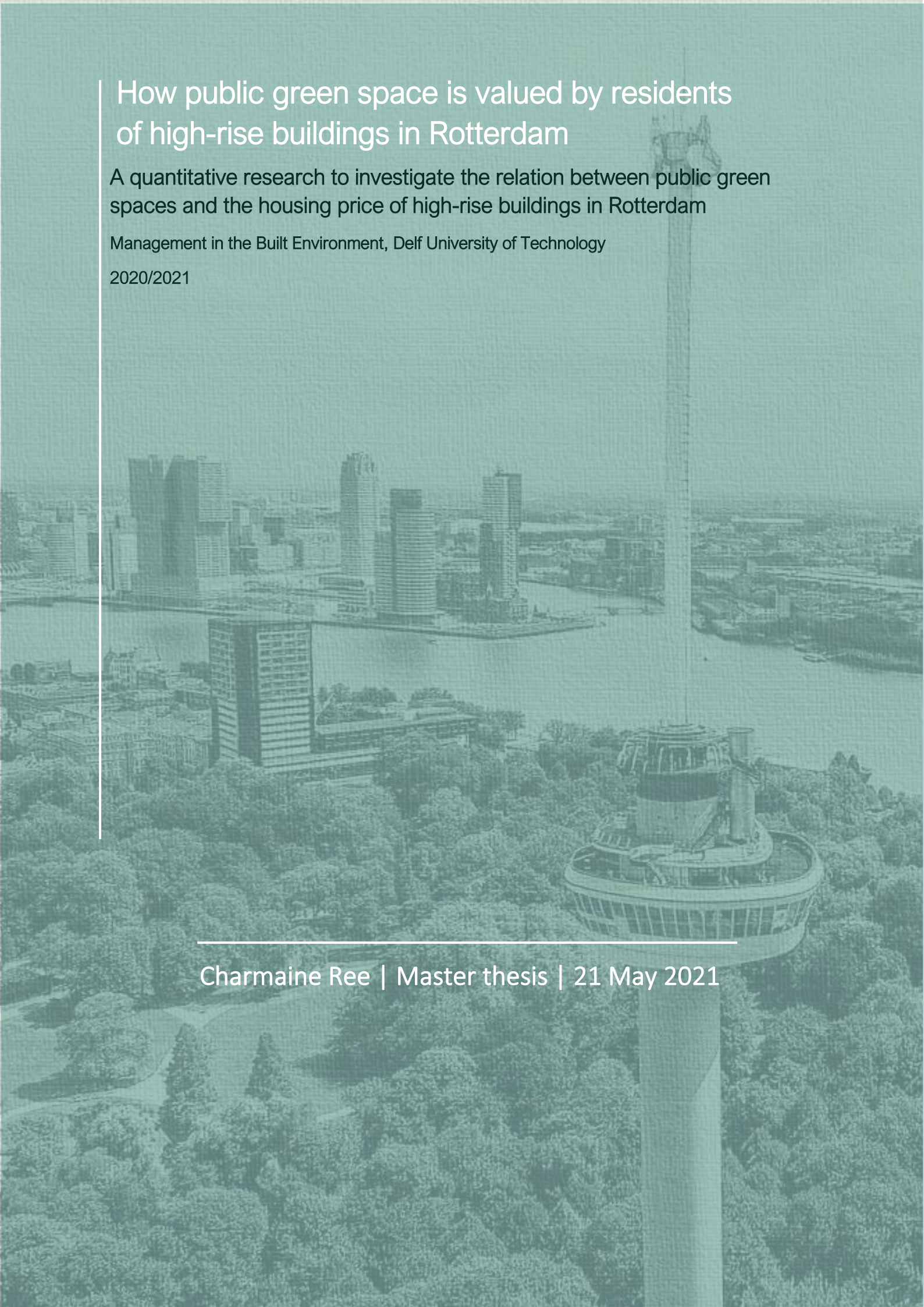
How public green space is valued by residents of high-rise buildings in Rotterdam

A quantitative research to investigate the relation between public green spaces and the housing price of high-rise buildings in Rotterdam

Management in the Built Environment, Delf University of Technology

2020/2021



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Abstract - This research investigated the determinant effect of public green spaces (PGS) on high-rise housing prices in Rotterdam. The growing population and tendency of people to gravitate towards city centers, have led to an increase in high-rise residential buildings in The Netherlands. It is therefore of high importance to optimize the integration of these buildings within its surroundings to increase the liveability, an important aspect of this is PGS. The gap in literature and social problems showed that there is a current mismatch with the desired and current needs of PGS regarding residents of high-rise buildings. The importance of PGS for residents of high-rise buildings is reflected by the housing price. The housing price indicates how much residents are willing to pay for certain variable of PGS and was used to evaluate different variables of PGS. The variables of PGS are divided into five domains: the environmental, social, cultural, functional and safety domain. Each of the domains indirectly affects the liveability of residents and citizens. The domains are identified by a comparison between international studies and Dutch municipal vision documents. The identified variables of the domains are further analyzed by a quantitative research, performed by a hedonic pricing model (HPM). Within this HPM, nine high-rise buildings were selected in the city of Rotterdam that provided an input of 977 apartments for the HPM. The regression showed a generally positive determinant effect of PGS on the housing price for high-rise buildings in Rotterdam. The strongest effect is the presence of having a PGS within 300m from the apartment, which impacts the housing price with a maximum of 17.7%. The view effects included in the HPM show a positive effect for both the number of green views and the specific PGS. The effects of the other PGS domains are correlated with the distance and view variables which makes it complex to quantify the effects of these domains separately. Interviews with developers of high-rise buildings, Stichting Hoogbouw and the municipality of Rotterdam were conducted to validate the results of the regression analysis and to assess the variables and aspects that are more difficult to objectively measure, such as the attractiveness of PGS. The main take-away of this research is that PGS have a positive determinant effect on the housing price of high-rise buildings which emphasizes the importance of having PGS nearby high-rise buildings. This study could be used as part of a reference approach for marketing research or during approval sessions regarding investment decisions to make stronger argumentations to implement PGS in the surrounding of high-rise buildings.

Key words – Public green space (PGS), high-rise buildings, housing price, regression analysis, hedonic pricing model, liveability

Preface

This research investigates the extent of the determinant effect of PGS on the housing price of high-rise buildings in Rotterdam. It is conducted as the final part of the graduation of the master track Management in the Built Environment (MBE) at the faculty of Architecture of the Technical University Delft.

Ever since I was about 9 years old, I have had a great fascination for high-rise buildings. I always wondered what little world resided beyond their often-impressive façades. At primary school, I already gave a speech about the immense buildings of Rem Koolhaas, with little enthusiasm of my classmates I may add. During my studies, I luckily found more enthusiasts and my own interest in high-rise buildings deepened and expanded as I took an interest in the complex urban developments of high-density regions. This made it a logical step to choose high-rise buildings as topic for my graduation thesis. Combined with my Rotterdam origin and educational interest in finance, I am coming full circle after that speech in primary school.

The rapidly growing population creates dense cities, which makes green elements nowadays even more important in the built environment. Therefore, this study assesses the effect of public green spaces (PGS) on the housing price of high-rise residential buildings. This relation between PGS and high-rise buildings fits perfectly within the scope of my masters and my educational interest in finance and economic aspects of real estate. My recent internship at Fakton Development, where they specialize in financial strategies for resilient places, was an essential part of the completion of this work.

This research would not have been possible without the help of my mentors. That is why I really want to thank my mentors from the TU Delft, Peter de Jong, and Ellen Geurts. They have encouraged me throughout the whole process with valuable feedback. Their expertise in the field was indispensable, Peter de Jong in particular for his extensive expertise in high-rise construction and Ellen Geurts for her background in social economics. In addition, I want to thank my company supervisor Ronald Daalman, who guided me during my internship at Fakton development. His pertinent feedback and connections in the high-rise real estate sector were of great value. I would also like to thank my colleagues from Fakton for their help, advice, and humour during the process. Writing this thesis during the isolation of COVID pandemic made me appreciate the assistance of my tutors and colleagues even more.

Finally, I would like to thank my friends and family for their support during this process. Having the patience to listen to the roller coaster of emotions during the ups and downs of the process, was highly appreciated. And thereby, a special thank you to my sister Isabelle which I often used as my testing audience.

Hopefully, you enjoy reading this graduation research. If any questions arise or you want to know more about this topic, feel free to contact me. I will happily answer your questions and share my enthusiasm for high-rise buildings.

Sincerely,

Charmaine Ree

Delft
May 2021

Extensive summary

1. Introduction

The housing demand is growing in the Netherlands in response to population growth. One answer to this problem is the development of high-rise buildings. These new high-rise buildings involve, however, new problems regarding liveability (Li et al., 2012). The problems arise both within the context of the building, as with the surroundings of the building. Public green spaces (PGS) are an important factor that contributes to this liveability of the residents of high-rise buildings. The gap in knowledge between PGS and high-rise residents causes multiple problems. Seen from the social context, there is a mismatch between the desired and current value of PGS for residents of high-rise buildings i.e. current PGS does not fulfill all the residential preferences. Both high-rise residents and other citizens desire higher qualitative public spaces with more greenery (Licher, 2020). Leby and Hashim (2010) describe that the residential valuation of PGS concerns liveability. This thesis defined liveability as the quality of life and satisfaction of the residents and citizens in the urban environment. Academic studies regarding the liveability of high-rise buildings in Dutch cities are still missing, which leads to a gap in knowledge of understanding how the improvement of liveability can be reached.

Another problem is the complexity of measuring the value of PGS experienced by residents by an objective approach. A common approach is to measure the willingness to pay, i.e. the price value residents are willing to pay as measure of residential preferences (Jim, Chen, 2010). This willingness to pay can be extracted from the housing price. A comprehensive study on the valued PGS aspects is still missing. Additionally, performed studies about the value of public green mainly focused on low-rise buildings (Noor et al., 2015; Wong et al., 2011). Due to the significant differences between low-rise and high-rise buildings, such as floor level and private outdoor spaces, it is not recommended to directly apply these conclusions to high-rise residential buildings.

Scope

The context of this research lies within the city of Rotterdam and includes newly developed high-rise buildings with a minimum height of 70 meters. Rotterdam is seen as one of the leading Dutch cities as it comes to high-rise buildings (Gemeente Rotterdam, 2019). Due to the accessibility of data, the selected buildings consist of relatively new developed buildings. The research focuses on PGS aspects and its financial arrangements between municipalities and developers of high-rise buildings in Rotterdam. The housing price is defined as the listed VON-price of these developments as this corresponds with the price that the apartments are put of the market. To make the value of PGS more tangible, the aspects of PGS are further elaborated on by the term liveability in this research. To establish these aspects within the Dutch context, high-rise vision documents of the five largest Dutch cities are investigated.

Relevance

The scientific relevance of this research is to contribute to the knowledge of understanding liveability aspects regarding the housing price of high-rise buildings in Dutch cities. The emphasis lies on the liveability created by PGS, as experienced by the residents created by PGS. The research elaborates further on existing studies where liveability aspects are measured and relates liveability to the housing prices. A quantitative valuation of PGS is useful during market pricing and decision making on pricing strategies. It can also be useful for municipalities and developers who are looking for a proper location to build residential high-rise buildings or PGS. Due to the absence of an objective measurement value, new developments are often cut back on PGS. Additionally, the results of the positive effect of PGS could

be used as motivator for municipalities and developers to make better investment agreements with each other for PGS.

A contribution to the knowledge of understanding liveability variables of PGS in regard to housing prices of high-rise buildings is made by assessing the relation between PGS and high-rise buildings. Therefore, the following research question is formulated: *To what extent have public green spaces (PGS) a determinant effect on the housing price of high-rise buildings in Dutch cities?* To give an elaborate answer to the main research question, multiple sub-questions are established that investigate the importance of PGS for various actors, the factors of PGS that influence the housing price and how the housing price of high-rise buildings is determined.

2. Literature study

The main concepts of this research are defined by an international literature study. PGS are areas which contain green elements that contribute to a better quality of life (Noor et al., 2015; Gifford, 2007). This study demarcates PGS as spaces that are inviting to reside in, not as a transit route. PGS encompasses many different types of spaces with various variables. The most common type of PGS are parks and forests. Other types of PGS are the public green areas within a building such as public rooftops. This study combines the identified types within small parks, signature parks and public green roofs. Collective gardens are included in the study as well, as they are seen as an important part of the promotion during the sale of the apartments. PGS entail many variables which can influence the liveability of residents and citizens. Liveability can be divided into five identified liveability domains: the social, environmental, functional, cultural and safety domain. The research method in chapter 3 elaborates further on how these domains are connected to PGS to make the research more tangible.

The interest of municipalities and high-rise residential building developers in PGS relate to the financial arrangements of these projects. High quality PGS may be in everyone's best interest but come with a price. In the Netherlands, the municipality is in general responsible for these expenditures. Nevertheless, the Dutch municipality can recover costs from other actors by different approaches (Hobma, 2020). These approaches are done by an active land policy, a facilitating land policy or a mixture of both. If users and property owners benefit from the added value of the public space as well, other options to ask financial contribution can be investigated. Therefore, land value capture could be used to generate public benefit from public action (Wen, Goodman, 2013). International land policies show the concept land value capture, defined as the value of the property including both the land value itself as well as the improvements that have been made (Wen, Goodman, 2013). This term entails different concepts to recover cost from developers.

The determination of the housing price is quantitively identified for this research that can be seen as the price that the buyer is willing to pay for owner-occupied dwellings and monthly rent for renter-occupied dwellings (Kain, Quigley, 1970). The structure of the housing price is depended by many factors such as the building and environmental variables for the buildings. The research divided these variables into:

- structural building variables for high-rise buildings
- Environmental variables, both physical and functional
- Social variables, including social-cultural and social-economic

3. Research method

The effect of PGS on the housing price of high-rise buildings in Rotterdam is performed by a quantitative research, supplemented with a qualitative research. First, the international literature study is compared

with municipal high-rise vision document of cities in the Netherlands (Rotterdam, Amsterdam, Den Haag, Eindhoven) to see if the identified PGS variables apply for the Dutch context as well. This is completed with a survey among Dutch residents to confirm and explore the important PGS variables. The identified variables from the comparative literature study are used within the quantitative research to test the hypothesis: *PGS have a positive determinant effect on the housing prices of high-rise buildings in Dutch cities.* The other variables of the building and its environment identified in section 2.4 will be included as well to provide a more representative outcome. Some social and environmental variables are excluded from the research since the context lies within one city, Rotterdam. The research has collected data by selecting nine high-rise residential buildings in Rotterdam. Data of these buildings is gathered by setting multiple variables of both the buildings and surroundings variables. The quantitative research used a regression analysis, the hedonic pricing model (HPM), that identified the impact that independent variables have on the housing price, seen as the dependable factor. The independent variables include variables of the building, environment and PGS variables. The HPM is performed in the statistical program R-studio. The data collection is performed to identify the building, environment and PGS variables for each of the 977 apartments within the nine selected buildings.

The same cases are used for an explorative qualitative research since this research connects variables of PGS that are also used in the quantitative research. The qualitative research can be seen as an addition to the quantitative research to explain the relation between the PGS variables and housing price that are more difficult to measure by a quantitative research. An overview of the research methods is shown in figure A. The qualitative research used interviews with experts from high-rise buildings and urban development. Figure A illustrates an overview of the performed research methods.

Figure A: Research method sequence (own figure)

4. Findings

The goal of this research was to answer to the research question 'to what extend have PGS a determinant effect on the housing price of high-rise buildings in Rotterdam?'. The context of this research lies within the city of Rotterdam and includes newly developed high-rise buildings with a minimum height of 70 meters. The willingness to pay for certain PGS variables is assessed by investigating their specific effects on the housing price. The extent of the determinant effect of PGS on the housing price is investigated per domain of the PGS. An overview of the identified variables that influences the housing price of high-rise buildings is shown in figure B.

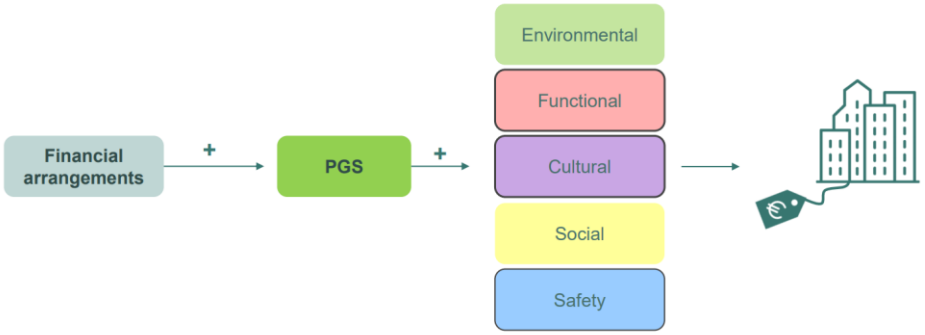


Figure A: Research method sequence (own figure

Overall, the regression analysis show that PGS have a positive determinant effect on the housing price of high-rise buildings. This is according to the expectations from the literature that formulated the hypothesis. The hypothesis is therefore confirmed. The regression analysis identified the functional and cultural variables as the two PGS domains that have the highest effect on the housing price of high-rise buildings. The presence of a park within 300m is identified as the largest impact on the VON-price, namely an increase of 15.7 to 17.7%. The view effects of the cultural domain show a general positive impact on the VON-price. They are measured for the number of PGS views, the certain types of signature parks and the iconic landmarks of Rotterdam. Having two green views from your apartment increases the housing price with 7.1% compared to having no PGS view at all. As the sight on a PGS can only be seen without any obstruction of other buildings, it is assumed that this percentage includes also positive effect of having no obstructive buildings in your view. These outcomes are supported by the results of sub-question 2 which identified the functional, cultural and safety domains as most important for the housing price of high-rise buildings. The expected high influence of the safety domain cannot be fully confirmed by the regression analysis as the safety variables were difficult to measure. In addition, some variables of PGS have overlap between the liveability domains. This was already suggested by the literature study that addressed the overlap between the social and safety domains. This research measured the (positive) impact that PGS have on the housing price. Despite this, it is important to keep in mind that the most important variable that determines the housing price is not a PGS variable but the living area in square meters of the apartment.

During the HPM, it became clear that the variables of the PGS domains have multiple overlaps which could create intercorrelated results. To overcome this, some of the variables are excluded from the definite models. Testing models have eventually led to two regression models. These models differ in the separation or clustering of the green view effects. The regression models show generally a positive effect of PGS variables on the housing price of high-rise buildings in Rotterdam, and thereby, do not reject the hypothesis of this research.

One of the main difficulties of regression analyses is to meet the key assumptions needed for an unbiased outcome, described in section 3.5.1. As the housing price is determined by many variables, the regression analysis was the most suitable approach for this research. Although, the interconnection of independent variables is the most difficult aspect about including many variables in the regression. The testing models showed the intercorrelation between. Despite preventing this intercorrelation as much as possible by meeting the key assumptions, it is still possible that there are some variables that still intercorrelate. Therefore, the coefficients of the regression analysis can only be identified as reference point, not as a decisive conclusion. The interviews are used as extra validation of the results

which show that most of the important results from the regression analysis are valid, according to the experts.

A few assumptions can be made for variables that were harder to measure within the regression model. This is done by two approaches. First, some assumptions can be drawn from looking at the coefficients from the regression analysis of view variables and the presence of a PGS within 300m. The significant effects of both variables can by partially explained by the social, environmental and safety domain. Having an attractive PGS nearby could encourage actors to use it more frequently, which increases the interaction within the city. This higher interaction ultimately improves both the social aspects, such as sense of belonging, as well as the safety aspects. The positively effect of green view from the apartments is correlated to the physical well-being of residents by means of the view on natural elements.

A second approach includes the variables for safety, social and physical indexes within a regression model, shown in appendix E. These indexes show a strong positive influence on the VON-price in the testing models of the HPM, ranging from 14.1 to 22.5% compared to a lower index score. This can be explained as these indexes cluster many variables that contribute to a pleasant living environment. This explains also the multicollinearity with the distance variable, which is why these indexes were excluded from the definite regression analyses.

The overall positive impact of PGS on the housing price of high-rise buildings in Dutch cities is a valuable outcome for multiple actors. The results can be useful during market pricing and decision making on pricing strategies for high-rise building developments. It is an important step to emphasize the value of PGS among developers and the municipality by making the value more tangible. It can also be useful for municipalities and developers who are looking for a proper location to build residential high-rise buildings or PGS. Only the city of Rotterdam is included, which makes it a reliable result for high-rise buildings of Rotterdam where multiple aspects of both the building and its environment are taken into consideration. Finding a positive effect on the presence of PGS can be used as insight to investigate the effect of the absence of PGS. As the research emphasizes on the importance of having PGS, it is interesting to look at what happens if the quality and quantity of PGS declines. This research can be used as key stone for quantifying the value of PGS. This research led to a quantified value that could possibly be expressed in a compensation for residents if PGS characteristics decline. Further research in jurisdictional regulations is needed to identify the possibilities for certain claims.

The research further points out the desire to improve the communication between a high-rise developer and municipality regarding financial arrangements for public spaces, including PGS. Seen from the interviews, both parties agree that a more transparent policy regarding the money flow could be beneficial for the quality of PGS. Further research is advised to discover new insights in the improvement between the communication between developers and the municipality.

Content

Colophon 3

Preface 5

Summary 6

1. Introduction 6

2. Literature study 7

3. Research method 7

4. Findings 8

Glossary 14

1. Introduction 15

1.1 Problem statement 15

1.2 Scope 16

1.3 Societal and scientific relevance 17

1.4 Research question 17

1.5 Dissemination and audiences 18

1.5 Personal study targets 18

1.6 Research guide 18

2. Literature study 20

2.1 Residential high-rise buildings 20

2.2 Public green spaces 21

2.2.1 Types of public green 21

2.2.2 Public green space and liveability 22

2.3 Financial arrangements for PGS 26

2.3.1 Current practice in the Netherlands 26

2.3.2 Examples from other countries 28

2.4 Determination of high-rise housing prices in The Netherlands 29

2.4.1 Definition housing price 29

2.4.1 Determination housing price 29

2.5 Conclusion 30

2.6 Goals and objectives 31

2.7 Deliverables 31

2.8 research approach 31

3.Research Method 32

3.1 Hypothesis 32

3.2 Type of study: empirical research 32

3.3 Research methods: from literature study to semi-structured interviews 33
3.4 Data collection 36
3.5 Data analysis 38
3.5.1 Hedonic pricing method 38
3.5.2 Semi-structured interviews with experts 43
3.5.3 Summary of the data analysis 44
3.6 Data plan & ethical considerations 44
4. Data output 45
4.1.1 Sampling area & building selection 45
4.1.2 PGS selection 47
4.1.3 PGS variables selection 48
4.2 Importance of PGS for residents, municipalities, and developers 51
4.2.1 Resident's perspective 51
4.2.2 Municipal's perspective 52
4.2.3 Developer's perspective 54
4.3 PGS variables influencing the housing price of high-rise buildings 55
4.4 Determination of the housing price of high-rise buildings in Rotterdam 63
4.4.1 HPM outcomes 63
Outcomes other variables 70
5. Discussion and conclusions 71
5.1 Conclusion 71
5.2 Limitations 74
5.3 Implications 75
5.4 Recommendations 76
6. Reflection 78
6.1 Method & results 78
6.2 Personal reflection 78
7. References 80
Figures: 83
Appendix A: Flowchart liveability perspectives and domains 85
Appendix B: variables of hedonic pricing model with sources 87
Appendix C: Dog friendly PGS in Rotterdam 88
Appendix D: concepts, variables and variables from the research 90
Appendix E: HPM models with testing models 91
Appendix F: R-script regression model 1,2 94
Appendix G: Survey 97

Appendix H: interview protocol 105
Appendix I: PGS and parks 107
Appendix J: View variables and their data source 108
Appendix K: Land value capture types in foreign countries 109
Appendix L: Background interviewees 109
Appendix M: Instruments to recover cost from developers 110

Glossary

- **Domains:** The five liveability domains which are environmental, social, functional safety and cultural.
- **Financial arrangements:** arrangements and decisions about PGS made between municipality and high-rise building developers.
- **Heteroscedasticity:** the variance of the residuals (error terms) is dependent of the value of the dependent variable. The hypothesis for the presence of heteroscedasticity is tested by the Breusch-Pagan test. The hypothesis can be rejected by a p-value < 0.05.
- **Hedonic Pricing Method (HPM):** In the context of the housing market, a HPM can be used as a regression analysis to express the house prices as a function of a vector of multiple independent variables of the buildings and its surrounding.
- **High-rise residential building:** Residential tower with a hight of at least 70m.
- **Liveability**: The quality of life and satisfaction of the residents and citizens in the urban environment.
- **LVC:** Land Value Capture. A public financing approach that allows parties to recover and reinvest land value increases that are generated through public investments.
- **Multicollinearity:** the independent variables are highly correlated with each other. This is tested via Variance Inflation Factor (VIF) values. In general, a value higher than 10 could indicate the presence of multicollinearity which could cause a biased outcome.
- **Public green spaces (PGS):** Public space with natural elements.
- **PGS variables**: Variables of PGS that contain variables of one of the liveability domains.
- **Regression analysis:** Statistical analysis that estimates the relationship between a dependent variable and independent variables, by a quantitative approach.
- **Semi-public/private gardens:** gardens located on the roofs of the high-rise buildings that are accessible for all residents.

1. Introduction

Housing demand is growing in the Netherlands in response to population growth. This demand is not distributed evenly over the country, as people tend to gravitate towards the larger cities. These cities have grown increasingly dense as a consequence (Stoeldraijer et al., 2020). Horizontally, there is hardly any space left to allocate new dwellings in the inner cities. This scarcity is partially solved by the (increased) constructions of vertical residential houses in high-rise buildings. The municipality of Rotterdam and Stichting Hoogbouw already outlined the social need to create more high-rise buildings before (Gemeente Rotterdam, 2019).

Of course, the rapidly growing amount of high-rise residential buildings also poses new challenges, such as the citizen's attitude towards high-rise buildings (Li, Sun Jones, 2012) and the willingness of people to reside in high-rise buildings. To create a successful high-rise residential building, it is therefore highly important to generate more and updated information regarding the integration of high-rise buildings in current society from various perspectives: integration with the rest of the surroundings and matching to public space, pricing and valuation systems, sustainability, and liveability (Niu, 2004; Wong, Chau, Yau, Cheung, 2011; Yeh, Yuen, 2011). The need of a better understanding regarding liveability of high-rise buildings and its surroundings was pointed out before by Li et al. (2012) and Yeh and Yuen (2011.) Public green spaces (PGS) are of key important to enhance liveability in urban environments (Skalicky & Čerpes, 2019). The appearance of PGS within a building and its surroundings proved especially important to residents of high-rise buildings (Gifford, 2007). Therefore, the focus in this research is the relation between these PGS and high-rise buildings.

1.1 Problem statement

The rapid growth of increase in high-rise buildings has partially solved the housing shortage, but gives rise to new problems regarding liveability, such as safety problems and social interaction as experienced by residents of high-rise buildings (Li et al., 2012). These problems arise both within the context of the building, as with the surroundings of the building. When reviewing literature on the social context of high-rise building, multiple problems arise. Formulating the problem statements explains why these aspects of high-rise buildings and its surroundings need to be investigated. It eventually contributes to obtain new insights in the development of successful high-rise buildings.

Seen from the social context, there is a mismatch between the desired and current value of PGS for residents of high-rise buildings i.e. current PGS does not fulfill all the residential preferences. For example, new high-rise buildings can cause an increased density in a city which could lead to increased pressure on and overcrowding of the existing public space, resulting in a reduced valuation of these spaces by residents (Raaij, 2020). Both residents of high-rise buildings and other citizens desire a higher qualitative public space with more greenery. The COVID-19 pandemic has recently amplified this desire for green surroundings (Licher, 2020).

Leby and Hashim (2010) describe that the residential valuation of PGS concerns liveability. This thesis defines liveability as 'the quality of life and satisfaction of the residents and citizens in the urban environment'. The scarcity of insights in liveability in relation to green spaces could cause misconceptions between the development of such spaces and the desires of residents as residents want an environment that contributes to the quality of life. Academic studies regarding the liveability of residents of high-rise buildings in Dutch cities are still missing, which leads to a gap in knowledge of understanding how the improvement of liveability can be reached.

It is difficult to objectively measure the value of PGS experienced by residents. A common approach is to measure the willingness to pay, i.e., the price value residents are willing to pay as measure of

residential preferences (Jim, Chen, 2010). This willingness to pay can be extracted from the housing price. Several studies elaborated on the added value residents of willing to pay for aspects of PGS but focused mainly on the direct aspects of PGS (e.g., accessibility, view), rather than the indirect aspects of PGS (e.g., air quality, pollution). A comprehensive study of both the direct and indirect impact is still missing.

The studies that elaborated on the added value residents are willing to pay for PGS, also mainly concerned low rise residential housing (Noor et al., 2015; Wong et al., 2011). High-rise variables such as the view on PGS and floor level were not included in these studies. Due to these significant differences between low-rise and high-rise buildings, it is not recommended to directly apply these conclusions to high-rise residential buildings. Section 2.4. will further elaborate on these different variables that could affect the willingness to pay for PGS.

The value of PGS regarding high-rise residential buildings could be very interesting in terms of, investment decisions and concerns both parties investing in high-rise residential buildings as well as parties investing in PGS. In addition, Li et al. (2012) discuss that various studies show contradictive outcomes of different liveability studies in high-rise buildings. This contraction can be explained by the different contexts of cities. Residents appreciate a high quality of PGS as this contributes to the quality of life (Noor et al., 2015). High quality PGS are also in the best interest of the municipality and developers, as these create an overall more attractive area for people to reside in and could influence the housing price (Hobma, 2020). However, these places are expensive to realize. Public spaces with high quality greenery result in higher investments. Investments are now mainly done by the municipality, with often limited resources. Financial arrangements could be used by the municipality to recover costs from developers of adjacent new construction project (Hobma, 2020). This could result in a larger budget to create high quality PGS where all parties benefit from.

In conclusion, the extent of the effects of PGS regarding liveability on high-rise buildings has not been investigated before in a comprehensive study in Dutch cities. This study therefore investigates the relation of PGS and high-rise residential buildings and gives new insights in potential improvement of this interaction. This study also includes the financial arrangement of PGS, to understand the interest of municipalities and developers.

1.2 Scope

The research focuses on PGS aspects and its financial arrangements regarding municipalities, developers, and high-rise building residents in Dutch cities. To find answers to the problems and literature gaps mentioned in section 1.1, this research focusses on the Dutch residential market. More specifically, it focusses on the residential high-rise buildings in the city of Rotterdam. Rotterdam is seen as one of the leading Dutch cities as it comes to high-rise buildings, which makes it a suitable city for this research (Gemeente Rotterdam, 2019). Section 3.5.2 elaborates further on the selection of the city Rotterdam. The definition of high-rise buildings focusses on newly developed high-rise residential buildings above 70 meters. Investigating newly developed buildings creates new insights in the current trends among high-rise buildings. In addition, the data collection is easier to access for these buildings.

To make the value of PGS more tangible, the aspects of PGS are further elaborated on by the term liveability in this research. To establish these aspects in the Dutch context, high-rise vision documents of the five largest Dutch cities are investigated. Quality of life and thereby liveability is mainly depending on social interactions and safety for high-rise residents (Yuen, 2011). This interaction is most positively influenced by the appearance of PGS within a building and its surroundings (Gifford, 2007). To understand the existence and development of public green areas, the research tackles the Dutch land policy as well. This is elaborated further in section 2.3.1.

Considering the given timeframe, this research only discusses the financial arrangements regarding PGS between developers and the municipality. The relation between high-rise buildings and PGS are most affected by the negotiations between these two parties. Thus, the financial arrangements between residents are excluded from this research. Section 2.3 will discuss the arrangements in more detail.

1.3 Societal and scientific relevance

The scientific relevance of this research is to contribute to the knowledge of understanding liveability aspects and the effect they have on the housing price of high-rise buildings in Dutch cities. The emphasis lies on the liveability created by PGS, as experienced by the residents created by PGS. The research elaborates further on existing studies where liveability aspects are measured and relates liveability to the housing prices. A similar process was undertaken by Jim and Chen (2010), who assessed the link between the housing price and the value of landscape elements. This research contributes to the missing gap in literature concerning valuation of liveability that affects the residents of high-rise buildings, within the context of Dutch cities. In addition, it is a contribution to the review of how PGS are funded in the Netherlands. This could provide better justification for funding and investing in PGS (Jim, Chen, 2010).

In addition to the justification of investing in PGS, this study will assess the importance of PGS during investment decisions. Raaphorst (Raaphorst, M., personal email, 25 March 2021) discusses this by addressing the need of making the value of public spaces more quantifiable. Due to the absence of an objective measurement value, new developments often cut back on investments in high quality PGS.

Multiple cities have established a municipal vision on high-rise buildings and its surroundings, formulated in a vision document. The documents contain guidelines on how high-rise buildings should be implemented in the city to achieve certain goals established by the municipality. These visions do not provide however concrete measures to establish effectiveness in the increase of the liveability for both the residents of the high-rise and citizens. A quantified valuation of liveability aspects regarding PGS is missing, which could show a clear distinction in the value of liveability measurements.

The societal relevance of the thesis is to give a more elaborate view in the relation between PGS and high-rise housing prices. Thereby, the research will be a contribution to solving the current mismatch with existing and desired liveability measurements for high-rise building residents, stated in the problem statement in chapter 1.1. The results of this research are significant for multiple actors within multiple phases of the real estate development. The results can be useful during market pricing and decision making on pricing strategies. It can also be useful for municipalities and developers who are looking for a proper location to build residential high-rise buildings or PGS. In addition, the results contribute to emphasizing liveability aspects of PGS in high-rise residential developments.

1.4 Research question

The relation between PGS aspects and housing prices have been studied before. However, these studies focused mainly on low-rise buildings and did not include the financial arrangements of PGS. Studies on PGS, including its liveability aspects, and high-rise housing prices are scarce, especially for a specific Dutch context. More insights in what residents are willing to pay for high PGS aspects are needed for better investment decisions. The primary aim of this research is therefore to assess the relation between PGS and the housing price of high-rise buildings. Within the scope of this research, the current investment strategies of PGS in the Netherlands will be reviewed.

The main research question of this research is:

To what extent have public green spaces (PGS) a determinant effect on the housing price of high-rise buildings in Dutch cities?

The willingness to pay for high quality PGS is approached by the housing price in this paper. The main research question is established by a combination of the following sub-questions:

1. *Why are public green spaces of importance for residents, municipalities, and developers?*

By answering this question, a comprehensive answer will be given on which aspects PGS entail. These aspects affect multiple actors. The actors that will be discussed in this research are high-rise building residents, developers and Dutch municipalities. In addition, the PGSs will be discussed within the boundaries of liveability aspects.

2. *What factors of PGS could influence the housing price of high-rise buildings in Dutch cities?*

In relation to sub-question 1, the factors that influence the importance of PGS could have an effect on the housing price of high-rise buildings in Dutch cities. Furthermore, other aspects, regarding PGS, such as its financial arrangements, that could influence the housing price are discussed. The impact on the housing prices gives insights in how willing residents are to pay for certain aspects regarding PGS.

3. *How is the housing price of residential high-rise buildings in Rotterdam determined?*

Housing prices of residential high-rise buildings are determined by various variables. This research will investigate how these variables influence the housing price of high-rise residential buildings.

By answering the research questions, a more elaborate view can be given of the relation between PGSs and the housing prices of high-rise residential buildings while considering the various aspects regarding PGS. The added value that PGS can contribute to high-rise residential buildings can be assessed by looking at the added value of properties due to the presence of PGS. This result can provide new insights into the current financial approach to develop and maintain PGS in the Netherlands. The impact of PGS on housing prices can be established by looking at the effect these spaces have on the housing price of residential high-rise buildings. Combined with the other determinants found by sub-question 3, a hedonic pricing method can be used to access the values of the PGS in regard to the housing prices. The potentially high impact of green spaces to property valuation may affect investment decisions made for both high-rise buildings as PGS.

1.5 Dissemination and audiences

This research focusses mainly on actors that are interested in knowledge of high-rise residential buildings and public green spaces. This audience are mainly actors from the municipality and the developers of high-rise buildings. In addition, land policy is accessed in the literature study which can be interesting for both municipalities, governments, and developers.

1.5 Personal study targets

This graduation research tackles multiple personal interests, such as high-rise Dutch buildings, building economics and quantified research methods. With this research, more knowledge will be gained on these subjects. In addition, an integrative research of these subjects increases the student's ability to combine multiple aspects into a quantitative research. Another study target is to combine the theoretical academic perspective with the practical perspective obtained by the graduation internship.

1.6 Research guide

The research guide, illustrated in figure 1, shows an overview of the process that includes the research introduction, literature study, data collection, analysis, conclusions, and discussion.

To address the effects of PGS by the liveability domains, first, a comparative study is done for PGS between the liveability domains found in international literature and the domains found in high-rise vision documents of the four major Dutch cities (Amsterdam, Rotterdam, Den Haag, Utrecht). Secondly, the effects of PGS are discussed by the found domains of the liveability aspects observed in the comparison study. The effects of PGS found in literature are then compared with an exploratory survey among Dutch citizens. The comparison study of liveability domains and the exploratory survey for the effects of PGS, are discussed in chapter 4.

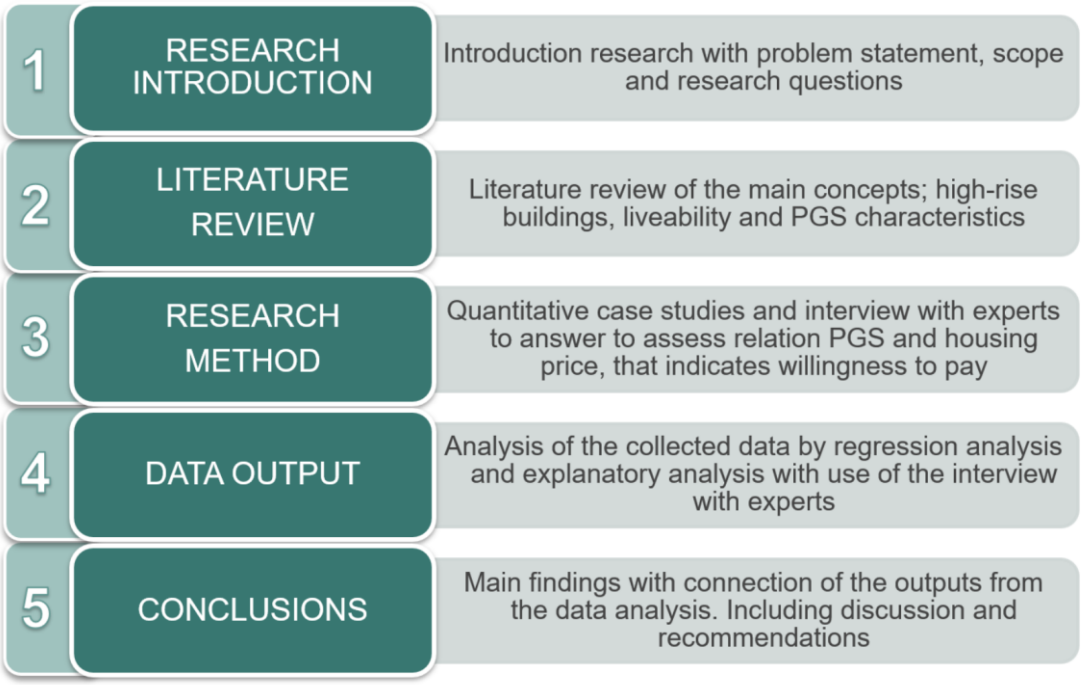


Figure 1: research guide to assess the relation between PGS and apartments of high-rise buildings (own figure)

2. Literature study

To give a comprehensive view on the interaction between PGS and the residential high-rise housing price, a literature study is presented first to define the concepts discussed in the problem statement. Residential high-rise buildings, PGS and related concepts as liveability, as well as financial structure are elaborated on. Lastly, the concept housing price is explained and how it is structured.

2.1 Residential high-rise buildings

There is an immense portfolio of high-rise buildings all over the world. Many countries have established their own definition of a high-rise building since the context and rules may differ between countries. In the Netherlands, the definition of high-rise changed over the years. Although there is not one clear definition for Dutch high-rise buildings, the standard height for a Dutch high-rise building is nowadays set as 70 meters for buildings in the larger cities of the Netherlands (Zandbelt & van den Berg, 2008). The expansion of the WTC tower at Beursplein in Rotterdam is seen as the start of increasement in high-rise Dutch buildings, built in 1986.

The first building above 100 meters high in the Netherlands was constructed after the World War II. Residential high-rise has experienced an immense change in its reputation over the last decades (Zandbelt & van den Berg, 2008). After World War II, there was an immense housing shortage due to the destruction of many buildings. This led to a significant increase in, formerly called, high-rise residential towers after 1950. The city of Rotterdam especially was heavily damaged in an aerial bombardment on 14 May 1950 and had to be rapidly rebuild post-war to accommodate the city's citizens. High-rise residential towers were cheaply built in the suburbs and resulted in low-quality dwellings. An example of these hastily constructed building complexes is the neighbourhood Ommoord in Rotterdam, shown in figure 2. Due to the small budget, minimal attention was paid to the surroundings of the buildings. Over the years, capital-driven residents moved towards more spacious dwellings, which lead to social impoverishment of the towers as it became a breeding ground for crime and social problems (Zandbelt & van den Berg, 2008).

Figure 2: Gallery flats in Ommoord (Funda, n.d.)

In the late 1960s, attention shifted towards the buildings of more sustainable residential high-rise buildings and at more appealing locations. The accomplishment of sustainable dwellings is reached by high-quality requirements, both for the construction and its surroundings (Zandbelt & van den Berg, 2008). The Hoge Heren in Rotterdam, built in 2001, is the first residential high-rise tower above 100 meters, which triggered a second building trend for residential high-rise buildings to build. These towers are tinner compared to the gallery flats after the World War II.

One of the main problems residential high-rise has currently to deal with, is the lack of integration with its surroundings (Zandbelt & Van den Berg, 2008). To tackle these problems and align high-rise buildings with the municipal visions of Dutch cities, multiple Dutch cities have established vision documents where guidelines for high-rise buildings are described. In section 3.5, these guidelines will be further discussed to select the data.

2.2 Public green spaces

PGS are areas which contain green elements that contribute to a better quality of life (Noor et al., 2015; Gifford, 2007). This study demarcates PGS as spaces that are inviting to reside in, not as a transit route. Despite the attributed positive effects of PGS, the quality and quantity of green spaces has declined over the years in the more urban areas (Maas, Verheij, Groenewegen, De Vries, Spreeuwenberg, 2006). To intervene in this declining process, it is important that more insights are obtained about the importance of these spaces for various actors.

2.2.1 Types of public green

PGS encompasses many different types of spaces with various variables. The most common type of PGS are parks and forests. Other types of PGS are the public green areas within a building such as public rooftops. Gifford (2007) discusses the need for public areas to enlarge social interaction for residents of high-rise buildings. Gifford's study shows that especially areas with natural green elements increase social interaction.

Previously described public spaces in several different literature studies were combined with the database of Centraal Bureau voor Statistiek (CBS), which resulted in a list of Dutch types of PGS (Noor et al., 2015; Pincetl, Gearin, 2005; CBS, 2020). A requirement of these spaces is that they have seating to accommodate there instead of only using it as a walkthrough. There are differences in size and accessibility for certain visitors, such as immobile persons and children within these types. Examples are shown in figure 3 and 4. PGS in the Netherlands encompass:

- Public green roofs
- Other public green spaces within a building
- Small park and large parks
- Forests
- Recreative spaces, including sport fields
- Semi-public and public greenery

Figure 3: Public green roof Rotterdam (Gemeente Rotterdam, 2019)

Figure 4: Kralingse Bos (City Rotterdam, 2018)

According to Jim and Chen (2010), the availability of neighbourhood parks, within a radius of 800m, has a positive impact of 14.93% on the apartment sale prices of high-rise buildings in Hongkong. Noor et al. (2015) estimate that the impact of availability of a park within a radius of 400m is between 3 and 12% of the housing price. In addition, their study has found a positive effect of 1.9% on the apartment price concerning the view on these parks. Jim and Chen (2010) included larger and smaller neighbourhood parks as they both contribute to an increasement in the quality of life. Parks of all sizes were therefore also included in this research.

Green roofs are also included in this research as Binti Shukri and Misni (2017) state that the main goal for creating a public roof is to create a pleasant view. It is expected that this has a positive influence on the housing price of high-rise buildings. These roofs can be private or public, where the private green roofs could have an influence of the view of high-rise residential buildings. Residents appreciate the view on green aspects, included green roofs. They can experience less stress by looking at a green view. Therefore, landlords and/or developers can ask a higher price for apartments with this type of views (Getter & Rowe, 2006).

Urban parks and other public open spaces are often part of urban planning (Pincetl, Gearin, 2005). The implementation of PGS in urban planning enhances integration of PGS with the rest of the city, but also complicates matters as more actors are involved. Each of these actors has a different interest in these spaces, which makes the function of the areas more complex. To fully understand the actors' interests and the complexity of the development of PGS, the effects of PGS are further elaborated. In addition, the national land policy regarding developments of PGS in the Netherlands is further elaborated on in section 2.3.

2.2.2 Public green space and liveability

The rapidly growing population leads to new development challenges for local and state governments all over the world. With new real estate developments, it is important to keep in mind that these developments should be environmentally beneficial for all residents (Leby, Hashim, 2010). Public utilities and green spaces have an important role in providing quality to the life of residents of high-rise buildings and other citizens, which relates closely to liveability. Therefore, this study puts the effects of PGS on the built environment and multiple actors into context by the term liveability to make the effects more tangible. An overview is given of the concept liveability.

Liveability definition

Liveability encompasses many elements on multiple scales which makes it a challenging term to define. Leby and Hashim (2010) state that liveability is an overarching term with a variety of meanings, depending on both the measurements and the perspective of these measurements. Liveability can be described as "a reflection of quality of life, wellbeing and/or the satisfaction of the needs of people" (De Haan et al., 2014, p. 123). O'Brien (in Li, Sun, Jones, 2012) defines that liveability is concerned with the quality of space and the built environment, regarding safety and functionality. Liveability is also defined as the aspect that concerns satisfaction of human needs in urban, communal, and environmentally context (Shaw et al., 2004). What stands out is that many literature studies define liveability in relation to the quality of life, wellbeing, and peoples' satisfaction.

In addition, different perspectives wherein liveability takes place are distinguished (Li et al., 2012; Skalicky & Čerpes, 2019). Regarding the context of high-rise residential buildings, this thesis tackles liveability within the urban environment. Li et al. (2012) call this residential environmental liveability, where liveability is defined by a building residents-centred evaluation. Skalicky & Čerpes (2019) define liveability from an urban environment as well but they interpret it from a residents' and citizens' perspective.

Taking the various definitions and perspectives into consideration, the thesis defined liveability as '*the quality of life and satisfaction of the residents and citizen in the urban environment'.*

Liveability domains

Since liveability is an overarching term for many aspects regarding the quality of life, it can influence this quality in different domains (Leby, Hashim, 2010; Li et al., 2012; Skalicky and Čerpes, 2019). Expressing liveability in domains helps to make a more comprehensive and measurable representation of liveability (Skalicky & Čerpes, 2019).

In accordance with the given liveability definition, Leby and Hashim (2010) distinguish four domains within liveability, which are: social, physical, functional and safety. A similar division of liveability domains is given by Skalicky and Čerpes (2019). These four domains are environmental, social, functional and cultural, which shows overlap with the domains Leby and Hashim (2010) identified. Skalicky and Čerpes (2019) combined the social with the safety domain, where Leby and Hashim (2010) stated them as separate domains. An explanation of these domains is given in table 1.

Table 1: Liveability domains based on the studies of Skalicky, Čerpes (2019) & Leby and Hashim (2010) and Hasselaar (2011) and the relation with PGS.

Domains	Explanation
Environmental	Quality of life, and thereby liveability, is partly determined by the quality of its environment. Therefore, it is crucial to achieve a high-quality residential environment where environmental impact of buildings is reduced, and renewable energy generation is maximized. In addition, the environmental domain contains the protection public´s health to ensure high quality living (Skalicky, Čerpes, 2019).
Social	Social interaction and intimacy increase the residential wellbeing of the environment, what affects liveability (Leby and Hashim, 2010). The interaction involves multiple social aspects such as the sense of belonging, enjoyment, comfort and safety.

Functional	The functional domain prevents users and residents from social and environmental isolation by facilities to location and communication systems and a wider social environment (Skalicky and Čerpes, 2019)
Cultural	The cultural domain affects the community's mindset and identity of the inhabitants. It also includes aspects of the attractiveness of the building and its environment (Skalicky and Čerpes, 2019).
Safety	Safety is seen as a basic need which results in a safe neighbourhood that affects the quality of life (Leby and Hashim, 2010).

Some overlap between the domains can be seen from their descriptions. Both Leby and Hashim (2010) and (Skalicky and Čerpes, 2019) use various variables to further determine the domains. A comparison of these variables is stated in table 2.

Table 2: Liveability domains, comparison of the studies of Skalicky, Čerpes (2019) and Leby and Hashim (2010)

Domains	Variables Leby and Hashim (2010)	Variables Skalicky and Čerpes (2019)
Environmental	Environmental quality, open spaces, maintenance of built environment	Compact and effective growth, protection of natural resources, waste and recycle management
Social	Behaviour of neighbours (nuisance), community life and social contacts, sense of place	Sense of belonging, sense of safety, sense of enjoyment and comfort,
Functional	Availability and proximity of amenities, accessibility, employment opportunities	Accessibility, integration into a wider urban structure, flexibility of residential environment
Cultural	-	Context and identity, human oriented environment, attractiveness, and readability
Safety	Number of crimes, number of accidents, feeling of safety	-

Leby and Hashim (2010) stated the social and safety dimensions separately, where Skalicky and Čerpes combined these two within the sociological dimension. Both studies have divided the domains into multiple variables to measure liveability. Leby and Hashim (2010) focused mostly on how the residents experienced the attributes and dimensions of liveability in their neighbourhood by doing a survey among residents. The results revealed that residents are most concerned about their safety. As the safety domain is experienced highly important, this thesis considers safety as a separate domain instead of combining it with the social domain.

Qu and Hasselaar (2011) describe certain liveability aspects in Dutch cities. These aspects focus mainly on the domain of social interaction on multiple levels. By increasing the individual responsibility of residents and urban citizens, higher liveability can be created which is also mentioned by Skalicky and Čerpes (2019). In addition, Qu and Hasselaar (2011) emphasize the functional domain as another important part to increase liveability in the Netherlands. This functional domain has resemblances with the criteria of Skalicky and Čerpes (2019), especially for the accessibility and integration to a wider urban structure. In addition, Leby and Hashim (2010) emphasise on the importance for developers to look at the preferences of residents since liveability of neighbourhoods is a crucial element in the welfare and

development of a city. The functional domain especially shows a crucial element for the welfare of the city.

PGS within the context of liveability variables

PGS is seen as an important instrument that influences liveability for both residents as citizen of urban neighbourhoods. To make the research for PGS more tangible, the effects of PGS and its aspects, can be assessed by the domains of liveability. An overview of which aspects of PGS influences these liveability domains shows the possible interest various actors have, such as the residents, citizen, municipality, and developers. As the general goal of Dutch municipalities is to create an attractive area for citizen, employees, and visitors, they benefit from improved liveability by PGS as well (Gemeente Eindhoven, 2020; Gemeente Den Haag, 2017; Gemeente Rotterdam, 2019; Gemeente Amsterdam, 2011). Section 4.3 elaborates further on which PGS variables there are and how they are put into the context of the liveability domains.

Functional variables of liveability presumably have the highest impact on the housing prices as multiple international studies on this topic found a strong positive correlation between the distance to PGS and the housing prices (Jim, Chen, 2010; Qu, Hasselaar, 2011; Yeh, Yuen, 2011; Noor et al, 2015). Noor et al. (2015) estimate that the impact of availability of a park within a radius of 400 meter is between 3-12% of the housing price. As for the social variables, Gifford (2007) mentioned that residents of high-rise buildings miss a certain level of social interaction with neighbours and other people. PGS could play an important role to increase this interaction. It is expected that Dutch residents will have this same desire for more social contacts. It is expected that the desire for social contacts and interaction will be reflected in the willingness to pay and thereby the housing price. This research has the variable view categorized as part of the cultural domain since it is part of the aesthetic experience. The view is expected to have a positive influence on the housing price as well, based on a similar study by Noor et al. (2015). Having a view on green spaces could lift the housing price by 2-6% (Jim, Chen, 2010; Noor et al., 2015).

The municipality of Rotterdam mapped many liveability aspects in one smart map, called the neighbourhood index. This index is divided into three variables: the physical, social and safety index. Figure 5 shows an overview of these indexes for Rotterdam. The colours are coded into a 5-scale rating, where 0 is the lowest and 5 the highest index score.

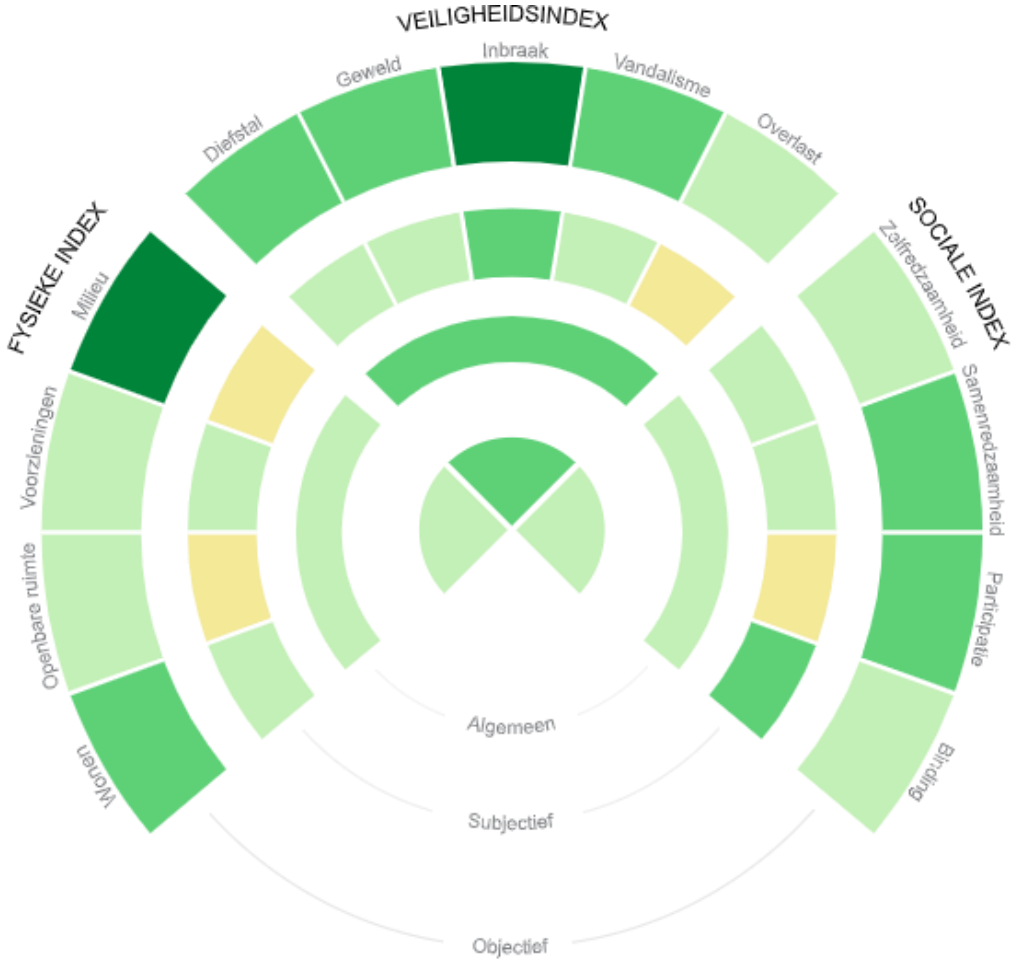


Figure 5: Physical, Safety and social index of Rotterdam (Gemeente Rotterdam, n.d.).

2.3 Financial arrangements for PGS

As stated before, the interest of municipalities and high-rise residential building developers in PGS relate to the financial arrangements of these projects. High quality PGS may be in everyone's best interest but come with a price. In the Netherlands, the municipality is in general responsible for these expenditures. Nevertheless, the Dutch municipality can recover costs from other actors by different approaches (Hobma, 2020). This thesis focusses on the cost recovery from developers of adjacent buildings. The current practice of financial arrangements in the Dutch context is discussed first, followed the approaches from foreign countries.

2.3.1 Current practice in the Netherlands

Development of PGS and other public facilities are established by the Dutch land policy which acts according to the spatial planning act, Wet Ruimtelijke Ordening (WRO), since 2008 (Buitelaar, Witte, 2011). The policy serves as a framework for the establishment of spatial land policies, regarding real estate, public space, infrastructure, greenery, and leisure (Smits, Deloitte, Ramp, Nab, Santing, 2013). The national government, provinces and especially the municipalities carry out this policy (Rijksoverheid, n.d.). Land policy is used as an instrument to succeed in spatial objectives to improve the built environment (Smits, et al., 2013). Two main types of land policies can be distinguished in the Netherlands: the active land policy and the facilitating land policy.

In an active land policy, the municipality takes on an active role and steps forward during area development. Often, the municipality is already owner of the raw land, although, it can also acquire land. This active land policy helps to give other actors more clarity by formulating the objectives for the developing area, this helps to be more involved in the project and overall contributes to better progress. Other actors can collaborate about choosing the location and creating a successful relationship with all involved parties. The municipality actively supports the area development by contributing to the market parties (Smits, et al., 2013). Land that is ready for construction will eventually be put on the market as land lots (De Kam, 2007). Costs made by the municipality will be calculated in the price of land allocation (Smits, et al., 2013). In conjunction with creating more clarity and trust between actors by an active land policy, the active land policy is used by the municipality to financially benefit from the added value of the developed land. Development of public investments on the land could increase the WOZ value of buildings in the surroundings. The municipality is owner of land destined for public space, including PGS. Thereby, the active land policy is the most used policy to develop or improve public spaces. Financial arrangements to recover costs for developments in this type of policy is hard as land with public space functions will not be allocated to private actors.

In a facilitating land policy, also known as passive land policy, the municipality does not take initiative regarding land procedures. Private parties will carry the risks during most of the phases of land development. The main role of the municipality in this approach is setting boundaries for the development. This policy is often used when the municipality has little to no property rights (Gemeente Rotterdam, 2018). This method is mostly used for developments of high-rise buildings in the municipality of Rotterdam as most of the land, other than public space, is not owned by the municipality. The costs made by the municipality needed for development of the land are mostly recovered by developers.

The main difference between these two types is the risk-distribution between the municipalities and private parties. In general, the party that carries out the risks has the most opportunity to financially benefit from this type of land policy. The higher the risk, the higher the benefit. To benefit most from this risk distribution, hybrid forms of these two types emerged over the years such as Public Private Partnerships (PPS, in Dutch PPS) (Smits, et al. 2013).

If the parties do not come to an agreement, cost recovery and location decisions can be made by a public law exploitation plan. The exploitation plan offers legal certainty regarding the nature and the amount of the contribution paid by the developer. This plan needs to be formulated simultaneously with the zoning plan. The exploitation plan contains requirements regarding site preparation, utilities and public facilities. It includes an estimation of the costs and benefits for the development (Smits, et al., 2013).

In practice, it seems to be more complex to point out who is responsible for financing the development and maintenance for PGS. If users and property owners benefit from the added value of the public space as well, other options to ask financial contribution can be investigated. Therefore, land value capture could be used to generate public benefit from public action (Wen, Goodman, 2013). This term, however, is not used that often in the Netherlands. The Dutch financial arrangements to finance public facilities correspond to the definition of value capture. Section 2.3.2 gives a more in-depth overview of land value capture.

Dutch municipalities have four negotiation options available regarding the cost recovery from developers or property owners. These are land allocation (grond uit te geven), anterior agreements (anterieure overeenkomst), exploitation plan and betterment levies (baatbelasting) (Hobma, 2020).

Figure 6 gives an overview of the cost recovery instruments. A further explanation of these instruments is given in appendix M.

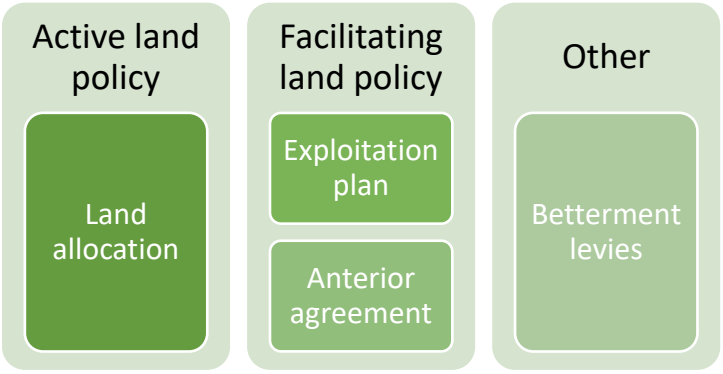


Figure 6: land policy instruments for cost recovery in the Netherlands (own image, based on Hobma, 2020 and Smits et al., 2013)

Besides the PGS variables that are connected to liveability, the financial arrangements of PGS might have an indirect influence on the housing price as well. Public facilities such as PGS are important aspects for urban development areas as residents give a certain value to these spaces. They could get attached to certain PGS and want their favourite park to be well-maintained. The quality and maintenance of PGS are costly. If there is not enough money, these spaces could lose their quality. Greenery that once had certain memories for residents is removed due to deferred maintenance. Their so beloved park could lose its value for the residents which makes it a less attractive area to live nearby. To prevent this, the municipality can use multiple financial arrangements to recover costs from developers and make high-quality and maintenance feasible. The more money can be recovered by actors such as developers, the more money can be collected to build feasible high-quality PGS.

2.3.2 Examples from other countries

Land value is defined as the value of the property including both the land value itself as well as the improvements that have been made (Wen, Goodman, 2013). The relationship between land value and housing prices is considered important for promoting the healthy development of the real estate market (Wen, Goodman, 2013).

Due to the growing population, there is a growing need for public improvements as more and more people use public facilities. Public improvements to PGS are financed by the municipality and the government in The Netherlands, as stated in section 2.3.1. However, high costs could cause problems in the feasibility of these projects (Hobma, 2020). To finance these facilities, land value capture can be used. Land value capture is a public financing approach that allows parties to recover and reinvest land value increases that are generated through public investments (Germán, Bernstein, 2018). The basis of land value capture consists of generating public benefit by public action (Suzuki, Murakami, Hong, 2015). This research will not go further into detail about the LVC as its only focusses on the current policies of The Netherland. More background information regarding different LVC methods can be found in Appendix K.

In the future, The Netherlands can improve its land value capture procedures by studying the procedures of foreign countries with successful land value capture. For the feasibility of this thesis, only the Dutch existing financial arrangement regarding cost recovery for PGS are taken into consideration.

2.4 Determination of high-rise housing prices in The Netherlands

2.4.1 Definition housing price

Seen from a quantitative perspective, the housing price is the price that the buyer is willing to pay for owner-occupied dwellings and monthly rent for renter-occupied dwellings (Kain, Quigley, 1970). This is identified as the price that the dwelling is put off the market, the transaction price. The price that the dwelling is put on the market is seen as the listed price. In a perfect housing market, there is an equilibrium between these prices. However, due to a disbalance in the demand and supply side, there is a disbalance between these two prices caused by the housing shortage, outbidding and the time that the dwelling was on the market.

This research focusses on owner occupied listed prices of newly built high-rise apartments. In contrast to the outbidding on listed prices of existing apartments, people pay the listed price for newly build apartments without outbidding. This makes the listed price of newly build apartments more suitable for this research as these prices are better to compare. The price is the gross prices as it is listed in the advertisement. It represents the amount of money people are willing to pay for specific apartments seen from the developer's perspective. Compared to the real estate market of other segments in Dutch cities, the apartment prices of high-rise buildings lie within the mid to high segment.

The listed price is often expressed in the VON-price (Vrij Op Naam) or K.K. price (Kosten Koper). The VON-price includes the costs that the seller has to take for his own account. This includes the transfer tax, cadastral costs, and notary fees. In contrast to the VON-price, the buyer is accountable for the transfer tax and the notary fees (Hypotheker, n.d.). VON-prices are generally used for the listed prices of newly built apartments. Therefore, this research only uses VON-prices.

Visser et al. (2006) discussed three different types of housing prices to access the relation between the building and environmental variables and the housing price. The first approach is to use the WOZ-value (WOZ-waarde). The WOZ-value reflects the market value of a property, through a valuation of similar properties in the neighborhood. This led to the disadvantage that the WOZ-value is not equal to the current market value. The second approach is to use an estimated value of the property, estimated by real estate agents and/or a home appraiser. Its main disadvantage is that these estimations can deviate considerably from reality which can give a biased outcome. The third approach is to use the transaction price, defined as the actual price that both the buyer and seller has approved on in exchange for the property (Visser et al. 2006). This reflects the value of a property and its surroundings, which is established under certain market conditions. Visser et al. (2006) consider this the best suitable approach as the actual transaction price reflects the value of the property and its surrounding that the buyer is willing to pay for. In general, the transaction price meets the listed price of newly built properties. The listed price is the suggested value for which a property is put for sale on the market. Data access for these prices are easier to collect for newly developed high-rise buildings than the actual transaction price for existing dwellings. That is why this research uses the data from listed prices of newly built high-rise apartments.

2.4.1 Determination housing price

The housing price depends on many factors such as the land value and variables of the building and its environment (Hill, 2013; Wen, Goodman, 2013).

The structure of the housing price of a dwelling reflects the desires a buyer is willing to pay for. The structure represents many diverse variables of the building and its environment. Many studies have done research to these variables. The study of Kolbe and Wustemann (2014) have divided these variables by structural, location and environmental variables. Within these variables, there are multiple

variables. Visser, Van Dam and Noorman (2006) have defined similar variables regarding the physical building, the physical environment, the social-cultural and social-economic environment, and the functional environment. The variables of the variables in both studies are formulated in table 3. For this research combined the identified variables of Kolbe and Wustemann (2014) and Visser et al. (2006) to give a comprehensive overview of the variables.

Regarding high-rise residential apartments, the structural building variables are further divided into building level and unit level. The property level represents all the variables of the dwelling itself. The building level variables are the same for all the apartments of the same building.

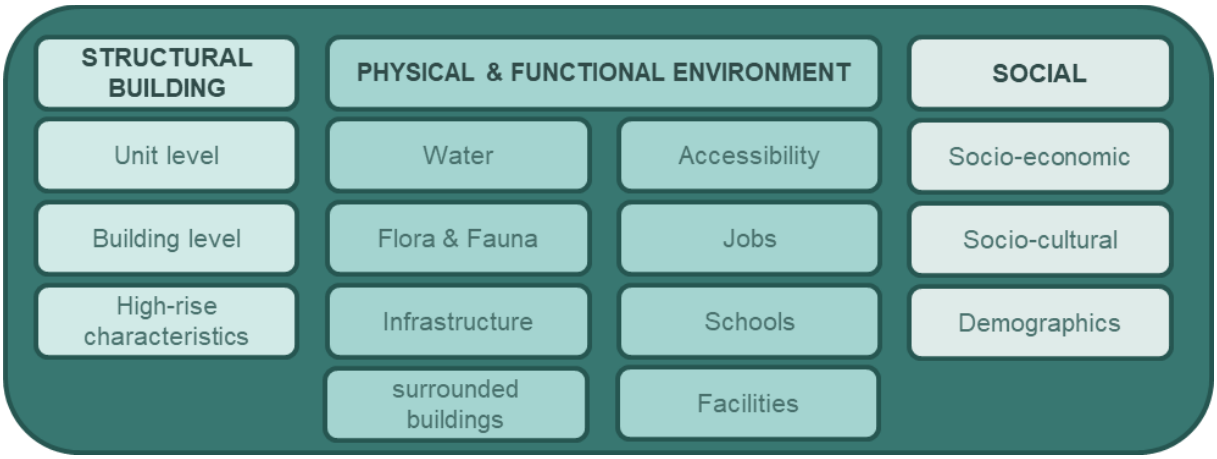


Figure 7: Variables that determines the housing price (own table)

However, these studies do not focus on high-rise residential buildings that contain other variables which can influence the housing price such as vertical premiums, the view, and the floor levels (Wong et al., 2011). This research will include these variables in the research methodology. Jim and Chen (2010) state that view variables for each individual apartment affects the housing price. Their study shows that neighborhood parks influence the housing price by the distance and the view factors that the studied apartments have. Another study of high-rise buildings shows two other variables that influences the housing price (Wong et al., 2011). These are the floor level and building height. Floor level is defined as the vertical location of an apartment in a multi-story building. The added value to the housing price is described as the vertical height premium. The other variable is the building height which represents the vertical distance between the ground level and the roof (Wong et al., 2011). Figure 7 shows the high-rise variables that are found by the literature study. These variables will be implemented in the research methodology.

2.5 Conclusion

A definition of high-rise residential buildings for the Netherlands is given. In addition, the aspects and definition of PGS is identified which shows that it is connected to the liveability of residents. Literature shows that PGS are highly connected to the identified liveability domains. These domains will be used for further research about the PGS variables. Even though these variables are found by an extensive literature research, the actual PGS variables could differ per country due to cultural and demographic differences. This research will further explore and compare the important PGS variables of each domain for the Dutch context later in chapter 3 and 4.

Another PGS variable is the financial arrangement of their development between municipalities and developers. The municipality can use various sorts and structures within the Dutch land policy to recover costs from developers. Literature shows that the most suitable approach for the development of PGS is the active land policy as most of the public land is owned by the municipality. Comparing the financial

arrangements with the results of the housing price could lead to new findings regarding funding approaches. This will be further investigated in chapter 3 and 4.

2.6 Goals and objectives

By researching the link between PGS and the housing price of high-rise residential buildings in Rotterdam, the main objective is to contribute to the knowledge of high-rise buildings and the relation to its surroundings in the city of Rotterdam. Therefore, the research creates a method to measure the impact of PGS on the residential housing price. For this, a comprehensive view of factors that relate to PGS which residents find important is made. This research is a start to take all the factors into account and make the value of PGS quantifiable. Therefore, stronger during arguments of developments (e.g. consideration in location decision of high-rise building and/or PGS). This led to new insights that can be a useful new insight for developers whether to invest in certain measurements for liveability that are related to PGS. Additionally, another objective is to assess the current funding approaches for public green spaces and relate them to the housing prices of residential high-rise buildings. Hereby, a beginning is made to review the current funding approaches of public facilities in The Netherlands.

2.7 Deliverables

The deliverables are discussed in the same order as the research method is performed. The main deliverable of this research is to approach the relation between the PGS aspects and the housing price by a mainly quantitative approach. Aspects of the relation that could not be quantified are further verified by a qualitative approach. To find this relation, the concepts and variables needed for this research are investigated first by the literature study and survey.

2.8 research approach

Figure 8 shows the conceptual framework of the research which illustrates the main concepts needed to answer the research questions. The main research tackles the influence of PGS on the housing price of high-rise residential buildings. There is a potential value of PGS reviewed by residents which can be measured by how much residents are willing to pay for certain spaces, expressed in the housing price (Jim, Chen, 2010). The deliverables of the literature study on PGS showed multiple aspects that have influence on PGS and thereby could indirectly influence the housing price. These aspects concern qualitative and quantitative variables, such as the attractiveness of a PGS and the accessibility to it. The PGS domains lie within these variables. Another aspect of PGS is the financial arrangement of PGS that concerns the municipality and high-rise building developers. The financial arrangements have a certain influence on the quality of PGS and its maintenance, which indirectly influences the high-rise housing price. The conceptual framework lies within the scope of the city Rotterdam.

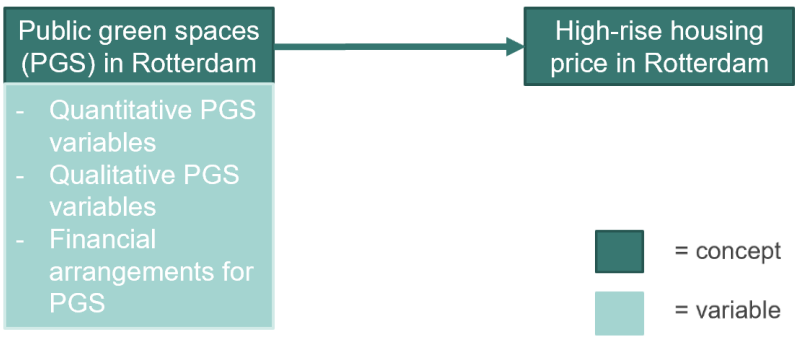


Figure 8: Conceptual framework of PGS and the housing price (own figure)

3. Research Method

This chapter discusses the methodology applied in this research. To find a comprehensive answer to the main research question, multiple methodologies and analyzes are applied. Section 3.1 discusses the hypothesis that is formulated to test the main research question of the research. Thereafter, the conceptual framework is explained, followed by the various methodologies. Section 3.4 discusses the sequence of the research method used for this research. Finally, 3.5 discusses how the data is collected and analyzed. Appendix B contains an overview of the concepts, variables and their matching research methods.

3.1 Hypothesis

The conceptual framework in figure 8 illustrates the two concepts, PGS and the housing price of high-rise building in Rotterdam, that are investigated in this research by the research question "To what extent have PGS a determinant effect on the housing price of high-rise buildings in Dutch cities?". This question is mainly reviewed by a quantitative approach. Therefore, a hypothesis is formulated to prove or disapprove the assumption that PGS influence the housing price. The following hypothesis is formulated*: PGS have a positive determinant effect on the housing prices of high-rise buildings in Dutch cities.* This hypothesis is tested for the various variables of PGS. Multiple PGS variables are researched in relation to the housing price of high-rise buildings which are divided into the different liveability domains: functional, social, environmental, cultural and safety. Based on the literature study in section 2.2, it is expected that most of the variables of these domains will have a positive determinant effect on the housing price of high-rise buildings. Therefore, the overall hypothesis is that PGS will have a determinant effect on the housing price of high-rise buildings in Dutch cities. The extent of the (positive) effect may, however, differ for each variable.

The hypothesis focusses on the variables of PGS. The literature study shows that the housing price is based on building and other environment perspectives as well. Therefore, the housing price and building variables are included in the research as well to put the influence of PGS into perspective. Based on the international literature study stated in chapter 2, the housing price is a combination of multiple dimensions. A deeper exploration is performed to test the hypothesis by looking at possible variables that affect the housing price. A more encompassing answer is given by also focusing on variables that are not only related to PGS. These environmental and building variables lie within the scope of the city Rotterdam and high-rise residential buildings. Building variables that influence the housing price are the view, building year, apartment size and floor level (Hill, 2013; Wong, Chau, Yau, Cheung, 2011). Figure 7 illustrates the building variables that are taken into consideration in the research. Especially the building variables have the largest influence on the housing price (Jim, Chen, 2010). The high-rise building variables such as floor height are included as well.

The following sections of chapter 3 discuss the approach and methodology to test the hypothesis. These sections explain that the formulated hypothesis cannot entirely be tested by the quantitative approach.

3.2 Type of study: empirical research

An empirical research is performed to collect all the necessary data to answer the research questions, as the hypothesis is tested against results that are based on real life data. The relation between PGS and high-rise housing prices is investigated by a correlation study to clarify the impact of PGS on the housing price. As this relation is investigated by the willingness to pay, more knowledge is acquired about the desires of the residents of high-rise buildings regarding PGS.

The data collection consists of both quantitative primary and secondary data. Regarding secondary data, existing datasets of residential high-rise buildings are analysed that contain VON-prices and information

regarding the apartment and its surroundings. Both a quantitative and qualitative research is performed to collect the data. The main reason for choosing a quantitative research is to express the value of PGS in numbers. This helps to make investment decisions made by municipalities, developers, urban designers, and policy makers more tangible. Aspects, such as parking and sustainable measurement, are already expressed in numbers. Expressing PGS in number makes it more compatible to compare it with the other aspects (Blaikie, Priest, 2019). The quantitative research tests the formulated hypothesis. Quantitative research methods aim for a more scientific objective result as a large amount of data is collected and statistically analysed.

Measuring the impact of PGS on high-rise residential prices is complex and not only covered by a correlative quantitative research. Some indirect qualitative aspects of PGS are difficult to place in a quantitative research. An example of this are the social effects of PGS such as the sense of belonging. Therefore, an explorative qualitative research is conducted as well as an enrichment on the quantitative results.

3.3 Research methods: from literature study to semi-structured interviews

Various research methods are assessed to answer the research questions. Table 4 gives an overview of the research methods, data collection and data analysis to answer the research questions. The sequence of the research methods is shown in figure 9. These methods are further explained.

Figure 9: Research method sequence (own figure)

First, an international literature study is established to gather information regarding the concepts discussed in chapter 2. The literature study is used as basis for the answers the concepts of all three sub-questions. The international literature study in chapter 2 gives a broad view on the aspects of PGS, such as its variables and financial arrangements. However, the problem statement in 1.1 discussed contextual differences that could lead to other variables that are found to be important by residents.

Another study is therefore conducted to compare the international literature study to the PGS variables that are important for Dutch residents and municipalities. This smaller, comparative study is performed by two methods where the results of both methods are compared to the international literature study. The first method is observing PGS variables by analysing the Dutch municipal high-rise vision documents. The second method is conducting a survey among Dutch residents to explore if the variables and domains of PGS found in literature are similar to what Dutch residents find most important. As PGS have a very wide range of possible variables that may have a relationship to the housing price, it is possible that this survey identifies new variables that have not been discussed in the international literature study. It is expected that residents of high-rise buildings have slightly different needs regarding the aspects of public green space areas. The survey is only used as a modest explorative study to look for possible deviations from the completed literature study, to give the most comprehensive answer to the research question as possible. The results of the literature study are leading as where the results of the

survey may only lead to a supplement to the literature study. The comparative literature provides mainly the answer for sub-question 2.

After the literature study and survey, a correlation study is primarily assessed by a quantitative statistical method to measure the impact of PGS and the housing price of high-rise buildings. This method is used as the effect of PGS on the housing price of high-rise buildings is measured by data collected from existing residential high-rise buildings in Rotterdam. The city of Rotterdam can be seen as chosen case study wherein multiple samples buildings are chosen for the study. Section 3.4 discusses the data collection needed for this research method. This quantitative method is used to find the determinant effect of PGS on the housing price of high-rise buildings which is part of the main research question.

After the quantitative statistical method, the qualitative research can be seen as an addition and exploration to the quantitative research. Semi-structured interviews with experts are used as qualitative research method to further investigate the effect of PGS variables on the housing price of high-rise buildings. Interviewees that have a certain expertise on PGS in relation to high-rise housing in Rotterdam could add new insights to the variables of PGS that are harder to measure by the quantitative approach. In addition to the quantitative results, it helps to better understand the founded correlations between PGS and the housing price of high-rise buildings. This method helps to fully answers the sub-questions and thereby the main research question. It validates the outcomes of the quantitative research by comparing it with the experience from the practice. By interviewing experts of high-rise buildings and urban development, the results found by the academic research can be validated by practice. In addition, the validation of the quantitative research technique is discussed in the interviews.

A semi-structured interview is mainly chosen as the number of interviewees is small cause it gives the interviewer the possibility to deviate from the interview. The opportunity to be flexible is necessary in a small, scaled interview research.

Selection interviewees

The interviewees are selected based on several criteria:

- The combined results of all interviews should cover the perspectives of all three actors discussed in this research, namely the residents, high-rise developers, and municipality.
- As the sample units are collected from one city, the expertise of the interviewees should be focused on the same city.
- The expertise of the high-rise developers should focus on recently developed high-rise buildings as the research focusses on recently developed high-rise buildings.
- The interviewee of the municipality should be from the same city as the selected city for this research.

Possible interviewees were selected by contacting the urban development department of the municipality of Rotterdam, developers from the selected high-rise buildings and Stichting Hoogbouw. Stichting Hoogbouw collects the expertise of multiple firms and people that are related to the development of high-rise buildings in the Netherlands (Stichting Hoogbouw, n.d.).

Table 3 shows an overview of the conducted interviews and the discussed themes. As the interviews are used as addition and exploration to the quantitative research, there was not a strict minimum number of respondents needed.

Table 3: Overview interviews (own table)

Interviewee	Area of expertise	Themes
A) Former director Stichting Hoogbouw & high-rise resident	High-rise buildings, both national and international High-rise resident	PGS: views, availability, improvements, connection. Arrangements between municipality and high-rise developers, high-rise development in foreign countries
B) Developer of AM	Developments in Rotterdam, including residential high-rsie	PGS: view, availability, How PGS is calculated in price, research method, arrangements between municipality and high-rise developers
C) Developer of BPD	Developments in Rotterdam, including residential high-rsie	PGS: interaction, liveability, quality. Financial arrangements, improvements of financial arrangements, lessons learned from foreign countries, determination of housing price
D) Municipal urban developer	Urban development of Rotterdam, expert in development of public space	PGS: importance over the years, Financial arrangements, improvements of financial arrangements Urban development strategies

Appendix D shows the full overview of the research method, including the variables of the concepts that were excluded from the research given the timeframe and the broadness of these variables. An overview thereof is given in table 4.

Table 4: operationalization table of the research study

Sub-questions	Concepts	Variables	Data collection & analysis	Source of information
1. Why are public green spaces of importance for residents, municipalities, and developers? (Taking financial relation into consideration < housing price)	-Public green spaces (PGS) - Liveability - Environmental, social, functional, cultural and safety domain	- Environmental: Air quality, noise disturbance, heath effect - Social: Interaction with others in PGS, - Functional: distance to PGS, accessibility to PGS - Cultural: View from and on PGS, - Safety: Feeling save in and around PGS	Literature study, interviews	High-rise vision documents municipality; Google Scholar, Scopus Primary qualitative data
2. What factors of PGS could influence the housing price of high-rise buildings in Dutch cities?	- Housing price - Indirect and direct factors subtracted from the liveability variables - Financial arrangements made by municipality and developers during development	- Transaction price - List PGS variables that lead to indirect effect - List PGS variables that lead to direct effect - Contribution developers via exploitation plan - Contribution developers via anterior agreement	Literature study, survey, comparative literature study, interview experts (developers and municipalities)	Literature review on RQ1, Google Scholar, developer, municipal employee

3. How is the housing price of residential high-rise buildings in Dutch cities determined?	Variables: Structural building; Social environment; Physical environment; Functional environment; + Financial arrangements of PGS + Literature hedonic pricing and other methods	- Transaction price - List of variables concerning these variables - Including list of PGS variables (indirect, direct and contribution developers via anterior agreement of exploitation plan)	Literature study, interview experts	Primary data obtained from: Documentation RQ1 and 2, Google Scholar, Real estate agents (NVM-makelaars),
Main RQ: To what extent have public green spaces (PGS) a determinant effect on the housing price of high-rise buildings in Dutch cities?	- Housing price - effects of PGS - Other effects (obtained from RQ3)	- Transaction price (unit price/m2) - Quantifying the variables from RQ3	Statistical method by case studies via Hedonic Pricing Method for selected buildings, Interview experts	Primary data of 9 chosen high-rise towers, extracted from real estate agents, developers, high-rise experts, ArcGIS, Google Maps, Google Earth Secondary data of VON-prices, extracted from real estate brokers

3.4 Data collection

The various research methods lead to different sorts of data collection. First, multiple data sources are used to collect the data regarding the concepts of the literature study, such as Google Scholar and high-rise vision documents of Dutch municipalities. Data on the explorative survey is collected among residents of urban Dutch cities. To have a big enough catchment area, the survey is conducted among residents of all types of housing. A Google format is used as tool to perform the survey, shown in appendix G. The literature for the Dutch context is found in municipal high-rise vision documents of the four largest cities of The Netherlands.

Data collection for the quantitative research is found by multiple sources. Most information regarding de buildings and apartments variables are provided by the real estate brokers and the developers responsible for the high-rise buildings. Information regarding PGS adjacent to the selected high-rise buildings is mostly found by ArcGis, Google Maps and the websites of the high-rise towers.

During the data collection, it became clear that some variables are less suitable to include in a quantitative research. Some of the variables are hard to express in numerical or ordinal numbers which is required for the statistical quantitative research. Some variables are too time consuming to collect all their data necessary. An example are the variables to express attractiveness of a PGS. The data of financial arrangements of PGS are not put into the quantitative research as it is expected to have an indirect relation to the housing price which is expected not to show results in the statistical model. Data for financial arrangements is collected via the semi-structured interviews and Google Scholar.

Interviews with experts collected data for financial arrangements of PGS and variables of PGS that are harder to quantify. In addition, it collected information to understand and verify the outcomes of the quantitative research. The expertise lies within the field of the development of high-rise buildings and PGS. It is desired to record the interviews to be completely focused on the conversation. This is also beneficial for the data analysis, to have the opportunity to listen to the whole interview once more. In addition, it is a useful tool to easily transcribe (part of) the interview. When interested in the recording or the transcriptions, this can be requested. The interview protocol is sent to each interviewee beforehand. The protocol can be found in appendix H. For each interview, the set-up might change a bit due to the differences between interviewers.

Method of unit sampling

An understanding of the relation between PGS and housing prices is analyzed in real-life context by selecting existing cases of high-rise buildings and PGS. The data needed for the data analysis is collected by unit sampling, which is executed via multiple steps, shown in figure 10. First, the city is selected. Choosing only one city makes the study more unambiguous as the regional factors will be comparable. This makes the number of variables included in the regression model less complex. The selected city should have enough residential high-rise buildings to collect enough data for the research.

Afterwards, residential high-rise buildings of that city are chosen to conduct various variables of them, included the VON-price. The definition of a high-rise residential building for this thesis is described as a tower of at least 70m, which is used as criteria for the building selection. Many researchers agree that there should be at least 10 observation per variables. As this research uses approximately 30 variables, there should be at least a sample size of 300. This means that the selected buildings must contain at least 300 apartments.

PSG is selected by visualizing all green spaces situated in the selected city, shown in appendix I. Regarding the feasibility of the study, not all PGS near the selected buildings can be put as separate variable in the research. A distinction is made between the smaller parks and the signature parks. The selection for the signature parks is based on the lists of most popular parks stated by the municipality of Rotterdam (Gemeente Rotterdam, n.d.).

Consequently, the selected PGS variables are divided by the 5 domains found in section 2.2. There are two types of PGS variables identified: 1) variables that can be easily measured or categorized and 2) Other variables, such as attractiveness of the PGS, that are harder to measure. The relation between housing prices and variables that are (partly) excluded from the regression model, are investigated by the interviews with experts.

Many PGS variables are observed via multi-media resources, such as Google Maps, Google Earth and the websites of the selected high-rise buildings that contain video-walkthroughs that also show the multiple views of the apartments.

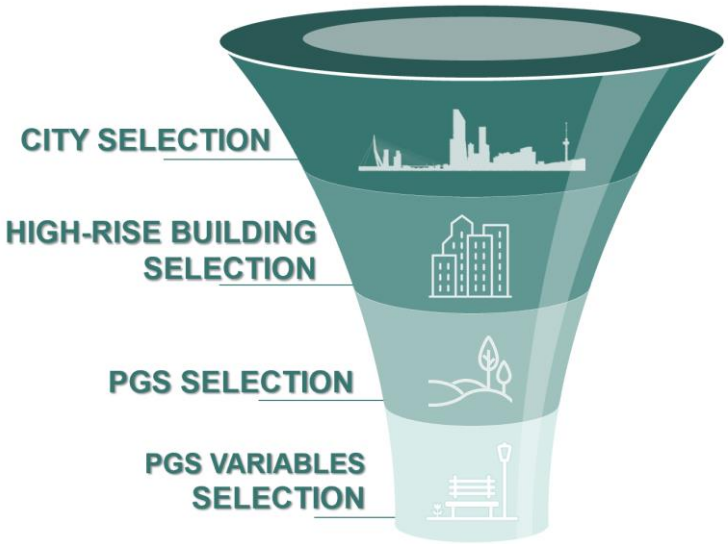


Figure 10: unit sampling sequence to collect data needed for the data analysis (own figure).

3.5 Data analysis

The collected data is further analyzed to test the hypothesis. As multiple methods and collection techniques are used, the data analysis consist of multiple techniques as well, shown in table 4 for each research method.

The most suitable analyzing technique for the data of the quantitative statistical research method is searched. This is done by a comparison between various data analyzing techniques that are most used in similar studies that investigate variables that have a determinant effect on the housing price, shown in table 5. A regression analysis estimates the relationship between a dependent variable and independent variables, by a quantitative approach (de Haan & Diewert, 2013, p.50). A contingent valuation method, performed by a survey, estimates the value that people put on a good by asking their willingness to pay to obtain the good.

Table 5: comparison between data collection techniques (own table)

Data analyzing techniques	Advantages	Disadvantages	Source
Regression analysis (Hedonic pricing method)	- Objective results - Frequently used method for similar research	- Large amount of data needed (reduced by choosing similar locations) - Some more indirect effects of PGS are harder to measure in	Kolbe & Wüstemann, (2014); Visser et al. (2006)
Analyzing interview experts	- A large data set is not needed	- Questionable level of certainty for large research	Visser et al. (2006)
Contingent valuation method (by a survey)	- No additional requirements for the existing data - Collect specific data on variables	- Low level of certainty since it is based on hypothetical transaction	Visser et al. (2006); Jim, Chen (2011)

3.5.1 Hedonic pricing method

Based on table 5, a regression analysis is used for the quantitative statistical research method. This analysis is a reliable method to identify multiple variables that have an impact on another dependable variable. The dependable variable in this research is the housing price of high-rise buildings in Rotterdam, expressed as the VON-price. The independent variables of the research are the variables of PGS, the building and its surroundings. This the most suitable approach to test the hypothesis as it could include many of these variables.

For this research, the hedonic pricing model (HPM) is applied as regression model, founded by Rosen in 1974. In the context of the housing market, a HPM can be used as a regression analysis to express house prices as a function of a vector of multiple variables (Noor et al., 2015; Hill, 2013). This research takes the form of a multiple regression analysis. With a multiple regression analysis, the (linear) relationship can be seen between multiple independent variables X and the dependent variable P (Kolbe, Wustemann, 2014). The housing price is dependent variable P in the research. The simplest form of the HPM for this research can be expressed as (Jim, Chen, 2010):

$$P = f\ (x_1, x_2, \dots, x_n)$$

This formula shows that the price is a function of the multiple independent X variables that are included in the regression model. The X variables can be grouped into the variables that have a determinant

effect on the housing price. These are the variables found in section 2.4 and the PGS variables found in section 4.2.

The basic form of a HPM can be written in a single regression analysis. In this form, one dependable variable is measured against only one independent variable.

$$P = \beta_0 + \beta_1 * S_1 \dots S_k + \varepsilon$$

P = housing price, the dependent variable
β_0 = the intersection with the y-axis
β_1 = regression coefficient, represents the influence of the relevant independent variable on the dependent variable P
$S_{1..k}$ = Value of the independent variable
ε = Standard error term.

The regression model is done by use of a data analyzing statistical program, called R. R is an analytic tool used for analyzing statistical data. The hedonic pricing model (HPM) is the chosen regression model and further analyzed in section 4.3.

Validity

The validity of the regression model is examined by comparing the results of the coefficients with theories found in the literature study. Multiple similar studies from other countries provided information about the effect of green spaces, parks, or other types of green on the housing price. Although these studies are slightly different to the context of this research, it can be roughly used to check the accuracy of the results of the model. Additionally, the results are discussed during the interviews which compares the results to the experience of the experts. Validity of the quantitative results within the regression model is performed by including control variables of the structural building and environmental variables of the selected buildings. Additionally, several tests are performed to indicate possible biased outcomes due to insignificant results, multicollinearity, or heteroscedasticity.

Variables

The multiple regression analysis is an extension of the single linear regression. It is important to make a comprehensive selection of the included independent variables. Variables that are expected to have influence on the housing price should be included to provide valid outcomes. Therefore, the variables of the building its environment that could influence the relation between PGS and the housing price are included as well.

The dataset used for the regression analysis contains apartments of multiple high-rise buildings. The apartments within one building can differ from each other in VON-price as there are differences between the apartments, floor levels and other conditions such as orientation. Other environmental and social differences could occur between the various buildings. When using the regression model, it is important to include in the model the features that have been assumed that will influence the buyers purchasing behaviour (Visser et al., 2006). Yet, it is inevitable to omit all independent variables that have impact on the housing price due to the timeframe and the accessibility to data within this research. In practice, omitted variable bias will always be present but it is important to keep it as low as possible (De Haan & Diewert, 2013, pp. 50-53). To diminish this bias, the study selected only one city. The selected buildings in this city have all somewhat the same location and demographics. It is therefore assumed that some demographic, social and environmental variables that are not included in this research will not have a large determinant effect on the results of the regression model. The selection of included and excluded variables for the sampling of the data further discussed in section 4.1.

The HPM can suffer from a distorted picture if too many important variables are omitted (Hill, et al., 2013). Too many variables can also distort the results if independent variables are mutually related. This is called multicollinearity which can occur when there are redundant variables included in the model.

Section 2.5.1 discussed the structural building, environmental and social variables that could influence the housing price. The PGS variables contain multiple variables that can be seen as environmental variables. Nevertheless, the effects of PGS variables are stated as a separated variable in the regression analysis to keep the focus on PGS. These PGS variables are further divided into the five domains, further elaborated in section 4.2.1. The multiple regression analysis expresses the structural building variables as S, the environmental variables as N, the social variables as T and the PGS variables as Z. This gives the following formula.

$$P = \beta_0 + \beta_1 * S_a \dots S_k + \beta_2 * N_a \dots N_{k+} \beta_n * T_a \dots T_n + {}_+ \beta_4 * Z_a \dots Z_n + \varepsilon$$

The HPM assumes that there is equilibrium in the housing market. In reality, there is not a desired supply available for every household at the desired place and at the desired time. In the housing pricing research, it is however not uncommon to assume that the housing market is in balance when the research comprises a clear geographic area and time period (Visser et al., 2006). The research selected high-rise buildings with delivery dates between 2016 and 2023 to diminish the time variables. Besides different time periods, inflation is a factor that is considered. Inflation can be corrected by adjusting a price index on the transaction prices of the houses. The inflation effect on VON-prices throughout the years is adjusted by multiplying this price with the Consumer Price Index (CPI). The CPI score correlates with the date the property was put on the market (CBS, 2021). Section 3.5.3 explains further how the negative effects of time related and contextual differences are diminished in this research.

Table 6 shows the various variables that are included in this HPM with their description. A distinction is made between the structural building, environmental, social and PGS variables.

Table 6: descriptive statistics for quantitative variables (own table).

Variable	Variable	Description	Min.	Max.	Mean	Stand. deviation
Housing price						
Log(VONPriceINDEXED)	Dependent variable	VON-price of selected apartments, adjusted with CPI index	12.06	14.89	13.12	12.42
Structural variables						
FLOOR	Independent	Floor level of the apartments	0.00	50.00	14.27	10.89
Log(AREA)	Independent	Total floor area of the apartment (m²)	3.664	6.043	4.527	3.635
Log(AreaOutdoor)	Independent	Date and quarter of the start of the construction	0.000	5.513	2.639	3.016
nRooms	Independent	Number of rooms per apartment	1.000	6.000	3.021	0.784
nBedrooms	Independent	Number of bedrooms per apartment	0.000	5.000	1.957	0.744
nBathrooms	Independent	Number of bathrooms per apartment	1.000	3.000	1.103	0.308
nToilets	Independent	Number of toilets per apartment	1.000	4.000	1.424	0.583
RegQuarterstart	Independent	Relative quarterly year that construction of the high-rise has started, expressed in months	-11.000	3.000	0.6805	4.379
Regquarterdelivery		Relative quarterly year that construction of the high-rise is delivered, expressed in month	-5.00	16.00	11.99	3.345
Orientation N (0,1)	Reference dummy variable		0	1	0.076	NA
OrientationNO (0,1)	Dummy variable	Sun orientation NO	0	1	0.14	0.345
OrientationNW	Dummy variable	Sun orientation NW	0	1	0.151	0.358

OrientationO	Dummy variable	Sun orientation O	0	1	0.127	0.333
OrientationZO	Dummy variable	Sun orientation ZO	0	1	0.141	0.348
OrientationZ	Dummy variable	Sun orientation Z	0	1	0.147	0.353
OrientationZW	Dummy variable	Sun orientation ZW	0	1	0.128	0.335
OrientationW	Dummy variable	Sun orientation W	0	1	0.116	0.321
Orientationoverallview	Dummy variable	360 degrees orientation of the apartment	0	1	0.004	
Balcony	Independent	Number of balconies per apartment	0.000	12.000	0.9806	0.655
Terrace	Independent	Number of terraces per apartment	0.000	1.000	0.1537	0.361
Loggia	Independent ordianl	Number of loggias per apartment	0.000	2.000	0.1648	0.377
Continuousbalcony (0,1)	Dummy; 0=reference dummy	The apartment has a continuous balcony over the entire length of the apartment, or not	0	1	0.3256	0.467
dExterior	Dummy; 0=reference dummy	The apartment has 0 or more exterior spaces, or not	0	1	0.9687	0.174
Environmental variables						
Erasmusbrug	Dummy; 0=reference dummy	View on Erasmusbrug from the apartment	0	1	0.119	0.324
Euromast	Dummy; 0=reference dummy	View on Euromast from the apartment	0	1	0.274	0.446
Willemsbrug	Dummy; 0=reference dummy	View on Willemsbrug from the apartment	0	1	0.160	0.367
Haven	Dummy; 0=reference dummy	View on Haven from the apartment	0	1	0.104	0.306
Maas	Dummy; 0=reference dummy	View on Maas from the apartment	0	1	0.501	0.500
City Centre	Dummy; 0=reference dummy	View on the City centre of Rotterdam	0	1	0.298	0.457
Landmark	Dummy; 0=reference dummy	View on the landmark of Rotterdam	0	1	0.416	0.493
PGS variables						
Meter300PARK (0,1)	Dummy; 0=reference dummy	Total floor area of the private outdoor space (m^2)	0	1	0.2952	0.456
DogFriendly500m	Dummy; 0=reference dummy	Accessible PGS for dogs	0	1	0.2801	0.449
Children500m	Dummy; 0=reference dummy	Accessible PGS for children, children friendly	0	1	0.7381	0.440
CollectiveGarden	Dummy; 0=reference dummy	The building has a semi-private garden or roof that is shared with the neighbours (1), or not (0)	0	1	0.423	0.494
NGreenview	Reference variable	Number of green views from the apartment	0	1	0.560	0.695
UitgestrektVIEWNW	Dummy; no = reference dummy	Within the building there are stores and/or retail shops	0	1	0.149	0.357
HetPark	Dummy; 0=reference dummy	View on Het Park from the apartment	0	1	0.181	0.385
Kralingseplas	Dummy; 0=reference dummy	View on Kralingse Plas from the apartment	0	1	0.0849	0.279
ParkDeEsch	Dummy; 0=reference dummy	View on Park De Esch from the apartment	0	1	0.0667	0.250
Mallegatpark	Dummy; 0=reference dummy	View on Mallegatpark from the apartment	0	1	0.0951	0.293
Wijnhaven	Dummy; 0=reference dummy	View on Wijnhaven from the apartment	0	1	0.284	0.451
SafetyPGS	Dummy	General safety rate index of areas wherein PGS is situated (green label)	0	5	3.857	0.350
PhysicalPGS	Dummy	General physical rate index of areas wherein PGS is situated (green label)	0	5	3.550	0.731
SocialPGS	Dummy	General physical rate index of areas wherein PGS is situated (green label)	0	5	3.574	0.729

As shown in table 6, some variables used in the regression model have multiple classifications and can be dependent, independent numeric and independent categorical variables. These variables are labeled

as *dummy* variables. The dummy variables have a non-continuous value of 0 or 1 (De Haan & Diewert, 2013, pp. 50-53). Many variables included in the regression model have the categories "No" or "Yes" which can be coded as 0 and 1, respectively. Other categorical variables that have more than 2 two options, such as the sun orientation of the apartment, can be put into dummy variables as well. Dummy variables can make these categorical variables into a series of variables where their value is coded as 0 or 1. For example, the sun orientation could be divided into multiple dummy variables that represent a direction. A dummy variable for the direction of North could be coded in 1 if the direction is north and 0 if the direction is another direction. This is done for all sun directions.

Correlation results of dummy variables need to be compared to a certain level to explain the possible level correlation. A reference dummy is a variable that is selected as category of comparison which encompasses a certain base level. The variables that are selected as reference dummy are shown in table 6. These dummy variables are not included in the regression model as all the other dummy variables are measured relative to this default reference dummy. For example, the dummy variable for having a park within a radius of 300m is measured against the reference dummy variable of not having a park within the radius of 300m.

Type of HPM

Various equations form of the HPM have been established by empirical studies, such as the linear, the double logarithm or semi-logarithm. An overview on the different forms of HPM used in similar studies is shown in table 7. Many studies used a logarithmic form to reduce outliers in the results of the variables. Logarithmic forms reduce the problem of non-constant variance of the errors as prices tend to be logarithmic-normally distributed. A linear regression model could have been another suitable form for analyzing housing prices if the lot sizes of the high-rise buildings are known (De Haan & Diewert, 2013, p.50). The lot sizes of some of the planned constructed buildings are not accessible yet, which made the linear model unrealistic for this research. Therefore, the semi-logarithmic form is used.

The larger numeric variables are logarithmically transformed to evenly distribute their results to prevent outliers. A logarithmic model shows the extent in which the independent variable will affect the dependent variable in a percentage instead of an absolute value. The chosen HPM form can be expressed by the following formula.

$$Ln\,P = \beta_0 + \beta_1 * S_a \dots S_k + \beta_2 * N_a \dots N_k + \beta_3 * T_a \dots T_n + + \beta_4 * Z_a \dots Z_n + \varepsilon$$

Table 7: comparison between HPM studies concerning the effects on the housing price (own table)

Authors	Method	Topic	Variables	Data
Jim and Chen (2010)	Log-log	External effect of neighbourhood parks and landscape elements on high-rise residential value	Structural, neighbourhood, environment, view	1471 apartments, Hong Kong
Sander and Polasky (2009)	Log-log	Estimating value of views and open space	Structural, Neighbourhood, view, open space, market segment	5364 residential properties, Minnesota, USA
Saphores and Li (2012)	Log-log	Estimating the value of urban green areas	Structural, neighbourhood, infrastructure, land cover powers	20660 single family detached houses, LA, USA
Noor et al. (2015)	Linear (with GIS*)	Sustainable urban regeneration: GIS and hedonic pricing method in	Open space elements	All semi-detached houses, Subang Jaya, Malaysia

		determining the value of green space in housing area		
Wong et al. (2011)	Linear	Property price gradients: the vertical dimension	Structural building and apartment variables, view	807 apartments, Hong Kong

* Geographic Information System

Key assumptions for HPM

The regression model expresses the extent of how much the dependent variable is explained by the independent variables by R^2. This term interprets how many percent of the variation is explained by the included variables, varying from a value between 0 and 1. The adjusted R^2 represents how much of the outcome is predicted by the model but considers the amount of included independent variables. Compared to other similar studies, an adjusted R^2 above 0.75 is desired to draw proper conclusions (Jim, Chen, 2010; Sander, Polasky, 2009). Additionally, significant conclusions can only be drawn for outputs of the regression analysis with a *p*-value of $p<0.05$.

Besides the adjusted R^2 value and the *p*-level, a few key assumptions are considered to provide a reliable outcome of the HPM model:

- No multicollinearity: the independent variables are not highly correlated with each other. This is tested via Variance Inflation Factor (VIF) values. In general, a value higher than 10 could indicate the presence of multicollinearity which could cause a biased outcome.
- No heteroscedasticity: the variance of the residuals (error terms) is independent of the value of the dependent variable. The hypothesis for the presence of heteroscedasticity is tested by the Breusch-Pagan test. The hypothesis can be rejected by a *p*-value < 0.05.

3.5.2 Semi-structured interviews with experts

The analysis of the semi-structured interviews tends to have a deductive approach as most of the PGS variables discussed in the interviews are mostly predetermined by the results of the regression analysis. However, other concepts such as the financial arrangements of PGS and the relation between developers and municipalities are not predetermined. Therefore, the analysis of the interviews uses a quite unstructured approach. Themes are found from the transcripts, which are compared to the other interviews and the results found in the regression analysis. The analysis of the semi-structured interview is additionally used as further understanding of the results, such as the coefficients of certain PGS variables from the regression analysis.

Validity & reliability

Reliability discusses the consistency of a measure to be able to replicate the study. For the semi-structured interviews, reliability is assured by explicitly elaborating the multiple steps taken during the interview. Therefore, the interview protocols are included in this research in Appendix H. The interviewees are selected by the stated criteria. As the interviews were mainly as explorative function, the structure of the interviews is quite unstructured. Due to the semi-structured character, some themes were more elaborated on than others. This could possibly cause different answers when repeating the study.

Validity tells something about the accuracy of the measure. For semi-structured interviews external and ecological validity are applied (Bryman, 2016). External validity indicates whether the results of the research can be generalized to a larger population. As the whole research is sampled from only one city, no generalization can be made for a larger scale. The research gives valuable new insights for the chosen city. Further research could be done in other cities to expand the external validity. Ecological validation aims to set a natural environment for the interviewees. Due to COVID, this was hard to maintain. To

avoid differences in outcome due to differences in settings, all interview were taken online via Microsoft Teams. After the interviews, the main findings are shared with the interviewees to check the results once more.

3.5.3 Summary of the data analysis

As multiple methods and collection techniques are used, the data analysis consist of multiple techniques as well, summarized in figure 11.

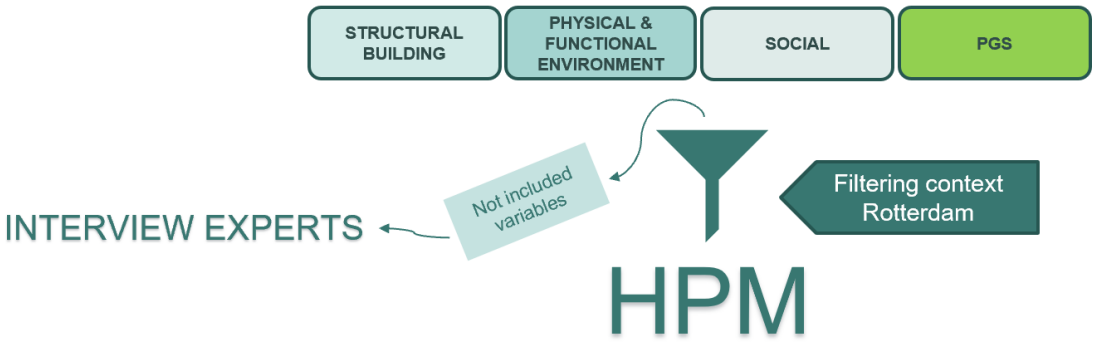


Figure 11: overview of data analysis (own figure)

3.6 Data plan & ethical considerations

The most important responsibility of performing quantified research is making the audience aware of potential limitations of the results concerning reliability and applicability, according to Jones (2000). The complexity of data collection for quantitative research is to find a balance between conducting a reliable outcome and dealing with outliers. Modifying data just to make a more attractive outcome should be avoided (Jones, 2000). Therefore, all collected data of the 977 apartments are included in the research. To find a reliable outcome is mainly conducted by various tests in R-studio to avoid intercorrelated results between the included variables. If some of the independent variables show a non-significant result, these are still included in the model to optimize the results as reflection of the reality. Although, it is impossible to include all variables. For this reason, the results are critically compared with literature and validated by interviews with experts. During the data collection, all information is stored offline.

Concerning the ethical considerations for the interviews, the main consideration was to make sure that the content of the interviews is remained confidential and only used for educational terms. The interviews were recorded and are stored offline to secure its confidentiality. The recorded interviews will be removed after the graduation. Additionally, the interviewees were not aware of the identity of the other interviewees. This could increase the credibility of the answers given by the interviewees. All the conducted interviews are performed by a voluntary participation of the interviewees.

4. Data output

The data output discusses the main findings of the sub-questions. The answers are found by the analysis of the multiple research methods discussed in chapter 3. Before answering the questions, first, the selection of the sample size sequence from figure 10 on page 37 is further elaborated on to conduct the suitable data.

4.1.1 Sampling area & building selection

The selection of the city is done by comparing the number of high-rise buildings in the largest five cities of the Netherlands, the so called G5 cities (Stichting Hoogbouw, 2021). Eindhoven is the newest addition to the traditional G4 as they have the ambiguous plan to focus more on high-rise in the future (Gemeente Eindhoven, 2020). Table 8 shows the number of high-rise buildings in the G5 cities, including new development plans.

Table 8: List of residential high-rise towers in the Netherlands (Fakton, 2020)

City	Total	Residential
Amsterdam	96	43
Rotterdam	115	59
Den Haag	88	57
Utrecht	35	14
Eindhoven	30	14

Rotterdam has relatively the most residential high-rise buildings, compared to the other cities. For this reason, the city of Rotterdam is chosen as study location. The towers are located near different types of PGS.

Consequently, suitable high-rise buildings are chosen. A list of suitable residential towers in Rotterdam is shown in table 9. Buildings as The Rotterdam and The Sax, that contain other functions such as offices and a hotel, are included in the research if the main function of the building is for residential purposes As section 3.4 mentioned, this research focusses on the data from new developed high-rise buildings as the more accessible listed price can be interpreted as the transaction price.

Table 9: list of new residential high-rise towers in Rotterdam (Fakton, 2020)

	Rotterdam	Building height	Number owner-occupied apartments	Start sale	Completed in
1	Zalmhaventoren I	215m	295	2018Q4	2022Q2
2	Zalmhaventoren II	70m	90	2018Q4	2022Q2
3	Zalmhaventoren III	70m	90	2018Q4	2022Q2
4	The Sax I: Philadelphia	71m	225	2019	2022
5	The Sax II: Havana	170m	225	2019	2022
6	The Modernist	125m	312	?	2022
7	The One	110m	220	?	2024
8	Waterside III	70m	0 (only rent)	2021Q1	2022Q4
9	Rotta Nova	70m	275	?	?
10	Stack	72m	85	2020Q4	2024Q1
11	DWNTWN	70m	200	2020Q4	2024Q4
12	Casa Nova	110m	115	2018Q4	2022Q4
13	Parkhaven	70m	142	?	?
14	Die Piekstraat	74m	130	2020Q4	2023Q3

15	Maasbode	70m	94	2020Q4	2023Q2
16	De Post	150m	250	2020Q3	2022Q2 (delayed)
17	Imagine	70m	162	2021Q1	2024Q2
18	The Muse	74m	96	2016Q4	2020Q1
29	Cooltower	150m	284	2017Q2	2022Q2
20	SAWA	50m	53	2021Q1	2023Q2

From this list, the data of the 9 highlighted residential high-rise buildings is used in the regression analysis due to accessibility of the respective data. These are shown in figure 16. Most of the selected high-rise buildings are concentrated near the city centre, two towers are in Delfshaven and two towers in Feijenoord. The suitable high-rise towers from table 9 are presented on a map, shown in figure 14. Newly developed high-rise buildings seem to have a stronger interaction with semi-public green spaces compared to older high-rise buildings. This is mainly expressed in a collective garden on the roof. Figures 12 till 15 show some impressions of the newly developed high-rise buildings and their interaction with the semi-public green spaces. Thereby, the assumption in 2.1 is correct.

Figure 12: SAWA tower with collective garden (top010, 2020)

Figure 13: Parkhaven next to Het Park (Parkhaven010, n.d.)

Figure 14: semi-public entrance Maasbode (Van Wijnen, n.d.)

Figure 15: Maasbode Rotterdam (Van Elewout, 2020)

Some of these buildings focus on the interaction with the public space by creating a transition between the public space and the semi-public entrance of the apartments. An example of this is the Maasbode, shown in figure 14 and 15.

Some of the newly built high-rise buildings from table 9 show interesting aspects in relation to PGS. For example, the project of Parkhaven. This is a new project that is exceedingly integrated with the highly

valued PGS of the monumental Euromast and Het Park. It is a development project that contains multiple towers located at Parkhaven. The development of the buildings takes the monumental characters of Het Park and Euromast into account. It is an example of a high-rise development that not only develops the high-rise building but also the area around it. The plan includes landscape architecture as well to connect the new plan with the green character of its surroundings. Multiple aspects that concern both resident as citizens are included in the developments such as water, health, circularity, mobility, energy, and nature. Various solutions of these aspects are situated in the new developed PGS (ParkHaven & Partners, n.d.).

The socio-economic and demographic differences between the chosen towers is limited due to choosing only one city. Yet differences do occur in the various neighbourhoods of the city. According to the neighbourhood profile (Gemeente Rotterdam, n.d.), Feijenoord has different demographic and socio-economic variables then the other districts. The hedonic pricing model included the safety index of the area of the nearest park for each high-rise building. However, this still gives only a small insight in the social demographics of the differences in neighbourhoods. This is something that is taken into consideration when looking at the results of the hedonic pricing model.

Figure 16: Map of the selected residential high-rise towers and signature PGS in Rotterdam (Own image via ArcGis)

4.1.2 PGS selection

Some of the preselected parks in appendix I are not located near the selected high-rise buildings or the high-rise buildings do not have a view on them. Therefore, only the parks illustrated in figure 16 are included in the research.

For other recreative spaces, such as allotments, sport fields and green areas near water, a quantitative estimation of the impact on the housing price is not found. It is expected that these spaces have similar effects as the smaller parks as the variables of these spaces have many resemblances with parks. Therefore, this research makes no distinction between these types of PGS and the smaller parks.

Remarkably, many websites of the included buildings promoted the presence of a collective garden that is shared with neighbors. The suggested need for green spaces could be provided by these gardens as well. These gardens are therefore added to the analysis to eventually make a comparison between the effect of the garden and the effect of public green.

4.1.3 PGS variables selection

All the included variables in the HPM are shown in table 6 on page 40. The variables regarding PGS are mainly based on the literature study presented in chapter 2 that discusses the role of PGS on the liveability domains. The variables that resident's value most about PGS are divided in the liveability domains, shown in table 10. Compared to table 6 from the HPM model, not all variables of PGS are included in the regression analysis. Some variables are not included due to the given timeframe, accessibility to data and multicollinearity between variables.

Table 10: liveability variables of PGS (own table)

Liveability domains	*Variables of PGS*
Environmental	Sustainability: Air quality (NO2 concentration), noise disturbance, biodiversity, water storage Public's health: physical and mental well-being.
Social	Interaction with others in PGS, sense of belonging, enjoyment and comfort, place to meet with friends.
Functional	Distance and accessibility to PGS, accessibility target groups (kids, dog owners, etc.), multifunctionality, facilities (walking paths, coffee bars)
Cultural	View from and on PGS, attractiveness PGS, cleanliness, green view, opportunity to undertake cultural activities
Safety	Feeling save in and around PGS, crime rates in and around PGS, kids friendly, social security, street lighting
Financial arrangements	Type of financial arrangements (anterior agreement or exploitation plan), more detailed explanation of the type of financial arrangement

Environmental variables PGS

Many environmental variables, such as the contribution to air quality, require a time-consuming research such as the biodiversity of PGS. Therefore, most of the environmental variables could not be included in the regression analysis. A more general approach is done to still assess the environmental via the regression model. Therefore, a physical index variable is included in the testing process of the HPM. This physical variable includes a valuation of the living environment, public space, facilities, and environmental aspects such as the air quality (Gemeente Rotterdam, n.d).

Social variables PGS

The social variables are difficult to express in a statistical regression analysis. Therefore, social variables of PGS that affects the housing price are assessed by the interview with someone from Stichting Hoogbouw and a project developer. In addition, the social index of the neighbourhood is included in the

regression analysis to assess a general overview of the impact of social aspects on the housing price. These aspects include self-reliance, cooperation, participation, and connection with the neighbourhood (Gemeente Rotterdam, n.d).

Functional variables PGS

These functional are included in the regression analysis as Jim & Chen (2010) discusses that distance and accessibility to parks have a high influence on the housing price, compared to other park variables. A 300m distance is seen as the maximum walkable distance residents are willing to walk to facilities for leisure such as parks (CROW, 2016). Most functional variables are expressed as dummy variables; expressed as 1 if the distance between a park and the buildings meets the criteria, expressed as 0 if it does not meet the criteria. The distances between the parks and buildings are measured by Arcgis. Some functional variables are not included in the HPM such as multifunctionality and certain facilities. Reason therefore is that collecting data of these variables to include in the HPM would be very time consuming. In addition, multiple studies point out that especially distance and accessibility influence the housing price most. Other, not measured, functional variables will be investigated by the interviews. Additionally, the presence of a park includes other factors that could affect the relation with the housing price. During the analysis this is taken into account and elaborated on in the main findings.

The two largest target groups of the selected buildings are the single households and households without children. Most of these groups do not require special facilities in PGS. It could be that some own a dog, that is why the research included dog friendly PGS. See Appendix C for the maps that include dog friendly parks in Rotterdam. Children friendly PGS are included as well as some of the high-rise buildings focus on families, such as de Maasbode. The children friendly PGS are found by google maps the website of the municipality of Rotterdam (Gemeente Rotterdam, n.d.) A requirement for being children friendly is the presence of playground equipment. Further research could look at the accessibility of parks for other target groups such as fewer mobile residents. Due to the timeframe, this is excluded from this research.

Cultural variables PGS

Attractiveness and view of PGS from the apartments are included as cultural variables. Attractiveness and view both result in a stress relieved environment (Groenewegen et al., 2006). The views of the apartments are divided over famous landmarks (Erasmusbrug, Euromast), the larger parks and water (Maas). The landmark views and water are both integrated in the regression model due to its promotion on the websites of the high-rise buildings. For instance, the website of the Piekstraat promotes the water view by naming the apartments with water view the name ‘waterloft’ (Piekstraat, n.d.). This suggests that apartments with water view have a certain status that is positively valued by buyers.

For each apartment, the view on PGS, landmarks and water are reviewed via different multi-media sources. Appendix J shows an overview what source is used for the view variables of each of the selected high-rise buildings. Figure 17 shows the Northeast view from the location of the Imagine tower on a height of 41m. This view shows that the apartments at a height of 40m have a view on the Maas and the Kralingse Plas. This approach is done for all apartments and all orientations. As most of the adjacent buildings are 8th floor levels heigh, an expansive view over the city and even further away is seen from the 8th floor or higher. Expansive views variables are measured in the regression analysis as well. The views of apartments that contain view videos are measured in a similar way.

Figure 17: Google Earth used as tool to measure the view variables (Google Earth)

Safety variables PGS

Due to the timeframe of the research, it is impossible to include all safety variables in the regression analysis. A more general approach is provided to measure the impact of the safety domain of nearest PGS to the selected high-rise buildings. This safety index of the neighborhood profile is a measure of the city that shows how the various areas and neighborhoods of Rotterdam are reviewed in social, physical and safety terms. The scores of this profile are based on facts and figures and the opinion of the residents (Gemeente Rotterdam, n.d.). Additional information regarding safety variables of PGS is extracted by interviews with someone from Stichting Hoogbouw and a high-rise building developer.

Financial arrangements PGS

The selected towers are newly developed high-rise buildings of which almost all of them are currently in the development process. These buildings are often part of a new zoning plan wherein the agreements for financial arrangements are established. As these processes are still ongoing for many of the selected buildings, it is hard to find out what exact arrangement is established between the developers and municipality. For example, zoning plan 'Cool' is the zone wherein various towers of the regression model are situated such as the Cooltower, de Maasbode and DWNTWN. A zoning plan for this area is arranged between developers and the municipality. A complex series of consultations between the municipality and the developers have led to exclusion of the Maasbode as this is already a plan on its own. The rest of the zoning plan does not need an exploitation plan as the costs of the included land development is insured through future land allocation (Gemeente Rotterdam, 2020).

For these reasons, financial arrangements are not included in the regression model as it is seen as an indirect effect on the housing price. The results of the regression analysis can be used as incentive to improve the financial arrangements if the results of the PGS domains show a positive impact on the housing price. More detailed insights are desired as there is little known on the relationship of financial arrangement of PGS and housing prices. This is done via interview the municipality of Rotterdam and developers.

4.2 Importance of PGS for residents, municipalities, and developers

Looking back at the term liveability and its domains, PGS is seen as an instrument that influences liveability. The importance of PGS is a multifactorial concept, closely related to the term liveability. PGS can be viewed from the perspective of each of the five liveability domains as all these domains contribute to the quality of life of residents. The importance of PGS for other actors is intertwined with the resident's quality of life. Therefore, the importance of PGS is first analyzed for the residents by the literature study and the interviews.

4.2.1 Resident's perspective

Residents want to live in an area where they feel at home, safe and at a place that satisfies their needs concerning the urban and environmentally context (Shaw et al., 2004). This closely relates to liveability and thereby the quality of life for the residents. Public utilities and PGS have an important role in providing high liveability levels. For example, it helps to increase the mentally and physical well-being of residents (Skalicky and Čerpes, 2019). Providing high quality of life and thereby a high level of liveability is therefore the main reason why PGS is important for residents of urban areas.

A similar answer can be given for the more specific residents of high-rise buildings. As many high-rise residents do not have a large apartment with a large private or semi-private outdoor space, they need other facilities to create a high quality of life. According to interviewee C, a higher quality can be accomplished by the surrounded neighbourhood through PGS, or within the building itself. Consequently, the PGS are important for many residents of high-rise buildings to still accomplish a high level of liveability. Other facilities within the building could increase the liveability as well, such as privately shared rooftop gardens or shared living rooms within the building. The Sax, for example, is a high-rise building that accomplishes a high level of liveability by including shared living rooms and a large semi-private rooftop garden.

> ***You are only willing to live in a small and compact apartment if the overall quality is high enough.*** - Interviewee *C.*
> *(P. Becht, online interview, June 4, 2021)*

Over the years, the anonymity of high-rise buildings is becoming a problem which is addressed by the municipality of Rotterdam (Gemeente Rotterdam, 2019). PGS near the building and the semi-private rooftops could increase the level of social interaction which decreases the level of anonymity. The results of the interviews show, however, mixed opinions regarding the problem of anonymity. Interviewee B agrees that PGS and green roofs could increase the interaction with residents and citizen to solve the problem of anonymity. On the other hand, interviewee A, former Stichting Hoogbouw, does not fully agree on the statement that the anonymity of high-rise is a large problem. "Some residents choose to fully experience the large space of the city by living very private and not having contact with their neighbours", (J. Klerks, Online interview, April 26, 2021). For these residents, living anonymous does not necessarily lead to a decrease in quality of life.

Not all the different target groups of high-rise buildings have the same priority for certain PGS variables when looking at the importance of PGS for residents of high-rise buildings. Interviewee C, the developer of BPD, emphasize that safety and interaction variables of both the building and the surrounded PGS are highly valued by families.

> ***We should look at the wishes from the families and their children. Children of all ages should be able to play safely in and around the building.*** - Interviewee *C.*
> *(P. Becht, online interview, June 4, 2021)*

Since the municipal vision of 2008 (Binnenstadsplan 2008) to densify the city Rotterdam, more room is given to pedestrians and cyclist instead of cars. This vision has also led to add more greenery in the city, according to interviewee B - the urban developer of the municipality of Rotterdam.

If the city center becomes more attractive with less cars, the area becomes more quiet and more pleasant. - Interviewee *D.* *(E. Arends, online interview, June 2, 2021)*

According to interviewee B, the interaction with the neighborhood has become a more important role throughout the past ten years. "Je woont achter de voordeur, maar je leeft daarbuiten" (M. Corbeau, online interview, April 22, 2021), reflects the importance with the outdoor space.

In this research, PGS are defined as spaces with natural elements. Examples given in the interview show spaces that are sometimes hard to define as PGS, but still show the same qualities as PGS with natural green. For example, Schouwburgplein. At first, this was a large space that was not used to its full potential. Visitors only sat at the benches at the edge of the square, the middle of the square was mainly used as walk through. To motivate citizen and visitors to use make use of areas in an innovative and enjoyable way, HUNK-design created a new layout for Schouwburgplein (Bouwenuitvoering, 2017). Artificial grass is placed on the field with a playful pattern to make the space more attractive, shown in figure 18. Eventually, the area attracts more users that will sit on the grass. The success of the artificial grass suggest that natural elements not necessarily have to be actual natural element. Further research could investigate of all elements of artificial PGS have the same effect as natural PGS.

Figure 18: The new layout of Schouwburgplein (Schouwburgplein, n.d.)

4.2.2 Municipal's perspective

The analyzed municipal vision documents reveal the importance by the municipal's overall goal. This goal for municipalities is to create a better performing city that attracts residents, employees, and visitors (Gemeente Eindhoven, 2020; Gemeente Den Haag, 2017; Gemeente Rotterdam, 2019; Gemeente Amsterdam, 2011). This implies that the PGS variables concerning liveability domains are also important for the municipalities. Rotterdam has made multiple strategies to maintain an attractive city that attracts residents and other visitors, such as the Hoogbouwvisie 2019 and the Binnenstadsplan 2008. Within these strategies, multiple plans are stated to increase the amount of greenery in the inner city. As interviewee D states, the city centre of Rotterdam has not much green. To overcome this shortage, thousands

Two thousand trees have been planted at the Nieuwe Binnenweg alone. - Interviewee *D.* *(E. Arends, online interview, June 2, 2021)*

of trees have been strategically planted over the last couple of years, to fulfil the need for a higher quality of outdoor space.

The municipality can hardly make profit with the developments of PGS. As stated in 2.3, higher qualitative PGS result in dwellings with a higher WOZ value. This could contribute to higher taxes that the municipality can levy, such as the OZB taxes. According to interviewee D, the extra budget coming from the taxes is withheld from the money the municipality gets from the government.

Financial arrangements between municipality and high-rise developer

Creating high quality PGS often involves high development costs of which most is paid by the municipality. This suggests a constraint to creating high-quality PGS. Highly qualitative PGS are valued by the municipality, but this is only possible if there is financial feasibility. The financial arrangements between a municipality and high-rise developer influences the financial feasibility. As section 2.3 discusses, multiple arrangements are possible between developers and the municipality. High-rise buildings in Rotterdam are mainly developed by anterior agreements as, according to interviewee D, the municipality hardly owns land that has no public function. PGS, on the contrary, are mainly developed by an active land policy.

Financial arrangements for the development of PGS contain multiple difficulties that were expressed during the interviews, of which an overview is given in table 11. A remarkable finding is that both developers and the municipality desire a more transparent policy during the arrangements. Both parties point out that arrangements about ownership of certain PGS are challenging as well. In general, the party who pays is also the party that decides the exact implementation of PGS should look like.

> *"Wie betaalt bepaalt"*
> - Interviewee *B.*
> *(M. Corbeau, online interview, April 22, 2021)*

Table 11: interview results concerning the financial arrangements for PGS (own table)

Interviewee	Statement regarding financial arrangements for PGS	Improvements for arrangements between municipality and developer
A) Former Stichting Hoogbouw & high-rise resident	Financial arrangements between municipality and developer are mostly based on the traditions of our Dutch land policy. These makes it hard to negotiate.	Learn from developments in foreign countries. In America, for example, it is easier to negotiate between developer and municipality about developments of public space that are adjacent to the high-rise development
B) Developer AM	Multiple agreement options exist to recover costs from a developer to facilitate the built environment. The main problem is that a developer has no say in where this contribution will be used for due to the many rules and regulates of the Dutch policy	No improvements given.
C) Developer BPD	Private parties have little say and insights in the development of PGS due	More transparency in the policy regarding arrangements for PGS. Especially with

	to a lack of transparency on both sides of the developer and municipality	regard to the money flow and ownership of certain PGS. Learn from the development arrangements of foreign countries were negotiations are easier made.
D) Municipality Rotterdam, urban developer	Municipality mainly pays for development of PGS. Developers are allowed to financially contribute, but most of them will not do so due to the high costs	Financial transparency for developers that possesses land . Omgevingswet

Impact of new developments on PGS

Building high-rise buildings is very complex in an existing dense area such as the inner city of Rotterdam. Many discussions and arrangements are made between multiple actors, about adding a higher quality to the existing area. Discussions about PGS are included as well. Some developments of residential high-rise buildings include over 150 dwellings. This is comparable with the number of ground bounded houses for an entire street. Despite that both developments could contain the same number of dwellings, interviewee D, emphasizes on the more important PGS discussions for the development of residential high-rise buildings in dense cities.

> ***Adding a tower in an existing city is a much different development than adding the same number of dwellings in a street outside the city. These dwellings have gardens and parks and green, which leads to a whole other discussion than talking about the development of high-rise apartments.*** - Interviewee *D (E. Arends, June 2, 2021).*

The quality of the existing area needs to be upgraded to cope with the new residents. Therefore, discussions regarding PGS are very important for the municipality to maintain or increase the quality of neighbourhood and thereby, keeping the residents to reach to overall municipal goal.

4.2.3 Developer's perspective

Developers that work on high-rise residential buildings have a mutual interest in optimizing the different aspects of liveability since it makes their own development more attractive and valuable. As mentioned in the in-depth interview with a developer, some developers are interested in the interaction between a property and its surrounding public space to make a more attractive area, not only to the benefit of the residents of the property, but also for the city itself according to interviewee C. Developers are willing to help to pay for the costs of PGS by various financial arrangements, but they often want an active role in return. According to interviewee B and C this is difficult to achieve due to many regulations of the Dutch policy.

Residents highly value having an apartment in a well-connected location through different public spaces such as PGS. Interviewee C addresses that this is not a new vision, but nowadays we integrate the interaction better within the design brief. Despite that the interaction with the outdoor space is seen as an important value for residents, it might not have that much influence on the housing price, according to the interviewee. Especially as the demand for houses is exceptionally high. It could, however, speed up the time that the apartment is put on the market. If it has a pleasant outdoor space, people could be more rapidly convinced that this is the right apartment for them.

Semi-private green rooftops are seen as important element to increase the quality of living in high-rise buildings. This awareness has increased over the years, especially during the COVID 19 pandemic, according to interviewee C. Despite this awareness, not all roofs turn into green gardens due to financial considerations. According to interviewee D, most developers want to receive their profit immediately after they have sold the building.

> ***If a developer can choose between a green roof or a climate installation, then they often opt for the climate installation, not a green roof. The yield of such an installation is received immediately after selling the building. The yield of a green roof is only after 10 to 15 years visible.*** - Interviewee *D.*
> *(Online interview, June 2, 2021)*

According to the interviewee C, there is a constant dilemma regarding the financial agreements of PGS between developers and the municipality. Developers want to contribute to the development of PGS that are near their high-rise developments. However, the Dutch regulations make it very difficult to directly contribute to these PGS. Subsidies and contributions regarding improvements to the built environment are divided over various savings. It is not possible for a developer to choose for which improvement his contribution will be used. It is only possible for a developer to have say in the design of the public space if this is part of their own development area. A high-rise building development consist often of a small area that does not include the public space of the surrounded area. The developer could address certain ideas or wishes for the surrounded public space, but it is uncertain if the municipality will take these ideas into consideration.

4.3 PGS variables influencing the housing price of high-rise buildings

Section 4.2 discussed why PGS is important for residents of high-rise buildings. This important aspects of PGS are further discussed by the PGS variables for each liveability domain. To investigate the important PGS variables that could influence the housing price of high-rise buildings within the Dutch context, a comparative literature study is done. This is done between the international literature study from chapter 1, the high-rise vision documents of the four largest cities in the Netherlands, and the survey. Important PGS variables found in these studies indicate that they are highly valued by residents. This value is translated into the willingness to pay that is measured by the housing price of high-rise buildings.

Municipal high-rise vision document

Each vision document stated multiple requirements regarding liveability of both the residents, the citizens, and the visitors. The vision of The Hague focused more on the visitors of the city, where Eindhoven was more involved with the liveability of the citizen (Gemeente Eindhoven, 2020; Gemeente Den Haag, 2017). Remarkably, all the requirements given in de vision documents can be categorized within the five domains. With these requirements, a flowchart is made to show the different relations between requirements of the high-rise buildings, requirements of the city and liveability of the residents and/or citizen. The extensive flowchart is shown in Appendix A, the more simplified version is shown in figure 19. Figure 19 illustrates that all domains lead to liveability.

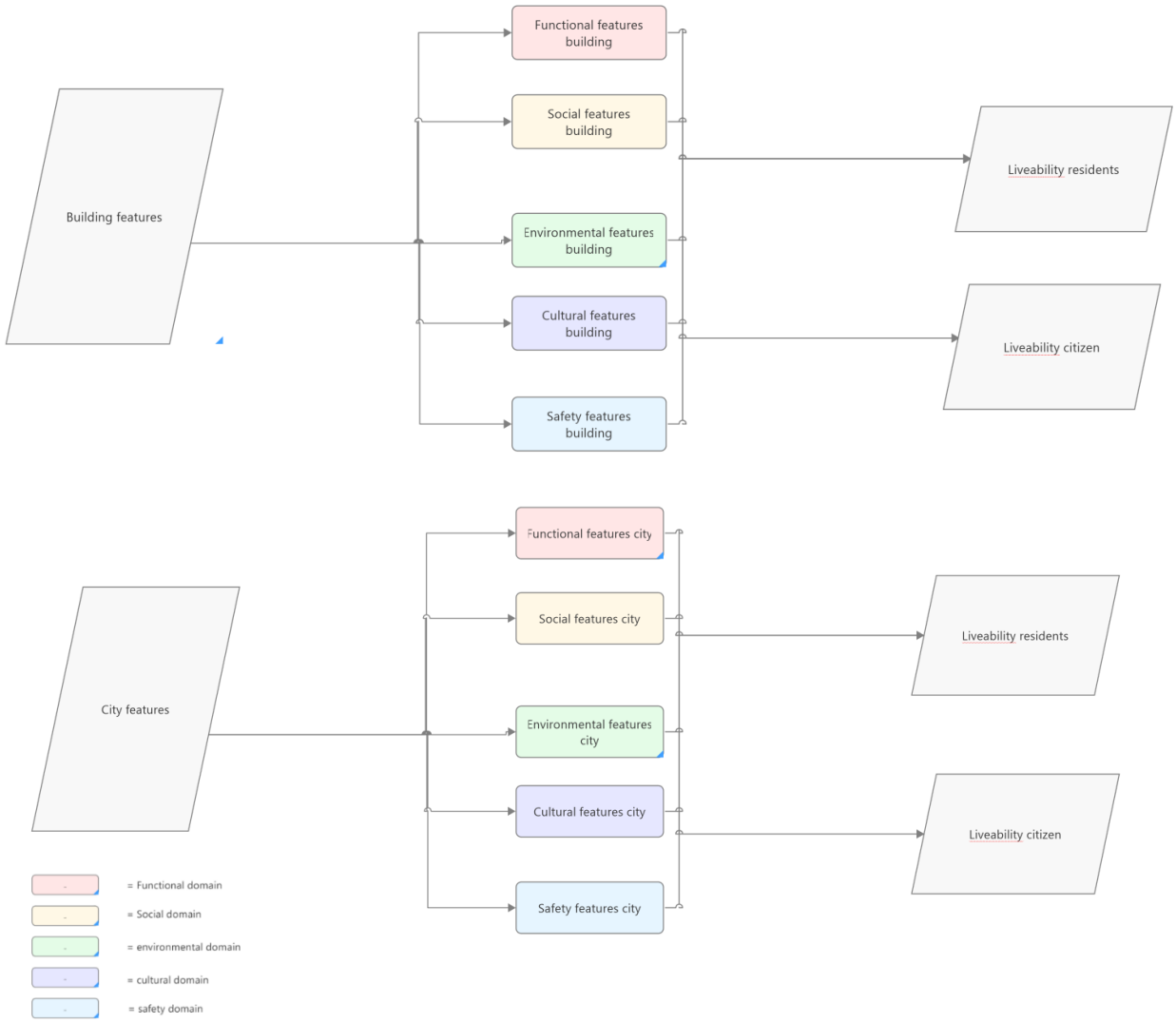


Figure 19: Flowchart of liveability perspectives and domains (own figure)

These two simplifications show that both the building as the city features could have influence on the liveability of residents and citizens (Gemeente Eindhoven, 2020; Gemeente Den Haag, 2017; Gemeente Rotterdam, 2019; Gemeente Amsterdam, 2011). Comparing these findings with the literature studies for the liveability domains show that the vision documents recognize different perspectives of liveability, which are building and city features. Leby and Hashim (2010) discuss similar perspectives in which liveability can be seen from the quality of the dwelling, the quality of the physical environment, quality of the social environment and the safety of the neighbourhood. The combination of these findings leads to the following overview in which the discussed domains and perspectives are put together, illustrated in figure 20.

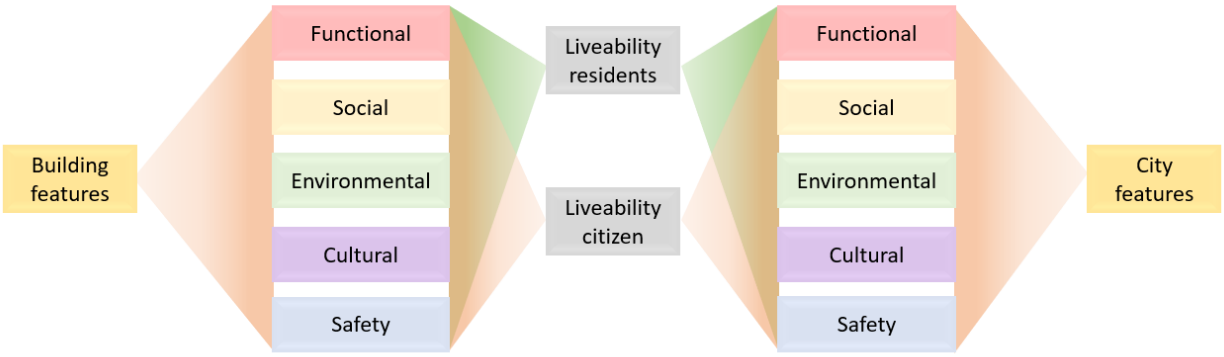


Figure 20: Framework liveability and features of building and city (own figure)

Value of the PGS variables from comparative study

The comparison of the international literature study and municipal vision documents emphasize on the importance of PGS by its different domains.

The functional domain of PGS is mainly affected by its accessibility and availability for residents and citizens as this affects the quality of life the most (Skalicky and Čerpes, 2019).

As for the social domain, PGS spaces can contribute to increasement of social contacts, community life and enjoyment. Especially residents of high-rise buildings without their own private outdoor space are encouraged to make use of the outdoor spaces and interact with other citizens (Jim, Chen, 2010).

PGS affects the environmental domain on both sustainable goals and variables for well-being (Skalicky and Čerpes, 2019). The sustainability goals include air quality, noise disturbance, and biodiversity. Concerning the public health, these spaces contribute to both the physical and mental well-being. Research in environmental psychology concluded that natural elements have a positive effect on the well-being through stress relieve and the improvement of a person's concentration. This physical and mental well-being is enlarged by the increasement of the number of green spaces in the living environment (Groenewegen, Van den Berg, De Vries and Verheij, 2006). Therefore, the effect of well-being aspects of the environmental variables can be partly explained by the presence of PGS nearby the high-rise buildings through the functional domain.

The cultural domain is affected by PGS through its appearance. The appearance of this space affects the community mindset and the identity of the residents and citizen which is often measured by the attractiveness of the space (Skalicky and Čerpes, 2019). Attractiveness is a subjective term which could differ per inhabitant. As PGS includes public green rooftops as well, these affect the attractiveness of the building or environment experienced by its residents. Binti Shukri and Misni (2017) state that creating a pleasant view is one of the main goals creating a public roof. Attractiveness could have a large influence on the housing price of high-rise buildings. Attractiveness is, however, difficult to measure for the quantitative research. Section 4.3 will further elaborate on this.

Public spaces, such as PGS, play an important role in the safety experienced by inhabitant of urban cities. A neighbourhood with high crime rates is often seen as an unsafe environment that increases fear among residents and citizen (Leby, Hashim, 2010). It is undesirable to live near a PGS where the crime rates are high or/and there is a feeling of unsafety experienced by citizen. Interviewee C agrees that one of the main values for high-rise residents is to feel safe.

Table 12 gives an overview of the PGS variables found in the international literature study and municipal vision documents.

Table 12: Public green space aspects put in the context of liveability domains (own table)

Liveability domains	PGS variables	
	Literature findings	*Survey*
Environmental	Sustainability: Air quality, noise disturbance, biodiversity Public's health: physical and mental well-being.	Sustainability: Air quality, noise disturbance, biodiversity, water storage Public's health: physical and mental well-being.
Social	Interaction with others in PGS, sense of belonging, enjoyment, and comfort.	Interaction with friends, enjoyment, and comfort.
Functional	Distance and accessibility to PGS	Distance, accessibility to PGS, accessibility for target groups (e.g. dog owners), all season access, sun and shadow spots, facilities (e.g. walking paths, coffee bar)
Cultural	View from and on PGS, attractiveness PGS, cleanliness	View from and on PGS, attractiveness PGS, cleanliness, place to undertake something
Safety	Feeling save in and around PGS, crime rates in and around PGS	Feeling save in and around PGS, crime rates in and around PGS, kids friendly, social security, good street lighting

PGS variables for the Dutch context further explored in a survey

The survey among Dutch included the identified PGS domains and their variables to make an inventory to see if the aspects from the literature correspond with the opinion of the respondents. The questions included in the survey can be found in appendix G. The results of the survey consist of 89 responses from Dutch residents. Thereby it is not statistically significant as it should reflect the whole Dutch population. This is considered since it is only used as explorative survey. It may only lead to a supplement to the literature study.

The most important PGS domain experienced by the respondents, is assessed by looking at the combined percentage from the "important" and "very important" scores. From all domains, the safety domain is acknowledged as most important by 89.9%. Figure 21 to 25 illustrate the outcomes of the PGS domain variables.

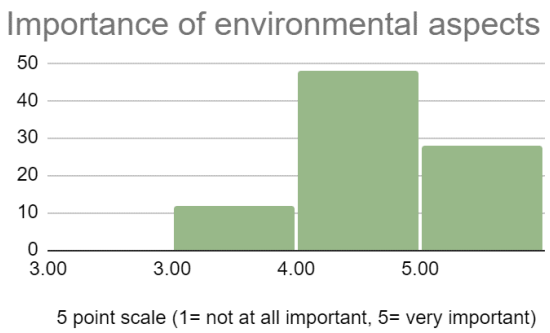


Figure 21: importance environmental aspects (own figure)

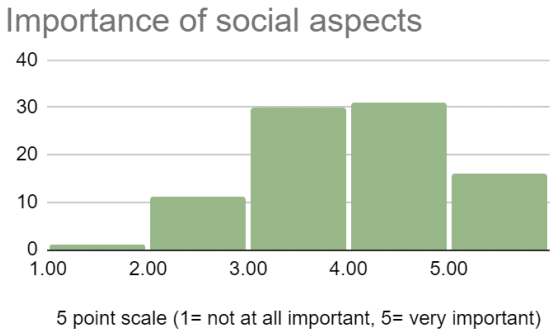


Figure 22: importance social aspects (own figure)

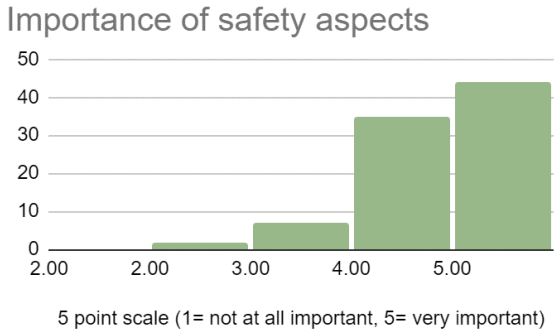


Figure 23: importance safety aspects (own figure)

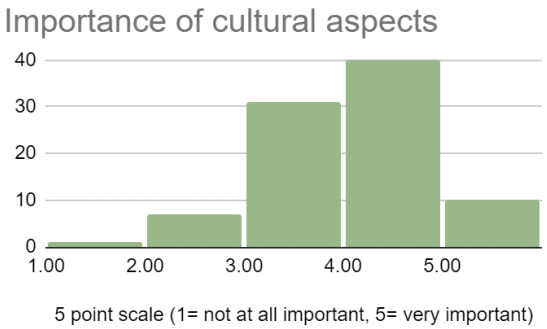


Figure 24: importance cultural aspects (own figure)

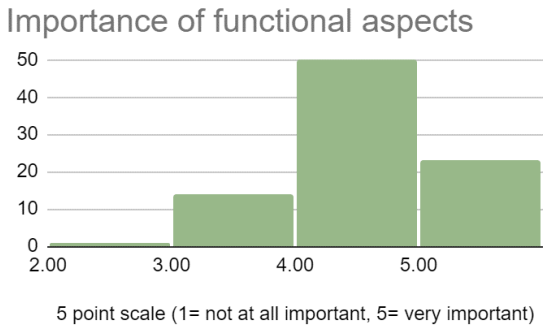


Figure 25: importance functional aspects (own figure)

The cultural domain is experienced as least important. The view factor is implied within this domain. As multiple literature studies identify this variable as quite important for high-rise buildings, this is still included in this research. The survey was done among residents of all types of dwellings. As only 47.7% of the respondents answered that they live in an apartment, this could be an explanation for the low score on view variables. Interviewee A, which is also a high-rise resident claims that the views are one of the main reasons to live in his current apartment. Not only the PGS views are highly valued by residents. The study of Sander and Polasky (2009) identify water views as a positive effect on the housing price as well.

The social aspects of the social domain scored relatively low in the survey. On the other hand, Yuen (2011) emphasize on the social interaction between residents of high-rise buildings. As the explorative survey does not have a statistic significance and is performed by both residents of ground bounded houses and apartments, it is likely that the social variables might be of importance to the residents. Interviewee C agrees that some residents of high-rise towers do want to have social interaction with their neighborhood.

> ***There are also high-rise residents who highly value the interaction with the city. If the interaction with the city is pleasant by means of a park or greenery, for example, this could be of more distinctive value than the height of the apartment.***
>
> - Interviewee *C.*
> *(P. Becht, online interview, June 4, 2021)*

The respondents mainly agreed on the variables found in literature, summarized in table 12 on page 58. The results of the survey are added to this table and show many similarities. None of the variables extracted from literature were convincingly experienced as 'not important'. For this reason, none of the variables are excluded from the research. A few new variables were mentioned in the survey, such as.

- sun and shadow spots
- all seasons access
- water storage

These variables are all indirectly part of the already mentioned variables. Sun and shadow spots and all-seasons access can be seen as part of 'enjoyment and comfort'. The water storage can be seen as an element of the sustainable variables of the environmental domain.

Some safety variables mentioned in the survey showed overlap with the accessibility variables concerning the functional domain. This indicates ones more that there is overlap between the domains. In conclusion, no additional key variables regarding PGS were found in the survey.

Observations during the data collection

During the data collection, some interesting observations were made about certain PGS variables of the cultural domain.

An example of the view videos of Cooltower is shown in figure 26 t0 28. These videos provide a 360 view on 3 height levels; 60m, 90m and 120m. Figure 29 shows the south-west view of the apartments at a building height of 100m, which reveals an impressive view on the Erasmusbrug, Leuvehaven, Euromast and Het Park.

Figure 26: South-east view at 60m from the location of the Cooltower (Cooltower, n.d.)

Figure 27: South-east view at 90m from the location of the Cooltower (Cooltower, n.d.)

Figure 28: South-east view at 120m from the location of the Cooltower (Cooltower, n.d.)

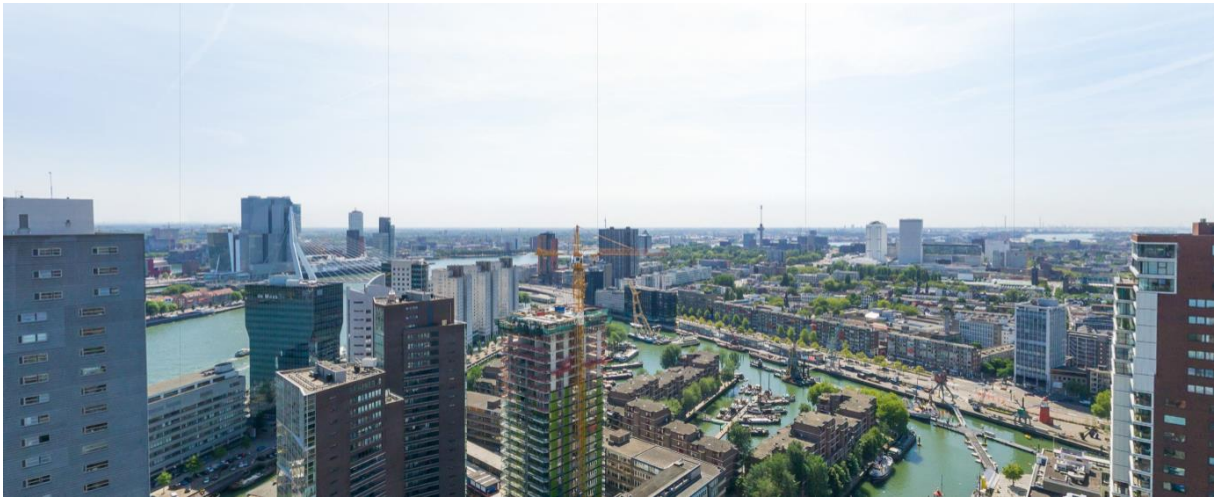


Figure 29: South-west view at 120m from the location of the Cooltower (Cooltower, n.d.)

The many view videos on the websites of the high-rise residential buildings suggest that view is an important aspect for the sale of these apartments. This is confirmed by both the interviews with the developers and the former director of Stichting Hoogbouw. Interviewee C addresses another phenomenon of view variables.

> ***The most important aspect of view is whether the view is obstructed by other buildings, these apartments have often a higher housing price. Especially when you have a view on aspects that identify Rotterdam, such as the Erasmusbrug. Being able to say that your apartment is higher than the rest of the surrounded buildings is something some people are willing to pay for.***
>
> - Interviewee *C.*
>
> *(P. Becht, online interview, June 4, 2021)*

The comparative literature study and observations during the data collection, show that all liveability domains are important for residents of the Dutch G4 cities. The survey among residents confirms this result. Both the survey and the international literature study identify the safety domain to be the most important as this contributes significantly to the quality of life of the residents. On the contrary, the municipal vision documents do not emphasize that much on this aspect. Instead, they emphasize most on the social interaction between the buildings and the public space. A reason for this is that this interaction indirectly relates to the social safety of residents and citizen and thereby creates solutions for a safer environment. This shows that there is a certain amount of overlap between the liveability domains. This overlap can also be seen in other variables. PGS could generate a wide range of ecosystem functions and environmental externalities which is valued for residents living nearby these PGS. Living nearby a PGS could increase the quality of life by indirect positive effects of the other variables of other domains.

Remarkably, interviewees A and B state that the positive effects of PGS are sometimes not directly perceived. Sometimes, this is only noticed when there is a sudden absence of it. This research focusses mainly on the presence of certain PGS variables. Further research could look at the consequences when PGS is suddenly absent.

4.4 Determination of the housing price of high-rise buildings in Rotterdam

Section 2.4 discussed the multiple variables that determine the housing price of high-rise buildings in Rotterdam. The VON-price is used for the housing price. As the sample size is taken in one city, some of the physical & functional environment and social variables from section 2.4 are excluded from the analysis. Excluded variables are for example, schools, jobs, and demographic variables. The included variables are combined with the PGS variables found in section 4.2 and put into the regression analysis to determine the effect on the housing price.

4.4.1 HPM outcomes

The HPM included 977 apartments of 9 high-rise buildings in Rotterdam. Appendix D shows a full overview of what variables are included and which ones are excluded. The outcomes of the HPM are discussed by a division in PGS variables and the other, non PGS, variables. PGS variables are further divided into the five domains. In general, only for the significant outputs that have a $p<0,05$, a conclusion can be formulated. For some variables without a statistically significant outcome, assumptions are stated.

Appendix E illustrates the overall outcome of the hedonic pricing models. The coefficients reflect the height of the premium that the corresponding variable has on the housing price of the included dependent variables in the hedonic pricing model. In general, the results of the HPM show a positively determinant effect on the housing price of high-rise buildings. All interviewees agree that PGS contributes to a higher quality of life.

The added value of greenery near apartments in the city center could easily have a 10 to 15% influence on the housing price.

- Interviewee *C.*

(P. Becht, online interview, June 4, 2021)

Compared to table 7 of chapter 3, some variables are left out. During the regression analysis, some variables showed a large influence on each other due to multicollinearity. Therefore, some of these variables are left out in HPM. Further sections will go further into detail which variables are left. Additional models (model 3, 4 and 5) are used to provide information of both variables for some variables that show multicollinearity to still provide information on both variables. Table 13 shows which variables are included into the multiple models.

Two different hedonic pricing models are established to find correlations with PGS variables and the VON-price. The models differ from each other due to two different approaches of investigating the correlation of view factors with the VON-price. The first model combined all views on PGS into one variable. The second model separated the views of the PGS by including different dummy variables for each PGS. Table 13 illustrates the different variables of the two models.

Table 13: Included variables HPM for model 1 and 2 (own figure)

	Model 1	Model 2
VON-Price Indexed (dependent variable)	X	X
Floor level	X	x
Area, outdoor area	X	X
Number of rooms, bedrooms, badrooms, toilets	X	X
Date start construction	X	X
Date delivery construction	X	X
Orientation sun	X	X
Type of outdoor area	X	X
Distance to public transport within 500m	X	X
Distance to PGS within 300m	X	X
View on Erasmusbrug	X	X
View on the Maas	X	X

View on Euromast	X	X
View on collective (rooftop) garden	X	X
Number of views on PGS	X	
View on Wijnhaven		X
View on Het Park		X
View on Kralingse plas		X
View on Mallegatpark		X
View on Zuiderpark		X
View on Dokhaven		X
Observations	977	977
Adjusted R^2	0.916	0.913
F-score	287.523	256.037

Appendix E shows the coefficients and intercepts of both the models. Both models have a high adjusted R^2 of 0.916 and 0.913, respectively. This indicates that the correlation is reliable and that most this correlation is determined by the included independent variables.

The definite two models are preceded by several testing models. The testing models are mainly performed to test the key assumptions for a HPM, which are heteroscedasticity and multicollinearity. The Breusch-Pagan test showed a *p>0.05* which concludes that the hypothesis for heteroscedasticity cannot be rejected for the two definite models. The VIF scores of most variables were under 10 for the two models, except for the orientation values. During the testing phase, some variables that were initially included in the model showed multicollinearity with other variables. As for this reason, some of these variables are left out of the model.

Functional

The PGS variables of the functional domain were initially included by various variables in the hedonic pricing model, shown in table 15. This table shows per variable the percentage of impact on the VON-prices of the selected high-rise buildings.

The variable distance is expressed by the dummy variable if the distance to a PGS is within 300m. A 300m distance is seen as the maximum walkable distance residents are willing to walk to facilities for leisure such as parks (CROW, 2016). The HPM uses a dummy variable for this variable as it has two options, “yes = 1” and “No = 1”. Figure 30 shows the proximity to a PGS for the included apartments. This figure shows most of the included apartments have a proximity of 300m or less to a PGS.

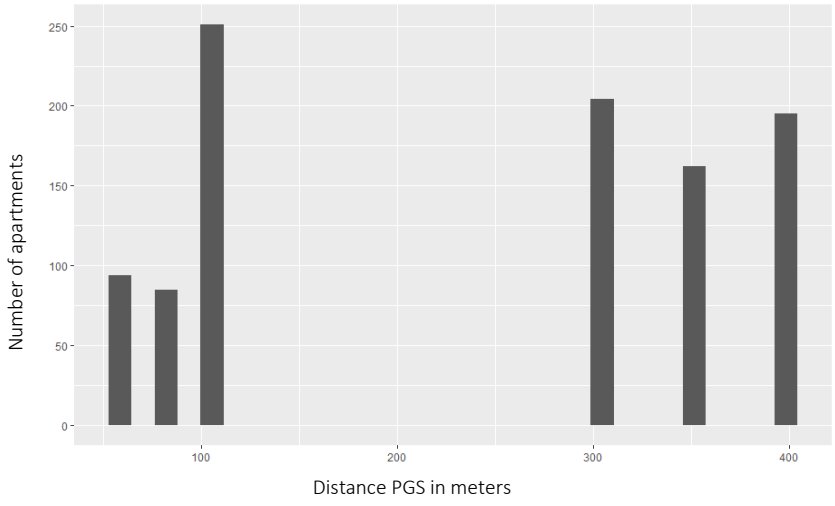


Figure 30: Distance to signature park for the selected high-rise buildings (own figure)

The two hedonic pricing models show a strong relation between a PGS and the VON-price with a correlation of 0.157 and 0.177, shown in table 14. If a PGS is located within 300 meters of the high-rise building apartment there is a premium of 15.7 to 17.7%, compared to the situation were this is missing. This effect shows the residents' urge of wanting a PGS nearby their apartment. The high premium suggests a reflection of the underlying appreciation of the associated benefits such as aesthetics, sense of belonging and well-being. The difference in between the percentages of the two models can be explained by a possible positive impact of the view variables that are included in model 2.

Compared to other studies that determined the effect of public spaces regarding the housing price, the results of this study are a bit higher. Jim & Chen indicated an increase of 14.93% in housing price for high-rise apartments in Hong Kong within a walking distance. Noor et al. (2015) found an increase between 3-12% for housing prices of all sorts of properties in Selangor Malaysia. A comparison with studies that included ground bounded houses in their studies to determine the correlation between the distance to green spaces and the housing price, show that this correlation is higher for high-rise buildings than ground bounded houses. This assumes that high-rise residents have a higher urge to live nearby PGS. As apartments often have less outdoor space than other type of houses, this could explain the urge for having a PGS nearby and the willingness to pay for this.

The dummy variable of having a signature PGS within a five-minute walking distance is left out of the HPM as this is highly correlated with the dummy variable of having a PGS within 300m. The PGS closest to the selected high-rise buildings were mainly signature PGS. Six out of the nine selected high-rise buildings have a signature park as nearest PGS.

Accessibility target groups

Table 14 shows also the variables to assess the relation with accessibility for different target groups and the VON-price. As they have a large intercorrelation to the dummy variable of the distance to a PGS, the accessibility for different target groups is left out of the definite hedonic pricing models. The PGS that were closest to the high-rise buildings were all children friendly. Therefore, it can be assumed that this indicator has the same coefficient as the 300m distance variable. For the accessibility of PGS that allows dogs, a testing model is performed that included a dummy variable for this and excluded the 300m distance dummy variable. Performing this testing model could still indicate a possible effect on the VON-price. The rest of the variables remained the same. The coefficients of these variables are also put in table 15. The coefficient for PGS that allows dogs is 0.058. The presence of a PGS that allows dogs within a radius of 500m increases the VON-price with 5.8% compared to the absence of such PGS. This is a significant lower percentage than the distance variable of having a PGS within a radius of 300m, which could indicate that residents valuate the accessibility for dogs lower. Probably because not all residents have a dog. These are only assumptions, as the distance and accessibility dummy variable are not put into the same HPM model. In addition, both the distance and accessibility variables use a different radius which probably affect the coefficients.

Table 15: Outcomes of the functional PGS variables from the HPM (own table)

	Dummy variables	Model 1 coefficients	Model 2 coefficients	Testing model 3 coefficients
Distances	METER300PARK1	0.177 ***	0.157***	-
	ParkWalkSig1	-	-	-
Accessibility to PGS for target groups	DogFriendly500m1	-	-	0.058***
	Children500m1	0.177***	0.157***	

Significant codes: '***' = p<0,001, '**' = p<0,01 , '*' = p<0.05 , ' . ' = p<0.1

DogFriendly500m variable is performed by another regression model to prevent a biased outcome due to too many variables and multicollinearity.

The selected high-rise buildings are located close to each other which might affect the outcomes regarding functional variables of PGS. Further research is needed to see if the effect of the functional variables of PGS on the VON-price would be differently if the high-rise buildings were further spread across Rotterdam.

PGS are located within a typical area with various variables such as socio-economic and environmental variables. Since variables such as socio-economic and other demographic indicators are not included in the regression model, it is highly plausible that the impact 15.7 to 17.7% cannot fully be addressed to only the functional domain. Additionally, PGS often interact with water elements generally which have a positive impact on the housing price as well (Sander, Polasky, 2009). This is confirmed by the interview with the developer of AM.

Cultural variables

As Jim and Chen (2010) mentioned, the view on neighbourhood parks has an important role in the urban aesthetics of a city. Aesthetics of surroundings are highly influenced by the appearance of green and natural elements and thereby biodiversity. In addition, the visuals of natural elements could benefit the mental well-being of residents (Groenewegen et al., 2006).

This research investigated the view effect on the VON-price by including the views on the signature parks in Rotterdam. If the high-rise building has a collective garden, the view on this garden is included as well. As it is expected that the view on landmarks of Rotterdam have an effect on the VON-price as well, the views are also included. During the research analysis, the view variables are performed by two different approaches. The first approach investigates if more views on PGS indicate a higher premium on the VON-price. The second approach determines the view effect on the VON-price for each signature PGS separately.

Approach 1: clustering the PGS views

The first approach bundles the views on signature parks within one numeric variable, called Nviews. This variable identifies four levels of signature parks views: 0 views, 1 view, 2 views and 3 or more views. The result of 0 views is used as reference output, which can be interpreted as baseline. Figure 31 shows the distribution of number of views for the apartments. Most apartments have no view on the signature parks which can be explained as most of these apartments are located on the lower floor levels. Obstruction of adjacent buildings and other structures affect the view on these parks.

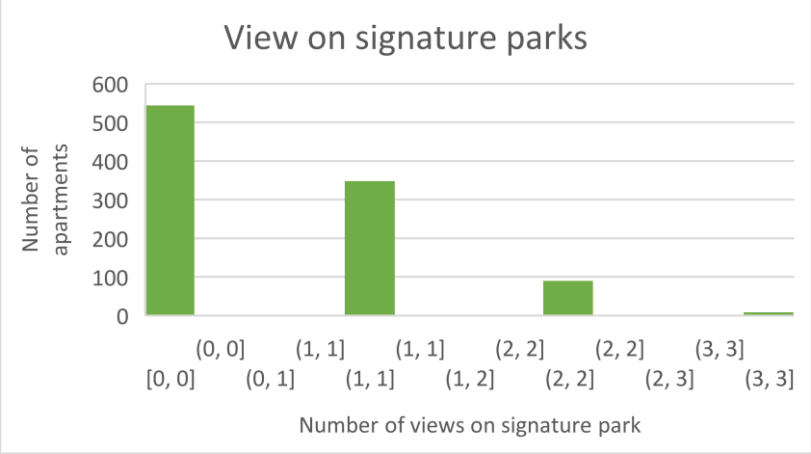


Figure 31: Number of views on signature parks

The results of the HPM for view aspects are shown in table 16. The view on one signature park has a positive coefficient of 0.004 but is not statistically significant. Therefore, it cannot be concluded that

having only 0 view does not have an impact on the housing price. Two views on signature parks shows a positive coefficient of 0.071 and has a statical significance. In other words, two views on signature parks results in an increase of 7.1% of the VON-price, compared to 0 views. In general, this assumes that residents are willing to pay more for the accessibility of views on signature parks. The view on natural elements positively affects the aesthetics of an urban area (Groenewegen et al., 2006). These natural elements are present in all the signature parks of Rotterdam.

The absence of statistically significance for 1 view could suggest that this has no significant influence on the housing price as the model indicates a low coefficient. However, this is only an assumption. The lack of statistical significance for 3 views or more could be explained by the low frequency of this measured variable. The estimated coefficient for 3 views or more is 0.094 which is inconclusive since it is not unlikely that there would be a positive effect on the VON-price.

Table 16: Outcomes of the cultural variables of PGS from the HPM (own table)

	Dummy variables	Model 1 coefficients	Model 2 coefficients
Number of views on signature PGS	Nviews 1	0.004	
	Nviews2	0.071***	
	Nviews 3 or more	0.094	
View on collective (rooftop) garden	Rooftopgardenview1	0.067***	0.055***
View on Erasmusbrug	Erasmusbrug1	0.030**	0.021
View on the Maas	Maas1	0.014	0.021
View on Euromast	Euromast1	0.013	-0.009
View on City centre	CityCentre		0.016
View on Wijnhaven	Wijnhaven1		-0.009
View on Het Park	HetPark1		0.060***
View on Kralingse plas	KralingsePlas1		0.018
View on Mallegatpark	Mallegatpark1		0.010
View on Dokhaven	Dokhaven1		0.050*

Significant codes: '***' = p<0,001, '**' = p<0,01 , '*' = p<0.05 , ' . ' = p<0.1

Approach 2: separating the PGS views

The second approach separates the view on the included PGS. Some of the signature parks that were identified in chapter 3, such as De Boompjes and Zuiderpark, are not included in the view effects as none of the apartments had a view on these parks. Figures 32 to 35 show the presence of the views on the included PGS for each of the apartments. From the 977 included apartments, most of them did not had a view on any of these PGS. Compared with the included PGS, Het Park is most seen from the apartments. Het Museumpark was difficult to measure due to the absence of green elements that stand out from a distance. Therefore, this park is eventually excluded from the regression analysis.

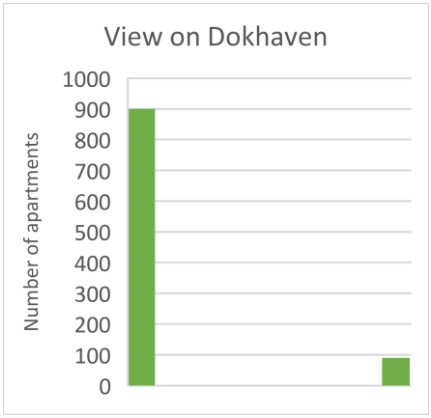


Figure 32: view on Dokhaven (own figure)

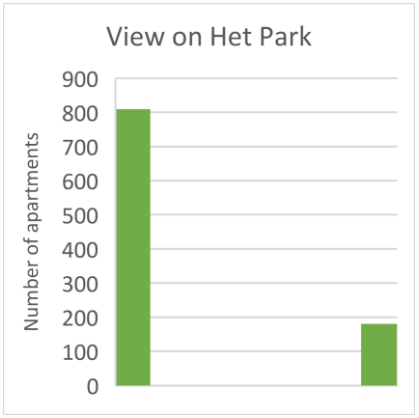
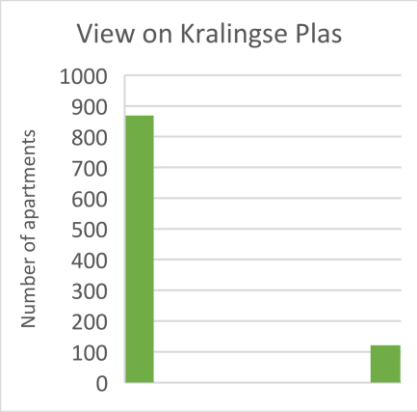


Figure 33: view on Het Park (own figure)



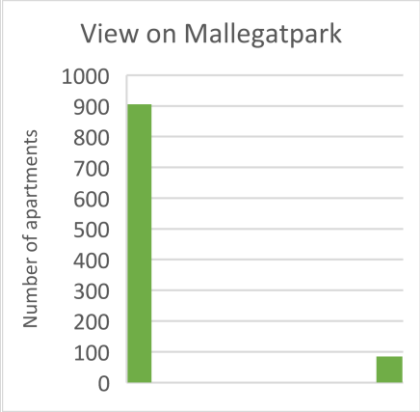


Figure 34: view on Kralingse Plas (own figure) Figure 35 Mallegatpark (own figure)

The results of the second approach are shown in table 16, identified by the coefficients of model 2. The separate PGS show in general a positively coefficient which indicates that residents are willing to pay more for a view on these PGS, indicated by the positive effect on the VON-price. However, not all coefficients are statically significant. A view on Het Park creates an increasing effect on the VON-price with 6%. This is the highest increasement compared to the other views on PGS. Het Park can be seen as one of the most popular PGS from Rotterdam as this also locates the iconic Euromast. This explains the relatively high influence. Having a Dokhaven view positively influences the VON-price with 5.0%. Despite that this park is less popular than the signature parks, it contains many natural green elements, combined with a view on the Maas. This could explain the positive view effect. The interview with the former director of Stichting Hoogbouw agrees that having a green view could be beneficial for the satisfaction of residents. This indirectly relates to the liveability level which is affected by their willingness to pay, translated in the housing price.

Other view variables

The view on collective gardens shows a positively impact on the VON-price by 5.55 to 6.7%. Models 1 and 2 show a slightly discrepancy of 1.15% which suggest that the separate views in model 2 have a small effect on the dummy variable of view on collective gardens. The positive effect of having a view on a collective garden indicates the aesthetics benefits from looking at green roofs instead of looking at the installations on a roof. As a view on the collective garden indicates the presence of one, the positive coefficient could also suggest that it is beneficial to have such a garden. This view effect suggests that looking at green roofs from other buildings could positively affect the housing price. This indicates that residents are willing to pay more to look at green roofs.

The landmarks show positive coefficients related to the VON-price, as expected to the observations from the websites stated in 4.1. This suggests that residents are more willing to pay for apartments with a certain view on popular aspects of the city Rotterdam. The positive effects on the VON-price for view on both PGS and landmarks confirms this assumption. Interviewee A and B both state that the view aspects on green, landmarks and water are indeed an important aspect that determines the housing price. Interviewee C agrees that the higher the apartment, the higher the price.

BPD developers respond to the increasing trend to focus more on the view factors of the higher apartments - Interviewee *C. (P. Becht, online interview, June 4, 2021)*

Environmental variables

The environmental variables are mostly excluded from the regression analysis due to the broadness and time-consuming aspects of the environmental domain. There is one variable used in the regression model that gives a broad indication of the environmental aspects of the area wherein the PGS is located that is closest to corresponding high-rise building. This is the physical index, explained in section 2.2.2. During the tests of the HPM models, it became clear that this index shows a high collinearity with other variables included in the models. Therefore, this index variable is left out of the final regression models. The fourth model in Appendix E refers to the testing model that includes the physical index. This model indicates a statistically significant coefficient of 0.225 for a physical index of 3, compared to a physical index of 2 that is used as reference data. Remarkably, a higher physical score of 4 has a lower impact than having an index of 3, illustrated in table 17. The physical index contains elements that are aspects of facilities, environment and living experience (Gemeente, n.d.). A high physical score of 4 could indicate that living too close to such facilities could cause nuisance which is less appreciated than having an index score of 3.

Table 17: results of HPM testing models that included the index scores (own table)

	Variables	Model 4 (physical)	Model 5 (social)	Model 6 (safety)
Physical index	Physicalindex3	0.225***	-	-
	Physicalindex4	0.144***	-	-
Social index	Socialindex3	-	0.176***	-
	Socialindex4	-	0.141***	-
Safety index	Safetyindex 4	-	-	0.153***

Significant codes: '***' = p<0,001, '**' = p<0,01 , '*' = p<0.05 , ' . ' = p<0.1

It is not surprising that the index highly affects the VON-price as this index contains many variables. Multicollinearity is assumed via the VIF test that identifies a relatively high correlation between the independent variables and the strength of this the index variable. Further research is needed to divide the variables that this index contains. The division can exclude the variable that causes this multicollinearity.

Social variables and safety variables

Initially, the social and safety variables were measured by the neighborhood indexes, established by the municipality of Rotterdam (n.d.). These are stated in table 17. The coefficients of these indexes show a strong positive influence on the VON-price in the testing models of the HPM, ranging from 14 to 17.6% compared to the lower baseline scores of the indexes. This can be explained as these indexes cluster many indicators that contribute to a pleasant living environment (Gemeente, n.d.). This also explains the multicollinearity with the distance variable, which is why these indexes were excluded from the definite regression analyses.

As the VIF test shows a score higher than 10 for possible multicollinearity, a second approach is established to make conclusions for these two domains. Some assumptions can be drawn from looking at the coefficients from the regression analysis of view variables and the presence of a PGS within 300m. The significant effects of both indicators can be partially explained by the social, environmental and safety domain. Having an attractive PGS nearby could encourage actors to use it more frequently, which increases the interaction within the city. This higher interaction ultimately improves both the social aspects, such as sense of belonging, as well as the safety aspects. The positively effect of green view from the apartments is correlated to the physical well-being of residents by means of the view on natural elements.

Reflecting on the use of the HPM, there are a lot of combinations of the variables included in the HPM possible. Further study should indicate what the best combination of these variables is to create a reliable outcome as much as possible, and in the meantime minimize the intercorrelation of independent variables.

Outcomes other variables

Variables of the building variables show the highest influence on the VON-price. The apartment area in square meters has the highest impact on the VON-price. The variables of the VON-price, area and exterior area are put into a logarithm to control the possible outliers. As expected, an orientation to the south shows a positively impact, compared to the baseline variable north. Apartments with more than two orientations, such as North and South (labelled as NZ) show a significant impact on the VON-price of 14.1 to 20.1%. The difference between these number indicate that the separated views from model 2 affect this number. Interviewee C, the developer of AM, confirms that view and sun orientation are factors that are taken both into account regarding view variables. Therefore, it can be concluded that sun orientations influence the view variables. This is confirmed by the relatively high VIF score of the orientation variables from the HPM.

A surprising result is the largely negative impact of the presence of a collective garden. Appendix E shows a negative impact of 12.8 to 15.4% on the VON-price. This is surprising, as many new developments intensively promote the presence of these gardens. In addition, the view effect on these gardens shows a contradictory outcome since these positively influence the VON-price. One possible explanation is that the presence of these gardens involves higher service costs (huurcommissie, n.d.) that reduces the willingness to pay, reflected in the VON-price. More research is needed to explore the effects of service costs regarding the VON-price. Interviewee C agrees with the literature study that semi-public gardens on the roofs or garages of high-rise buildings are another aspect that has become more a trend over the last decade. It creates an attractive view for both the apartments and the surrounded buildings. A resident of Rotterdam is aware of the relatively low amount of green in the street view. It might be nice for them to have at least a view with a green roof from their own apartment. Therefore, a view with a green roof could be appreciated even more. However, the interviewee is uncertain if this could be translated into an added value on the housing price. The effect might be too small, but it adds quality to the surrounded area.

5. Discussion and conclusions

This chapter provides the main conclusions and discussion of this research.

5.1 Conclusion

The goal of this research was to answer the main research question '*To what extend have PGS a determinant effect on the housing prices of high-rise buildings in Rotterdam?*'. The research showed the initial interest of PGS of multiple actors, what PGS aspects and non PGS aspects determine the housing price and to what extent these determines the housing price.

The context of this research lies within the city of Rotterdam and includes newly developed high-rise buildings with a minimum height of 70 meters. The willingness to pay for certain positive PGS variables is assessed by investigating their specific effects on the housing price.

Importance of PGS for residents, municipalities, and developers

The overall interest of PGS for multiple actors is investigated to recognize the importance of this research. The literature study identified that the importance of PGS is closely related to the term 'liveability', as is confirmed by the interviews of the developers and former director of Stichting Hoogbouw. Former director of Stichting Hoogbouw states that residents want to feel connected with the city. PGS can be seen as an important instrument to enhance liveability as it relates to all the liveability domains found in the comparative literature study. This connection with the city is achieved by a higher quality of life which is related to liveability as this is defined as the quality of life and satisfaction of the residents and citizens in the urban environment. The underlying goal of the municipality is to create a better performing city that attracts residents, employees, and visitors. This implies that the aspects of PGS concerning liveability domains are also important for the municipalities. Developers that work on high-rise residential buildings have a mutual interest in optimizing the different aspects of liveability since it makes their own development more attractive and valuable. As mentioned in the in-depth interview with a developer, some developers are interested in the interaction between a property and its surrounding public space to make a more attractive area, not only to the benefit of the residents of the property, but also for the city itself.

The interest of municipalities and developers is also highly connected to the financial arrangements of PGS. Creating high quality PGS often involves high development costs that is mainly paid by the municipality, performed according to the Dutch land policy. Financial arrangements could be made between high-rise developers and municipality which could lead to higher investments in PGS and thereby higher quality of PGS. All interviews confirm, however, that the current possibilities for these arrangements encounter complications concerning transparency, ownership, and constraints in negotiation due to the many rules and regulations of the Dutch land policy. Developers are willing to help to pay for the costs of PGS by various financial arrangements, but often demand an active role in the spending of their contribution in return. This complicates the process.

PGS variables influencing the housing price of Dutch high-rise buildings

This importance of PGS is further investigated by looking at the PGS variables for each liveability domain that could influence the housing price. The conclusions of the comparative literature study, supplemented with the statements from the interviews, are illustrated in figure 36.

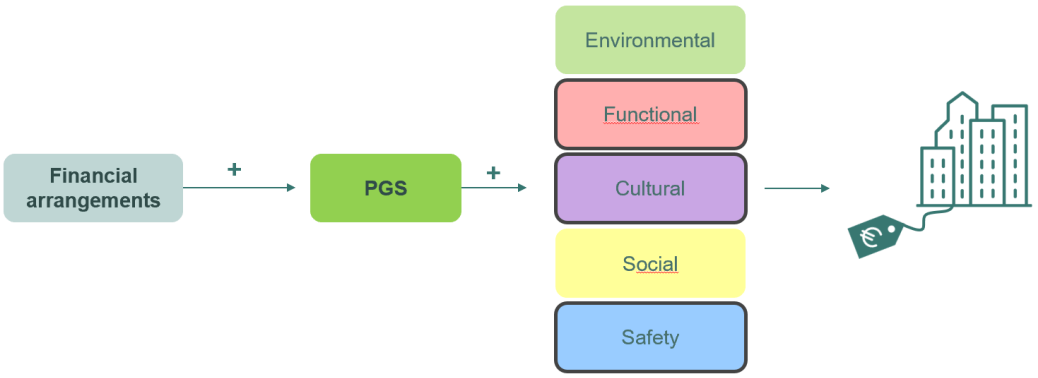


Figure 36: an overview of what factors directly and indirectly could have determinant effect on the housing price of high-rise buildings in Rotterdam, according to the findings of the comparative literature review and the interviews (own figure)

The environmental domain is of importance to residents as this contributes to both sustainability and public's health variables. Although, it is still uncertain if these could impact the housing price as the comparative literature study show no certain emphasize of the environmental aspects. The theory of Skalicky and Čerpes (2019) state that the environmental domain contributes to the well-being of residents that indirectly relates to higher liveability. Sustainability also, indirectly, contributes to the health of the residents. Seen from the comparative literature study, the municipality and residents value distance and accessibility to PGS the most important variables regarding the functional domain. The cultural domain contributes to the importance of PGS as this is connected to the attractiveness of PGS and the view variables. The social domain of PGS affects the liveability of residents particularly by the interaction between PGS and the rest of the city, according to the study of Qu and Hasselaar (2011). This social interaction is, however, not identified as most important factor within the survey and the interviews with the developers. The conducted comparative literature study and survey indicate that the safety and functional domain are identified as the most important domains as experienced by residents. Interestingly, according to the interviewees with both developers, the view variables are important factors that could increase the housing price. They contribute to the feeling of freedom and aesthetical satisfaction which is highly valuated by residents.

The municipal vision documents do not emphasize that much on the safety aspect. Instead, they emphasize most on the social interaction between the buildings and the public space. A reason for this is that this interaction indirectly relates to the social safety of residents and citizen and thereby creates solutions for a safer environment. This shows that there is a certain amount of overlap between the liveability domains.

Determination of the housing price of high-rise buildings in Rotterdam

The variables that determine the housing price are found by the literature study from 2.4 and the comparative literature study for the PGS variables. The sample size excluded multiple socio and environmental variables from the quantitative research. The extent of impact is analyzed by a regression analysis. Two regression models are performed that differ in the separation or clustering of the green view effects. The regression models show generally a positive effect of PGS variables on the housing price of high-rise buildings in Rotterdam, which confirms the hypothesis of this research. The effects on the VON-price are discussed per liveability domain.

Functional domain

The presence of a park within 300m shows the highest determinant effect on the housing price, namely an increase of 15.7 to 17.7%. The high premium suggests a reflection of the underlying appreciation of

the associated benefits such as aesthetics, sense of belonging and well-being. The interviews with the formal director of Stichting Hoogbouw and the developer point out that residents looking to buy a property might not immediately value the proximity to PGS as important. This appreciation could come as residents live there for a longer time. It could also be unconsciously appreciated as the appearance of PGS smoothly changes the aesthetics of Rotterdam. Compared to similar studies, the impact of the functional domain is relatively high. A reason for this could be that high-rise residents have a higher desire to have PGS within walking distance, compared to other studies that focused more on ground bounded houses. These studies showed a maximal increase 12% on the housing price for having a PGS within walking distance. As variables such as socio-economic and other demographic indicators are not included in the regression model, it is highly plausible that the impact 15.7 to 17.7% cannot fully be addressed to only the functional domain. Interviewee B and C agree that the presence of a park is highly valued by residents of high-rise buildings. However, the statements of the interviews show contradicting outcomes as not all developers agree that the value of PGS could be directly related to the housing price.

Cultural domain

As for the cultural domain, the view effects are measured for the number of PGS views, the certain types of signature parks and the iconic landmarks of Rotterdam. Having two green views from your apartment increases the housing price with 7.1% compared to having no PGS view at all. As the sight on a PGS can only be seen without any obstruction of other buildings, it is assumed that this percentage includes also positive effect of having no obstructive buildings in your view. As for the separate signature parks, having a view from your apartment on Het Park, one of the most iconic parks in Rotterdam, specifically shows an increase of 6.0% to the housing price. As expected, the landmarks such as the Erasmusbrug show a positive effect on the VON-price as well with an increase of 3.0%. The interview with the developer confirms these findings, as view aspects are seen as highly desirable for residents. Especially for a city with certain iconic landmarks.

Social, environmental and safety domain

A few assumptions can be made for variables that were harder to measure within the regression model. This is done by two approaches. First, some assumptions can be drawn from looking at the coefficients from the regression analysis of view variables and the presence of a PGS within 300m. The significant effects of both indicators can by partially explained by the social, environmental and safety domain. Having an attractive PGS nearby could encourage actors to use it more frequently, which increases the interaction within the city. This higher interaction ultimately improves both the social aspects, such as sense of belonging, as well as the safety aspects. The positively effect of green view from the apartments is correlated to the physical well-being of residents by means of the view on natural elements.

A second approach includes the variables for safety, social and physical indexes within a regression model, shown in appendix E. These indexes show a strong positive influence on the VON-price in the testing models of the HPM, ranging from 14.1 to 22.5% compared to a lower index score. This can be explained as these indexes cluster many variables that includes other domains.

Overall, the regression analysis show that PGS have a positive determinant effect on the housing price of high-rise buildings. This is according to the expectations from the literature that formulated the hypothesis. The hypothesis is therefore confirmed. The regression analysis identified the functional and cultural as the two PGS domains that have the highest effect on the housing price of high-rise buildings. This is supported by the results of sub-question 2 which identified the functional, cultural and safety domains as most important for the housing price of high-rise buildings. The expected high influence of the safety domain cannot be fully confirmed by the regression analysis as the safety variables were

difficult to measure. In addition, some variables of PGS have overlap between the liveability domains. This was already suggested by the literature study that addressed the overlap between the social and safety domains. This research measured the (positive) impact that PGS have on the housing price. Despite this, it is important to keep in mind that the most important variable that determines the housing price is not a PGS variable but the living area in square meters of the apartment.

One of the main difficulties of regression analyses is to meet the key assumptions needed for an unbiased outcome, described in section 3.5.1. As the housing price is determined by many variables, the regression analysis was the most suitable approach for this research. Although, the interconnection of independent variables is the most difficult aspect about including many variables in the regression. The testing models showed the intercorrelation between. Despite preventing this intercorrelation as much as possible by meeting the key assumptions, it is still possible that there are some variables that still intercorrelate. Therefore, the coefficients of the regression analysis can only be identified as reference point, not as a decisive conclusion. The interviews are used as extra validation of the results which show that most of the important results from the regression analysis are valid, according to the experts.

5.2 Limitations

Multiple practical limitations are acknowledged due to the given timeframe for the research and the complexity of intercorrelations that could be included in the regression analysis. The main limitation of this research can be found in the complexity of inclusion of variables regarding PGS.

- There is a risk of bias due to overlap between the liveability domains and, thereby, their variables. Results of regression analysis could be biased by functional variables other than the presence of PGS. PGS in Rotterdam are often located near other elements that could affect the housing price, such as water which could influence the attractiveness of the PGS. Consequently, besides the effect on the functional domain, this could also affect the cultural domain.
- As the literature discussed, the results of regression analysis are highly context dependent. Therefore, the coefficients from the regression analysis could not be generally used for other cities. Additionally, comparing the results with other studies makes it difficult as every study uses its own variables, methods, and study area. Therefore, no generalization of the impact of PGS can be drawn for a larger sample size (Sander, Polasky, 2009).
- The housing price is expressed by a broad scope of variables. Due to the timeframe of this study, it was impossible to include all these variables in the hedonic pricing model. An attempt is made. However, many locations dependable variables showed intercorrelations with the independent variables regarding PGS. Including these would have let to independent variable bias. Therefore, multiple location variables are left out the regression analysis. This could have resulted in slightly different results of the regression even though the key assumptions of the HPM met the requirements.
- Not all interviewees are convinced that a high quality of PGS can directly be related to a higher housing price. The interview with the developer from AM confirms the positively effect of PGS on the quality of the living area. She finds it, however, difficult to directly relate this increased quality to a higher housing price. Contradicting to the interview with the developer of AM, the interview with the BPD developers is convinced that PGS easily could lead to a 10 to 15% increase on the housing price. Using the willingness to pay as measurement to determine the value of PGS is a topic of discussion.
- This research used dummy variables for the presence of PGS since only the acceptable walking distance is investigated. Further studies could include a continuous variable to get an extensive overview on the distance effects. This might show possible negative consequences of living

nearby noisy areas. Living nearby crowded places such as shopping centres could increase nuisance values that lower the housing value (Sander and Polasky, 2009). Further research or adjusting these variables is recommended to see if this applies to crowded PGS as well.

5.3 Implications

The results of this research have multiple important implications for the developers, municipality, and residents. Overall, the research can be seen as starting point to make the value of PGS more tangible. This is needed to put more emphasize on the magnitude of PGS for creating higher quality of life for its residents. The research showed that this importance is reflected in all the five liveability domains. Currently, the Netherlands has many planned high-rise building developments to catch up with foreign countries that are more established in developing high-rise buildings. The prognosis is that the Netherlands will have 440 high-rise buildings in 2040, which is double the current number (Vastgoed Journaal, 2021). If the impact of PGS on the housing prices of high-rise buildings will not be acknowledged, the mismatch between the desires of high-rise residents and current PGS becomes even larger.

Therefore, the municipality, developers and residents should all become more aware of this impact. The municipality should implicate the effects of PGS within the urban developments of new PGS. This can also be done for improvements of existing PGS as higher quality of PGS is desired when the population grows, confirmed by the interview with the urban developer of the municipality of Rotterdam. Developers of high-rise buildings should take the different effects of PGS variables on the housing price into consideration when developing new high-rise buildings to maintain a high quality of life. To fully consider these impacts, the method of measuring the impact of PGS can be useful during pricing strategies. The interview with the developer of BPD suggest that quality of life can be both achieved within the buildings as in the surroundings due to PGS or similar spaces. Semi-private rooftop gardens could be used to increase the quality of life for example. The results can also be useful for municipalities and developers who are looking for a proper location to build residential high-rise buildings or PGS. Only the city of Rotterdam is included, which makes it a reliable result for high-rise buildings of Rotterdam which took multiple aspects of both the building and its environment into consideration. Therefore, it could be especially useful as an advice for developments in Rotterdam. Additionally, the results of the positive effects of PGS could be used as motivator for municipalities and developers to make better investment agreements with each other.

> ***All newly developed buildings will be built at a place where already buildings stand or have stood. So, no green space is extracted for new buildings.*** - Interviewee *D. (E. Arends, online interview, June 2, 2021)*

The main results show the impact of the presence of certain PGS variables. But what happens if there is a (sudden) absence of PGS? The consequences for municipalities and residents should be considered if PGS that residents were attached to disappeared. The interview with the urban developer of the municipality of Rotterdam states that no existing green space will be removed for other developments. Although, it could happen that only a small portion of PGS, such as a tree, is removed. The resident could contact the municipality, but currently it is very uncertain if the resident can make a solid complaint to claim the value of the tree back. The methods used in this research could help to quantify the value of a particular PGS, which could be useful for further jurisdictional procedures to claim the value of the PGS back.

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5.4 Recommendations

During this research, some interesting aspects for possible future studies were identified. The main recommendations are summed up for further research and for municipality, residents and developers. An overview is given in figure 37.

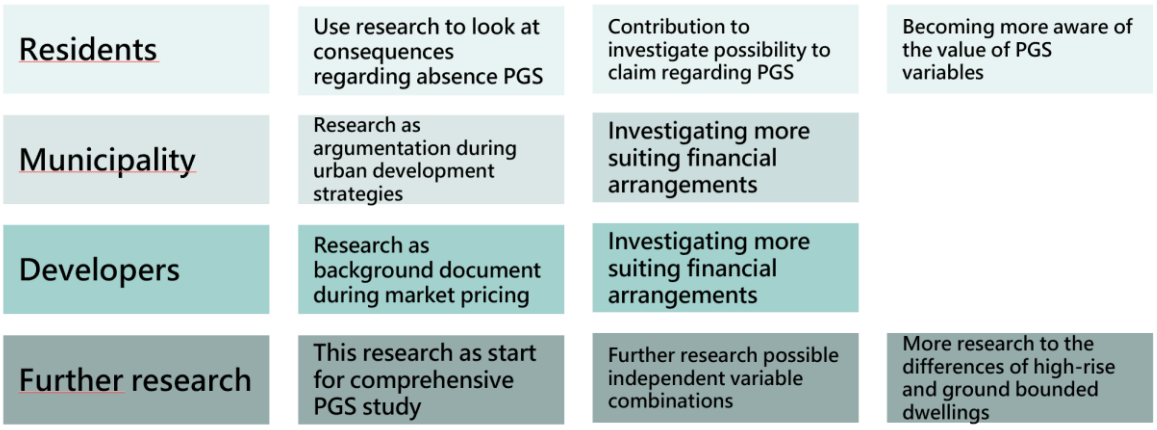


Figure 37: recommendations per actor (own figure)

Further research

The main recommendation is to use the input of the regression analysis in this research as key stone for a more extensive research on PGS and high-rise buildings in Rotterdam. This can be supplemented by other variables that were too complex to measure in the HPM given the timeframe of the graduation process. Other variables that relate to PGS, such as the air quality, could be implemented. Additionally, more locational, and socio-economic aspects of the area could be implemented to make the results an even better replication of the reality.

This research could be expanded to a larger sampling size to create a higher external validity. A more diverse and larger sampling size might lead to key differences compared to the results of this research.

This study assessed the PGS value by only looking at the willingness to pay regarding the VON-price. High-rise residents often pay monthly service costs for facilities such as a collective garden or gym facilities. Further research is recommended to investigate if the monthly payment affects the willingness to pay for certain facilities. Especially since this research found a negative effect of these facilities on the housing price which could indicate that this is related to (too) high monthly payments.

This study found a higher impact of PGS within a radius of 300m, compared to other studies that identified the walkable distance to a PGS. A comparative study between ground bounded houses and high-rise cities could verify if the larger impact of the presence of PGS on the VON-price is caused by a higher appreciation of the residents of high-rise buildings. This leads to important conclusions that are useful for a better connection between the wishes of residents and the implementation of PGS.

Developers of high-rise buildings

Price structure of newly build dwellings are substantiated by a marketing research. According to the interview with the developer of AM, this is conducted by multiple sources such as empirical data from the neighborhood, consultancies, and brokers. Within this search, proximities to parks, supermarkets, public transports, and other facilities are included in the pricing calculations. This marketing research is only used as advice, it is not automatically decisive for the final price. The final decision for which the price is put on the market is made by the developer. The method of this research could be used as

reference approach for the marketing research or during approval sessions regarding investment decisions. During these discussions, an overview of quantified effects on the housing price put in a reference document could be useful to justify the price structure. Like the market research, it is not desirable to use it as a decisive tool. The experience of developers comes first. With this experience, they can evaluate the results from research.

Another recommendation is to use the results of the semi-private rooftops as reference during the decisions for the purpose of the roof. Meeting the energy requirements should probably always be more important, however, it can help to be willing to look at other solutions to meet this sustainability requirement.

Municipality of Rotterdam

Similar to the recommendation of the developers, the methods and results of this research can be used to during urban redevelopment strategies to add more greenery to the city.

According to interviewee C, a developer can have contact with the potential buyers when he is involved until the sale of the apartments. This contact gives insights in the opinion of buyers which can be used as lessons learned for next projects. During the development, the architects and developers have a say in the looks and variables of the building. These fall within the guidelines the municipality determines. According to the interviewee C, buyers are rarely asked for their opinion via small participation projects. Especially when it is used to gain new insights in the opinion about public space. The main reason for this is that the municipality sets up the guidelines for the interaction with the public space. A developer and architect must work between these guidelines which leaves less room for creativity. Earlier involvement of all the actors could lead to better matching developments, both for PGS and high-rise buildings.

Financial arrangements

As section 4.2.2 discusses, various approvements can be made between the developer and the municipality. Further research is needed to look more into detail at the current negotiations, especially focused on the aspects of transparency regarding payments and ownership rights. Interviewee D discusses the new Environmental and Planning Act (Omgevingswet) that helps to simplify the regulations for spatial projects. Although, interviewee C has its doubts as it takes many years until this act is fully integrated in the Dutch land policy. This transition phase could cause new communications struggles.

> ***This act makes it possible to easily split the costs of the construction of certain urban developments in a fixed percentage, instead of using the previous complex additional payment arrangements.***
>
> . - Interviewee *D.*
>
> *(E. Arends, online interview, June 2, 2021)*

Further research is needed to investigate the disadvantages of this new act.

6. Reflection

6.1 Method & results

The research used a wide variety of different research methods. Initially, only the quantitative regression analysis, a HPM, was chosen to apply. During the process, this method showed some limitations that could affect the quality of the research. HPM is a frequently used model for empirically assessing the effect of structural and location aspects. Although it is a commonly used approach, some flaws were identified during the process. As Kauko (2003) explains, the HPM shows difficulties regarding its flexibility, functional discontinuity and data quality. Additionally, the nature of the value formation can be questioned as it might not fully assess a reliable reflection of the value of variables included in the model.

To give my research a more comprehensive outcome, interviews with experts are conducted. Although this does not entirely solve all the flaws of the regression model, the statistical results can be validated into the practical context of high-rise and PGS developments. By doing both a quantitative and qualitative method, given the time frame, not all aspects regarding PGS variables can be fully investigated. The results of my research methods give mainly key elements as starting point to assess the valuation of PGS comprehensively.

6.2 Personal reflection

Looking back at the whole graduation process it was a rollercoaster of various emotions. Choosing the general topic was quite easy. Ever since the start of my bachelor Architecture, I always had a fascination for high-rise buildings and high-density areas. To choose a topic that interested me for over so many years made the start of my graduation very exciting. Looking further into detail in the topic of high-rise buildings, I found it hard to find a research gap in literature that was innovating enough to investigate. The period until the P2 consisted of reading, reading, and further reading to determine the research subject and find a suitable methodology. Despite the challenge of finding a knowledge gap, the motivation to proceed had always been there. Halfway the P2, there was a sudden decline in my motivation and progress of the graduation. I could not draw clear conclusions from the read literature, so I struggled to further define my subject. My mentors guided me as much as possible through this process and helped me find interesting perspectives of high-rise buildings and liveability aspects.

The working from home situation, due to the COVID 19 pandemic, resulted in extra difficulties for me to find help by the mentors and especially by other students. Looking back at the emotional roller coaster for the P2, I was relieved that there was progress made within a few weeks for the P2. Although, the results of the P2 were too broad and many concepts were still undefined or vague.

After the P2, some mayor changes had to be made within the approach of my graduation. Together with my mentors, we established more meetings to keep them updated. Additionally, I reached out to other students to discuss the process. Despite the improvements made in the process, it was still a difficult period as some key research decisions had to be made. The period before the P3 consisted mainly of finetuning the research method and identifying the variables and indicators to include in the research. This process was very time consuming since I had difficulties to scope the topic.

The P3 showed that the chosen statistical approach might not give an entirely reliable result. At first, this was a major disappointment for me as my expectations regarding graduation were to come up with significant findings that will have large influence on the body of knowledge, concerning high-rise buildings. Processing the feedback gave me a turning point in the, so far, difficult process of my

graduation. From this point, I decided to quickly start with the data collection. By collecting data, I obtained a better overview of the possibilities for the further analysis of my research. The period of collecting data was a fun process as it finally showed some of the results that were first only hypothetical findings from literature reviews.

By doing both a quantitative and qualitative I might have asked to much of myself given the timeframe of the graduation process. Despite the additional work of conducting interviews and analysing them, I gained more confidence in the result of my research. Thereby, combining quantified data with practical experience from people that have worked with high-rise buildings was very interesting. Hearing the actual opinion of both interviewees and participant from the survey made my research more tangible. As this was one of my personal study goals, I am very happy that these are included in my research. Towards the P4 was an intensive process, especially for finding the balance in the regression analysis between a biased outcome and inclusion of important variables. Looking back at this process, I think that a large progress is made. Some further elaboration of the results from the regression analysis has to be made. This is mainly done by conducting 2 more interviews with someone from the municipality of Rotterdam and a developer. In my opinion, the charm of my research is the unique combination of doing both a quantitative and qualitative research.

During the period towards my P5, I tried to include all the feedback that was given during my P4. This was mainly to look at the larger context, the meaning of my results and a restructuring of the last 3 chapters. The biggest challenge in this phase was to know when certain aspects of the thesis are done. It feels like an ongoing report that is never fully finished. While putting my results in the larger context, multiple new news articles appeared that discussed the rising trend of high-rise buildings and its pros and cons. This once again proved that my topic is important for the future of high-rise real estate in the Netherlands. I am proud that I could have contribute a small part in the relatively, yet to be discovered world of Dutch high-rise buildings.

7. References

Binti Shukri, F. A., & Misni, A. B. (2017). The impact of roof gardens at high-rise residential buildings on property values. *Sustainable Development and Planning IX*, *226*, 39.

Blaikie, N., & Priest, J. (2019). *Designing social research: The logic of anticipation*. John Wiley & Sons.

Bouwen en Uitvoering. (2017). Perzisch tapijt landt op Schouwburgplein. Retrieved May 9, 2021 from https://bouwenuitvoering.nl/varia/perzisch-tapijt-landt-op-schouwburgplein-otterdam/

Buitelaar, E., & Witte, P. (2011). *Financiering van gebiedsontwikkeling. Een empirische analyse van grondexploitaties.* Den Haag, Planbureau voor de Leefomgeving.

CBS. (2021). Consumentenrpijzen; prijsindex 2015=100 [dataset]. Retrieved from: https://opendata.cbs.nl/statline/#/CBS/nl/dataset/83131ned/table?fromstatweb

CBS. (2020). Nabijheid voorzieningen; afstand locatie, wijk- en buurtcijfers 2019 [dataset]. Retrieved from: https://www.cbs.nl/nl-nl/cijfers/detail/84718NED?q=natuur%20en%20milieu

CROW. (2016). *Voetganger* [Dataset]. Retrieved from https://www.crow.nl/duurzame-mobiliteit/home/systeemintegratie/voetganger/loopafstanden-in-cijfers

De Haan, F. J., Ferguson, B. C., Adamowicz, R. C., Johnstone, P., Brown, R. R., & Wong, T. H. (2014). The needs of society: A new understanding of transitions, sustainability and liveability. *Technological Forecasting and Social Change*, *85*, 121-132.

de Haan, J., & Diewert, E. (2013). Hedonic Regression Methods. *Handbook on Residential Property Price Indices*, 49–64. https://doi.org/10.1787/9789264197183-7-en

De Kam, G. R. W. (2007). *Grondbeleid belangrijk fundament onder prestatieafspraken*. Bank & Gemeente, vol. jul/aug, iss. 34, (2007), pp. 18-22

De Zeeuw, W. C. T. F. (2013). Grondbeleid: met een paar moderniseringen kunnen we weer vooruit. *VHV Bulletin, 41 (juli), 2013*.

Fakton. (2020). *Hoogbouw G4* [Database]. Access on request.

Gemeente Amsterdam, (2011). Hoogbouw in Amsterdam. Retrieved from https://www.amsterdamsebinnenstad.nl/archief/hoogbouw/hoogbouwvisie.pdf

Gemeente Eindhoven, (2020). Verdichtingsvisie Eindhoven. Retrieved from https://www.eindhoven.nl/projecten/overige-projecten/verdichtingsvisie-binnenstad

Gemeente Den Haag, (2017). Eyeline en Skyline. Retrieved from https://denhaag.raadsinformatie.nl/modules/13/overige_bestuurlijke_stukken/421594

Gemeente Rotterdam (n.d). *Wijkprofiel.* Retrieved March 29th 2021, from https://wijkprofiel.rotterdam.nl/nl/2020/rotterdam

Gemeente Rotterdam. (n.d.). *Parken*. Retrieved June 14 2021, from https://www.rotterdam.nl/vrije-tijd/parken/

Gemeente Rotterdam (2018). *Grondbeleid.* Retrieved February 18th 2021, from: https://www.watdoetdegemeente.rotterdam.nl/jaarstukken2018/paragrafen/grondbeleid/

Gemeente Rotterdam (2019). Hoogbouwvisie 2019. Retrieved from https://www.stichtinghoogbouw.nl/wp-content/uploads/2019/10/Hoogbouwvisie-2019.pdf

Gemeente Rotterdam (2020). Vaststelling bestemmingsplan 'Cool'. Retrieved from https://www.planviewer.nl/imro/files/NL.IMRO.0599.BP1109Cool-va01/vb_NL.IMRO.0599.BP1109Cool-va01.pdf).

Germán, L. & Bernstein, E. (2018). *Land value capture* [brochure]. Retrieved from https://www.lincolninst.edu/sites/default/files/pubfiles/land-value-capture-policy-brief.pdf

Getter, K. L., & Rowe, D. B. (2006). The role of extensive green roofs in sustainable development. *HortScience*, *41*(5), 1276-1285.

Groenewegen, Peter P., Agnes E. Van den Berg, Sjerp De Vries, and Robert A. Verheij. "Vitamin G: effects of green space on health, well-being, and social safety." *BMC public health* 6, no. 1 (2006): 1-9. Retrieved from https://bmcpublichealth.biomedcentral.com/articles/10.1186/1471-2458-6-149

Hill, R. J. (2013). Hedonic price indexes for residential housing: A survey, evaluation and taxonomy. *Journal of economic surveys*, *27*(5), 879-914.

Hobma, F. (2020). Gemeentelijke strategieën voor private bijdragen aan publieke voorzieningen. Retrieved December 22, 2020, from https://www.gebiedsontwikkeling.nu/artikelen/gemeentelijke-strategie%C3%ABn-voor-private-bijdragen-aan-publieke-voorzieningen/

Huurcommissie. (n.d.). *Servicekosten.* Retrieved at May 9th 2021 from https://www.huurcommissie.nl/faq/servicekosten-en-nutsvoorzieningen/welke-kostenposten-vallen-onder-servicekosten

Hypotheker. (n.d.). Vrij op naam. Retrieved on April 28th 2021 from https://www.hypotheker.nl/begrippenlijst/huis-kopen/vrij-op-naam/#:~:text=Het%20kopen%20van%20een%20woning,staat%20k.k.%20'kosten%20koper'.

Jim, C. Y., & Chen, W. Y. (2010). External effects of neighbourhood parks and landscape elements on high-rise residential value. *Land Use Policy*, *27*(2), 662-670.

Jones, K. (2000). A regrettable oversight or a significant omission. *Ethical Considerations in Quantitative Research in Education.'In Situation Ethics in Educational Research, Simons, H. and Usher, U.(eds)*, 147-161. Retrieved from https://eprints.soton.ac.uk/26792/1/Jones_ethics_in_quant_methods_2000.pdf

Kauko, T. (2003). Residential property value and locational externalities. Journal of Property Investment & Finance.

Kain, J. F., & Quigley, J. M. (1970). Measuring the value of housing quality. *Journal of the American statistical association*, *65*(330), 532-548.

Kolbe, J., & Wüstemann, H. (2014). *Estimating the value of urban green space: a hedonic pricing analysis of the housing market in Cologne, Germany* (No. 2015-002). SFB 649 Discussion Paper.

Leby, J. L., & Hashim, A. H. (2010). Liveability dimensions and attributes: Their relative importance in the eyes of neighbourhood residents. *Journal of construction in developing countries*, *15*(1), 67-91.

Li, C., Sun, L., & Jones, P. J. (2012). Liveability of high-rise housing estates: a resident-centered high-rise residential environment evaluation in Tianjin, China. *ththt*. Retrieved from http://orca.cf.ac.uk/50205/1/Chenguang.pdf

Licher, H. (2020, September 3). Rotterdam na Corona: minder verstenen, meer vergroenen. *NRC.* Retrieved at September 20, 2020 from https://www.nrc.nl/nieuws/2020/09/03/rotterdam-na-corona-minder-verstenen-meer-vergroenen-a4010487

Maas, J., Verheij, R. A., Groenewegen, P. P., De Vries, S., & Spreeuwenberg, P. (2006). Green space, urbanity, and health: how strong is the relation?. *Journal of Epidemiology & Community Health*, *60*(7), 587-592.

Niu, J. (2004). Some significant environmental issues in high-rise residential building design in urban areas. *Energy and buildings*, *36*(12), 1259-1263.

Noor, N. M., Asmawi, M. Z., & Abdullah, A. (2015). Sustainable Urban Regeneration: GIS and Hedonic Pricing Method in determining the value of green space in housing area. *Procedia-Social and Behavioral Sciences*, *170*, 669-679.

Piekstraat. (n.d.). *Woningtypes*. Retrieved from https://www.piekstraat.nl/woningtypes/

Pincetl, S., & Gearin, E. (2005). The reinvention of public green space. *Urban geography*, *26*(5), 365-384.

Qu, L., & Hasselaar, E. (2011). *Making room for people: choice, voice and liveability in residential areas* (p. 196). Techne Press.

Raaij, M. (2020). Jaaroverzicht 2020: verdere verdichting stedelijke gebieden. Retrieved from https://architectenweb.nl/nieuws/artikel.aspx?ID=48625

Rijksoverheid. (n.d.). Grondbeleid. Retrieved at Februari 22 2021 from https://www.rijksoverheid.nl/onderwerpen/ruimtelijke-ordening-en-gebiedsontwikkeling/grondbeleid

Saphores, J. D., & Li, W. (2012). Estimating the value of urban green areas: A hedonic pricing analysis of the single family housing market in Los Angeles, CA. Landscape and urban planning, 104(3-4), 373-387.

Sander, H. A., & Polasky, S. (2009). The value of views and open space: Estimates from a hedonic pricing model for Ramsey County, Minnesota, USA. Land Use Policy, 26(3), 837-845. Retrieved from https://reader.elsevier.com/reader/sd/pii/S0264837708001324?token=7E9188BF377AEC5B7F6BC48627E4066249FE034DBE3FACBDE55A1F9DEC7B44AB7FAA73A18BC0853A86CD9CC105406460&originRegion=eu-west-1&originCreation=20210510132750

Shaw, K., Frazer, S., Robbins, C., Smith, I., Fuller, C., Geddes, M., Johnstone, C., & Nunn, A. (2004). *Liveability in NDC areas* (No. 22). https://core.ac.uk/download/pdf/4149247.pdf

Skalicky, V., & Čerpes, I. (2019). Comprehensive assessment methodology for liveable residential environment. *Cities*, *94*, 44-54. Retrieved from https://www.sciencedirect.com/science/article/pii/S0264275118315671?casa_token=1n_ebcEegtsAAAAA:H_R7pgk0I80oJqMieKaFxHn5Jptt7OYFMHgYBdY111PysyH9eWzcMvbpPYOQP9BRlYXIyCe6.

Smits, M., Ramp, M., Nab, M., Santing, J., Deloitte (2013). Overheveling kosten eerste aanleg riolering van grondexploitatie naar rioolheffing. *Grexpert*, (31), 1–7. Retrieved from https://www2.deloitte.com/content/dam/Deloitte/nl/Documents/real-estate/deloitte-nl-grexpert-nummer-31-2013.pdf.

Sorel, N., Tennekes, J., Galle, M. (2014). Bekostiging van publieke voorzieningen bij organische gebiedsontwikkeling. *PBL (Planbureau voor de Leefomgeving), 7, 10-12.* Retrieved from

https://www.pbl.nl/sites/default/files/downloads/PBL_2014_Bekostiging-van-publieke-voorzieningen-bij-organische-gebiedsontwikkeling_1057.pdf

Stichting Hoogbouw. (n.d.). Stichting. Retrieved on June 14, 2021, from https://www.stichtinghoogbouw.nl/.

Stichting Hoogbouw. (2021). Podcast 3 de toren van Babel. Retrieved on April 2, 2021, from https://www.stichtinghoogbouw.nl/stichting/

Stoeldraijer, L., De Regt, S., Van Duin, C., Huisman, C., & Te Riele, S. (2020, December 16). Bevolkingsprognose 2020-2070: Retrieved February 17, 2021, from https://www.cbs.nl/nl-nl/longread/statistische-trends/2020/bevolkingsprognose-2020-2070-?onepage=true

Suzuki, H., Murakami, J., Hong, Y. H., & Tamayose, B. (2015). *Financing transit-oriented development with land values: Adapting land value capture in developing countries*. The World Bank.

Vereniging Eigen Huis. (n.d.). Gemeentelijke belastingen. Retrieved February 26, 2021, from https://www.eigenhuis.nl/hypotheken/belastingen/gemeentelijke-belastingen#/

Visser, P., van Dam, F., & Noorman, N. (2006). *De prijs van de plek: Woonomgeving en woningprijs*. NAi Uitgevers.

Wen, H., & Goodman, A. C. (2013). Relationship between urban land price and housing price: Evidence from 21 provincial capitals in China. *Habitat International*, *40*, 9-17.

Wong, S. K., Chau, K. W., Yau, Y., & Cheung, A. K. C. (2011). Property price gradients: the vertical dimension. *Journal of Housing and the Built Environment*, *26*(1), 33-45.

Yeh, A. G., & Yuen, B. (2011). High-rise living in Asian cities. In *High-rise living in Asian cities* (pp. 1-8). Springer, Dordrecht.

Yuen, B. (2011). Liveability of tall residential buildings. In *High-rise living in Asian cities* (pp. 129-147). Springer, Dordrecht.

Zandbelt & van den Berg. (2008). *Hoogbouw: een studie naar Nederlandse hoogbouwcultuur*. Retrieved from https://www.stichtinghoogbouw.nl/download/hoogbouwbeleid.pdf

Figures:

CasaNova. (n.d.). Uitzicht [image]. Retrieved from https://casanova-rotterdam.nl/uitzicht

City Rotterdam. (n.d.). Kralingse Plas – Kralingse Bos [image]. Retrieved from https://www.cityrotterdam.com/bezoek/parken-rotterdam/kralingseplas-kralingsebos/

Cooltower. (n.d.). *Uitzichten* [image]. Retrieved from https://thecooltower.nl/uitzichten

Funda. (n.d.). Ommoord [image]. Retrieved from https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.funda.nl%2Fkoop%2Frotterdam%2Fommoord%2Fappartement%2F&psig=AOvVaw3Yf0CYGUa_lcCeT7CuvhRc&ust=1603731914126000&source=imagesss&cd=vfe&ved=0CA4QjhxqFwoTCOjx6I2d0OwCFQAAAAAdAAAAABAD

Gemeente Rotterdam. (n.d). *Wijkprofiel* [image]. Retrieved March 29th 2021, from https://wijkprofiel.rotterdam.nl/nl/2020/rotterdam

Gemeente Rotterdam (2019). Hoogbouwvisie 2019 [image]. Retrieved from https://www.stichtinghoogbouw.nl/wp-content/uploads/2019/10/Hoogbouwvisie-2019.pdf

Parkhaven010. (n.d.). Parkhaven 010 [image]. Retrieved from https://www.parkhaven010.nl/

Schouwburgpleinrotterdam. (n.d.). Yoga op ’t Schouwburgplein [image]. Retrieved May 9 2021 from https://schouwburgpleinrotterdam.nl/activiteiten/yoga/

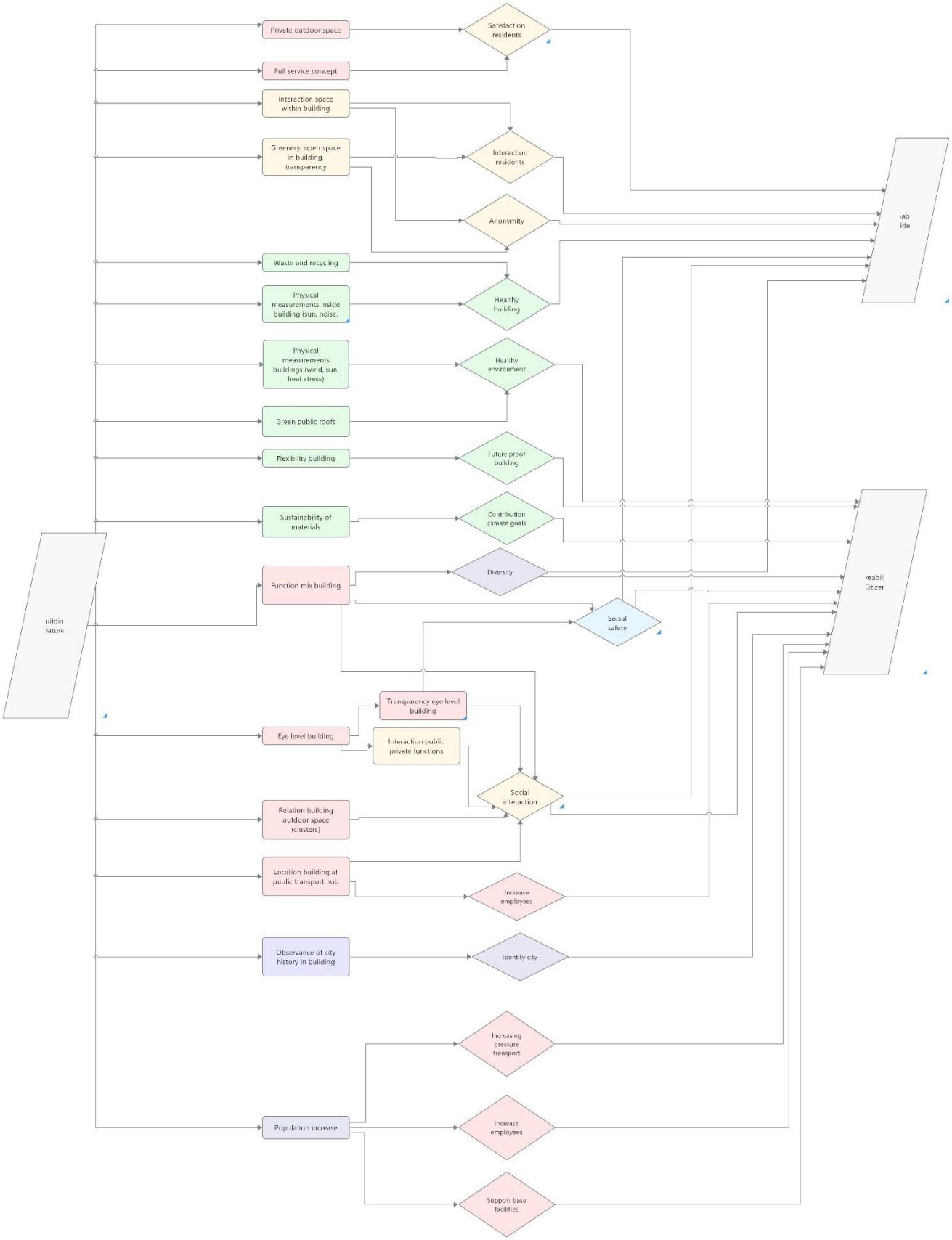
Top010.nl. (2020). SAWA Lloydpier [image]. Retrieved from https://nieuws.top010.nl/sawa-lloydpier-rotterdam.htm

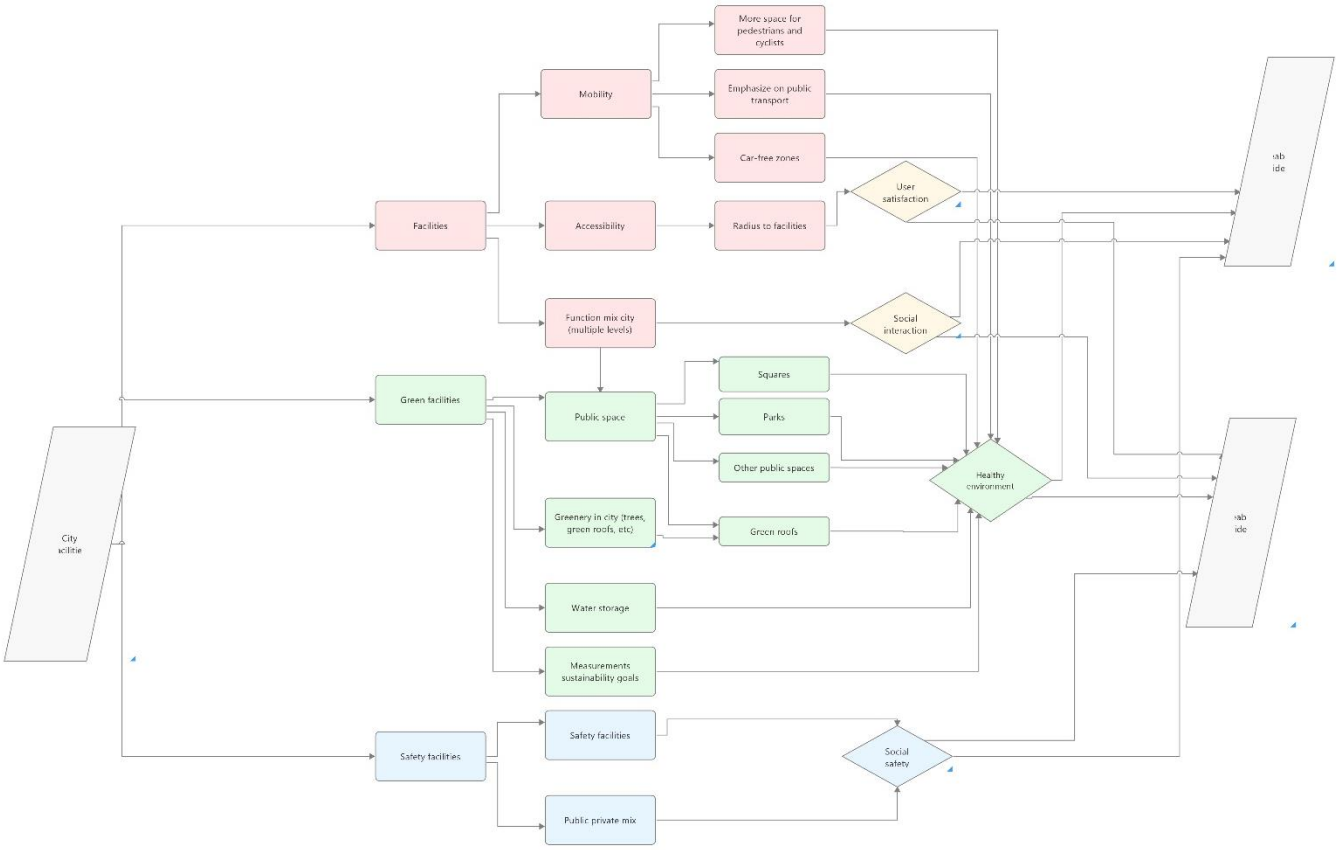
Van Dijk, F. (2018). Je hond uitlaten in Rotterdam. Retrieved April 15th 2021 from: https://indebuurt.nl/rotterdam/gemeente/je-hond-uitlaten-in-rotterdam-hier-vind-je-per-wijk-waar-dit-mag-zonder-bekeuring~63070/7/

Van Elewout, R. (2020). Ooit maakten drukkers er De Maasbode, op dezelfde plek wonen straks miljonairs [image]. Retrieved from https://www.ad.nl/rotterdam/ooit-maakten-drukkers-er-de-maasbode-op-dezelfde-plek-wonen-straks-miljonairs~a546c409/

Van Wijnen. (n.d.). De Maasbode [image]. Retrieved from https://www.vanwijnen.nl/nieuws/de-maasbode-wonen-in-een-rijwoning-op-5-hoog/

Appendix A: Flowchart liveability perspectives and domains

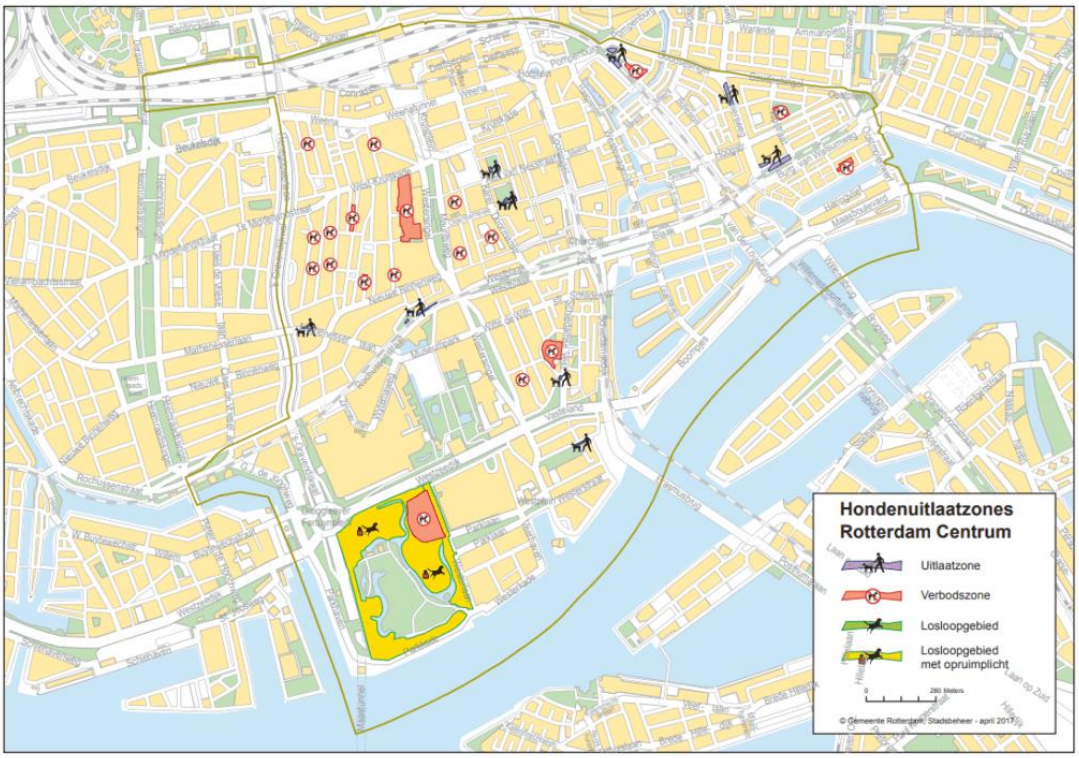


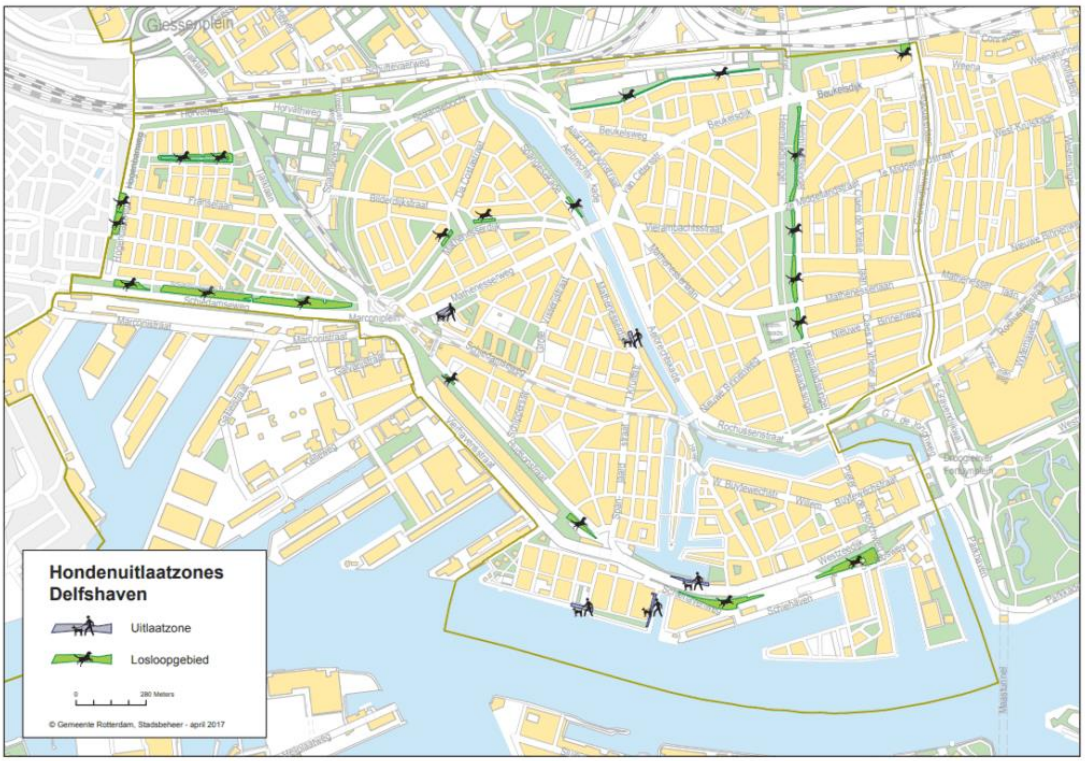

More space for pedestrians and cyclists
Mobility
Emphasize on public transport
Car-free zones
User satisfaction
Facilities
Accessibility
Radius to facilities
Function mix city (multiple levels)
Social interaction
Green facilities
Squares
Public space
Parks
Other public spaces
Healthy environment
City facilitie
Greenery in city (trees, green roofs, etc)
Green roofs
Water storage
Measurements sustainability goals
Safety facilities
Safety facilities
Social safety
Public private mix

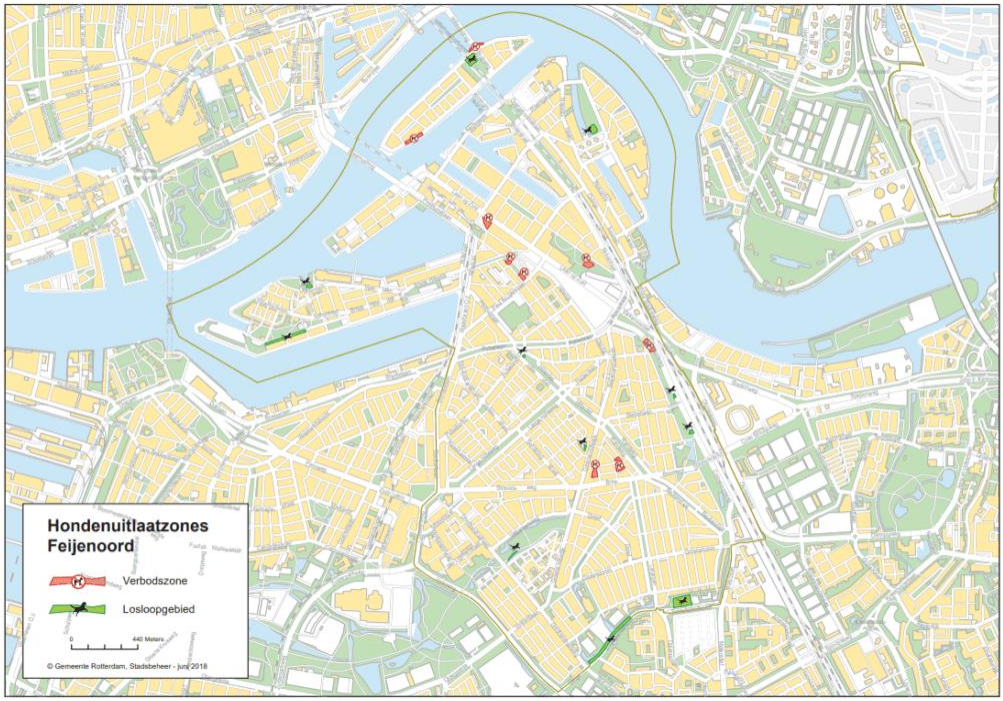
Appendix B: variables of hedonic pricing model with sources

Variable	Structural building variables	Environmental variables	PGS variables
Tower 1 **(CasaNova)**	**https://casanova-rotterdam.nl/files/finder/verkoopbrochure.pdf**	Google Maps, ArcGis, Gemeente Rotterdam (n.d.)	Google Maps, ArcGis
Tower 2 **(Cooltower)**	OOMS makelaars, Thomas Keijs & Daniël Stout, price list on request **https://thecooltower.nl/woningzoeker**	Google Maps, ArcGis, Gemeente Rotterdam (n.d.)	Google Maps, ArcGis
Tower 3 **(DWNTWN)**	https://downtownapartments.nl/wp-content/uploads/2020/12/2.-Prijslijst-Downtown-Apartments.pdf https://downtownapartments.nl/woningzoeker/	Google Maps, ArcGis, Gemeente Rotterdam (n.d.)	Google Maps, ArcGis
Tower 4 **(Imagine)**	https://www.imagine-rotterdam.nl/nl/aanbod/	Google Maps, ArcGis, Gemeente Rotterdam (n.d.)	Google Maps, ArcGis
Tower 5 **(Maasbode)**	OOMS makelaars, Thomas Keijs & Daniël Stout, price list on request **https://www.nieuwbouw-demaasbode.nl/woningzoeker**	Google Maps, ArcGis, Gemeente Rotterdam (n.d.)	Google Maps, ArcGis
Tower 6 **(Piekstraat)**	TW3, Mariska Verwaal, price list on request	Google Maps, ArcGis, Gemeente Rotterdam (n.d.)	Google Maps, ArcGis
Tower 7 **(SAWA)**	https://account.woneninsawa.nl/aanbod/	Google Maps, ArcGis, Gemeente Rotterdam (n.d.)	Google Maps, ArcGis
Tower 8 **(Stack)**	TW3, Mariska Verwaal, price list on request	Google Maps, ArcGis, Gemeente Rotterdam (n.d.)	Google Maps, ArcGis
Tower 9 **(The Muse)**	OOMS makelaars, Thomas Keijs & Daniël Stout, price list on request	Google Maps, ArcGis, Gemeente Rotterdam (n.d.)	Google Maps, ArcGis

Appendix C: Dog friendly PGS in Rotterdam







(Van Dijk, 2018)

Appendix D: concepts, variables and subvariables from the research

Concepts	Variables	Sub variables	Research method initially	Extra information	Kolom2
Housing price	VON price	VON-price apartments	Quantitative		
	Inflation rate	CPI index	Quantitative		
Structural building	Structural building characteris	Floor area by square meter [m²]	Quantitative		
		Area outdoor [m²]	Quantitative		
		Number of rooms	Quantitative		
		Number of bedrooms	Quantitative		
		Number of toilets	Quantitative		
		Date start construction	Quantitative		
		Date delivery construction	Quantitative		
		Orientation sun	Quantitative		
		Outdoor area	Quantitative		
		Balcony	Quantitative		
		Logia	Quantitative		
		Terrace	Quantitative		
		Continuous balcony	Quantitative		
		Collective garden	Quantitative		
		Gym facilities (yes/no)	Quantitative	Left out later stage	
Liveability	The five domains	*See PGS variables*			
PGS	Environmental	Air quality [CO2 emission]	Qualitative	Left out later stage	
		Noise disturbance [number of complaints]	Qualitative	Left out later stage	
		Diversity fauna	Qualitative	Combined to sustainability	
		Diversity flora	Qualitative	Combined to sustainability	
		Water storage solutions in PGS	Qualitative	Combined to sustainability	
		Physical well-being	Qualitative		
		Mental well-being	Qualitative		
		Interaction in PGS	Qualitative , quantitative	Social index for the quanitative method	
	Social	Sense of belonging	Qualitative		
		Enjoyment and comfort	Quantitative, quantitative	Social index for the quanitative method	
		Place to meet	-	Left out	
	Functional	50 meter from PGS	Quantitative	Left out later stage	
		300 meter from PGS	Quantitative, Qualitative		
		5 min walk from signature PGS	Quantitative	Left out later stage	
		Children friendly PGS within 500m	Quantitative		
		Dog friendly PGS	Quantitative		
		Multifunctionallity	-	Left out	
		Facilities by physical index	Quantitative, Qualitative		
	Cultural	View on signature PGS	Quantitative, Qualitative		
		View on Het Park	Quantitative		
		View on Mallegatpark	Quantitative		
		View on Museumpark	Quantitative		
		View on Dokhaven	Quantitative		
		View on De Esch	Quantitative		
		View on Kralingseplas	Quantitative		
		View on Landmarks	Quantitative, Qualitative		
		View on Euromast	Quantitative		
		View on Erasmusbrug	Quantitative		
		View on Willemsbrug	Quantitative		
		View on water	Quantitative, Qualitative		
		Attractiveness PGS by residents	Qualitative, quantitative	physical index for the quanitative method	
		Cleanliness	Qualitative, quantitative	physical index for the quanitative method	
		Undertake cultural activities	-	Left out	
	Safety	Feeling of safety near PGS	Quantitative, qualitative	safety index for the quanitative method	
		Crime rates near PGS	Quantitative, qualitative	safety index for the quanitative method	
		Children friendly PGS within 500m	Quantiative	Left out later stage	
		Social security	Quantitative, qualitative	safety index for the quanitative method	
	Financial arrangments	Type of financial arrangement	Qualitative		
		Opportunity to optimalizate arrangment	Qualitative		

Appendix E: HPM models with testing models

results

	Dependent variable:					
	log(VONPriceINDEXED)					
	(1)	(2)	(3)	(4)	(5)	(6)
FLOORLEVEL	0.009***	0.009***	0.008***	0.012***	0.011***	0.011***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
log(Area)	0.596***	0.610***	0.536***	0.597***	0.595***	0.577***
	(0.026)	(0.027)	(0.027)	(0.026)	(0.026)	(0.025)
log(AreaOutdoor + 1)	0.057***	0.050***	0.059***	0.068***	0.060***	0.064***
	(0.010)	(0.010)	(0.010)	(0.009)	(0.010)	(0.009)
nRooms	0.030**	0.046***	0.046***	0.023*	0.030**	0.027**
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
nBedrooms	0.011	-0.011	0.028**	0.030**	0.018	0.031***
	(0.013)	(0.012)	(0.014)	(0.012)	(0.013)	(0.012)
nBathrooms	0.068***	0.058***	0.088***	0.055***	0.050***	0.052***
	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
nToilets	0.064***	0.078***	0.074***	0.066***	0.071***	0.070***
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
RegQuarterstart	0.012***	0.019***	0.012***	0.014***	0.014***	0.015***
	(0.002)	(0.003)	(0.004)	(0.002)	(0.002)	(0.002)
Regquarterdelivery	0.011***	0.0003	0.011***	0.013***	0.012***	0.011***
	(0.002)	(0.003)	(0.004)	(0.002)	(0.002)	(0.002)
OrientationNO	-0.025	-0.042*	-0.051**	-0.039*	-0.028	-0.027
	(0.023)	(0.024)	(0.024)	(0.023)	(0.023)	(0.023)
OrientationNW	0.007	-0.023	-0.026	-0.027	-0.011	-0.011
	(0.023)	(0.024)	(0.024)	(0.023)	(0.023)	(0.023)
OrientationO	-0.032	-0.041	-0.069***	-0.019	-0.015	-0.016
	(0.023)	(0.025)	(0.024)	(0.023)	(0.023)	(0.024)
OrientationZO	0.031	0.011	0.003	0.023	0.038	0.039*
	(0.024)	(0.026)	(0.025)	(0.023)	(0.023)	(0.023)
OrientationZ	0.094***	0.074***	0.053**	0.110***	0.106***	0.106***
	(0.024)	(0.027)	(0.025)	(0.023)	(0.024)	(0.024)
OrientationZW	0.040*	0.003	0.001	0.022	0.039*	0.041*
	(0.023)	(0.027)	(0.024)	(0.023)	(0.023)	(0.023)
OrientationW	0.062***	0.032	0.011	0.061***	0.064***	0.065***
	(0.024)	(0.026)	(0.024)	(0.023)	(0.023)	(0.024)
OrientationNZ	0.201***	0.141***	0.192***	0.311***	0.268***	0.296***
	(0.038)	(0.042)	(0.042)	(0.033)	(0.036)	(0.033)
OrientationZWNW	0.088	0.050	0.065	0.004	0.054	0.052
	(0.063)	(0.064)	(0.065)	(0.064)	(0.063)	(0.064)

OrientationNONW	0.004	-0.002	-0.007	-0.011	0.020	0.017
	(0.045)	(0.046)	(0.047)	(0.044)	(0.043)	(0.043)
OrientationNOZW	0.005	-0.036	-0.016	-0.033	0.009	0.012
	(0.085)	(0.087)	(0.088)	(0.087)	(0.086)	(0.086)
OrientationZOZW	-0.004	-0.029	-0.026	-0.011	0.025	0.025
	(0.050)	(0.052)	(0.052)	(0.050)	(0.050)	(0.050)
OrientationWO	0.165**	0.135*	0.181**	0.234***	0.192***	0.222***
	(0.072)	(0.074)	(0.077)	(0.072)	(0.073)	(0.072)
Orientationoverallview	0.089	0.077	0.037	0.157**	0.191***	0.190***
	(0.072)	(0.063)	(0.075)	(0.061)	(0.061)	(0.061)
Balcony	0.017**	0.025***	0.016*	0.008	0.013	0.011
	(0.009)	(0.009)	(0.009)	(0.008)	(0.009)	(0.008)
Terrace	0.102***	0.103***	0.101***	0.115***	0.109***	0.110***
	(0.015)	(0.015)	(0.016)	(0.015)	(0.015)	(0.015)
Logia	-0.010	-0.025*	-0.022	-0.029*	0.014	0.012
	(0.014)	(0.015)	(0.015)	(0.017)	(0.013)	(0.013)
Continuousbalcony	-0.075***	-0.081***	-0.088***	-0.100***	-0.083***	-0.088***
	(0.012)	(0.012)	(0.013)	(0.012)	(0.012)	(0.012)
Collectivegarden1	-0.154***	-0.128***	-0.112***	-0.158***	-0.130***	-0.140***
	(0.013)	(0.016)	(0.022)	(0.012)	(0.012)	(0.011)
Publictransport1	-0.023	0.024	0.101***			
	(0.017)	(0.023)	(0.030)			
METER300PARK1	0.177***	0.157***				
	(0.019)	(0.025)				
Rooftopgardenview1	0.067***	0.055***	0.068***			
	(0.014)	(0.014)	(0.014)			
DogFriendly500m1			0.058*			
			(0.033)			
nGreenview1	0.004		0.008			
	(0.012)		(0.013)			
nGreenview2	0.071***		0.046**			
	(0.019)		(0.020)			
nGreenview3	0.094		0.095			
	(0.104)		(0.109)			
HetPark1		0.060***				
		(0.018)				
Mallegatpark1		0.010				
		(0.018)				
Kralingseplas1		0.018				
		(0.017)				
Dokhaven1		0.050*				

HPM 1 = Clustured view variables

HPM 2 = Separated view variables

HPM 3 = Dog friendly variable

HPM 4 = Physical variable

HPM 5 = Social variable

HPM 6 = Safety variable

		(0.027)				
Wijnhaven		-0.009				
		(0.013)				
Euromast1	0.013	-0.009	0.037***			
	(0.013)	(0.017)	(0.014)			
Erasmusbrug1	0.030**	0.021	0.042***			
	(0.014)	(0.015)	(0.015)			
Maas1	0.014	0.021	0.022*			
	(0.012)	(0.013)	(0.012)			
CityCentre		0.016				
		(0.013)				
Physicalindex3				0.225***		
				(0.024)		
Physicalindex4				0.144***		
				(0.015)		
Socialindex3					0.176***	
					(0.018)	
Socialindex4					0.141***	
					(0.016)	
Safetyindex4						0.153***
						(0.015)
Constant	9.573***	9.644***	9.787***	9.532***	9.553***	9.618***
	(0.098)	(0.104)	(0.099)	(0.094)	(0.095)	(0.092)
Observations	977	977	977	977	977	977
R^2	0.919	0.916	0.911	0.916	0.915	0.914
Adjusted R^2	0.916	0.913	0.908	0.913	0.912	0.912
Residual Std. Error	0.115 (df = 939)	0.117 (df = 936)	0.120 (df = 939)	0.117 (df = 946)	0.118 (df = 946)	0.118 (df = 947)
F Statistic	287.528*** (df = 37; 939)	256.037*** (df = 40; 936)	261.361*** (df = 37; 939)	342.253*** (df = 30; 946)	338.660*** (df = 30; 946)	348.536*** (df = 29; 947)
Note:						*p<0.1; **p<0.05; ***p<0.01

results

TRUE

Appendix F: R-script regression model 1,2

```
library(stargazer)
library(tidyverse)
library(VIF)
library(caret)
library(ggplot2)
library(car)

library(readxl)
FINAL <- read_excel("MBE/Jaar 2/Graduation/P4/FINALdataset.xlsx",    sheet = "Calctab")
View(FINAL)

FINAL$Orientation <- factor(FINAL$Orientation, c("N", "NO", "NW", "O", "ZO", "Z", "ZW", "W", "NZ",
"ZWNW" , "NONW", "NOZW", "ZOZW" , "WO", "overallview"))

FINAL$Locationvariable <- factor(FINAL$Locationvariable, c("stadsdriehoek","Feijenoord",
"schiemond", "KvZEntrepot" ))

FINAL$dExterior <- factor(FINAL$dExterior, c(0, 1))
FINAL$Collectivegarden <- factor(FINAL$Collectivegarden, c(0, 1))
FINAL$Sportfacility <- factor(FINAL$Collectivegarden, c(0, 1))
FINAL$UitgestrektVIEW <- factor(FINAL$UitgestrektVIEW, c("None","Yes"))
FINAL$Greenview <- factor(FINAL$Greenview, c(0, 1))
FINAL$Landmark <- factor(FINAL$Landmark, c(0, 1))

FINAL$UitgestrektNO <- factor(FINAL$UitgestrektNO, c(0, 1))
FINAL$UitgestrektNW <- factor(FINAL$UitgestrektNW, c(0, 1))
FINAL$UitgestrektZO <- factor(FINAL$UitgestrektZO, c(0, 1))
FINAL$UitgestrektZW <- factor(FINAL$UitgestrektZW, c(0, 1))

FINAL$Rooftopgardenview <- factor(FINAL$Rooftopgardenview, c(0, 1))
FINAL$Willemsbrug <- factor(FINAL$Willemsbrug, c(0, 1))
FINAL$Erasmusbrug <- factor(FINAL$Erasmusbrug, c(0, 1))
FINAL$Euromast <- factor(FINAL$Euromast, c(0, 1))
FINAL$HetPark <- factor(FINAL$HetPark, c(0, 1))
FINAL$Kralingseplas <- factor(FINAL$Kralingseplas, c(0, 1))
FINAL$ParkDeEsch <- factor(FINAL$ParkDeEsch, c(0, 1))
FINAL$Mallegatpark <- factor(FINAL$Mallegatpark, c(0, 1))
FINAL$Maas <- factor(FINAL$Maas, c(0, 1))
FINAL$Haven <- factor(FINAL$Haven, c(0, 1))
FINAL$Dokhaven <- factor(FINAL$Dokhaven, c(0, 1))
FINAL$MuseumPark <- factor(FINAL$MuseumPark, c(0, 1))
FINAL$MuseumPark <- factor(FINAL$Zuiderpark, c(0, 1))

FINAL$nGreenview <- factor(FINAL$nGreenview, c("0", "1", "2", "3", "4"))
FINAL$Nviews <- factor(FINAL$Nviews, c("0", "1", "2", "3", "4", "5"))

FINAL$METER300PARK <- factor(FINAL$METER300PARK, c(0, 1))
FINAL$METER50PARK <- factor(FINAL$METER50PARK, c(0, 1))
FINAL$METER800PARK <- factor(FINAL$METER800PARK, c(0, 1))
FINAL$Publictransport <- factor(FINAL$Publictransport, c(0, 1))
```

```
FINAL$DogFriendly500m <- factor(FINAL$DogFriendly500m, c(0, 1))
FINAL$Children500m <- factor(FINAL$Children500m, c(0, 1))
FINAL$ParkWalkSig <- factor(FINAL$ParkWalkSig, c(0, 1))
FINAL$Tower <- factor(FINAL$Tower, c("CasaNova", "Cooltower", "DWNTWN", "Maasbode",
"TheMuse", "Piekstraat", "Stack", "SAWA", "Imagine"))

HPM1    <- lm(log(VONPriceINDEXED) ~ FLOORAREA +log(Area) + log(AreaOutdoor+1) +  nRooms +
nBedrooms + nBathrooms + nToilets +  RegQuarterstart + Regquarterdelivery + Orientation + Balcony
+ Terrace + Logia + Continuousbalcony + Collectivegarden + Publictransport + METER300PARK +
Rooftopgardenview + nGreenview + Euromast + Erasmusbrug + Maas , data=FINAL)

summary(HPM1)

HPM2    <- lm(log(VONPriceINDEXED) ~ FLOORAREA +log(Area) + log(AreaOutdoor+1) +  nRooms +
nBedrooms + nBathrooms + nToilets +  RegQuarterstart + Regquarterdelivery + Orientation + Balcony
+ Terrace + Logia + Continuousbalcony + Collectivegarden   + Publictransport + METER300PARK +
Rooftopgardenview + HetPark + Mallegatpark + Kralingseplas  + Dokhaven + Wijnhaven + Euromast +
Erasmusbrug +  Maas + CityCentre, data=FINAL)

summary(HPM2)

HPM1testdog <- lm(log(VONPriceINDEXED) ~ FLOORAREA +log(Area) + log(AreaOutdoor+1) +
nRooms + nBedrooms + nBathrooms + nToilets +  RegQuarterstart + Regquarterdelivery +
Orientation + Balcony + Terrace + Logia + Continuousbalcony + Collectivegarden +
Rooftopgardenview + DogFriendly500m + Publictransport + nGreenview + Euromast + Erasmusbrug +
Maas , data=FINAL)

summary(HPM1testdog)

HPM1test2physical         <- lm(log(VONPriceINDEXED) ~ FLOORAREA +log(Area) +
log(AreaOutdoor+1) +  nRooms + nBedrooms + nBathrooms + nToilets +  RegQuarterstart +
Regquarterdelivery + Orientation + Balcony + Terrace + Logia + Continuousbalcony + Collectivegarden
+ Physicalindex , data=FINAL)

summary(HPM1test2physical)

HPM1test3social           <- lm(log(VONPriceINDEXED) ~ FLOORAREA +log(Area) + log(AreaOutdoor+1)
+  nRooms + nBedrooms + nBathrooms + nToilets +  RegQuarterstart + Regquarterdelivery
+ Orientation + Balcony + Terrace + Logia + Continuousbalcony + Collectivegarden + Socialindex,
data=FINAL)

summary(HPM1test3social)

HPM1test4safety           <- lm(log(VONPriceINDEXED) ~ FLOORAREA +log(Area) +
log(AreaOutdoor+1) +  nRooms + nBedrooms + nBathrooms + nToilets +  RegQuarterstart +
Regquarterdelivery + Orientation + Balcony + Terrace + Logia + Continuousbalcony + Collectivegarden
+ Safetyindex, data=FINAL)

summary(HPM1test4safety)

car::vif(HPM1)
```

```
car::vif(HPM2)

stargazer(HPM1,HPM1a, HPM1testdog, HPM1test2physical, HPM1test3social, HPM1test4safety,
type = "html", title = "results", out = "~/MBE/Jaar 2/Graduation/P4/resultsfinall.htm", aling=TRUE)
```

Appendix G: Survey

Publieke groenruimtes in uw omgeving

Voor mijn afstudeeronderzoek van de master Management in the Built Environment aan de TU Delft doe ik onderzoek naar de relatie tussen publieke groenruimtes en huizenprijzen van hoogbouwtorens in Rotterdam. Publieke groenruimtes omvatten parken, groenstroken, grasvelden, bossen, publieke groene daken, etc. Voor mijn onderzoek ben ik op zoek naar inzichten over hoe bewoners denken over aspecten van publieke groenruimtes. Deze korte vragenlijst geeft inzichten in welke aspecten van publieke groenruimtes bewoners als belangrijk beschouwen. De vragenlijst is anoniem en uw antwoorden zullen strikt vertrouwelijk blijven. Dank u voor uw tijd en support!

1. In wat voor type gebouw woont u?

Mark only one oval.

- ◯ Grondgebonden woning (woning op straatniveau)
- ◯ Appartement (met minder dan 18 verdiepingen)
- ◯ Appartement (met meer dan 18 verdiepingen)
- ◯ Anders

2. Welke karakteristieken van publieke groenruimtes (parken, bos, grasveld, etc.) vindt u belangrijk voor uw omgeving?

_____

_____

_____

_____

_____

De volgende vragen zullen diverse aspecten behandelen van publieke groenruimtes voor uw omgeving. Aspecten van publieke groenruimtes kunnen verdeeld worden in 5 subcategorieën; omgevingsaspecten, functionele aspecten, sociale aspecten, veiligheidsaspecten en culturele aspecten.

3. Omgevingsaspecten omvatten onder andere duurzaamheidselementen, de volksgezondheid en de kwaliteit van de omgeving. Op een schaal van 1 tot 5, hoe belangrijk beschouwt u omgevingsaspecten van publieke groenruimtes in uw omgeving?

Mark only one oval.

	1	2	3	4	5	
Helemaal niet belangrijk	◯	◯	◯	◯	◯	Zeer belangrijk

4. Rangschik de volgende omgevingselementen van publieke groenruimtes in uw omgeving

Mark only one oval per row.

	Helemaal niet belangrijk	Niet belangrijk	Neutraal	Belangrijk	Zeer belangrijk
Luchtkwaliteit	◯	◯	◯	◯	◯
Geluidshinder	◯	◯	◯	◯	◯
Biodiversiteit	◯	◯	◯	◯	◯
Elementen die bijdragen aan de fysieke gezondheid (zoals ruimte om sporten te kunnen beoefenen)	◯	◯	◯	◯	◯
Elementen die bijdragen aan de mentale gezondheid (zoals een plek om tot rust te komen)	◯	◯	◯	◯	◯

5. Zijn er andere omgevingselementen van publieke groenruimtes die u als belangrijk beschouwt maar nog niet benoemd zijn? Zo ja, beschrijf deze alstublieft.

6. Functionele aspecten van publieke groenruimtes bevatten zoal de bereikbaarheid en integratie met de stad. Op een schaal van 1 tot 5, hoe belangrijk beschouwt u functionele aspecten van publieke groenruimtes in uw omgeving?

Mark only one oval.

	1	2	3	4	5	
Helemaal niet belangrijk	◯	◯	◯	◯	◯	Zeer belangrijk

7. Rangschik de volgende functionele elementen van publieke groenruimtes in uw omgeving

Mark only one oval per row.

	Helemaal niet belangrijk	Niet belangrijk	Neutraal	Belangrijk	Zeer belangrijk
Toegankelijkheid naar publieke groenruimtes vanaf uw woning	◯	◯	◯	◯	◯
Afstand van publieke groenruimtes tot aan uw woning	◯	◯	◯	◯	◯

8. Zijn er andere functionele elementen van publieke groenruimtes die u als belangrijk beschouwt maar nog niet benoemd zijn? Zo ja, beschrijf deze alstublieft.

9. Sociale aspecten van publieke groenruimtes omvatten zoal sociale interactie met andere bewoners, gevoel van verbondenheid en vermaak. Op een schaal van 1 tot 5, hoe belangrijk beschouwt u sociale aspecten van publieke groenruimtes in uw omgeving?

Mark only one oval.

	1	2	3	4	5	
Helemaal niet belangrijk	◯	◯	◯	◯	◯	Zeer belangrijk

10. Rangschik alstublieft de volgende sociale elementen van publieke groenruimtes in uw omgeving

Mark only one oval per row.

	Helemaal niet belangrijk	Niet belangrijk	Neutraal	Belangrijk	Zeer belangrijk
Interactie met anderen in publieke groenruimtes	⬭	⬭	⬭	⬭	⬭
Gevoel van verbondenheid (zoals elementen die u thuis laten voelen, in plaats van een steriele omgeving)	⬭	⬭	⬭	⬭	⬭
Faciliteiten voor vermaak in publieke groenruimtes	⬭	⬭	⬭	⬭	⬭
Faciliteiten voor comfort in publieke groenruimtes	⬭	⬭	⬭	⬭	⬭

11. Zijn er andere sociale elementen van publieke groenruimtes die u als belangrijk beschouwt maar nog niet benoemd zijn? Zo ja, beschrijf deze alstublieft.

12. Veiligheidsaspecten van publieke groenruimtes zijn een basisbehoefte om gebruikers zich veilig te laten voelen en misdaadcijfers laag te houden. Op een schaal van 1 tot 5, hoe belangrijk beschouwt u veiligheidsaspecten van publieke groenruimtes in uw omgeving?

Mark only one oval.

	1	2	3	4	5	
Helemaal niet belangrijk	◯	◯	◯	◯	◯	Zeer belangrijk

13. Rangschik de volgende veiligheidselementen van publieke groenruimtes in uw omgeving

Mark only one oval per row.

	Helemaal niet belangrijk	Niet belangrijk	Neutraal	Belangrijk	Zeer belangrijk
Gevoel van veiligheid in en rondom publieke gronruimtes	◯	◯	◯	◯	◯
Lage misdaadcijfers	◯	◯	◯	◯	◯

14. Zijn er andere veiligheidselementen van publieke groenruimtes die u als belangrijk beschouwt maar nog niet benoemd zijn? Zo ja, beschrijf deze alstublieft.

15. Culturele aspecten van publieke groenruimtes beïnvloeden de manier van denken van de gemeenschap en de identiteit van de bewoners. Het omvat aspecten van aantrekkelijkheid van publieke groenruimtes. Op een schaal van 1 tot 5, hoe belangrijk beschouwt u culturele aspecten van publieke groenruimtes in uw omgeving?

Mark only one oval.

	1	2	3	4	5	
Helemaal niet belangrijk	◯	◯	◯	◯	◯	Zeer belangrijk

16. Rangschik de volgende culturele elementen van publieke groenruimtes in uw omgeving

Mark only one oval per row.

	Helemaal niet belangrijk	Niet belangrijk	Neutraal	Belangrijk	Zeer belangrijk
Zicht op publieke groenruimtes vanaf uw woning	◯	◯	◯	◯	◯
Aantrekkelijkheid van publieke groenruimtes	◯	◯	◯	◯	◯
Schone en goed onderhouden publieke groenruimtes	◯	◯	◯	◯	◯
Zicht op (publieke) groendaken (ALLEEN als u in een appartement woont)	◯	◯	◯	◯	◯

17. Zijn er andere culturele elementen van publieke groenruimtes die u als belangrijk beschouwt maar nog niet benoemd zijn? Zo ja, beschrijf deze alstublieft.

Bedankt voor uw deelname!

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Google Forms

Appendix H: interview protocol

Introductie onderzoek:

Voor mijn master Management in the Built Environment aan de TU Delft doe ik bij Fakton Development mijn afstudeeronderzoek naar de relatie tussen publieke groen ruimtes en waardering daarvan door bewoners van hoogbouw. In het onderzoek wordt de waarde die bewoners hechten aan karakteristieken van groen ruimtes vertaald naar de invloed hiervan op de appartementsprijzen. Voor het onderzoek wordt er gekeken naar de verschillende karakteristieken van publieke groenruimtes die mogelijk effect hebben op de appartementsprijzen van hoogbouw. De waarde van publiek groen kan voortkomen uit karakteristieken die met de belevingskwaliteit te maken hebben, maar ook met de invloed (zeggenschap en verantwoordelijkheid) op deze ruimtes. Het onderzoek focust zich op residentiële nieuwbouwtorens in Rotterdam.

Achtergrond onderzoek

Hoogbouw is niet meer weg te denken uit een stad als Rotterdam. Met deze opkomende hoogbouwtrend is het belangrijk dat er goed gekeken wordt naar de aansluiting met de stad en de wensen van de bewoners. Een mismatch tussen de connectie van hoogbouw met de omgeving en de wensen van de bewoners kan invloed hebben op de leefbaarheid van de stad en de bewoners. Eigenschappen van publieke groenruimtes kunnen een grote invloed hebben op de leefbaarheid, vandaar dat dit onderzoek zich toespits op de waardering van publieke ruimtes door bewoners van hoogbouw.

Publieke groenruimtes zijn openbare ruimtes met natuurlijke elementen, te denken aan parken, publieke (groen)daken en grasvelden. De waardering van deze ruimtes door hoogbouw bewoners vertaalt zich in de hoeveelheid die bewoners bereid zijn te betalen voor bepaalde karakteristieken en/of invloed van deze ruimtes, af te leiden uit de appartementsprijs. Hiervoor is er onderzoek gedaan naar het effect van publieke groenruimtes op de appartementsprijs van hoogbouwtorens in Rotterdam. De karakteristieken van groene ruimtes zijn verdeeld in sociale, functionele, culturele, omgevings- en veiligheidsaspecten. Tevens zijn financieringsmogelijkheden voor publieke groenruimtes ook meegenomen in het onderzoek.

Onderzoeksmethode

Het onderzoek is grotendeels gedaan door middel van een kwantitatief onderzoek waarbij 9 hoogbouwtorens in Rotterdam zijn onderzocht. Daarbij is de correlatie van verschillende eigenschappen van publieke groen ruimtes gemeten ten opzichte van de appartementsprijs van de hoogbouwtorens. Ter verheldering en verbreding van de resultaten van dit kwantitatieve onderzoek zal er een kwalitatief onderzoek plaatsvinden door middel van interviews met experts. Daar zal dieper ingegaan worden op hoe de relatie van publieke groen ruimtes en hoogbouw terug te zien is in de praktijk.

Voorafgaand aan het interview zou ik graag uw toestemming vragen om het gesprek op te nemen. De opnames zullen enkel voor kennisdoeleinden worden gebruikt waarbij de resultaten worden geanonimiseerd. Het interview bestaat uit een aantal vooropgestelde thema's waarbij ruimte zal zijn voor aanvullende vragen die eventueel uit het gesprek volgen.

Bij voorbaat dank voor uw medewerking.

Met vriendelijke groet,

Charmaine Ree

Interview overzicht

Onderstaande vragen en volgorde worden gezien als richtlijn, daarvan kan afgeweken worden tijdens het interview.

Introductie

- Introductie interviewer & geïnterviewde
- Introductie onderwerp: relatie hoogbouw en publieke groenruimtes (met korte intro over definitie en eigenschappen van publieke groenruimtes)
- Algemene ervaringen geïnterviewde met hoogbouw

Thema 1: Algemene indruk relatie publieke groen ruimtes tot hoogbouw

- Vanuit werkervaring geïnterviewde
- Mogelijk verschil tussen waar architecten en ontwikkelaren op inspelen en welke waarde bewoners hechten aan publiek groen
- Veranderingen in waarde van publiek groen door de jaren heen (vanuit perspectief bewoners, gemeente, ontwikkelaar en/of architect)
- Onderscheid publiek groen en privaat groen (bv. balkon)
- Publieke groen ruimtes in relatie tot hoogbouwvisie

Thema 2: Karakteristieken publieke groenruimten

1) Functionele aspecten (bv. afstand, bereikbaarheid)

- Introductie functionele aspecten, welke volgens onderzoek de grootste invloed hebben op de appartementsprijs
- Belang om hoogbouw aan te sluiten op deze functionele aspecten (vanuit diverse perspectieven)

2) Omgevingsaspecten (luchtkwaliteit, biodiversiteit)

- Introductie omgevingsaspecten
- Belang om hoogbouw aan te sluiten op deze omgevingsaspecten

3) Sociale en veiligheidsaspecten (gevoel van verbondenheid, sociale interactie, veiligheid op straat)

- Introductie sociale en veiligheidsaspecten
- Connectie met hoogbouw en anonimiteit
- Belang om hoogbouw aan te sluiten op deze omgevingsaspecten

4) Culturele aspecten (zicht op groen, esthetisch)

- Introductie culturele aspecten
- Zicht op publieke groen ruimtes lijkt een steeds belangrijkere rol te worden bij verkoop van woontorens (dmv uitzichtfilmpjes), mogelijke verklaring
- Belang om hoogbouw aan te sluiten op deze culturele aspecten

Overige onderwerpen thema 2

- Verklaring waarom sommige karakteristieken van groen niet terug te zien zijn in de appartementsprijs en sommige wel (bv. Nabijheid van groen wel, veiligheidsaspecten bij groen niet)
- Publieke (groen) ruimtes kunnen ook in het gebouw voorkomen. Hoe spelen verschillende actoren zoals gemeente en ontwikkelaar daarop in? Draagt dit bij aan zowel leefbaarheid van de stad als de leefbaarheid van de bewoners van de toren?
- Potentie publieke groenruimtes maximaliseren, in relatie tot hoogbouw

Thema 3: Afspraken over publieke groenruimtes tussen ontwikkelaar en gemeente

- Introductie over afspraken tussen gemeente en ontwikkelaar (bv. Exploitatie via anterieure overeenkomst)
- Bijdrage aan publieke voorzieningen (zoals groen ruimtes) via kostenverhaal, toelichting eigen ervaring
- Toelichting of vorm van overeenkomst invloed heeft op de inspraak van ontwikkelaren op naastgelegen publieke groen ruimtes
- Relatie tussen het kostenverhaal en de waarde van publiek groen ervaren door bewoners, kan een effectiever kostenverhaal leiden tot hoogwaardige groen ruimtes?
- Andere vormen van kosten verhaal, bijvoorbeeld via eigenaren

Afsluiting interview

Appendix I: PGS and parks

The map shows all the PGS and parks in the city of Rotterdam. As not all PGS lie near the selected high-rise buildings, some of them are excluded from the research. The parks that were excluded from the research have a grey letter type. Important to mention is that the selected high-rise buildings did not have a view on the excluded parks, otherwise they were

- Het Park
- Kralingse Bos
- Vroesenpark (not near one of the high-rise buildings)
- Museum Park
- Dakpark Delfshaven (not near one of the high-rise buildings, no view on it as well)
- Dockhavenpark
- De Esch
- Luchtpark Hofbogen (not near one of the high-rise buildings, no view on it as well)
- Zuiderpark (not near one of the high-rise buildings, no view on it as well)
- Boompjes

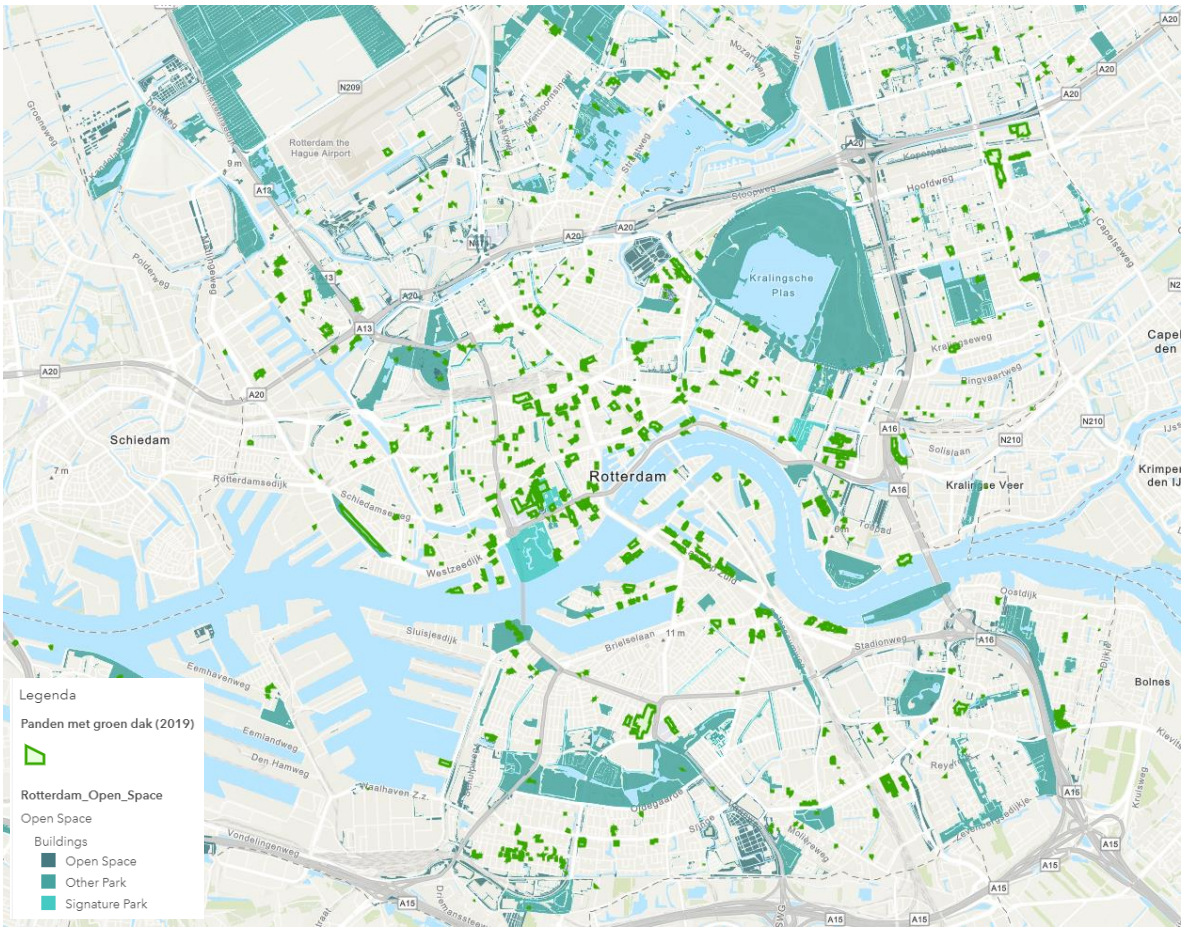

Figure 15: Map with green roofs and PGS in Rotterdam in 2019 (ArcGis, 2019)

Appendix J: View variables and their data source

The videos are used to indicate the view from each floor level and apartment. Google Earth and the view videos from other buildings are used for towers that did not had these videos. Table 11 shows approach to receive the view variables for each apartment building. Google Earth has a tool to adjust the camera height which makes it a proper tool to use for measuring the view variables. Figure 16 is an example of using Google Earth as tool to measure the view variables for the Imagine tower.

Table 11: data approach view from residential high-rise buildings and their sources

High-rise building	Source	Website
Stack	Website view video	https://www.stackrotterdam.nl/
DWNTWN	Website view video	https://downtownapartments.nl/the-view/
Imagine	Google Earth, view video used from Piekstraat tower	
CasaNova	Website view video	https://casanova-rotterdam.nl/uitzicht
The Muse	View video used from CasaNova	
Piekstraat	Website view video	https://www.piekstraat.nl/nieuws/a-different-point-of-view/
Maasbode	Google Earth, view video used from Cooltower	
SAWA	Google Earth, view video used from Stack	
Cooltower	Website view video	https://thecooltower.nl/uitzichten

Appendix K: Land value capture types in foreign countries

Land value capture types in foreign countries

Many countries already use certain instruments, such as betterment contributions, charges for building rights, inclusionary housing and zoning, linkage or impact fees, and certain applications of the property tax (Germán, Bernstein, 2018).

San Francisco (USA) uses development impact fees, where developers are charged a certain amount in exchange for approval of the development project. These revenues finance the cost of public investments adjacent to the new construction (Germán, Bernstein, 2018).

Other land value captures are stated below, based on the tools Germán and Bernstein (2018) identify:

- Betterment contributions: fees to property owners to invest in public goods from which the owners benefit from.
- Charges for building rights: developers pay the municipality a certain fee for additional development rights, which funds infrastructure or other public improvements. For example, to be able to build a higher building.
- Exactions: developers pay the municipality in land or cash to receive special permission required to develop and get in return additional public services near the development.
- Impact fees: developers pay the municipality a one-time contribution what is meant to cover the costs associated with a developer's impact on certain public services.
- Property tax and tax increment finance: This can be an important form of land value capture as well-functioning property tax system base obligations on the market value of the real estate. But that link is not automatic. They are not in themselves an additional means of land value capture. Land value increases in areas with well-functioning property tax systems, which should generate higher values for properties near planned public investments. Their taxations do capture some value from private actors for the public sector (Germán, Bernstein, 2018).

Appendix L: Background interviewees

Four interviews are conducted for this research.

Interviewee A: Jan Klerks

The second interviewee is a high-rise expert with various working experience within the context of high-rise buildings in both the Netherlands and America. During his career, he worked as former director at Stichting Hoogbouw, launched a skyscraper platform where new knowledge regarding high-rise is bundled, he has worked at CTBUH and published several high-rise magazines. In addition, he is also a high-rise resident in Rotterdam.

Interviewee B: Michelle Corbeau

One interview is conducted with a developer from AM, a large developer firm in the Netherlands. She has gained a lot of expertise for urban projects over the past 19 years in Zuid-Holland. Currently, she is the head of the development for the Zalmhaventoren which is the largest high-rise building in the Netherlands.

Interviewee C: Paul Becht

Region manager of BPD for over 20 years. Mainly active in the preliminary stage of projects in the region of Rotterdam. Especially for residential projects

Interviewee D: Emiel Arends

Urban developer for the municipality of Rotterdam. He is one of the writers of the municipal high-rise vision document of Rotterdam of 2011 and 2019. Therefore, he is mainly specialized in urban developments that contain high-rise buildings.

Appendix M: Instruments to recover cost from developers

1) Land allocation
2) Anterior agreements

This agreement is concluded when the land is already acquired by the developer. The costs, made by the municipality, for public facilities and other aspects that are beneficial for the developer, could be recovered. This requires an anterior agreement between the municipality and the developer (Smits, Deloitte, Ramp, Nab, Santing, 2013). The agreement is concluded before determining the zoning plan. The anterior agreements have two main advantages compared to the exploitation plan. First, the developers have more influence over the content of the agreement. Secondly, setting up an anterior agreement is less time and cost consuming than setting up an exploitation agreement (Hobma, 2020). The anterior agreement is part of the facilitating land policy (De Zeeuw, 2013).

3) Exploitation plan

As mentioned earlier, the exploitation plan is the public law approach concerning cost recovery. It can relate to costs directly related to the exploitation of the area, financial contributions for supra-urban facilities (bovenwijkze voorzieningen) and/or plan equalizations (bovenplanse verevening) (Hobma, 2020). An exploitation plan is usually executed when the municipality and developer do not come to a decision concerning the cost recovery. The act of spatial planning (Besluit Ruimtelijke Ordening, Bro) included a list of costs that can be recovered from developers (Smits et al., 2003; Hobma, 2020). Part of the exploitation plan is the 'Fonds Bovenwijkse Voorzieningen', defined as a fund that finances costs for facilities of which other developments or existing areas can profit from. Within the exploitation, there is a post in which the costs for these kinds of facilities are proportional included. This fund combines multiple exploitations of adjacent developments. This creates possibilities to use the surplus from one development for supplementing the deficit of another development (Sorel, Tennekes, Galle, 2014).

4) Betterment levies

Another type of cost recovery is Betterment levies. For this method, municipalities tax the property owners instead of the real estate developers. Taxing betterment levies is possible if facilities have been developed in an area by or with the cooperation of the municipality, which benefits the property owners. It is not possible to recover costs that is applied by the spatial planning act (WRO). Betterment levies could be used for improvements for already developed areas in which the WRO is not applicable (Smits, et al. 2013). The municipal council takes a funding decision, which indicates to what extent the costs for the realized facilities will be recovered with a betterment levy. Nevertheless, the strict law of the tax court and the cost consuming operation makes it an infrequently used cost recovery approach (Hobma, 2020).

5) Other forms

Regarding PGS, there are other financial arrangements the municipality could use as instruments to recover costs from property owners. An example of this is the property tax (onroerendezakenbelasting). This tax is a percentage of the WOZ-value, paid monthly by the property owners. The municipality can alter these taxes yearly, depending on the rise or decline of WOZ-values (Vereniging Eigen Huis, n.d.). Comparing the Dutch context to international land policies, an important distinction is made in the

terminology. International land policies often use the term land value capture to recover costs for public investments (Hobma, 2020). Land value capture is discussed in the next section.

In addition to the cost recovery approaches, financial contributions can also be used to generate funding for public facilities. PGS can be included in costs of supra-district facilities (Hobma, 2020). Multiple areas can benefit from these facilities. The costs can be recovered from the developers of the adjacent areas. The financial contribution is defined in a private law agreement within an anterior agreement or an exploitation plan (Hobma, 2020). The value capturing instruments may provide new opportunities for financing in the future that is not yet used in the Netherlands (Hobma, 2020).