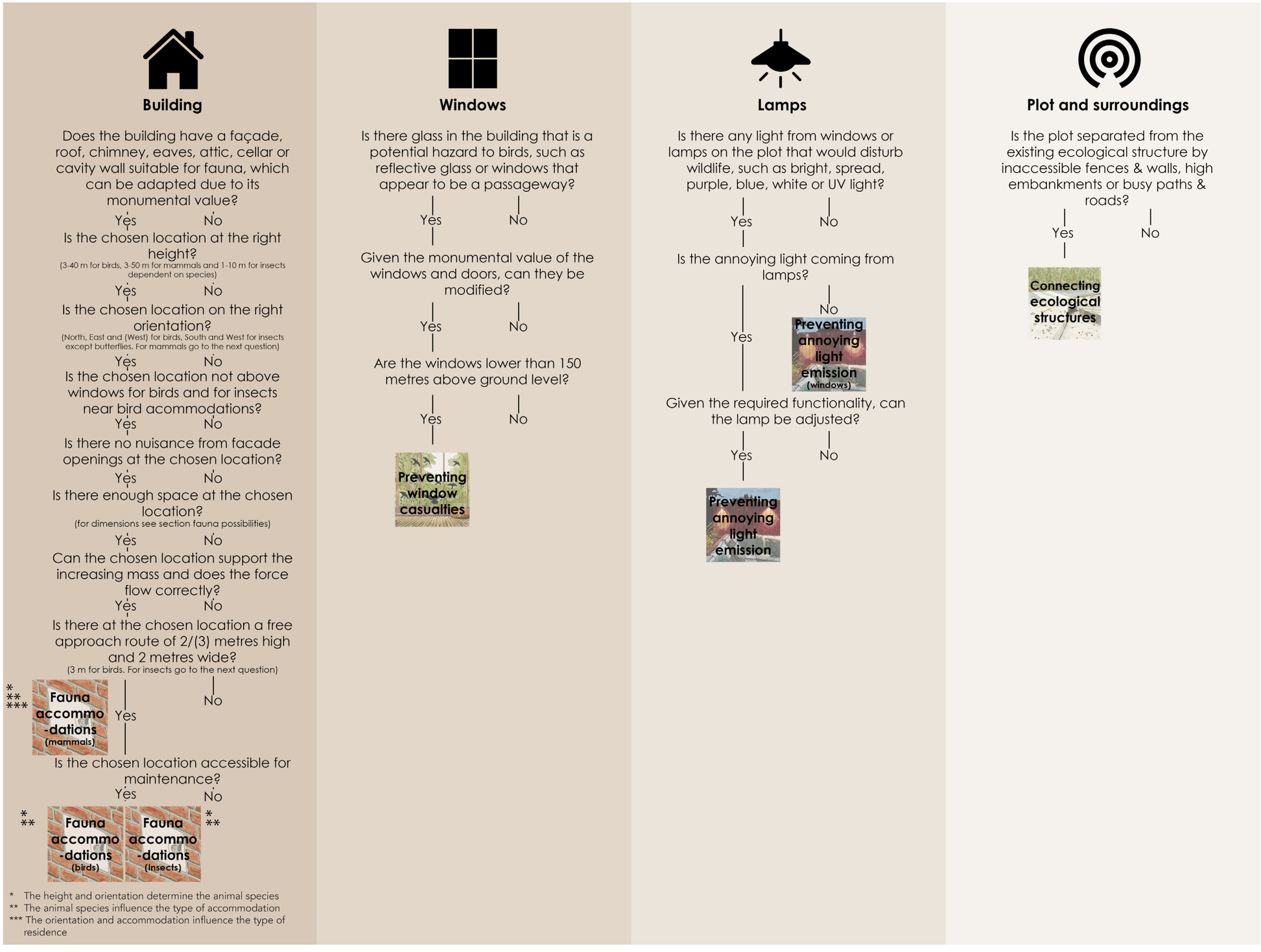

Figure 80: Decision tree of the nature-inclusive fauna possibilities

10 Case study Koudenhorn building

In this subchapter, the decision trees of the flora, water and fauna possibilities are tested. This is done by analysing the monumental Koudenhorn building on the topics of the questions from the decision trees. The building will be analysed on: water & greenery structures, site plan, subsurface, mass, facades, building elements in the facades, value assessment and structure. For each analysis, the questions from the decision trees are addressed. Finally, all decision trees are filled in and the nature inclusive possibilities that could be applied follow.

10.1 Koudenhorn building

The Koudenhorn building is located in the historic centre of Haarlem on the West side of the Spaarne and next to the Nieuwe Gracht. Previously, an ox market was located on the site of the building. In 1756, it was moved to another location in the city. On the empty spot a deaconry house was built from 1768-1771. It housed 670 poor old people, 150 poor children, 80 commensals and the cities poor. The building consisted of a square building around a courtyard with a lower flank. In 1810, the poor were moved to another location and the building was used as a barrack. It held this function until 1960, with an interim period from 1946 to 1950, when the building was used by the Allies. In 1960, the flank was demolished, after which the building was used by the police, a studio and a jazz band until 1968. In 1968, the construction of an extension was started and the police moved in. The police are still based there today. The main building in neo clasical style is a national monument and was the main work of architect Jan Smit. The annex in the new objectivity style is not monumental and was designed by architect Willem Bollebakker/Bernson. For this reason, the case study will focus on the main building and the outdoor space. (Noord Hollands Archief, 2020; Rijksmonumenten, 2020)

Figure 81: S.b.t. student group Technical University Delft. (2022, January 1). [Facade Koudenhorn building]

10.2 Water- & greenery structures

The map on the right shows the public water, greenery and trees. Private green space, water and trees are not included in this map, with the exception of the case study plot. The inner city is surrounded by water and several canals run through it. In addition, there are almost no ditches, ponds and puddles to be found here. The realisation of the aforementioned elements can increase biodiversity in the city. There is not much green in the city except for a few large green locations such as the Kenaupark, the Bolwerken and the Nelson Mandela Park. There are also many streets with trees and in the aforementioned green locations. Also. there are many streets where there are no trees at all. The case study is one of the most water-rich urban blocks in the city. The plot is surrounded by water on three sides. In addition, the dotted black arrows indicate the existing ecological structure in the vicinity of the case study, which the building and its outdoor space can connect to. The water structure is connected. However, the tree structure is interrupted locally on the Northern and Western borders of the plot. The plot is also separated from the ecological structure by high quays on the North, East and West side. A blocking bicycle shed on the West side and a busy road on the East side.

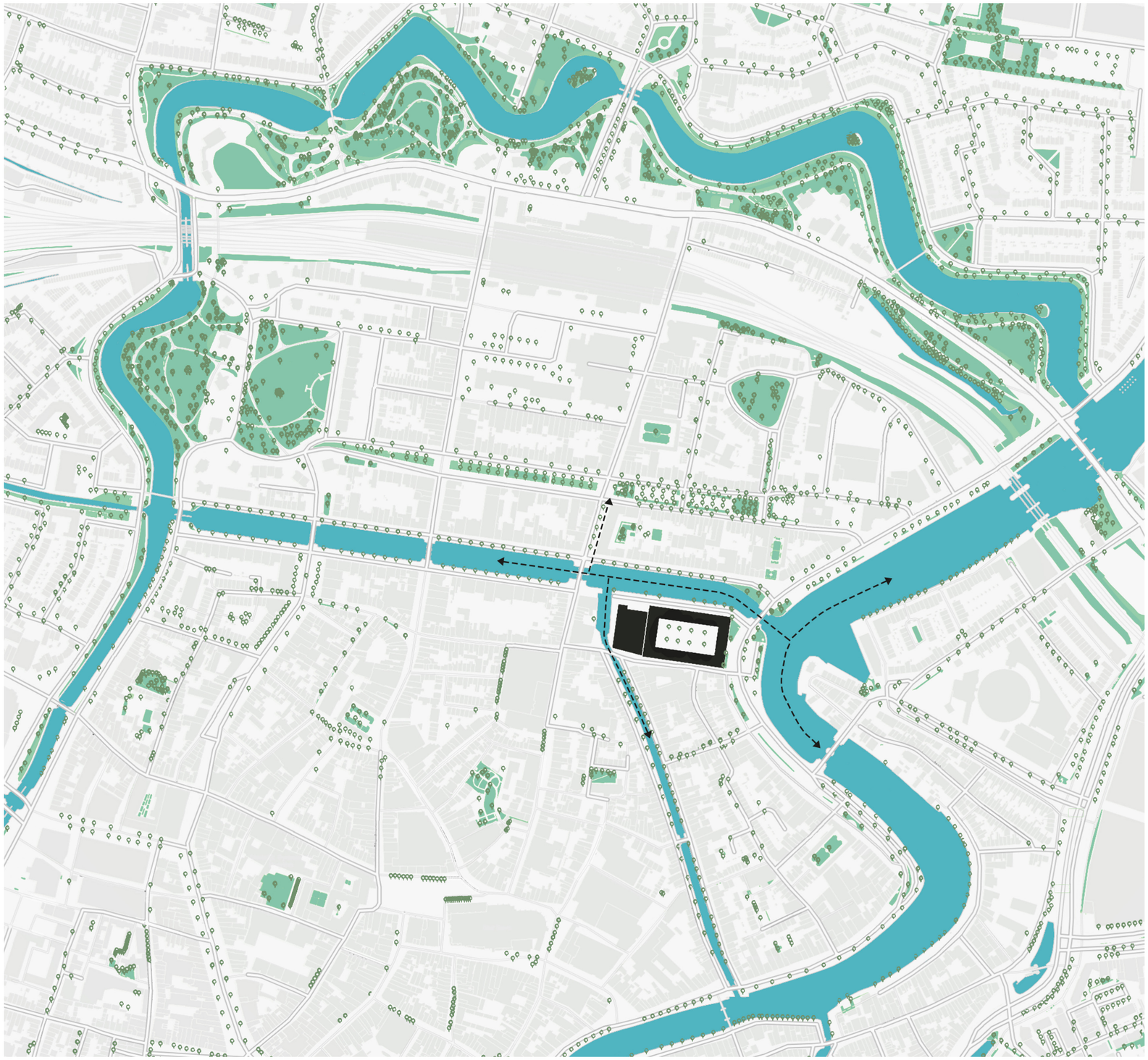

Figure 82: Analysis of water & greenery structures

10 Case study Koudenhorn building

10.3 Site plan

In view of the existing roof windows, dormers and installations, there is sufficient space on both the flat and sloping roof sections for a nature-inclusive roof. There is also a passageway to the roof. The watercourse of the Nieuwe Gracht is sufficiently wide for the installation of a floatland, so that the mobility and flow of the water is not impeded. The Bakenessergracht is narrower, so the floatlands should be placed against the quay. This is not recommended. The water is stagnant to gently flowing freshwater. For all but the Zakstraat and Bakenessergracht facades, there is sufficient space for planting facade greenery and doing maintenance. On the Zakstraat there is currently a narrow non-functional pavement that could be used for this purpose. There is also little traffic, so that any maintenance can be done temporarily. Only in front of the East façade are a number of trees close to the façade that would impede a possible approach route of swifts and bats. The quay wall is not part of a water defence system. The plot is flat and there is little relief. it is unknown where cables and pipes are located. However, there are many large trees present, whereby distance must be kept in the placement of ponds, puddles, wadies and the like. Trees must not cause any damage to the property and must be placed at a minimum distance of 2 metres from the plot boundary. Above ground level, there is sufficient space for the application of nature-rich possibilities. In addition, the lights are located on the facades of the building. These serve to increase traffic and social safety and are therefore necessary. The other lamps are not directly needed.

Legenda

- Building
- Road
- Cycle path
- Parking
- Pavement
- Private garden
- Monumental tree
- Tree
- Green
- Water
- Lot border
- Entrance
- Bus stop
- Electric charging point
- Bench
- Waste point

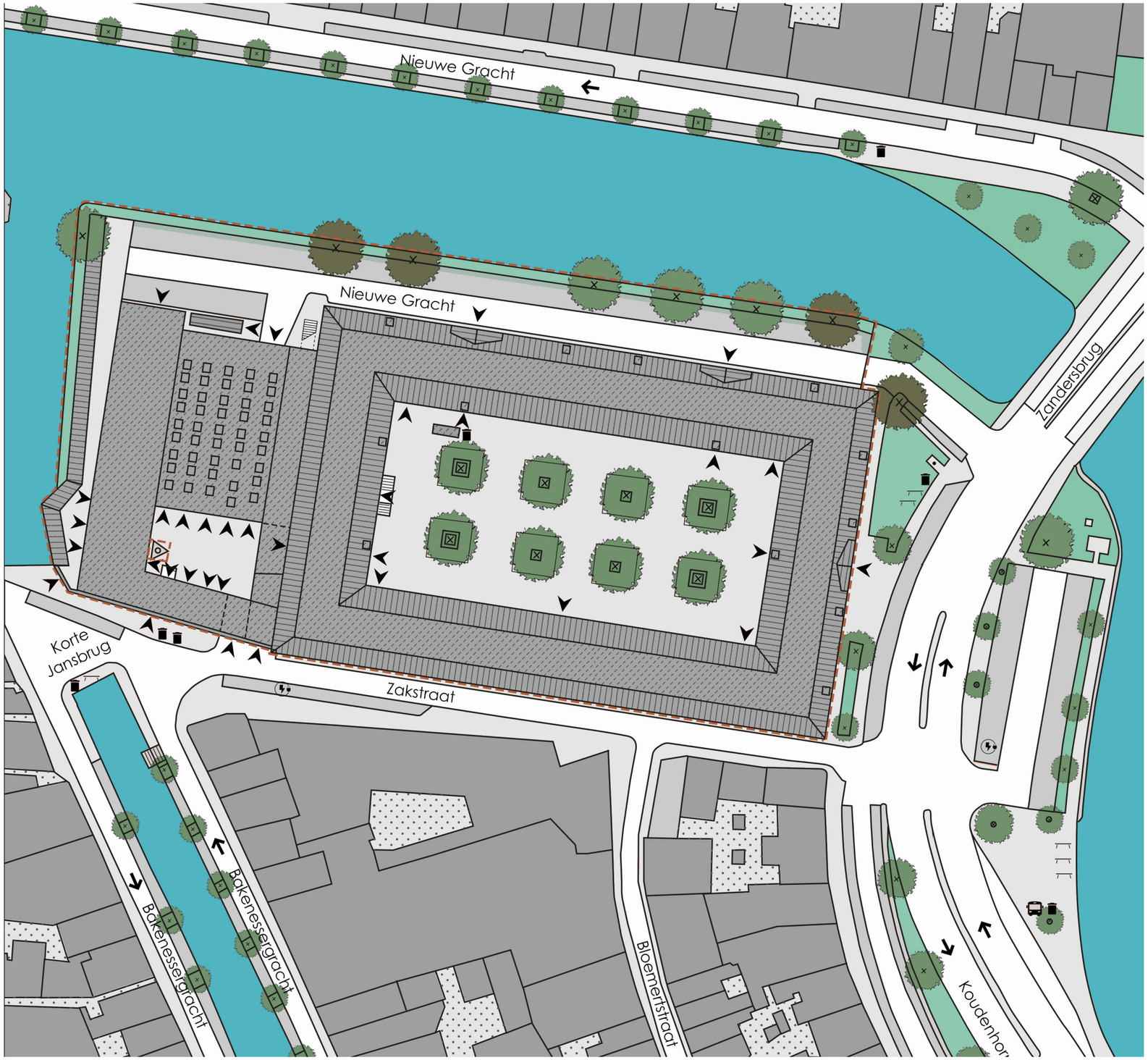

Figure 83: Site plan analysis

10 Case study Koudenhorn building

10.4 Subsurface

In the figure, the soil of Haarlem has been mapped. It shows that Haarlem was built on a sand ridge, which lies below the West side of the plot. To the East of that sand ridge lies a natural sand plain. This is underneath most of the plot. On the East side, the subsoil consists of clay and peat. This soil has been raised with sand, which varies in height. The average thickness of the sand package on the East side of the sand ridge is 2 metres. The type of soil determines the characteristics of the soil, such as seepage and settlement. There is water around the Koudenhorn building, which is on average 2 metres lower than the adjacent land. The water level fluctuates throughout the year. Therefore, it can be assumed that the groundwater level fluctuates around -2 metres. In addition, the plot is located in the historical centre of Haarlem, which means that the highest archaeological expectations can be found there. The analysis shows that the soil under the lot is a good foundation for vegetation. This is due to the suitable soil type and the low groundwater level, which prevents rotting of the roots. However, the risk of dehydration must be taken into account. In addition, the type of soil and water level determine the structure of natural pavement, ponds, wadies, banks and ecological puddles.

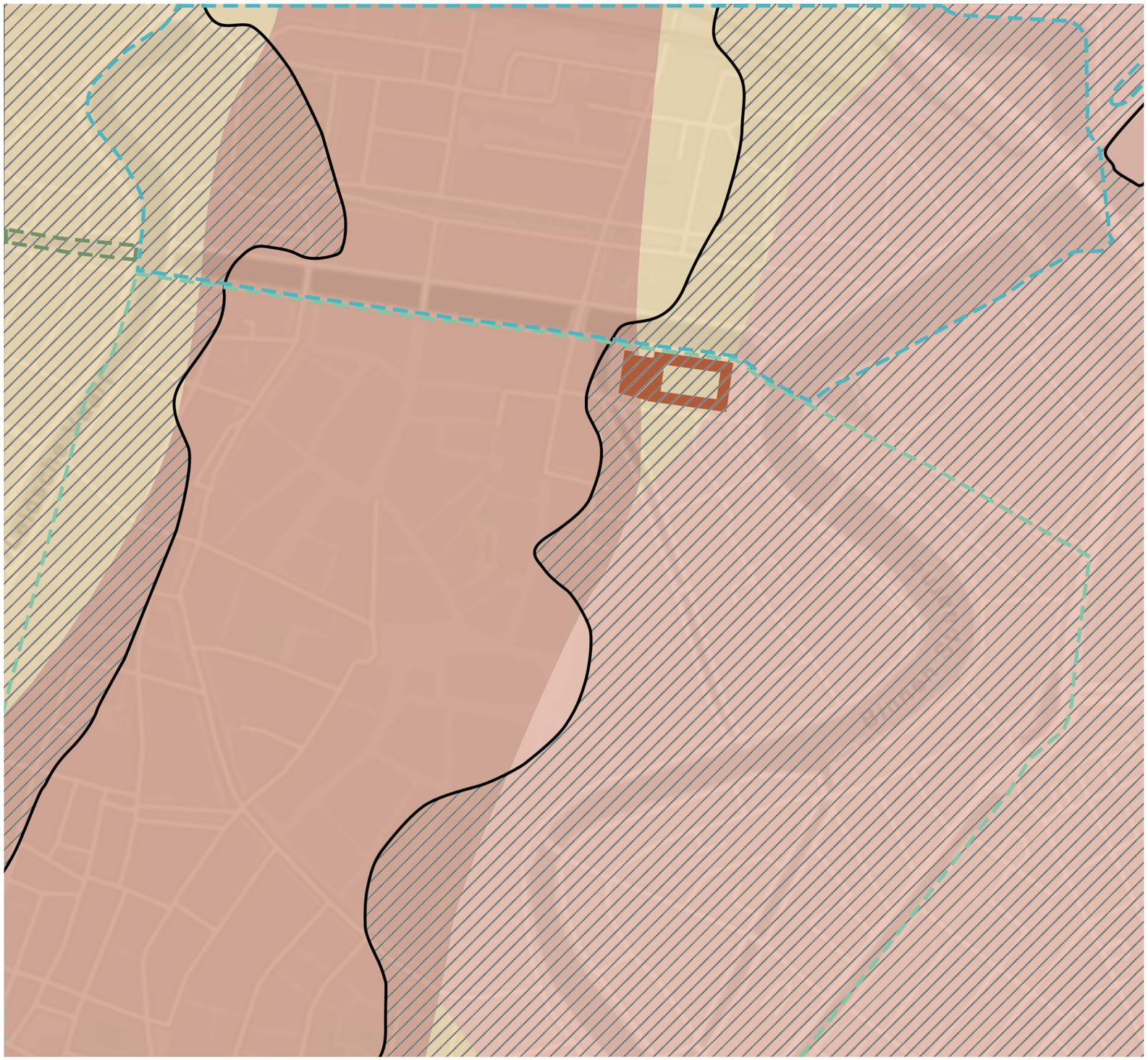

Figure 84: Analysis of the subsurface

10 Case study Koudenhorn building

10.5 Mass

In the figures, a volume study of the building has been done, indicating the generally prevailing wind direction. The building has a height of 15.1 metres, which is below the fauna boundary of 150 metres. Therefore, all nature-inclusive possibilities have value for fauna. The slope angle of the pitched roof sections is 49 degrees, which means that blue, semi-extensive, intensive, brown roofs and roof gardens are not possible. Only an extensive green roof is possible here in terms of pitch, because it can be placed at a maximum pitch of 60 degrees. On the flat roof, all nature-inclusive roofs are possible in terms of pitch. In addition, bird accommodations can only be placed on the North, East and (West) facades of the building and bee accommodations on the South and West facades. The shape of the building provides many façades on different orientations, which makes a number of façades suitable for birds and bees, among others. An ecological puddle needs to receive 50% of the daily sun. On the North side of the courtyard, to the left and right of the building, this is the case. On the Southern side of the courtyard and to the North of the building, the location is unsuitable. In addition, the roof pitch determines the structure of the nature-inclusive roofs. The façade orientation defines the type of mammal accommodation. The generally prevailing wind direction in combination with buildings and objects determines if trees will need a supporting structure. The amount of sunlight also influences the suitable flora species.

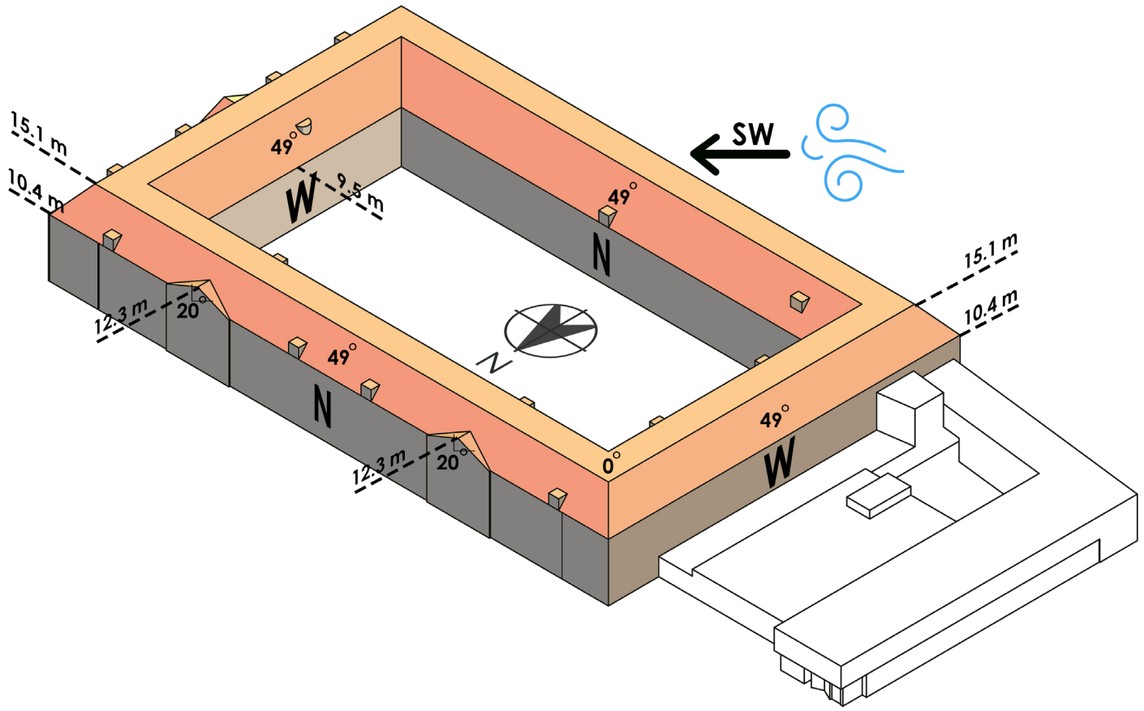

Figure 85: Mass study

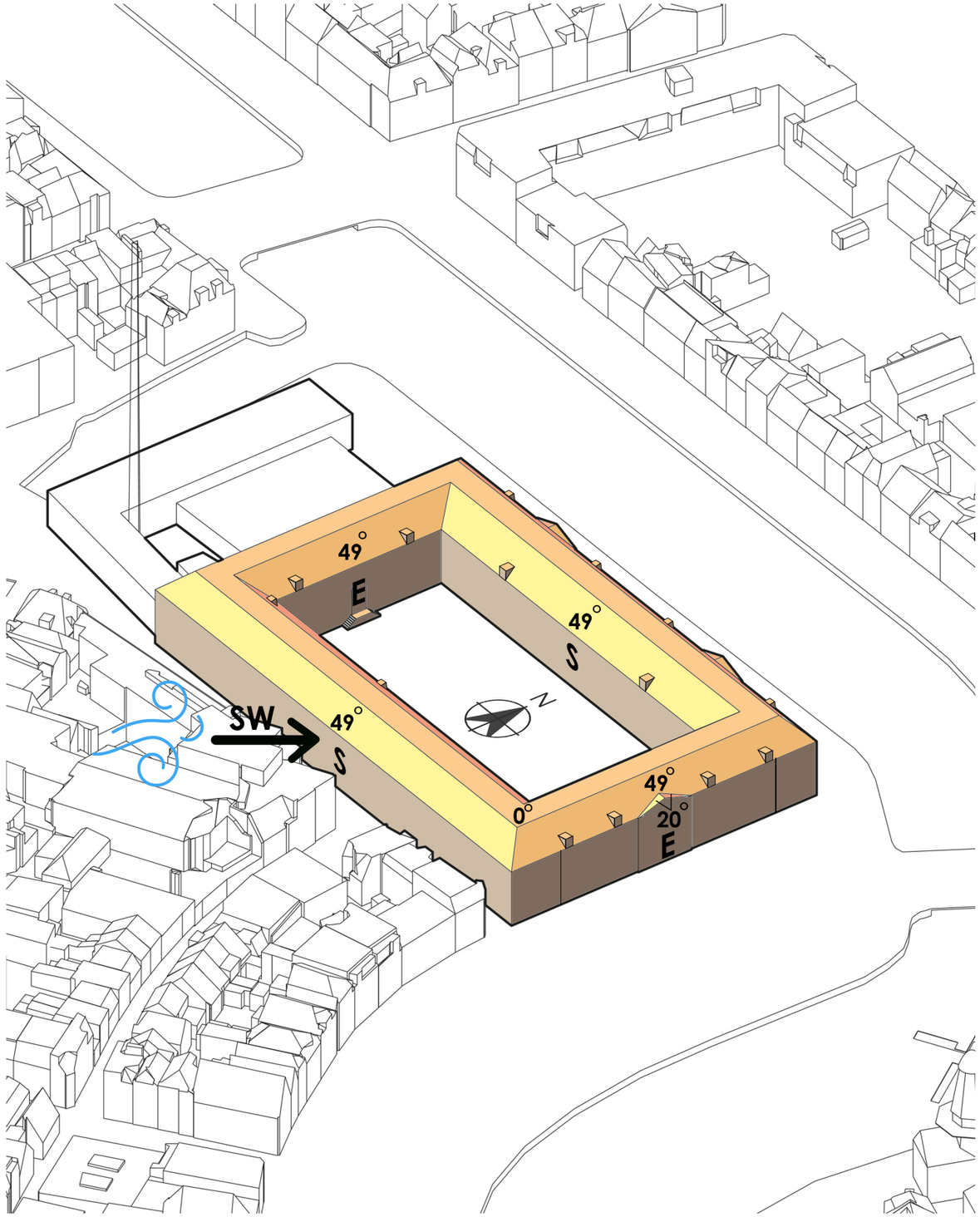

Figure 86: Mass study birds eye

10 Case study Koudenhorn building

10.6 Facades

The figures here and on the following pages show the facades of the building. In fact, there is sufficient space for facade greenery on the entire brick façade. Provided that it is not placed too close to façade openings in order to prevent nuisance. The facade surfaces are sufficiently large for the various fauna accommodations. Two height lines have been applied in the façade at 1 and 3 metres above ground level. The placement of insect accommodations is possible from a height of 1 metre. There are also no existing bird accommodations. The brown areas show the possible position of insect accommodations. Mammal and bird accommodations are also possible from a height of 3 metres (the brown and dark brown areas). It is best not to place bird accommodations above façade openings in order to prevent nuisance. There is enough space left on the façade

Legenda

- Possible position insect accommodation
- Possible position insect & mammal accommodations
- Possible position insect, mammal and Bird accommodations
- Possible dangerous window
- Annoying light emission
- 1 or 3 metres heightline

Figure 87: Facade Koudenhorn (above) & Bakenessergracht (beneath)

0 25M

10 Case study Koudenhorn building

where positioning is possible. For the nature-inclusive flora possibilities that will be placed on the lot, sufficient space is available near the façade, because there are many closed façade sections and the windows are provided with a breast wall. At present, there is no trace of swallows or bat accommodations on the façades, so that the placement of trees will not interfere with the approach route of these species. In addition, it has been indicated which windows could pose a potential danger to fauna. Only the roof windows have been identified as potentially dangerous, because these windows reflect the air and are sufficiently large. Certain lights on the façades on the side of Nieuwe Gracht, Bakenessergracht and the courtyard façade of Zaksraat also constitute a nuisance for fauna. This is mainly due to the white colour of the light, but also the brightness and spread of the rays. In addition, the positioning of their accommodation on the façade determines the bird and bat species that use them. The height of the façade influences the type of façade greenery that can be used.

Legenda

- Possible position insect accommodation
- Possible position insect & mammal accommodations
- Possible position insect, mammal and Bird accommodations
- Possible dangerous window
- Annoying light emission
- 1 or 3 metres heightline

Figure 88: Facade Nieuwe Gracht (above) & Zakstraat (beneath)

0 25M

10 Case study Koudenhorn building

Legenda

- Possible position insect accommodation
- Possible position insect & mammal accommodations
- Possible position insect, mammal and Bird accommodations
- Possible dangerous window
- Annoying light emission
- 1 or 3 metres heightline

Figure 89: Facade courtyard side Koudenhorn (above) & courtyard side Bakenessergracht

0 25M

10 Case study Koudenhorn building

Legenda

- Possible position insect accommodation
- Possible position insect & mammal accommodations
- Possible position insect, mammal and Bird accommodations
- Possible dangerous window
- Annoying light emission
- 1 or 3 metres heightline

Figure 90: Facade courtyard side Zakstraat (above) & courtyard side Nieuwe Gracht (beneath)

0 25M

10 Case study Koudenhorn building

10.7 Building elements in the facades

The overview on the right shows the different elements that make up the façade. It can be seen that the building has three different eaves, behind which or in which fauna accommodations can be made. The windows and doors can also be seen. The glass surface in these elements is reduced by the rod division and wooden cut-outs in front of the glass. This prevents birds from seeing the glass as a passageway. Only the roof window can be identified as potentially dangerous, because this window type reflects the air and has a large glass surface. The building elements also determine the possible fauna accommodations and the associated species.

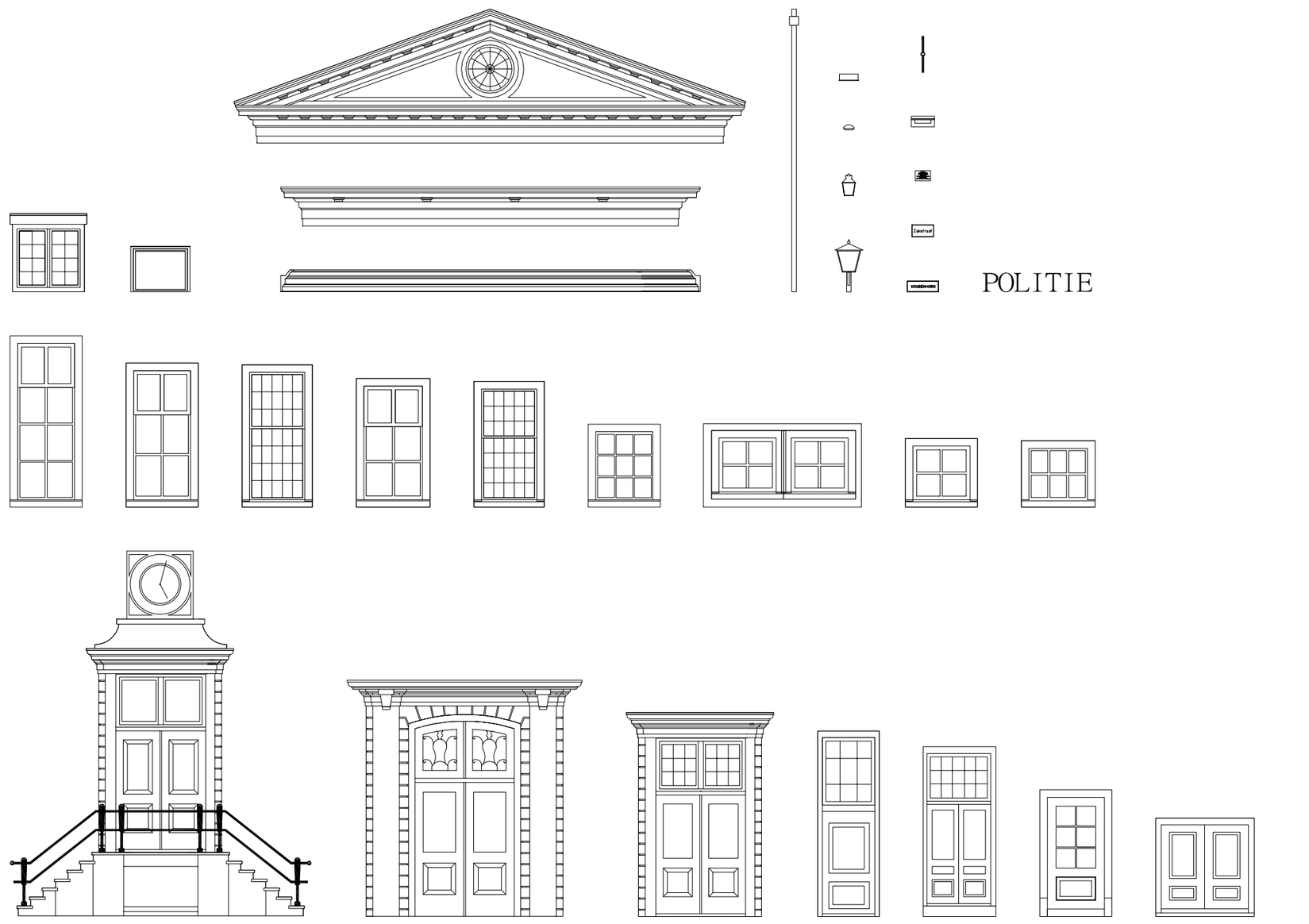

Figure 91: Analysis of the building elements in the facades

10 Case study Koudenhorn building

High value
Positive value
Indifferent value

Elements by category (Values)	Age value	Historical value	Int. commemorative value	Non int. commemorative value	Use value	New-ness value	(Relative) Art value	Rarity value	Total value
Surroundings/setting									
Water									17
Site									
Broadcasting tower									8
Bicycle shed									8
Smoking shelter									9
Quay walls									11
Entrance gate									9
Fences									6
Green									
Trees									13
Planting									7
Benches around trees									8
Car parking									8
Skin (exterior)									
Exterior brick walls									12
Roof									
Tile roof									12
Bitumen roof									6
Entrance									
Exterior entrances									13
Interior entrances									15
Clock entrance									13
Exterior doors									10
Windows									
Wall windows									10
Wall windows round									14
Roof windows									7
Roof dormers									10
Roof edges									14
Gutters									11
Facade anchors									10
Roof fences									6
Platform									13
Letterbox									11
Lighting									
Decorative lighting									10
Functional lighting									8
Street signs									
Koudenhorn street sign									8
Zakstraat street sign									9
Police sign									11
Information sign									9
Facade layout									
Layout main building									7
Layout South and West									8

Figure 92: Value assessment national monument

10.8 Value assessment

The value assessment is about the surroundings, site and exterior skin of the building. In the scheme, the various elements are arranged per category and they are valued on 8 values by means of a colour code. A blue box means an high value, a green box a positive value, and a yellow box an indifferent value. An high value equals 3 points, a positive value equals 2 points, and an indifferent value equals 1 point. In the last row, the assigned values are added up. If an element scores below 9 points, it gets an indifferent value, between 9 and 12 points a positive value, and above 12 points an high value. In the façade drawings on the following pages, the elements in the façades and on the plot are indicated by their colour. In addition, each element is explained separately as to why it has a certain value.

The scheme shows that the water, trees, entrances, wall windows round, roof edges, platform, and facade layout except the South and West facade have an high value. For this reason, it is not desirable to make visible adjustments to these elements. The quay walls, entrance gate, exterior brick walls, tile roof, exterior doors, wall windows, roof dormers, gutters, facade anchors, letterbox, decorative lighting, Zakstraat street sign, police sign, information sign, are valued with a positive value. These elements may be modified if there is a good reason for doing so. The bicycle shed, fences, planting, car parking, bitumen roof, roof windows, roof fences, functional lighting, koudenhorn street sign, facade layout South and West facade have an indifferent value, allowing free adjustment. The valuation of the elements shows which parts could be adapted when a nature-inclusive possibility is applied. In addition, the value and materialisation of the façade influence the way in which facade greenery climbs. This is to prevent the facade from being damaged.

Figure 93: Value assessment facade Nieuwe Gracht (top), Koudenhorn (top-centre), Zakstraat (bottom-centre) and Bakenessergracht (bottom)

0 25M

Figure 94: Value assessment facade courtyard Nieuwe Gracht (top), Koudenhorn (left-middle), Bakenessergracht (right-middle) and Zakstraat (bottom)

0 25M

10 Case study Koudenhorn building

High value
Positive value
Indifferent value

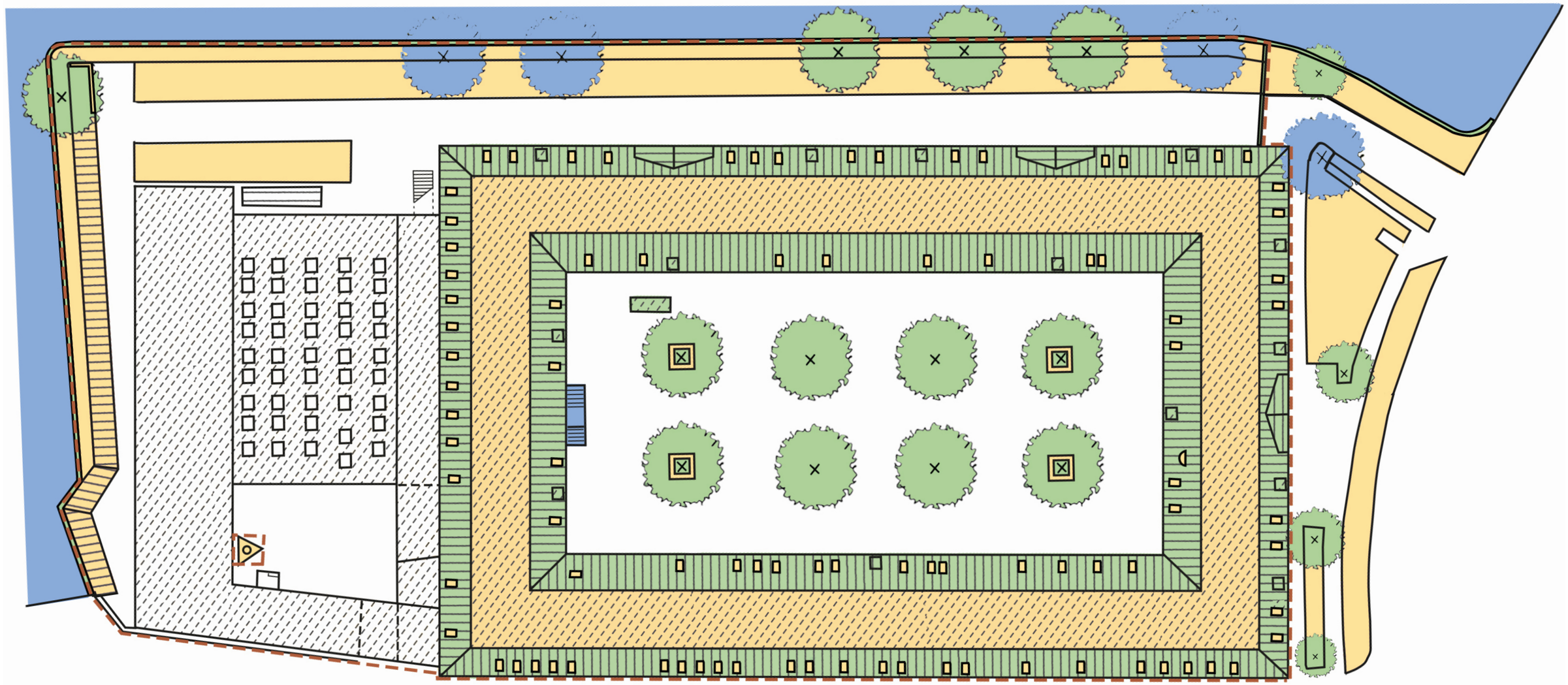

Figure 95: Value assessment plot

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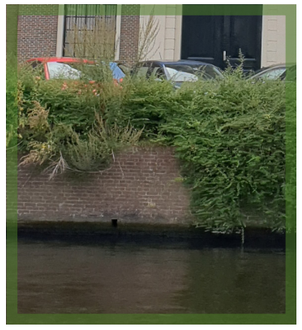
10 Case study Koudenhorn building

Water
On the North side of the lot is the Nieuwe Gracht, on the East side the Spaarne and on the West side the Bakenessergracht. The water was already there when the deaconesses' house was built. The water is important to the city's history. Haarlem was built on the Spaarne River. The water has always been an important part of the building. The monumental entrances therefore face the water. The water has numerous functions, such as regulating the water balance, is good for biodiversity and greatly enhances the spatial quility.



Quay walls
The quay walls are quite old, so they have a certain age value. The walls are already visible in old drawings and later in photographs. Because of this, these elements form part of the memory. The quay walls still serves its purpose and holds the ground behind it. The status of these walls is unknown but still looks sufficient. This element is common in Haarlem and beyond.

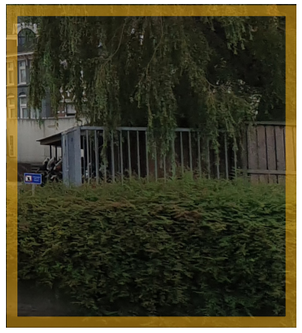
Planting
There is planting along the quays and in front of the building. On the quays, it mostly consists of berberissen and a few butterfly bushes. The planting at the front is slightly more varied. The planting is poorly maintained. The butterfly bushes are popular among the fauna, but the berberis is less so. The planting makes the building more attractive, but the poor maintenance limits this.

Broadcasting tower
The transmission tower is not old, as it dates from 2001. This mast adds nothing to history. The mast is used for telecommunications, partly by the police. For this reason, it unintentionally brings to mind its current function as a police station. It is currently still in use and is in good condition. The mast is an eyesore and therefore has an indifferent art value. In addition, these masts are common in the Netherlands.

Entrance gate
The electronic gate is probably not very old, so the age value is limited. The text on the gate is reminiscent of its current function. The gate still functions well and is in good condition. It has a low uniqueness value because it is a frequently used element.

Benches around trees
The benches around the trees are of limited age. The condition is good and still usable. The simple design has a low art value. The element is more common.

Bicycle shed
It is unclear what the exact construction date of the bicycle shed is, but it was placed somewhere in the last decade. In addition, it is not intentionally or unintentionally reminding of the (previous) function(s). The shed can still be used. However, the shed disconnects from the water. The shed is in fairly good condition, has no art value and the whole of the Netherlands is full of them.

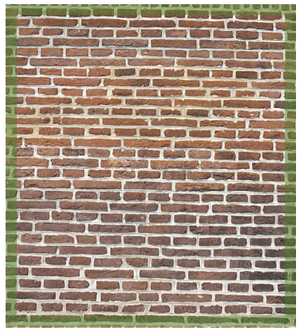


Fences
Given the reasonably good condition of the fences, it can be assumed that they are not very old. For this reason, this element has a low age value. The current use is unknown. The elements could be reused in the design. In addition, it is a frequently produced element.

Car parking
Car parking spaces are located along the Nieuwe Gracht and the Koudenhorn. The exact placement date is unknown, but it lies between 1960 and 1975. The parking areas can be used to park cars, but form a physical barrier for fauna. However, they also form a visual barrier. It disrupts the view of the water from the building and the view of the monument from the surrounding area. For this reason, the car parking spaces have an indifferent art value.

Smoking shelter
It is unclear what the exact construction date is, but it was installed somewhere in the last decade. It does not remind one of its former functions. Besides, the shelter is still quite usable. Maybe not as a smoking cabin, due to the changing lifestyle, but it can be used in a different way. The condition is quite good and the materials can still last reasonably long. It does not have a great art value and this element is very common.

Trees
There are eight plane trees in the courtyard. Along the quay, there is a single weeping willow and six plane trees. At the front, an oak, an elm and two lime trees. Some of the trees are old, giving them monumental status. This concerns three plane trees along the quay. The oak tree at the front is also protected for dendrological reasons. The trees are in full leaf and show no signs of disease, which means they are still very useful. The trees make the city attractive. The younger trees aren't unique, but the old ones are.



Exterior brick walls
The brick outer walls are original and still in good condition. There are no cracks visible and the pointing is still good. The facades have a constructive function. The building material fits well into the context. Bricks are a common facade material in the Netherlands and therefore not unique.

Figure 96: Value assessment Photo's

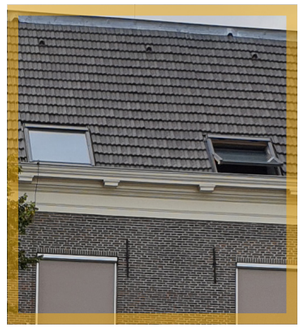
10 Case study Koudenhorn building

Tile roof

The tile roof is located on the sloping roof parts. The tiles are already visible in the original building plans. However, they have a new shape and are made of a different material, namely concrete flat mulden. The tile roof is complete and there are few defects to discover. The roof tiles protect the building from various weather influences. It is possible that birds are nesting under the roof tiles. It is also a very widely used product in the Netherlands. This is because of the many rivers, which provide the raw material for the product. This gives historical value.

Clock entrance

The clock entrance is located on the West side of the courtyard. The entrance is already visible in the original drawings. However, the windows above the doors were placed at a later stage and there was originally a bell above the clock. The door functions properly and the condition is good. In this entrance there are many decorations. The entrance is visible on many photos and drawings and unintentionally reminds visitors of the former function of the building. It was a high-quality entrance.



Roof windows

The roof windows are located in the sloping roof of the main building. They were not present in the original plan. Sometimes there were dormers at these locations, some of which were replaced by roof windows over time. The windows are positioned high, making it difficult to look outside. The windows do let in a lot of light and provide fresh air. The condition is fine. The simple design of this mass-produced item results in a low art value.

Bitumen roof

The bitumen roof is located on the flat roof parts. Originally, there was a mastic roofing package at those places, which may no longer be used due to changing regulations. For this reason, it has been replaced by bitumen. The lifespan of bitumen is short, which is why it has to be replaced regularly. This is not an easy job. It is a simple roof finish without any art value. Bitumen roofs are widely used in the Netherlands.

Exterior doors main building

These doors are present in 4 different designs. They match the original design except for the door handles. The doors are less a reminder of the former function of the building compared to the main entrances. The doors function properly and are in good condition. They are functionally designed and have only small profiling in the door surface. Some of the doors are fitted with single-glazed windows with a rod division.

Roof dormers

The dormers are located on the sloping roof of the building. In the original drawings, these elements are already visible, but were more richly detailed with an ornamental edge and boards. In the original design, they were present in a greater number. These have been replaced by roof windows over the years. The condition is good and the windows are lower positioned. The windows provide light, space and fresh air. The windows no longer have the art value it once had. It is a frequently used building element.

Haarlems Dagblad. (2012, September 14). [Roof Koudenhorn 2]

Exterior entrances

There are three of these type of entrances in the main building. One in front and two on the side of the Nieuwe Gracht. The entrances are already visible in the original building plans. The tympanums are original, but the doors themselves are most likely replaced. These entrances appear in many photographs and drawings and unintentionally remind visitors of the building's former function. The door functions properly and is in fine condition. The decorations are craftsmanship and provide a high art value.

Wall windows

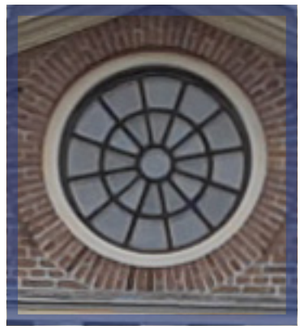
These windows are present in 9 different designs. Some of the windows differ from the original design in that the rod arrangement has been changed. This is not the case for the windows near the exterior entrances. As a result, certain window frames are most likely replaced. The windows have been fitted with single-glazing and the frames with rear windows. These increase the insulation value, but decrease the aesthetic value. The windows provide light views and fresh air. The windows are in good condition. The simple rod arrangement has limited art value.

Roof edges

A roof edge can be found on the inner and outer facades of the building, both edges differ from each other. The roof edges are already visible in the original drawings. The condition seems good. The roof edges mainly have an aesthetic function, but it is also possible that bats are housed here. The fine detailing ensures a high art value. This element can be found on many old buildings.

Interior entrances

In the main building, four of these entrances border the courtyard. They are already visible in the original plans, but after some time glass was placed in the doors. The tympani are original. These entrances were high-quality entrances for the users. The entrances appear in many photographs and drawings and unintentionally remind visitors of the building's former function. The door functions properly and is in fine condition. The tympani are decorated, but less than the entrances on the outer side of the building.



Wall windows round

These round windows are located above the three main entrances on the outer side of the building. The windows correspond to the original design. These windows are fitted with single glazing. Also, the frames are equipped with rear windows. These increase the insulation value and reduce the aesthetical value. The windows are in good condition. The shape of the windows with fine rods provides an art value. Round windows are less common, but not unique.

Gutters

This type of gutter can be found on all facades. In photos from 1930, these gutters were already visible. However, in the past, a simpler type was used, which was replaced by this type after 1973. The gutters belong to the building. They function properly and are in good condition. Some gutters have a plastic part in them. The gutters have a simple decoration.

Figure 97: Value assessment Photo's

10 Case study Koudenhorn building

Facade anchors

A simple type of facade anchor is found in the building, which consists of a black straight bar. The facade anchors are located on the masonry facade. Presumably, the facade anchors have been there for quite some time and may have been installed or removed over time. The wall anchors anchor the floor beams to the wall and keep the same wall in place. In addition, they provide small cold bridges. The simple execution ensures a low art value. These elements can be found on many buildings.

Decorative lighting

There are five of these decorative lamps on the facades of the building. Two on the East façade on both sides of the entrance and three on the South façade. The lamps were installed in 1975, but similar lamps can also be found in the same position before that. The lamps next to the entrance bear the inscription Police, which unintentionally serves as a reminder of the building's function. It is unclear if the lamps still work, but the condition seems good. The lamps have decorations that increase their art value.

Police sign

The poice sign is located on the East façade of the building above the entrance. The letters were placed in 1975 and unintentionally commemorate the current function of the building. The letters are made of metal in a golden colour, which creates a luxurious look. The letters are in good condition.

Roof fences

The roof fences are located on the flat roof parts and have been installed in the past decades in order to reach the installations on the roof safely. The installations do not require regular inspection. This can also be done with other safety measures. The fences are visible and detract from the building aesthetics, so the elements are rated with an indifferent art value. The fences are standard elements still in a good condition.

Functional lighting

There are three types of functional lights on the inside and outside façades of the building. It is unclear when the lamps were installed, but considering the object, they are at most a few decades old. It is unclear if the lamps still function, but the condition looks fine. These mass-produced lamps are extremely simple in design and do not fit the facades. For this reason, the lamps have an indifferent art value.

Information sign

This information sign is located on the East façade of the building next to the entrance. The exact date of its placement is unknown, but it was placed somewhere between 1979 and 2002. The sign is informative and a reminder of the former functions of the building. The sign is made of plastic and the text is still clearly readable. The simple design gives it a low art value.

Platform

The platform is located on the West side of the courtyard. It consists of a platform with stairs on either side with a green metal balustrade. The element is already visible in the original building plans. However, it was more ornate in design and contained an opening in the side of the platform. The condition is good, so it can last for a long time. However, the openings in the balustrade do not comply with the current building regulations. The decorations on the balustrade provide an art value. Such a platform is still common.

Koudenhorn street sign

The Koudenhoorn street sign is located on the East facade of the building. The exact date of placement is unknown, but it dates from before 1946. The sign is still clearly readable, but the colours have faded over time. It is a frequently produced element.

Facade layout main building except South and West facade

The facades fit in reasonably well with the neoclassicism, except for the South and West facades. For this reason, these facades detract from the building and therefore have an indiffent art value. The South and West façades and the West façade of the courtyard have been greatly modified over time. The other facades follow the layout of the original design. The stylistic features are reminiscent of the building, which gives it an unintentional commemmorative value.

Letterbox

This letterbox is located in the East façade of the building next to the entrance. This letterbox was placed somewhere between 1964-1976. The letterbox is still in use and the natural stone it is made of will still last a long time. It is a rather simple design.

Zakstraat street sign

This Zakstraat street sign is located on the South facade of the building. Given its condition, the sign is not very old and is still clearly legible. It is a frequently produced element.

Layout South and West facade

The facades fit in reasonably well with the neoclassicism, except for the South and West facades. For this reason, these facades detract from the building and therefore have an indiffent art value. The South and West façades and the West façade of the courtyard have been greatly modified over time. The other facades follow the layout of the original design. The stylistic features are reminiscent of the building, which gives it an unintentional commemmorative value.

Figure 98: Value assessment Photo's

10 Case study Koudenhorn building

10.9 Structure

Below is a calculation of the upper roof beam. The calculation shows that this beam can carry an additional weight of 400 kg/m2. Therefore, all nature-inclusive roofs except the intensive green roof are possible. The adjacent figure shows that the masonry facade is load-bearing. Higher up in the facade, fewer forces act. see figure. Therefore, the force distribution must be taken into account when placing fauna stones. Given the thickness and status of the brickwork, it can be assumed that the façade can bear the extra weight of possible fauna accommodations and facade greenery. In addition, the building has a tile roof, attic and crawlspace, in which fauna can be housed. However, it lacks a cavity.

Roof beam (top)

Strength calculation

$q_{UGT} = Y_{FG} \times (q_{eg} + q_{rb}) + Y_{FQ} \times q_{v.b.}$

General (CC2) > $Y_{FG} = 1.2$ and $Y_{FQ} = 1.5$

The roof floor is not accessible and consists of an 18 mm thick oak floor with additional added mass to be determined.

$q_{rb\ floor} = 0.12530\ KN/m^2$

$q_{rb\ extra} = 3.92270\ KN/m^2$

$q_{rb} = 0.12530\ KN/m^2 + 3.92270\ KN/m^2$

$q_{rb} = 4.048\ KN/m^2$

$q_{rb\ resting\ on\ beam} = l \times q_{rb}$

$q_{rb\ resting\ on\ beam} = 1.5\ m^1 \times 4.048\ KN/m^2$

$q_{rb\ resting\ on\ beam} = 6.072\ KN/m^1$

$q_{eg\ beam} = 0.18890\ KN/m^1$

$q_{v.b.} = q_k \times l$

$q_{v.b.} = 1\ KN/m^2 \times 1.5\ m^1$

$q_{v.b.} = 1.5\ KN/m^1$

$q_{UGT} = 1.2 \times (0.18890\ KN/m^1 + 6.072\ KN/m^1) + 1.5 \times 1.5\ KN/m^1$

$q_{UGT} = 9.76308\ KN/m^1$

$M_d = (1/8) \times q_{UGT} \times l^2$

$M_d = (1/8) \times 9.76308\ KN/m^1 \times 4^2$

$M_d = 19.52616\ KN/m^1 > 19{,}526{,}160\ N/mm$

$W = (b \times h^2) / 6$

$W = (100\ mm \times 270^2\ mm) / 6$

$W /= 1{,}215{,}000\ mm^2$

$Sigma_{m,d} = M_d / W$

$Sigma_{m,d} = 19{,}526{,}160\ N/mm / 1{,}215{,}000\ mm^2$

$Sigma_{m,d} = 16.07091\ N/mm^2$

$U.C. = Sigma_{m,d} / f_{m,d}$

$U.C. = 16.07091\ N/mm^2 / 16\ N/mm^2$

$U.C. = 1.00 = 1.00$

Complies! The additional added mass can be 400 kg/m2

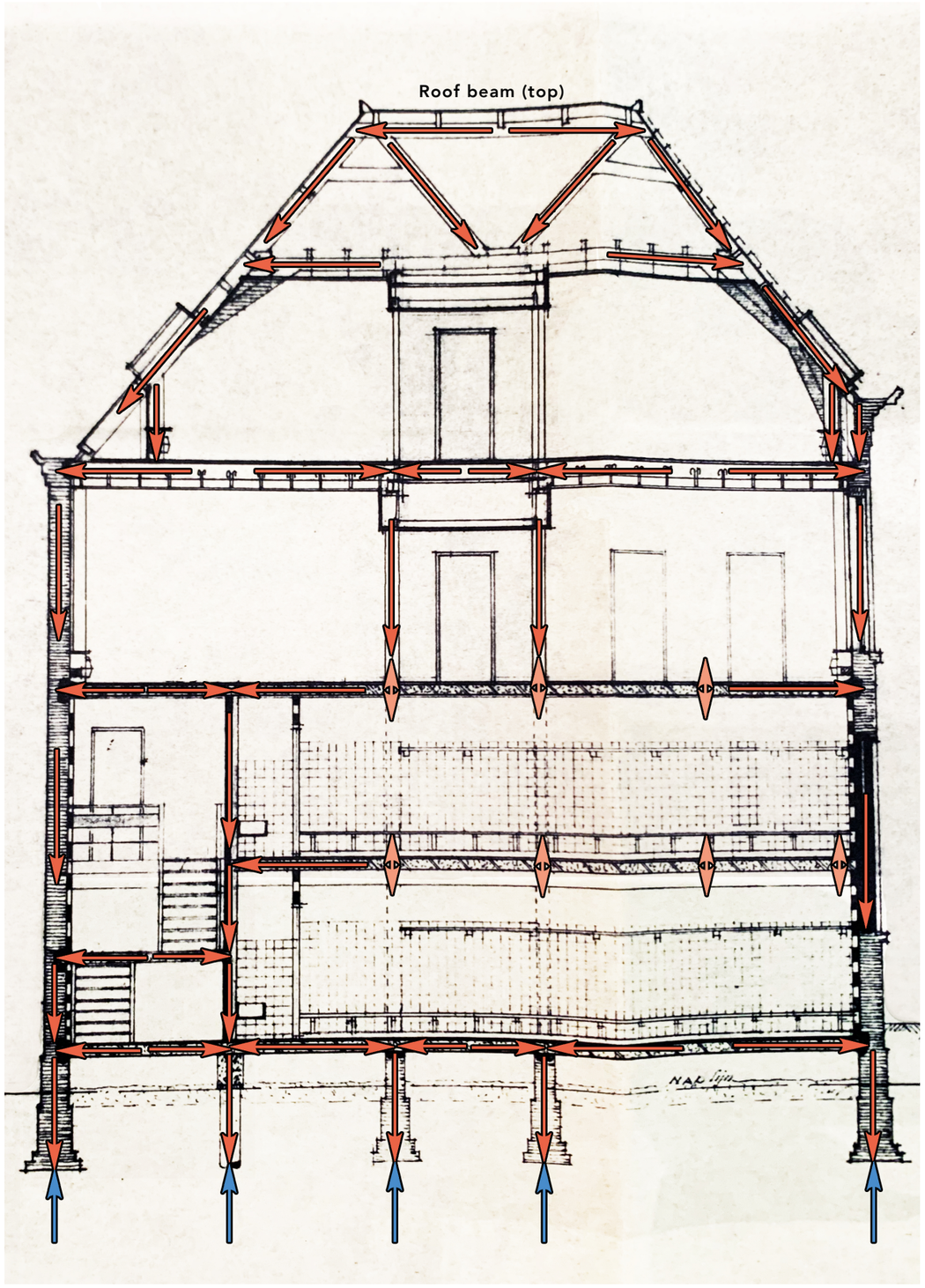


Figure 99: Force distribution in building cross-section

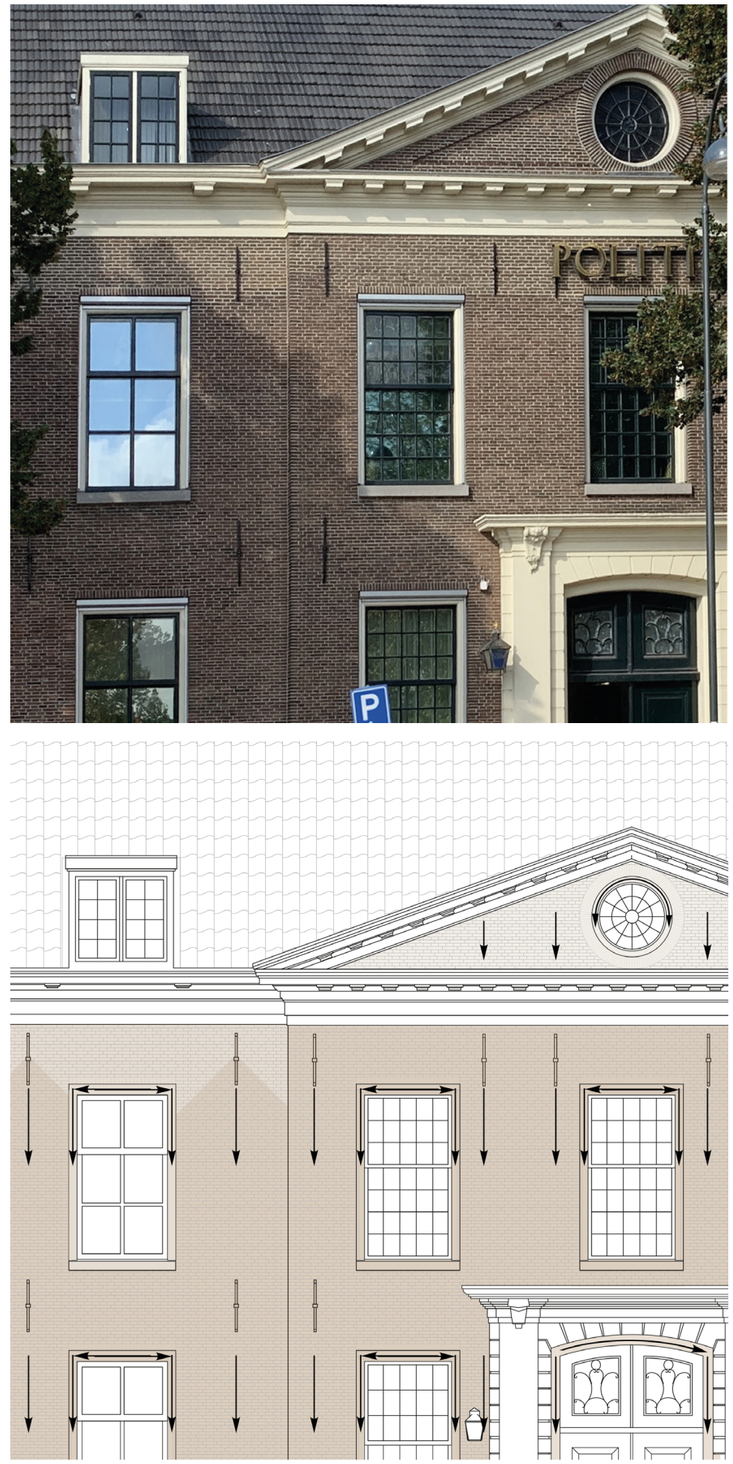


Figure 100: Force distribution in facade view

10 Case study Koudenhorn building

10.10 Nature-iclusive problems

In the figure an overview has been made of all nature-inclusive problems. It can be seen that there is a lack of nature inclusiveness on both the plot and the building. In addition, the connection of the plot with its surroundings is broken by blocking elements such as the bicycle shed parallel to Bakenessergracht, the car parking parallel to Nieuwe gracht and the wall at Korte Jansbrug. The courtyards are also difficult to reach for fauna that is unable to fly. This is because these areas are enclosed by the building. In addition, there are dangerous busy roads and paths. These are formed by the main Koudenhorn road, which is driven at 50 km/h, and the road along Nieuwe Gracht, where cars drive in and out. Another problem are the +/- 2m high and hard quays along the water, which make the connection with the ecological structure difficult. There are also dangerous windows, which seem to form a passageway or are highly reflective. There is annoying light emission from a number of lamps on the plot. This is due to the bright, spread and white light coming from these lamps. Finally, there is a gap in the ecological tree network. This happens along the Bakenssergracht and Nieuwe gracht. There is no green network at all. The ecological water network, on the other hand, is continuous.

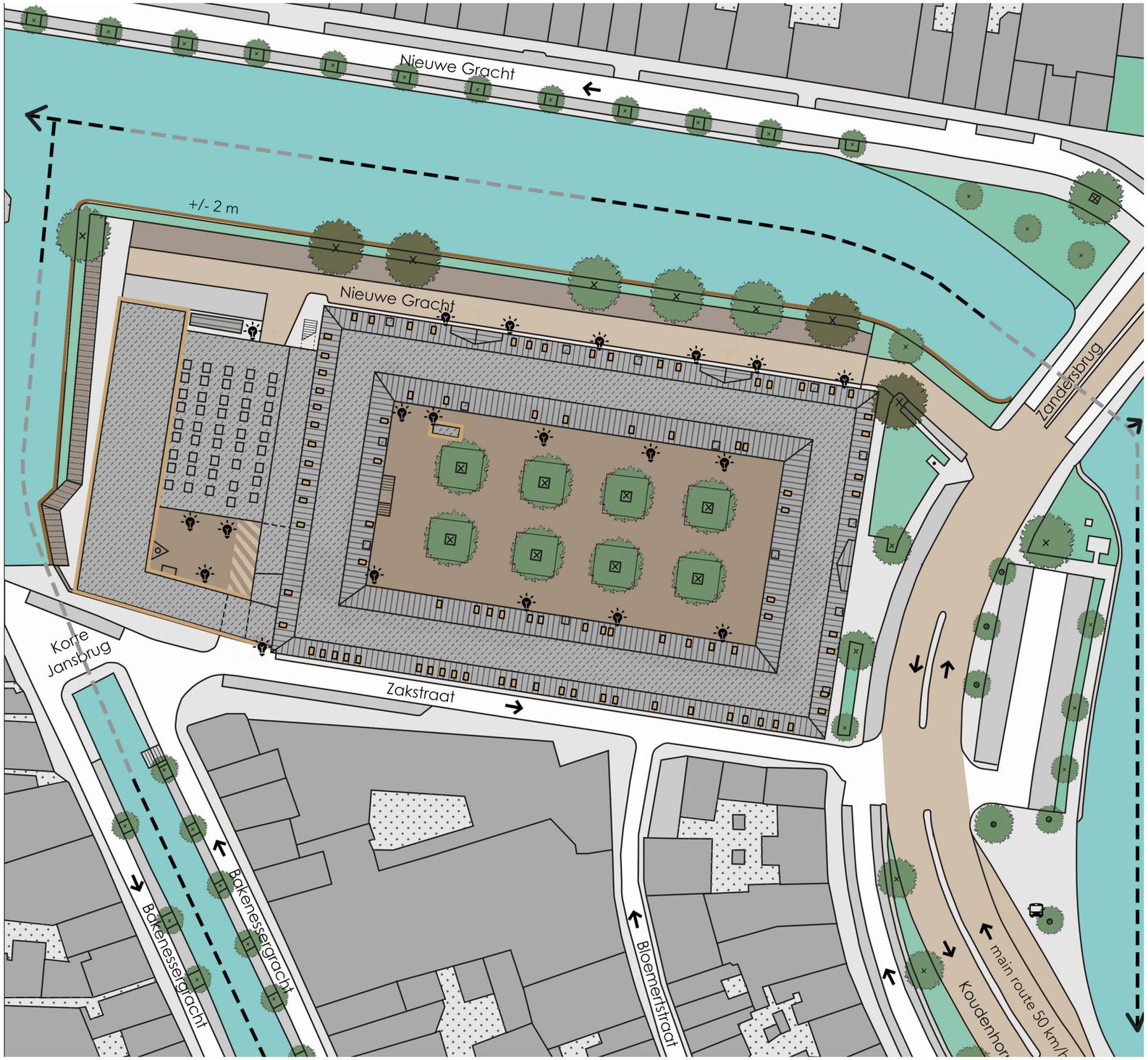
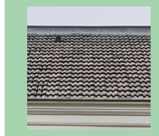


Figure 101: Nature-inclusive problems

10 Case study Koudenhorn building

10.11 Filled in decision trees

Tile roof

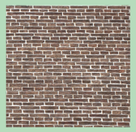


Monumental value: positive
Height: 10.4-15.1m
Angle of inclination: 49
Available space: sufficient
Additional load capacity: (400kg/m2)
Accessible: yes

Bitumen roof

Monumental value: indifferent
Height: 15.1m
Angle of inclination: 0-3
Available space: sufficient
Additional load capacity: 400kg/m2
Accessible: yes

Exterior brick walls



Monumental value: positive
Height: 0-9.6m
Available space: sufficient
Additional load capacity: sufficient
Accessible: yes
Sensitivity: sensitive
Moisture regulation: poor

Quay walls

Water protection element: no
Monumental value: positive

Outdoor area

Height: 0m
Available space: sufficient
Soil: sand
Groundwater level: low
Wind speed: low-medium

Roads and paths

Height: 0m
Users: cars, bikes & people
Used by disabled: no
Frequency: high
Soil: sand
Groundwater level: low

Roof

Given the monumental value of the roof, can it be modified?
Yes / No
Is the roof lower than 150 metres above ground level?
Yes / No
Does the roof have a suitable angle of inclination?
(up to 10 degrees for an intensive green roof & brown roof, up to 45 degrees for a semi-extensive green roof & roof garden (if usable) and up to 60 degrees for an extensive green roof)
Yes / No
Is there enough space available on the roof?
Yes / No
Can the roof structure support an additional weight?
(at least 54 kg/m2 for an extensive green roof, a. l. 270 kg/m2 for an semi-intensive green roof, a. l. 1.080 kg/m2 for an intensive green roof, a. l. 180 kg/m2 for a brown roof and for a roof garden, it depends on the design)
Yes / No

* ** Green roof (extensive)
* ** Green roof (semi-extensive)
* Brown roof

Can the roof be accessed?
Yes / No
* Green roof (intensive)
Roof garden * **

* The solar demands influence the suitable vegetation types
** Additional adjustments are required at an angle of inclination of 35 degrees and above

Roof

Given the monumental value of the roof, can it be modified?
Yes / No
Is the roof lower than 150 metres above ground level?
Yes / No
Does the roof have a suitable angle of inclination?
(up to 10 degrees for an intensive green roof & brown roof, up to 45 degrees for a semi-extensive green roof & roof garden (if usable) and up to 60 degrees for an extensive green roof)
Yes / No
Is there enough space available on the roof?
Yes / No
Can the roof structure support an additional weight?
(at least 54 kg/m2 for an extensive green roof, a. l. 270 kg/m2 for an semi-intensive green roof, a. l. 1.080 kg/m2 for an intensive green roof, a. l. 180 kg/m2 for a brown roof and for a roof garden, it depends on the design)
Yes / No

* ** Green roof (extensive)
* ** Green roof (semi-extensive)
* Brown roof

Can the roof be accessed?
Yes / No
* Green roof (intensive)
Roof garden * **

* The solar demands influence the suitable vegetation types
** Additional adjustments are required at an angle of inclination of 35 degrees and above

Facade

Given the monumental value of the facade, can it be modified?
Yes / No
Is the chosen position lower than 150 metres above ground level?
Yes / No
Is there sufficient vertical and horizontal space?
Yes / No
Does the façade greenery not cause any nuisance near façade openings?
Yes / No
Can the façade structure support the required additional weight?
Yes / No
Is the chosen location accessible for maintenance?
Yes / No

* ** Facade greenery

* The solar demands and maximum growing heights influences the suitable vegetation types
** The materialisation of the façade influences the type of facade greenery; for a sensitive or poorly moisture-regulating façade, do not use self-adhesive climbing plants but another type

(Quay) walls

Given the water protection can the quay wall be adjusted?
(for other walls go to the next question)
Yes / No
Given the monumental value of the wall, can it be modified?
Yes / No

* ** Green (quay) walls

* The solar demands and maximum growing heights influences the suitable vegetation types
** Receiving water is important for the positioning

Outdoor area

Is there an outdoor area?
Yes / No
Is the chosen position lower than 150 metres above ground level?
Yes / No
Does the flora possibility not cause any nuisance near façade openings?
Yes / No

* Stacked branches and tree trunks

Is there at the chosen location sufficient room for growth, both above and below ground?
Yes / No
Is there good soil at the chosen location, given the type of soil and groundwater level?
Yes / No

* (Flowery) planting
* Shrubs and hedges

The chosen position is not on an important water barrier?
Yes / No
The chosen position has a minimum distance of 2 metres to the plot boundary?
Yes / No
By growing in the chosen position, can no damage be done to the surroundings or dangerous situations arise?
Yes / No
Does the chosen position not form a barrier to fauna accommodation?
Yes / No

* ** Trees

* The solar demands and maximum growing heights influences the suitable vegetation types
** If subjected to strong winds, an additional supporting structure is required

Roads & paths

Is the chosen position lower than 150 metres above ground level?
Yes / No
Does the path not have to be accessible to the disabled?
Yes / No

* ** *** Natural pavement

* The solar demands and maximum growing heights influences the suitable vegetation types
** The kind, number and weight of the user affect the type
*** The soil composition and groundwater level influences the build up

Figure 102: Filled in decision tree of the nature-inclusive flora possibilities

10 Case study Koudenhorn building

Tile roof

Monumental value:	positive
Height:	10.4-15.1m
Angle of inclination:	49
Available space:	sufficient
Additional load capacity:	(400kg/m2)
Accessible:	yes

Bitumen roof

Monumental value:	indifferent
Height:	15.1m
Angle of inclination:	0-3
Available space:	sufficient
Additional load capacity:	400kg/m2
Accessible:	yes

Outdoor area

Height:	0m
Available space:	sufficient
Soil:	sand
Groundwater level:	low

Embankment

Height:	0m
Water protection element:	no
Available space:	sufficient
Soil:	sand
Water quility:	freshwater
Water intensity:	low

Water

Water intensity:	low
Available space:	sufficient
Water quility:	freshwater

Roof

Given the monumental value of the roof, can it be modified?
- Yes
- No

Is the roof flat?
- Yes
- No

Is the roof lower than 150 metres above ground level?
- Yes
- No

Is there enough space available on the roof?
- Yes
- No

Can the roof structure support an additional weight of at least 135kg/m$_2$?
- Yes
- No

Can the roof be accessed?
- Yes
- No

* 

* The solar demands influence the suitable vegetation types

Roof

Given the monumental value of the roof, can it be modified?
- Yes
- No

Is the roof flat?
- Yes
- No

Is the roof lower than 150 metres above ground level?
- Yes
- No

Is there enough space available on the roof?
- Yes
- No

Can the roof structure support an additional weight of at least 135kg/m$_2$?
- Yes
- No

Can the roof be accessed?
- Yes
- No

* 

* The solar demands influence the suitable vegetation types

Outdoor area

Is there an outdoor area?
- Yes
- No

Does the outdoor area have a flat surface?
- Yes
- No

Are there no cables, pipes or tree roots in the ground at the chosen location?
- Yes
- No

**

** 

Is there at least 50% of the day's sunshine at the chosen location?
- Yes
- No

** 

* The solar demands influences the suitable vegetation types
** The soil composition and groundwater level influences the build up

Embankment

Is there a water bank present?
- Yes
- No

Given the water protection, can the bank be adjusted?
- Yes
- No

Are there no cables, pipes or tree roots in the ground at the chosen location?
- Yes
- No

* ** *** 

* The solar demands and water quility influences the suitable vegetation types
** The soil composition influences the build up
*** The intensity of the stream and waves of the water will influence the build up and the choice of vegetation species

Water

Is there water present?
- Yes
- No

Is the water stagnant or slow flowing?
- Yes
- No

The chosen location does not impede the mobility and flow of water?
- Yes
- No

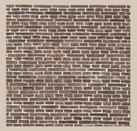
* ** 

* The solar demands and water quility influences the suitable vegetation types
** The intensity of the stream and waves of the water will influence the build up and the choice of vegetation species

Figure 103: Filled in decision tree of the nature-inclusive water possibilities

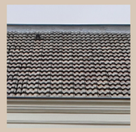
10 Case study Koudenhorn building

Exterior brick walls



Monumental value:	positive
Height:	0-9.6m
Orientation:	all
Available space:	sufficient
Additional load capacity:	sufficient
Free approach route:	yes
Accessible:	yes

Tile roof



Monumental value:	positive
Height:	8.7-15.1m
Orientation:	all
Available space:	sufficient
Additional load capacity:	sufficient
Free approach route:	yes
Accessible:	yes

Roof edge

Monumental value:	high
Height:	8.3-8.7m & 9.6-10.4m
Orientation:	all
Available space:	sufficient
Additional load capacity:	sufficient
Free approach route:	yes
Accessible:	yes

Attic

Monumental value:	indifferent
Height:	13.0-15.0m
Orientation:	all
Available space:	sufficient
Additional load capacity:	sufficient
Free approach route:	Yes
Accessible:	yes

Smoking shelter

Potential hazard:	passageway
Monumental value:	positive
Height:	0-2.6m

Entrances

Potential hazard:	none
Monumental value:	high
Height:	<4.1m

Building

Does the building have a façade, roof, chimney, eaves, attic, cellar or cavity wall suitable for fauna, which can be adapted due to its monumental value?

Yes / No

Is the chosen location at the right height?

(3-40 m for birds, 3-50 m for mammals and 1-10 m for insects dependent on species)

Yes / No

Is the chosen location on the right orientation?

(North, East and (West) for birds, South and West for insects except butterflies. For mammals go to the next question)

Yes / No

Is the chosen location not above windows for birds and for insects near bird acommodations?

Yes / No

Is there no nuisance from facade openings at the chosen location?

Yes / No

Is there enough space at the chosen location?

(for dimensions see section fauna possibilities)

Yes / No

Can the chosen location support the increasing mass and does the force flow correctly?

Yes / No

Is there at the chosen location a free approach route of 2/(3) metres high and 2 metres wide?

(3 m for birds. For insects go to the next question)

Yes: Fauna accommo-dations (mammals) * ** ***

No

Is the chosen location accessible for maintenance?

Yes: Fauna accommo-dations (birds) * **; Fauna accommo-dations (Insects) * **

No

* The height and orientation determine the animal species
** The animal species influence the type of accommodation
*** The orientation and accommodation influence the type of residence

Windows

Is there glass in the building that is a potential hazard to birds, such as reflective glass or windows that appear to be a passageway?

Yes / No

Given the monumental value of the windows and doors, can they be modified?

Yes / No

Are the windows lower than 150 metres above ground level?

Yes / No

Preventing window casualties

Figure 104: Filled in decision tree of the nature-inclusive fauna possibilities

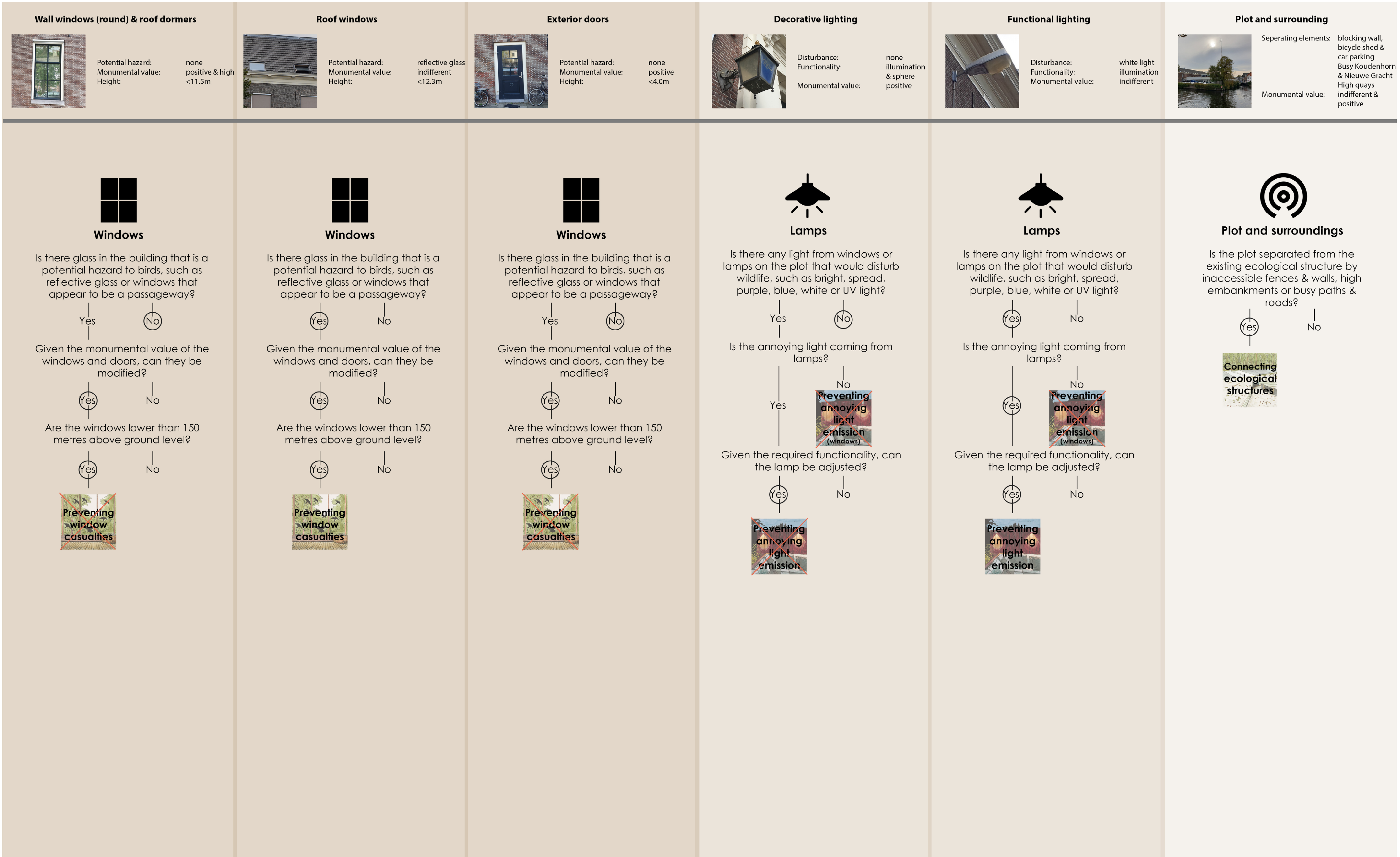


Figure 105: Filled in decision tree of the nature-inclusive fauna possibilities

10 Case study Koudenhorn building

10.12 Results

The various decision trees were filled in based on the analyses made earlier. The final results are shown in the scheme. The scheme is divided into the categories: flora, water and fauna. The first column shows the element being analysed. The second column shows the suitable nature-inclusive possibilities. In the last row, the possibilities are further specified if possible. The scheme shows that the Koudenhorn building lends itself perfectly for the application of many nature-inclusive possibilities. On the plot, all nature-inclusive possibilities, except the intensive green roof and the natural bank, can be applied to the monumental building and the outdoor space.

The analyses show the lack of nature-inclusiveness on both the plot and the building. It appeared that there was a gap in the ecological tree network along the Bakenessergracht and the Nieuwe Gracht at the plot location. This gap could be closed. An ecological green network is currently missing. For this reason, a start can be set here. The results will be used in the nature-inclusive redesign of the Koudenhorn building.

This case study shows that to fill in the decision trees, a specific element with a specific location has to be dealt with, because the questions from the decision trees cannot be answered generically. For this reason, the roof has to be split into the flat and the sloping roof part and the different facades have to be treated separately.

Suitable flora possibilities

Elements	Possibilities	Subheading (if possible)
Tile roof	Green roof (extensive)	
Bitumen roof	Green roof (extensive)	
	Green roof (semi-extensive)	
	Brown roof	
	Roof garden	
Exterior brick walls	Facade greenery	Climbing plants with an escorting substructure, hanging and climbing greenery in containers & greenery in substrate attached to the facade
Quay walls	Green (quay) walls	Creating and filling new holes
Outdoor area	St. branches and tree trunks	
	(Flowery) planting	
	Shrubs and hedges	
	Trees	
Roads and paths	Natural pavement	Semi paved surfaces, paving with open areas for vegetation, open paving elements with vegetation & steppingstones between vegetation

Suitable water possibilities

Elements	Possibilities	Subheading (if possible)
Tile roof	-	
Bitumen roof	Blue roof	
Outdoor area	Natural pond	
	Natural wadi	Infiltration wadis & mixed wadis
	Ecological puddle	
Embankment	-	
Water	Floatland	

Suitable fauna possibilities

Elements	Possibilities	Subheading (if possible)
Exterior brick walls	Mammals accommodations	Add-on boxes & built-in boxes
	Birds accommodations	Nesting stones & nesting boxes
	Insect accommodations	Nesting stones & nesting boxes
Tile roof	Mammals accommodations	Between roof layers
	Birds accommodations	Birds shelter roof tiles
Roof edges	Mammals accommodations	Add-on boxes & under roof edges
	Birds accommodations	Nesting boxes
	Insect accommodations	Nesting boxes
Attic	Mammals accommodations	Attic, bat boxes
	Birds accommodations	Nesting boxes
Smoking shelter	Preventing window casualties	Stickers, sandblasting figures, vertical lines, tinted foil, textures or bird safety glass & rod division
Entrances	-	
Wall win. (round) & roof dorm.	-	
Roof windows	Preventing window casualties	Stickers, sandblasting figures, vertical lines, tinted foil, anti-reflective, textures or bird safety glass & rod division
Exterior doors	-	
Decorative lighting	-	
Functional lighting	Prev. annoying light emission	Changing light colour
Plot and surrounding	Con. ecological structures	Fauna passages, fauna accespoints & guidance walls
+Fauna flats & insect hotels		

Figure 106: Results decision trees

11 Summary and recommendations

11.1 Summary

The central research question will be answered by means of a summary and recommendation. The central research question is: 'How can Dutch monumental buildings in an urban context be redesigned to be more nature-inclusive?'

The research showed that a nature-inclusive building has many advantages for its human and animal users. For example, a nature-inclusive building improves: activities, health, the immune system, the mental state, the quality of the living environment, social connections, biodiversity and can be food or produce food. It is important to note that there is much overlap between the various benefits. One advantage may be related to the other. In this way, the combined effect can be large. It should also be noted that the quality of the green space influences the various benefits. High-quality greenery has a more positive effect than low-quality vegetation.

Some of the animal species found in the Netherlands depend entirely (1.6%) or to a large extent (8.7%) on the city. This is mainly due to the favourable living conditions in the city, which makes them eager to forage there. The study focuses on birds, mammals, and insects (butterflies and bees). The population trends of Dutch urban breeding birds and butterflies show that the number has declined significantly in recent decades. In recent years, similar trends have been seen in the urban mammal and bee populations. However, these populations seem to be stabilising, partly due to the improvement of the living environment. This illustrates the importance of improving the living conditions for animals in the city. Research showed that 30 bird species are highly dependent to neutrally dependent on Dutch cities. On the list of these bird species, nature-inclusive options are targeted, except for fauna accommodations. Five bird species from this list, including the swift, house martin, house sparrow, starling, and jackdaw, will be the focus. These species breed in or on buildings. Similarly, a list of mammals has been drawn up. This list includes 17 mammal species. On the list of these mammal species the nature-inclusive possibilities are focused, except for the fauna accommodations. With the exception of the polecat, stoat, weasel, vole, and black rat, due to the great disturbance these species could potentially cause. Six bat species, including the common, nathusius and soprano pipistrelle, serotine bat, lesser horseshoe bat, and parti-coloured bat live in or on the façades. These species are targeted by the fauna accommodations. Butterflies and wild bees are also targeted. No distinction is made between specific species, but the entire group is aimed at. Additional research has been done into the bird and mammal species that live in or on buildings, the wild bees and butterflies. These other requirements can be included in a redesign.

In addition, there are lists of red animal species, which include animal species that are endangered or have already become extinct. Especially the species on this list need extra attention for conservation. Of the bird species that are targeted, the house sparrow and house martin are on that list. A large part (16 species) of the urban mammals are included on that list, including the hedgehog, rabbit, serotine bat, lesserhorseshoe bat and parti-coloured bat. Butterflies and bees are equally in bad condition. There are 52 butterfly species and 219 bee species on the red lists. Particularly the highly endangered and rare species would benefit from more nature-inclusive buildings in the urban environment.

Twenty nature-inclusive options were discussed, with some of them being further subdivided (see Figure 103). The possibilities are divided into three categories: flora, water, and fauna. The possibilities that could be applied to the facades and the immediate surroundings of a building are adressed. A sketch has been made of each possibility and a description has been given. Several design options are described for the various possibilities. It should be mentioned that there are many other possible ways of applying the option. The creativity of the designer is therefore required. In addition, there is a description of what should be taken into account when applying it to a Dutch monumental building. Subsequently, three decission trees were created on the basis of the points of attention (see Figures 78, 79 & 80). By filling in the questions in these diagrams, designers and building owners of Dutch urban monumental buildings can see which nature-inclusive options they could apply in a redesign to make their building more nature-inclusive. It also gives them insight into which aspects they might have to adjust in order to make the application of a nature-inclusive possibility possible.

The nature-inclusive possibilities

Flora
- Green roof
  - Extensive green roof
  - Semi-intensive green roof
  - Intensive green roof
- Roof garden
- Brown roof
- Façade greenery
- Green (quay) walls
- Trees
- Shrubs and hedges
- (Flowery) planting
- Natural pavement
- Stacked branches and tree trunks

Water
- Blue roof
- Natural pond
- Ecological puddle
- Natural wadi
- Natural bank
- Floatland

Fauna
- Fauna residences
  - Bird accomodations
  - Mammal accomodations
  - Insect accommodations
- Connecting ecological structurea
- Preventing window casualties
- Preventing annoying light emission

Figure 107: The nature-inclusive possibilities regarding flora, water, and fauna

Next, the decission trees were tested using a case study of the Koudenhorn building. This case study shows that in order to fill in the decision trees, a specific element with a specific location has to be treated, because the questions from the decision trees cannot be answered generically.

The results of the completed decision trees of the Koudenhorn building show which nature-inclusive options can be applied to the building. These results are visible in Figure 106. The analyses show the lack of nature inclusiveness on both the plot and the building. There appeared to be a gap in the ecological tree network along the Bakenessergracht and the Nieuwe Gracht on the plot location. This gap could be closed. An ecological green network is currently lacking. For this reason, a start can be made here. The results will be used in the nature-inclusive redesign of the Koudenhorn building.

11 Summary and recommendations

Application
In order to make a Dutch monumental building in an urban environment more nature-inclusive, the decision trees can help to clarify which nature-inclusive possibilities could be applied and which aspects may have to be adapted to make them possible. For this, the questions from the decision trees need to be answered. For this purpose, specific building elements with a specific location must be used. The questions can be answered by means of various analyses of: water & greenery structures, site plan, subsurface, mass, facades, building elements in the facades, value assessment and structure. The toolbox includes a clear description of what the possibility entails, the additional points of interest and an optional design. Next, the designer or building owner can make a plan to integrate the nature-inclusive possibility on their own plot. This with the ultimate goal of increasing biodiversity. The research into the city-dependent bird, mammal and insect species that live in or on buildings can be used to create an ideal habitat for these species.

11.2 Recommendations

Currently, there are only a few nature-inclusive buildings in the Netherlands. Nature-inclusive building is not only strongly on the rise in the Netherlands, but also internationally. In the future, large-scale tenders in the Netherlands will be granted partly on the basis of a nature-inclusive scoring system.

According to research, nature-inclusive building is quite good for the business case. It is therefore advisable to show nature-inclusiveness. When integrating nature-inclusive options, it is advisable to bring in additional expertise. It is also recommended to arrange management and maintenance from the start. In addition, not only the benefits for biodiversity should be considered, but also the other benefits. There are options for every Dutch monumental building to increase nature inclusiveness. Not only large, but also small applications can be of great added value for biodiversity.

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