SPATIAL QUALITY IN MODULAR BUILDING

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Abstract

The Netherlands is facing a large housing crisis, with a shortage of 390.000 dwellings in 2023. To speed up the construction process, modular building can be used. In this paper, the creation of spatial quality within modular building is investigated. Spatial quality is here understood as the combination of experience value, user value, and future value. The investigation focused on the communal spaces of buildings. Literature was used to find fifteen positive influences on spatial quality. An assessment method was created by observing how many influences were present within specific cases. By comparing this result to an initial judgement of the spatial quality of the cases, the reliability of this tool was found to be good. When comparing the communal spaces of the different case studies to each other, not every influence was directly affected by the change of the organization. When considering only the influences that change with different organizations, the exterior vertical core and "portiek" organization both scored the highest, suggesting these ways of organizing the communal space of modular building brings the highest spatial quality. The assessment method that was used to get this result should be expanded further to remove some of the flaws. The current method does not apply a weight to the different influences, and there might be other influences not yet included in the assessment.

Keywords: *modular building, spatial quality, housing, apartment buildings*

I. INTRODUCTION

The Netherlands is facing a housing shortage, requiring an additional 390.200 houses in 2023 (Groenemeijer et al., 2024). These houses should be constructed as quickly as possible but should still have quality. Modular building could provide a solution for the issues of construction speed (Palmboom, 2023, p.14). In this paper, modular building refers to the construction method where three-dimensional modules are created in a factory and then shipped as one unit to a construction site. This type of modular building is also sometimes referred to as industrial building, as the modules that make up a building are created almost on an assembly line. Besides the construction speed modular building has many other advantages, the most important of which have been collected in table 1.

Table 1: overview of advantages of modular building

Advantage	Explanation	Source
Fast construction	As the modules are produced in an industrial way, on an assembly line, less time is spent on the construction. The modules can be fabricated before the site is ready, which speeds up the construction even more	(Palmboom, 2023, p.14)
Short time spent on site	Since the modules are produced in a factory, the amount of time needed on site is minimal.	(Palmboom, 2023, p.14)
Safe construction	A factory is a controlled environment, which means less chance of long falls or other harm that can occur in traditional construction	(Palmboom, 2023, p.14)
Simple planning	The planning is much simpler, as all the parts of the module just need to arrive to the factory	(Palmboom, 2023, p.14)
Weather independence	Since the factory is a covered space, rain has little influence on the construction.	(Palmboom, 2023, p.14)
Plug-and-play installations	The installations can be installed into the modules in the factory, which means that there are no skilled workers needed on site for this installation	(Wallance, 2021, p.203-204)
Demountable	If the connections between the modules can be reversed, the modules become demountable, which can reduce the need for new building materials and the waste produced by construction	(Wallance, 2021, p. 183-184)

Modular building does face its own challenges, however. The buildings can have a temporary look, especially when a shipping container was used as the basis of the modules (Palmboom, 2023, p.16). The number of modular units the current industry can supply is also not always fast enough to keep up with the speed at which modules can be mounted on site (Wallance, 2021, p.36). And, most relevant to this research, modular buildings often have a limited variation, which can lead to repeating and monotonous exterior spaces (Palmboom, 2023, p.14). This could have a negative effect on the spatial quality of the spaces surrounding modular buildings, especially the communal spaces (CRA & FRK, 2023, p. 56).

This paper uses a definition of spatial quality which is derived from by the Dutch law, specifically the fourth memorandum spatial planning *(vierde nota ruimtelijke ordening)*. This document by the Ministry of Housing, Spatial Planning, and the Environment first named spatial quality as the goal of national policy (Tweede Kamer der Staten-Generaal, 1988, p.7). To define spatial quality the ideas of Vitruvius were transformed to be more applicable in the modern day. Vitruvius stated that every building should have venustas, firmitas and utilitas, or beauty, strength, and utility. This was then changed to experience value *(belevingswaarde)*, future value *(toekomstwaarde)*, and user value *(gebruikswaarde)* (VROMraad, 2011).

While the concept of spatial quality could be further elaborated, this is not the focus of the research. The discussion on the exact properties of spatial quality could be endless, as the VROMraad (2011) also states. They also state that spatial quality is a characteristic, not an entity. Without a concrete case to work on, the specific definition of the characteristic is impossible to give. Still, some general understanding of spatial quality exists, as the quality of a space.

This paper focusses on the spatial quality of the communal space, which is here seen as the space between the private dwelling and the public street. This space is also referred to as collective space, semi-public space, or semi-private space. These spaces often have a communal character, because they are shared by a small group of people. These spaces are both the most varied between different modular buildings and more at risk of having a low spatial quality, as individuals are not able to make changes by themselves. To focus on the variation between different communal spaces, the differences in spatial quality between different organizations of the building will be investigated.

The combination of spatial quality and modular building has not been investigated thoroughly yet. There is a need to combine these topics, as the spatial quality within modular building is not something that comes naturally. The Dutch government has issued the creation of three booklets regarding the topic of spatial quality in modular building, showing that there is indeed a problem to be found (Palmboom, 2023) (CRA & FRK, 2023). These publications are a good basis but can be expanded more.

II. METHODOLOGY

To answer the research question, *how can communal spaces with spatial quality be created within 3D modular Dutch apartment buildings?*, three sub questions are formulated, which together answer the research question. An overview of the methodology can be seen in figure 1.

The first sub question, *what specific factors influence the spatial quality within the communal spaces of apartment buildings?*, aims to find what specific factors influence the spatial quality of communal spaces. This sub question will be answered by analyzing existing literature on spatial quality. The literature consists of texts that describe in more detail what spatial quality is, and how it is created. The ways spatial quality is created are via factors that influence the spatial quality in a positive way.

All the influences that were found in the literature will be mentioned in this paper. Most of the influences are included in the rest of the paper, but some of the influences are not useable in this paper, for a variety of reasons. The rest of the influences will be combined into a shorter selection, to avoid overlaps in the final list. This final list is then adapted to apply only to communal spaces.

Chapter 3 will result in two lists of influences on the spatial quality. One of these lists is the full list of all the influences on spatial quality that are mentioned, minus the group that was left out for not being usable. The second list is only the spatial quality influences that can change when the type of communal space changes. Both lists will be used as an assessment method, by simply looking at cases and determining how many of the influences are included.

The second sub question, *how does spatial quality manifest in specific cases of 3D modular apartment buildings?*, will translate the results of the first sub question to more concrete cases. A group of modular apartment buildings will be assessed to see how the influences identified in the first sub question are integrated within cases. Only one of these cases consists of prefabricated modules, all the other buildings have a modular apartment type that is repeated many times over.

The main selection criteria for the case studies was the difference in the way the communal space is organized. When the assessment is applied, the different organizations will reveal which type of communal space has the highest spatial quality and which has the lowest. The influences that are included in the assessment method can all be measured in some way, to allow a more objective comparison between different organizations.

This section will yield two results, because of the two different assessment methods. The first result, based on the assessment with the general assessment method, will reveal which of the case studies has the highest spatial quality, and which has the lowest. The second result, based on the specific assessment method, will reveal which organization of the communal space has the highest spatial quality, out of the organizations present in the case studies.

The third sub question, *how reliable is the assessment method previously created?*, will be answered with a house of quality analysis, and the overview of which case study has the highest spatial quality, and which has the lowest. The house of quality analysis will reveal if the assessment method contains any influences that are counted twice, and if there are no strong negative correlations between the influences.

Before the case studies are judged with the assessment method, they will be judged based on the initial perception of spatial quality. This will not result in a score, but in an order from highest to lowest spatial quality. This ranking will be compared to the result of the assessment method, to see if the assessment method matches the perceived spatial quality. The result of this section will be insight into the validity and reliability of the results found in the second section.

Together, these sections answer the research question. The influences on spatial quality found in the literature will be applied to eight case studies, to reveal which type of communal space has the highest spatial quality. The validity of this assessment will also be assessed, which leads to a reliable overview of the best ways to create spatial quality within modular Dutch apartment buildings.

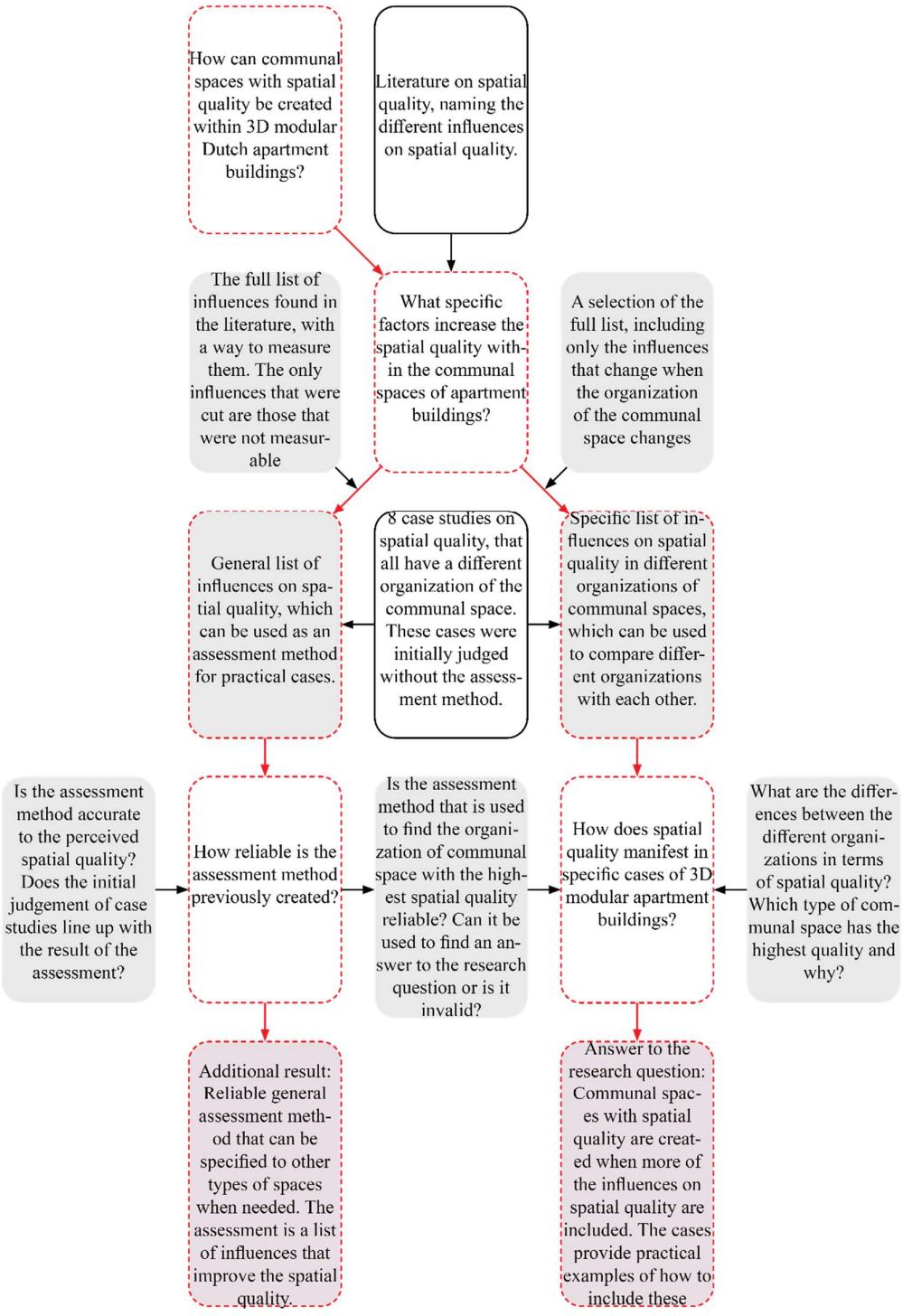

Figure 1: schematic overview of the methodology

III. THE CREATION OF SPATIAL QUALITY

This section aims to answer the question: What specific factors influence the spatial quality within the communal spaces of apartment buildings? To answer this question, five texts on spatial quality were consulted. All these sources mention several influences on spatial quality. These influences were collected and grouped, as the various sources had some overlap, or influences that were very closely related. This resulted in fifteen influences, spread out over six categories.

This chapter will first discuss the sources and their definition of spatial quality, along with a brief description of the sources. This information is important to understand the sources better and understand how they approach spatial quality.

The second part of the chapter presents an overview of the influences found in the sources. The interesting parts of this overview will be elaborated upon. To move towards an assessment method, a description of how these influences can be measured is also included.

3.1. Overview of the Sources

A few of the sources all use a very similar definition of spatial quality. This definition is derived from the definition used by the Dutch law, in the fourth memorandum spatial planning *(vierde nota ruimtelijke ordening).* This document by the Ministry of Housing, Spatial Planning, and the Environment first named spatial quality as the goal of national policy. To define spatial quality the ideas of Vitruvius were transformed to be more applicable in the modern day. Vitruvius stated that every building should have venustas, firmitas and utilitas, or beauty, strength, and utility. This was then changed to experience value *(belevingswaarde)*, future value *(toekomstwaarde)*, and user value *(gebruikswaarde)*. The definition of spatial quality as a combination of these three values is used in most of the literature on spatial quality.

The first source is by the College van Rijksadviseurs (CRA) and the Federatie Ruimtelijke Kwaliteit (FRK), who have written the booklet Spatial quality for industrial residential building *(ruimtelijke kwaliteit bij industriële woningbouw)*. This booklet was written for the Dutch Ministry of the Internal and Kingdom Relations, with input from a few other Dutch ministries. It was written as the second part of a trilogy, focusing on the architectural scale. The first volume focusses on the urban scale and the third volume will focus on governance (CRA & FRK, 2023, p.12). The booklet discusses both the challenges and demands for industrial building, which is the term they used for modular building with 3D prefabricated elements. In total, there are seven quality demands, and seven challenges identified. The definition used is the same as was used in the Dutch law (CRA & FRK, 2023, p.16).

The second source, environmental quality and space *(omgevingskwaliteit en ruimte)*, explains the development of Dutch government policy on spatial quality. The book was written in anticipation of a new Dutch law that would be published after the book. The author, José van Campen, has worked on various documents relevant to the Dutch policies discussed in the book. The book does not aim to define spatial quality itself, it mainly discusses the way different laws relating to spatial quality. Therefore, most sections consider spatial quality to be the combination of experience value, future value, and user value. The book has one section that is specifically relevant, which is a table mentioning several influences on spatial quality (Campen, 2013, p.7). These factors are also organized in the different values. Each cell is open for interpretation, so the people involved in a project can give meaning to the different cells themselves. The matrix includes factors like pattern, composition, efficiency, and flexibility.

The third source, spatial quality *(ruimtelijke kwaliteit)*, is an exploratory document produced by the VROM-raad, a committee from the Dutch Ministry of Housing, Spatial Planning, and the Environment. The document was written as an exploration of the concept of spatial quality to the Minister. In this document the definition given in the Dutch law is expanded, but the three values are still at the core.

The fourth source, Quality in multiplicity (*kwaliteit in meervoud)*, is a research paper trying to expand the concept of spatial quality. It follows the same interpretation of spatial quality that is presented in the Dutch law. This interpretation is expanded upon by finding more concrete factors to complete the three values. To achieve this, they are combined with four interests, those being economic, social, ecological, and cultural. This resulted in the matrix of spatial quality, which is the main conclusion of the research (Hooimeijer et al., 2001)

The final source is a paper by Acre and Wyckmans, titled *Spatial Quality Determinants for Residential Building Renovation: A Methodological Approach to the Development of Spatial Quality Assessment*. The paper aims to find spatial quality determinants and found four groups of determinants. These are view, internal spatial arrangement, transition between private and public spaces, and perceived, built, and human densities. This source does not use the same definition of spatial quality that is used in the Dutch law but does touch on some common points, like the importance of a human perception in combination with more technical aspects. The paper tries to define spatial quality by creating an assessment method, which would include all the determinants for spatial quality. It is stressed that spatial quality should not be used just on the urban scale, but also on the building and neighborhood scale.

3.2. Collection of the influences

From the sources, fifteen influences on the spatial quality were collected, divided into six categories, shown in table 2 on the next page. These influences are mentioned in the literature as having a positive effect on the spatial quality of a space. A more detailed description of how the literature mentions these influences can be found in appendix A.

There are some parts of these influences that need to be elaborated. The first category of influences includes an interpretation of the literature. A few places make a mention of a gradual transition between the public and private domain. This usually refers to buildings where the private domain is directly connected to the public domain, while this is not the focus of this paper. This paper concerns itself with the communal spaces of apartment buildings, which means this influence was changed into a gradual transition from communal to private, instead of from public to private.

The balance between structure and diversity also needs to be addressed. The literature mentions both structure and diversity as having a positive effect on the spatial quality. These influences are often very contradictory, which is why these influences were combined into one. A building should have a balance between diversity and structure to have a good spatial quality. This balance is also mentioned in the sources.

The quality of a view is mentioned as having a positive influence on the spatial quality within the paper by Acre & Wyckmans. Determining whether a view has quality can quickly become subjective, and Acre & Wyckmans encountered the same issue. To solve it they used a text by Kevin Lynch, who states that a quality view has the following elements: transparencies, overlaps, vistas, panoramas, and/or articulating elements. When more than half of these elements are present, the view will be considered of quality.

Sustainability is more difficult to judge within a single space, so for this category the entire building will be considered. This category is quite clearly focused on increasing the future value of a space. It is rare for a single space to have a sustainability plan and more common for such a plan to exist for an entire building. The literature also mentions multiple sustainability strategies. Determining which of these is the best is not the intention of this paper, so this category will be rated on whether one of these strategies is present in a building.

Not all the influences that were mentioned in the literature are included in table 2. The influences that were excluded were most of the time not explained enough to be used in this paper. For example, Campen (2013, p.7) mentions that shape has an influence on the spatial quality, but it is not elaborated how shape influences the spatial quality or when this influence can be observed. Beauty is also mentioned to have a positive effect on the spatial quality, but since there is no objective answer to the question of what beauty is, this influence was also left out (Botton, 2013, p.77). A more detailed description of all the influences that were left out can be found in Appendix A.

Table 2: Spatial quality influences

Category	Influence	Observation
Gradual Transition from Communal to Private (CRA & FRK, 2023, p. 60).	Physical Barriers (Acre & Wyckmans, 2014)	The presence of physical barriers between public/communal spaces and private spaces
	Outdoor private space (Acre & Wyckmans, 2014)	The presence of private space within the public/communal space
Accessibility	Accessibility (CRA & FRK, 2023, p.60) (Hooimeijer et al., 2001)	Clearly indicated entrances that are accessible
	Boundaries (Campen, 2013, p.7)	Clear boundaries between spaces
Structure & Diversity	Structure (Campen, 2013, p.7) (CRA & FRK, 2023, p. 56)	A balance between a rigid structure and diversity. The space should be neither monotonous nor chaotic.
	Diversity (Campen, 2013, p.7) (CRA & FRK, 2023, p.52)	
Transparency	Enclosure (Acre & Wyckmans, 2014)	The percentages of the surfaces that are open
	Quality of view (Acre & Wyckmans, 2014)	A view which includes transparencies, overlaps, vistas, panoramas, and/or articulating elements
Functions	Multifunctionality (Campen, 2013, p.7) (VROMraad, 2011)	Two distinct functions taking place in the same space
	Efficient use of space (Campen, 2013, p.7) (Hooimeijer et al., 2001)	Lack of redundant space where no function can occur
Sustainability (VROMraad, 2011)	Changeability (Campen, 2013, p.7) (CRA & FRK, 2023, p.72)	The space shows some elements that can be changed or removed to change the function
	Flexibility (Campen, 2013, p.7)	The space is organized so that other functions can also take place
	Demountability (CRA & FRK, 2023, p.76)	The building has demountable connections
	Efficient maintenance (Campen, 2013, p.7)	Methods were used to have technical systems accessible for maintenance
	Nature inclusive (CRA & FRK, 2023, p.76) (VROMraad, 2011)	The building is designed with the local ecosystem in mind

3.3. Adaptation for communal space

This assessment method can be used to assess the spatial quality of almost any space, but for this paper only the influences that are applicable to communal spaces are important. Therefore, some of the influences will not be used when formulating a conclusion in the next chapter. These influences are Quality of view, changeability, flexibility, demountability, efficient maintenance, and nature inclusive. These influences are not strongly tied to the organization of the communal space. This does not mean these factors have no influence on the spatial quality of communal spaces, just that the organization of communal spaces does not directly influence them.

The assessment method now has two versions for two different uses. The full assessment method can be used on practical cases, to assess how many influences on spatial quality these cases include. The second is a theoretical assessment method, more suited to investigate the difference between different organizations in terms of spatial quality. The full assessment method provides a basis which can be adapted to a specific assessment method by leaving out the influences that are not relevant to the type of space that is to be investigated.

The full assessment method will still be used for a large part of the paper, since it deals with practical cases. The assessment method will be evaluated by comparing it to the initial judgement of the spatial quality within the cases. This initial judgement was done on practical cases, so all the influences should be included. In some places, where the difference between the different organizations is discussed, it is not logical to include the influences that do not change with the different organizations.

3.4. Conclusion

This section has summarized five sources into a list of fifteen influences, divided into six categories. Each of these influences has a positive effect on the spatial quality. Table 2 provides a list of all these influences, along with a way to measure these influences. This basic assessment method was then applied to communal spaces by excluding six influences that do not change when the organization of the communal space does.

IV. SPATIAL QUALITY WITHIN THE CASES

This chapter aims to answer the question: How do different organizations score in terms of spatial quality? To answer this question, eight case studies were selected. These cases were selected based on their organization, since this is what shapes the communal space of apartment buildings. The cases are a mix of both well-known projects and lesser-known projects.

First, the scoring method for the cases will be further explained, to reveal why each score was given to the different cases. Next each of the cases will be shortly discussed, after which the scoring for each case is presented. The interesting findings from the assessment method will be presented at the end of the chapter.

4.1. Scoring method for the cases

Before the scoring of the cases is presented, it is important to know how these scores were decided. For most of the influences an effort was made in chapter 3 to make them as observable as possible. A more detailed account of when an influence was considered incorporated can be found in table 3, which continues on the next page.

Table 3: incorporation criteria for the influences.

Influence	Considered incorporated when:
Physical Barriers	The space included some form of physical barrier between the communal and private domain. In this set of cases the only physical barrier that was found was a staircase
Outdoor private space	There was a space within the communal space that was private in nature. This would mean that there was some space for residents to have their own activities within the communal space
Accessibility	The space was accessible, and the entrances were indicated in a clear way. This indication needs to be more than the door itself, having something that clearly stands out from the rest of the hallway
Boundaries	There was some form of boundary between the different parts of the communal space. Within the cases, these boundaries took the form of staircases and doors.
Structure	The space had a clear structure with regularity. In cases where the structure was too dominant the space lacked elements that broke up the space
Diversity	The space also had some elements that do not follow a strict rule. If every part of a space did not follow any rules, the space would be considered too chaotic
Enclosure	A sizable part of a space was not enclosed. Within the cases this occurred when one of the walls was completely open
Quality of view	At least three of the five elements that make a view with quality were incorporated. These elements are transparencies, overlaps, vistas, panoramas, and articulating elements.
Multifunctionality	The space served multiple functions. Within this set of cases this would be a function other than circulation, as that is the primary function of the spaces that were investigated.
Efficient use of space	No part of the space was functionless. This would be a part of the space where no function could realistically take place. Within the cases this occurred when residents were not able to use the space directly in front of their door.

Table 3 (continuation): incorporation criteria for the influences.

Changeability	The space included some elements that could be changed to change the function of the space itself. This change would require some renovation of the space, as otherwise the space would be flexible instead.
Flexibility	The space could change its function with minor changes. This is slightly different from a multifunctional space, as the different functions do not have to take place at the same time.
Demountability	The building is made from demountable materials or elements. Within the cases this was observed in a modular project, which already had plans to be demounted and moved.
Efficient maintenance	An effort was made to make the maintenance of a space easy. Within the cases this was observed when the technical installations were placed on the outside of the apartments, which allows maintenance without access to the individual units.
Nature inclusive	The building adds to the ecosystem. The way the building contributes can be varied, but there should be some observable habitats for at least one species of animal.

4.2. Overview of the cases

Eight cases of Dutch apartment buildings were used in this chapter, each presenting a different type of communal space. The cases can be split into two groups, a group of well-known projects and a group of lesser-known projects. The well-known projects were all found in the book *het ontwerpen van woningen* (Leupen, B. & Mooij, H., 2008, p.142, 146, 150, 158). This book was chosen as it organized projects into different topics, with one topic presenting cases with different circulation spaces. These cases present more unique and uncommon types of communal space, like Ijplein Oost III, which has the entire communal space as one long staircase. The other cases in this group are the GWL terrain, Honingerdijk, and Punt & Komma.

The lesser-known projects are projects that have been previously visited by the author. These projects usually feature more standard types of communal space, serving as a set of cases showing less experimental and more conventional circulation spaces. This group includes the Sibeliuslaan, De Grote Eik, Westpoint, and Berenkuil.

Before the actual scoring took place, an initial judgement of the cases was made, based upon the initial feeling of the spaces. When this initial judgement is compared with the actual scoring, it will reveal if the perceived spatial quality is in line with the theoretical assessment method created in chapter 3. This order, along with a picture of the communal space, can be seen in table 4. More pictures, along with a more detailed description of the projects, can be found in appendix B.

Table 4: initial judgement of the cases, with pictures

Name project + Communal space type	Picture	Description of communal space
GWL terrain Elevated street		The building is organized so that all units have a front door directly in the communal space, creating a street.
Honingerdijk Double height gallery		The hallways feature a staircase to lead to the apartments on the floor above. This communal space with a double height.
Sibeliuslaan Exterior vertical core		The communal space is almost entirely vertical, consisting of a staircase going four floors up, connected to a small hallway and indoor space.
Punt & Komma Portiek		This building has one elevated space to which all of the front doors connect. This space is reached directly from the street with a staircase
De Grote Eik Gallery		This building has a quite standard gallery, which includes an indent for each apartment.
Westpoint Interior core		The entire communal space is on the inside of the building, fully enclosed by the apartments. It is structured around an elevator core.
Berenkuil hallway		This building has a very standard hallway, with apartments on both sides. The staircase on the side of the building connects directly to this hallway
Ijplein Oost III Diagonal hallway		The communal space is entirely made up of the vertical circulation, creating a sort of diagonal hallway.

None of these projects are modular projects, except for the Berenkuil. Most of the projects can still be considered modular buildings, with modules that are assembled on site, rather than prefabricated. This was done since the variety of organization methods was greater in this selection. This is still relevant to modular building, as the modules can be organized in a lot of different configurations. Appendix B also shows a simplified floorplan of each of the cases, where one of the modules is indicated.

4.3. Results

Table 5 shows if the different cases incorporated the different influences found in chapter 3 in their communal spaces. Appendix C goes into more detail on why the cases were scored like this.

Table 5: Scoring of the cases

Influence	GWL terrain	Honinger dijk	Sibelius laan	Punt & Komm	De Grote Eik	Westpoint	Berenkuil	Ijplein Oost III
Physical Barriers	N	N	Y	Y	N	N	N	N
Outdoor private space	N	N	N	N	N	N	N	N
Accessibility	N	Y	N	Y	Y	Y	N	N
Boundaries	Y	Y	Y	Y	Y	N	N	N
Structure	N	Y	Y	N	N	Y	N	N
Diversity								
Enclosure	Y	Y	Y	Y	Y	N	N	N
Quality of view	Y	Y	Y	N	Y	N	N	N
Multifunctionality	N	N	N	N	N	N	N	N
Efficient use of space	Y	N	Y	Y	N	Y	Y	Y
Changeability	N	N	N	N	N	N		N
Flexibility								
Demountability							Y	
Efficient maintenance	N	Y	Y	N	N	Y	Y	N
Nature inclusive	N	N	N	N	N	N	N	N
Total	4/12	6/12	7/12	5/12	4/12	4/12	3/12	1/12
Ranking	4	2	1	3	4	4	5	6

A few observations can be made when looking at the scoring of the different cases. Firstly, outdoor private space, multifunctionality and nature inclusivity were found in none of the cases. All the spaces that were included were monofunctional, just serving as the circulation space of the building. Honingerdijk and Grote Eik did attempt to create some outdoor private space, but neither of these cases were successful. These are also the two cases that did not have an efficient use of space, as the outdoor private space remained unused and therefore inefficient.

The case that scored the highest is the Sibeliuslaan. The only two influences that it did not include were accessibility and sustainability, along with the three influences that were not present in any of the cases. The accessibility is not present because of the lack of an elevator, and the fact that the entrances are not very obvious. It included none of the sustainability methods.

The last thing to point out is that none of the cases that did not have a good balance between structure and diversity had too much diversity. All five cases that were out of balance were too structured. The results do not suggest a reason for this, as these five cases all scored differently in the presence of the other influences.

4.4. Assessment of the organization systems

As discussed in chapter 3.3, not all influences are related to the organization of the communal space, which is what the focus of this research is. Table 6 shows how the different organizations scored on the influences that are relevant to the organizations.

Table 6: Scoring of organizations

Name project	Communal space type	Score
Sibeliuslaan	Exterior vertical core	5/8
Punt & Komma	Portiek	5/8
Honingerdijk	Double height gallery	4/8
GWL terrain	Elevated street	3/8
De Grote Eik	Gallery	3/8
Westpoint	Interior core	3/8
Berenkuil	Hallway	1/8
Ijplein Oost III	Diagonal hallway	1/8

The highest scoring organizations are the exterior vertical core and the portiek, with both including five out of eight influences. That would suggest these organization types create the most spatial quality when used.

The exterior vertical core scores a lot of points because the staircase is a very efficient element in the building. It creates a clear physical barrier between public and communal, which is also a clearly observable boundary. Because the circulation space and the communal space are the same, the space is also very efficient. Because the staircase is outside the enclosure is also very good. It does lose points on accessibility, as the entrance to the staircase is not clearly marked.

The portiek also uses the staircase as both a physical barrier and a boundary. The double floor opening it creates in the façade is a clear indication, meaning accessibility is included. The difference with the exterior vertical core is that the portiek structure does not break the structured façade like the exterior vertical core does, meaning the balance between structure and diversity is not good.

The hallway and the diagonal hallway both included only one of the influences on spatial quality, that being the efficient use of space. The hallway has no elements that divide the space, which means that the physical barrier, accessibility, and boundaries are not included. There are also no other functions taking place in the hallway, including outdoor private functions. The hallway is very structured without much enclosure. The space is efficient since there is no wasted space in the hallway. The diagonal hallway has staircases which could be considered as boundaries or physical barriers, but since they did not differ from the rest of the space these elements were not enough to have these influences included.

4.5. Conclusion

This chapter has shown a general assessment method for spatial quality tested on eight different cases. These cases were selected because of the different organizational methods of the communal space they represent. When only the influences that are affected by the organization of the communal space are considered, the exterior vertical core and portiek organization score the highest, with five out of eight influences included. The hallway and diagonal hallway score the lowest, both only including one of eight influences. Chapter five will investigate if the assessment method is reliable.

V. RELIABILITY

This section aims to answer the question: how reliable is the assessment method previously created? To achieve this, two methods are used. The first is a comparison between the initial judgement and the final scoring, and the second is a house of quality analysis to investigate the correlation between the different influences found. This will reveal if there are any influences that are counted double. The influences that are not affected by the building organization are included here, since these factors might have influenced the initial judgement of the cases.

5.1. Comparison between initial judgement and final scoring

This section relies on the initial judgement and final scoring of the different cases to see if the assessment method matches the perceived spatial quality. This comparison can be seen in table 7. The fact that these two lists match well gives credibility to the assessment method, as it was able to support the perceived spatial quality. It also strongly suggests that there are no major influences on spatial quality that were overlooked in the literature.

Table 7: comparison of initial score and final score

Initial Ranking	Final Ranking	Difference
GWL Terrain	Sibeliuslaan	2 higher
Honingerdijk	Honingerdijk	0
Sibeliuslaan	Punt & Komma	1 higher
Punt & Komma	GWL Terrain	3 lower
De Grote Eik	De Grote Eik	0
Westpoint	Westpoint	0
Berenkuil	Berenkuil	0
Ijplein	Ijplein	0

The only case where the assessment method was inaccurate in matching the perceived spatial quality is the GWL terrain. Pointing to the exact reason for this difference is not possible, as this would require more research. A first hypothesis is that the initial perception of the case was skewed because it was based only upon pictures, and not on a visit. If this is indeed the reason for the difference, it is unclear why the judgement of the other well-known cases is not different from final scoring. The initial judgement of these cases also happened via pictures and not a previous visit.

5.2. House of quality analysis

The house of quality analysis shows how the different influences relate to each other. It consists of two parts, both with slightly different functions. Table 8 shows the analysis. The top of the table shows how strong the influence of the row is on the column. For example, the presence of outdoor private space has quite a strong influence on the multifunctionality, so the relation is marked with the number 3, indicating a strong relation. On the other hand, multifunctionality only has a weak influence on the presence of outdoor private space, so the relation is marked with 1, indicating a weak relation.

The second part shows what the nature of the relation is. It shows if the two influences have a positive or negative correlation, and how strong this correlation is. Only the parts of the table where an influence was identified in the first part are filled in. For example, outdoor private space and multifunctionality have a strong positive correlation.

Table 8: house of quality analysis

Influence of the row on the column, were, 0 = no relation, 1 = weak relation, 2 = some relation 3 = strong relation	Physical Barriers	Outdoor private space	Accessibility	Boundaries	Structure	Diversity	Enclosure	Quality of view	Multifunctionality	Efficient use of space	Changeability	Flexibility	Demountability	Efficient maintenance	Nature inclusive
Physical Barriers		1	2	3	0	0	1	0	0	1	0	1	0	0	0
Outdoor private space	3		2	3	0	2	2	0	3	0	0	0	0	0	0
Accessibility	2	1		3	0	2	1	0	0	0	0	0	0	0	0
Boundaries	3	2	3		0	0	0	0	1	0	0	0	0	0	0
Structure	0	0	0	0		3	0	0	0	1	0	0	1	0	0
Diversity	0	0	0	0	3		0	0	1	1	0	1	0	0	0
Enclosure	1	2	0	0	0	0		0	2	0	1	2	0	0	1
Quality of view	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Multifunctionality	0	1	0	0	0	1	0	0		3	1	2	0	0	0
Efficient use of space	1	0	0	0	1	0	0	0	3		0	3	0	0	0
Changeability	0	0	0	0	0	0	0	0	1	0		3	2	0	0
Flexibility	1	0	0	0	0	1	0	0	3	2	3		0	0	0
Demountability	0	0	0	0	0	0	0	0	0	0	3	2		3	0
Efficient maintenance	0	0	0	0	0	0	0	0	0	0	0	0	2		0
Nature inclusive	0	0	0	0	0	2	0	2	1	0	0	0	0	1	

Correlation between influences, were -2 strong negative -1 negative 1 positive 2 strong positive	Physical Barriers	Outdoor private space	Accessibility	Boundaries	Structure	Diversity	Enclosure	Quality of view	Multifunctionality	Efficient use of space	Changeability	Flexibility	Demountability	Efficient maintenance	Nature inclusive
Outdoor private space	2														
Accessibility	-1	1													
Boundaries	2	2	2												
Structure															
Diversity		1	1		-2										
Enclosure	-1	1	1												
Quality of view															
Multifunctionality		2		-1	-1	1	1								
Efficient use of space	-1				1	-1			2						
Changeability							-1		1	2					
Flexibility	-1					1	2		2	1	2				
Demountability					1						1				
Efficient maintenance													2		
Nature inclusive						1		1	1					-1	

The table reveals that there are no redundant influences in the assessment method. If there was one influence that had a strong positive correlation with many other influences, it would be redundant to include it. Boundaries has the most positive correlations, with physical barriers, outdoor private space and accessibility. None of the influences are completely separated, all of them have some correlation with at least one other influence.

The presence of strong correlations would be more problematic if the assessment method were connected to a scoring system. In that case some of the influences would have been counted twice, which would mean the weighting has to change. However, the assessment method presented in this paper does not present different scores for different influences, it only counts how many of the influences were present.

The lack of strong negative correlations is also a good sign, as it reveals there are not a lot of contradictions. The only strong negative correlation is between structure and diversity, which is a special case in the assessment method, as they are two opposite influences that need to be balanced.

5.3. Conclusion

This section showed the assessment method created in chapter 3 is reliable. The assessment method was able to match the perceived spatial quality, which means the assessment method is coherent with reality. A house of quality analysis revealed no problematic correlations between the different influences. If the assessment method were to be made into a scoring method, there would be some relations that should be investigated to ensure no influences are scored twice.

VI. Conclusions

This paper was written to answer the question: how can communal spaces with spatial quality be created within 3D modular Dutch apartment buildings? To achieve this, first a general assessment method of spatial quality was created. This assessment method was based upon literature, and noted fifteen influences on the spatial quality, which are noted in table 2.

This assessment method was applicable to any practical case, but not suitable to compare different organizations of communal spaces with each other, as it included six influences that were not strictly tied to the type of communal space. Leaving these influences out created an assessment method that could compare different organizations of communal spaces to each other. Both the general and specified assessment method were used on eight case studies, which all had different organizations of the communal space.

It was then investigated to see if the general assessment method was reliable. This was done by comparing it to an initial judgement of the case studies. The assessment method lined up to the initial judgement almost perfectly, with only one case that was initially judged too high. This means that the assessment method is reliable at indicating the perceived spatial quality.

The specified assessment method revealed that the exterior vertical core and portiek organization included the most influences on spatial quality. Both organizations use the staircase in an efficient way, where it becomes a physical barrier and a boundary at the same time. The assessment method also revealed that the hallway and diagonal hallway included the least influences on spatial quality. These organizations create repetitive spaces with no elements to break that structure, that are also mostly enclosed.

VII. DISCUSSION

The assessment method that forms the basis of this paper has a few flaws that should be addressed here. Firstly, is the lack of weighting in the assessment, which means very influence has a weight of one. The assessment would be improved if there was a way to give weight to the different influences, but this is beyond the scope of this paper. It would require questionnaires to discover how the different influences are experienced by people.

Second is the reliability of the assessment method. This was investigated here by comparing an initial judgement to the final scoring. This initial judgement is not objective and highly personal, which can cause issues for the conclusions drawn from it. The assessment method also provided no insight into why the GWL terrain was judged too high initially, which could suggest that an influence is missing from the assessment method, or the initial judgement was flawed.

The assessment method presented in the previous sections can be used in an incorrect way, which should be mentioned here so that it is avoided. The assessment method is not meant to be a checklist to follow. It should mostly be used to assess different variants, not to create them. Hooimeijer et al. (2013) also mention this when discussing the matrix they created in their research.

This research was not able to use prefabricated modular projects as case studies, which would have improved the quality of the results. The cases that are included in this paper are all modular projects, but not prefabricated projects. This was done to increase the number of unique organizations of communal spaces, which would have been limited with only prefabricated modular buildings. The results still apply to prefabricated modular buildings as these buildings often have a lot of possibilities for design of the communal spaces.

The assessment method presented here could also be applied to other types of spaces, by adapting the general assessment method to another specific assessment method. This could reveal how spatial quality can be created in other types of spaces.

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APPENDIX A: SPATIAL QUALITY INFLUENCES IN THE LITERATURE

Public/Communal to private

Various sources mention the importance of a gradual transition from the public to the private domain (Acre & Wyckmans, 2014) (CRA & FRK, 2023, p. 60). Since this paper focusses on the communal spaces of buildings, this transition makes more sense as the transition between communal and private spaces. The influences mentioned in the literature are still applicable to this situation.

The first influence on a gradual transition from communal to private is the presence of physical barriers between them (Acre & Wyckmans, 2014). These barriers make the transition less sudden, which is an improvement of the spatial quality. The barriers do not have to be visual barriers, but could also be a low fence, for example.

The physical barriers are closely related to the second influence, which is the presence of outdoor private space (Acre & Wyckmans, 2014). These spaces lead to more interaction between the public and private domain, which improves the quality of the space. This space should also have some physical barriers, as discussed before. It should be mentioned that outdoor is not the right term to use here, as the private spaces should be in the transition from public to private. The place where these domains meet is not always outside.

Accessibility

The literature mentions the influence accessibility has on the spatial quality (Campen, 2013, p. 7) (CRA & FRK, 2023, p.60) (Hooimeijer et al., 2001). Here once again a translation needs to be made from the literature to this paper, as the entrances are in two spaces. There is the access to the communal space, and the access to the private space. In most cases this will translate to vertical circulation as access to the communal space, and the front door as access to the private space. This section will focus on the accessibility of the communal space, as sub chapter 3.2. already discussed the access of the private spaces.

The first influence is the accessibility itself, referring to how easy it is to access a space. This comes down to the clear indication of the entrances, as this improves accessibility (CRA & FRK, 2023, p.60). Good accessibility improves the spatial quality (Hooimeijer et al., 2001).

The second influence is the boundaries between the different spaces (Campen, 2013, p.7). This influence is about the relation between the different spaces, and what the interaction between them looks like. The boundary between different spaces should be clear, as this improves the spatial quality.

Structure and diversity

This section discusses two larger factors, as opposed to one. This is because these factors are almost opposites and should be in balance. The literature mentions both structure and diversity as having a positive influence on the spatial quality (Campen, 2013, p.7) (CRA & FRK, 2023, p.52 & p.56). The balance between these two factors is also mentioned.

On one hand of this balance is the structure (Campen, 2013, p.7). Structure here does not refer to the physical structure that carries the forces present within the building to the foundation, but rather to the logic behind the organization of a space. The structure has a positive influence on the spatial quality, as it creates a strong pattern with clear hierarchies (Campen, 2013, p.7) (CRA & FRK, 2023, p. 56). This makes the space understandable and logical.

On the other side of this balance is diversity (Campen, 2013, p.7). Diversity here does not refer to the presence of different people within the building, but rather to a diversity in the appearance of a space. A lack of diversity creates monotonous spaces, which have a negative influence on the spatial quality. A diverse space has some accents, recognizable points that are different from the rest of the space (CRA & FRK, 2023, p.52). What these accents look like can be very diverse. A diverse space has room for expression which improves the spatial quality.

As mentioned, these two influences need to be in balance. A space needs to have a clear structure and pattern, but this should not lead to a monotonous space. On the other hand, if a space is too diverse, it

can become chaotic, which can also lower the spatial quality. A balance needs to be achieved, where a space has a clear structure which is sometimes broken to have diversity and recognizability.

Transparency

The transparency of the facades is mentioned in the literature, but commonly in a way that is not applicable to this paper (Acre & Wyckmans, 2014). The literature calls for another balance, this time between privacy and the amount of sunlight in a space. However, the spaces that are investigated in this paper are not private spaces, but rather communal spaces. Still, some of the influences on the transparency the literature mentions are applicable.

The first influence is the enclosure of a space (Acre & Wyckmans, 2014). This refers to the part of the surfaces of a space that is present or not present. A space without any openings in the façade nor ceiling has a very high enclosure, while a space that is completely open to the outside has a very low amount of enclosure. A lower enclosure is considered better for the spatial quality. Not only does this provide more views, but it also allows more light into a space.

The presence of a view alone does not reveal a lot about the quality it offers to a space (Acre & Wyckmans, 2014). To improve the spatial quality, a view needs to have quality itself. This second influence, the quality of the view, is difficult to measure exactly. Acre & Wyckmans (2014) encountered the same issue and solved it by using a text by Kevin Lynch. This text states that the quality of a view is improved with the presence of transparencies, overlaps, vistas, panoramas, and articulating elements. The presence of these elements is more objective, which makes this influence more measurable.

Functions

The functions a space fulfills is also mentioned in the literature as an influence on the spatial quality (Campen, 2013, p.7). The literature mentions a few times that a function has a positive influence on the spatial quality. The presence of a single function is not mentioned here since the communal space has a function by nature. It needs to connect the public space to the front doors of private spaces. There are some sources that comment more on the functions of a space, which are mentioned here.

The first influence is multifunctionality, which has a positive influence on the spatial quality (VROMraad, 2011). When a space facilitates multiple functions, it attracts more people. Monofunctional spaces do not have this quality and have a negative association. Multiple functions make sure a space is not monofunctional

The second influence is the efficient use of space (Campen, 2013, p.7). The function(s) a space fulfills should be organized efficiently, so that there are no functionless parts of a space. Efficient use of space improves the spatial quality, as it makes sure there are no areas without function. These areas without function would be bad for the spatial quality, as mentioned before.

Sustainability

Spatial quality should not be lost in the future, so sustainability is also mentioned in the literature (CRA & FRK, 2023, p.72) (Campen, 2013, p.7) (VROMraad, 2011). A sustainable space is here understood as a space which has a function for the longest possible time. There are a few ways in which a building can be sustainable, which are all mentioned in the literature. Sustainability also greatly increases the future value of a building, so it improves spatial quality directly. Not all these influences are strictly on the scale of the communal space, but rather on the scale of the building. This is because it is often the case that an entire building has a vision on sustainability, not just one space. Since a sustainable building increases the future value of all the spaces within it, sustainability still increases the spatial quality of the communal spaces.

The three methods to create a sustainable building that are mentioned are changeability, flexibility, and demountability. The presence of one of these methods is seen as a positive influence on the spatial quality. Changeability refers to being able to change a space when there is the need to (Campen, 2013, p.7) (CRA & FRK, 2023, p.72). This is similar to flexibility, where a space allows various functions to take place from the start (Campen, 2013, p.7). Demountability looks at the end of the life cycle of a building, where it should be possible to demount a building instead of destroying it (CRA & FRK, 2023,

p.76). The demounted parts of the building can be remounted in a different place, prolonging the life of the individual elements instead of the entire building.

A second influence on the future value of a building is the efficiency of maintenance (Campen, 2013, p.7). If maintenance can be done efficiently, the lifespan of the building is increased. Broken installations can easily be replaced, instead of needing drastic renovations. A third influence is the building being nature inclusive (CRA & FRK, 2023, p.76) (VROMraad, 2011). Designing a building in harmony with the local ecosystem can also increase the future value of the building, therefore increasing the spatial quality. A nature inclusive design that includes nature, meaning the building not only becomes a habitat for people, but also for animals.

Non-applicable influences

Some of the influences found in the literature could not be applied to the communal space of buildings, because they relate to a larger scale. These factors still have an influence on the spatial quality, they are just not present in communal spaces.

Firstly, there is the physical boundaries of the block, which refers to the way the building block looks (Acre & Wyckmans, 2014). This could be applied to the scale of the communal space, but that would require a clear definition of the concept of beauty. This is not an attainable goal, as is also mentioned in the text.

Second is integration, which refers to integrating the function of the building into its context (Acre & Wyckmans, 2014). This is difficult to apply to the scale of the communal space, as the function it serves is related to its context.

The third influence that is not applicable is the efficient construction (Campen, 2013, p.7). This refers to not using more materials than needed when constructing the building. Not only is this difficult to determine without doing structural calculations for a building, but it is also often difficult to notice in the communal space. Therefore, the influence this has on the spatial quality of the communal space is small.

Influences that were not included

Some of the influences mentioned in the literature are not precise enough to be usable in this paper or insufficiently explained to be judged. These influences are still important for the spatial quality, but they are impossible to include in the next chapter, when cases need to be compared.

Beauty is mentioned in the literature as having an influence on spatial quality, but this is too subjective to use in an objective comparison (Campen, 2013, p.7 & p.55). There have been attempts to create a concrete guideline to describe beauty, but in the end there is no answer to the question of what beauty is. Therefore, it cannot be used in this paper. (Botton, 2013, p.77)

Shape, process, and cohesion are all not explained enough to be used (Campen, 2013, p.7). The literature mentions these influences once, but no judgement is made on what improves the spatial quality. It is not explained which shape should be used or avoided, which means it cannot be judged. It could be interpreted that a space should need a shape to have spatial quality, but a space without a shape is not possible. Process is similar, where it is not stated which process is good or bad. For cohesion it is unclear if the literature refers to a cohesion for the residents, or a cohesion in the design of the building. Cohesion in the design is somewhat included in the balance between structure and diversity.

Interference, time, and development are all too unclear to be used in the comparison (Campen, 2013, p.7). From the literature it is unclear how these influence the spatial quality, as the factors are all imprecise. It is not clear how development influences the spatial quality, or how interference should be interpreted.

Expandability is a bit different, as it is more specific than some of the other concepts, but not on the scale of the communal space (Campen, 2013, p.7). Expandability refers to being able to add or expand the existing building after the construction, but this is usually not visible in the communal space. It is another strategy to make a building more sustainable, as it allows for the building to be expanded when the need arises.

APPENDIX B: DETAILED CASE STUDY PROJECT INFORMATION

GWL terrain

This building was designed as part of a redevelopment of the old water company in Amsterdam. The architects were tasked with connecting the apartments to the ground floor as much as possible in the five-story tall building, to ensure the residents would take care of the shared green spaces. The building hosts sixteen dwellings, with four units being repeated four times. All these units are connected to a walkway on the first floor, which connects to the street via a staircase on the side (Leupen, B. & Mooij, H., 2008, p.142). Figure 2 shows the building, and a simplified floorplan. The floorplan for each case study is roughly the same scale.

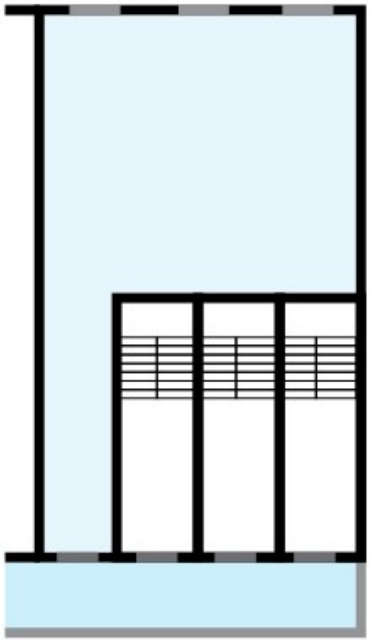

Figure 2: GWL terrain pictures and floorplan

Honingerdijk

This seven-story building is organized along two large galleries, which are covered with glass. The glass is in place to protect the residents against the noise of the busy street next to it. Each of the galleries is double height, with a staircase leading up visible inside the space. The apartments on the floor below the gallery is connected with a staircase directly behind the private front doors. This means that three different units are repeated throughout the building (Leupen, B. & Mooij, H., 2008, p.158). Figure 3 shows the building, and a simplified floorplan.

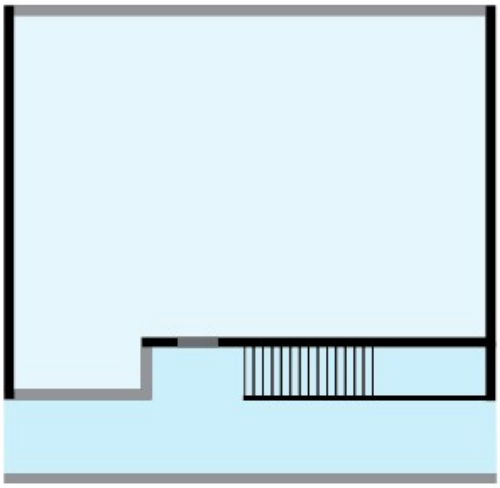

Figure 3: Honingerdijk pictures and floorplan

Sibeliuslaan

This four-story building in Eindhoven is connected via six staircases placed on the outside of the building. These staircases connect to two symmetrical units per floor, which are repeated throughout the entire building. Figure 4 shows the building, and a simplified floorplan.

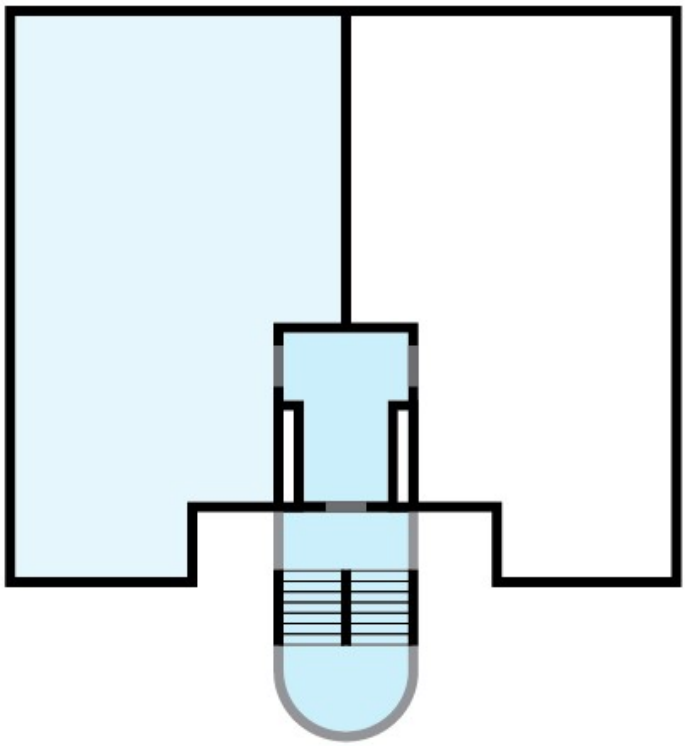

Figure 4: Sibeliuslaan pictures and floorplan

Punt & Komma

This building in The Hague was designed in the typical “portiek” organization, which is a Dutch organization where the dwellings are accessed from a small elevated exterior space. Within the portiek, this building connects six dwellings on three floors, with another two dwellings being accessed via the ground floor directly. Since the organization is mirrored, this creates four different units within the building. This organization is similar to the GWL terrain building, only centered around a core instead of a street (Leupen, B. & Mooij, H., 2008, p.146). Figure 5 shows the building, and a simplified floorplan.

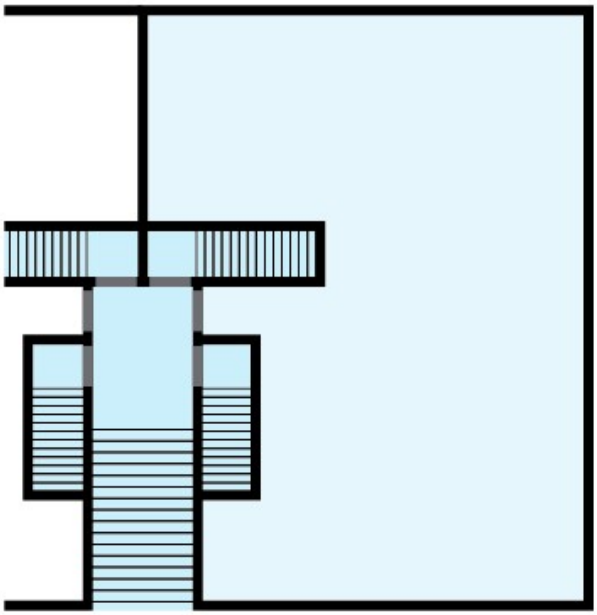

Figure 5: Punt & Komma pictures and floorplan

De Grote Eik

This building shows a standard gallery circulation system, connecting the many floors and providing a view over a large park in Tilburg. Each of the units has a small setback where the front door is located. The galleries are connected to an elevator at the side of the building. Figure 6 shows the building, and a simplified floorplan.

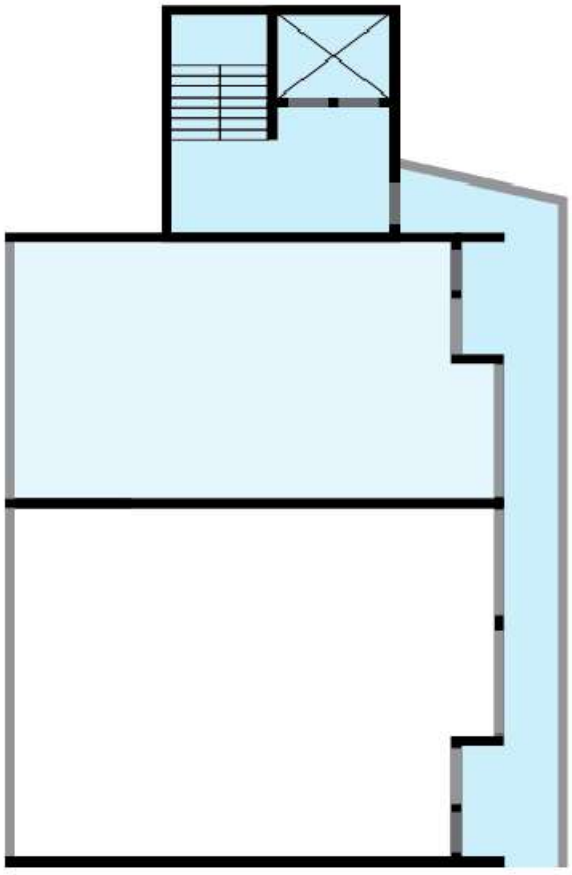

Figure 6: De Grote Eik pictures and floorplan

Westpoint

This building in Tilburg was the tallest building in the Netherlands at the time it was constructed in 2004. Each floor has four apartments that are connected to the elevators with a small hallway. The four apartments are all the same. The side of the building features an artwork of different colored lights, which has made it one of the most recognizable buildings of Tilburg (Kuijer, n.d.). Figure 7 shows the building, and a simplified floorplan.

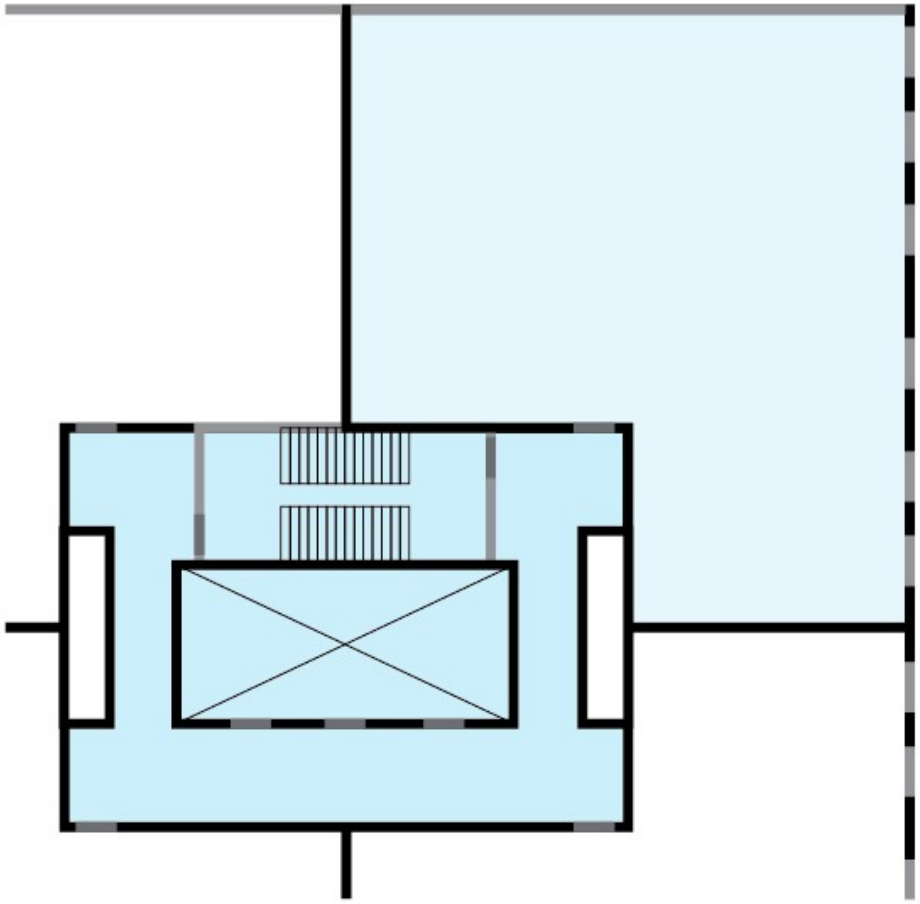

Figure 7: Westpoint pictures and floorplan

Berenkuil

This building represents a very typical hallway structure. The modular building hosts twenty units per floor, enclosing a hallway on both sides. The building was designed to be removed after a few years, which is why the modular design was chosen (leegwater, n.d.). Figure 8 shows the building, and a simplified floorplan.

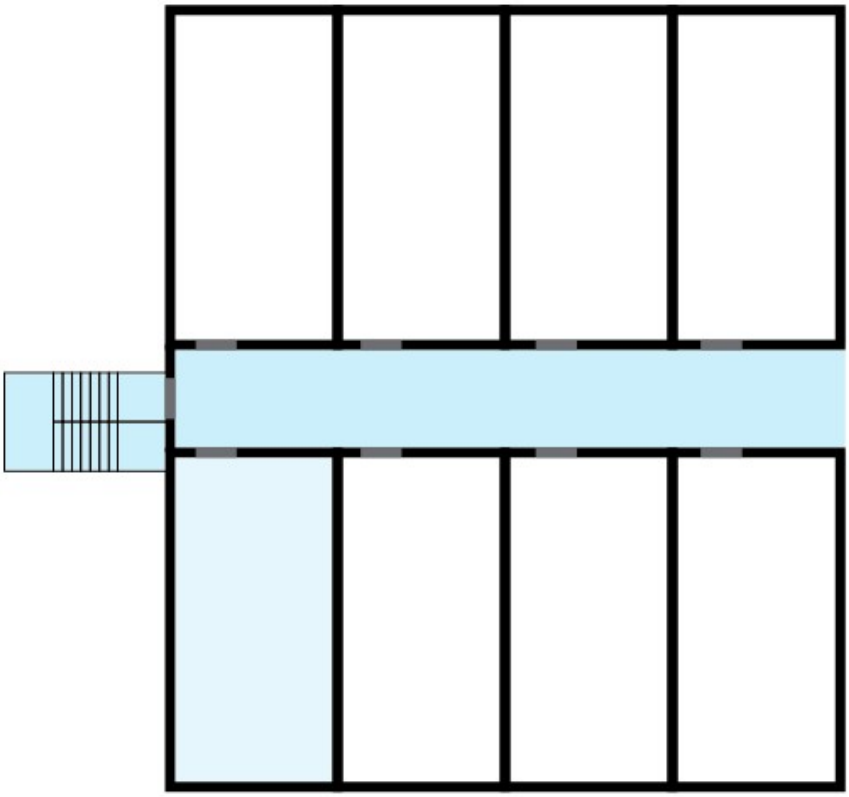

Figure 8: De Berenkuil pictures and floorplan

Ijplein Oost III

This building was designed as part of a new residential area in Amsterdam. The architects responsible for the masterplan of this area designed this building block as well. The neighborhood is set up so that the streets all look towards the IJ river. Most apartments are connected to a long diagonal hallway running up through the entire building, which gives access to four of the eight apartments. The other four are connected by a gallery on the top floor and another portiek structure on the ground floor. Since the apartments are mirrored, there are four different units (Leupen, B. & Mooij, H., 2008, p.150). Figure 9 shows the outside of the building, and a simplified floorplan.

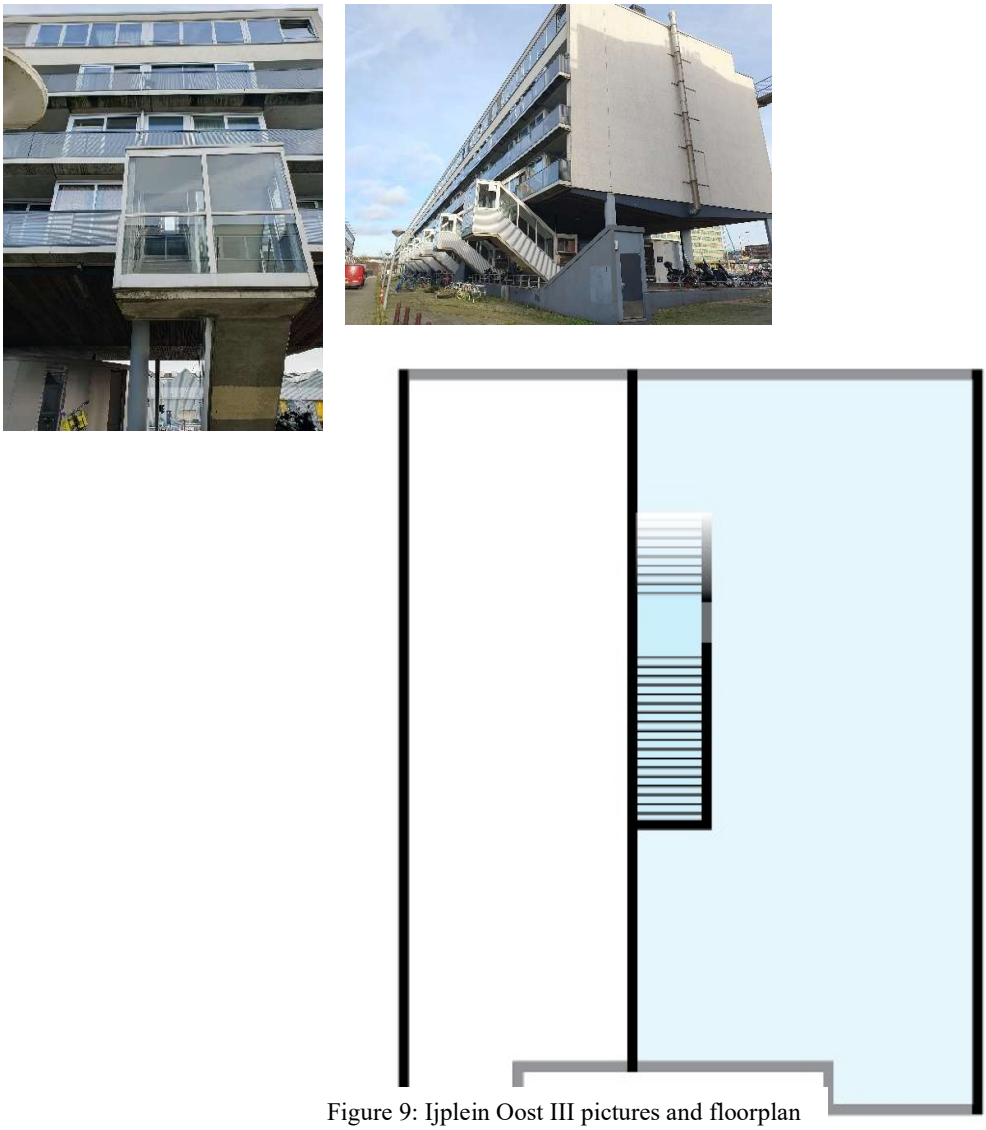

Figure 9: Ijplein Oost III pictures and floorplan

Appendix C: Elaboration of case study scoring

Influence	GWL terrein	Honingerdijk	Sibeliuslaan	Punt en komma	Westpoint	De Grote Eik	Berenkuil	Ijplein oost
Physical Barriers	All the doors are directly connected to the communal space, without a barrier	Some of the private spaces are separated by a staircase from the communal space, but only one in three units are	The staircase makes the spaces gradually more private, which can be seen as a physical barrier	The staircase acts as a physical barrier, separating the street from the small space higher up which connects to the doors	No physical barriers are present in the space, only a change in the colour of the carpet	There is no clear barrier between the communal and private space, doors open directly into communal space	There is no clear barrier between the communal and private space, doors open directly into communal space	A staircase can be concidered a physical barrier, but in this case this does not apply as it not an optional structure
Outdoor private space	The space in front of the doors could be claimed, but this did not appear to happen	There was enough space to claim, but there were signs in the elevator indicating that this was not allowed due to fire safety.	There was no private space in the communal space. The staircase can be used as a small balcony, but that would be shared with two units	There is no private space within the communal. There is also no space to claim, and this was not observed.	There is a small area outside the front door that can be claimed, but this was not done. At most there was a painting or a doormat	Each apartment has a small setback where the door is located, but these spaces are not private and not used	There is no private space, and also no space to claim for the residents. Most apartments do have a doormat in the hallway	There is no private space, and also no space for the residents to claim
Accessibility	The entrances are not very clearly marked, and there is a staircase without an elevator present	The entrances were brightly painted blue doors, which stood out from the rest of the space	Entrances are not accessible via an elevator. Staircases are easy to miss when walking on the ground floor	The entrance to the communal space was also visible from the lack of windows surrounding it. The colour of these spaces was also different from the rest of the building	The elevators were clear entrances, and the stairwell had a glass door as a boundary	There is an elevator, and the door to the gallery is obvious in the room since it brings in a lot of light from outside	Entrances are not marked clearly, as they match the white walls too well	Entrance to communal space is not on the street, but bellow the building. Private entrances are marked only by the staircase having a small landing
Boundaries	Both a gate and a staircase form a barrier between the different parts of the communal space	The large communal space was sepparated by sets of doors in a few places, creating clearer boundaries	Staircases provide a clear but non-obstructive boundary between spaces, the door is a clear boundary between outside and inside	The staircase also forms a clear physical boundary separating public from communal. This is strengthened by other materials in the walls and floor	Boundaries were not clearly marked, no doors in the hallway separating the elevators from the hallway. Only boundary in the communal space was the carpet	There is a door between the elevator room and the gallery itself, creating a clear boundary	There are no boundaries in the space, just one long corridor	There are no clear boundaries, since the entire communal space is one long corridor, just at an angle
Structure	The hallway is skewed towards structure, as the doors are evenly spread out over the wall in a very structured way. There are no elements to break that structure	The balance between structure and diversity is very good in this building. There is a very diverse construction repeated a few times untill a door offers separation from the rest of the units.	This building is quite balanced in terms of structure and diversity.The same structure is used multiple times, but between them are other elements which break the rigid structure.	The balance is quite heaviliy scewed towards structure, with every communal space looking the same. The windows are placed in a strong grid, which on regular intervals is broken by the entrances.	Quite a good balance, the space has a clear unity in the design, but the spaces are not monotonous. There is some individual expression with personal items in the outdoor private space	The space has a very strong structure, with little variation, leading to a lack of diversity	The space is very skewed towards structure, the same repetative door is spread evenly in the hallway	The façade of the building is very monotonous, as it is one white wall with regular windows and the staircase structure at a regular interval. From the inside this is less noticable, but still not many elements offer diversity.
Diversity								
Enclosure	One of the walls is almost completely open	One of the facades is almost completely open	Good enclosure, a lot of openness since the staircases are outside	The communal space is open on the side of the staircase, which is a large area.	This space did not have any openings to outside	One of the facades is almost completely open	There are only some small windows at the ends of the hallway	The hallway is very enclosed, only having openings at the ends.
Quality of view	The trees in front of the building provide transparencies and overlaps, while the buildings behind create articulating elements. Vistas are present in the streets, and the wide view creates a panorama	The trees in front of the building provide transparencies and overlaps, while the buildings behind create articulating elements. Vistas are present in the streets, and the wide view creates a panorama	Quite good view, with overlapping trees, a panoramic view of the courtyard and a pine tree as articulating element.	the view does not have a lot of quality, as it lacks transparencies, overlaps, vistas, and panoramas. The only articulation is the communal space on the other side of the street	This space did not have any openings to outside, so the view was not good	The view has a high quality, with overlaps from the trees, vistas, panoramas and articulating elements in the buildings of the park	The window does not provide a view, as it is too narrow to see anything through it.	The view does not have a high quality, as it looks towards one builing, which does not have transparencies, overlaps, or vistas. There are some articulating elements
Multifunctionality	The space is monofunctional	The communal space is wide enough for multiple functions, but this seems prohibited by the building owners for fire safety.	The space is monofunctional, except for a single notice board in the hallway	The space is monofunctional	The space is monofunctional	The space is monofunctional	The space is monofunctional	The space is monofunctional
Efficient use of space	The space is efficient, there are no redundant spaces.	Due to the ban on furniture in the communal space some of the space becomes functionless.	The space is used efficiently, the vertical circulation is also the communal space	The space is quite efficient, the only inefficiency is the width of the staircase, which allows for multiple people to walk beside each other.	The space was used efficiently, barely any redundant space was present	The setbacks for each apartment are mostly wasted space, they are too public and small for other activities.	The space is quite efficient, having no places that seem redundant	The space is very efficient, as the vertical circulation and the hallway are in the same space.
Changeability	The space is difficult to change, and does not seem demountable as the main material used is brick.	The connections are not demountable, and it is hard to imagine another function taking place in this space	Spaces have a very set function, making them hard to change. No demountable connections are present in the building	Spaces have a very set function, making them hard to change. No demountable connections are present in the building	The rooms are set in function and difficult to change. Connections are not demountable, and little change could occur	The building is quite fixed in its function, and the connections are not demountable	This building was designed to be demountable, and there are already plans to move the modules to another location in a few years	The building does not appear very demountable, and the spaces are very rigid. It is difficult to have other functions in the staircased hallway
Flexibility								
Demountability								
Efficient maintenance	The technical installations are organized for each individual unit, without an elevator	One of the doors seems to lead to an utility space, allowing for easier maintenance	Technical installations are accessible from the small hallway between apartments	The technical systems are not accesible from the communal space	Hallway has many panels, behind which installations are placed	Technical systems are not visible/accessible from the communal space, likely to be arranged per unit	The installations are accessible via a panel in the hallway, making maintenance easier	Technical systems were not visible in the hallway, suggesting they are organized per unit. The lack of an elevator also makes maintenance more difficult
Nature inclusive	There is no connection between the building and the ecosystem	There is no connection between the building and the ecosystem	There is no connection to the ecosystem, despite the high amount of trees surrounding the building	There is no connection between the building and the ecosystem	Barely any connection to the ecosystem, the only ecological value it provides is for birds of prey to catch pigeons	There is no connection between the building and the ecosystem	There is no connection between the building and the ecosystem	There is no connection between the building and the ecosystem