DESIGN FOR WELLBEING THROUGH BIOPHILIC PATTERNS: DESIGN PRINCIPLES FOR DUTCH RESETTLEMENT HOUSING

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ABSTRACT

Dutch resettlement housing for refugees is stressed due to the ongoing refugee crisis. As a result, the quality of housing cannot always be guaranteed, with negative consequences in terms of wellbeing. Architects, therefore, need tools to better integrate well-being into resettlement housing. Biophilic design offers a solution to combine wellbeing and dwelling. However, the suitability of this design approach has not previously been tested for resettlement housing and its target group. By compiling a pattern language from literature and testing it with both case studies and the Dutch regulation framework, a toolkit has been created for architects. The suitability of applying biophilic design in Dutch resettlement housing has been shown. The toolkit contains principles for the different patterns as well as generic principles. To translate these principles into practical tools, they are supported by various tools. This way, the architect has the opportunity to properly integrate biophilic design for well-being into the design, raising the quality of resettlement housing.

KEYWORDS: *Biophilic design, Biophilia, Wellbeing, Dutch resettlement housing, Design principles, Design tools*

I. INTRODUCTION

Currently, Europe is in the throes of the refugee crisis. Hundreds of thousands flee their homes in search of safety and a better life (Universiteit Leiden, no date). This is noticeable in the Netherlands as well. In 2023 alone, more than 50.000 refugees have registered in Ter Apel, hoping for asylum in the Netherlands (CBS, no date). After an often long journey and going through the application process in Ter Apel, refugees are housed in an Asylum Seekers Centre, Asiel Zoekers Centrum (AZC) in Dutch. They will be placed at different places in the Netherlands and will wait there until their procedure is completed. Housing and help are organised by the Centraal Orgaan Opvang Asielzoekers (COA) during this procedure. Many people remain in resettlement housing even after getting status while waiting for housing (COA, no date b).

The right to adequate housing for refugees in resettlement housing in the Netherlands currently falls short of habitability (Kinderombudsman & Nationale Ombudsman, 2023). The housing does not extensively support the wellbeing of its residents. At the same time, the dominant user group of the architecture is prone to mental health issues due to their past trauma (United Nations and Office of the United Nations High Commissioner for Human Rights, 1991).

When looking at architecture that supports wellbeing, different approaches can be seen in literature. Van der Voordt (2021) summarises seven approaches for this purpose. Only some of these theories can be applied to AZC architecture due to the scale, program and/or application. Salutogenic outcomes are especially important for this target group. This outcome focuses on (general) prevention and not treatment of specific diseases. As residents have had their own experiences, a generalist approach is needed. With salutogenic architectural design as a goal, you still need a method or strategy to accomplish this. An already widely researched design strategy applicable to dwellings on the scale of an AZC is biophilic design (Van Der Voordt, 2021). As of yet, this has not been applied to resettlement housing, and there are no practical design tools or principles to support the architect during the design.

Because such a translation of wellbeing architecture to resettlement housing has not yet been made, (mental) health and wellbeing are not an integral part of the design yet.

1.1. Objective And Research Question

The objective of this research is to translate the knowledge of biophilic design elements and their effects on (mental) wellbeing into practical design principles and tools for architects to design for users of resettlement housing. This will result in tailored design principles and tools for resettlement housing in the Netherlands. The principles and tools will be based on pattern languages previously proposed in literature.

This paper is set up to answer the following research question:

How can biophilic design elements be translated into practical design principles and tools to be used to increase the overall wellbeing of residents in resettlement housing in the Netherlands within the framework of the COA?

Sub questions;

- How can we categorize biophilic design elements, and how are they relevant for wellbeing?
- How can we analyse biophilic case studies, and what can we learn from them?
- What is the current state of the relationship between AZCs and biophilic design?
- What practical implications does the implementation of biophilic design elements in resettlement housing have within the COA's set framework?

1.2. Paper Layout

The research question will be answered by the use of literature studies, case studies, observation and interviewing. The research will be divided into four substantive parts, each answering their own (sub)question. The first part and chapter will be used to gain a thorough understanding of the role of biophilic design in the wellbeing of the users. A clear pattern language will be distinguished on which to base further explorations in this research. Secondly, chapter three will aim to clarify how biophilic principles have previously resulted in biophilic designs. A foundation for design principles and tools can be made. The next chapter will look into the architecture of the AZC and its current relationship with biophilic design. The last chapter will show how the functionality of the AZC can be maintained based on the framework of the COA in regard to the design principles and tools. If needed, the design principles and tools can be added, adapted or removed. Lastly, the main question will be answered in the conclusion.

II. Biophilic Design And Wellbeing

This chapter will aim to gain a thorough understanding of the role of biophilic design in the wellbeing of the users. A clear pattern language will be distinguished on which to base further explorations in this research.

2.1. Biophilia

To understand biophilic design, it is important to take a step back and look at its origin. The term biophilia was first introduced by psychoanalyst Enrich Fromm in 1974 in his book *The Anatomy of Human Destructiveness.* He describes biophilia as a psychological orientation towards all that is alive. This view changed the way the relationship between humans and nature was looked at. Later on, biologist Edward O. Wilson defined biophilia as the innate tendency of humans to seek connection with nature and other forms of life in his book *Biophilia* (1984). He even concluded that it is not only a mere tendency but also has a genetic basis, in part. Wilson (1984) argues that we are so instinctively

drawn to other forms of life because we have spent more than 99% of our evolution surrounded by nature.

With this evolutionary approach from biophilia, other fields of research, such as architecture and urban planning, were influenced soon. The form of expression of biophilia in architecture is often seen in biophilic design and stems from the same connection to nature (Abdelaal & Soebarto, 2018).

2.2. Biophilic Design

Biophilic design, due to the evolutionary origin of this architectural approach, is an adequate and efficient way of designing interiors, buildings and urban environments to encourage the biophilia of the user (Barbiero and Berto, 2021). Using biophilic design principles is not only beneficial for nature and, therefore, sustainability and nature-inclusivity in the built environment. Benefits for its human users range from improved health, increased wellbeing, decreased violence and crime rates and reduced stress levels (Söderlund & Newman, 2015). Multiple researchers and architects have constructed their own frameworks to classify natural aspects and elements to be able to design with biophilic elements. Two frameworks, by Kellert (2008 and 2018) and Browning and Ryan (2014), stand out because of their regular use in studies about biophilic design (Zhong et al., 2019). An overview of proposed frameworks over time can be seen in Figure 1.

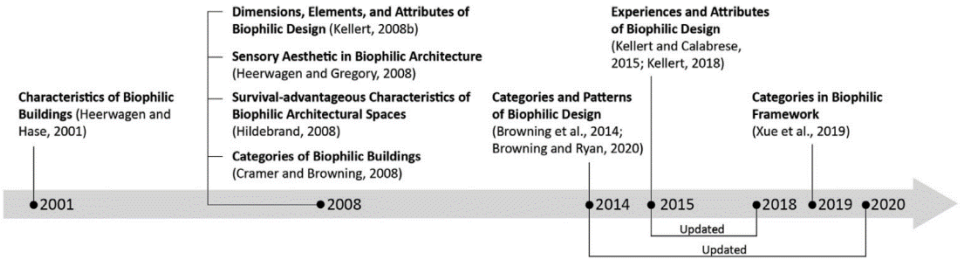

Figure 1. Overview of proposed frameworks over time (Zhong et al., 2019)

Although the origins and goals of the frameworks are the same, their methods and approaches differ. Due to the greater amount of overlap in the framework of Kellert (2018) and the connection to the architectural pattern language by Alexander (1974) in the framework of Browning and Ryan (2014), this research will take the framework from Browning and Ryan (2014) as leading principles.

Both Kellert and Browning and Ryan divide their frameworks into three categories. Browning and Ryan (2014) distinguish the categories of *Nature in the space, Natural analogues* and *Nature of the space* among their 14 patterns. As seen in Appendix 1, the natural analogues and nature of the space influence the wellbeing and positive emotions of its users the most. In contrast, nature in the space has shown to have other benefits as well such as stress reduction. As this research aims to increase the wellbeing of refugees in resettlement housing, all patterns related to emotion and wellbeing will be explored in this further research because of their suitability for future design assignments.

2.3. Wellbeing And Biophilic Elements

To be able to compose principles in further research, it is important to gain a deeper understanding of the relationship between wellbeing for resettlement housing and the biophilic patterns that relate to it. This will ensure a clear focus and targeted principles and tools. It is important to notice the role of duration of exposure in the effects of the patterns on wellbeing. The best duration of exposure is dependent upon the target group and desired effect. Empirical evidence shows that benefits from the patterns for wellbeing can occur within 5 to 20 minutes of exposure. The exposure time is not desired for all patterns (Terrapin Bright Green, 2014). The different patterns and their relation to wellbeing will be discussed below.

2.3.1 Visual Connection with Nature

The first pattern to be mentioned by Browning and Ryan in 2014 is the visual connection with nature. The pattern is characterised as a view of living systems and natural processes. Kellert (2018) mentions that views of nature typically exert their greatest impact when they are at relatively moderate to short distances, at modest heights, and viewed from sheltered spaces. The benefits of a visual connection can be seen in reduced stress levels, positive emotional functioning and improved concentration and recovery rates (Browning & Ryan, 2014). These benefits for the wellbeing of users increases with views with greater levels of biodiversity. In comparison, the increase of the benefit is greater with an increase in biodiversity than an increase in natural vegetative area (Terrapin Bright Green, 2014).

2.3.2 Non-Visual Connection with Nature

Next to the visual connection, the non-visual connection with nature also poses benefits to wellbeing. The pattern is characterized by auditory, haptic, olfactory, or gustatory stimuli that engender a positive reference to nature (Browning and Ryan, 2014). When the non-visual sensory interactions are experienced as non-threatening they improve mental health and wellbeing (Terrapin Bright Green, 2014).

2.3.3. Thermal & Airflow Variability

Although partly overlapping with the non-visual connection with nature, thermal and airflow variability show their own benefits to wellbeing. The pattern focuses on different aspects of ambient qualities such as air temperature, relative humidity, airflow across the skin, and the radiant temperature of surrounding surfaces. If comparable to natural experiences they create a feeling of comfort resulting in a greater feeling of wellbeing (Browning and Ryan, 2014).

Heerwagen (2006) explained that evidence has shown that people like moderate levels of sensory variability in the environment, including variation in light, sound and temperatures, and that an environment devoid of sensory stimulation and variability can lead to boredom and passivity.

2.3.4. Presence of Water

The sight of water is visually appealing and able to engaging a lot of different other senses including sound, smell, touch, taste (Kellert, 2018). Research on the benefits of the presence of water mainly focuses on the view of bodies of water. Orians and Heerwagen (1993) state that preferred views contain bodies of clean water in their visual preference research. Terrapin Bright Green (2014) states that natural scenes without a body of water and urban scenes with elements of water show near-equal benefits to health. Unnatural or urban scenes have less pleasurable or restorative effects. The presence of water pattern has a positive emotional response on users and increases their wellbeing (Terrapin Bright Green, 2014).

2.3.5. Connection with Natural Systems

The Connection with Natural Systems pattern aims to raise both awareness of natural settings and with hope of increasing environmental stewardship of the ecosystems within which those properties prevail (Terrapin, 2014). By integrating the building into the ecosystems it will be built in, the building will be not only beneficial for its users but for its environments as well.

A space or building with a good Connection with Natural Systems connects the user to a greater whole, making them aware of the seasonality and temporality (Terrapin, 2014). Kellert (2008) states that the temporal element can be expressed culturally. The experience is often relaxing, nostalgic, profound or enlightening, and frequently anticipated, therefore increasing the wellbeing of the user (Terrapin, 2014).

2.3.6. Biomorphic Forms and Patterns

Biomorphic forms and patterns provide a connection to nature for the user. The use results in a more visually preferred environment Decorating and designing space with natural patterns and forms has

been done for a long time. Classic buildings often have design elements that are derived from nature. More contemporary architecture focuses on organic forms and soft edges (Terrapin Bright Green, 2014). The use of biomorphic forms and shapes results in a reduction of stress and enhancement of cognitive performance. This contributes to the overall wellbeing of users (Terrapin Bright Green, 2014).

2.3.7. Material Connection with Nature

Natural materials are often an effective way of creating indirect contact with nature. Natural materials possess visual and tactile qualities that few, if any, artificial materials can replicate (Kellert, 2018). Natural materials can, for example, be used as building materials, furnishings, fabrics, or around the building. The physical and psychological exposure to natural materials typically evokes a strong and frequently deeply satisfying and beneficial human response, increasing wellbeing (Kellert, 2018). Not only materials but also variables of natural materials such as colours can have a beneficial effect (Terrapin Bright Green, 2014). The quantity of natural material has to be adapted based on the use of the space, as different ratios have different effects. Studies show that a room that is completely covered in natural material (such as wood in this study) results in a tranquil environment, which may not be desirable in all scenarios (Terrapin Bright Green, 2014).

2.3.8. Complexity and Order

A balanced information richness in the design can be a source of intellectual stimulation and emotional satisfaction. Users typically prefer diversity in both natural and built settings over homogeneity, sameness, and uniformity. The pairing of order and complexity are complementary and have evolved because of their positive effect on wellbeing (Kellert, 2018). It is beneficial to create a coherent spatial hierarchy, as can be seen in nature. The coherence can be found in studies about fractal geometries and preferred views (Browning & Ryan, 2014). Immensely complex designs can result in discomfort, such as psychological stress and nausea (Terrapin Bright Green, 2014).

2.3.9. Prospect [and Refuge]

Another complementary pairing is prospect and refuge. Although Browning and Ryan (2014) introduce prospect as a separate biophilic pattern, Kellert (2018) clearly states the importance of prospect in combination with refuge. The unimpeded view, pleasant because of the ability to surveil and plan, that characterises prospect, can create discomfort if seen in too much of the design. Especially in dwellings, where privacy and refuge are important, a balance must be found between prospect and refuge (Kellert, 2018). If correctly implemented, wellbeing is promoted through reduced stress, reduced perceived vulnerability and improved comfort (Browning and Ryan, 2014).

2.3.10. Mystery

Browning and Ryan (2014) describe mystery as the promise of more information through sensory stimuli that fascinate. Kaplan and Kaplan (1989) first mention the need for mystery based on the basic needs of people: to understand and to explore. Benefits for wellbeing are based on visual preference studies and research on pleasure responses to anticipatory situations (Browning & Ryan, 2014). While other patterns can be experienced in a static way, the mystery pattern implies dynamics. Intending to encourage exploration, it is able to reduce stress and support cognitive restoration (Terrapin Bright Green, 2014).

2.3.11. Risk/Peril

The biophilic pattern of risk, sometimes called peril, can be implemented to cause a feeling of exhilaration with the user. The feeling of thrill makes exploration through the landscape or building irresistible. It is, however, important that the risk is controllable and not too much to ensure that the experience stays positive. This means that the risk must be harmless and accompanied by a sense of safety. A positive experience can cause strong dopamine or pleasure responses. This results in in more motivation, better memory and overall feeling of happiness, increasing the wellbeing of the user. The exposure to the pattern must be of short duration as long exposure can lead to negative influence (Terrapin Bright Green, 2014). The use of the biophilic pattern is not suitable for all user groups.

Consideration will have to be given to whether the effect is desirable in the proposed design and in which parts of the design.

2.4. Conclusion

In conclusion, biophilic design elements have shown clear benefits for the wellbeing of the user. Remarkable is the focus on sight as a main sense, although the other senses play an important role as well. To be able to categorise the elements and make them applicable to architectural design, the Christopher Alexander inspired pattern language of Browning and Ryan (2014) can be used. By combining literature by Kellert, Browning and Ryan and other authors, a comprehensive overview is given on which to base further case studies. Although all patterns are beneficial for wellbeing, they sometimes operate on different scale levels of the design. While some can be found on the level of the dwelling, such as a visual connection to nature, others are mostly found on the biggest scale of the environment, such as a connection to natural systems. The patterns have different effects on wellbeing and have to be tailored to the needs of the users and spaces when designed. These differences do not imply there is no relation between the patterns. The translation of the different patterns into elements that can be used in resettlement housing is not yet clear and will be delved into deeper.

III. Biophilic Architecture To Principles And Tools

> We can't replicate the past, but we can seek to selectively "go back to the future" by using the distinctive uses and technologies of our age to capture the best elements of historic biophilic design. (Kellert, 2018, p.113)

Historic and previous examples of biophilic design can be as widely varied and studied to gain a deeper understanding of how biophilic patterns can be applied in future design. Kellert (2018) describes that the building cannot be seen apart from its surroundings. By doing so, the architect would lose the connection to the greater (eco)system and lose the biophilic qualities of the design. It is, therefore, important to analyse and apply biophilic design through the scales. To implement this in this research, case studies will be studied on three different levels; The context, the building, and the unit. This will be compared to the existing literature on the application of the patterns by Browning and Ryan through data from their research at Terrapin Bright Green in 2014. Appendix 2, shows the tools as proposed by Browning and Ryan (2014). The comparison and analysis of literature and case studies will result in different design principles and tools. The design principles will have to be adhered to when designing while tools will provide practical suggestions to apply patterns within the principles.

3.1. Methodology Analysing Case-Studies

Case studies require criteria for the selection of appropriate cases to use the results in resettlement housing design. For this research, the following criteria are important;

1. The design must be realised
2. The design must be built in a climate similar to that of the Netherlands (or the differences must be easily recognisable) so the applicability of the biophilic and natural elements can be directly translated into principles
3. The building must be a semi-public or residential
4. Multiple case studies must be done in order to reach a more objective end result

When looking at the overview in the previous chapter, multiple questions arise that aid when composing principles and tools. To be able to gain a deeper understanding and compare the different case studies the following questions must be answered;

- How are the patterns applied to the design?
- How are the patterns related in this design?
- On which scale level do the patterns operate?
- Which architectural elements are influenced by the biophilic patterns?

For each case study, the following table will be made in order to compare and to compose principles.

Table 1. Example of case study table.

Overview of patterns	Application pattern	Relationship patterns	Scale level patterns	Architectural elements
Visual connection to nature				
Non visual connection to nature				
Thermal and airflow variability				
Presence of water				
Connection to natural systems				
Biomorphic forms and patterns				
Materiality				
Complexity and order				
Prospect and refuge				
Risk an peril				
Mystery				

3.2. Results

The full case-studies can be found in Appendix 3. A summary and conclusions from the different case studies will be discussed below.

3.2.1. Case study 1 - Carabanchel collective housing by TAAs arquitectos / 2022 / Madrid, Spain

Figure 2. Carabanchel collective housing by TAAs arquitectos. (De Guzmán, no date)

The project of TAAs Arquitectos is situated in Madrid and houses 159 social housing units. The focus of this design was to create a comfortable building with biophilic elements. Especially important is the form and orientation of the building that is able to catch the northern winds that can be used to cool down the building in summer as well as make sure that lots of daylight enters the apartments. A second thing about the building that immediately catches the eye is the material use, which is completely based

on sustainability and Madrid's material culture (TAAs, 2022). In Appendix 3.1, the patterns discussed below can be seen in and on visual material of the project. An example of the analytical drawings can be seen in Figure 3.

Figure 3. Example of analysis of biophilic elements in Carabanchel collective housing. (Illustration made by author)

The project in Madrid mainly focuses on the Nature in the space and Nature of the space patterns. They can be found on the scale of the environment as well as the building but are seen to a lesser extent in the dwellings. Due to the compact urban structure in which the building is situated little nature is seen in the surroundings, complicating the nature in the space patterns. The architects decided to focus on the airflow in and around the building and have given less priority to adding greenery or creating non-visual connections. Another focus point of the project was the materiality. Resulting in an interior with lots of natural materials, enabling the complexity and order pattern to blossom. Remarkably, the exterior of the building shows little of the biophilic patterns used on the interior. In comparison with literature findings on the use of patterns in design, we can see that minimal tools are used. However, when used, they are implemented throughout the whole building, improving the quality of the biophilic benefits. In addition to literature, this case studies show ways of providing refuge with horizontal elements such as ceilings and floors. Next to that, materiality is based on local availability, strengthening the connection with local natural systems.

3.2.2. Case study 2 - Biofilische school De Verwondering by ORGA architecten / 2021 / Almere, the Netherlands

Figure 4. Biophilic school De Verwondering by ORGA architecting. (ORGA architect, 2021).

The biophilic school De Verwondering is located in Almere, the Netherlands. Designed by ORGA architecting, it strives to make nature guiding in the design. The inspiration comes from the concept of natural habitats in which animal species can coexist and thrive. The school building has 14 classrooms divided into three clusters oriented to create a large natural in-between space for central communal functions. They strive to create healthy spaces that generate curiosity, contributing to an optimal learning environment for the children. Because of the target group, playfulness is optimised. Children can explore the playground, grow their own fruit and vegetables there or look after fish, guinea pigs and the chickens themselves in the outdoor classroom. In this way, the project wants to breed an awareness of natural processes and biodiversity among students at an early age and show them that you are rewarded if you take care of and nurture nature. Thus, they learn a sense of responsibility and respect for the natural world that, according to ORGA, is currently lacking among many adults (Bruggink, 2023). In Appendix 3.2., the patterns discussed below can be seen in and on the visual material of the project. An example of the analytical drawings can be seen in Figure 5.

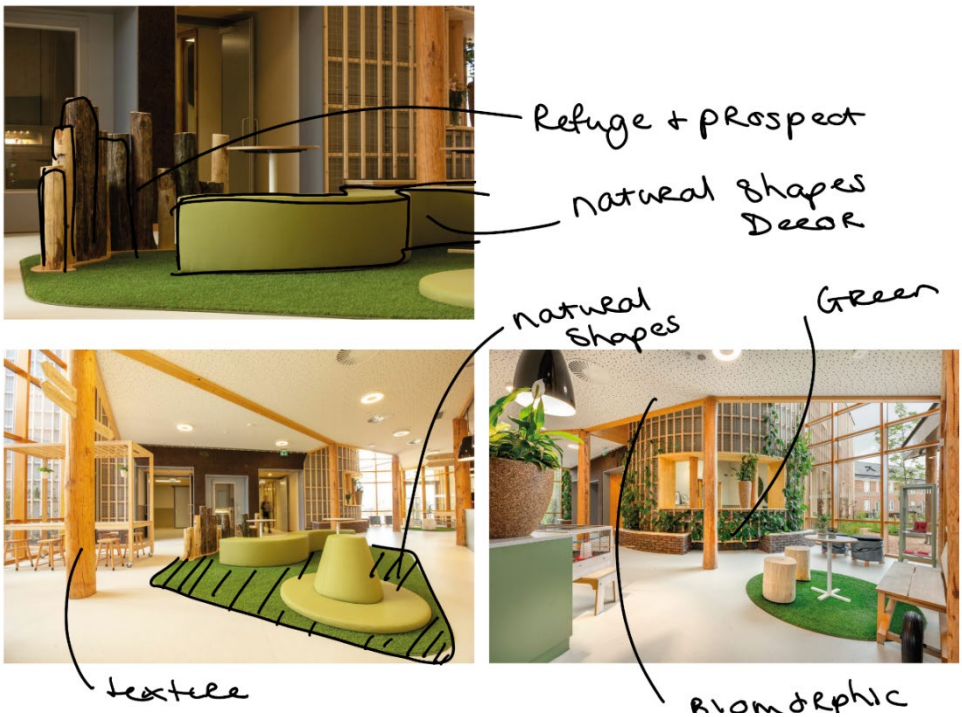

Figure 5. Example of analysis of biophilic elements in De Verwondering.

Remarkably, all patterns are present in the design of the De Verwondering. Another striking thing is that almost all patterns are present at all scale levels. This shows that biophilic design is thoroughly integrated and enhances its qualities. The patterns that are not seen on the level of the classroom usually have a good reason as to why they are not. These patterns invite you to explore but this is not desirable when having class. The patterns apply to many different architectural design elements. In comparison to literature, we can see that multiple tools have been applied per pattern. This results in higher quality biophilic design. This case study does show the importance of setting ambitions per scale level and type of space you design to ensure the right effect of the pattern.

3.2.3. Case study 3 - Once Upon a Time in the Perche House by Java Architecture / 2022 / Les Genettes, France

Figure 6. Once Upon a Time in the Perche House by Java Architecture. (Dethier, no date).

The French Java Architecture has renovated a 70' family home in the north of France. This project intended to improve the thermal properties of the building as well as implement more natural light, and integrate the building into the context. As the private owners wished, the original building was extended using a Douglas wooden structure to create a home that fit their current needs and used (semi) local materials. The implementation of the light can be seen through the use of floor-to-ceiling windows, windows in the doors that lead to outside areas and the addition of windows in general. The implementation into the context was done by the selection of materials, wood and second hand roof tiles. The building shape refers to a contemporary farm in the middle of a clearing. This was done to imply that the building has always been there (Caballero, 2024). In Appendix 3.3., the patterns discussed below can be seen in and on the visual material of the project. An example of the analytical drawings can be seen in Figure 7.

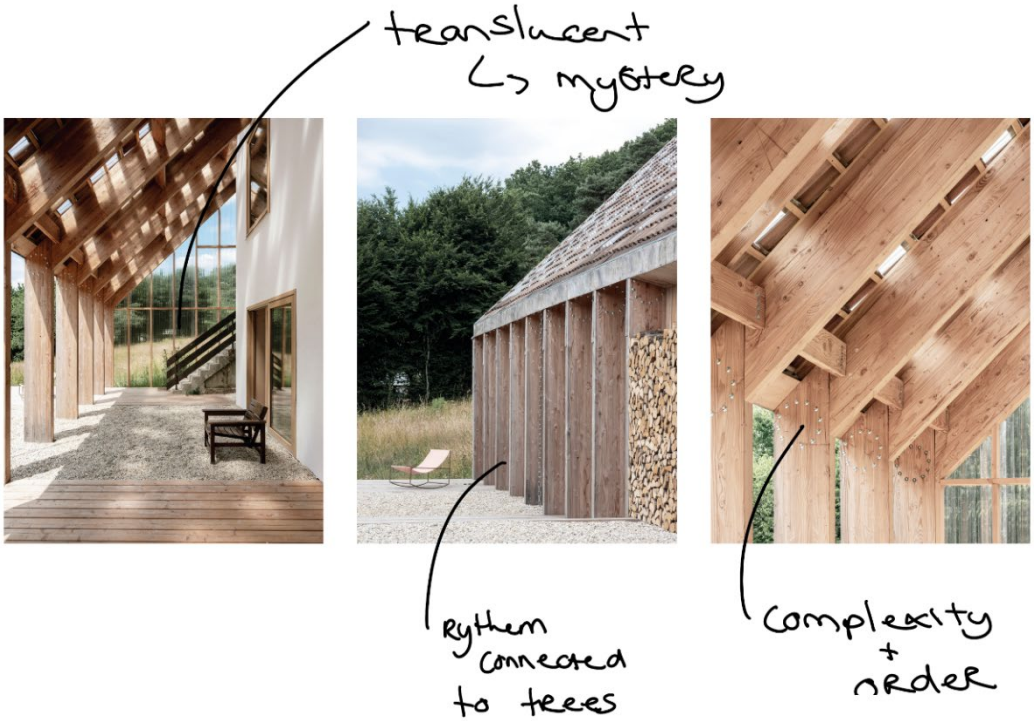

Figure 7. Example of analysis of biophilic elements in Once Upon a Time in the Perche House.

A lot of the patterns are used in this design. However, we see that the patterns have little relationship with the other patterns. This results in a weaker biophilic design. The design is heavily reliant on the site it is on. This is used in the visual connection and the connection to other natural systems. This design does manage to implement the presence of water through multiple senses [sight, sound] in the design with no body of water nearby. In comparison to literature, we see that the design facilitates the experience of nature through its design instead of (artificially) adding elements to the design. This does not encourage relationships between patterns.

3.3. Conclusion

The patterns of Browning and Ryan (2014) can clearly be seen in the case studies as presented above. They serve as an inspiration on how to implement the different patterns in designs that show similarities with resettlement housing. As expected, the implementations of the patterns are done on different scale levels. While the natural analogies patterns [materiality and biomorphic forms and patterns] operate on the smaller scales of a design, the nature in the space and nature of the space can be seen throughout the whole building. The case study's main focus is sight, but we can see that by adding other senses to the experience, patterns bear a higher quality. The different functions of the projects result in different use and execution of the pattern, showing the importance of a tailored approach.

Combining the case studies' findings with literature makes it evident that not all tools can be implemented in a design. Browning and Ryan (2014) present an optimised and complete overview of the application of the patterns. The success of the application of biophilic design patterns can be measured by the degree of integration of the patterns by the different scales and the degree and intensity of the relationship with other patterns. Quality goes over quantity. In Table 2, an overview of available design principles and tools is given. The first general principles can be extracted from the analysis and are mentioned below.

1. Set clear ambitions for each space and each scale level you design.

Not all patterns accomplish the same feeling that contributes to wellbeing. Careful consideration of the suitability of a pattern is needed.

2. Biophilic design has to be applied integrally to ensure the effectiveness of the patterns

The connection to other natural systems is made easier and more accessible if the different scale levels all hold biophilic elements. That way the design functions as its own natural system as well.

Table 2. Overview of design principles and tools.

Overview Patterns	**Design principle**	**Design tools**	**Relationship to other patterns**
Visual connection to nature	In all spaces in which a user resides for more than 5 minutes, a visual connection with nature must be offered.	- Biodiversity - Animals - Clean body of water - Sites soil/earth/terrain - Vegetation	Non-visual connection with Nature Presence of Water Biomorphic Forms&Patterns Prospect
Non-visual connection to nature	Multiple sensory experiences must be implemented in rooms where users reside for more than 5 minutes.	- Bird sounds - Fragrant herbs or flowers - Seasonal changes - Wind - Sunlight/shade - Natural textures - Water sounds - Warm/cold surfaces	Visual connection with Nature Thermal & Airflow Variability Material connection with Nature Presence of Water
Thermal and airflow variability	Variability should be deployed at the early phases of the design at the building scale and unit scale.	- Solar heat - Orientation towards wind/sun - Natural ventilation - Passive climatization - Vegetation - Water	Connection with Natural Systems
Presence of water	Water must be made accessible through at least one sense.	- Flowing bodies of water - Visual access - Temporality/seasonality of water	Visual connection with Nature Non-visual connection with Nature Connection with Natural Systems Prospect Risk/Peril
Connection to natural systems	Connections to natural systems must be implemented on the context and building scale.	- Weather changes - Geology - Animals - Seasonal changes - Pollination	Visual connection with Nature Non-visual connection with Nature Presence of Water
Biomorphic forms and patterns	Biomorphic forms and patterns must be applied integrally through all scales.	- Fibonacci inspired - Applied to decor - Applied to building shapes and forms: walls, layout, building elements e.g.	Visual connection with Nature Complexity & Order
Material connection with Nature	Material choices must be based on their connection to nature and the context.	- Natural colours - Natural materials - Natural shape	Visual connection with Nature Non-visual connection with Nature Biomorphic Forms & Patterns Complexity & Order
Complexity & order	Complexity has to be implemented on context	- Fractals - Exposure of construction or system	Visual connection with Nature

	and building scale. Order has to be implemented on building and unit scale.	- Auditory - Organisation based on fractals	Non-visual connection with Nature Biomorphic Forms & Patterns Material connection with Nature
Prospect and refuge	The building scale focuses on prospect while the unit scale focuses on refuge.	- Focal lengths - Partition heights - Transparency - Open floorplan - Prospect/refuge from weather	Visual connection with Nature Presence of Water Mystery Risk/Peril
Risk/peril	Careful consideration has to be made prior to designing, of the suitability of risk/peril for the target group to prevent negative effects.	- Heights - Water - Predator	Visual connection with Nature Presence of Water Prospect
Mystery	Depended on the function of the building, mystery can be implemented but should bear a distinctly different nature form Risk/Peril.	- Partial obscurance - Imperceptible sources - Scent - Movement - Translucency - Light/shadow	Visual connection with Nature Non-visual connection with Nature

IV. Resettlement Housing (AZC) Architecture

The COA maintains a strict spatial program of requirements for their different types of resettlement housing. Although it comments on the functionality of the different spaces to be realised, it mentions little specifics about the ambition or goal of the space in terms of the feeling of the space. In their chapter about wellbeing they opt for the utilisation of colour as a means to increase wellbeing. Biophilic design could provide an integral addition to increase the wellbeing.

In this next part of the research, the state of different resettlement housing projects in the Netherlands will be analysed to gain more insight into its current relationship with biophilic design. As visiting current projects is challenging for an outsider, this chapter will use images from the internet used by architects, news outlets and the COA itself. The collection of images will be analysed on the different scale levels due to the lack of completeness of projects. This ensures that the case studies can be conducted systematically and the outcomes can be more easily applied to future design. All pictures are from regular shelters throughout the Netherlands.

4.1. Context

In Appendix 4.1., the collection of photos from different media outlets is displayed. Figure 8 is an example of a context in which an AZC might be situated.

Figure 8. Aerial photo of AZC Leersum. (COA, no date).

Table 3. Overview of application patterns on scale level of context.

	Application pattern	**Architectural elements**
Visual connection to nature	The visual connection with nature is generally strong. This can be explained by the location of the AZCs. Diversity on the site is generally low.	Windows
Non visual connection to nature	The environments of the AZC give opportunities for connections of natural sounds and scents.	Site location
Thermal and airflow variability	The spatial composition of the AZCs gives opportunities for thermal and airflow variability.	Windows
Presence of water	Water is sporadically found on the site. Although some plans try to integrate bodies of water, they are not seen on sites.	-
Connection to natural systems	No connection to natural systems is actively sought.	-
Biomorphic forms and patterns	The environment uses the shapes used before as guidance. In renovation projects, this means that the environment usually houses unnatural forms and patterns. The clustering of buildings in newly built projects often has more organic organisation, but this does not always show in the landscaping.	Organisation of space
Materiality	-	-
Complexity and order	-	-
Prospect and refuge	Prospect plays an important role in the organisation of elements on the context scale. Little refuge is seen.	Organisation of space
Risk an peril	A risk that could be mentioned is the possibility of encountering animals. It seems like this is not deliberately is sought after by the designs.	Organisation of space
Mystery	With a great emphasis on prospect, mystery is not excessively presented in the different projects.	-

4.2. Building

In Appendix 4.2., the collection of photos from different media outlets is displayed. Figure 9 is an example of a shared facility within the building.

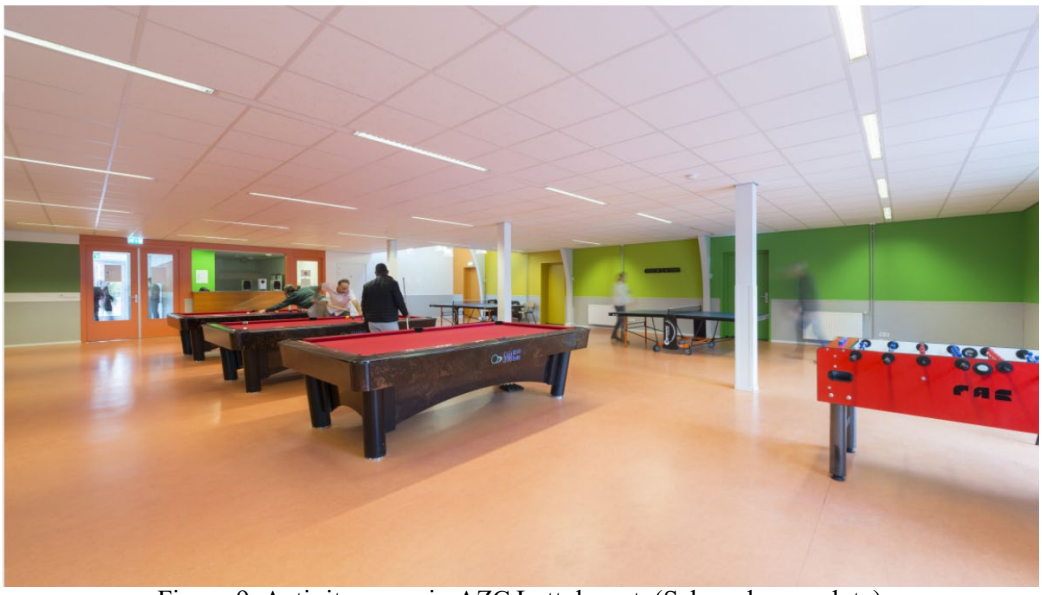

Figure 9. Activity room in AZC Luttelgeest. (Scheerder, no date)

Table 4. Overview of application patterns on scale level of the building.

	Application pattern	**Architectural elements**
Visual connection to nature	As mentioned at the environment scale, visual connection with nature is present in quite some AZC buildings.	Windows
Non visual connection to nature	Scent and sound could be experienced through openable windows but are minimal.	Windows
Thermal and airflow variability	Mechanical ventilation is seen to be used in most AZC's. This results in a more constant temperature and airflow.	Windows
Presence of water	Water is not seen in the building. and neither are views of bodies of water. The experience of water in the building is not accentuated.	-
Connection to natural systems	The connection to natural systems mostly relies on sight of already existing natural systems when analysing on the building scale.	Windows
Biomorphic forms and patterns	Building shapes often are rectangular. Some integrate curved edges in the building.	Shape
Materiality	The materials used in the buildings are mostly unnatural. Some natural elements are implemented but are not part of an integral plan. The use of colour is very visible in the building and its public functions. The colour green is used very often.	Walls - Construction
Complexity and order	Building constructions or systems are sometimes visible in the buildings. As floor plans could not be acquired, no analysis could be made of complexity and order in the organisation of the whole.	Construction - Systems
Prospect and refuge	From the pictures, emphasis is put on prospect in the public parts of the building. As floor plans could not be acquired, no analysis could be made of prospect and refuge in the organisation of the whole.	Organisation of space
Risk an peril	Some elements of risk and peril can be found such as floor to ceiling windows or double heights. These are not commonly found.	Windows,
Mystery	Some design play with mystery through curving edges.	Shape

4.3. Unit [dwelling]

In Appendix 4.3., the collection of photos from different media outlets is displayed. Figure 10 is an example of a unit for a resident.

Figure 10. Bedroom for four residents at AZC Budel.

Table 5. Overview of application patterns on scale level of the unit.

	Application pattern	**Architectural elements**
Visual connection to nature	The visual connection to nature is often offered. However, due the density in the dwellings the view is not always possible.	Windows
Non visual connection to nature	Apart from opening of a window there is no way of experiencing nature in another way in the dwelling most of the time.	Windows
Thermal and airflow variability	The thermal and airflow variability is experienced through openable windows. Cross ventilation is often not possible.	Windows
Presence of water	There is no direct presence of water seen during this analysis.	-
Connection to natural systems	No connection on dwelling scale.	-
Biomorphic forms and patterns	Forms and patterns used in the dwelling are mostly unnatural.	-
Materiality	Little natural materials are used in the dwelling. The use of colour, as seen in abundance in public space, is not seen in the dwelling.	-
Complexity and order	Cannot be commented on due to the lack of floorplans.	-
Prospect and refuge	Refuge is offered in the dwelling. Especially in the bedrooms, small windows and clear entrances ensure a feeling of refuge.	Space proportions - Organisation of space

Risk an peril	No architectural elements of risk have been seen on the dwelling scale.	-
Mystery	Some mystery is seen in the bigger shared functions of the dwelling. The shape of the room can cause mystery as sounds may not be identifiable. This can also be interpreted as risk which might not be desirable.	Shape

4.4. Conclusion

When concluding it is important to keep in mind that no AZC has been built with biophilic principles in mind. However, it is interesting to see that some elements naturally occur while others are not yet present. This can give insight into which tools have to actively be added in resettlement housing.

The site of most AZCs gives plenty of opportunity for a connection with nature due to their proximity to nature. When looking at the analysis, the connection with nature mostly relies on a visual connection. No indication is found that the orientation of the building(s) is based on creating this visual connection with nature. Other nature in the space elements are not implemented in the building and are reliant on the building envelope and in particular (openable) windows.

Regular shelter does not automatically result in a purpose-built design. Purpose-built designs seem to take the patterns of nature in the space more into account. To guarantee quality biophilic design in resettlement housing, it is important to completely renovate or purpose-build a design to create an integrated design.

The applied elements in the designs focus on sight as a way to connect with nature. Improvements in the biophilic application could be made if multisensory experiences are added and patterns are applied consistently through the different scales.

V. COA FRAMEWORK

To adapt the principles and tools so they can be useful for resettlement housing, the influence of the framework of the COA and the outcomes of the analysis of the current AZCs are of importance. Apart from square meters, the spatial program of requirements, as mentioned earlier in this research, sets a framework of ambitions that applies to the AZC as a whole. To compose tools that are fitting in the Dutch landscape of asylum, these ambitions and values must be taken into account when composing principles and tools for resettlement housing in the Netherlands. This could mean adding, adjusting or removing tools based on the flexibility, sustainability, affordability, liveability, safety or controllability of the design.

> Individuals may respond differently to Biophilic elements, which need to be considered in Biophilic design….This can be used by designers when considering Biophilic design by understanding the type of tasks and stressors that people will experience in their environment. (Gillis and Gatersleben, 2015, p. 957)

5.1. Flexibility

There are two reasons to build with flexibility in mind for the COA. Due to fluctuations in the influx of residents, it is important to be able to build in aid of this. This shows in the ability to turn off installations in case of vacancy in a room. This prevents bacterial growth, such as legionella, and minimises costs during this time. The choices regarding load-bearing walls or structures have to be carefully made. Within dwellings, this enables different layouts if needed. In the service buildings a shift of functions has to be possible. This has effects on the load-bearing structure as well as the installations.

Reallocation must be considered when redeveloping or constructing a new resettlement location. Thus, the site can be given a second purpose after COA use. When taken into account in the early stages of the design, flexible future use saves costs and can be seen as a more sustainable option.

Concerning the design tools and principles, this results in difficulties with the principle of adapting the use of patterns to function. It is important to realise the future possible uses of the design. Comparing the functions and ambitions of the spaces for both intended and future use will give the designer direction when choosing pattern applications. However, one has to be careful as to not make a general design as the intention of the use of biophilic design is lost. Therefore, the first principle will be adapted in the final overview of the composed toolkit: Set clear ambitions for each space and each scale level you design for both current use as well as future use.

5.2. Sustainability

The COA describes that sustainability is not limited to the construction of the asylum seekers' centre; the design, use and operation of the entire location (property and grounds) should also be considered within the framework of sustainability. For the COA, this means that sustainability is a long-life site with relatively low operating costs and few adjustments. The COA is open to creating sustainable solutions if they are possible within the (financial) project frameworks.

As biophilic design actively seeks a connection with nature and will not disturb it, sustainability is a high priority when designing following its patterns. If the outcome of a biophilic design is appreciated, the likelihood of the longer use of the design is higher. This will result in a longer lifespan of the building and a payback period, making the financial investment more worth it. Especially if the building is also designed for flexible use after the use as an AZC, the investment period is even longer. Sustainability will, therefore, have no effect on the tools or principles that are found in previous research.

5.3. Affordability

The COA uses the total cost of the building (TCO), including investment, exploitation, and maintenance costs, in the budget for an AZC. Maintenance and lifespan play important roles. The financial investment is comparable to social housing in the Netherlands.

Biophilic design has economic benefits visible in multiple sectors, such as healthcare, dwelling, and leisure. Many tools cost little or nothing to implement (Ryan, Browning, and Walker, 2023). Tools are often focused on organizing space on different scales and do not necessarily add square metres, need extra maintenance, or call for bigger investments.

5.4. Liveability

COA is entrusted by law with the material and immaterial reception of asylum seekers in resettlement housing. The basic principle is that the reception is sober but humane but not inferior to the quality of facilities generally accepted in the Netherlands. In this sense, there is a strong comparison with social housing: simple, affordable, and liveable. COA must, therefore, comply with the Buildings Decree, with the exception of the points described in section 3.7.

In COA's vision, the asylum seeker's own responsibility and independence are crucial. Research (OVVM) has shown that a pleasant living environment is a prerequisite for taking responsibility and self-reliance. Within this, a number of focal points are identified by the COA:

- Privacy: Asylum seekers need privacy, this is translated into, among other things, having their own lockable room, but also, for example, the use of glass. In the house, the asylum seeker does not want to be asylum seeker is not visible from the outside, so large transparent glass surfaces are not desirable, this is immediately taped off in practice.
- Recognisability: Recognisable architecture is important for the whole, but also the recognition of one's own home. It should be simple (sober) but at the same time human and of a human scale.
- Colour use: What COA explicitly does not want are anonymous residential barracks. A good and well-considered use of colour has a positive influence on the atmosphere of a room and the mood of its users. The colour choice for the buildings is determined by function. Orienting to

the site is simplified for all users, but especially for smaller children. For the grounds, the use of colour should reinforce the living environment; a pleasant stay in the outdoor space, but easy to maintain and safe.

- Quality: The quality of the environment influences user behaviour. This applies not only to the aforementioned humanity and recognisability but also to the state of maintenance. An environment that is clean and whole invites positive behaviour. Because of intensive use, every place, inside or outside, should be robust and molest-proof. In case of damage or soiling, this should be easy to update.

With the goal of applying the tools of this research in order to increase wellbeing, the liveability of resettlement housing should increase. The need for refuge is highlighted and, therefore, should be made a priority when designing for resettlement housing in the Netherlands. The need for diversity of experiences can also be seen in the framework of the COA. The multisensory experience of biophilic design should, therefore, have distinctions even within spaces of the same function. Colour use could be one way to accomplish this. Replaceability or sturdiness should also be taken into account. This is primarily focused on the materiality of the building.

5.5. Safety

Safety is approached from two perspectives. The first is the safety of the residents. There are several guidelines to ensure safety.

- Because a large number of residents are unable to swim, access to large bodies of water should be minimised.
- Buildings, or parts of buildings, must not be ascendable.
- Social safety is ensured by the minimalisation of unexpected encounters.
- Social safety is realised by design that values prospects and has a friendly appearance.
- Security is intended to keep unwanted visitors out of the site/building.
- The grounds, as well as entrances to buildings, should have as few concealed corners or places where people can hide as possible. Building entrances should be surveyable (as much as possible) from a central point.

Secondly, the safety of staff is of importance because of the occurrence of incidents. The safety of staff is ensured by the following guidelines:

- There are accessibility zones where asylum seekers are not allowed to enter or are allowed to enter only upon request, such as for a doctor's appointment.
- All locations are given a risk, Inventory, and Evaluation plan. This guideline is the result of the architecture and does not influence the design process.
- Technical solutions are used, such as (electronic) locking of doors, a walkie-talkie system, escape routes and alarms on consulting rooms, etc.

When looking at the biophilic principles and tools, the importance of prospect is stressed in this part of the framework by the COA. Prospect must be applied to all spaces except for the room of the resident. This can be seen as a design principle. Another remarkable aspect is the proximity and accessibility of bodies of water that could play a big role in the presence of water pattern. Direct access to large bodies of water must, therefore, be discouraged. The presence of water has to be implemented through seasonality and visual access.

5.6. Controllability

Controllability addresses a financial aspect as well as a human aspect. The financial aspect focuses on the installations in the building and the need to control the use. The human aspect focuses on the need for the right balance between sturdiness and the human aspects of the building. This balance is determined by the manager and the head of housing from the COA. When designing this balance is not yet determinable and can therefore only partly be taken into account. As all aspects discussed in this

research have an effect on the emotional wellbeing of residents, the aim would be to create a safe and calm environment where the risk of incidents is kept to a minimal.

5.7. Conclusion

The influence of the framework of the COA is most visible in design principles that need to be added or adapted.

Adapted:

- [Principle 1] Set clear ambitions for each space and scale level you design, both for current and future use.

Added:

- Create a calm environment for wellbeing
- Prospect must be applied to all spaces except for the room of the resident.
- The multisensory experience of biophilic design should, therefore have distinctions even within spaces of the same function to enhance wayfinding

The design tools need very limited adaptations to be suitable for resettlement housing. This is partly because of their unforced nature. The only tools that need adaptation are the tools concerning water. The proximity and accessibility of the water must be closely monitored, as most residents cannot swim. This imposes a great risk. The tools concerning the direct experience of larger bodies of water must be removed from the list of possible tools.

VI. CONCLUSION AND DISCUSSION

Research focused on biophilic design shows that the effect of this design approach has positive effects on our wellbeing. By combining previous knowledge with architecture, several pattern languages have emerged. The pattern language of Browning and Ryan (2014) provides guidance to explore which aspects of biophilic design may be important to improve the wellbeing of refugees in resettlement housing in the Netherlands. Due to the varying effects of patterns, such as calming and inducing movement, designs can be adapted to the needs of a target group.

An outline of various design principles and tools was first developed through case studies. This resulted in insights into practical issues of applying biophilic design to design. Following this were several generic and specific design principles to be adhered to in design. In addition, design tools were developed to support the principles.

Because it is important to include the user's needs in assessing the tools, research was conducted into current resettlement housing in the Netherlands. This showed that the visual connection with nature is already present in many projects. However, this is the only pattern found at different scales. This can be explained by the fact that resettlement housing is not built with the intention of biophilic design. Furthermore, the pattern of Prospect & Refuge was also evident in current designs.

Since resettlement housing in the Netherlands is offered through COA, this study included their framework for assessing the tools. This led to changing a principle and adding generic principles. Several tools that focused on the direct experience of water had to be removed due to COA's experiences and values.

All this information has been translated into an overview of various design principles and tools that can be used to improve the wellbeing of refugees in Dutch resettlement housing. In Figure 11 and 12, the various principles and tools are offered in a visual diagram that provides information on the application, scale level and relationship with other patterns. In this way, future design tasks can be approached early on with an integral, biophilic lens.

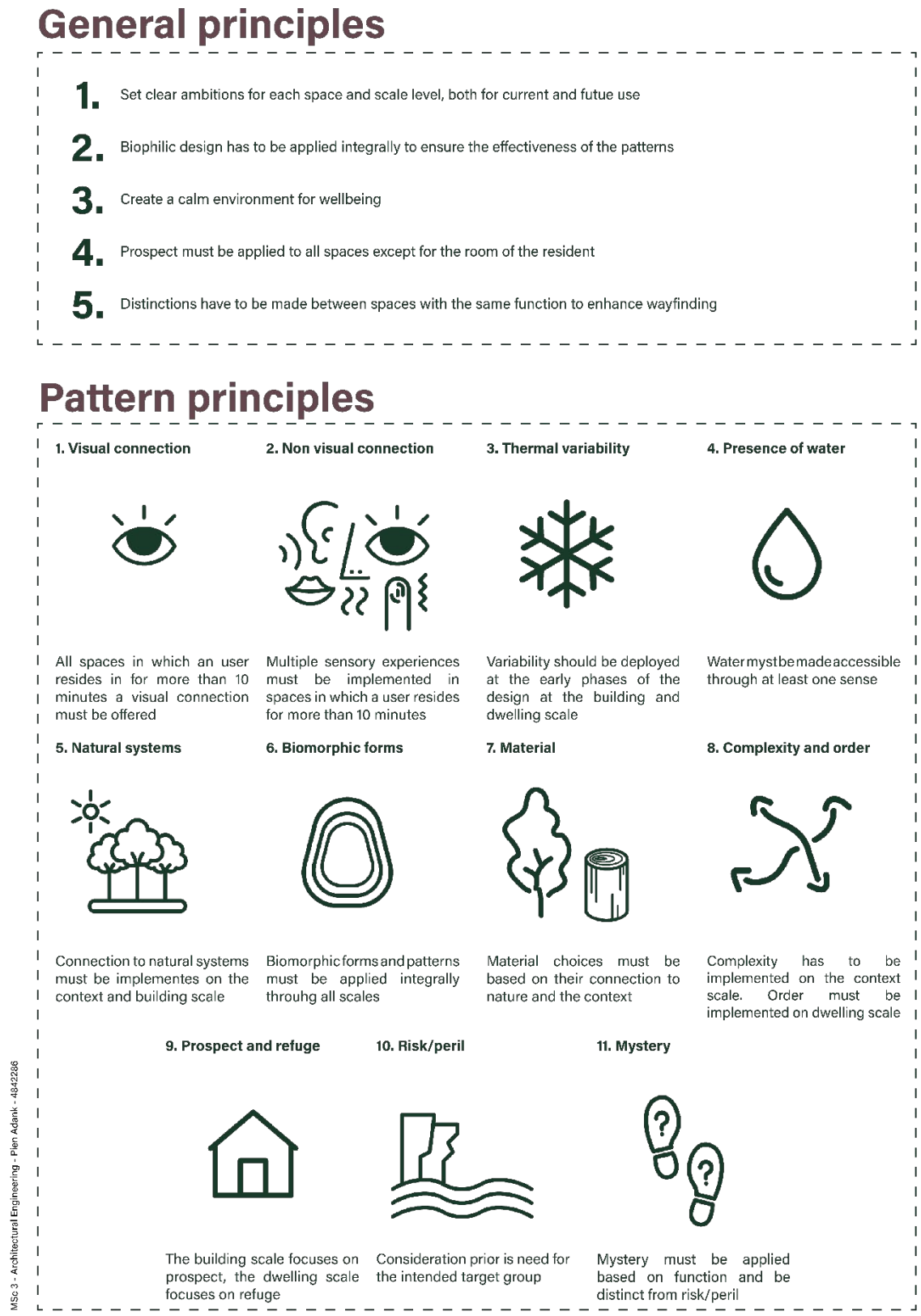

Figure 11. General and pattern principles biophilic design in resettlement housing.(Illustration made by author)

Figure 12. Architectural tools biophilic design in resettlement housing.(Illustration made by author)

This research specifies Dutch resettlement housing and, due to the COA framework, can only be used in the Netherlands. However, most of the values from the framework will be applicable to other countries as well.

Although previous research has shown the benefits of biophilic design on wellbeing, the principles and tools in this research cannot guarantee the same outcomes. Empirical research would have to be done to test whether the design, in which principles and tools are incorporated, has the desired effects.

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11. General and pattern principles biophilic design in resettlement housing.(Illustration made by author)
12. Architectural tools biophilic design in resettlement housing.(Illustration made by author)

APPENDIX 1

	14 PATTERNS	*	STRESS REDUCTION	COGNITIVE PERFORMANCE	EMOTION, MOOD & PREFERENCE
NATURE IN THE SPACE	Visual Connection with Nature	* * *	**Lowered blood pressure and heart rate** (Brown, Barton & Gladwell, 2013; van den Berg, Hartig, & Staats, 2007; Tsunetsugu & Miyazaki, 2005)	**Improved mental engagement/ attentiveness** (Biederman & Vessel, 2006)	**Positively impacted attitude and overall happiness** (Barton & Pretty, 2010)
	Non-Visual Connection with Nature	* *	**Reduced systolic blood pressure and stress hormones** (Park, Tsunetsugu, Kasetani et al., 2009; Hartig, Evans, Jamner et al., 2003; Orsega-Smith, Mowen, Payne et al., 2004; Ulrich, Simons, Losito et al., 1991)	**Positively impacted on cognitive performance** (Mehta, Zhu & Cheema, 2012; Ljungberg, Neely, & Lundström, 2004)	**Perceived improvements in mental health and tranquility** (Li, Kobayashi, Inagaki et al., 2012; Jahncke, et al., 2011; Tsunetsugu, Park, & Miyazaki, 2010; Kim, Ren, & Fielding, 2007; Stigsdotter & Grahn, 2003)
	Non-Rhythmic Sensory Stimuli	* *	**Positively impacted on heart rate, systolic blood pressure and sympathetic nervous system activity** (Li, 2009; Park et al, 2008; Kahn et al., 2008; Beauchamp, et al., 2003; Ulrich et al., 1991)	**Observed and quantified behavioral measures of attention and exploration** (Windhager et al., 2011)	
	Thermal & Airflow Variability	* *	**Positively impacted comfort, well-being and productivity** (Heerwagen, 2006; Tham & Willem, 2005; Wigö, 2005)	**Positively impacted concentration** (Hartig et al., 2003; Hartig et al., 1991; R. Kaplan & Kaplan, 1989)	**Improved perception of temporal and spatial pleasure (alliesthesia)** (Parkinson, de Dear & Candido, 2012; Zhang, Arens, Huizenga & Han, 2010; Arens, Zhang & Huizenga, 2006; Zhang, 2003; de Dear & Brager, 2002; Heschong, 1979)
	Presence of Water	* *	**Reduced stress, increased feelings of tranquility, lower heart rate and blood pressure** (Alvarsson, Wiens, & Nilsson, 2010; Pheasant, Fisher, Watts et al., 2010; Biederman & Vessel, 2006)	**Improved concentration and memory restoration** (Alvarsson et al., 2010; Biederman & Vessel, 2006) **Enhanced perception and psychological responsiveness** (Alvarsson et al., 2010; Hunter et al., 2010)	**Observed preferences and positive emotional responses** (Windhager, 2011; Barton & Pretty, 2010; White, Smith, Humphryes et al., 2010; Karmanov & Hamel, 2008; Biederman & Vessel, 2006; Heerwagen & Orians, 1993; Ruso & Atzwanger, 2003; Ulrich, 1983)
	Dynamic & Diffuse Light	* *	**Positively impacted circadian system functioning** (Figueiro, Brons, Plitnick et al., 2011; Beckett & Roden, 2009) **Increased visual comfort** (Elyezadi, 2012; Kim & Kim, 2007)		
	Connection with Natural Systems				**Enhanced positive health responses; Shifted perception of environment** (Kellert et al., 2008)
NATURAL ANALOGUES	Biomorphic Forms & Patterns	*			**Observed view preference** (Vessel, 2012; Joye, 2007)
	Material Connection with Nature			**Decreased diastolic blood pressure** (Tsunetsugu, Miyazaki & Sato, 2007) **Improved creative performance** (Lichtenfeld et al., 2012)	**Improved comfort** (Tsunetsugu, Miyazaki & Sato 2007)
	Complexity & Order	* *	**Positively impacted perceptual and physiological stress responses** (Salingaros, 2012; Joye, 2007; Taylor, 2006; S. Kaplan, 1988)		**Observed view preference** (Salingaros, 2012; Hägerhäll, Laike, Taylor et al., 2008; Hägerhäll, Purcella, & Taylor, 2004; Taylor, 2006)
NATURE OF THE SPACE	Prospect	* * *	**Reduced stress** (Grahn & Stigsdotter, 2010)	**Reduced boredom, irritation, fatigue** (Clearwater & Coss, 1991)	**Improved comfort and perceived safety** (Herzog & Bryce, 2007; Wang & Taylor, 2006; Petherick, 2000)
	Refuge	* * *		**Improved concentration, attention and perception of safety** (Grahn & Stigsdotter, 2010; Wang & Taylor, 2006; Wang & Taylor, 2006; Petherick, 2000; Ulrich et al., 1993)	
	Mystery	* *			**Induced strong pleasure response** (Biederman, 2011; Salimpoor, Benovoy, Larcher et al., 2011; Ikemi, 2005; Blood & Zatorre, 2001)
	Risk/Peril	*			**Resulted in strong dopamine or pleasure responses** (Kohno et al., 2013; Wang & Tsien, 2011; Zald et al., 2008)

Figure 9. Biophilic Design Patterns & Biological Responses (Terrapin Bright Green, 2014).

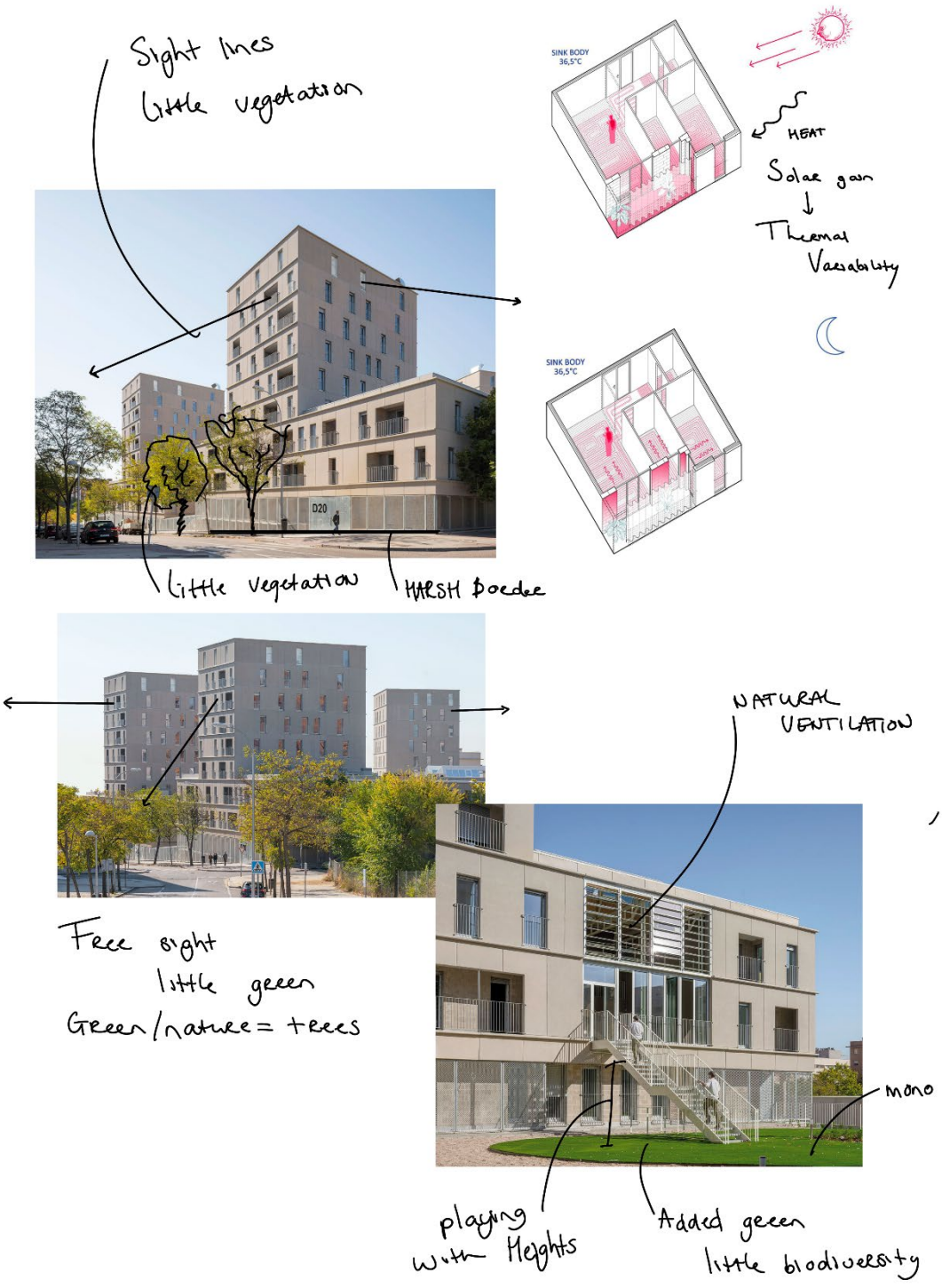
APPENDIX 2

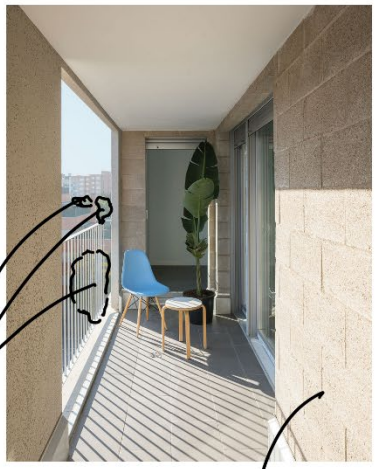
Overview of design tools and relationships by Terrapin Bright Green (2014).

Overview Patterns	**Design Tools**	**Relationship to other patterns**
Visual connection to nature	- Biodiversity - Animals - Clean body of water - Sites soil/earth/terrain - Vegetation	Non-visual connection with Nature Presence of Water Biomorphic Forms & Patterns Prospect
Non visual connection to nature	- Bird sounds - Fragrant herbs or flowers - Seasonal changes - Wind - Sunlight/shade - Natural textures - Water sounds - Warm/cold surfaces	Visual connection with Nature Thermal & Airflow Variability Material connection with Nature Presence of Water
Thermal and airflow variability	- Solar heat - Orientation towards wind/sun - Natural ventilation - Passive climatization - Vegetation - Water	Connection with Natural Systems
Presence of water	- Flowing bodies of water - Visual access - Temporality/seasonality of water	Visual connection with Nature Non-visual connection with Nature Connection with Natural Systems Prospect Risk/Peril
Connection to natural systems	- Weather changes - Geology - Animals - Seasonal changes - Pollination	Visual connection with Nature Non-visual connection with Nature Presence of Water
Biomorphic forms and patterns	- Fibonacci inspired - Applied to décor - Applied to building shapes and forms: walls, layout, building elements e.g.	Visual connection with Nature Complexity & Order
Material connection with Nature	- Natural colours - Natural materials - Natural shape	Visual connection with Nature Non-visual connection with Nature Biomorphic Forms & Patterns Complexity & Order
Complexity & order	- Fractals - Exposure of construction or system - Auditory - Organisation based on fractals	Visual connection with Nature Non-visual connection with Nature Biomorphic Forms & Patterns Material connection with Nature
Prospect and refuge	- Focal lengths - Partition heights - Transparency - Open floorplan - Prospect/refuge from weather	Visual connection with Nature Presence of Water Mystery Risk/Peril
Risk/peril	- Heights - Water	Visual connection with Nature Presence of Water

	- Predator role	Prospect
Mystery	- Partial obscurance - Imperceptible sources - Scent - Movement - Translucency - Light/shadow	Visual connection with Nature Non-visual connection with Nature

APPENDIX 3.1. ANALYSIS DRAWINGS Carabanchel Collective Housing by TAAs Arquitectos





Views of Nature

Facade natural material

obscured view → mystery

Risk

Complexity + order

Exposed cons.

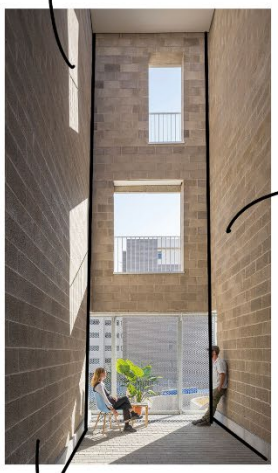
Refuge

Set back Refuge

~ Risk

Untreated aluminium

light + shadow



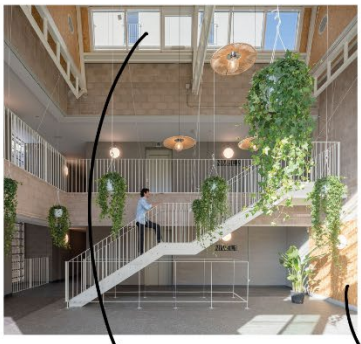
natural local material

High walls

↳ Refuge

Common Areas

Complexity & Order
exposed structure



Thermal + Airflow Variability

View of nature

Mystery

Natural materials

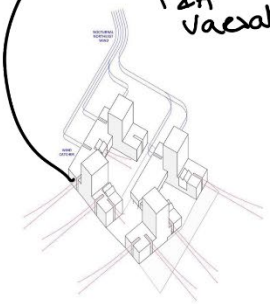
Risk

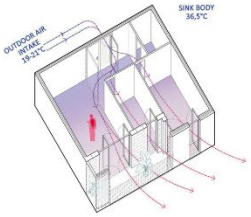
Sound ↓ more sound nature

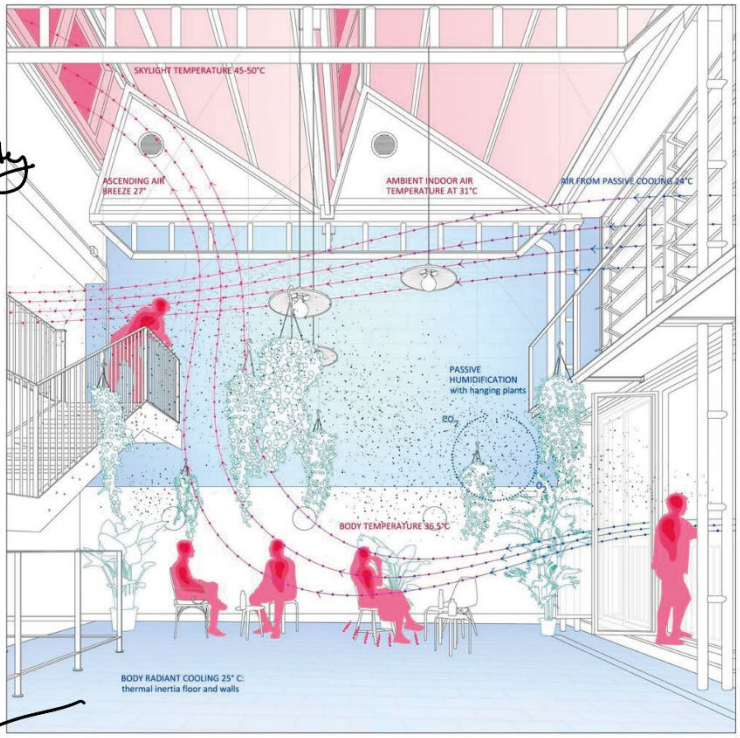
Disconnect nature

Context scale

T&A Variability





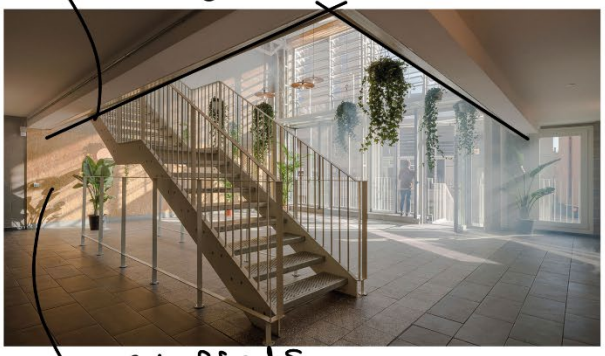


Thermal + airflow variability

refuge context

prospect

refuge + mystery



materials

Overview of patterns	Application pattern	Relationship patterns	Scale level patterns	Architectural elements
Visual connection to nature **	The visual connection to nature is mostly present in the common entry areas of the building. With its urban surroundings there is little nature visible. The projects has added some greenery in the created courtyards but not a lot.	Connection to natural systems	Building - Unit [Dwelling]	Window orientation - Outdoor spaces - Shape of building
Non visual connection to nature *	The building creates an environment that is lower in noise levels compared to its surroundings. This creates an oasis that connects the inhabitants closer to nature. Due to the organisation of the building the sound and feel of the wind is also noticeable.	Thermal and airflow variability	Context - Building	Building shape
Thermal and airflow variability ***	Thermal and airflow variability is very present in the building. Even though the climate of this projects results in extreme temperatures in summer, passive cooling systems are applied. The shape optimalisation catches the wind that is then distributed throughout the building. The mass of the facade helps to regulate the temperature. Passive humidification is accomplished through plants in the common areas.	Materiality	Context- Building- Unit [Dwelling]	Roof - Windows- Orientation - Floors - Walls
Presence of water	-	-	-	-
Connection to natural systems	-	-	-	-
Biomorphic forms and patterns	-	-	-	-
Materiality **	The materials used in the common areas of the building all have a natural origin. The materials refer to the locally used materials in the Madrid area and play with texture. Examples of materials used are: Exposed grey bricks, natural stones, pressed wood and untreated aluminium. Natural materials are mostly used indoors and cannot always be seen on a dwelling level.	Thermal and airflow variability - Non visual connection - Complexity and order - Connection to natural systems	Context - Building	Floors - walls - Ceiling - Construction
Complexity and order **	The complexity and order of this building can be found in the choice of materialization and the exposing of the structure of the building. Both create a balance between visually appealing and enough overview to not get	Materiality	Building	Construction - Floor - Walls - Ceilings

	overstimulated. This is not seen in the dwellings.			
Prospect and refuge **	Refuge can be found in own dwellings. The prospect is seen to a certain extend in the building hallway structure. Upon exiting the dwelling, inhabitants can get an overview of the entire hallway and can orientate themselves with the window at the end of the hallway. Prospect is especially visible in the building shape and the ability to get an overview of the different courtyard systems. Refuge in the outdoors can be found under the cantilevered part of the building in the middle of the plot.		Context - Building	Wayfinding - Shape
Risk an peril *	The use of risk is minimal in this project. This could be due to the nature of the project, dwelling. Exploration is not desired as much as in other building typologies. Small risks can be found in the positioning of the stairs in the outdoor area or the use of French doors is both the common areas as well as the dwellings, enabling users to walk right up to the edge of the balconies/common areas.		Context - Building - Unit [Dwelling]	Suspensions? - Edges
Mystery **	The mystery pattern can be seen in the partly obscuring of parts of the building. In the common areas, the entrance to the area is partly obscured due to the overhanging walkways of the first floor. In the common areas, the windows in the ceiling partly obscure the rest of the building. In the outdoor area, the refuge area underneath the building obscures the view of the total building.	Prospect and refuge - Views of nature	Building	Floors - Windows

APPENDIX 3.2. ANALYSIS DRAWINGS De Verwondering by ORGA architects

natural systems

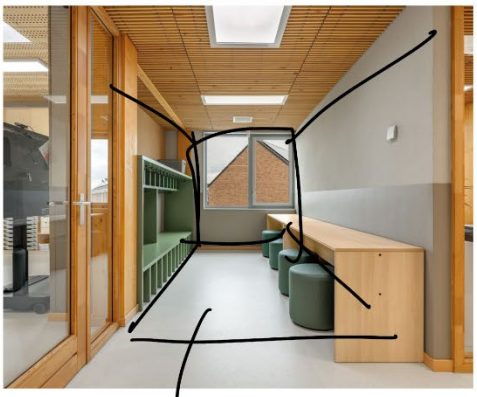
presence of water

'green' facade

Biodiversity

Controlled risk in play


water
Airflow

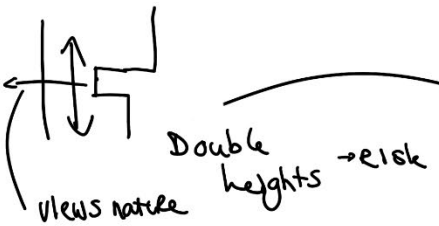

Refuge


prospect
sightlines
natural landscaping

Leaf structure = Biomorphic

exposed = C+O

Refuge



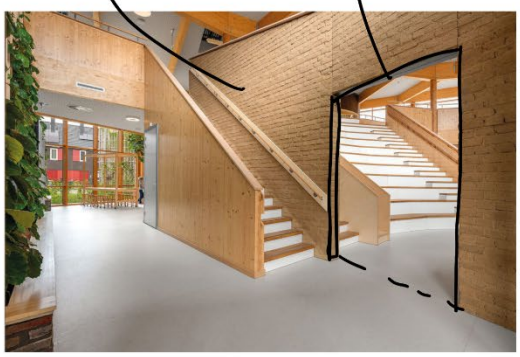
Double heights → risk

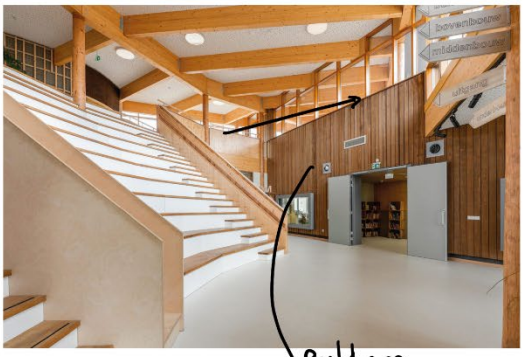
views nature

Slide = risk

Poetal mystery

natural materials





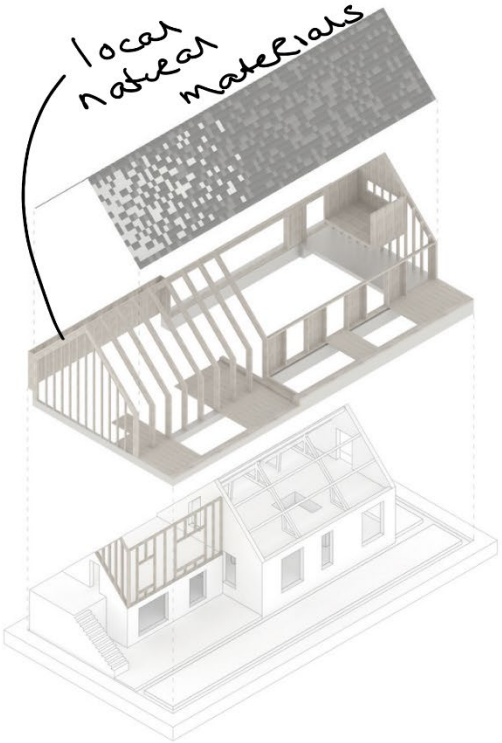
Rythem

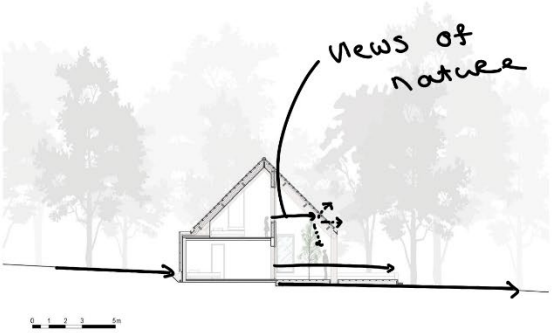
Overview of patterns	Application pattern	Relationship patterns	Scale level patterns	Architectural elements
Visual connection to nature ***	Due to the landscaping of the site and its surroundings the architects were able to make sure that all rooms in the building have a visual connection to nature. This contains both greenery and and water.	Non visual connection	Building - Unit [Classroom]	Windows - orientation
Non visual connection to nature ***	There are several ways in which the design creates a non visual connection to nature. Firstly, the design plays to the other senses such as touch (natural materials and textures and wind) as well as smell (greenery and water) and even taste with their implemented gardens. Secondly, the design uses activities in and around the building to create connections to other natural systems.	Visual connection to nature - Thermal and airflow variability	Context - Building - Unit [Classroom]	Construction - Walls - Floors - Ceilings - Landscaping
Thermal and airflow variability **	Natural ventilation is used throughout the building. All rooms have openable windows and the air quality gets enhanced by the presence of large walls of greenery throughout the building. The variability may also be noticeable on the site because of the presence of water	Non visual connection to nature - Connection to natural systems	Context - Building - Unite [Classroom]	Orientation - Windows
Presence of water ***	The proximity of the water on the site is used to integrate water in the outdoor areas of the design. Users can approach the water and interact with it. In case of heavy rainfall, water can be experienced directly on the site as well.	Visual connection to nature	Context	Landscaping
Connection to natural systems ***	The ecology of the site and its surroundings are taken into account during the design. The choice of vegetation is based on the site, taking into	Thermal and airflow variability	Context - Building	Landscaping - Activities/Programming - Walls

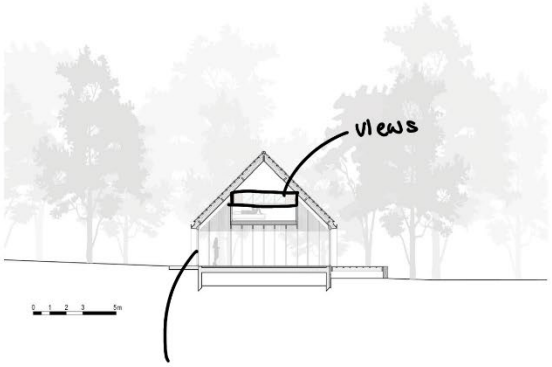
	account the species naturally present. This is done on the site, the facade and the interior walls. Connection to natural systems can also be seen in the urban farming and stormwater flow.			
Biomorphic forms and patterns **	Biomorphic forms and shape are visible on different scale levels. The landscaping of the design is completely organic. The building shape is based on a leaf connecting the different parts of the building. While the core of the building chooses rounded corners and the leaf shape, the building parts that connect to the neighbourhood are still unnatural and orthogonal. The interior of the building and furniture also has organic shapes and forms.	Complexity and order	Context - Building - Unit [Classroom]	Landscaping - Construction - Facades - Walls - Roof - Furniture - Fixtures
Materiality ***	Most of the materials used in this project are natural materials. From the visible materials to the construction, natural materials were the norm. Local materials were used in order to construct such as clay and straw.	Connection to natural systems	Context - Building - Unit [Classroom]	Landscaping - Walls - Doors - Windows - Floors - Ceilings - Facade - Construction - Fixtures - Furniture
Complexity and order ***	The balance between complexity and order is clearly visible. The classrooms have a greater sense of order while the common areas have higher level of complexity. The ultimate level of complexity is seen on the site. This is reflected in the use of materials, the exposing of the construction and furniture such as patterned carpet or plants.	Materiality - Biomorphic forms and patterns	Context - Building - Unit [Classroom]	Construction - Walls - Floors - Ceilings - Facade - Furniture
Prospect and refuge ***	The central hall and meeting spaces are connecting the three main areas in the building. This common	Visual connection to nature	Context - Building - Unit [Classroom]	Windows - Shape - Wayfinding

	area is visible from the central hallway of the three areas. Lots of transparency offer prospect throughout the building as well as the open structure of the common area.			
Risk and peril ***	There are examples of controlled risk in the building. The open structure plays with height and elements such as the slide provide some risk. On the exterior the playground and the water provide examples of the risk pattern.	Mystery	Context - Building	Furniture - Landscaping
Mystery ***	Mystery is created in the common areas of the building and on the site. Because of the open structure in the common area, the obstruction of views and the controlled use of sound invite to explore the building. The playground and small height differences on the plot give this same feeling.	Risk and Peril	Context - Building	Walls -

APPENDIX 3.3. ANALYSIS DRAWINGS Perche House by Java architects

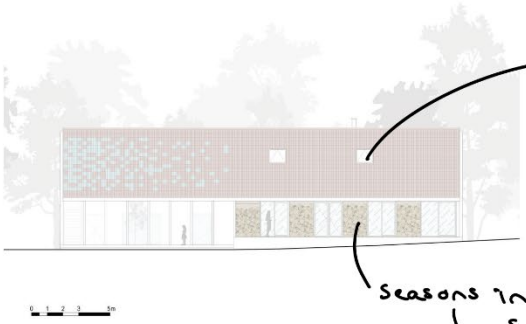

local
natural
materials

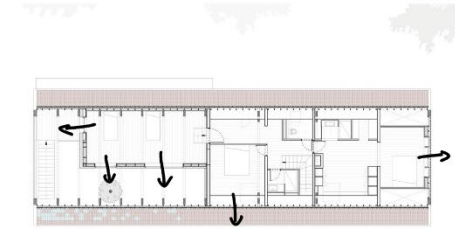

views of
nature

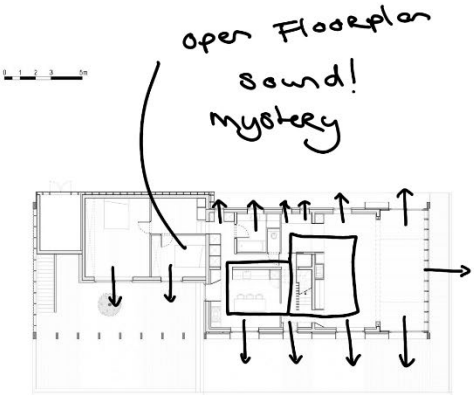

views
Transparency
façade

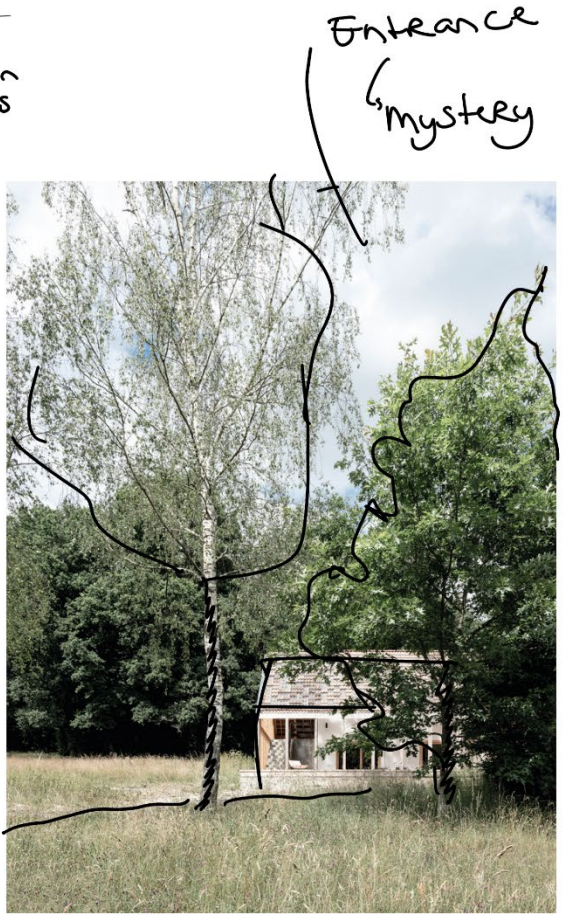

Diversity
(natural)
Biodiversity
(+0 Facade
rythem
views of
nature


views of nature


ticking
Rainwater
seasons in
logs




open Floorplan
sound!
mystery


Entrance
&
mystery

Sunlight variability

sound
rain

natural materials

visible construction

sound

Rain chain
↳ visual conn

sun patches

translucent
↳ mystery

rythem
connected
to trees

complexity
+
order

mystery

playfullness

embedded

Refuge

translucent
↳ mystery

rythem
connected
to trees

complexity
+
order

mystery

playfullness

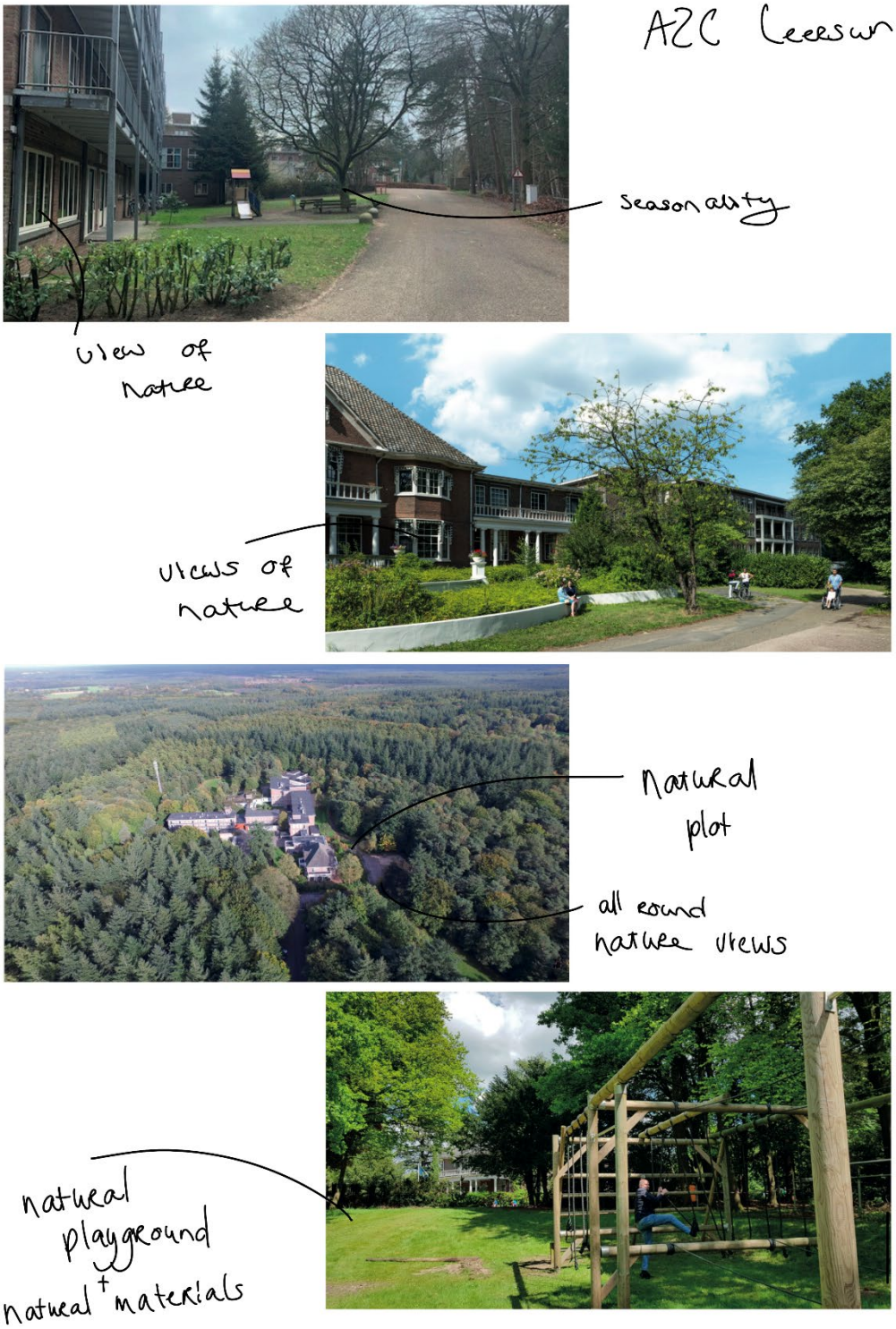
embedded

Refuge

Overview of patterns	Application pattern	Relationship patterns	Scale level patterns	Architectural elements
Visual connection to nature ***	All rooms in the design have an excellent visual connection to nature. This enabled by the size of the plot and size of the project.		Context - Building - Unit [Room]	Windows
Non visual connection to nature ***	Sound plays the biggest role in the non-visual connection to nature in this project. The gravel stones, dripping of water on the rain chains and the sound of the rain on the rooftiles and window provide the connection. Smell will undoubtedly also play a role when looking at the proximity of the forest to the project. The use of transparent roof tiles creates a play with the sunlight throughout the day.	Presence of water - Connection to natural systems	Building	Roof - Systems - Windows
Thermal and airflow variability *	The building can be naturally ventilated which causes airflow variability.	Visual connection to nature	Building - Unit [Room]	Windows - Organisation
Presence of water **	Although there is no water on the plot, the presence of water pattern can be found in the use of rain chains. This makes sure that when there is rain, the water flow is made visible.	Visual connection to nature - Connection to natural systems	Building	Fixtures
Connection to natural systems *	The design chooses to not interfere with its surroundings, giving the user the opportunity to observe en experience nature and its changing experiences. The storage of the logs on the outside of the building can be used by smaller species.		Context - Building	Landscaping
Biomorphic forms and patterns	-	-	-	-
Materiality **	Almost all newly added materials (especially construction) are natural materials. They are displayed.	Complexity and order	Building - Unit [Room]	Construction - Floors - Roof - Door - Windows - Facade
Complexity and order **	Complexity and order mainly shows in het exposing of the structure	Materiality	Context - Building	Construction - Doors - Windows - Facade

	throughout the whole building. The natural complexity and order of the site is preserved. Some complexity is introduced by the different heights within the building and the facade rythems.			
Prospect and refuge **	Within the building, there is a clear overview creating prospect for the user. The bedrooms are more closed off and provide refuge for the user. Around the building, overhangs provide refuge while the deck provides prospect. There is no refuge in the direct environment.		Building	Organisation - Wayfinding
Risk an peril *	The little risk that can be found in the project is het edge of the deck. This can however, also be seen as a boundary.		Building	Floor
Mystery***	The mystery pattern can be found plenty in this design. This may be explained by the type of project as exploration is appreciated. The open floorplans, creating mystery with sound and sight provide a base to explore. The openings within the building are shaped to draw the user to the outside. Thirdly, the east facade is made out of translucent material. This result in a blurry view of the forest that lays beyond, inviting the user to explore. Lastly, the entrance to the building is partly obscured by trees creating mystery upon entering.	Non visual connection to nature	Context - Building	Wayfinding - Organisation - Doors - Facade - Landscaping

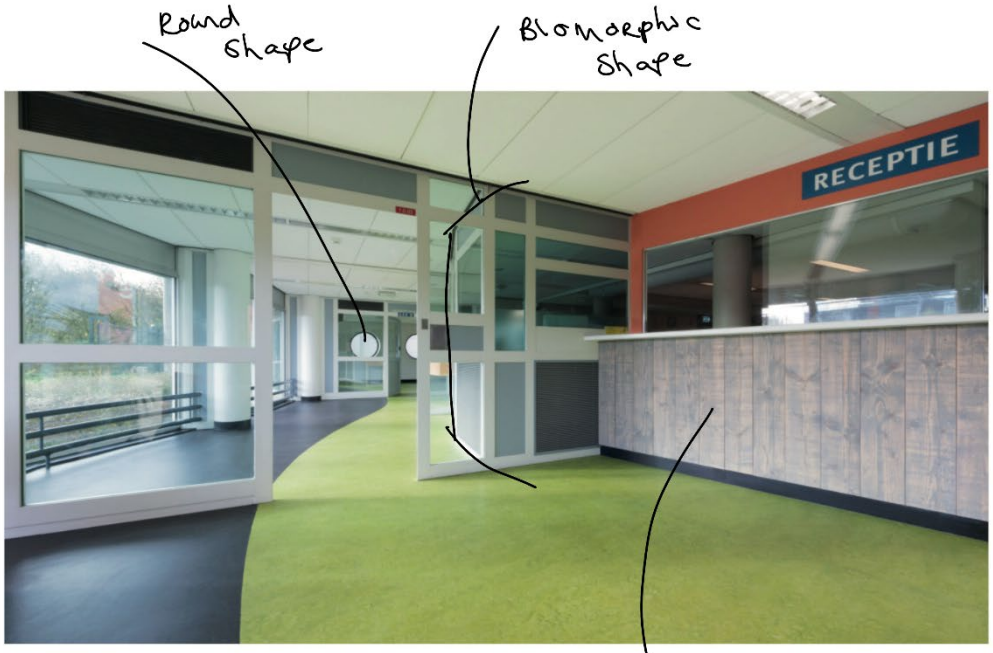
APPENDIX 4.1. ANALYSIS DRAWINGS Context AZC

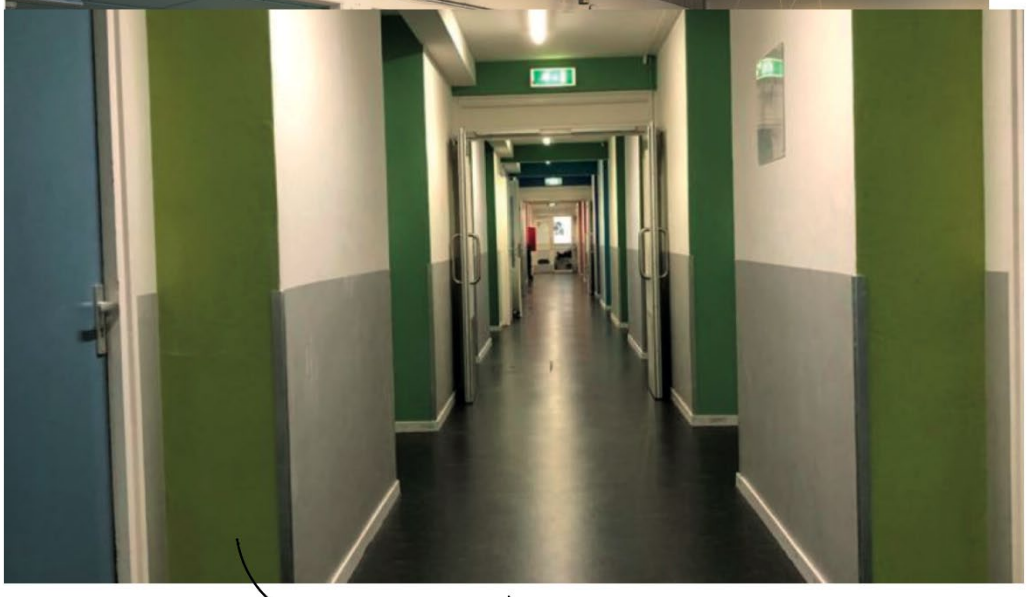


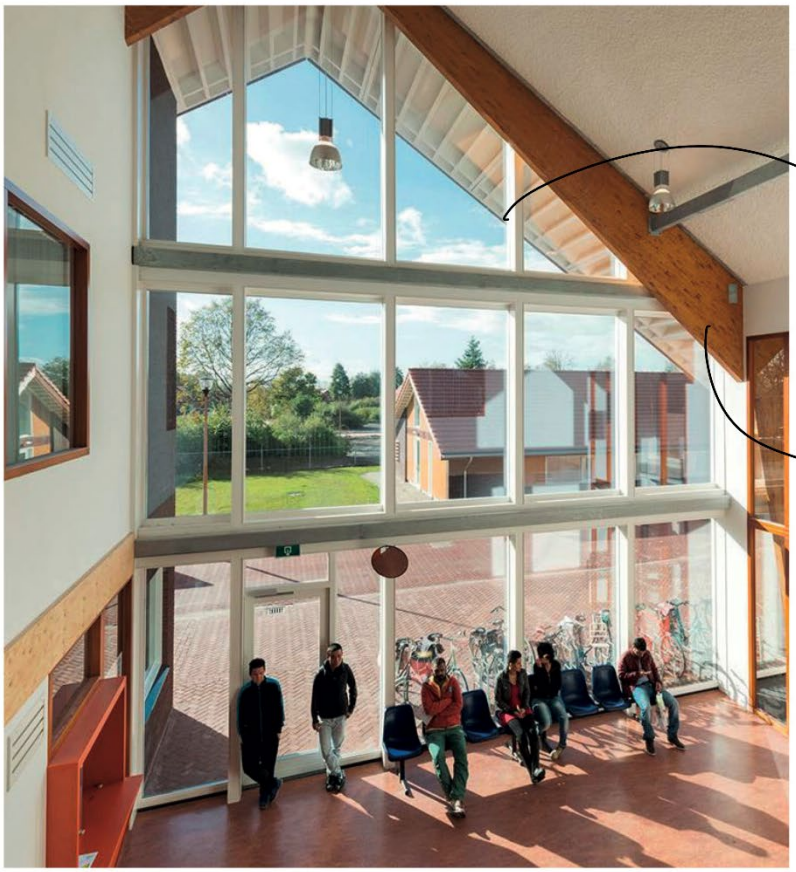

prospect
medium privacy
mono culture

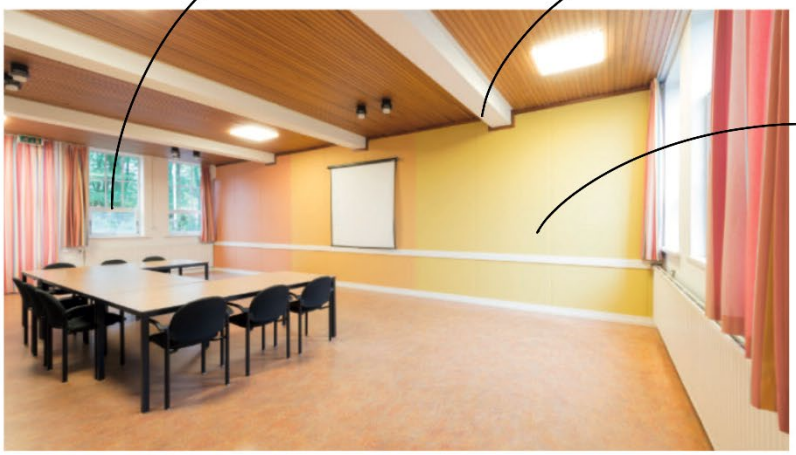

views of green
prospect
mono culture

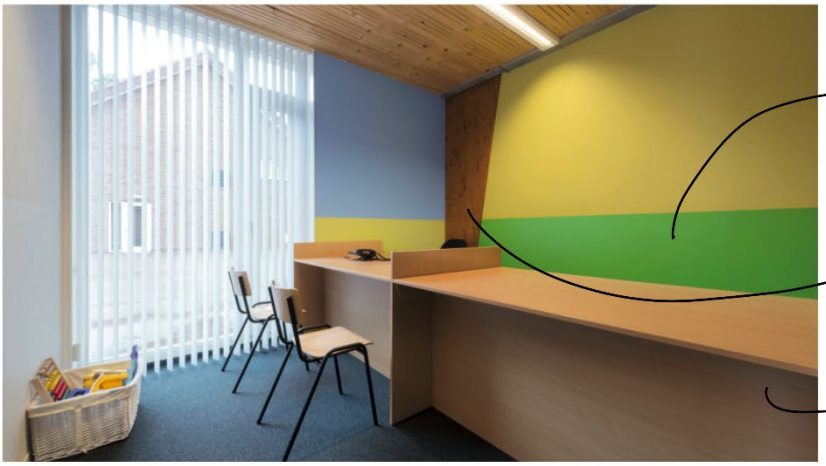
APPENDIX 4.2. ANALYSIS DRAWINGS Building AZC






Refuge from weather
Exposed structure


View of nature
Exposed structure
Warm tones colour



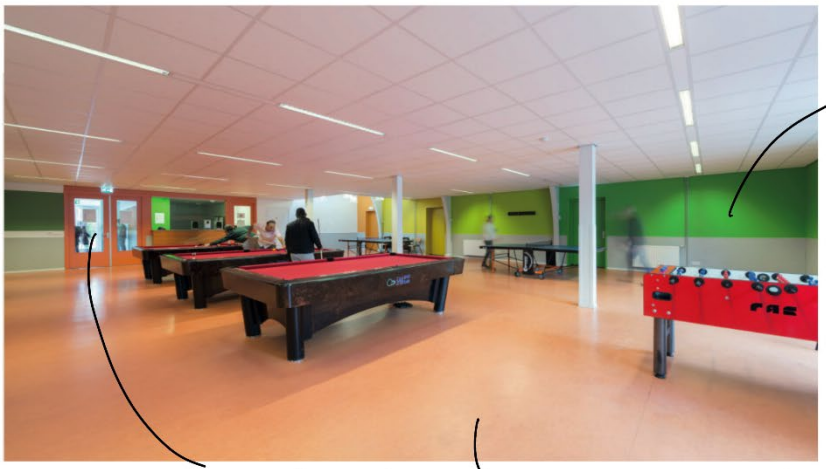
use of colour for wellbeing

Exposed structure

natural material

use of colour

Exposed structure



use of colour

prospect

unnatural materials

unnatural material

no view

operable window

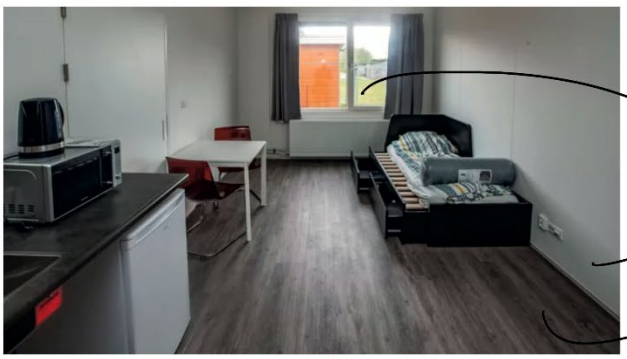
warm colour

lots of hooks

Exposed system

natural material

APPENDIX 4.3. ANALYSIS DRAWINGS Dwelling AZC




View of nature
use of colour
impeccible sources


View of nature
impeccible sources
faux natural material