MASTER

Sustainable residential real estate

A study to gain insight into the perception and preferences of residential consumers

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Preface

This master thesis is the final product of the master track Architecture, Building and Planning – Urban Systems and Real Estate at Eindhoven University of Technology. This thesis is about receiving insight into the assigned importance of sustainability by residential consumers and how sustainability is perceived by them.

I have often been told that it is wise to complete your studies before you start working. In hindsight, I should have followed this advice. In 2017 I started my thesis and during the research, I started working as a real estate developer. Unfortunately, this has caused a standstill in this research for a number of years. In 2022 I decided to resume the research and to complete the thesis after all.

Before I go any further, I would like to thank a few people. First of all, I would like to thank my supervisors Stephan Maussen, Theo Arentze and Dujuan Yang for their guidance and constructive feedback throughout the process. I would also like to thank my wife Lucia for her support during the research and her encouragement to resume the research. I am excited to complete this research and complete my master's degree.

Piet Romme

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Summary

Introduction

The built environment has a major impact on the environment and is a large contributor to climate change. In the Netherlands it consumes approximately 35% of the energy and emits 15% of the CO_2 emissions. Half of all the materials that are used in the Netherlands can be contributed to the construction of real estate. Approximately 15% of all building materials become waste without ever being used. Besides this the built environment also has an impact on other environmental components.

There is a major development task for new residential property in the Netherlands. It is estimated that there is a shortage of 331,000 dwellings; 4.2 percent of the total housing stock. The shortage of houses is expected to increase further in the coming years. In 2025, a shortage of 419,000 dwellings (5.1 percent) is expected. In order to reduce the housing shortage, the Dutch government has set a target to realize 900,000 new dwellings before the end of 2030. This is in line with the recently launched 'Actieagenda Wonen', Housing Action Agenda. This initiative is drafted by a coalition of 34 organizations which aims to develop 1 million additional dwellings during the next 10 years through new construction, restructuring and transformation. This development task is an additional challenge for achieving the environmental and climate targets of the Paris Climate Agreement. In addition, the climate targets and many aspects of sustainability have not been sufficiently included in the current regulations. The aim should therefore be that newly added property goes beyond regulations, i.e. that they are developed in a sustainable way.

Real estate developers are facing the following dilemma: either develop residential real estate that comply with regulations or pursue higher sustainability ambitions. Social goals and mission statements of the real estate developers are important, but ultimately the continuity of the business is a precondition to exist. To ensure continuity, the final product must be attractive for residential customers. Residential consumers must be willing to pay enough for the additional sustainability measures. The literature suggests that a significant part of residential consumers assign importance to sustainability and are willing to pay extra for it (Steg, et al., 2021). However, the literature does not show to what extent importance is attributed to sustainability by consumers when purchasing a dwelling. It is also not clear how much more consumers are willing to pay for additional sustainability measures. The literature indicates that not all sustainability measures are perceived as equally sustainable by consumers (Perlaviciute, et al., 2016). It is unclear for property developers how much importance residential consumers in the owner-occupied segment attach to sustainability, and whether they are willing to pay for the additional measures. It is also not clear which sustainability components are perceived as most sustainable by residential consumers. This makes it difficult for residential real estate developers to determine the sustainability ambitions.

This results in the following research question:

> *To what extent do residential consumers attach importance to sustainability in the purchase decision, which sustainability components are perceived as most sustainable and what is the willingness to pay for the additional sustainability measures?*

Residential consumers can be divided into homeowners or tenants. This study is focused on homeowners or people who are looking for an owner-occupied ground-level dwelling. Multi-family dwellings are not included because their physical dwelling characteristics differ from ground-level dwellings.

Methodology

To answer the research question, a literature study and an explorative study have been conducted. In the literature study the physical dwelling characteristics that have the most influence on the property value were determined. This resulted in the following list that was used as an input for the explorative research: construction year, size of dwelling, dwelling type, number of rooms, size of private outdoor space, parking space, quality of building and energy efficiency.

The literature was also reviewed to conduct a definition of sustainable real estate development and to determine the sustainability components. The definition of the Brundtland report (1989) for sustainable development was slightly modified to make it a suitable definition for sustainable real estate development. The following definition was created for this study:

> A strategy that encompasses the whole of plan development, design, construction, use, demolition and reuse, in order to achieve social, environmental, economic, spatial and process-oriented objectives to be realized in accordance with the socially desirable level.

The list of sustainability components (indicators) was derived from analyzing several sustainability rating tools for real estate. This resulted in the following list of sustainability components: energy, water, materials, ecology, future proof, spatial quality, transport, pollution, health and well-being. These components were used as input for the explorative research.

In the explorative part, a rating scale exercise (RSE) was used as a measurement approach to determine which sustainability components (indicators) were perceived the most sustainable by residential consumers. The data for the RSE was collected with a questionnaire. In the questionnaire, respondents were asked to rate on a ten-point Likert scale how sustainable they perceived the presented hypothetical dwellings (profiles). These profiles consisted of four sustainability components: energy, water, material and ecology. Each sustainability component had three possible levels, e.g. the component energy has the following levels: level 1 - energy label A, Level 2 – energy label A++ and level 3 – energy label A++++. The presented profiles had varying component levels. The RSE consisted of four components; each component had three possible levels. This resulted in 81 possible profile outcomes. The required number of profiles for the questionnaire was reduced to nine with a fractional factorial design. The sustainability components that were used in the RSE had been derived from the sustainability indicators that were identified in the literature study. Not all the identified sustainability indicators were included. The reason for this was that they were not directly related to the physical dwelling characteristics of the property object or could not be influenced by the property developer. In addition, the sustainability components and the associated levels had to be understandable for the research population, who generally had no prior knowledge about sustainable real estate development. In the questionnaire the scores and measures of the different levels were also visualized, to help respondents better understand the different sustainability component levels.

A discrete choice experiment (DCE) was used as measurement approach to determine how much value was attributed to sustainability in the purchase decision of a dwelling and what the willingness to pay for additional sustainability measures was. The data for the DCE was collected with the same questionnaire. Respondents were asked to make a choice between two hypothetical dwellings (profiles) or the option 'neither'. The profiles consisted of five attributes that had varying levels. Each attribute had three possible levels resulting in 243 possible alternatives. This number is reduced with a fraction factorial design to 27 different profiles. Each choice set consisted of two profiles. With a randomization tool, each respondent was presented nine choice sets. The attributes for the DCE were derived from the literature review. Not all characteristics were included because of the scope of the research. Additionally, it had to be possible to operationalize the characteristics so that they were understandable for the respondents. The following physical dwelling characteristics were included: dwelling size, outdoor space and parking space. The attribute energy was replaced by the attribute ‘sustainability level’. The attribute (dwelling) price was added to the DCE to determine the willingness to pay for the different dwelling characteristics. Each attribute of the DCE had three possible levels, for example, attribute ‘dwelling size’ had: level 1 – 110m², level 2 – 120m² and level 3 – 130m².

As mentioned before, the RSE and DCE were part of a questionnaire. This questionnaire also included several selection questions to determine if the respondents met the criteria of the research population. The personal and environmental awareness questions were used to gain insight into the respondents. One thousand invitations to participate in the questionnaire were distributed in different residential neighbourhoods that consisted mainly out of ground-level dwellings. The neighbourhoods where the invitations were distributed were located in the following villages and cities: Etten-Leur, Prinsenbeek, Breda, Tilburg and Utrecht.

Results

Thirty-seven respondents completed the questionnaire, one of which was rejected because it had invalid answers. Several descriptive analyses were performed on the data to determine if the sample was representative for the intended research population. The analysis showed that there was a significantly higher percentage of male (66%) respondents than females (33%). The other social and economic characteristics of the respondents seemed in line with the intended research population.

The data of the RSE was analyzed with a regression model and the DCE data was analyzed with an MNL model. It was unfortunately not possible to conduct a Latent Class (LC) model due to the relatively small sample size of 36 respondents. The results of the RSE indicated that every sustainability component had at least one level that had a significance of ($p<0.10$) or lower. The relative importance of the sustainability components showed that the components ‘material’ and ‘energy’ were perceived as the most sustainable (respectively 33.9% and 32.3%), followed by ‘water’ (22%) and ‘ecology’ (11.7%).

The estimates of the MNL model indicated that the sustainability level with the highest score also had the highest utility value. The levels of the attribute price and dwelling size were not significant in the MNL model. The other attributes had at least one level that had a significance of $p < 0.10$ or higher. The relative importance scores of the attributes showed that most importance was ascribed to the attributes ‘parking’ (41.6%), followed by the attributes ‘sustainability level’ (25.9%) and ‘outdoor space’ (16.3%).

By including the attribute ‘price’ in the DCE it was possible to determine the willingness to pay (WTP) for the dwelling attributes that were included in the DCE. The WTP indicated how much more respondents would pay for the highest level compared to the base level of a specific attribute. Several calculations were performed to determine the WTP for sustainability and other dwelling characteristics that are presented in the DCE. The mid-price level was used to determine the WTP instead of the highest price level, because the mid-price level is almost significant and the highest price level not. The calculations show that the sample group was willing to pay € 73,826 more for the attribute level with highest sustainability score (sustainability score of 8) in comparison to the base level (sustainability score of 4).

Conclusion and discussion

The aim of this research was to receive insight into how much importance residential consumers ascribe to sustainability when purchasing a dwelling and determine their willingness to pay for the additional sustainability measures. The research also tried to determine which sustainability components were perceived as most sustainable by the respondents. By answering the different parts of the research question, answers could be given to the overall problem statement.

The regression analysis results of the RSE data indicated that residential consumers perceived the components 'material' and 'energy' as most important contributors to the overall sustainability. Followed by the component 'water'; the least importance was ascribed to the component 'ecology'. The MNL model showed that respondents ascribed significant importance to the overall sustainability in the DCE. This indicates that respondents ascribed significant importance to the sustainability level of a dwelling in comparison to the following dwellings characteristics: dwelling size, outdoor space and parking space. The WTP indicated that residential consumers were willing to pay 17.6% more for an identical dwelling with a high sustainability level (sustainability score of 8) compared to the base level (sustainability score of 4). The sustainability score was indicated on a scale of 1 to 10. The WTP rating suggested that there was a willingness to pay more for additional sustainability measures among residential consumers.

There are a number of parts in this study that can be discussed. Firstly, it can be argued that the respondents in the sample are not representative enough for the intended research population. The male respondents were overrepresented in the sample. The geographical location of the respondents was limited to Utrecht city and different cities and villages in the province of Noord-Brabant. This may have led to a distorted picture of the research results.

Secondly, a limitation in the RSE was that not all sustainability indicators from the literature search had been included in the RSE. The number of sustainability components in the RSE was limited to four. The starting point for the selection was that the sustainability components fell within the scope of the study and were easy to operationalize.

Another possible limitation of this study is that the attributes in the DCE were limited to a set of physical dwelling characteristics. Many physical dwelling characteristics, such as the location and environmental characteristics were not included. It is possible that other results can be found in real life when consumers also take location and environmental characteristics into account. Nevertheless, the WTP rating does indicate that residential consumers are willing to pay more for additional sustainability measures.

Recommendations

The findings of this study indicate that residential consumers perceive more sustainability components than just energy as important contributors for the overall sustainability. Residential consumers (as a group) seem willing to pay more for the additional sustainability measures. Based on the research, the following additional sustainability measures are recommended for residential real estate developers to implement in their projects.

Firstly, it would be interesting for developers to invest in additional PhotoVoltaic (PV) panels. PV panels are a relatively affordable measure to improve the energy performance of a dwelling. The sustainability component material is perceived as an important contributor to sustainability. However, it is currently still relatively expensive to build dwellings entirely in wood. It can be interesting to design parts of a dwelling in wood, such as the inner cavity leaf. In addition, the developer can control CO_2 emissions in the design process by choosing specific materials. Some building material suppliers have lower CO_2 emissions than others. Furthermore, for the sustainability component ‘water’, it is attractive to invest in measures to save tap water and to irrigate rainwater, e.g. by having a water-saving shower head, sedum green roof or a large rain barrel. Installing water purification systems in the dwelling to use rainwater or shower water is not recommended because the installations and maintenance costs are relatively high. Lastly, the measures for ecology are relatively affordable, such as the use of built-in nest boxes and the use of hedges. It could be a consideration for a developer to offer ecological garden plans as an additional work option. These garden plans can promote biodiversity and improve water irrigation. It is recommended that residential real estate developers explore the summed-up sustainability measures in the design process. In the design process the feasibility of the additional measures can be further determined.

1. Introduction

1.1. Background

The built environment has a big impact on the (natural) environment and is a large contributor to climate change. The built environment is worldwide responsible for 38.1% of the annual energy consumption (World Economic Forum, 2016), in the European Union (EU) real estate is responsible for 40% of the energy use and 36% of the CO_2 emissions (Agentschap NL, 2013). The built environment in the Netherlands consumes approximately 35% of the energy and emits 15% of the CO_2 emissions (Rijksdienst voor Ondernemend Nederland, 2019). According to RVO (2018), half of all the materials that are used in the Netherlands can be contributed to the construction of real estate and approximately 15% of all the building materials becomes waste without ever being used. Within the European Union (EU), the construction sector is responsible for 25 - 30% of all the waste (Carra & Magdani, 2016; CLO, 2017).

The built environment is also responsible for water pollution on several fronts. There are several metals used in construction such as zinc, copper and lead that can end up in the water when they come into contact with (rain)water. While zinc and copper are not highly toxic to humans, they are toxic to small aquatic plants (Boogaard & Palsma, 2020). There are also building materials, substances and gases in real estate that can have a negative effect on human health. One can think of carbon monoxide, nitrogen dioxide, radon, thoron and particulate matter (Milieucentraal, 2021). These substances and gases can be released during the manufacturing of building materials, in the construction process or during the exploitation/ use of the property object. Besides causing CO_2 emission, building materials also have an impact on the (natural) environment, i.e. mining activities, environmental pollution during the manufacturing, shipping, the damage to ecosystems due to logging, etc.

Furthermore, new real estate in undeveloped areas causes the loss of nature or agricultural land. The loss of nature or agricultural land can have negative effects. For example, new buildings can lead to the loss of habitat for various plant and animal species (Dijkshoorn-Dekker et al., 2020). It can cause a loss of valuable agricultural land and food production capacity. The construction activities and future residents can cause increased nitrogen emissions that may have a negative effect on nearby nature (RIVM, 2019). As real estate (development) has a significant impact on the environment and climate, there is a need to develop new real estate in a more sustainable way.

Climate change has been one of the most important global policy themes in recent years. In 2019, the Netherlands passed a climate law to achieve the goals of the Paris Climate Agreement. The national climate targets for 2030 and 2050 are set in the Climate Act (Klimaatwet, 2019). The goal for the Netherlands is to emit 49% fewer greenhouse gases by 2030 compared to 1990. By 2050, the Netherlands wants to emit 95% fewer greenhouse gases. As an intermediate goal, the Netherlands wants to use 50% fewer primary raw materials by 2030. More than 200 organizations in the Netherlands have supported these objectives by signing the Raw Materials Agreement (Grondstoffenvoorzieningszekerheid, 2018). These objectives are elaborated in five Transition Agendas: Construction, Biomass & Food, Consumer Goods, Plastics and Manufacturing Industry.

The Dutch government has described the approach for achieving the objectives of the Climate Act in ‘the 2021-2030 Climate Plan’. This Climate Plan contains the main points of the climate policy for the next 10 years. It also examines the latest scientific insights into climate change, technological developments, international policy developments and the economic consequences. In the Climate Plan, various sustainability objectives are formulated for each sector to achieve the objectives of the Climate Act. It states that the construction and built environment in the Netherlands must be made more energy-efficient and that CO_2 emissions must be strongly reduced. It also states that by 2030, 1.5 million homes must get rid of gas. The goal is for the entire housing stock to be gas-free and energy-neutral by 2050. The government wants to achieve this by shifting the energy tax. Natural gas is taxed more heavily while electricity is spared. In addition, attractive financing and subsidies are provided to make real estate more sustainable (Ministerie van Economische Zaken en Klimaat, 2020).

New sustainability regulations have been drawn up for new buildings in the Netherlands. A higher energy performance of newly-built property has been demanded since 1 January 2021 through the Building Decree in the form of 'Nearly Energy Neutral Buildings' (BENG) regulation. New buildings do not receive a gas connection as of July 1, 2018. Since January 2018, it is mandatory to submit a calculation of the environmental impact of the materials that are used for new buildings, in a building permit application. This calculation is called Environmental Performance Buildings (MPG), and this shows the environmental impact by a shadow price. The total shadow price of a building must be under a certain threshold which depends on the property type (RVO, 2018).

The aforementioned shows that the government is stimulating sustainable property development with regulations and incentives. However, this is mainly aimed at energy performance and the reduction of greenhouse gases. As mentioned earlier, real estate also has an impact on other aspects of the environment. In the policy of the EU and the national government, the aspects of biodiversity, sustainable water use, health, well-being and equal development opportunities are underexposed in regulations of new real estate. At this moment, the focus in regulation is mainly on the CO_2 emissions and energy consumption.

Apart from the current regulations, there are several initiatives in the construction and real estate sector to develop residential real estate more sustainably. The market has developed several energy concepts for real estate, e.g., 'Nul op de Meter' (Zero on the Meter, NOM) and ‘Energy-Neutral’ . In the real estate and construction sector, there are also initiatives for other sustainability components, such as biodiversity, water management, sustainable material use, health, etc. Additionally, different labels and certificates have emerged to rate the sustainability of real estate. They evaluate property objects or areas and determine an overall score based on the different sustainability components. These labels and certificates are mainly used for commercial real estate, but they are increasingly used for residential real estate. Well-known sustainability certificates are Gemeentelijke Praktijk Richtlijn (GPR), Building Research Establishment Environmental Assessment Method (BREEAM) and Leadership in Energy and Environmental Design (LEED). Banks also increasingly attach importance to sustainability. Homeowners can get a green mortgage if they purchase an energy-efficient dwelling. A green mortgage consists of a discount on the rent and extra mortgage space. The increasing number of market initiatives and the attention for this subject in real estate journals and conferences, shows that the awareness and initiatives for sustainability is growing among organizations that are involved in the development of real estate.

In addition to the sustainability challenges, there is also a major development task for new residential property in the Netherlands. The continuing tightness in the housing market has played an important role in the upward price trend (NVM; Brainbay, 2020). In 2020, there was a shortage of 331,000 dwellings in the Netherlands, this is 4.2 percent of the total housing stock (Ministerie van Binnenlandse Zaken en Koninkrijkrelatie, 2020; Actieagenda wonen, 2021). The housing shortage is expected to increase further in the coming years. For 2025, a shortage of 419,000 dwellings (5.1 percent) is expected (Actieagenda wonen, 2021). This housing shortage has a large impact on the prosperity and well-being of the Dutch society. Especially, first-time buyers are hit hard by the consequences of the housing shortage.

In order to reduce the housing shortage, the Housing Action Agenda (Actieagenda Wonen) has been launched. This is an initiative of a broad coalition involving 34 organizations, that aims to add 100,000 new dwellings each year through new construction, restructuring and transformationfor a period of 10 years. This would amount to 1 million additional dwellings (Actieagenda wonen, 2021). The central government has largely adopted the recommendations of Housing Action Agenda and has set the goal to realize 900,000 new dwellings before the end of 2030. This objective means an additional challenge for achieving the climate and environment targets.

1.2. Problem outline

There is a large development task for new housing in the Netherlands. The Dutch government has the aim of developing 900,000 new dwellings before the end of 2030. It is important that these dwellings are developed in a sustainable way. In recent years, the EU and the Dutch central government have already drawn up sustainability objectives and regulations for new real estate. These regulations are mainly aimed at energy performance and CO_2 emissions, and less at environmental aspects such as water, health, the impact on flora and fauna. The possible measures for sustainability in real estate development exceed what is currently required in regulations. There are initiatives and real estate projects that have higher sustainability ambitions than the regulations. However, this is not yet the standard. A good explanation for this is that the majority of the new housing stock in the Netherlands is developed by commercial real estate/ project developers. For these organizations, it is important that investments will be recouped. This means that their customers must assign sufficient value to additional sustainability measures and must be willing to pay for it. The importance attached to sustainability and the willingness to pay for additional measures depend on the type of purchaser.

The housing market and thereby the purchasers of real estate developers can be divided into three different groups (De Nederlandsche Bank, 2018):

- owner-occupied dwellings (57%): private owned dwellings for own habitation;
- free rental properties (9%): non-regulated rental properties;
- social rental properties (33%): price-regulated rental properties with an income limit.

The majority of social housing stock in the Netherlands is owned by housing associations. Housing associations operate on a nonprofit basis and their main purpose is to accommodate lower socio-economic classes. The majority of the private rental housing sector is owned by institutional investors and real estate funds. Institutional investors include pension funds, banks and insurance companies. Real estate developers can determine the sustainability ambitions of housing associations and investors quite easily. All housing associations in the Netherlands are members of Aedes. Aedes is the union of Dutch housing corporations; every housing corporation is a mandatory member. The housing associations and the Dutch government have made agreements on sustainability (AEDES, 2019). Housing associations can pursue higher sustainability ambitions. These ambitions can be made clear when these organizations acquire dwellings in development projects. The same principle applies to residential property investors. These investment funds usually purchase with an investment strategy. The requirements for the property, including sustainability, are usually recorded and will be communicated to a property developer in the form of a list of requirements. This way, real estate developers can quite easily determine the sustainability requirements of an investor or housing association.

While real estate developers can quite easily gain insight into the sustainability ambitions of housing associations and residential property investors, this insight is lacking for private customers of newly-built dwellings. The importance that owner-occupied residential consumers attach to sustainability and the willingness to pay for it are critical factors to determine the sustainability measures of a real estate project. Analysis of the literature indicates that residential consumers attach importance to sustainability and that they are willing to pay for additional sustainability measures. A Dutch consumer study, Dossier Duurzaam (2019) shows that there is a growing awareness of sustainability among consumers when purchasing products. According to this study, 53% of the consumers pay attention to sustainability when purchasing products. In addition, the share of consumers willing to pay extra for sustainability has been increasing for several years and is now 38%. Interestingly, 43% of the respondents indicate that they distrust sustainability claims (Dossier Duurzaam; b-open; SAMR, 2019). The awareness for sustainability among residential consumers is implicitly visible in a study of Brounen and Kok (2011). They have performed a hedonic regression analysis between energy labels and the market price of dwellings in the Netherlands. The analysis shows that there is a positive correlation between the height of an energy label and the market price of dwellings (Brounen & Kok, 2011). Similar research has been conducted in Sweden, Ireland and Germany. These studies show the same correlation between the energy labels and market prices of dwellings (Hyland, et al., 2013; Högberg, 2013; Amecke, 2012). The relationship seems stronger when there is a downturn in the housing market (Hyland, et al., 2013). Another interesting conclusion from these studies is that the relationship between energy labels and market prices becomes stronger when a large part of the housing stock has an energy label. An explanation for this phenomenon is that consumers can more easily compare energy performance of dwellings with each other when a large part of the housing stock has an energy label (Hyland, et al., 2013; Högberg, 2013; Amecke, 2012). A study of Perlaviciute et al. (2016) indicates that the perceived environmental impact of sustainability by consumers can be different from the actual environmental impact. In this study equally sustainable measures are not perceived equally sustainable by consumers. For example, environmentally friendly natural gas measures are not perceived as equally environmentally friendly as PV panels (Perlaviciute et al., 2016). This suggests that consumers value sustainable measures differently, regardless of the real environmental benefits.

The literature suggests that a significant part of residential consumers attributes importance to sustainability and is willing to pay extra for it. However, it is not yet known to what extent importance is attributed to sustainability by consumers when purchasing a dwelling. It is also not clear how much more consumers are willing to pay for additional sustainability measures. The literature indicates that not all sustainability measures are perceived equally sustainable by consumers. Real estate developers are faced with a dilemma: either develop residential property that complies with regulations or pursue higher sustainability ambitions. Insight into how much importance residential consumers assign to sustainability and which measures they perceive most sustainable helps real estate developers and other stakeholders take the right measures for new dwellings.

1.3. Problem statement

The problem outline shows that it is unknown how much importance is assigned to sustainability by residential consumers when purchasing a dwelling. It is also not clear which sustainability components are perceived the most sustainable by residential consumers and what the willingness to pay is for the additional sustainable measures. This makes it difficult for residential real estate developers to determine the sustainability ambitions. This observation results in the following problem statement:

> *Real estate developers do not know whether they should follow the current regulations or pursue higher sustainability ambitions. It is unknown to what extent residential consumers attach importance to sustainability when purchasing a dwelling and whether they are willing to pay for additional sustainability measures. In addition, it is also unknown which sustainability components are perceived as most sustainable by residential consumers. Resources (e.g. money, time etc.) and opportunities for sustainable development might be wasted as long as this insight is missing.*

1.4. Scope

The focus of this study is on owner-occupied residential real estate, not on the rental market. Different dwelling types can be distinguished: terraced houses, semi-detached houses, detached houses, upstairs and downstairs houses, patios, apartments, studios, maissonettes, etc. A subdivision of ground-level and multi-family houses can be made. This study only includes ground-level dwellings, i.e. terraced houses, semi-detached houses, detached houses and patios. Multi-family dwellings are excluded from this study because ground-level dwellings have other sustainability measures than multi-family buildings. Due to the available time and resources, it was not possible to research apartments and ground-level dwellings. The study has been conducted and limited to the Netherlands.

1.5. Research objective and questions

1.5.1. Research objective

The research objective results from the problem outline and problem statement. The research objective of this research is:

> *Receive insight into how much importance residential consumers assign to sustainability when purchasing a dwelling and assess their willingness to pay more for the additional sustainability measures. In addition, determine which sustainability components are perceived as most sustainable.*

The insight that is gained with this research will be interesting for real estate developers and other stakeholders, such as construction companies, architects, advisors and municipalities. It informs the developers how much importance their customers, the residential consumers, attach to sustainability when purchasing a dwelling, which sustainability measures they perceive as most sustainable, and to what extent consumers are willing to pay for additional sustainability measures. This helps developers with the dilemma they are facing: following the sustainability regulations or pursue higher sustainability ambitions.

1.5.2. Research questions

The research question consists of two parts. The first part provides insight into the extent to which residential consumers attach importance to sustainability in the purchase decision of a dwelling and how much they are willing to pay for it. The second part of the research question provides insight into which sustainable components and measures are perceived as most sustainable by the residential consumers.

> *To what extent do residential consumers attach importance to sustainability in the purchase decision, which sustainability components are perceived as most sustainable and what is the willingness to pay for the additional sustainability measures?*

In order to answer the main research question, sub-questions have been formulated. Each sub-question is discussed in this thesis and they will be used to answer the main research question. The sub-questions are:

1. *Which property characteristics are most valued by residential consumers when purchasing a dwelling?*
2. *What is sustainable real estate development and how can it be defined?*
3. *What property characteristics and measures affect sustainability?*
4. *Which sustainability components are perceived as most sustainable by residential consumers?*
5. *How much value is assigned to sustainability by residential consumers in comparison to other dwelling attributes in a purchase decision?*
6. *What is the willingness to pay for additional sustainability measures by residential consumers?*

1.6. Relevance

1.6.1. Practical relevance

This research is relevant for all organizations involved in the development of residential real estate, but especially for residential real estate developers. Many residential real estate developers are faced with the dilemma of whether they should adhere to current regulations or pursue higher sustainability ambitions. An important criterion for these organizations is that the dwellings must be marketable. Furthermore, it is important to know which aspects of sustainability the residential consumer perceive as most sustainable.

1.6.2. Scientific relevance

Prior studies have been conducted to examine the general environmental awareness of consumers and their willingness to pay more for sustainable products. Additionally, studies have been conducted to the energy performance of dwellings and the property value. In these studies, the influence of the overall sustainability of a dwelling and the dwelling price, willingness to pay, have not been studied. Therefore, this study is an attempt to provide more insight into the attributed importance to sustainability by residential consumers and gain insight into their perceived sustainability.

1.7. Conceptual model

The conceptual model, see figure 1.1, captures the relationship between the major themes in this study. In this model, the 'residential consumer' can be seen as the Unit of Analysis (UoA). As can be seen, the property value and perceived sustainability of a dwelling need to be predicted. With regard to this study, the property value is a direct result of the sustainability level and other dwelling characteristics. The dwelling characteristics also determine the performance of the sustainability components. These sustainability components together determine the overall sustainability level of a property object. The conceptual model indicates that the willingness to pay is determined by the dwelling characteristics and sustainability level of a property object. The perceived sustainability of a dwelling is directly determined by the different sustainability components.

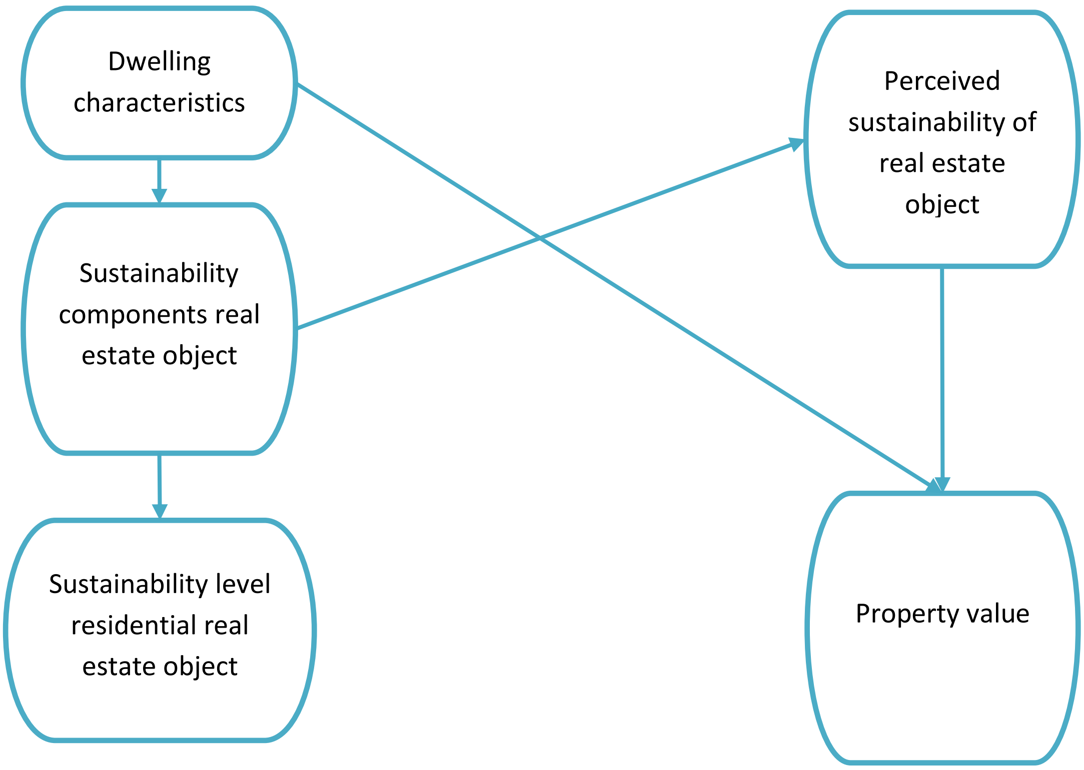


Figure 1.1: Conceptual model

1.8. Research design

This research consists of four parts: a literature review, an explorative study, the results and the conclusion. In the first part, existing relevant literature has been examined to specify key concepts and to operationalize research variables. In the literature study, the value contribution for real estate by residential consumers has been analyzed by reviewing various studies that mention variables that influence the property value. The variables that were mentioned the most in the analyzed literature were considered the most important attributes to influence the value of residential real estate.

The definition for sustainable property development in this study was derived from different sources. Moreover, several sustainability rating tools have been analyzed to determine which indicators influence the sustainability level of a dwelling. The descriptive part resulted in answering the first three research sub-questions.

The second part consists of an explorative research. Its aim was to determine how much importance residential consumers ascribe to sustainability in comparison to other attributes when purchasing a dwelling, and which sustainability components are perceived as most sustainable by residential consumers. These data were collected with two stated experiments, a Rating Scale Exercise (RSE) and a Discrete Choice Experiment (DCE). The data for the RSE and DCE were collected with a questionnaire.

When the data was collected, a regression analysis was used for the RSE data to determine the relative importance of the sustainability components. A multinomial logit model (MNL model) was used to estimate the relative importance and the value contribution of the different attributes in the DCE. These estimates were used to answer the last three sub-questions. After having described the results of the explorative research, the conclusions were drawn and discussed. The last chapter ends with several recommendations. In figure 1.2, the different parts of the research have been graphically displayed.

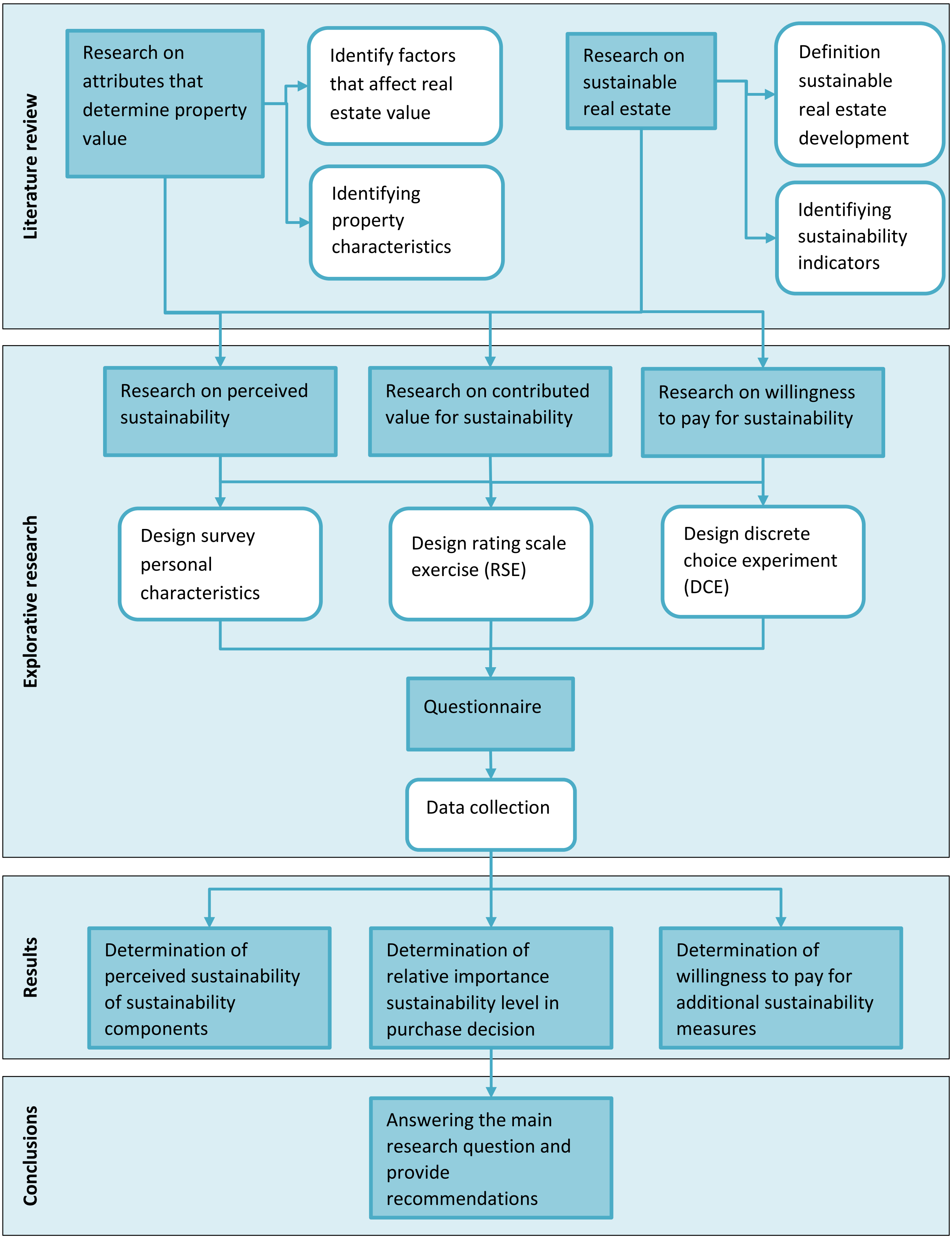


Figure 1.2: Research design

1.9. Reading guide

Chapter 1: Introduction
In the first chapter, the problem outline, problem statement, research objective, research question, sub-questions and conceptual model are described.

Chapter 2: Residential real estate value
In the second chapter, the concept of residential real estate value is explained and defined. A literature review was performed to determine which factors have an influence on the real estate value. The first sub-question is answered by listing the physical dwelling characteristics that are mentioned the most in the reviewed literature.

Chapter 3: Sustainable property development
The second and third sub-questions are answered in the third chapter. The concept of sustainable real estate development is explained and defined for this research. This answers the second sub-question. Several sustainability certificates and rating tools for real estate were analyzed to determine the indicators that have an influence on the sustainability of a dwelling. The mentioned sustainability indicators are listed in this chapter. This answers the third sub-question.

Chapter 4: Research methodology
In the fourth chapter the chosen research method for the explorative study is described. This starts with describing the chosen measurement approach and the analysis methods. Subsequently, the questionnaire for this research is presented, the intended research population is determined and the distribution strategy for the questionnaire is explained.

Chapter 5: Data description
The descriptive statistics of the collected data are described in the fifth chapter. The descriptive statistics are compared with other data sources to determine whether the collected data set is usable for further analysis.

Chapter 6: Results
The results of the data analysis are presented and explained in the sixth chapter. In this chapter the last three sub-questions are answered. The data analysis shows which sustainability components are perceived as most sustainable by the respondents, how much value is assigned to sustainability in comparison to other attributes and what the willingness to pay is for additional sustainability measures.

Chapter 7: Conclusion and discussion
In the last chapter the conclusions are drawn and discussed. The aim of this research is to identify how much importance residential consumers assign to sustainability when purchasing a dwelling and determine which sustainability components are perceived as most sustainable. In addition, the willingness to pay for additional sustainability measures is determined. This chapter ends with recommendations towards real estate developers.

2. Residential real estate value

The concept of 'value' can be interpreted and defined in different ways. Value can be seen as something that a person or society finds worth pursuing, such as good behavior, honesty or friendliness. The other way to interpret value is the worth of a service, material, object or product expressed in a currency. In this study it is assumed that the property value reflects the value assigned by residential consumers.

In this chapter the concept of residential real estate value is defined. The variables and the dwelling characteristics that have an influence on the property value are also displayed. The literature is analyzed to determine the dwelling characteristics that have the most influence on the property value.

2.1. The concept of real estate value

The value of a dwelling is an estimate of the property price at a certain time. The value of the dwelling is estimated with a property appraisal (Ten Have, 2009, 2011). Berkhout (2019) distinguishes three real estate valuation approaches or methods: the comparative valuation approach, the income valuation approach and the cost valuation approach. The comparison and regression method are part of the comparative approach. With the comparison method, the value is derived from transactions of comparable objects. The appraiser corrects the value for real estate characteristics and the market situation. The comparative approach and associated appraisal methods are most often used to estimate the market value of owner-occupied dwellings. The income valuation approach is often used to determine the value of investment objects; the cost valuation approach is used to determine the value for very specific real estate, i.e. a power plant, an agricultural company, etc. The comparative approach is the starting point in this study (Berkhout, 2019).

The literature shows that real estate value is influenced by both internal and external factors. Internal factors are dwelling characteristics that are specific to a property object. Visser and Van Dam (2006) group the internal factors in four dimensions: physical characteristics of the house, physical environmental characteristics, social environmental characteristics and functional environmental characteristics (Visser & van Dam, 2006). These categories are described in more detail in paragraph 2.3.

The housing market, and thus property values, are also influenced by external factors. These factors influence the property values of a segment or the entire housing market in a region, country or worldwide. The credit crisis, global banking crisis, that took place in the period from 2008 to 2013 clearly shows that the real estate value is influenced by external factors. During this period real estate prices decreased in the Netherlands. The credit/ banking crisis caused a worsened economic situation, higher unemployment, financing problems and low consumer confidence. These factors caused the housing market to slow down and prices to fall. External factors can be divided into two groups, namely, market factors and government policy. The influence of the external and internal factors is further identified and discussed in paragraph 2.2 and 2.3.

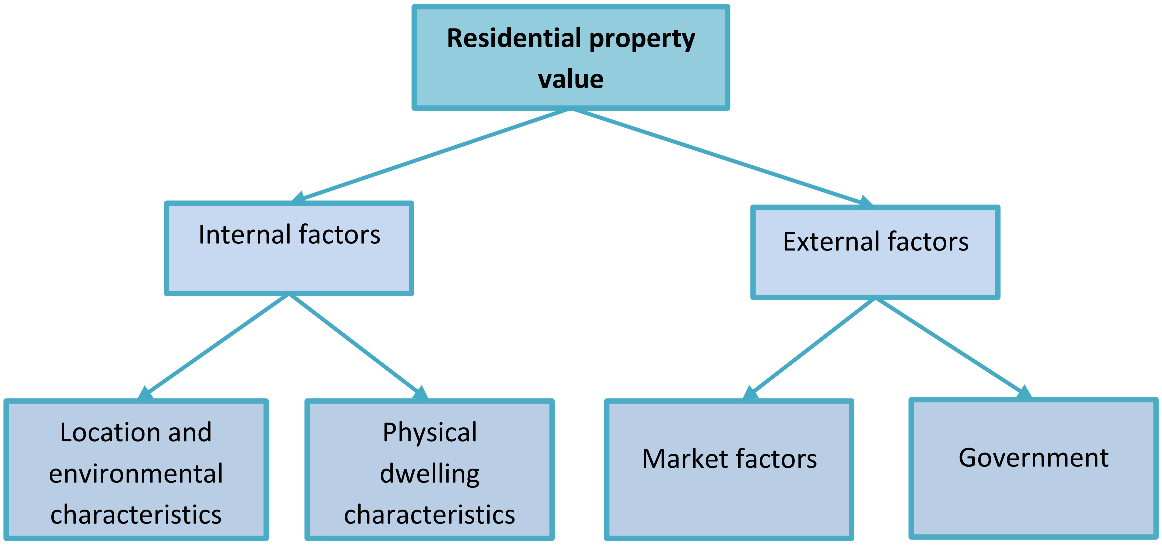


Figure 2.1: Overview of the internal and external factors that influence property value

The concepts of price and value are often confused with each other. Both terms are described to clarify the difference between them. The term 'price' stands for the 'paid amount' , i.e. the legal delivery of a real estate object from a purchase agreement. Prices are an economic final agreement and have a signaling function (Vis, 2010). Ten Have (2011) describes that the market price is established as soon as the ask price (i.e. the asked price of the prospective seller) and the bid price (i.e. the amount that a prospective buyer makes as an offer) have reached the same level. The point where the bid price and the ask price meet is called the market price. The market price is defined by Ten Have (2011) as follows:

> "The market price is the amount at which the balance is reached, and a transaction is effected in a dynamic market" (ten Have, 2011, p. 37).

The value of a real estate object is determined on the basis of the chosen valuation principle. Since this research focuses on owner-occupied residential real estate, the market value is retained in this research. In the comparison method, the market value is derived from old transactions of comparable objects and market developments. The aim of a market value appraisal is to estimate a price of an object in a transaction free of restrictions and burdens. Formulated more strictly in accordance with the market value definition by Ten Have (2011):

> Market value is the estimated price at which the property that would be transferred by a willing seller on the day of its valuation to a willing buyer at an appropriate distance from each other, after following proper negotiation involving the parties with knowledge of business, would have acted with caution and without coercion (ten Have, 2011, p. 38).

In a perfect market, these concepts are in balance with each other. This is not the case in the real estate market. This means that in practice there are differences between the concepts of price and value. The real estate market is an imperfect market because it lacks full transparency, has limited accessibility and incomplete information provision.

2.2. External factors

Various external factors and actors haven an influence on the residential real estate value. In this chapter they are further explained.

2.2.1. Market factors

The price of housing is determined in a combination of three submarkets: the housing market, the financing and investment market, and the construction and land market (Eskani & van Dam, 2013). The interplay of these markets can be explained by the theoretical four-quadrant model of DiPasquale & Wheaton (1992), see figure 2.2.

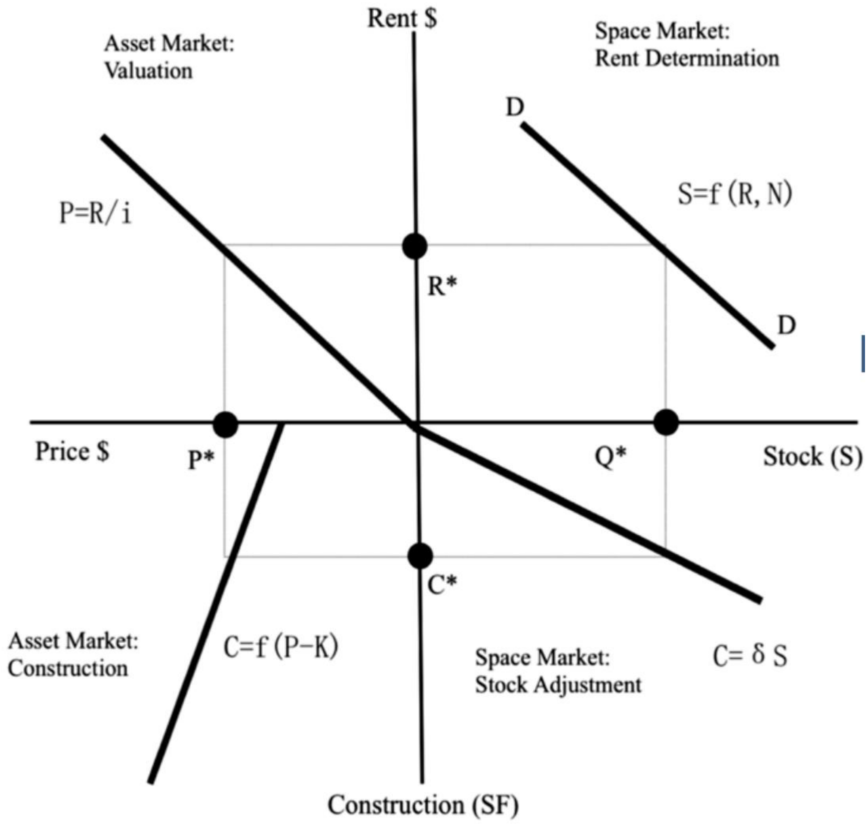


Figure 2.2: Four quadrant model (DiPasquale & Wheaton, 1992, p. 192)

The housing market

The housing market shows the supply and demand. The size of the demand for housing depends on the number of households and household composition. The population forecasts show that the number of households in the Netherlands will continue to increase over the next two decades (Centraal Bureau voor de Statistiek, 2021; Planbureau voor de Leefomgeving, 2015). The size of the demand for housing is also determined by economic factors; economic cyclical factors that influence the spending space (income), the willingness to invest and the tendency to move. An economic upturn, with a lot of spending space among residential consumers, will result in a higher relocation tendency and has a price-pushing effect. In a recession, there is less room for spending among residential consumers, less consumer confidence and a wait-and-see attitude, resulting in a lower relocation tendency. This has a price-depressing effect (Haffner, et al., 2011).

The finance and investment market

The price of (owner-occupied) dwellings is strongly determined by the financing options of residential consumers. In the four-quadrant model of the housing market (figure 2.2.), the transition of the price of housing services into the value of the real estate is made in the financing and investment market. Naturally, interest rates have a major influence on property prices (Renes, et al., 2006). During periods of low mortgage interest rates, there have been major price increases for housing (Eskani & van Dam, 2013). In addition to interest rates and demand-side factors such as households and income growth, the borrowing capacity also plays a role in price development (Renes, et al., 2006). During the housing crisis of 2008-2013, it became apparent that restrictions in the provision of credit had an oppressive effect on property prices. The mortgage interest tax deduction also seems to have an influence on property prices. Whether seen as a subsidy on the price of housing services or as a reduction in the effective mortgage interest rate, in both cases it has a price boosting effect on property prices, due to the relationship with user costs or income.

The construction and land market

In the real estate economic theory, the land value is residual. Residential property prices are determined by the demand for housing in a particular location, as well as the ability to finance. The difference between the property price and development costs is reflected in the land value. The price of newly-built dwellings is derived from the property prices in the existing stock.

The interaction of markets

The residential real estate market is a stock market. There is a large stock of existing residential real estate and the number of net additions (new construction minus demolition) per year is relatively small. This also applies to the portion that is traded annually (sold or re-rented). Because newly-built production is relatively small and only reacts with a significant delay to price developments in the existing housing stock, its price development is sensitive to factors in the housing and financing market, but also to the supply for sale (DiPasquale & Wheaton, 1992). The property prices are therefore almost entirely determined by the existing stock.

The financial banking crisis from 2008 to 2013 resulted in a fall in residential property prices, a decline in newly-built production and a decrease in relocation mobility. These events are interrelated with each other. The low confidence of (residential) consumers and institutional actors on the housing market, including housing corporations, real estate developers, banks and municipalities, have led to a downward spiral due to a wait-and-see attitude (Haffner, et al., 2011). In the period after the credit crises (2014 - 2022), there have been significant property price rises. First in regions with a tight housing market, later it spread to other regions. These price increases seem to be the result of a housing stock shortage, in combination with a low interest rate.

2.2.2. Government influence on real estate value

The national government has withdrawn from the supply side of the housing market and spatial planning. Decisions regarding the number of additions to the housing stock and their locations are left to local authorities, the provinces and municipalities. This also applies to social housing. The national government privatized social housing in the early 1990s. This means that the influence and control of social housing has been largely left to the market and municipalities. Since 2021 the national government seems to have increased the policies and regulations on the housing market again. The government's policy intends to build 900,000 new dwellings before the end of 2023. The government enforces that two thirds of this housing stock should be intended for social and affordable rental housing.

The national government has a significant influence on the demand-side of the housing market by means of tax schemes, such as mortgage interest relief, transfer tax and other financial support schemes, such as the individual housing benefit. The tax schemes have a direct effect on the consumer's spending limit (Haffner, et al., 2011). Finally, the national government uses building and sustainability regulations and subsidies indirectly to control the newly added housing stock. Functional and technical requirements are set for new construction in the Building Decree (Bouwbesluit). The national government has translated various sustainability ambitions into criteria for new construction, such as the Energy performance (Bijna Energieneutrale Gebouwen (BENG)), gas-free new construction and an environmental impact buildings (Milieu Prestatie Gebouwen (MPG)) requirement when applying for a building permit. In existing buildings, the government is also propelling people to go gas-free by increasing the energy tax on gas.

2.3. Internal factors

In this section the internal factors that influence the real estate value are covered. These factors are dwelling, residential environmental and location characteristics. These characteristics are unique and specific for property objects. Residential location and dwelling attributes are internal factors that needed to be critically examined and analyzed in order to ascertain the market value of a given dwelling. In the literature, various dwelling characteristics are mentioned with a varying effect on the residential real estate value. Visser and Van Dam (2006) group these attributes in four dimensions. The following four dimensions are listed:

A. Physical characteristics of the house: construction year, dwelling type, dwelling size(surface area (m^2) and volume (m^3)), number of rooms, nature and layout of house, size of the plot in m^2, presence of garden or outdoor space (size and location/ spatial orientation), parking facilities (e.g. parking garage, carport or parking space), aesthetic and architectural quality, state of maintenance of the house and installations, the level of finishing, limits to real rights to home or land, energy usage, etc.;
B. Physical environmental characteristics, such as the amount of green space and water, the building density in the neighbourhood, the view from the house, the nature and quality of the built environment, the quality of the public space in the neighbourhood and the nuisance factors in the dwelling and environment (e.g. noise, asbestos, environmental pollution, stench, etc.);
C. Social environmental characteristics: the composition of the population in terms of the (un)employment rate, (social) safety, crime rate, percentage of non-western immigrants, the percentage of rented and owner-occupied homes, and the average income in the neighbourhood;
D. Functional environmental characteristics: the accessibility of and distance to various facilities, infrastructure and employment from the home, availability/ accessibility of jobs, accessibility of and distance to all kinds of facilities.

The four dimensions that are distinguished in the study of Visser and Van Dam (2006) can be divided into two groups: the location/ environmental characteristics and physical dwelling characteristics. The distinction between the two groups can be made because of the dimensions; physical environmental characteristics, social environmental characteristics and functional environmental characteristics are linked to the environment and location of a property object. The physical characteristics are part of the property object itself, i.e. dwelling type, surface, number of rooms, garden, etc.

2.3.1. Location and environmental characteristics

Residential property value is influenced by different location and environmental characteristics. In the housing market, both demographic factors and housing preferences play a role on the demand side (ten Have, 2011). According to Eskani and van Dam (2013), the impact of the factors and actors on the property value can vary considerable per region, city and neighbourhood. In the housing markets of Amsterdam and Utrecht, the same actors and factors play a role in determining property values as in, for example, Parkstad Limburg or Northeast Groningen, but the importance and weight of the various price-determining factors can differ between these regions. One of the most important determining differences between regions is the size of the demand compared to that of the supply. Comparable owner-occupied dwellings can therefore be more expensive in certain regions than in others (Eskani & van Dam, 2013). Although on the basis of the economic principle of supply and demand it can be expected that the supply will more or less automatically adapt to high demand (markets tend towards equilibrium). Due to all kinds of institutional and operational restrictions in the built environment and real estate sector, the supply (the adjustment of the housing stock) only reacts hardly or slowly on the demand for housing.

There can also be large differences within cities or regions. Specific neighbourhoods can have higher prices than others. This is caused by physical environmental characteristics, such as the amount of green space and water, the building density in the neighbourhood, the nature and quality of the built environment and the quality of the public space in the neighbourhood, as well as social environmental characteristics: the composition of the population, the (un)employment rate, the percentage of rented and owner-occupied homes, and the average income in the neighbourhood, and functional characteristics of the living environment: the accessibility of and distance to various facilities, infrastructure and employment from the dwelling.

The physical characteristics of the residential environment have an influence on the property price. This category is about physical features, such as green space, quality of the public space, children's play facilities, presence of a busy road, railway, industrial complexes, etc. (Visser & van Dam, 2006). This applies to both urban and rural areas.

The influence of the social characteristics of the residential environment on the property value is difficult to study, since it concerns characteristics that are difficult to operationalize. According to Visser and Van Dam (2006), the price of a dwelling is related to the social economic status of the neighbourhood, and the number of non-western immigrants in the neighbourhood. Dwellings located in environments with a lower social economic status have lower property values per square meter (Visser & van Dam, 2006; 2008).

The research of Visser and Van Dam (2006) shows the influence of functional environmental factors on the property value. With regard to the functional characteristics of the living environment, two characteristics stand out. Firstly, employment in the vicinity is a price-determining factor: the more accessible jobs, the higher the property values. The proximity of employment can therefore be seen as a good indicator for the pressure on the regional housing market. This effect seems stronger for dwellings within urban areas (Visser & van Dam, 2006).

2.4. Physical dwelling characteristics

A literature search was performed to identify physical dwelling characteristics that have an influence on the property value. The saturation principle has been applied; the following twelve publications that mention physical dwelling characteristics have been analyzed (van Arnhem & Berkhout, 2013; Visser & van Dam, 2006; Grether & Mieszkowski, 1973; Ferlan, et al., 2017; Hassan, et al., 2021; Sirmans, et al., 2020; Selim, 2008; Vastmans, et al., 2016; Vastmans, 2013; Buitelaar, et al., 2014; Brounen & Kok, 2011; Herath & Maier, 2010). In the literature study 30 different physical dwelling characteristics were identified. These were plotted against the consulted literature in a matrix. The matrix specifies all physical dwelling characteristics for each publication. Characteristics that are very similar are clustered in groups. The complete matrix can be found in Appendix 1. In table 2.1, the characteristics that are mentioned in the literature are displayed. For each characteristic is displayed how many times it is mentioned in the consulted literature. The characteristics are clustered in 17 different groups, based on similarity and overlap.

Physical dwelling characteristic	Number of times mentioned in literature	Category	Number of times mentioned in literature
Construction year	9	**Construction year**	**9**
Dwelling size (m²)	11	**Dwelling size (m²)**	**11**
Volume dwelling (m³)	2	**Volume dwelling (m³)**	**4**
Height ceiling	2		
Dwelling type	8	**Dwelling type**	**8**
Layout	5	**Number of rooms**	**21**
Number of rooms	10		
Number of bathrooms and toilets	4		
Basement	2		
Floor level (in buildings without an elevator)	5	**Floor level (in buildings without an elevator)**	**4**
Orientation dwelling	2	**Orientation dwelling and garden**	**5**
Orientation outdoor space (garden/ balcony)	3		
Size of lot	4	**Size of private outdoor space (garden/ balcony)**	**10**
Availability private outdoor space (garden/ balcony)	2		
Size of private outdoor space (garden/ balcony)	4		
Parking space or garage	9	**Parking space**	**9**
State of repair/ level of maintenance	8	**Quality of the building**	**19**
Level of finish inside	5		
Construction material (maintenance)	6		
Architectural design	3	**Aesthetic quality**	**4**
Monument	1		
Unobstructed view from the home	2	**Unobstructed view from the home**	**2**
Energy efficiency	5	**Energy efficiency**	**14**
Energy label	1		
Isolation quality dwelling	2		
Heating system (e.g. fireplace, central heating, underfloor heating)	6		
Availability of (security) fence	1	**Availability of (security) fence**	**1**
Availability of luxury attributes (e.g. swimming pool, sauna, jacuzzi, sport facilities, etc.)	4	**Availability of luxury attributes (e.g. swimming pool, sauna, jacuzzi, sport facilities, etc.)**	**4**
Limits to real rights	1	**Limits to real rights**	**1**
Quality noise isolation outside and inside (e.g. neighbourhood noise, inside noise, installations, etc.)	2	**Noise disturbance**	**2**

Table 2.1: Overview of physical dwelling characteristics from the literature review

The list with characteristics that are mentioned in the literature is quite long and extensive. It is expected that not all characteristics mentioned in the literature are equally important. To make the list with characteristics more compact and comprehensive, it has been decided to group characteristics into categories and only include characteristics that are mentioned at least five times or more in the literature. Table 2.2 lists the most commonly mentioned dwelling characteristics categories with a brief description.

Physical dwelling characteristics	Description
Construction year	Construction year
Dwelling size	Size of dwelling
Dwelling type	Type of house
Number of rooms	Number of rooms
Size of private outdoor space	Size of garden or balcony
Parking space	Parking facilities (e.g. parking garage, carport or parking space)
Quality of the building	State of maintenance of the house and installations, the level of finishing
Energy efficiency	Energy efficiency of the dwelling

Table 2.2: Overview of most valued physical dwelling characteristics

2.5. Conclusion

This chapter identified and reviewed the literature on which attributes and actors influence the residential real estate value, in order to answer the first sub-question.

> *Which property characteristics are most valued by residential consumers when purchasing a dwelling?*

In this study, the market value of a property object was used to reflect the value assignment of the residential consumers. The market value is defined as follows:

> Market value is the estimated price at which the property that would be transferred by a willing seller on the day of its valuation to a willing buyer at an appropriate distance from each other, after following proper negotiation involving the parties with knowledge of business, would have acted with caution and without coercion (ten Have, 2011, p. 37).

The literature shows that the market value of a dwelling is influenced by both external and internal factors. The external factors can be divided into market factors and government policy. The following markets influence the property value: the housing market, the financing and investment market, and the construction and land market. The external factors were not considered in this study because they are not part of the property object itself and influence the whole housing markets. The internal factors are the property characteristics, these can be categorized as physical dwelling characteristics, physical environmental characteristics, social environmental characteristics and functional environmental characteristics. The categories of physical environmental characteristics, social environmental characteristics and functional environmental characteristics are largely linked to the location and environment of an object. These categories were not further taken into account because of the complexity and the scope of this research.

A literature study was conducted to identify the physical dwelling characteristics that are valued the most by residential consumers. Twelve different studies and real estate appraisal books were analyzed. The physical dwelling characteristics that are mentioned in the reviewed literature are listed in a matrix, see Appendix 1. In the matrix it is indicated in which studies the physical dwelling characteristics are mentioned. The characteristics were clustered into different categories based on similarity and overlap. This resulted in 17 categories that are presented in table 2.1. The categories that are mentioned the most in the literature are construction year, size of dwelling, dwelling type, number of rooms, size of private outdoor space, parking space, quality of building and energy efficiency. It was assumed in this research that these categories are the most valued physical dwelling characteristics by residential consumers.

3. Sustainable real estate development

In this chapter the concepts of sustainability and sustainable (real estate) development are clarified. Followed up by an analysis of sustainability assessment methods to determine indicators and measures that influence the sustainability of real estate objects. These sustainability indicators are matched with the scope of this research.

3.1. Evolution of sustainability and sustainable development

The definition of sustainability and sustainable development has changed over time. It strongly depends on the context, situation, location and time. In terms of environmental impact, sustainability can best be described in terms of humanity's need to survive adverse effects on earth (Commission on Environment and Development, 1987). A sustainable society is one that is 'enduring, self-reliant, and less vulnerable to external forces'. This can be reached through renewable and efficient energy use, the conservation of water and soil, and harvest regulation (Demirel, 2020).

The concept of sustainability can be traced back to forestry in 19th century Germany. At the time, forestry recognized that natural resources could only be taxed to a certain extent. In forestry this meant that as much wood could be felled as there was growing (Morgenstern, 2007; Demirel, 2020). This principle shows that sustainability should not be seen as an end product but rather as a process. Different sectors have incorporated this idea of sustainability that originated in the forest industry.

The ideas about sustainability received a major boost in the 1970s when the negative (side) effects of economic development manifested themselves. The dominant, one-sidedly oriented economic growth mindset came under discussion, both from an ecological and social point of view. Some economists also commented on how natural resources were used in production processes. The environmental problems have been made visible to governments and societies in countless publications.

One of the best-known international reports on this subject is ‘The Limits to Growth’. This report was commissioned by the Club of Rome. The report warns about the consequences of exponential growth in population and consumption. Based on calculated scenarios, it was made plausible that if the growing trends in demand, use and pollution of natural resources continued, many resources would be exhausted or seriously polluted within a few decades. This would eventually lead to the collapse of 'the Earth's ecosystem' (Meadows, et al., 1972). The impact of the report was amplified by the oil crisis of 1973. The first oil crisis in 1973 exposed the dependence on fossil fuels. This crisis generated attention for energy savings. In the construction sector, this has led to the first insulation requirements for new buildings and the implementation of energy-saving programs in existing buildings. Thermopane (double glazing) and cavity wall insulation are energy saving measures that were used in new buildings from then on. In 1987, the World Commission on Environment and Development led by Norwegian Prime Minister Brundtland published the report 'Our Common Future', commonly known as the Brundtland report. The committee introduces a definition for sustainability that can still be considered current and inspiring:

> Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Commission on Environment and Development, 1987).

In the Brundtland report, the concept of sustainability and sustainable development has been expanded to include a social and economic component. Before that, sustainability was only focused on the environmental impact. This report recommended that countries stimulate development that considers social and environmental factors, in addition to economic growth (Pope, et al., 2004; Demirel, 2020). The Brundtland report has become an important cornerstone for sustainability and a reference book for researchers, policymakers and governments. The ideas of this report are the basis of Agenda 21. Agenda 21 is a non-mandatory program with sustainability goals of the United Nations (UN). It forms a guideline for nations to develop their national sustainability policies. The UN's Rio de Janeiro Conference on Environment and Development of 1992 approved the recommendations of the report. The latter conference, also known as the Earth Summit, is where Agenda 21, often referred to as the 'blueprint' for sustainability in the 21st century, was established. Agenda 2030 is an elaboration of the objectives of Agenda 21. This framework consists of 27 sustainable development goals (SDGs). The Sustainable Development Goals were adopted by the United Nations in 2015 as the new global sustainable development agenda for 2030. The Paris Agreement of COP 21 (2015) is strongly linked to the SDGs. The countries that participate in the Paris Agreement must devise Nationally Determined Contributions (NDCs) every five years. In the NDCs, every country must describe and justify its efforts to reduce national emissions and adaptations to the impacts of climate change.

Three pillars of sustainability

If the Brundtland definition is used for sustainable real estate development, then the three parts, i.e. environmental, social and economic, must be treated with equal importance. There are different views on this, and some argue that more importance should be given to the environmental pillar than to the other two parts. The authors Lützkendorf & Lorenz (2007) provide a definition of how to treat the three different aspects of sustainable real estate development with equal importance:

> Thus, the concept of sustainable development can be interpreted as the journey towards one final destination: 'sustainability'. Sustainability is meant to be the desirable overall concept or goal of economies' or societies' development or evolution, respectively. The term circumscribes an equilibrium state of an economy or society with regard to environmental, economic and social conditions (Lützkendorf & Lorenz, 2007, p. 645).

Definition sustainable real estate

The definition of 'Brundtland' for sustainable development is widely accepted and is often directly translated to sustainable real estate development in the Netherlands. Real estate is an important section for the sustainability goals due to its environmental and climatic impact, and is therefore important for achieving the sustainability goals. This section attempts to clarify the concept of sustainable real estate and sustainable real estate development. Lützkendorf and Lorenz (2007) describe a sustainable building as:

> A sustainable building is meant to be a building that contributes – through its characteristics and attributes – to sustainable development. By safeguarding and maximizing functionality and serviceability as well as aesthetic quality, a sustainable building should contribute to the minimization of life cycle costs; the protection and/ or increase of capital values; the reduction of land use, raw material and resource depletion; the reduction of malicious impacts on the environment; the protection of health, comfort and safety of workers, occupants, users, visitors and neighbours; and (if applicable) to the preservation of cultural values and heritage (Lützkendorf & Lorenz, 2007, p. 646).

The definition of Lützkendorf & Lorenz (2007) shows that sustainability relates to the entire life cycle of an area or object and not only to one or two phases. This means that a property object or an area must contribute to the sustainability goals during its exploitation/ use but also after this phase. In practice, the terms green building and sustainable building are often used interchangeably. However, there is a difference: a green building is limited to the environmental impact, while a sustainable building also takes into account the social and economic impact of a building during its life cycle. The Brundtland definition for sustainability development is slightly modified in this study to make it more suitable for real estate development. The following definition of sustainable real estate (development) is devised for this research:

> A strategy that encompasses the whole of plan development, design, construction, use, demolition and reuse, in order to achieve social, environmental, economic, spatial and process-oriented objectives to be realized in accordance with the socially desirable level.

3.2. Measurement method sustainability real estate

Sustainable real estate (development) is not a well-defined concept. Without a clear definition of a concept or goal, it is challenging to measure progress towards that concept or goal. At real estate, sustainability goes further than an energy label, MPG score or other regulations. In this study, sustainability is operationalized and framed using sustainability rating tools. Various sustainability certification/ rating tools have been analyzed to find out which dwelling characteristics influence sustainability.

There are several rating systems that measure the sustainability levels of real estate objects/ areas. Each rating tool has its own set of attributes and weighting scheme to rate property objects/ areas (Melgar, 2019). The rating tools provide an objective way to evaluate real estate objects/ areas on a broad set of sustainability indicators. According to Benardi, et al. (2017) most of the sustainability rating tools have the following structure:

- Categories: categories of evaluation consist of indicators with varying points, summed to a total number of points that can be achieved
- Scoring system: performance measurement system that cumulates the number of possible points than can be earned
- Weighting system: the relevance of the assigned points within each category to the overall scoring system
- Output: the output shows in a direct and comprehensive manner the results of the evaluations during the scoring phase (Benardi, et al., 2017, quoted in Demirel, 2020)

In this research the following rating tools are analyzed: LEED (USA), BREEAM (UK) and GreenStar & Nabers (AUS). The reason that these rating tools were chosen is due to the international reputation of the tools and the transparency about what is measured. The aim of the analysis is to establish a set of sustainability components/ categories and indicators that can be used for this research. For the selection of these components and indicators, the following schemes were analyzed:

<u>BREEAM</u>
The following three BREEAM schemes were analyzed:

- BREEAM NL Asset
- BREEAM NL in Use: Management
- BREEAM NL in Use: Asset

<u>LEED</u>
The following two LEED schemes were analyzed;

- LEED v4.1 Residential: Single Family Homes
- LEED v4 for NEIGHBOURHOOD DEVELOPMENT

<u>Greenstar</u>
The Green Star certification scheme was analyzed.

Table 3.1, 3.2 and 3.3 show the overview of sustainability components and indicators that were mentioned the most in the analyzed rating tools. The total overview of the sustainability indicators that are derived from the analyzed rating tools is listed in Appendix 2. This list was minimized by merging indicators that were synonymous or had a large overlap. The different sustainability components and indicators that are part of this list are explained in Appendix 3.

Sustainability component	Sustainability indicator		Goal	Measurement/ measure
Energy	1	Sustainable energy sources	Generating renewable energy	Share of renewable energy in comparison to the total energy use
	2	Energy performance	Minimizing energy use to heat, cool, light and ventilate the building	Energy use of the building (BENG score)
	3	Monitoring energy use	Gaining real-time insight into the energy use of a building and the equipment in the building. The aim of this is to use renewable energy more efficiently	Provide users with real-time insight on an app on the phone or on a screen
	4	Energy efficient design	Design a dwelling that has a low energy requirement	Design a dwelling that minimizes the energy requirement for heating, cooling and ventilation. With design measures such as façade, size and orientation of windows
Water	5	Monitoring water consumption	Gaining insight into the tap water use of the different functions (e.g. showering, dishwasher, flushing toilet, etc.)	Provide users of the dwelling with insight into the different functions through monitoring software
	6	Water saving sanitary	Reduce tapwater use	Installation of water saving sanitary, such as a water saving shower head and a dual flush button or a flush disruptor in the toilet
	7	Reuse collected water	Reduce tapwater use	Use rainwater and re-use greywater
	8	Separate grey, black and rainwater	Prevent the spoilage of rainwater in the sewer	Separate sewage system
	9	Water management	Prevent the spoilage of rainwater in the sewer and promote water irrigation	There is no rainwater sewage. Rainwater is collected and irrigated in the area.
Material	10	Environmental impact	Minimize the negative environmental impact	Calculation of the environmental impact of the building materials
	11	Demountable materials	Providing the possibility of re-using building materials after the lifespan of a building	Non-toxic easy demountable and re-usable materials
	12	Material passport	Providing the possibility of re-using building materials after the lifespan of a building	The presence of a material passport

Table 3.1: Overview of sustainable components and indicators (part 1 of 3)

Sustainability component	Sustainability indicator		Goal	Measurement/ measure
Ecology	13	Ecological facilities	Support the local flora and fauna	The presence of nest boxes for birds, bats and insects and the use of indigenous plant species
	14	Green facilities	Reduce urban overheating	The presence of enough green space to prevent urban overheating
	15	Ecological impact	Minimize the ecological impact	Conducting ecological research and taking the right measures to keep the environmental impact as minimal as possible
	16	Land-preservation	Minimize the ecological impact	Minimize the carbon footprint of the buildings
Future proof	17	Lifespan	Minimize maintenance and maximize lifespan	Apply low-maintenance materials with a long lifespan
	18	Adaptability	Increase lifespan by easy (structural) adaptation of the building	Structural design that provides changes
Spatial quality	19	Neighbourhood patterns and spatial design	Increase connection of residents with the neighbourhood and support community	The quality of the public space and spatial design
	20	Functionality	A functional neighbourhood	The presence of daily necessities in the neighbourhood
	21	Diversity	Social inclusive neighbourhoods	The presence of housing in different price segments
	22	Beauty	Increase lifespan and impact users positively	Architectural quality of the buildings
	23	Identity	Increase recognition and connection of residents with the neighbourhood	Design of a neighbourhood that has an identity of its own and is recognizable

Table 3.2: Overview of sustainable components and indicators (part 2 of 3)

Sustainability component	Sustainability indicator		Goal	Measurement/ measure
Transport	24	Reduced car parking	Minimize car ownership and stimulate other modes of transportation	Reducing the number of parking spaces in the area
	25	Proximity of public transport	Encourage the use of public transport	Distance to public transport nodes
	26	Facilities for cyclists	Encourage bicycle use	The presence of parking facilities for bicycles
	27	Proximity of facilities	Minimize transportation	Distance to facilities in the area
	28	Car sharing	Minimize car ownership	The presence of shared cars in the area
	29	Electric charging stations	Stimulate the use of electric cars	The presence of charging stations in the area
Pollution	30	Waste collection	Minimize the environmental impact of waste	The presence of separate waste collection
	31	Light pollution	Minimize the light pollution in areas where it can harm the flora and fauna	A good lighting design for the public space and the use of light fixtures that reduce radiation to the environment
	32	Local water and air pollution	Minimize local water and air pollution	Minimize flux of metals (e.g. lead, zinc, copper) and toxic gases
Health and well-being	33	Air quality	Healthy indoor air quality	A good ventilation system that monitors the air quality on CO, CO_2 and humidity levels
	34	Daylight	Sufficient levels of daylight for the users	Presence of enough daylight in the most important rooms of the dwelling
	35	Thermal comfort	A pleasant temperature	Good isolation and thermal control by the end user
	36	Noise	Minimize internal and external noise	The presence of good noise isolation and spatial orientation of bedrooms
	37	Safety	Reduce chance of burglary	Applying recommendations of Police Certificate of Safe Living
	38	Harmful materials	Reduce exposure to toxic or harmful substances	Minimize the use of harmful materials

Table 3.3: Overview of sustainable components and indicators (part 3 of 3)

3.3. Conclusion

Through the findings from the literature review and analyses of sustainable certifications, the following sub-questions can be answered:

> *What is sustainable real estate development and how can it be defined?*
>
> *What property characteristics and measures affect sustainability?*

There is no uniform definition for sustainable real estate (development). This makes it difficult to determine the scope of this concept and to make it measurable. The definition of the Brundtland report”’ for sustainable development is widely used and accepted. However, this definition is quite general and does not cover all aspects of real estate development. The literature review shows that sustainability should be considered as an ongoing process during all the different phases; it is not limited to the construction and exploitation phase. It should include the whole of planning, design, construction, use, demolition and reuse, the so-called life-cycle approach. The following definition was devised for sustainable real estate development in this study:

> A strategy that encompasses the whole of plan development, design, construction, use, demolition and reuse, in order to achieve social, environmental, economic, spatial and process-oriented objectives to be realized in accordance with the socially desirable level.

The literature shows that sustainable real estate development is broader than an energy label, MPG score or other measures or regulations. As stated before, there is no unambiguous definition for sustainable real estate (development). This makes it difficult to indicate what needs to be measured. There are several sustainability certificates/ rating tools for real estate. These rating tools determine an overall sustainability score based on the scores of different indicators. These indicators have an effect on the overall sustainability. In this study, several sustainability rating tools have been analyzed to find out which sustainability indicators would be considered and viewed as most important. In table 3.1, 3.2 and 3.3, a list of 38 sustainability indicators is presented that are subdivided into the following components: energy, water, material, ecology, future proof, spatial quality, transport, pollution, health and well-being.

4. Research methodology

In chapter 2 an overview of the physical dwelling characteristics that have an influence on the property value was presented. The definition for sustainable real estate development and a list of sustainability indicators were presented in chapter 3. However, it is not yet clear which sustainability indicators (components) are perceived as most sustainable by residential consumers and how much value overall is attributed to sustainability in the purchase decision.

In paragraph 4.1 the measurement approach is described. The theoretical foundations of the chosen measurement approaches are further explained in the paragraphs 4.1.1 to 4.1.3. The questionnaire that was used in this research is presented in paragraph 4.2. In paragraph 4.3 the target research population and distribution are described.

4.1. Measurement approaches

There are various approaches to measure preferences and choices. Figure 4.1 shows an overview of the different measurement approaches. Kemperman (2000) states that the data for the models can be collected with a revealed or a stated modeling approach. Revealed models are based on observations. With a revealed choice/ preference modeling approach, the utility values and attribute weights are derived from observed choices/ preferences in a real market situation. Statistical sources are often times used as data for this (Kemperman, 2000). A stated measurement approach is based on artificial data of surveys. The data collection for the stated approach involves the elicitation of responses to predefined hypothetical alternatives in which respondents state their preferences/ choices. With this, either a compositional or a decompositional approach can be used (Kemperman, 2000; Klanderman, 2019).

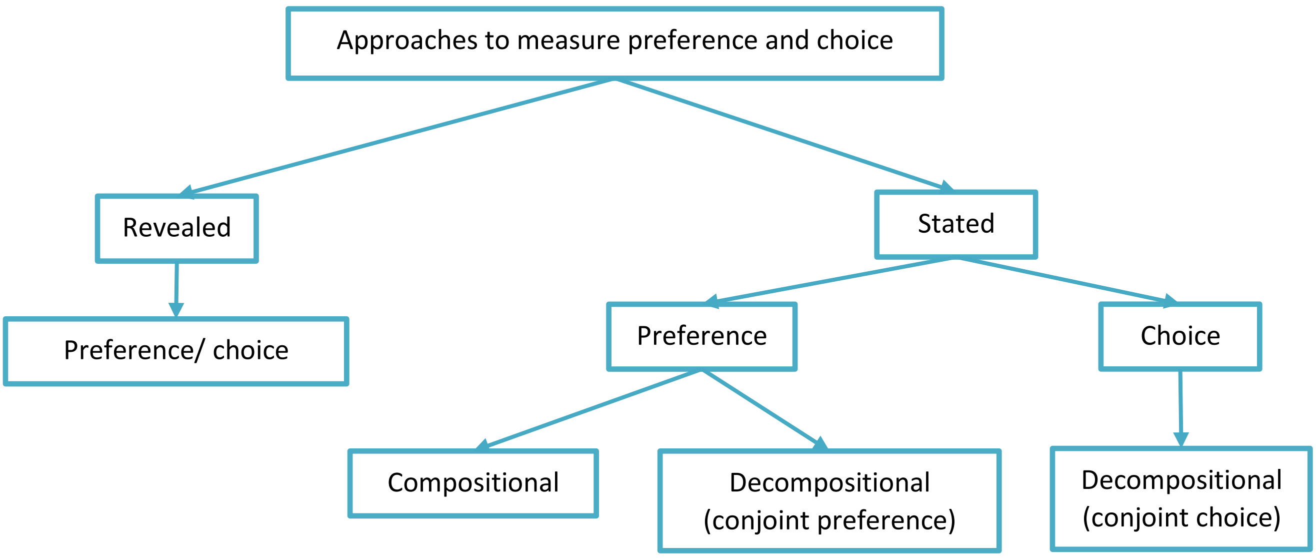


Figure 4.1: Overview of measurement approaches (Kemperman, 2000, p. 83)

When using a compositional approach, respondents are required to rate all levels of the attributes that have an influence on the alternative. In addition, respondents are also requested to indicate the relative weight of each attribute (Kemperman, 2000; Klanderman, 2019). This can be done, for example, by letting respondents divide 100 points over the various attributes (Green & Srinivasan, 1990). By multiplying the scores of each attribute with the relative importance and utility values of the alternatives, one can determine the predicted choices (Kemperman, 2000).

> Although the compositional approach has some practical advantages, Green and Srinivasan (1990) listed a number of possible problems: (i) respondents may not hold all else equal when they provide ratings for the levels of an attribute; (ii) social desirability effects may occur; (iii) respondents may answer on the basis of their own range of experience over existing products; (iv) the additive model is assumed as the literal truth; (v) any redundancy in attributes can lead to double counting; (vi) there is little chance to detect potential nonlinearity in the part-worth function; (vii) no respondent evaluation of choice or purchase likelihood can be obtained; and finally, (viii) respondents cannot express certain trade-offs among attributes (Kemperman, 2000, p. 85).

The decompositional approach works differently. Respondents are requested to rank or rate different profiles with varying attribute levels, or to make a choice between two or more presented profiles (Kemperman, 2000). The assumption is that respondents make a tradeoff between the attribute levels when ranking/ rating a profile or choosing between the presented profiles. These mimics the dilemmas respondents face in the real market situation (Green & Srinivasan, 1990; Kemperman, 2000; Klanderman, 2019). The decompositional, conjoint modeling approaches, derives the weights of the attributes (indirectly) from the ratings or choices of the respondents (Kemperman, 2000). The presented profiles consist of several attributes with varying levels. The number of levels is predetermined. It is mostly not possible to present all the possible combinations of attribute levels. Therefore, the researcher creates a predetermined set of conjoint profiles that combine certain attribute levels. The researcher controls for correlations in the design (Kemperman, 2000).

It was unfortunately not possible to use the revealed measurement approach to determine the preferences and choices of the residential consumers. The reason for this is that there are no suitable (transaction) data available that includes the necessary sustainability indicators. The sustainability data in real estate transactions are limited to an energy label (energy performance). Conjoint modeling provides a quantitative measurement approach to collect the necessary data. There are various studies that have proven that the decompositional approach is an effective measurement approach (Cornelissen, 2017; Nijënstein, 2012; Kemperman, Arentze, et al., 2016). Therefore, regarding this study, the stated data are collected using a decompositional approach.

4.1.1. Conjoint preference and choice modelling

As was demonstrated in the previous paragraph, the stated measurement approach elicits responses from people to predefined alternatives, whereby they hypothetically state their preferences, whereas revealed preference methods involve people's preferences being observed in real life (Wijnen, et al., 2015). The stated methods can be divided into conjoint preference and conjoint choice approaches (Kemperman, 2000). These approaches differ in the way the respondents are requested. The conjoint preference approach request respondents to rate or rank hypothetical profiles. When using a conjoint choice approach, respondents are presented with two or more profiles and are requested to make a choice between the presented profiles (Kemperman, 2000).

Respondents are given a predetermined number of alternatives in ranking exercises, and they are asked to rank these alternatives in order of 'least preferable' to 'most preferable' (Wijnen, et al., 2015). It is also possible to let respondents order presented profiles in different groups. The advantage of a ranking task exercise is that it is easier for respondents to rank or order different profiles in preference than by rating each profile individually. Respondents also have to consider all the alternatives carefully in a ranking/ ordering exercise and make trade-offs between the attributes of the profiles. The downside of a ranking exercise is that there is no information collected about the degree of preference (Kemperman, 2000; Ben-Akiva, et al., 1997). Rating Scale Exercises (RSE) require respondents to indicate their preference for the presented profiles by rating profiles on a Likert scale with a pre-specified range (e.g., from 1 to 5, where 1 = least preferred and 5 = most preferred). The data of the RSE provide information about the order and the degree of preference. The benefit of RSEs is that linear scale data is available, which allows tests for various model specifications (Kemperman, 2000). The conjoint choice approach includes discrete choice experiments (DCE). In a DCE, respondents are asked to make a choices between two or more hypothetical profiles. A choice set consists of two hypothetical profiles that have varying attribute levels. The respondents are asked to select their preferred profile. Usually, in the choice sets there is also an option 'neither' so that respondents can choose this option if the presented profiles are not good enough to be selected (Kemperman, 2000).

The DCE is based on the random utility theory (RUT), a theory of choice behaviour. According to RUT, individuals possess a latent (unobservable) construct called 'utility' for each choice alternative. RUT claims that this utility can be divided into two parts: an explainable part and an unexplainable (random) part. The individual's covariates and characteristics of the choice task form the explainable component, whereas all unknown factors (referred to as 'error terms') form the random component. In DCEs, a utility function is used to ascertain people's preferences. Additionally, according to economic theory, utilities are stable over time and people eventually attempt to maximize their utility functions. People are expected to make trade-offs within a resource constraint in DCEs. It is also expected that their decision-making processes follow the assumptions of these theories, as well as rational choice (Wijnen, et al., 2015).

When using a RSE respondents are expected to value each step on the rating scale equally. In contrast, with a DCE only one out of two presented options is chosen. A RSE is therefore typically more holistic because respondents evaluate all the attributes of a profile as a whole before rating it. However, van Wijnen, et al. (2015) states that a downside of a RSE is that it does not explicitly capture the trade-off between the attributes of the presented profiles. A DCE is thought to more accurately represent actual decision-making because it enables the estimation of overall preferences for any combination of attributes (Wijnen, et al., 2015). The DCE method is a data collecting method that is closer to real world behaviour than rating or ranking exercises. According to Kemperman (2000), residential consumers do not rate or rank different profiles but make choices in the real world. Another benefit of choice tasks is that the data enables to make predictions of demand and market share. If a researcher wants to make predictions with a RSE it is necessary to formulate ad hoc assumptions concerning residential consumers' decision rules. However, the choice models have the downside that the choice data provide minimal information about the non-chosen alternatives. Rating data gives more information about the attributes in the profiles (Kemperman, 2000).

The conjoint preference approach with a RSE is used in this study to evaluate how sustainable residential consumers perceive the different sustainability components of property objects. The conjoint choice approach with a DCE is used in this study to determine the importance of sustainability in comparison to other property object characteristics. In paragraph 4.1.2. and 4.1.3., the theoretical background of the Multinominal Logit Model and Willingness to Pay calculations are explained in more detail.

4.1.2. Multinominal logit model

The Multinominal Logit Model (MNL model) is a choice model that incorporates the Random Utility Theory to predict the probability that an alternative is chosen from a choice set with two or more alternatives (Kemperman, 2000). This probability can be calculated with the formula shown in equation 4.1.

$$P(i|A_q) = \frac{\exp(\mu(V_i))}{\sum_{i'} \exp(\mu(V_{i'}))} = \frac{\exp(V_i)}{\sum_{i'} \exp(V_{i'})} \quad i, i' \in A_q$$ Equation 4.1

$P(i|A)$ is the probability that alternative i is chosen, given a choice set A_q

V_i is the structural utility for alternative i

μ is a scale parameter, arbitrarily set to 1

The theory behind the MNL model is that an individual's choice for an alternative consists of deterministic and stochastic utility components. This means that the probability of choosing an alternative is not automatically equal to the highest utility but is based on the probability that the utility of an alternative exceeds the other alternatives (Klanderman, 2019). A scale parameter can be added to the formula when using multiple datasets. This research uses a single dataset. It is therefore not necessary to use a scale parameter (Kemperman, 2000; Klanderman, 2019).

With MNL models it is possible to recognize patterns in analyzed groups. However, it is impossible to determine with certainty what an individual will choose. When the characteristics of the observed group are known, it is possible to combine choice patterns with characteristics. MNL models do not take the differences between individuals into account.

4.1.3. Willingness to pay

The hypothetical profiles of conjoint choice and preference models consist of different attributes that have varying attribute levels. An example of an attribute is the 'dwelling size' or the 'size of the outdoor space'. If the attribute 'price' is part of the data set, it is possible to calculate the willingness to pay. The willingness to pay for an attribute is calculated by dividing the utility range of an attribute by the utility range of the attribute 'price'. This value is then multiplied by the difference between the highest price level and the base price level. The utility range of an attribute is the difference between the highest and lowest utility value of the levels of an attribute (Hensher, et al., 2015). The equation of the WTP formula is presented in equation 4.2.

$$WTP = \frac{\mathrm{Ra}}{\mathrm{Rp}}\ x\ Pd$$ Equation 4.2

R_a is utility range of attribute

R_p is utility range of the price

P_d is price difference (highest price level – base price level)

4.2. Questionnaire

In this section the construction of the questionnaire is described. In addition to the stated preference and choice experiment it is important that the personal characteristics of the respondents themselves are determined. The questionnaire is composed of the following sets of questions:

a) Screening questions respondents
b) Personal characteristics and environmental awareness
c) Perceived sustainability components (RSE)
d) Preferences of residential consumers for sustainability (DCE)

4.2.1. Screening respondents

The first part of the questionnaire is used to screen the respondents and determine if they meet the criteria of the intended research population. The intended research population are homeowners of ground-level dwellings or people who have a relocation tendency within two years for an owner-occupied ground-level dwelling. With multiple questions it was determined whether a respondent met the criteria of the intended research population.

Screening questions to select suitable respondents			
Variable / concept		**Level of measurement**	**Items**
Current dwelling type	In what type of dwelling do you live at the moment?	Nominal	Multiple Choice (6) 1 = Terraced house 2 = Corner house 3 = Semidetached house 4 = Detached house 5 = Apartment, flat, upstairs or downstairs apartment, storey apartment, porch apartment, maisonette or studio 6 = Other
Rent or owner-occupied new dwelling	Are you a homeowner or a tenant?	Nominal	Multiple Choice (2) 1 = Tenant 2 = Homeowner
Relocation tendency	Is there a relocation tendency to an owner occupied dwelling, and if so, within what period do you want to move?	Nominal	Multiple Choice (5) 1 = No 2 = Yes, within one year 3 = Yes, between one and two years 4 = Yes, between, two and five years 5 = Other
Desired dwelling type	To what type of dwelling do you want to move?	Nominal	Multiple Choice (6) 1 = Terraced house 2 = Corner house 3 = Semidetached house 4 = Detached house 5 = Apartment, flat, upstairs or downstairs apartment, storey apartment, porch apartment, maisonette or studio 6 = Other

Table 4.1: Operationalization of screening questions

4.2.2. Personal characteristics and environmental awareness

The second part of the questionnaire is used to identify personal characteristics and the environmental awareness of the respondents. In tables 4.2, 4.3 and 4.4, the questions are presented and operationalized. The data that was derived from the answers to these questions helped to create insight into the research population.

The operationalization of the variables age and gender is a standard and frequent practice. The answer to the open-ended question of age is an integer number. In this research, year of birth is used to indicate the age to reduce the chance on mistakes. The number of options for the household composition is minimized and derived from a classification used by the central statistics office, CBS (CBS, 2022d). Education level can be classified in several ways, but a common method is presenting a multiple-choice question where the highest level of education is asked. The eight education levels used in the questionnaire are derived from the CBS (CBS, 2022e).

A number of things are important for the operationalization of income. Respondents may perceive income as a personal question. Therefore, an income range is used and an option to not answer the question is included. Besides this, it is expected that many respondents do not know their exact income. In this questionnaire, income scales are used that were derived from the Dutch modus income. Respondents are asked to indicate their gross annual household income (before tax); this includes other income streams, like rent or dividend, in one of the presented income scales.

The respondents were asked to estimate the surface area (in m^2) of floor space of their current dwelling. If there is a relocation tendency, they were asked to insert the preferred surface area for their new dwelling. The most commonly occurring size ranges of ground-level dwellings were used. This helped respondents indicate the number of square meters. Instead of the full zip code, only the four digits of the zip code were requested to ensure the privacy of the respondents. The respondents were asked what their indication price would be for a new dwelling, if they planned to move within one year. If a respondent had an owner-occupied dwelling, they were also asked to estimate the value of their current dwelling.

Respondents were questioned how much importance they attribute to sustainability overall. The importance they attribute to sustainability was measured by several statements derived from research by Linda Steg, et al. (2021). Sustainability is expected to be a topic where people provide socially desirable answers. Socially desirable answers can be enforced in the propositions (Steg, Valkengoed, et al., 2021). That is why it was decided to alternate the approach of the propositions, so propositions for and against. Those statements were scored on a 7-point Likert scale, in which 1 = completely disagree and 7 = completely agree.

Operationalization of personal characteristics			
Variable / concept		**Level of measurement**	**Items**
Age	What is your year of birth?	Ratio	Open question (integer): birthyear is …
Gender	What is your gender?	Nominal	Multiple choice (3): 1 = Male 2 = Female 3 = Other
Household composition	What is your household composition?	Nominal	Multiple Choice (5) 1 = Single 2 = Couple without children (living at home) 3 = Couple with children living at home 4 = Single parent family 5 = Other
Educational level	What is your highest level of education?	Ordinal	Multiple Choice (8) 1 = Primary school 2 = MAVO, VMBO 3 = HAVO 4 = VWO 5 = MBO 6 = HBO, WO bachelor 7 = HBO Master, WO master 8 = Doctor (Ph. D)
Gross annual household income	What was your gross household year income? The household income belongs to you and a partner with whom you form a household, if applicable.	Ordinal	Multiple Choice (6) 1 = € 0 - € 38.000 2 = € 38.001 - € 76.000 3 = € 76.001 - € 114.000 4 = € 114.001 or € 152.000 5 = € 152.001 or more 6 = I don't know/ I prefer to not say
Size dwelling	How much square meters living area does your current dwelling have?	Ordinal	Multiple Choice (4) 1 = Less than 75 m^2 2 = 75 m^2 - < 100 m^2 3 = 100 m^2 – < 150 m^2 4 = 150 m^2 or more
Zip code	What are the four digits of your zip code?	Interval	Open question (integer): 4 numbers zip code

Table 4.2: Operationalization of personal characteristics (part 1 of 2)

Operationalization of personal characteristics			
Variable / concept		**Level of measurement**	**Items**
Property value current dwelling	Estimate the current market value of your dwelling.	Ordinal	Multiple Choice (7): 1 = Less than € 300.000 2 = € 300.000 –< 450.000 3 = € 450.000 -< € 600.000 4 = € 600.000 -< € 750.000 5 = € 750.000 -< € 900.000 6 = € 900.000 or more 7 = I don't know/ I'd rather not say
Price range new dwelling	If you have a relocation tendency within one you year, could you give a price indication of your new dwelling?	Ordinal	Multiple Choice (7): 1 = Less than € 300.000 2 = € 300.000 –< 450.000 3 = € 450.000 -< € 600.000 4 = € 600.000 -< € 750.000 5 = € 750.000 -< € 900.000 6 = € 900.000 or more 7 = I don't know/ I'd rather not say

Table 4.3: Operationalization of personal characteristics (part 2 of 2)

Environmental awareness **Below are five statements. For each statement, please indicate how strongly you agree or disagree with a statement: (1) Completely disagree - (7) Completely agree.**		
Variable / concept	**Level of measurement**	**Items**
I believe that climate change is real	Ordinal	7 point scale Completely disagree - Completely agree: 1 = Completely disagree 7 = Completely agree
The main causes of climate change are human activities	Ordinal	7 point scale Completely disagree - Completely agree: 1 = Completely disagree 7 = Completely agree
Climate change will bring about serious negative consequences	Ordinal	7 point scale Completely disagree - Completely agree: 1 = Completely disagree 7 = Completely agree
On one or more occasions I've switched to another brand of product because it was better for the environment	Ordinal	7 point scale Completely disagree - Completely agree: 1 = Completely disagree 7 = Completely agree
I am willing to pay extra money for sustainable products	Ordinal	7 point scale Completely disagree - Completely agree: 1 = Completely disagree 7 = Completely agree

Table 4.4: Operationalization of statements environmental awareness

4.2.3. Selection of sustainability components for RSE

In the questionnaire, a Rating Scale Exercise (RSE) was used to determine how sustainable respondents perceive the different sustainability components and measures. This was done by presenting different sustainability profiles to the respondents; they were requested to rate the presented profiles that had varying sets sustainability measures for the different components. The rating scores indicated the relative preferences for the different sustainability components. In this section the sustainability components for the RSE were selected.

In chapter 3, a list with sustainability indicators of residential real estate was composed by analyzing different rating tools. The sustainability indicators were subdivided into different categories/ components. The sustainability indicators that were not part of the physical dwelling or were hardly measurable were not included in the RSE. The reason for this was that these factors, e.g. facilities, neighbourhood, safety, etc., could not be controlled by the property developer. Moreover, some components correlate in such a way that they might be contradictory. Table 4.5 provides insight into the selection of the sustainability indicators. In table 4.6, an overview of the selected sustainability components is presented.

Sustainability component		Sustainability indicator	Included / not included in the research (*)	Explanation (**)
Energy	1	Sustainable energy sources	1	
	2	Energy performance	1	
	3	Monitoring energy use	1	
	4	Energy efficient design	1	
Water	5	Monitoring water consumption	1	
	6	Water saving sanitary	1	
	7	Reuse of collected water	1	
	8	Separate grey, black and rainwater	1	
	9	Water management	1	
Material	10	Environmental impact	1	
	11	Demountable materials	1	
	12	Material passport	1	
Ecology	13	Ecological facilities	1	
	14	Green facilities	1	
	15	Ecological impact	0	D
	16	Land preservation	0	D
Future-proof	17	Lifespan	0	D
	18	Adaptability	0	D
Spatial quality	19	Neighbourhood patterns and spatial design	0	D
	20	Functionality	0	D
	21	Diversity	0	D
	22	Beauty	0	D
	23	Identity	0	D
Transport	24	Reduced car parking	0	S
	25	Proximity to public transport	0	S
	26	Facilities for cyclists	0	S
	27	Proximity to facilities	0	S
	28	Car-sharing	0	S
	29	Electric charging stations	0	S
Pollution	30	Waste collection	0	D
	31	Light pollution	0	D
	32	Local water and air pollution	0	D
Health and well-being	33	Air quality	0	S
	34	Daylight	0	S
	35	Thermal comfort	0	S
	36	Noise	0	S
	37	Safety	0	S
	38	Harmful materials	0	S
(*) 1 = included / 0 = not included in the research (**) D = difficult to operationalize in a discrete choice experiment / S = this falls outside the scope of the research				

Table 4.5: Selection of sustainability components and indicators

Sustainability components	Description
Energy	Energy generation and use age
Water	Use of clean drinking water, absorption and re-use of rainwater
Material	The environmental impact of materials
Ecology	Ecological impact of the property object

Table 4.6: Overview of selected sustainability components for RSE

4.2.4. Specification of sustainability component levels

The levels for the sustainability components (attributes) are discussed in this section. For every component, three attribute levels have been chosen so that variation within components could be measured. The levels were determined through the literature study, knowledge and experience gained at Eindhoven University of Technology and as a real estate developer at Synchroon. The ranges of the attribute levels should fall between the respondents' own ranges in terms of plausibility and (current) experience (Kemperman, 2000). Table 4.7 provides a summary of all components and their corresponding component levels. There are various measures, installations, scores and labels that give an indication of how sustainable a dwelling is on a particular component. However, most consumers do not know what the scores of these labels and certificates mean and what the consequences are. That is why the different component levels were constructed with recognizable, labels, measures and installations.

Sustainable Components	Levels (measures)
Energy	Energy label A Energy label A++ Energy label A++++
Water	No (additional) water measures Measures for (rain)water storage in the garden/ dwelling • Green water storage roofs • Rainwater is collected in a rain barrel and used for the garden Measures for (rain)water storage and reducing clean water use • Green water storage roofs • Maximum 50% of the garden is paved • Rainwater is collected in a water container and used for the garden, to flush the toilet and to wash clothes
Material	No additional measures to lower the environmental impact of the building materials • Traditional building materials The CO_2 emissions of the building materials are 25% lower than the requirements in regulation • Conventional building materials with lower CO_2 emissions (e.g. environmentally friendly concrete) The CO_2 emissions of the building materials are at least 50% lower than the requirements in regulation • Biobased building materials (e.g. wood, paper and bamboo) • Recycled materials • Dismountable materials
Ecology	No additional measures to support the flora and fauna Built in (nest)boxes in dwelling • Birds, insect and bat boxes built in dwelling Built in (nest)boxes and mandatory greenery in the garden • Birds, insect and bat boxes built in dwelling • The garden has plants, hedges and trees that benefit the flora and fauna

Table 4.7: Overview of sustainability components and levels

4.2.5. Composing RSE

The sustainability profiles (alternatives) were composed by the components and levels that are mentioned in table 4.7. Each sustainability component has three levels, which results in 81 possible alternatives (3^4 = 81). Fractional factorial design was used to reduce the number of alternatives to 9 (Addelman & Kempthorne, 1961). By using an experimental design it is possible to choose the right combinations of levels for the profiles and control for mutual correlations. The benefit of this is that a smaller number of alternatives (profiles) can be presented to the respondents while still providing the possibility to estimate main effects of the components. In table 4.8, the 9 alternatives (profiles) were presented; pictures were used to clarify the sustainability measures. An example of a sustainability profile is shown in figure 4.2. Respondents were requested to rate on a ten-point scale how sustainable they perceived the presented profiles. All nine sustainability alternatives that resulted from the fractional factorial design were presented to the respondents in the questionnaire.

It is possible to (re)code the component levels with effect or dummy coding. The only difference between these two coding schemes is the final (base) level. The base level of dummy coding is coded with 0 and effect coding is coded using -1. Effect coding is used in this study because the utility value has a unique value other than 0 (Henscher, et al., 2005). In table 4.9 the coding scheme is presented.

Profile (alternative) Number	Energy	Water	Material	Ecology
1	Energy label A	No additional water measures	No additional measures environmental impact materials	No additional measures for biodiversity
2	Energy label A	Measures (rain)water storage dwelling/ garden	Measures to lower the environmental impact of the materials by 25%	Built in (nest)boxes and mandatory greenery in the garden
3	Energy label A	Measures (rain)water storage dwelling/ garden and reducing clean water use	The environmental impact of the materials is at least 50% lower than the requirements	Built in (nest)boxes in dwelling
4	Energy label A ++	No additional water measures	Measures to lower the environmental impact of the materials by 25%	Built in (nest)boxes in dwelling
5	Energy label A ++	Measures (rain)water storage dwelling/ garden	The environmental impact of the materials is at least 50% lower than the requirements	No additional measures for biodiversity
6	Energy label A ++	Measures (rain)water storage dwelling/ garden and reducing clean water use	No additional measures environmental impact materials	Built in (nest)boxes and mandatory greenery in the garden
7	Energy label A ++++	No additional water measures	The environmental impact of the materials is at least 50% lower than the requirements	Built in (nest)boxes and mandatory greenery in the garden
8	Energy label A ++++	Measures (rain)water storage dwelling/ garden	No additional measures environmental impact materials	Built in (nest)boxes in dwelling
9	Energy label A ++++	Measures (rain)water storage dwelling/ garden and reducing clean water use	Measures to lower the environmental impact of the materials by 25%	No additional measures for biodiversity

Table 4.8: Alternatives (profiles) after fractional factorial design

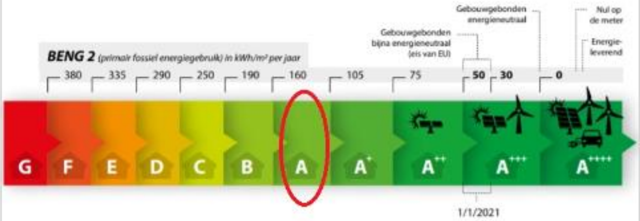
Component level	A11	A12
Level 1	1	0
Level 2	0	1
Level 3	-1	-1

Table 4.9: Effect coding scheme

*

Please indicate on a 10-point scale how sustainable you consider the set of sustainability measures below for a home as a whole (1 = very unsustainable - 10 = very sustainable).

p.s. Scroll down to enter the answer.

Sustainable components	Measures
Energy	Energy label A 
Water	No (additional) water measures
Material	No additional measures to lower the environmental impact of the buildingmaterials • Traditional building materials   
Ecology	No additional measures to support the flora and fauna

	1 (very unsus-tain-able)	2	3	4	5	6	7	8	9	10 (very sustain-able)
How sustainable would you scale the profile above on a ten point scale (1 = very unsustainable - 10 = very sustainable)?	○	○	○	○	○	○	○	○	○	○

Figure 4.2: Example of a RSE profile

4.2.6. Selection of attributes for DCE

As mentioned before, a questionnaire with a discrete choice experiment (DCE) was used to determine stated choices of residential consumers. With the results, the importance that respondents ascribe to different physical characteristics of a property object, including the sustainability level, can be determined.

In chapter 2 the factors that influence the property value were identified. The factors could be subdivided into two categories: external and internal factors. The external factors consist of various market variables and government regulations that have an influence on the property value, such as the interest rate, market sentiment, unemployment rate, etc. These external factors are not part of the property object and therefore do not reflect the value contribution of residential consumers for the property object.

The internal factors are linked to the physical object and its location. These characteristics are part of the real estate object. The location and environmental characteristics are not included in the DCE because the focus of this study is on the physical part of the property object. The physical dwelling characteristics that have the most influence on the property value were identified through a literature study, which resulted in the following physical dwelling characteristics: construction year, size of dwelling, dwelling type, number of rooms, size of private outdoor space, parking space, quality of building and energy efficiency. This selection is narrowed for the DCE, to the following four characteristics: size of dwelling, size of outdoor space, parking space and energy efficiency. The characteristic ‘construction year’ is excluded because this study focusses on newly built property. The characteristic ‘quality of building’ is excluded because it is hard to operationalize for the questionnaire. ‘Dwelling type’ is not included because it can become a dominant characteristic and may correlate with the characteristics ‘dwelling size’ and ‘size of the outdoor space’. The characteristic ‘number of rooms’ is not included because it is expected to correlate with the characteristic dwelling size. Chapter 3 showed that sustainable development is broader than the energy efficiency of a dwelling. The characteristic ‘energy efficiency’ is therefore replaced for the attribute ‘sustainability level’. The attribute ‘price’ has been added to the DCE determine the willingness to pay.

4.2.7. Specification of attribute levels

The DCE was conducted in a questionnaire by presenting several choice sets that consisted of two different hypothetical dwellings. Respondents were given the task to imagine that they were looking for a new dwelling and had to make a choice between two hypothetical dwelling profiles. Besides the two hypothetical profiles, there is also the option ‘neither’ if no choice could be made. These hypothetical dwellings (alternatives) had different attribute levels to describe the dwelling. The dwelling alternatives were developed through the use of an experimental design. The levels were determined using the results of the literature review (chapters 2 and 3), as well as knowledge and experience gained from Eindhoven University of Technology and Synchroon. The ranges of the attribute levels, according to Kemperman (2000), should fall between the respondents' own ranges in terms of plausibility and (current) experience. Table 4.10 provides a summary of all attributes and their corresponding attribute levels. With the levels used in the questionnaire, a more specific definition of each chosen attribute is provided.

Level of sustainability

There are different tools and certificates to measure the overall sustainability of residential real estate. Examples are the measurement tools and certificates of GPR or BREEAM. However, these certificates and tools are not common among the majority of the residential consumers. Therefore, another indicator was used in this questionnaire. The sustainability level was shown on a 10-point scale, where a score of 10 indicated the maximum level of sustainability for the components: energy, water, material and ecology, and a score of 1 indicated the absence of sustainability measures. The differences in choices should be large enough to find significant differences but it should not be too large, otherwise this attribute would dominate. Besides this it was important that the sustainability scores were relatable to residential consumers. A sustainability score of 6 points was the baseline level; the other two levels scored 2 points higher or 2 points lower. The following three levels of sustainability were used: score = 4, score = 6 and score = 8. The sustainability level score in the DCE was not based or linked to a tool or certificate. However, a RSE was performed to determine how sustainable different sustainability components, with different levels of measures, were perceived by respondents. It can be argued that the sustainability level of the DCE could be linked to the RSE design and its results to interpret the sustainability scores in this experiment.

Dwelling size

The attribute ‘size’ indicated the living area of a dwelling. The respondents of this study were looking for, or currently living in, dwellings in different price ranges, regions and dwelling sizes. In the questionnaire a base level of 120m² was used. This is a common number of square meters living area for ground-level dwellings in the Netherlands (CBS, 2018). The difference in surface areas should be large enough to detect a significant difference but not too large so that it becomes the dominant attribute in the experiment. Therefore, a size difference of 10m² was used, resulting in 110 m², 120 m² and 130 m².

Outdoor space

Outdoor space concerns the size of the garden, deck or balcony. The size levels were derived from average garden sizes of ground-level dwellings in the Netherlands (De Hypotheker, 2020). In the DCE the following three levels were used: 60m², 80m² and 100m².

Parking

The attribute ‘parking’ indicated the parking facilities in the DCE. These parking facilities could be subdivided into the following three different categories: ‘there is no own parking space available’ (no parking), ‘the car can be parked on public ground for free or with a parking permit’ (shared/ public parking space) or ‘the car can be parked in a shared parking garage or on own plot’ (individual parking space). This resulted in the following three categories of parking levels: no parking space, shared/ public parking space or individual parking space.

Dwelling price

In this study, the dwelling price refers to the residential real estate value. This attribute has been added in this questionnaire to indicate the willingness to pay for additional sustainability measures. The respondents of this questionnaire are looking for dwellings in different price segments. Price is a tricky attribute, if it is out of range what the respondent can afford or is too cheap, then the experiment becomes too little credible for the respondent. Therefore, three price levels were used that are in line with the average dwelling price in the Netherlands, € 448.000,- (buyer costs excluded) in Q2 2022 (NVM, 2022). The steps that were used for additional cost were; € 30.000,- up and below the base line price.

Dwelling attribute	Level (measure(s))
Sustainability level (Overall sustainability dwelling: 0 = low, 10 = outstanding)	• Sustainability score = 4 • Sustainability score = 6 • Sustainability score = 8
Dwelling size (in m²)	• 110 m² • 120 m² • 130 m²
Outdoor space (balcony or garden in m²)	• 60 m² • 80 m² • 100 m²
Parking (presence of parking spaces)	• no parking (also not in the public area) • shared/ public parking • own/ private parking place
Dwelling price (market value)	• € 420.000,- • € 450.000,- • € 480.000,-

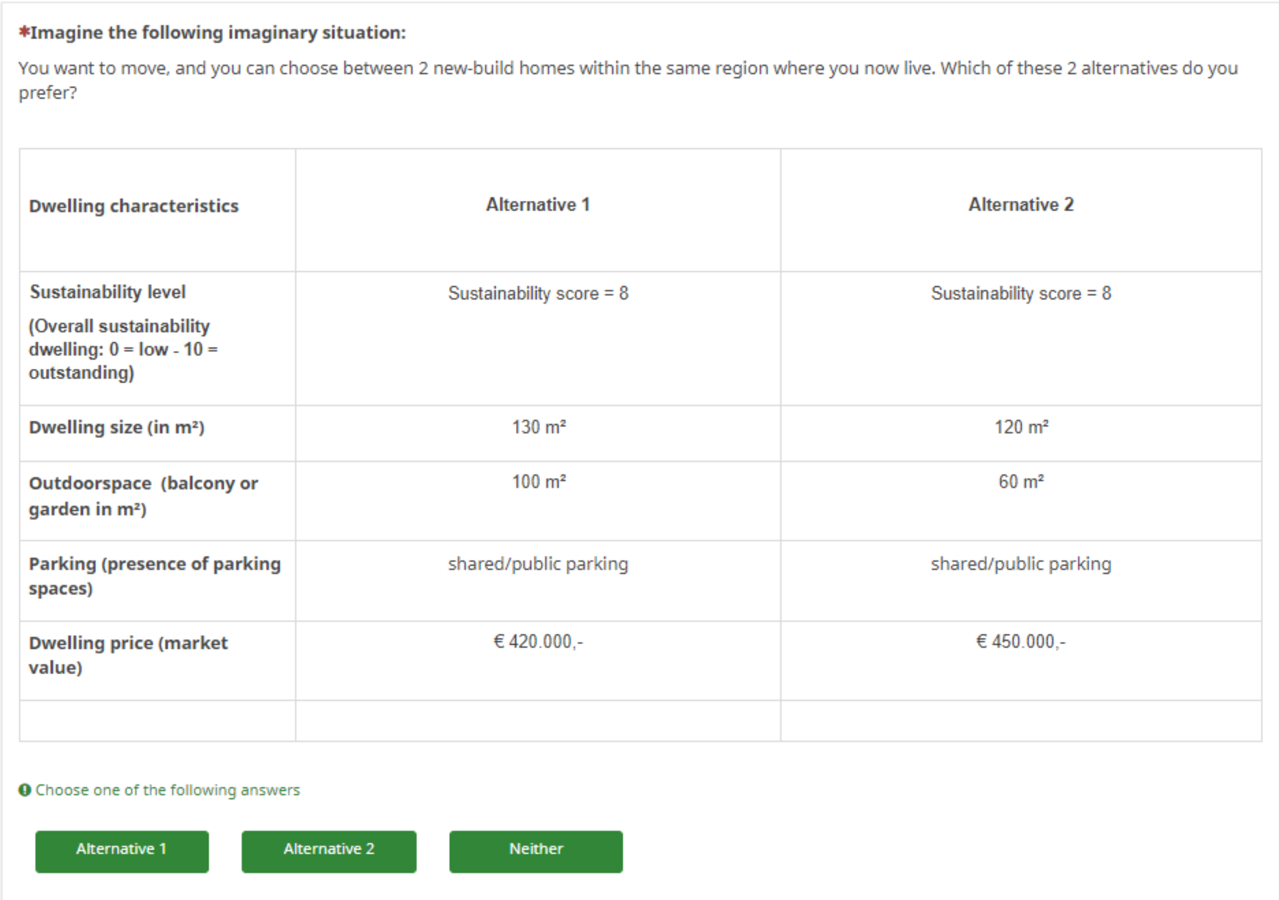
Table 4.10: Operationalization of attributes

4.2.8. Composing DCE

In table 4.8 the dwelling attributes and the levels (measures) are presented. Each dwelling attribute has three levels, which results in 243 possible alternatives (3^5 = 243). Fractional factorial design was used to reduce the number of alternatives (hypothetical dwellings) to 27 (Addelman & Kempthorne, 1961). By using an experimental design, it was possible to choose the right combinations of attribute levels for the profiles and control for mutual correlations. The advantage of this is that a smaller number of alternatives (profiles) could be presented to the respondents while still providing the possibility to estimate main effects of the attributes. In table 4.11 the 27 alternatives (profiles) are presented. The 27 alternatives were randomized four times to 54 choice sets with two-choice alternatives, see Appendix 8. These choice sets were divided into 6 different subgroups in the Limesurvey software which were presented alternately. Each respondent was requested to perform nine choice sets in the questionnaire. In figure 4.3 an example of a choice set is presented. As can be seen, five attributes were used to describe two hypothetical dwelling alternatives. The respondents were requested to indicate their choice. They had the options ‘dwelling 1’, ‘dwelling 2’ or ‘neither’. After the data collection the profiles were recoded with an effect coding scheme, see table 4.12. The purpose for the recoding was to estimate models with the collected data.

Profile number	Sustainability level	Dwelling size	Outdoor space	Parking	Dwelling price
1	sustainability level score = 4	110 m^2	60 m^2	no parking space	€ 420.000
2	sustainability level score = 4	110 m^2	80 m^2	shared/ public parking space	€ 480.000
3	sustainability level score = 4	110 m^2	100 m^2	individual parking	€ 450.000
4	sustainability level score = 4	120 m^2	60 m^2	shared/ public parking space	€ 450.000
5	sustainability level score = 4	120 m^2	80 m^2	individual parking	€ 420.000
6	sustainability level score = 4	120 m^2	100 m^2	no parking space	€ 480.000
7	sustainability level score = 4	130 m^2	60 m^2	individual parking	€ 480.000
8	sustainability level score = 4	130 m^2	80 m^2	no parking space	€ 450.000
9	sustainability level score = 4	130 m^2	100 m^2	shared/ public parking space	€ 420.000
10	sustainability level score = 6	110 m^2	60 m^2	no parking space	€ 420.000
11	sustainability level score = 6	110 m^2	80 m^2	shared/ public parking space	€ 480.000
12	sustainability level score = 6	110 m^2	100 m^2	individual parking	€ 450.000
13	sustainability level score = 6	120 m^2	60 m^2	shared/ public parking space	€ 450.000
14	sustainability level score = 6	120 m^2	80 m^2	individual parking	€ 420.000
15	sustainability level score = 6	120 m^2	100 m^2	no parking space	€ 480.000
16	sustainability level score = 6	130 m^2	60 m^2	individual parking	€ 480.000
17	sustainability level score = 6	130 m^2	80 m^2	no parking space	€ 450.000
18	sustainability level score = 6	130 m^2	100 m^2	shared/ public parking space	€ 420.000
19	sustainability level score = 8	110 m^2	60 m^2	no parking space	€ 420.000
20	sustainability level score = 8	110 m^2	80 m^2	shared/ public parking space	€ 480.000
21	sustainability level score = 8	110m^2	100m^2	individual parking	€ 450.000
22	sustainability level score = 8	120m^2	60m^2	shared/ public parking space	€ 450.000
23	sustainability level score = 8	120m^2	80m^2	individual parking	€ 420.000
24	sustainability level score = 8	120m^2	100m^2	no parking space	€ 480.000
25	sustainability level score = 8	130m^2	60m^2	individual parking	€ 480.000
26	sustainability level score = 8	130m^2	80m^2	no parking space	€ 450.000
27	sustainability level score = 8	130m^2	100m^2	shared/ public parking space	€ 420.000

Table 4.11: Alternatives after fractional factorial design


*Imagine the following imaginary situation:

You want to move, and you can choose between 2 new-build homes within the same region where you now live. Which of these 2 alternatives do you prefer?

Dwelling characteristics	Alternative 1	Alternative 2
Sustainability level (Overall sustainability dwelling: 0 = low - 10 = outstanding)	Sustainability score = 8	Sustainability score = 8
Dwelling size (in m²)	130 m²	120 m²
Outdoorspace (balcony or garden in m²)	100 m²	60 m²
Parking (presence of parking spaces)	shared/public parking	shared/public parking
Dwelling price (market value)	€ 420.000,-	€ 450.000,-

Choose one of the following answers

Alternative 1 | Alternative 2 | Neither

Figure 4.3: Example of a choice set

Attribute level	A11	A12
Level 1	1	0
Level 2	0	1
Level 3	-1	-1

Table 4.12: Effect coding scheme

4.3. Distribution of questionnaire

The target group for the questionnaire was residential consumers that either own or are looking for an owner-occupied ground-level dwelling in the Netherlands. Physical invitations with the request to participate in the online questionnaire were distributed in the following residential neighbourhoods:

- Willemsbuiten (Tilburg)
- Schoenmakershoek (Etten-Leur)
- Sportpark (Breda)
- Ginniken (Breda)
- De Staart (Prinsenbeek)
- Oog in Al (Utrecht)
- Hoge Weide (Utrecht)

The selection criteria for the neighbourhoods were that the main function is residential and that the surrounding area consists of housing stock with mainly of ground-level dwellings. The physical invitations were distributed in three city neighbourhoods and two village neighbourhoods, in order to control for location and possible difference between respondents of cities and villages. The questionnaire was digitalized with Limesurvey's online software. In Appendix 9 an example of the survey and the invitation can be seen. The questionnaire was conducted between 4 November 2022 and 19 November 2022.

4.4. Conclusion

The aim of the explorative research was to clarify which sustainability indicators (components) were perceived as most sustainable and how much overall value is attributed to sustainability in the purchase decision by residential consumers. A conjoint preference and a conjoint choice modeling approach were used to measure this. A questionnaire with a rating scale exercise (RSE) and a discrete choice experiment (DCE) were used for the data collection. Both methods have been proven to be useful in various research fields in identifying preferences. In the RSE, respondents were requested to rate profiles on how sustainable they perceived the presented profiles on a ten-point scale. In the DCE, respondents were asked to choose between two hypothetical dwellings or the option 'neither'. The profiles in the RSE and DCE consisted of a predetermined set of components/ attributes with varying levels. The findings of the literature study were used as input for the components/ attributes. The profiles of the RSE consisted of the following sustainability components: energy, water, material and ecology. In the questionnaire, each component had three levels. The following attributes were used for the DCE profiles: sustainability level, dwelling size, outdoor space, parking and price. Each attribute also had three levels in the questionnaire. The number of possible alternatives of the RSE and DCE were reduced with an experimental design to respectively 9 and 27 profiles. In the questionnaire. each respondent was requested to rate nine profiles and perform nine choice sets; the choice sets were selected through randomization.

The questionnaire that was used for the data collection consisted of three parts. The first part was used to determine if a respondent met the criteria of the intended research population. The second part was used to identify personal characteristics of the respondents and their environmental awareness. The last part of the explorative research consisted of a rating scale exercise (RSE) and discrete choice experiment (DCE). The data of the RSE was analyzed with a regression analysis. The DCE data could be analyzed with an MNL model. The willingness to pay (WTP) for additional sustainability measures were calculated with the output of the MNL model, which was possible because the attribute 'price' was included. The invitation to participate in the questionnaire was distributed via cards in different residential neighbourhoods in the Netherlands. The distributed cards had a QR code that was linked to the online questionnaire in Limesurvey. The targeted research population consisted of residential consumers who either are owner-occupied residential consumers with a ground-level dwelling in the Netherlands or want to buy one within two years.

5. Data description

In this chapter, the research sample is described and discussed. The socio-demographic data of the participants is described and compared with CBS (central statistical office) data. This comparison is made to determine the representativeness of the respondents in the sample data.

5.1. Distribution questionnaire

In table 5.1 the different zip codes of the respondents are presented. As can be seen, most respondents are from the neighbourhoods where the physical cards have been distributed.

	Frequency
3513 (Utrecht)	1
3533 (Utrecht)	9
3541 (Utrecht)	2
4835 (Breda)	1
4841 (Prinsenbeek)	6
4871 (Etten-Leur)	3
5026 (Tilburg)	13
5528 (Hoogeloon)	1
Total	36

Table 5.1: Overview of zip codes from respondents

5.2. Sample size

As mentioned earlier, the data were collected with an online questionnaire. The questionnaire was online available in Dutch and English. Approximately 1,000 households were requested to participate. Forty-eight people have started the questionnaire and 37 respondents have finished it. This resulted in a response rate of 3.7%. One case was rejected for giving invalid answers. Subsequently the answers of respondents on the screening questions were analyzed. The 36 respondents met the criteria of this research.

5.3. Personal characteristics

After the selection questions, socio-demographic data of the respondents was collected and their environmental awareness was determined. Most of the questions concerning personal data were compulsory, which resulted in a good insight into the personal characteristics of the sample. The following personal characteristics were compared with CBS data: age, gender, household composition, education level and gross annual household income. Unfortunately, there are no CBS data of homeowners available for all the socio-demographic characteristics. Data of the Dutch workforce population was used to check the representativeness of the sample when there was no data available of homeowners. It is likely that most homeowners are or were part of the Dutch workforce population. However, it is expected that the household composition, education level and net annual household income are different in the homeowners’ group than in the whole workforce population. A Cronbach’s Alpha test was performed on the environmental awareness data to determine if the respondents had consistent answers.

Gender

In table 5.2, the gender distribution of the sample is compared with the total Dutch population. As can be seen, the gender distribution of the sample is not comparable to the whole Dutch population. A Binomial test was conducted and this Bivariate test stated that that the difference is indeed significant (with p = 0.065). This implies that the proportions of males and females significantly differ from 0.5 in the sample data.

		N = 36	CBS (2022)	Test prop.	Exact sig. (2-tailed)
Gender	Male	24	49.7%	0.50	0.065
	Female	12	50.3%		
	Other				

Table 5.2: Overview gender distribution

Age

There is unfortunately no data available that shows the age of homeowners. In table 5.3 the age distribution of the sample is compared to the total Dutch workforce population. In the survey, respondents were asked to enter their year of birth. These data were recoded in segments to make it more suitable for comparison. The following age segments of CBS were used to recode the sample; 15-24, 25-34, 35-44, 45-54, 55-64 and 65-74 (CBS Statline, 2022a) . The category of 15-24 is not present in the sample. This is understandable since the average age to purchase a first dwelling is around the age of 30 (De Hypotheekshop, 2020).

		N = 36	Sample	CBS (2022a)
Age	15-24	0	0.0%	17.5%
	25-34	12	33.3%	21.1%
	35-44	8	22.2%	18.9%
	45-54	9	25.0%	21.1%
	55-64	7	19.4%	18.3%
	65-74	0	0.0%	3.2%

Table 5.3: Overview age distribution

Education

To make a comparison possible, the education levels of the sample were combined: primary school, (MAVO, VMBO), HAVO, VWO and MBO are combined and renamed to the level of vocational degree or lower. Undergraduate is HBO/ WO bachelor and Postgraduate is HBO/ WO master or Doctor (Ph. D) (Ministerie van Onderwijs, Cultuur en Wetenschap, 2021). There are no data available that show the highest achieved education level of homeowners. The sample data is therefore compared with the total Dutch population, see table 5.5. In the overview it can be noticed that the level of education differs quite a lot in the sample compared to total Dutch population. It can be argued that the total population gives a slightly distorted picture because the younger generation is significantly higher educated than the older generation. According to data of Eurostat (2022) 53.4% of the Dutch population between 30 and 35 years old falls under the category Undergraduate or Postgraduate. Moreover, higher educated people have a higher chance of having an owner-occupied dwelling. However, it is likely that the level of education of the sample is not a good representation of the homeowners in the Netherlands.

		N = 36	Sample	Eurostat (2022)
Highest level of education	Vocational degree or lower	1	2.8%	64.5%
	Undergraduate (HBO-/WO-bachelor)	21	58.3%	22.1%
	Postgraduate (HBO-/WO-master/Doctor)	14	38.9%	13.4%

Table 5.5: Overview highest achieved level of education

Estimate value dwelling

In the questionnaire, respondents were asked to estimate the current market value of their dwelling. In table 5.6 an overview is presented of the different ranges in which the respondents estimate the current market value of their dwelling. According NVM (2022), the average dwelling price in the Netherlands was € 448.000, - (buyer costs) in Q2 2022. There is unfortunately no data available that shows the distribution of dwelling prices in the Netherlands. The average dwelling price in the sample is a bit higher than the average dwelling price in the Netherlands.

	Frequency	Percentage
€ 300.000 - < € 450.000	9	25.0%
€ 450.000 - < € 600.000	6	16.7%
€ 600.000 - < € 750.000	10	27.8%
€ 750.000 - < € 900.000	7	19.4%
€ 900.000 or more	1	2.8%
I don't know/ I'd rather not say	3	8.3%
Total	36	

Table 5.6: Estimated property value dwellings

Household income

In table 5.7 the household incomes of the sample are presented. It can be seen that there is a significant portion of the respondents that did not provide their household income. Table 5.8 presents the gross household incomes of homeowners in the Netherlands (CBS, 2022c). The sample data cannot directly be compared with the CBS data, because CBS use other income scales. The household incomes in the sample data seem higher than the average household incomes in the Netherlands. Due to the small sample size a good representation of the gross household incomes is not present in the sample.

Gross household income	Frequency	Percentage
€ 0 - € 38,000	1	2.8%
€ 38,001 - € 76,000	9	25.0%
€ 76,001 - € 114,000	13	36.1%
€ 114,001 - € 152,000	6	16.7%
€ 152,001 or more	2	5.6%
I don't know/ I prefer don't to say	5	13.9%
Total	36	100.0%

Table 5.7: Gross household income distribution sample

Gross household income	Percentage
€ 0 - € 10,000	0.5%
€ 10,000 - € 20,000	0.8%
€ 20,000 - € 30,000	4.1%
€ 30,000 - € 40,000	7.5%
€ 40,000 - € 50,000	8.4%
€ 50,000 - € 100,000	38.5%
€ 100,000 - € 200,000	33.5%
€ 200,000 or more	6.7%

Table 5.8: Gross household income distribution homeowners (CBS, 2022c)

Household composition

The respondents have indicated their household composition. In table 5.9, the sample data are compared with CBS data of homeowners (CBS, 2022c). It can be seen that the one-person households are underrepresented in the sample and that the households with children living at home are overrepresented. The focus in this research was on residential consumers in owner-occupied ground-level dwellings. The sample data are mostly collected in residential neighbourhoods with ground-level dwellings. It can be assumed that one-person households are less likely to live in ground-level dwellings than couples and couples with children.

Household composition	N = 36	Sample	(CBS 2022c)
One person household	5	13.9%	39.0%
Couple without children (living at home)	12	33.3%	28.9%
Couple with children living at home	19	52.8%	32.2%
Total	36		

Table 5.9: Household composition

Environmental awareness

In the questionnaire, respondents were requested to rate five statements about the environment and sustainability. In table 5.10, the chosen minimum and maximum, the sum, the mean and standard deviations per statement are presented. The internal consistency between the answers of different sustainable statements and the willingness to pay for additional measures is measured with a reliability analysis. The Cronbach's Alpha test has a good score of α = 0.820. The score shows that the five statements are related to some degree. This means that the answers of the respondents for the different statements are in line with each other. This implies that environmental awareness is positive related to the willingness to purchase and extra pay for sustainable products.

Descriptive Statistics	**Minimum**	**Maximum**	**Mean**		**Std. Deviation**
	Statistic	Statistic	Statistic	Std. Error	Statistic
I believe that climate change is real	3	7	6.53	0.171	1.028
The main causes of climate change are human activities	2	7	5.94	0.236	1.413
Climate change will bring about serious negative consequences	3	7	6.17	0.193	1.159
On one or more occasions I've switched to another brand of product because it was better for the environment	1	7	5	0.298	1.789
I am willing to pay extra money for sustainable products	3	7	5.19	0.194	1.167

Table 5.10: Descriptive statistics environmental awareness

5.4. Conclusion

In this chapter the sample data of the questionnaire were analyzed. The sample data were collected from different neighbourhoods to create a diverse research population of homeowners that already have a ground-level dwelling or people who are searching for it. The personal characteristics of the respondents in the sample were compared with CBS and NVM data. Most of the personal characteristics in the sample seem to be representative for the intended research population with an exception for the characteristics gender, education and household income. The sample seems therefore suitable for further analysis.

The respondents' environmental awareness and willingness to pay were measured by letting them rate several statements regarding sustainability and climate change. The internal coherence of the statements was measured and it resulted in a good score. This means that respondents who indicated that they have a high environmental awareness also indicated they are willing to pay more for additional sustainability measures.

6. Results

In this chapter the results of the data analysis are presented. The outcomes of data the RSE data and DCE data are presented and the WTP calculation results are shown.

6.1. Regression analysis

The stated data of the rating scale exercise (RSE) are analyzed with a regression analysis. The data consist of a combination of profiles with varying (sustainable) components that are rated by respondents. This analysis was conducted to determine the sustainability scores and relative importance of each component level. The descriptive statistics of this analysis are presented in table 6.1. The original output of the NLOGIT6 analysis can be found in Appendix 10.

Goodness of fit	Regression model
R-squared value	0.329
Adjusted R-squared value	0.312
Model test F (8, 15) = 19.344	p < 0.01
Number of observations	324
Number of parameters	9

Table 6.1: Descriptive statistics of regression model

The regression model has a R-squared value of 0.329 and an Adjusted R-squared value of 0.312. These values may seem low but are actually normal for the prediction of human behavior (Jim, 2022). The F-ratio indicates whether the overall regression model is a good fit for the data. The model shows that the independent variables, statistically significantly predict the dependent variable, $F(8, 15) = 19.344$, $p < 0.01$ (i.e. the regression model is a good fit of the data). The descriptive statistics implies that the regression model is suitable and can be further investigated.

In table 6.2 the results of the regression analysis are presented. The perceived scores of the sustainability component levels are shown. The scores of the regression analysis show that the different levels of a component are rated in the expected order, the level with the highest ambitions has the highest score and the level with the lowest ambitions has the lowest score. The score of the constant is quite high. This indicates that the base levels of presented profiles have a relatively high sustainable rating. A possible explanation for this is that the base levels of the profiles are in line with the current newly built regulations. These regulations have quite high energy standards compared to the existing housing stock. The existing housing stock includes old dwellings with a poor energy performance.

The sustainability components have different significancy scores. The components energy, water and material have a significancy level of $p < 0.01$ and the component ecology has a significancy level of $p < 0.10$. The base level of each attribute is calculated by the sum of the two levels, output NLOGIT, and then multiplied by -1. In figure 6.1 the scores of the component levels are graphically presented.

Attribute	Level	Coefficient (β)	Sign.	t-value
Constant		7.577	***	83.18
Energy	Energielabel A (base)	-0.781		
	Energielabel A ++	-0.096		-0.74
	Energielabel A ++	0.877	***	6.8
Water	No additional water measures (base)	-0.651		
	Measures (rain)water storage dwelling/ garden	0.173		1.34
	Measures (rain)water storage dwelling/ garden and reducing clean water use	0.478	***	3.71
Material	No additional measures environmental impact materials (base)	-0.966		
	Measures to lower the environmental impact of the materials by 25%	0.191		1.49
	The environmental impact of the materials is at least 50% lower than the requirements	0.775	***	6.01
Ecology	No additional measures for biodiversity (base)	-0.373		
	Built in (nest)boxes in dwelling	0.145		1.13
	Built in (nest)boxes and mandatory greenery in the garden	0.228	*	1.77
Note: significance	p < 0.01 ***			
	p < 0.05 **			
	p < 0.10 *			

Table 6.2: Regression Model analysis

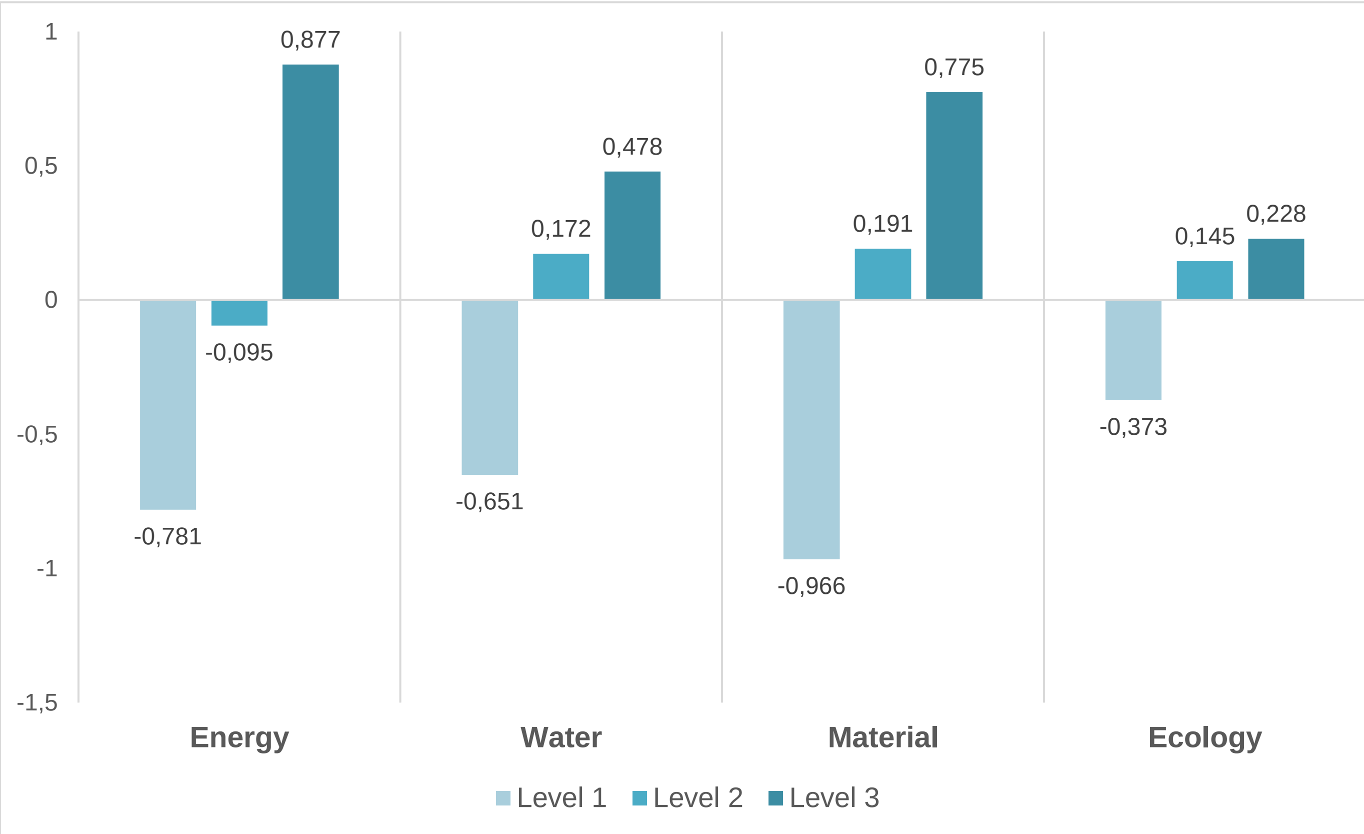


Figure 6.1: Scores of sustainability components

An overview of the sustainability components and the relative importance is presented in table 6.3. The range of the components is the difference between the highest and lowest score (Hensher, Rose, & Greene, 2015). The relative importance is determined by dividing the range of each component by the overall range (Randle, Kemperman, & Dolnicar, 2019). Respondents have perceived the components material (33.9%) and energy (32.3%) as most sustainable, followed by water (22.0%). The attribute ecology (11.7%) has the lowest relative score, indicating it is perceived as the least important sustainability component of the presented set.

Component	Range	Relative importance
Energy	1.657	32.3%
Water	1.130	22.0%
Material	1.741	33.9%
Ecology	0.602	11.7%
Overall	5.130	100.0%

6.3: Relative importance sustainability components

6.2. Multinominal logit model

The stated data of the discrete choice experiment (DCE) is analyzed with a multinominal logit model (MNL). This model shows the utility value of each attribute level (βk). With these data the relative importance of the attributes can be determined. The stated data consist of presented profiles and the choices made. The descriptive statistics of the MNL model are presented in table 6.4.

Goodness of fit	Multinominal logit model
Log-likelihood estimation model (LL(β))	-220.450
Log-likelihood null model (LL (0))	-355.950
McFadden's Rho-Squared (ρ^2)	0.381
Adjusted McFadden's Rho-Squared (ρ^2)	0.350
Number of observations	324
Akaike Information Criterion	-1.429
Number of parameters	11

Table 6.4: Descriptive statistics of MNL model

The Log Likelihood function of the estimated parameters is -220.450, the Log likelihood of the null model is -355.950. The McFadden's Rho² is 0.381 and the adjusted McFadden's Rho² is 0.350. According to McFadden, a value between 0.2 and 0.4 indicates a satisfactory model fit. The Akaike Information Criterion (AIC) is 1.429. The model indicators show that the model is useful for further analysis.

The utility values of all attribute levels are estimated by the MNL model. The output is presented in table 6.5. It can be seen that the attributes 'sustainability level', 'parking space' and 'outdoor space' have at least one level that has a significance of $p < 0.10$ or lower. The attributes 'dwelling size' and 'price' have no levels that are significant. The utilities show that having an own parking space (βk = 1.265) is preferred to having no parking option (βk = -1.558). The highest sustainability level has also the highest utility value (βk= 0.846). This indicates that the respondents of the sample have a strong preference for a higher level of sustainability. The attribute level with the largest outdoor space has also to highest utility value (βk= 0.695). In figure 6.2 the utility values of the attribute levels are graphically presented.

Attribute	Level	Coefficient (β)	Sign.	z-value
Constant	Constant	0.736	***	4.20
Sustainability level (score: 1-10)	Sustainability level score = 4 (base)	-0.927		
	Sustainability level score = 6	0.081		0.58
	Sustainability level score = 8	0.846	***	5.08
Dwelling size (living area)	110 m² (base)	-0.202		
	120 m²	0.034		0.25
	130 m²	0.168		0.97
Outdoorspace (garden/ balcony)	60 m² (base)	-0.407		
	80 m²	-0.289	*	-1.70
	100 m²	0.695	***	4.63
Parking space	No parking space (base)	-1.558		
	Shared/ public parking space	0.288	*	1.90
	Individual parking	1.265	***	7.88
Price (dwelling price)	€ 420,000 (base)	0.454		
	€ 450,000	-0.267		-1.59
	€ 480,000	-0.188		-1.26
Note: significance	p < 0.01 *** p < 0.05 ** p < 0.10 *			

Table 6.5: MNL model utility values

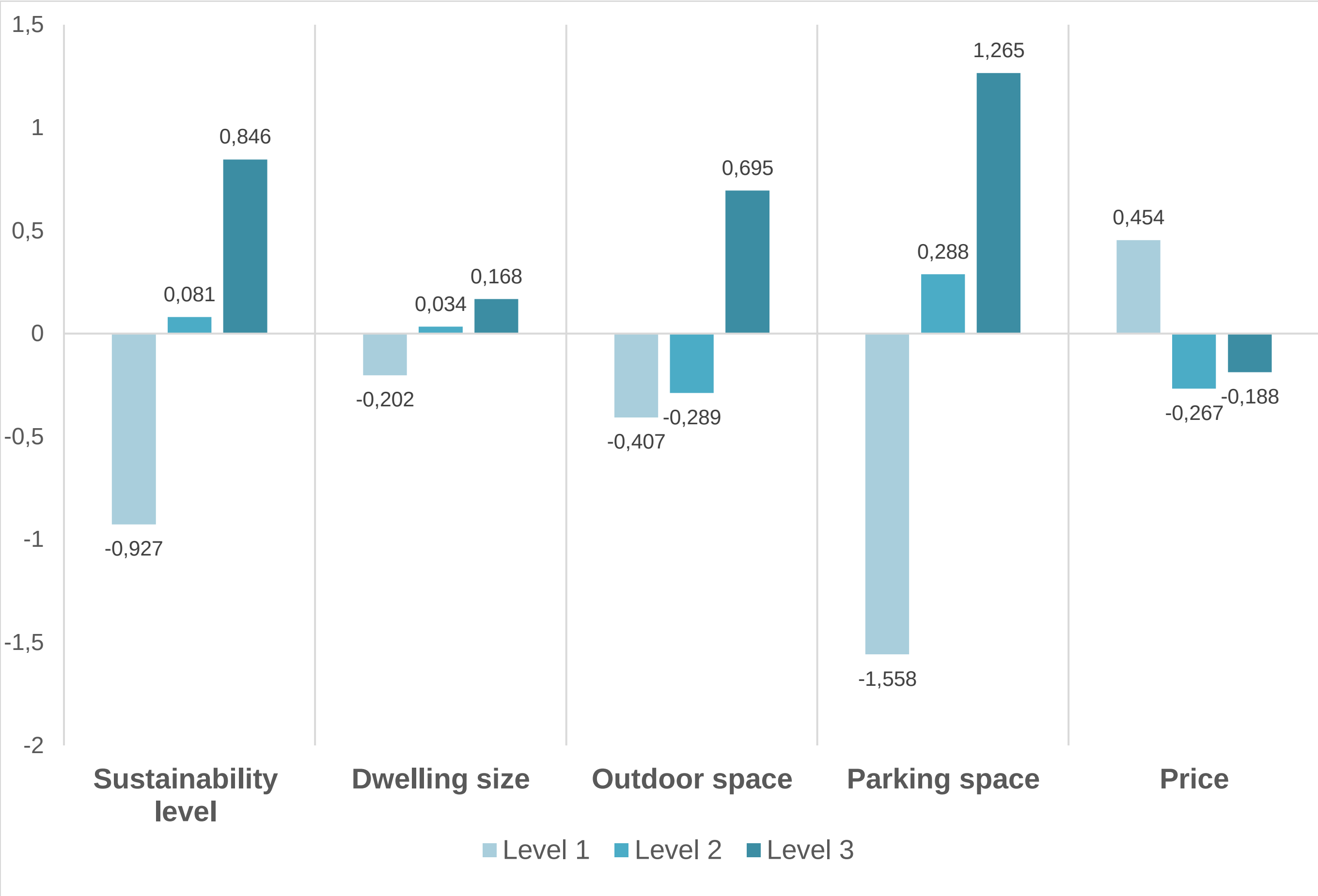


Figure 6.2: Utility values of dwelling attributes

The range and the relative importance of the attributes are determined with the same method as for the sustainability components. In table 6.6, the ranges and relative importance of the attributes are presented. It shows that respondents assign the highest relative importance to the attribute 'parking' (41.6%). The sustainability level has the second highest relative importance (26.1%). Followed by the attribute 'outdoor space' 16.2%. The attributes '(dwelling) price' and 'dwelling size' are not significant but have the following relative importance: dwelling price 10.6% and dwelling size 5.4%.

Attribute	Range	Relative importance
Sustainability level (score: 1-10)	1.773	26.1%
Size - living area	0.369	5.4%
Outdoor space	1.102	16.2%
Parking space	2.823	41.6%
Price	0.721	10.6%
Overall	**6.789**	**100.0%**

Table 6.6: Relative importance attributes DCE

6.3. Willingness to pay

The willingness to pay (WTP) for the different attributes is normally calculated by dividing the utility range of an attribute by the utility range of the price, and then multiplying it by the difference of the highest price level and the base price level. In this study, the difference between the mid-price level and base price level is used instead. The reason for this is that the levels of the attribute price are not significant. The mid-price level is almost significant and is therefore used, instead of the highest price level.

The results of the WTP calculations are presented in table 6.7. The table shows the willingness to pay for the highest attribute levels in comparison to the base levels. The results in the table suggest that respondents are willing to pay € 117,515 more for an identical dwelling that has an own parking space, this seems unrealistic. A possible explanation for the dominant effect of this attribute is that respondents live in residential neighbourhoods that have a lot of parking space and are more or less dependent on the car for transportation. Furthermore, the outcomes of the WTP calculations suggest that respondents are willing to pay € 73,826 more for a dwelling with a sustainability level of 8 in comparison to a dwelling that has a sustainability level of 4 (base level). The calculations also indicate that respondents are willing to pay € 45,889 more for a dwelling with the largest garden in comparison with the smallest, and € 15,380 more for the largest presented dwelling in comparison to the smallest. It should be noted that the levels of the attribute 'dwelling size' are not significant and can therefore not be seen as a result. Overall, it can be noticed that the WTP values are quite high. It seems plausible that respondents do not have attributed enough attention to the attribute 'price'. The MNL output shows that not one level of the attribute 'price' is significant.

Attribute		**Part-worth Utility**	**Size of utility range**	
Price (difference in €)	**Price (difference in %)**		0.721	
€ 0	0%	0.454		
€ 30,000	7.1%	-0.267		
€ 60,000	14.3%	-0.188		
Dwelling characteristics	**Part-worth Utility**	**Size of utility range**	**WTP (€)**	**WTP (%)**
Sustainability level		1.773	€ 73,826	17.6%
Sustainability level score = 4 (base)	-0.927			
Sustainability level score = 6	0.081			
Sustainability level score = 8	0.846			
Dwelling size		0.369	€ 15,380	3.7%
110 m² (base)	-0.202			
120 m²	0.034			
130 m²	0.168			
Outdoor space		1.102	€ 45,889	10.9%
60 m² (base)	-0.407			
80 m²	-0.289			
100 m²	0.695			
Parking space		2.823	€ 117,515	28.0%
No parking space (base)	-1.558			
Shared/ public parking space	0.288			
Individual parking	1.265			

Table 6.7: Willingness to pay for sustainability and dwelling characteristics

6.4. Conclusion

In this chapter the outcomes of the regression model, the MNL model and WTP calculations are presented and discussed. With the outcomes of these models and calculations it is possible to answer the following sub-questions:

> *Which sustainability components are perceived as most sustainable by residential consumers?*
>
> *How much value is assigned to sustainability by residential consumers in comparison to other dwelling attributes in a purchase decision?*
>
> *What is the willingness to pay for additional sustainability measures by residential consumers?*

The statistical parameters of the regression and MNL model indicate that the models are useable. The output of the regression model indicates that all the component levels with the most measures were perceived as most sustainable by the respondents. This shows that respondents were able to interpret the impact of the presented sustainability measures in a right way. All the sustainability components in the RSE have a significance level of $p < 0.10$ or lower. The relative importance of the different sustainability components is determined with the scores of the regression model. The relative importance of the components indicates the perceived sustainability, the components in the RSE have the following relative importance scores: material (33.9%), energy (32.3%), water (22%) and ecology (11.7%).

An MNL model was performed on the DCE data set to estimate the utility values of the attributes. The output of the MNL model shows that the highest score of the attribute 'sustainability level' also has the highest utility value. The levels of the attribute 'price' and 'dwelling size' are not significant in the MNL model. The other attributes have at least one level that has a significance of $p < 0.10$ or lower. The relative importance scores of the attributes show that most importance was assigned to the attribute 'parking' (41.6%), followed by the attributes 'sustainability level' (25.9%) and 'outdoor space' (16.3%). The results were quite surprising, a possible explanation for the dominating effect of the attribute 'parking' is that most respondents live in residential areas that have a lot parking space. It is plausible that the respondents are used to car transportation and expect parking to be available. It should be noted that the Regression and MNL model treat the sample as homogeneous. It can be expected that there is some heterogeneity. Due to the relatively low number of respondents, it was unfortunately not possible to conduct a Latent Class analysis.

Finally, several calculations were performed to determine the willingness to pay for sustainability and other dwelling characteristics that were presented in the DCE. The mid-price level was used to determine the WTP instead of the highest price level because all levels of the attribute 'price' are not significant. The mid-price level is almost significant and is therefore used instead of the highest price level. The WTP calculations showed that the sample group is willing to pay € 73,826 more for the attribute 'sustainability level' with the highest level (sustainability score = 8) in comparison to the base level (sustainability score = 4).

7. Conclusion and discussion

The aim of this research was to receive insight into how much importance residential consumers assign to sustainability when purchasing a dwelling and determine their willingness to pay for the additional sustainability measures. In addition, this research also tried to determine which sustainability components were perceived as most sustainable. In this chapter the conclusions are drawn. To accomplish the research objective the following research question was devised.

> *To what extent do residential consumers attach importance to sustainability in the purchase decision, which sustainability components are perceived most sustainable and what is the willingness to pay for the additional sustainability measures?*

To answer the main research question six sub-questions were formulated. The first three sub-questions were answered by conducting a literature study. In this study, the market value of a property object was used to reflect the value assignment of residential consumers. The literature showed that the market value of a dwelling is influenced by external and internal factors. The external factors were not considered in this study because they are not part of the property object itself and influence the whole housing markets. The internal factors are dwelling characteristics, which can be categorized as physical dwelling characteristics, physical environmental characteristics, social environmental characteristics and functional environmental characteristics. The categories 'physical environmental characteristics', 'social environmental characteristics' and 'functional environmental characteristics' were not used in this research because of the research scope.

Seventeen different studies and real estate appraisal books were analyzed to identify the physical dwelling characteristics that were valued most by residential consumers. The characteristics that were mentioned the most in the analyzed literature are construction year, size of dwelling, dwelling type, number of rooms, size of private outdoor space, parking space, quality of building and energy efficiency.

In the second part of the literature study, the concept of sustainable real estate was explored, and a definition of sustainable real estate development was created. The literature review showed that sustainability should be considered as an ongoing process during all the phases of a property object. The following definition for sustainable real estate development was devised for this research.

> A strategy that encompasses the whole of plan development, design, construction, use, demolition and reuse, in order to achieve social, environmental, economic, spatial and process-oriented objectives to be realized in accordance with the socially desirable level.

Several sustainability rating tools for real estate were analyzed to identify the indicators that affect the sustainability of residential real estate. The indicators were categorized into different sustainability components. The analysis resulted in the following list of sustainability components: energy, water, materials, ecology, future-proof, spatial quality, transport, pollution and health & well-being.

The perceived sustainability of the different sustainability components was determined by conducting a rating scale exercise (RSE). In the questionnaire, respondents were asked to rate on a ten-point Likert scale how sustainable they perceived the presented hypothetical dwellings (alternatives). These profiles consisted of the following four sustainability components: energy, water, material and ecology. Each sustainability component had three levels that consisted of different measures or scores. The presented profiles had varying compositions of component levels. The sustainability components that were used in the RSE were derived from the sustainability indicators identified in the literature study. Not all the identified sustainability indicators were included in the RSE because they are not directly related to the physical characteristics of the property object or cannot be influenced by the property developer.

The RSE data of the questionnaire were analyzed with a regression model. The output of this model showed the assigned sustainability scores of the respondents for each sustainability component level, the base levels were calculated. The data indicate that the respondents assigned the highest sustainability scores to the levels with the most sustainability measures. The relative importance of the sustainability components was determined through the scores from the regression analysis. All the sustainable components had at least one level that has a significance score of $p < 0.10$ or lower. The relative importance indicated which sustainability components were perceived as most sustainable by the respondents. Surprisingly, the component material (33.9%) had the highest relative importance, followed by the components energy (32.3%), water (22%) and ecology (11.7%).

The importance residential consumers attach to sustainability when purchasing a dwelling and the willingness to pay for the additional sustainability measures were determined with a discrete choice experiment (DCE). Respondents were asked to make a choice between two hypothetical dwelling (alternatives) or the option 'neither'. The two alternatives consisted of five attributes that had varying levels. Each attribute had three levels, resulting in various alternatives. The attributes for the DCE were derived from the literature review which identified the most important physical dwelling characteristics. However, not all characteristics were included in the design of the DCE. The physical dwelling characteristics: construction year, dwelling type, number of rooms and quality of the building were not used. In addition, the attribute energy was replaced with a broader attribute to indicate the sustainability level of a dwelling. The attribute '(dwelling) price' was added to the DCE to determine the willingness to pay for the different dwelling characteristics. The collected data of the DCE were analyzed with a Multinomial Logit Model (MNL). The MNL model provided the utility values for all attribute levels; the base levels of the attributes were calculated. The data show that the attributes 'sustainability level', 'outdoor space' and 'parking' have at least one level with a significance score of $p < 0.10$ or lower. The attributes 'price' and 'dwelling size' have no levels that are significant.

The relative importance of the attribute levels is determined through the output of the MNL model. The data show that the highest relative importance is assigned to the attribute 'parking' (41.6%), followed by the attributes 'sustainability level' (26.1%) and 'outdoor space' (16.2%). It was not expected that the attribute 'parking' would be considered the most important attribute. This outcome is further contemplated on in the discussion section. The high relative importance of the attribute 'sustainability' seems to indicate that the respondents of the sample assign a considerable value to sustainability.

The willingness to pay (WTP) for the additional sustainability measures is calculated with the utility ranges of the attributes 'sustainability level' and 'price'. The WTP calculations of the DCE data indicate that respondents are willing to pay € 73,826 more for the dwelling with the highest sustainability level score (8) compared to the dwelling with the lowest sustainability level score (4). It should be noted that the hypothetical dwellings (profiles) in the DCE only included three other physical dwelling attributes. It is possible that this gave a distorted picture. In real life, the dwelling consists of more dwelling attributes that influence the property value.

Answering the main research question

The results indicate that residential consumers as a group assign a considerable amount of importance to the sustainability of a dwelling in the purchasing decision. The overall sustainability level of the dwelling had the second highest relative importance score compared to the physical dwelling characteristics, respectively, parking space and outdoor space. The research results also indicate that residential consumers are willing to pay € 73,826 more for additional sustainability measures. Furthermore, the sustainability components ‘material’ and ‘energy’ are perceived as the biggest contributors to sustainability, followed by the components ‘water’ and ‘ecology’. This suggests that residential consumers perceive more sustainability components than just energy as important contributors for achieving overall sustainability.

Discussion

Like any study, this study has its limitations. The input of the DCE consisted of physical dwelling characteristics that were identified with a literature review. The characteristics that were mentioned the most in the assessed literature were included in the DCE. It can be argued that this method is not necessarily correct because it is limited to a restricted set of physical dwelling characteristics; the location and environmental characteristics were excluded, as the focus of this study was on the physical dwelling characteristics.

Several sustainability rating tools (certificates) were analyzed to identify sustainability indicators. The researcher has decided which sustainability components were used in the RSE. It can be argued that by doing so, other important sustainability indicators were ignored or that the study was too much focused on environmental attributes. The study was focused on the physical part of the property object; within this scope the sustainability components for the RSE have been chosen. Not all dwelling characteristics and sustainability components were included in the RSE and DCE. The reason for this was that the questionnaire had to be understandable and easy to complete for the majority of respondents. Too many dwelling characteristics and sustainability components would have led to a questionnaire that is difficult to understand.

The questionnaire that was used in this study was not longitudinal. The mood of the respondents and the current energy prices could have influenced the answers. It is possible that the results might change overtime when the energy prices normalize. Despite the current energy prices, the sustainability component energy did not dominate the RSE. The panel effect is also a limitation in this research. Each respondent performs nine rating and choice tasks. These ratings and choices are seen as individual results in the analyses but are actually performed by the same respondent. This can give a distorted picture of the results.

An important limitation of this study was the relatively small sample size. Because of this, not all results of the RSE and DCE were significant, and it was not possible to create latent class models. The respondents in the sample were also not geographically representative. The majority of the respondents were from a small research area: Utrecht (city) and several cities and villages in the province of Noord-Brabant. The sample data also have a higher percentage of males than females. The percentage of under-graduated and post-graduated respondents in the sample is higher compared to the Dutch population. The percentage of families with children in the sample is also higher than the Dutch population and the one- person households are under-represented. However, it can be argued that one-person households are less likely to live in ground-level dwellings than couples with or without children.

The regression analysis shows that the component material has a high relative importance compared to the other sustainability components. It was expected that the respondents assign more value to the attribute ‘energy’. A possible explanation for this is that the differences between the levels of the component material are larger than the differences between the levels of the component ‘energy’. In the RSE the component levels of ‘material’ are a, wooden construction method and a traditional building method, this can be perceived as a more significant difference than the difference between levels of the component ‘energy’, energy label A and A++++. The MNL model shows a very strong relative importance for the attribute ‘parking’. It is very likely that this is mainly caused by the attribute level ‘no parking space – also not on the public space’. A possible explanation for this result is that the questionnaires were conducted in residential areas with ample parking space. Therefore, the respondents were probably accustomed to using cars for transportation. However, this is a guess because the car ownership of the respondents is not actually known. In hindsight, it was better to exclude the attribute level of ’no parking space’ or to control for car ownership.

The calculations of the WTP indicate that residential consumers were willing to pay € 73,826 more for additional sustainable measures, and even € 117,515 more for a parking space. These WTP values seem quite high. A possible explanation for this is that there were only four physical dwelling characteristics present in the DCE. The limited number of physical dwelling characteristics can cause a higher relative importance than in a real-life situation in which residential consumers have to make trade-offs between other dwelling characteristics, as well as environmental and location attributes. Moreover, it does not seem realistic that residential consumers are willing to pay € 117,515 more for an identical dwelling with an available parking space.

Scientific recommendations

All these limitations offer opportunities for future research. It is recommended to collect a larger sample size that is more representative in order to have the possibility to determine latent class analysis. It would be interesting to know whether personal characteristics, such as income, level of education or environmental awareness would influence the importance that respondents attach to sustainability, or how sustainability is perceived.

Additionally, future research could also include a wider variety of physical dwelling characteristics in the DCE to create more realistic dwelling profiles. It is also recommended to reduce the parking attribute to two levels by dismissing the level of ‘no parking space’. This will prevent the parking attribute from dominating the DCE data. In the RSE, the levels of the sustainability component ‘material’ could be described differently to see whether this attribute will still have a high relative importance if the differences between the levels are not so considerable. It would also be interesting to include a wider range of sustainability components in the RSE to see the effect of other sustainability indicators.

Practical recommendations

The results of the study indicate that the residential consumers (as a group) are ready for additional sustainability measures and are willing to pay more for this. It is recommended for residential real estate developers to pursue higher sustainability goals than the current regulations. Furthermore, the research results show that residential consumers view sustainability in broader terms than the energy performance of a dwelling. The sustainability components ‘material’, ‘water’ and ‘ecology’ are also perceived as important contributors for the overall sustainability. The following additional sustainability measures are recommended towards residential real estate developers to implement in their projects.

It is interesting for developers to invest in additional PhotoVoltaic (PV) panels. PV panels are a relatively affordable measure to improve the energy performance of a dwelling. The sustainability component ‘material’ is perceived as an important contributor to sustainability. However, it is currently still relatively expensive to build dwellings entirely out of wood. It can be interesting to design parts of the dwelling in wood, such as the inner cavity leaf. In addition, the developer can control CO_2 emissions in the design process by choosing specific materials. Some building material suppliers have lower CO_2 emissions than others. For the sustainability component 'water', it is attractive to invest in measures to save tap water and to irrigate rainwater. Think of having a sedum green roof, a large rain barrel or applying a water saving shower head. Installing water purification systems in the dwelling to use rainwater or shower water is not recommended because the installations and maintenance costs are quite high. The measures for ecology are relatively affordable, such as the use of built-in nest boxes and the use of hedges. It could be a consideration for the developer to offer ecological garden plans as an additional work option; these garden plans can promote biodiversity and improve water irrigation. It is recommended to residential real estate developers to explore the outlined sustainability measures in the design process. In the design process, the feasibility of the additional measures can be further determined.

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Appendices

Appendix 1: Dwelling characteristics

Dwelling characteristics	van Arnhem & Berkhout (2013)	Visser & van Dam (2006)	(Vastmans, Helgers, Damen, & Goeyvaerts, 2016)	D. M. Grether and Peter Mieszkowsk (1973)	Nadja Ferlan, Majda Bastic, Igor Psunder (2017)	Hassan, Ahmad, & Hashim (2021)	Sirmans, Macpherson, & Zietz, (2020)	Selim S, (2008)	Buitelaar, Schilder, Bijlsma, & Bellaard (2014)	Brounen & Kok (2011)	Herath & Maier (2010)	Total times mentioned
Construction year	1	1	1		1		1	1	1	1	1	9
Dwelling size (m²)	1	1	1	1	1	1	1	1	1	1	1	11
Volume dwelling (m³)	1	1										2
Height ceiling	1			1								2
Dwelling type	1	1	1				1	1	1	1	1	8
Layout	1		1	1	1	1						5
Number of rooms	1	1	1	1	1	1	1	1		1	1	10
Number of bathrooms and toilets	1			1		1	1					4
Basement				1							1	2
Floor level (in buildings without an elevator)		1			1	1		1				4
Orientation (direction)	1				1							2
Orientation garden/balcony/outdoorspace	1	1							1			3
Size of plot	1		1			1			1			4
Availability private garden/balcony/outdoorspace	1				1							2
Size of private garden/balcony/outdoorspace	1	1				1	1					4
Parking facilities or garage (carport, caport + garage, garage, parkeerplaats	1	1	1	1	1		1	1	1		1	9
Aesthetic/Architectural quality (volume, gevelindeling detaillering, quality of materials used)	1											1
State of repair/Level of maintenance (inside and outside)	1	1	1	1	1		1		1	1		8
Level of finish inside	1		1	1				1			1	5
Construction materials (quality/maintenance)	1			1	1	1		1			1	6
Architectural design						1			1			2
Monument										1		1
Unobstructed view from the dwelling	1										1	2
Energy efficiency	1	1			1		1			1		5
Energy label										1		1
Isolation quality dwelling			1							1		2
Heating system (fireplace, central heating, vloerverwarming)	1			1	1			1		1	1	6
Availability of (security) fence						1						1
Availability of luxury attributes (swimming pool, sauna, fireplace jacuzzi, sportfacilities, etc.)			1	1				1			1	4
Limited real rights	1											1
Quality noise isolation outside and inside (neighborhood noise, inside noise, installations, etc.)					1	1						2

Property Attribute	Number of times mentioned in literature	Property group attribute	Number of times mentioned in literature
Construction year	9	Construction year	9
Dwelling size (m^2)	11	Dwelling size (m^2)	11
Volume dwelling (m^3)	2		
Height ceiling	2	Volume dwelling (m^3)	4
Dwelling type	8	Dwelling type	8
Layout	5		
Number of rooms	10		
Number of bathrooms and toilets	4		
Basement	2	Number of rooms/ lay out	21
Floor level (in buildings without an elevator)	5	Floor level (in buildings without an elevator)	4
Orientation (direction)	2		
Orientation garden/balcony/outdoorspace	3	orientation dwelling/garden	5
Size of lot	4		
Availability private garden/balcony/outdoorspace	2		
Size of private garden/balcony/outdoorspace	4	size of private outdoorspace (garden/balcony)	10
Parking facilities or garage (carport, caport + garage, garage, parkeerplaats	9	Parking facilities or garage (carport, caport + garage, garage, parkeerplaats	9
Aesthetic/Architectural quality (volume, gevelindeling detaillering, quality of materials used)	1		1
State of repair/Level of maintenance (binnen en buiten)	8		
Level of finish inside	5		
Construction material (maintenance)	6	Quality of building	19
Architectural design	2		
Monument	1	Aesthetic quality	
Unobstructed view from the home	2	Unobstructed view from the home	2
Energy efficiency	5		
Energy label	1		
Isolation quality dwelling	2		
Heating system (fireplace, central heating, vloerverwarming)	6	Energy efficiency	14
Availability of (security) fence	1	Availability of (security) fence	1
Availability of luxury attributes (swimming pool, sauna, jacuzzi, sportfacilities, etc.)	5	Availability of luxury attributes (swimming pool, sauna, jacuzzi, sportfacilities, etc.)	4
Limited real rights	1	Limited real rights	1
Quality noise isolation outside and inside (neighborhood noise, inside noise, installations, etc.)	2	Noise disturbitance	2

Appendix 2: Sustainability indicators

		BREEAM NL Asset	BREEAM NL in Use: Management	BREEAM NL in Use: Asset	LEED v4.1 Residential: Single Family Homes	LEED v4 for NEIGHBORHOOD DEVELOPMENT	Greenstar	Frequency
BREEAM NL Asset								
Management	Projectdesign	x				x		2
	life cycle costs	x						1
	responsible building practice	x						1
	commissioning and transfer	x						1
	transfer to management and aftercare	x						1
Health and Well-being	visual comfort	x						1
	internal air quality	x	x	x	x		x	5
	thermal comfort	x	x				x	3
	acoustic performance	x	x				x	3
	secure access and accessibility	x						1
	Biophilic Design	x						1
	safety	x						1
Energy	energy efficiency	x	x	x	x	x	x	6
	energy monitoring	x	x	x	x			4
	energy-efficient outdoor lighting	x						1
	passive design and environmental impact energy consumption	x						1
	energy-efficient cold and freezer storage	x		x				2
	energy-efficient elevators, escalators and moving walks	x						1
	energy efficient laboratories	x						1
	energy efficient equipment	x	x	x	x			4

Sustainability indicators part 1 of 17

		BREEAM NL Asset	BREEAM NL in Use: Management	BREEAM NL in Use: Asset	LEED v4.1 Residential: Single Family Homes	LEED v4 for NEIGHBORHOOD DEVELOPMENT	Greenstar	Frequency
BREEAM NL Asset								
Transport	avaiability of public- and company transport	x	x	x		x	x	5
	proximity to amenities	x	x	x		x		4
	offer of alternative transport	x		x		x		3
	maximum parking capacity	x				x		2
	transport plan	x						1
Water	waterconsumption	x	x	x		x		4
	monitor waterconsumption	x	x	x		x		4
	waterleak detection and prevention	x	x	x				3
	water efficient equipment	x	x	x		x		4
Materials	environmental impact construction materials	x						1
	responsible origin of building materials	x	x	x	x			4
	robustness of building materials	x						1
	material efficiency	x	x					2
	releasability	x						1

Sustainability indicators part 2 of 17

		BREEAM NL Asset	BREEAM NL in Use: Management	BREEAM NL in Use: Asset	LEED v4.1 Residential: Single Family Homes	LEED v4 for NEIGHBORHOOD DEVELOPMENT	Greenstar		Frequency
BREEAM NL Asset									
Waste	Waste management on the construction site	x							1
	storage space for recyclable waste material	x							1
	furnishing and finishing	x							1
	climate adaptation	x							1
	building flexibility	x							1
land use and ecology	location choice	x							1
	protection of ecological values	x				x			2
	ecological shared use of the construction site and environment	x		x					2
	long-term ecological management and shared use of plants and animals	x		x		x			3
Pollution	environmental impact of refrigerants	x	x	x			x		4
	nitrogen emissions	x							1
	run-off rainwater	x	x						2
	minimize light pollution	x							1
	noise disturbance	x							1

Sustainability indicators part 3 of 17

		BREEAM NL Asset	BREEAM NL in Use: Management	BREEAM NL in Use: Asset	LEED v4.1 Residential: Single Family Homes	LEED v4 for NEIGHBORHOOD DEVELOPMENT	Greenstar	Frequency
BREEAM NL in Use: Management								
Management	User manual		x					1
	Engagement and feedback		x					1
	Maintenance Policy and Procedures		x					1
	Environmental policy and procedures		x					1
Health and Well being	Thermal comfort		x				x	2
	Smoking Policy	x	x					2
	Indoor air quality	x	x	x	x		x	5
	Acoustic comfort	x	x				x	3
	Microbiological risk management	x	x					2
Energy	Energy usage	x	x	x	x	x	x	6
	Emission factor collective heating and cooling network\	x	x					2
	Generation and redistribution of electricity		x	x				2
	Energy saving research	x	x	x				3
	Use of energy consumption information	x	x	x		x		4
	Reduction of CO2 -emission		x					1
Water	Measuring water consumption	x	x	x	x		x	4
	Reuse of water		x		x			2
	Water consumption: Monitoring and reporting	x	x	x	x			4
	water policy		x					1

Sustainability indicators part 4 of 17

		BREEAM NL Asset	BREEAM NL in Use: Management	BREEAM NL in Use: Asset	LEED v4.1 Residential: Single Family Homes	LEED v4 for NEIGHBORHOOD DEVELOPMENT	Greenstar	Frequency
BREEAM NL in Use: Management								
Material flows	Sustainable purchasing		x	x				2
	Optimization of use, reuse and recycling of materials		x	x				2
durability	Emergency plans and climate-related physical risks		x					1
	Climate-related transition risks and opportunities		x					1
	Social risks and opportunities		x					1
	fire safety		x					1
	Safety risk assessment		x					1
Land use and ecology	Ecological research	x	x					2
	Biodiversity policy plan	x	x					2
Pollution	Limiting light pollution		x				x	2
	Checking facilities against pollution of natural waterways		x					1
	Replacing refrigerants		x	x			x	3
	Invasive Exotic Plant Species		x					1

Sustainability indicators part 5 of 17

		BREEAM NL Asset	BREEAM NL in Use: Management	BREEAM NL in Use: Asset	LEED v4.1 Residential: Single Family Homes	LEED v4 for NEIGHBORHOOD DEVELOPMENT	Greenstar	Frequency
BREEAM NL in Use: Asset								
Health	Daylight entry			x			x	2
	Prevention of overheating due to sun exposure			x				1
	Indoor and outdoor lighting			x				1
	Preventing flicker nuisance due to lighting			x				1
	View to the outside	x		x				2
	Ease of use and maintenance			x				1
	Air supply and exhaust points of the ventilation system		x	x	x		x	4
	Carbon dioxide (CO_2) monitoring	x		x				2
	Carbon monoxide (CO) monitoring	x		x				2
	Indoor and outdoor spaces			x				1
	Accessibility			x				1
	Radon risk			x				1
	Ambient air quality	x	x	x	x			4

Sustainability indicators part 6 of 17

		BREEAM NL Asset	BREEAM NL in Use: Management	BREEAM NL in Use: Asset	LEED v4.1 Residential: Single Family Homes	LEED v4 for NEIGHBORHOOD DEVELOPMENT	Greenstar	Frequency
BREEAM NL in Use: Asset								
Energy	Energy performance of the building	x	x	x		x	x	5
	Matching supply and demand of electricity (DSM)			x				1
	Control facilities indoor climate			x				1
	Local energy labeling methodology			x				1
	Solar panels (PV)			x				1
	Solar collectors			x				1
	Energy consumption monitoring	x	x	x	x		x	5
	Monitoring of dwellings		x	x				2
	Outdoor lighting and parking lot lighting			x				1
	Energy efficient elevators			x				1
Transportation	Alternative transport	x		x		x		3
	Proximity to public transport (OV)	x		x		x		3
	Proximity to basic facilities	x		x		x		3
	Road safety in the residential environment			x		x		2

Sustainability indicators part 7 of 17

		BREEAM NL Asset	BREEAM NL in Use: Management	BREEAM NL in Use: Asset	LEED v4.1 Residential: Single Family Homes	LEED v4 for NEIGHBORHOOD DEVELOPMENT	Greenstar	Frequency
BREEAM NL in Use: Asset								
Water	Measuring water consumption	x	x	x	x			4
	Water-saving sanitary facilities: Toilets	x		x				2
	Water-saving sanitary ware: Taps	x		x				2
	Water-saving sanitary facilities: Showers and baths	x		x				2
	Water-saving white goods			x				1
	Leak detection system	x		x				2
	Leak prevention	x		x				2
	Stop valves			x				1
	Limiting water use in the public drinking water network			x				1
Material flows	Condition measurement			x				1
	Provisions for reuse and recycling		x	x				2
	Building passport		x	x				2
Durability	Flood Risk Assessment			x				1
	Measures to reduce rainwater runoff		x	x				2
	Risk assessment for natural disasters			x				1
	Protective measures against damage		x	x				2
	Alarm systems			x				1
Land use and ecology	Area with landscaping			x				1
	Ecological Facilities			x				1

Sustainability indicators part 8 of 17

		BREEAM NL Asset	BREEAM NL in Use: Management	BREEAM NL in Use: Asset	LEED v4.1 Residential: Single Family Homes	LEED v4 for NEIGHBORHOOD DEVELOPMENT	Greenstar	Frequency
BREEAM NL in Use: Asset								
Pollution	Minimizing pollution of natural waterways	x	x	x				3
	Storage facility for chemical substances			x				1
	Limiting local air pollution	x		x				2
	Impact of refrigerants	x	x	x			x	4
	Automatic refrigerant leak detection	x		x				2

Sustainability indicators part 9 of 17

		BREEAM NL Asset	BREEAM NL in Use: Management	BREEAM NL in Use: Asset	LEED v4.1 Residential: Single Family Homes	LEED v4 for NEIGHBORHOOD DEVELOPMENT	Greenstar	Frequency
LEED v4.1 Residential: Single Family Homes								
Location and transportation	Prerequisite: Floodplain Avoidance				x			1
	LEED for Neighborhood Development				x			1
	Site Selection		x		x	x		3
	Compact Development				x	x		2
	Community Resources				x	x		2
	Access to Transit				x			1
Sustainable sites	Construction Activity Pollution Prevention				x			1
	Heat Island Reduction				x			1
	Rainwater Management				x			1
	Nontoxic Pest Control				x			1
Water efficiency	Water Use	x	x	x	x	x		5
	Water Metering	x	x	x	x			4
	Total Water Use	x	x	x	x			4
	Indoor Water Use	x	x	x	x			4
	Outdoor Water Use				x			1
Energy and atmosphere	Minimum Energy Performance	x	x	x	x	x	x	6
	Energy Metering	x			x			2
	Education of Homeowner, Tenant, or Building Manager				x			1
	Annual Energy Use	x	x		x			3
	Efficient Hot Water Distribution System				x			1
	HVAC Start-Up Credentialing				x			1
	Refrigerant Management				x			1

Sustainability indicators part 10 of 17

		BREEAM NL Asset	BREEAM NL in Use: Management	BREEAM NL in Use: Asset	LEED v4.1 Residential: Single Family Homes	LEED v4 for NEIGHBORHOOD DEVELOPMENT	Greenstar	Frequency
LEED v4.1 Residential: Single Family Homes								
Materials and resources	Certified Tropical Wood		x		x			2
	Durability Management		x		x			2
	Durability Management Verification		x		x			2
	Environmentally Preferable Products		x		x			2
	Construction Waste Management				x			1
	Material-Efficient Framing				x			1
Indoor environmental equality	Ventilation	x	x	x	x			4
	Combustion Venting		x		x			2
	Garage Pollutant Protection				x			1
	Radon-Resistant Construction				x			1
	Air Filtering	x	x	x	x			4
	Compartmentalization				x			1
	Enhanced Ventilation	x	x		x			3
	Contaminant Control				x			1
	Balancing of Heating and Cooling Distribution Systems		x		x			2
	Low-Emitting Products				x			1
Innovation	Prerequisite: Preliminary Rating				x			1
	Innovation				x			1
	LEED Accredited Professional				x			1
Regional Priority	Regional Priority				x	x		2

Sustainability indicators part 11 of 17

		BREEAM NL Asset	BREEAM NL in Use: Management	BREEAM NL in Use: Asset	LEED v4.1 Residential: Single Family Homes	LEED v4 for NEIGHBORHOOD DEVELOPMENT	Greenstar	Frequency
LEED v4 for NEIGHBORHOOD DEVELOPMENT								
Smart location and linkage	Smart location		x		x	x		3
	Imperiled Species and Ecological Communities Conservation					x		1
	Wetland and Water Body Conservation					x		1
	Agricultural Land Conservation					x		1
	Floodplain Avoidance					x		1
	Preferred Locations					x		1
	Brownfield Remediation					x		1
	Access to Quality Transit					x		1
	Bicycle Facilities					x		1
	Housing and Jobs Proximity					x		1
	Steep Slope Protection					x		1
	Site Design for Habitat or Wetland and Water Body Conservation					x		1
	Restoration of Habitat or Wetlands and Water Bodies					x		1
	Long-Term Conservation Management of Habitat or Wetlands and Water Bodies					x		1

Sustainability indicators part 12 of 17

		BREEAM NL Asset	BREEAM NL in Use: Management	BREEAM NL in Use: Asset	LEED v4.1 Residential: Single Family Homes	LEED v4 for NEIGHBORHOOD DEVELOPMENT	Greenstar	Frequency
LEED v4 for NEIGHBORHOOD DEVELOPMENT								
Neighborhood pattern and design	Walkable Streets					x		1
	Compact development				x	x	x	3
	Connected and Open Community					x		1
	Mixed-Use Neighborhoods					x		1
	Housing Types and Affordability					x		1
	Reduced Parking Footprint	x				x		2
	Transit Facilities				x	x	x	3
	Transportation Demand Management	x				x		2
	Access to Civic and Public Space	x		x	x	x	x	5
	Access to Recreation Facilities	x		x	x	x	x	5
	Visitability and Universal Design					x		1
	Community Outreach and Involvement					x		1
	Local Food Production					x		1
	Tree-Lined and Shaded Streetscapes					x		1
	Neighborhood Schools					x		1

Sustainability indicators part 13 of 17

		BREEAM NL Asset	BREEAM NL in Use: Management	BREEAM NL in Use: Asset	LEED v4.1 Residential: Single Family Homes	LEED v4 for NEIGHBORHOOD DEVELOPMENT	Greenstar	Frequency
LEED v4 for NEIGHBORHOOD DEVELOPMENT								
Green infrastructure and buildings	Green building					x		1
	Minimum Building Energy Performance	x			x	x	x	4
	Indoor Water Use Reduction	x	x	x	x	x		4
	Construction Activity Pollution Prevention	x				x		2
	Certified Green Buildings					x		1
	Optimize Building Energy Performance	x	x	x	x	x		5
	Outdoor Water Use Reduction					x		1
	Building Reuse					x		1
	Historic Resource Preservation and Adaptive Reuse					x		1
	Minimized Site Disturbance					x		1
	Rainwater Management					x		1
	Heat Island Reduction					x		1
	Solar Orientation					x		1
	Renewable Energy Production	x	x	x	x	x		5
	District Heating and Cooling					x		1
	Infrastructure Energy Efficiency					x		1
	Wastewater Management	x				x		2
	Recycled and Reused Infrastructure					x		1
	Solid Waste Management					x		1

Sustainability indicators part 14 of 17

		BREEAM NL Asset	BREEAM NL in Use: Management	BREEAM NL in Use: Asset	LEED v4.1 Residential: Single Family Homes	LEED v4 for NEIGHBORHOOD DEVELOPMENT	Greenstar	Frequency
LEED v4 for NEIGHBORHOOD DEVELOPMENT								
Green infrastructure and buildings	Light Pollution Reduction		x	x		x		3
Innovation	Innovation					x		1
	LEED Accredited Professional					x		1
Regional priority	Regional priority				x	x		2

Sustainability indicators part 15 of 17

		BREEAM NL Asset	BREEAM NL in Use: Management	BREEAM NL in Use: Asset	LEED v4.1 Residential: Single Family Homes	LEED v4 for NEIGHBORHOOD DEVELOPMENT	Greenstar	Frequency
Greenstar								
Management	Greenstar accredited profession						x	1
	Building information	x	x			x	x	4
	ongoing monitoring and metering	x	x			x	x	4
	tuning and commissiong						x	1
	environmental management						x	1
	green cleaning						x	1
	commitment to performance						x	1
indoor quality	quality of indoor air	x	x	x	x		x	5
	hazardous materials						x	1
	daylight & views	x	x	x			x	4
	lighting comfort	x	x				x	3
	thermal comfort	x	x	x			x	4
	acoustic comfort	x	x				x	3
	occupant comfort and satifasfaction						x	1
energy	greenhouse gas emissions		x				x	2
	peak elektricity demand						x	1
	alternative transport program	x				x	x	3
	transport modes survey						x	1
water	portable water						x	1
	fire protection testing water		x				x	2
materials	procurement and purchasing						x	1
	waste from operations	x					x	2
	waste from refurbishments						x	1

Sustainability indicators part 16 of 17

		BREEAM NL Asset	BREEAM NL in Use: Management	BREEAM NL in Use: Asset	LEED v4.1 Residential: Single Family Homes	LEED v4 for NEIGHBORHOOD DEVELOPMENT	Greenstar	Frequency
Greenstar								
land use and ecology	ecological value					x	x	2
	groundkeeping practices					x	x	2
	stormwater	x					x	2
emmissions	light pollution	x	x	x			x	4
	impacts form refrigeration	x	x	x			x	4
innovation	innovation						x	1

Sustainability indicators part 17 of 17

Appendix 3: Sustainability components and indicators

A list is conducted of real estate indicators that have an influence on sustainability, see table 3.1. The list is made by analyzing several sustainability rating tools. The sustainable indicators are divided into different components. The different sustainability components and indicators that are part of this are explained in this appendix.

Component: energy
The component energy is currently one of the best developed sustainability components for real estate. The aim of this component is to minimize energy use. Every building that is sold in the Netherlands need to have an energy label. This label indicates the energy efficiency of the dwelling. For new constructed real estate there are energy requirements laid down in the building decree. The energy requirements have been tightened in the past decades with the improvement of technology. Since January 1, 2021, the energy performance of (new) real estate has been measured in Nearly Zero-Energy Buildings, Bijna Energie Neutrale gebouwen (BENG). The BENG is determined on the basis of 3 requirements:

1. the maximum energy requirement in kWh per m2 of usable surface per year
2. the maximum primary fossil energy consumption, also in kWh per m2 usable surface per year
3. the minimum share of renewable energy in percentage

Energy performance and energy efficient design
The energy performance of a dwelling indicates how much energy is needed to; heat, light, ventilate and generate warm water. BENG 2 indicates how much energy a dwelling need for this. The following measures are improving energy performance of a dwelling; low temperature heating, insulation, heat back win systems through air and (shower) water). Besides this, the (sun) orientation and design of the dwelling have an effect on the energy demand of a building.

Sustainable energy sources
Energy usage of a dwelling can be minimized with an optimized energy performance. However, there is always some energy needed in a dwelling. How much of the used energy is from sustainable energy sources is indicated in BENG 3. The following measures generate sustainable energy, PV solar cells, PVT solar cells, solar water heaters, groundwater heat pumps and geothermic heat.

Monitoring energy use
Monitoring tools can help users to gain insight in the energy performance of their dwelling. This insight can help users to adjust their behaviour to lower their energy use. An example of this is the use of monitoring tools that provide insight in the generated energy with PV solar cells. Residents can use the dishwasher or charge their electric vehicle when this energy is generated. These changes can help to improve effective use of energy and helps reduce peak load on the electricity grid.

Component: water
The component water relates to water storage, climate adaptation, water consumption and water pollution. Various indicators for water emerge from the analysis of the certification tools. At first glance, water does not seem to be a major issue in the Netherlands because the tap water in the Netherlands is of good quality and affordable, water purification and water management are regulated by law. However, reducing water consumption has a direct effect on the energy use. Producing clean drinking water and purifying wastewater takes a lot of energy (Frijns, Mulder, Roorda, Schepman, & Voskamp, 2013). For purification, the amount and the level of pollution of wastewater is important.

The processing, storage and infiltration of rainwater in the area itself reduce the amount of wastewater and helps to retain more water in the ground. This is good for the local flora and fauna, especially during dry periods. This also applies to the installation of two sewer systems (gray and black water). There are various indicators and measures defined by the certification tools to limit water consumption and decrease the amount of wastewater. In addition to water consumption and pollution, the storage and disposal of rainwater is also an important theme (Frijns, Mulder, Roorda, Schepman, & Voskamp, 2013). The storage and management of water is important because this can prevent dehydration and flooding. One measure for this is water-permeable paving (Boogaard, Beenen, & Rombout J, 2008).

Monitoring water consumption
A real-time insight of the water consumption can help to create awareness among users and reduce the water consumption.

Water saving sanitary
Water saving sanitary measures help to reduce water use. Think about; water saving toilet (dual flush), water saving faucets, water saving shower heads, water saving shower installations, automatic faucets, etc.. The aim of these measures is to reduce the water usage.

Reuse collected water
Tap water consumption can also be reduced by using rainwater or reusing gray water (shower, washing machine, dishwasher, etc..). This water can be used for tasks that do not require clean tap water, think of watering the garden or flushing the toilet. These measures reduce tap water consumption and the amount of water that has to be purified. A simple measure for residential real estate is using a rain barrel to water the garden.

Separate grey, black and rainwater
The sewer system can be optimized by separating black and gray water. The gray water can after some simple purification be reused to flush the toilet.

Water management
The storage and disposal of rainwater in an area helps to infiltrate rainwater and regulate the ground water levels. Areas become more robust for heavy rain showers with good water management measures. There are several measures to improve the water management in an area, such as minimizing pavement/surfacing or the use of water-permeable pavement in an area contributes to the natural water infiltration. Other examples of measures are the construction of wadis, sedum roofs, gravel cases, infiltration crates, etc..

Component: material
There are different ways to indicate sustainable material use. It is possible to express the environmental impact of materials in CO2 emissions. In the Netherlands the CO2 impact of materials for new built real estate is regulated with Environmental performance buildings, Milieuprestatie Gebouwen, (MPG). Other indicators for sustainable material use are biobased material, reusability of material and the renewability. An important overall goal for the different sustainability indicators is that the materials are not harmful to people or the environment. The different material indicators are explained below.

Environmental impact
The Environmental impact Buildings, Milieuprestatie gebouwen (MPG) calculation is a measure that indicate how sustainable the used materials are by showing a shadow price (Rijksdienst voor Ondernemend Nederland, 2018). This score takes into account a large diversity of facets in the

emission of greenhouse gasses; winning the materials (agriculture, forestry or mines), production, transport, expected lifespan, reusability, emission of harmful substances, impact assembly and demolition, etc.. The MPG score is different than the cradle to cradle method (van Leeuwen, et al., 2018) (McDonough, Braungart, Anastas, & Zimmerman, 2003). The MPG calculation is a compulsory part for building permits in the Netherlands. The maximum score is now 0.8, the aim is to lower this gradually to 0.5 in 2030. Currently, clear requirements for the existing stock do not exist and the process for determining the impact of the existing building stock is very complex.

Material passport
Circularity and high-quality reuse of materials can be improved with a 'material passport'. However, it is difficult to draw up a material passport for existing buildings because information on the used materials could be missing. In the design process of new buildings it is easier to create a material passport. Material passports are not used on a large scale. For existing buildings it is possible to create a material passport for the new add material when a building is renovated. A material passport helps to create insight in the incoming and outgoing material streams. This can help to use materials more sustainable.

Demountable materials
The indicator 'demountable materials' addresses the ease by which materials can be disassembled and be reused. To make this possible the connections must allow reassembly and reuse. Besides this it is important that the materials and connections are non-toxic. It is difficult to disassemble materials at existing properties because most of the time the materials are not suitable for this. However, newly added materials can be demountable applied. It is possible in the design phase to integrate the principle of demountable materials.

Component: ecology
When developing an area or building, an intervention is made on the environment. The development can have a negative, neutral or positive influence. In the Netherlands it is necessary to carry out several ecological studies before an area can be given another destination. An environmental impact report/ Milieu effect rapportage (MER) must be drawn up for major area developments. The ecological studies shows the expected environmental effects of an (area) development. This allows the government to include the environmental effects in its decision on the plan or project. A MER is not necessary for a lot of residential area developments. Nevertheless, a study of the current flora and fauna and nitrogen deposition are always necessary. If there are protected species in the intended development area preventive measures should be taken. In addition, there are various ways to support the flora and fauna in the area that is been developed.

Land preservation and ecological impact
When developing new property, the current function of the location needs to be examined. The aim of the development is to convert the location to another function. This can be at the expense of, imperiled species and ecological communities, wetland and water body, and agricultural land conservation. The conversion of these functions can be at the expense of flora and fauna. It is a trade-off between different objectives. The aim should be to have as little impact as possible with an (area) development on the existing flora and fauna. Redevelopment within the existing contours of the city is therefore preferred. Brownfield remediation is a good example of careful use of existing locations and possible improving the flora and fauna.

Ecological and green facilities
Flora and fauna can be supported with various interventions in the public and private area. An ecological study indicates which species are already present in an area. Possible flora and fauna can be protected by making provisions in the realization phase and by implementing this in the landscape

design. During the realization phase, existing greenery can be shielded from the building activities and temporary nesting possibilities can be placed. In the final plan, a choice can be made for species and greenery in the landscape design that fit in and contribute to the local flora and fauna. Furthermore, nesting options can be included in the plan and in the (new) property. Finally, it is important to prevent invasive plant species from being applied or given a chance to establish themselves in the area, an example of this is the Japanese knotweed.

Component: future proof
A long lifespan of a building contributes to the reduction of material use, greenhouse gas emissions and land use. The following indicators are indicated in the certification ratings.

Lifespan
The lifespan indicates how robust and futureproof a building is developed. The lifespan is determined by how long a building can be exploited without major maintenance, renovation or transformation.

Adaptability
The adaptability and therefore the lifespan of a building can be increased by taking into account the following attributes in the design; option to adjust interior walls, adjustable installations, ceiling height and the option of making the home life-proof.

Component: spatial quality
The spatial quality contributes to the social and economic component of a location. Indicators from this component indicate how a location and building are experienced by users and visitors.

Neighborhood patterns and spatial design
This indicator is about the urban and spatial quality in an area. Aspects on which this can be assessed are walkable streets, compact development, mixed use neighborhoods, transit facilities, connected and open community, access to recreation facilities, access to civic and public space, neighborhood schools, visibility and universal design, community outreach and involvement

Functionality
The functionality of a building influences how efficient and effective a building can be used. The functionality of a building increases if it is useable for multiple functions. This indicator is more important for commercial real estate than for residential real estate.

Diversity, identity and beauty
Beauty and identity consist of several aspects and is mainly part of the aesthetic side of property. In the spatial planning memorandum, among others, the to distinguish between diversity, identity and beauty. The latter part is difficult to measure because of the strong personal dependence of this. The diversity and identity component are easier to measure in practice. Diversity can be indicated by considering the number of dwelling types. To give your own identity to a property object or a neighborhood, you can choose a specific style in the design, such as a modern style. According to Bolt must be tried to prevent anonymity. This can occur when too many identical housing types are present in large numbers in an area. Think of large areas of interpretation from the 60s and 70s with colossal flats with the same design (Bolt & Torrance, 2005). Variation in the housing types can contribute to the identity of an area.

Component: transport
In multiple sustainable certificates the importance for sustainable transport for end-users is appointed. Enabling a more sustainable way of transport for the (future) users of an area or building helps to reduce the environmental impact.

Reduce car parking
Paid parking policy is a measure to demotivate car use and stimulate other modes of transport. In newly developed residential areas, a lower parking standard is becoming more common.

Proximity of public transport
The distance to public transport nodes supports that residents and visitors travel by public transport.

Facilities for cyclists
The presence of good cycling infrastructure contributes to the use of bicycles. An example of this are bicycle store facilities.

Proximity of facilities
The presence of (shopping) facilities in the immediate vicinity contribute to the reduction of car transport movements. The close proximity of facilities encourages residents to visit these facilities on foot or by bicycle.

Car sharing
The availability of car sharing facilities in the neighborhood contribute to less car ownership and car use. Car sharing is often used to encourage people to don't purchase an own car.

Electric charging stations
Electric car charging stations in the neighborhood can help to increase electric car ownership.

Component: pollution
Minimizing environmental pollution during the whole process is an important component of sustainability. It can occur during different phases of a property object. Several indicators are listed below that are related to real estate and have an impact on pollution.

Light pollution
Some wildlife is affected by light. Artificial lighting can disrupt flora and fauna in several ways. This can be controlled by taking the light pollution into account during the design phase.

Waste collection
Waste can cause several problems. The lack of waste collection points can lead to litter in the area. As a result, plastic and other (harmful) materials can end up in the environment and disrupt the flora and fauna. Besides this, raw materials are lost if they are not collected properly.

The processing of household waste in the Netherlands is regulated by municipalities. However, the processing and the degree of separation are comparable in most residential areas. In most municipalities, GFT, paper and cardboard, and residual waste are separated. Plastic is also being collected separately in several municipalities. Often there are also glass collection points available in the city or village. There are two ways of separating waste, at the source (collection) or at the waste processing point.

However, waste can be better utilized when it is collected in mono streams. Mono streams are pure waste streams of a specific type of waste. An example of this is the separate collection of coffee dregs. By collecting the coffee dregs separately, it can be used in a high-quality way. For example, it can serve as a raw material for cosmetics, a nutrient for growing oyster mushrooms and many other applications are possible. The idea of the mono streams is therefore that separate collection makes higher-quality reuse possible. This way of processing waste can be supported by the provision of good facilities in a house or a neighborhood so that it becomes easy for residents to apply this method of waste collection.

During construction this can be anticipated by minimizing (construction) waste. Waste during demolition can be limited and the reuse of materials can be promoted by applying the cradle-to-cradle principle. This must be taken into account in the design, development and construction phases.

Local water and air pollution
In the exploitation phase real estate objects can emit harmful substances. Harmful substances can outflow into the soil or surface water, think of paint, heavy metals, etc.. It can also have harmful emission or evaporation of harmful substances into the air, such as asbestos, or harmful gases due to business activities. These emissions can be limited by choosing the right materials in the design phase.

Harmful emissions for the environment are CO2, Nox and f-gases. These emissions should be minimized during all phases. Before construction and demolition, the CO2 and Nox impact of equipment, (future) car use and heating can be calculated. Choices for the right equipment and minimizing car use minimize emissions.

Component: health and well-being
The average Dutch person spends between 80% to 90% of his time indoors, dwelling, office or school. There are studies that show that buildings can have a negative impact on health. In some cases, the building can have a very bad influence on the users and the 'sick building syndrome' may arise. In these buildings, people immediately become noticeable complaints or become ill. Examples of complaints are allergic reactions, eye irritation, constipation, headache and skin irritation. If the exposure lasts for a long time, this can lead to chronic illness (Wegener & Fedkenheuer, 2016). In addition to the sick building syndrome, the building can also affect the health and performance of the users in a way that is not immediately perceptible. In dwellings can be thought of; poor sleep, (winter) depression, stress and reduced mental performance (Wegener & Fedkenheuer, 2016). Not all of the above complaints are caused by the built environment. This can also be caused by other factors or a combination. In practice, aspects such as daylight incidence and air quality are important in the area of real estate development. In the Netherlands there is regulation for these aspects in the building decree. New built real estate is assessed on these aspects during the permit application.

Air quality
The air quality has a lot of influence on the health. A too high CO2 content reduces the (mental) performance, fatigue and a bad night's sleep (Satish, et al., 2012). Too high (fine) dust content can cause respiratory diseases and a feeling of tightness. Prolonged stay in a room that is too humid can cause rheumatism, lung diseases or fungal infections (Satish, et al., 2012). The cause of a bad air quality is most of the time related to poor ventilation. The air quality can be monitored with CO2, CO and moisture sensors. Ventilation can be optimized with these sensors. Besides this a good ventilation system and regular maintenance are a precondition. In the building permit there are several documents needed to show the air quality for new built property in the building permit.

Daylight
Daylight has a big influence on the biorhythm and health and wellbeing of humans. Sufficient daylight in buildings contribute to the health and wellbeing of humans. There are calculation by which can be determined if the dwelling has enough daylight or not. Especially the work and living spaces should have enough daylight. A minimal requirement for daylight is regulated for new built property in the building decree.

Thermal comfort
The temperature in a dwelling affects the living pleasure, sleep and mental performance. When a dwelling is too hot or too cold, this has a negative effect on the mental performance and sleep quality. Temperature perception is, of course, subjective. However, most people don't like to have drafts or cold falls in his home. The thermal comfort of a dwelling is the ability of a dwelling to create a comfortable indoor climate in different weather conditions. In winter, this means that the house must be sufficiently heated and that drafts must be prevented. In the summer, creating a cool indoor climate is a must. The thermal comfort is an interplay of different variables; orientation, crack sealing in the property object, sun blinds, heating and cooling installation, ventilation system, etc.. In the building decree TO juli is included, this measure makes demands on temperature regulation to prevent overheating. With the right design choices, a good indoor climate can be achieved in the design.

Noise
Noise disturbance is a problem in many places. Long-term noise pollution can lead to higher stress levels, sleep deprivation, increased blood pressure, palpitations, depression and burnout complaints. Noise disturbance is therefore an important theme. In the Netherlands there is the necessary legislation regarding noise from residential real estate. New built dwellings must meet noise requirements, otherwise a permit will not be issued. Noise nuisance can be taken into account in the design at noise-affected locations. In addition, it is important to limit internal noise disturbance. This requires extra attention, especially in high rise housing. By taking into account in the design the location of the sleeping quarters (not on the street side) and applying good sound insulation, the sleep, mental performance and enjoyment can be improved.

Safety
Safety is a theme that can be interpreted in various ways. It may have to do with fall safety in and outside the object, safety during construction for the people that are working on construction but also the surrounding area. Safety can also interpret as a set of measures to prevent crimes or measures in the field of road safety.

During the design, development and construction phase the safety during the construction should be taken into account, this is also the case for the use and maintenance of the object during the exploitation phase. In case of preventing crimes, the police hallmark Safe Living is often applied. Regarding traffic safety, measures can be taken to make the neighborhood more traffic safe by applying speedbumps, walking and cycling lanes, etc... The composition of residents in an area plays an important role in socially sustainable living. However, there are different views on how a neighborhood should be composed. The government, many municipalities and housing corporations seek to mix people from immigrant and autochthonous families with modal incomes in the neighborhood. The view of these parties is that this promotes the quality of life and the integration of disadvantaged groups. It is an assumption that has led to heated discussions among social scientists for several years. Critical sociologists argue that rich and poor, allochthonous and autochthonous people also live completely together in mixed neighborhoods (Bolt & Torrance, 2005).

Harmful materials
Some building materials can be toxic/harmful for the health of humans. The toxicity is most of the times not immediately effecting the health of users, but over a longer period it can cause health issues. A well-known example is the use of asbestos in real estate. In the design and development phase harmful materials should be chosen.

Appendix 4: Fractional factorial design RSE

Profile Number	Energy	Water	Material	Ecology
1	Energylabel A	No additional water measures	No additional measures environmental impact materials	No additional measures for biodiversity
2	Energylabel A	Measures (rain)water storage dwelling/garden	Measures to lower the environmental impact of the materials by 25%	Built in (nest)boxes and mandatory greenery in the garden
3	Energylabel A	Measures (rain)water storage dwelling/garden and reducing clean water use	The environmental impact of the materials is at least 50% lower than the requirements	Built in (nest)boxes in dwelling
4	Energylabel A ++	No additional water measures	Measures to lower the environmental impact of the materials by 25%	Built in (nest)boxes in dwelling
5	Energylabel A ++	Measures (rain)water storage dwelling/garden	The environmental impact of the materials is at least 50% lower than the requirements	No additional measures for biodiversity
6	Energylabel A ++	Measures (rain)water storage dwelling/garden and reducing clean water use	No additional measures environmental impact materials	Built in (nest)boxes and mandatory greenery in the garden
7	Energylabel A ++++	No additional water measures	The environmental impact of the materials is at least 50% lower than the requirements	Built in (nest)boxes and mandatory greenery in the garden
8	Energylabel A ++++	Measures (rain)water storage dwelling/garden	No additional measures environmental impact materials	Built in (nest)boxes in dwelling
9	Energylabel A ++++	Measures (rain)water storage dwelling/garden and reducing clean water use	Measures to lower the environmental impact of the materials by 25%	No additional measures for biodiversity

Profile Number	Energy	Water	Material	Ecology
1	0	0	0	0
2	0	1	1	2
3	0	2	2	1
4	1	0	1	1
5	1	1	2	0
6	1	2	0	2
7	2	0	2	2
8	2	1	0	1
9	2	2	1	0

Appendix 5: Effect coding RSE

Profile Number	Energy1	Energy2	Water1	Water2	Materia l1	Materia l2	Ecology 1	Ecology 2
1	-1	-1	-1	-1	-1	-1	-1	-1
2	-1	-1	1	0	1	0	0	1
3	-1	-1	0	1	0	1	1	0
4	1	0	-1	-1	1	0	1	0
5	1	0	1	0	0	1	-1	-1
6	1	0	0	1	-1	-1	0	1
7	0	1	-1	-1	0	1	0	1
8	0	1	1	0	-1	-1	1	0
9	0	1	0	1	1	0	-1	-1

Appendix 6: Fractional factorial design DCE

profile number	sustainability level	size	outdoor space	parking	price
1	sustainability level score = 4	110m²	60m²	no parking space	€ 420.000
2	sustainability level score = 4	110m²	80m²	shared/public parking space	€ 480.000
3	sustainability level score = 4	110m²	100m²	individual parking	€ 450.000
4	sustainability level score = 4	120m²	60m²	shared/public parking space	€ 450.000
5	sustainability level score = 4	120m²	80m²	individual parking	€ 420.000
6	sustainability level score = 4	120m²	100m²	no parking space	€ 480.000
7	sustainability level score = 4	130m²	60m²	individual parking	€ 480.000
8	sustainability level score = 4	130m²	80m²	no parking space	€ 450.000
9	sustainability level score = 4	130m²	100m²	shared/public parking space	€ 420.000
10	sustainability level score = 6	110m²	60m²	no parking space	€ 420.000
11	sustainability level score = 6	110m²	80m²	shared/public parking space	€ 480.000
12	sustainability level score = 6	110m²	100m²	individual parking	€ 450.000
13	sustainability level score = 6	120m²	60m²	shared/public parking space	€ 450.000
14	sustainability level score = 6	120m²	80m²	individual parking	€ 420.000
15	sustainability level score = 6	120m²	100m²	no parking space	€ 480.000
16	sustainability level score = 6	130m²	60m²	individual parking	€ 480.000
17	sustainability level score = 6	130m²	80m²	no parking space	€ 450.000
18	sustainability level score = 6	130m²	100m²	shared/public parking space	€ 420.000
19	sustainability level score = 8	110m²	60m²	no parking space	€ 420.000
20	sustainability level score = 8	110m²	80m²	shared/public parking space	€ 480.000
21	sustainability level score = 8	110m²	100m²	individual parking	€ 450.000
22	sustainability level score = 8	120m²	60m²	shared/public parking space	€ 450.000

23	sustainability level score = 8	120m²	80m²	individual parking	€ 420.000
24	sustainability level score = 8	120m²	100m²	no parking space	€ 480.000
25	sustainability level score = 8	130m²	60m²	individual parking	€ 480.000
26	sustainability level score = 8	130m²	80m²	no parking space	€ 450.000
27	sustainability level score = 8	130m²	100m²	shared/public parking space	€ 420.000

profile number	**sustainability level**	**size**	**outdoor space**	**parking**	**price**
1	0	0	0	0	0
2	0	0	1	1	2
3	0	0	2	2	1
4	0	1	0	1	1
5	0	1	1	2	0
6	0	1	2	0	2
7	0	2	0	2	2
8	0	2	1	0	1
9	0	2	2	1	0
10	1	0	0	0	0
11	1	0	1	1	2
12	1	0	2	2	1
13	1	1	0	1	1
14	1	1	1	2	0
15	1	1	2	0	2
16	1	2	0	2	2
17	1	2	1	0	1
18	1	2	2	1	0
19	2	0	0	0	0
20	2	0	1	1	2
21	2	0	2	2	1
22	2	1	0	1	1
23	2	1	1	2	0
24	2	1	2	0	2
25	2	2	0	2	2
26	2	2	1	0	1
27	2	2	2	1	0

Appendix 7: Effect coding DCE

profile number	sustainability level 1	sustainability level 2	size 1	size 2	outdoor space 1	outdoor space 2	parking 1	parking 2	price 1	price 2
1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
2	-1	-1	-1	-1	1	0	1	0	0	1
3	-1	-1	-1	-1	0	1	0	1	1	0
4	-1	-1	1	0	-1	-1	1	0	1	0
5	-1	-1	1	0	1	0	0	1	-1	-1
6	-1	-1	1	0	0	1	-1	-1	0	1
7	-1	-1	0	1	-1	-1	0	1	0	1
8	-1	-1	0	1	1	0	-1	-1	1	0
9	-1	-1	0	1	0	1	1	0	-1	-1
10	1	0	-1	-1	-1	-1	-1	-1	-1	-1
11	1	0	-1	-1	1	0	1	0	0	1
12	1	0	-1	-1	0	1	0	1	1	0
13	1	0	1	0	-1	-1	1	0	1	0
14	1	0	1	0	1	0	0	1	-1	-1
15	1	0	1	0	0	1	-1	-1	0	1
16	1	0	0	1	-1	-1	0	1	0	1
17	1	0	0	1	1	0	-1	-1	1	0
18	1	0	0	1	0	1	1	0	-1	-1
19	0	1	-1	-1	-1	-1	-1	-1	-1	-1
20	0	1	-1	-1	1	0	1	0	0	1
21	0	1	-1	-1	0	1	0	1	1	0
22	0	1	1	0	-1	-1	1	0	1	0
23	0	1	1	0	1	0	0	1	-1	-1
24	0	1	1	0	0	1	-1	-1	0	1
25	0	1	0	1	-1	-1	0	1	0	1
26	0	1	0	1	1	0	-1	-1	1	0
27	0	1	0	1	0	1	1	0	-1	-1

Appendix 8: Choice set combinations including random design

Set	Profile1	sustainability level	size	outdoor space	parking	price	Profile2	sustainability level	size	outdoor space	parking	price
1	**15**	sustainability level score = 6	120m²	100m²	no parking space	€ 480.000	**23**	sustainability level score = 8	120m²	80m²	individual parking	€ 420.000
1	**27**	sustainability level score = 8	130m²	100m²	shared/public parking sp	€ 420.000	**22**	sustainability level score = 8	120m²	60m²	shared/public parking sp	€ 450.000
1	**25**	sustainability level score = 8	130m²	60m²	individual parking	€ 480.000	**8**	sustainability level score = 4	130m²	80m²	no parking space	€ 450.000
1	**17**	sustainability level score = 6	130m²	80m²	no parking space	€ 450.000	**20**	sustainability level score = 8	110m²	80m²	shared/public parking sp	€ 480.000
1	**26**	sustainability level score = 8	130m²	80m²	no parking space	€ 450.000	**13**	sustainability level score = 6	120m²	60m²	shared/public parking sp	€ 450.000
1	**24**	sustainability level score = 8	120m²	100m²	no parking space	€ 480.000	**19**	sustainability level score = 8	110m²	60m²	no parking space	€ 420.000
1	**16**	sustainability level score = 6	130m²	60m²	individual parking	€ 480.000	**4**	sustainability level score = 4	120m²	60m²	shared/public parking sp	€ 450.000
1	**2**	sustainability level score = 4	110m²	80m²	shared/public parking sp	€ 480.000	**3**	sustainability level score = 4	110m²	100m²	individual parking	€ 450.000
1	**1**	sustainability level score = 4	110m²	60m²	no parking space	€ 420.000	**11**	sustainability level score = 6	110m²	80m²	shared/public parking sp	€ 480.000
2	**20**	sustainability level score = 8	110m²	80m²	shared/public parking sp	€ 480.000	**12**	sustainability level score = 6	110m²	100m²	individual parking	€ 450.000
2	**14**	sustainability level score = 6	120m²	80m²	individual parking	€ 420.000	**9**	sustainability level score = 4	130m²	100m²	shared/public parking sp	€ 420.000
2	**3**	sustainability level score = 4	110m²	100m²	individual parking	€ 450.000	**15**	sustainability level score = 6	120m²	100m²	no parking space	€ 480.000
2	**21**	sustainability level score = 8	110m²	100m²	individual parking	€ 450.000	**6**	sustainability level score = 4	120m²	100m²	no parking space	€ 480.000
2	**23**	sustainability level score = 8	120m²	80m²	individual parking	€ 420.000	**16**	sustainability level score = 6	130m²	60m²	individual parking	€ 480.000
2	**7**	sustainability level score = 4	130m²	60m²	individual parking	€ 480.000	**5**	sustainability level score = 4	120m²	80m²	individual parking	€ 420.000
2	**18**	sustainability level score = 6	130m²	100m²	shared/public parking sp	€ 420.000	**17**	sustainability level score = 6	130m²	80m²	no parking space	€ 450.000
2	**10**	sustainability level score = 6	110m²	60m²	no parking space	€ 420.000	**25**	sustainability level score = 8	130m²	60m²	individual parking	€ 480.000
2	**13**	sustainability level score = 6	120m²	60m²	shared/public parking sp	€ 450.000	**19**	sustainability level score = 8	110m²	60m²	no parking space	€ 420.000
3	**22**	sustainability level score = 8	120m²	60m²	shared/public parking sp	€ 450.000	**2**	sustainability level score = 4	110m²	80m²	shared/public parking sp	€ 480.000
3	**11**	sustainability level score = 6	110m²	80m²	shared/public parking sp	€ 480.000	**16**	sustainability level score = 6	130m²	60m²	individual parking	€ 480.000
3	**4**	sustainability level score = 4	120m²	60m²	shared/public parking sp	€ 450.000	**17**	sustainability level score = 6	130m²	80m²	no parking space	€ 450.000
3	**19**	sustainability level score = 8	110m²	60m²	no parking space	€ 420.000	**27**	sustainability level score = 8	130m²	100m²	shared/public parking sp	€ 420.000
3	**8**	sustainability level score = 4	130m²	80m²	no parking space	€ 450.000	**24**	sustainability level score = 8	120m²	100m²	no parking space	€ 480.000
3	**12**	sustainability level score = 6	110m²	100m²	individual parking	€ 450.000	**7**	sustainability level score = 4	130m²	60m²	individual parking	€ 480.000
3	**9**	sustainability level score = 4	130m²	100m²	shared/public parking sp	€ 420.000	**26**	sustainability level score = 8	130m²	80m²	no parking space	€ 450.000
3	**6**	sustainability level score = 4	120m²	100m²	no parking space	€ 480.000	**1**	sustainability level score = 4	110m²	60m²	no parking space	€ 420.000
3	**5**	sustainability level score = 4	120m²	80m²	individual parking	€ 420.000	**18**	sustainability level score = 6	130m²	100m²	shared/public parking sp	€ 420.000
4	**8**	sustainability level score = 4	130m²	80m²	no parking space	€ 450.000	**27**	sustainability level score = 8	130m²	100m²	shared/public parking sp	€ 420.000
4	**2**	sustainability level score = 4	110m²	80m²	shared/public parking sp	€ 480.000	**3**	sustainability level score = 4	110m²	100m²	individual parking	€ 450.000
4	**16**	sustainability level score = 6	130m²	60m²	individual parking	€ 480.000	**1**	sustainability level score = 4	110m²	60m²	no parking space	€ 420.000
4	**20**	sustainability level score = 8	110m²	80m²	shared/public parking sp	€ 480.000	**22**	sustainability level score = 8	120m²	60m²	shared/public parking sp	€ 450.000
4	**26**	sustainability level score = 8	130m²	80m²	no parking space	€ 450.000	**23**	sustainability level score = 8	120m²	80m²	individual parking	€ 420.000
4	**17**	sustainability level score = 6	130m²	80m²	no parking space	€ 450.000	**15**	sustainability level score = 6	120m²	100m²	no parking space	€ 480.000
4	**9**	sustainability level score = 4	130m²	100m²	shared/public parking sp	€ 420.000	**10**	sustainability level score = 6	110m²	60m²	no parking space	€ 420.000
4	**25**	sustainability level score = 8	130m²	60m²	individual parking	€ 480.000	**13**	sustainability level score = 6	120m²	60m²	shared/public parking sp	€ 450.000
4	**21**	sustainability level score = 8	110m²	100m²	individual parking	€ 450.000	**14**	sustainability level score = 6	120m²	80m²	individual parking	€ 420.000
5	**27**	sustainability level score = 8	130m²	100m²	shared/public parking sp	€ 420.000	**11**	sustainability level score = 6	110m²	80m²	shared/public parking sp	€ 480.000
5	**6**	sustainability level score = 4	120m²	100m²	no parking space	€ 480.000	**14**	sustainability level score = 6	120m²	80m²	individual parking	€ 420.000
5	**19**	sustainability level score = 8	110m²	60m²	no parking space	€ 420.000	**12**	sustainability level score = 6	110m²	100m²	individual parking	€ 450.000
5	**23**	sustainability level score = 8	120m²	80m²	individual parking	€ 420.000	**10**	sustainability level score = 6	110m²	60m²	no parking space	€ 420.000
5	**1**	sustainability level score = 4	110m²	60m²	no parking space	€ 420.000	**7**	sustainability level score = 4	130m²	60m²	individual parking	€ 480.000
5	**13**	sustainability level score = 6	120m²	60m²	shared/public parking sp	€ 450.000	**9**	sustainability level score = 4	130m²	100m²	shared/public parking sp	€ 420.000
5	**5**	sustainability level score = 4	120m²	80m²	individual parking	€ 420.000	**21**	sustainability level score = 8	110m²	100m²	individual parking	€ 450.000
5	**15**	sustainability level score = 6	120m²	100m²	no parking space	€ 480.000	**4**	sustainability level score = 4	120m²	60m²	shared/public parking sp	€ 450.000
5	**24**	sustainability level score = 8	120m²	100m²	no parking space	€ 480.000	**18**	sustainability level score = 6	130m²	100m²	shared/public parking sp	€ 420.000
6	**22**	sustainability level score = 8	120m²	60m²	shared/public parking sp	€ 450.000	**25**	sustainability level score = 8	130m²	60m²	individual parking	€ 480.000
6	**7**	sustainability level score = 4	130m²	60m²	individual parking	€ 480.000	**20**	sustainability level score = 8	110m²	80m²	shared/public parking sp	€ 480.000
6	**11**	sustainability level score = 6	110m²	80m²	shared/public parking sp	€ 480.000	**24**	sustainability level score = 8	120m²	100m²	no parking space	€ 480.000
6	**3**	sustainability level score = 4	110m²	100m²	individual parking	€ 450.000	**5**	sustainability level score = 4	120m²	80m²	individual parking	€ 420.000
6	**10**	sustainability level score = 6	110m²	60m²	no parking space	€ 420.000	**6**	sustainability level score = 4	120m²	100m²	no parking space	€ 480.000
6	**12**	sustainability level score = 6	110m²	100m²	individual parking	€ 450.000	**8**	sustainability level score = 4	130m²	80m²	no parking space	€ 450.000
6	**4**	sustainability level score = 4	120m²	60m²	shared/public parking sp	€ 450.000	**21**	sustainability level score = 8	110m²	100m²	individual parking	€ 450.000
6	**14**	sustainability level score = 6	120m²	80m²	individual parking	€ 420.000	**26**	sustainability level score = 8	130m²	80m²	no parking space	€ 450.000
6	**18**	sustainability level score = 6	130m²	100m²	shared/public parking sp	€ 420.000	**2**	sustainability level score = 4	110m²	80m²	shared/public parking sp	€ 480.000

Appendix 9: Example of online survey and invitation questionnaire

Selection criteria

*In what type of dwelling do you live at the moment?

Choose one of the following answers

- Terraced house
- Corner house
- Semi detached house
- Detached house
- Apartment, flat, upstairs or downstairs apartment, storey apartment, porch apartment, maisonette or studio
- Other:

*Are you a homeowner or a tenant?

Choose one of the following answers

- Tenant
- Home owner

*Is there a relocation tendency to an owner occupied dwelling, and if so within what period do you want to move?

Choose one of the following answers

- no
- yes, within one year
- yes, between one and two years
- yes, between, two and five years
- Other:

Personal question

*What is your year of birth?

Only numbers may be entered in this field.
Your answer must be between 1900 and 2022

*What is your gender?

Choose one of the following answers

- Male
- Female
- Other:

*What is your household composition?

Choose one of the following answers

- Single
- Couple without children (living at home)
- Couple with children living at home
- Single parent family
- Other:

*What is your highest level of education?

Choose one of the following answers

- Primary school
- mavo, vmbo
- havo
- vwo
- MBO
- HBO, WO-bachelor
- HBO master, WO-master
- Doctor (Ph.D)
- Other:

*What was your gross household year income? The household income belongs to you and a partner with whom you form a household, if applicable.

Choose one of the following answers

- € 0 - € 38.000
- € 38.001 - € 76.000
- € 76.001 - € 114.000
- € 114.001 - € 152.000
- € 152.001 or more
- I don't know/ I prefef don't to say

*How much square meters living area has your current dwelling?

Choose one of the following answers

- less than 75 m²
- 75 m² - < 100 m²
- 100 m² - < 150 m²
- >150 m² or more

*What are the four digits of your zip code?

Only numbers may be entered in this field.

Estimate the current market value of your dwelling?

Choose one of the following answers

- Less than € 300.000
- € 300.000 - < € 450.000
- € 450.000 - < € 600.000
- € 600.000 - < € 750.000
- € 750.000 - < € 900.000
- € 900.000 or more
- I don't know/ I'd rather not say

You can skip this question if you rent a property or do not wish to answer this question.

If you have a relocation tendency within one you year, can you give than a price indication of your new dwelling?

Choose one of the following answers

- Less than € 300.000
- € 300.000 - < € 450.000
- € 450.000 - < € 600.000
- € 600.000 - < € 750.000
- € 750.000 - < € 900.000
- € 900.000 or more
- I don't know/ I'd rather not say

You can skip this question if you do not plan to buy a new home within one year or do not wish to answer this question

Environmental awareness

*Below are five statements. For each statement, please indicate how strongly you agree or disagree with a statement: (1) Completely disagree - (7) Completely agree.

	Completely disagree (1)	2	3	4	5	6	Completely agree (7)
I believe that climate change is real	○	○	○	○	○	○	○
The main causes of climate change are human activities	○	○	○	○	○	○	○
Climate change will bring about serious negative consequences	○	○	○	○	○	○	○
I've switched to someone else brand because it was better for the environment	○	○	○	○	○	○	○
I am willing to pay extra money for sustainable products	○	○	○	○	○	○	○

Rating Scale Exercise (RSE)

Explanation: please read this text carefully

After this explanation, nine questions follow. In each question, an example home is presented with different sustainability measures. You are asked to indicate with the presented sample homes how sustainable you think a presented sample home is on an ascending 10-point scale: 1 = Very unsustain-able and 10 = Very sustainable.

The sustainability measures presented relate to the sustainability components; energy, water, material and ecology. In this experiment, three different measures are possible for each sustainability component. In each housing example, the composition of the sustainability measures is slightly different. The differences between the measures in the example homes presented can be large or small.

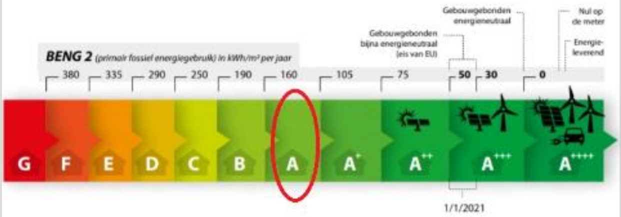
There are now nine questions in which you must indicate the sustainability of various example homes on a ten-point scale.

p.s. If your are filling this survey in on your phone, turn your phone 90 degrees to see the full questions.

*

Please indicate on a 10-point scale how sustainable you consider the set of sustainability measures below for a home as a whole (1 = very unsustainable - 10 = very sustainable).

p.s. Scroll down to enter the answer.

<table>
<tr><th>Sustainable components</th><th>Measures</th></tr>
<tr><td>Energy</td><td>Energy label A

</td></tr>
<tr><td>Water</td><td>No (additional) water measures</td></tr>
<tr><td>Material</td><td>No additional measures to lower the environmental impact of the buildingmaterials
• Traditional building materials


</td></tr>
<tr><td>Ecology</td><td>No additional measures to support the flora and fauna</td></tr>
</table>

	1 (very unsustainable)	2	3	4	5	6	7	8	9	10 (very sustainable)
How sustainable would you scale the profile above on a ten point scale (1 = very unsustainable - 10 = very sustainable)?	○	○	○	○	○	○	○	○	○	○

Discrete Choice Experiment (DCE)

Explanation: please read this text carefully

After this explanation, there are nine questions in which you have to make a choice between two fictitious houses presented as "Alternative A" and "Alternative B". Each fictitious house is made up of four dwelling characteristics and the dwelling price. In the presented dwellings, three different measures are possible for each dwelling characteristic. The figure below shows the three different measures for each characteristic. When filling in the choice questions, it is the intention that you imagine that you want to buy a dwelling and that you have the choice between the two presented alternatives, you choose the alternative that you prefer. If you really cannot make a choice between the two presented alternatives, there is also the option "Neither".

There now follow nine questions in which you have to make a choice between two example homes

P.s. if you are on your phone, turn your phone 90 degrees to see the full questions.

Dwelling characteristics	Measures
Sustainability level (Overall sustainability dwelling: 0 = low - 10 = outstanding)	• Sustainability score = 4 • Sustainability score = 6 • Sustainability score = 8
Dwelling size (in m²)	• 110 m² • 120 m² • 130 m²
Outdoorspace (balcony or garden in m²)	• 60 m² • 80 m² • 100 m²
Parking (presence of parking spaces)	• no parking (not even in the public area) • shared/public parking • own/private parking place
Dwelling price (market value)	• € 420 k • € 450 k • € 480 k

***Imagine the following imaginary situation:**

You want to move, and you can choose between 2 new-build homes within the same region where you now live. Which of these 2 alternatives do you prefer?

Dwelling characteristics	Alternative 1	Alternative 2
Sustainability level (Overall sustainability dwelling: 0 = low - 10 = outstanding)	Sustainability score = 8	Sustainability score = 8
Dwelling size (in m²)	130 m²	120 m²
Outdoorspace (balcony or garden in m²)	100 m²	60 m²
Parking (presence of parking spaces)	shared/public parking	shared/public parking
Dwelling price (market value)	€ 420.000,-	€ 450.000,-

Choose one of the following answers

Alternative 1 | Alternative 2 | Neither

Invitation to participate in the online questionnaire

Appendix 10: Output NLOGIT

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|-> Reset
|-> read ; file = "C:\nlogit\Data 20221205.csv"$
Last observation read from data file was     972
|-> create; icst=0$
|-> create; if (alt=1 | alt=2) icst=1$
|-> DISCRETECHOICE;Lhs = Ikeu
    ;Choices = 1,2,3
    ;Rhs      = icst,var1a,var1b,var2a,var2b,var3a,var3b,var4a,var4b,
    var5a,var5b
    ; keep    = probs$
Iterative procedure has converged
Normal exit:   6 iterations. Status=0, F=    .2204502D+03



----------------------------------------------------------------------------
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Discrete choice (multinomial logit) model
Dependent variable                Choice
Log likelihood function       -220.45019
Estimation based on N =     324, K =  11
Inf.Cr.AIC  =     462.9 AIC/N =    1.429
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            Log likelihood R-sqrd R2Adj
Constants only   -326.7572  .3253 .3137
Note: R-sqrd = 1 - logL/Logl(constants)
Warning:  Model does not contain a full
set of ASCs. R-sqrd is problematic. Use
model setup with ;RHS=one to get LogL0.
---------------------------------------
Response data are given as ind. choices
Number of obs.=   324, skipped    0 obs
--------+-------------------------------------------------------------------
--
        |                  Standard            Prob.       95% Confidence
    IKEU|  Coefficient       Error       z    |z|>Z*         Interval
--------+-------------------------------------------------------------------
--
    ICST|     .73595***      .17508    4.20  .0000      .39279   1.07910
   VAR1A|     .08054         .13788     .58  .5591    -.18969    .35077
   VAR1B|     .84644***      .16667    5.08  .0000     .51976   1.17311
   VAR2A|     .03379         .13680     .25  .8049    -.23433    .30191
   VAR2B|     .16783         .17267     .97  .3311    -.17060    .50626
   VAR3A|    -.28856*        .16971   -1.70  .0891    -.62118    .04406
   VAR3B|     .69544***      .15024    4.63  .0000     .40097    .98991
   VAR4A|     .28802*        .15175    1.90  .0577    -.00940    .58545
   VAR4B|    1.26482***      .16042    7.88  .0000     .95040   1.57924
   VAR5A|    -.26652         .16747   -1.59  .1115    -.59475    .06170
   VAR5B|    -.18761         .14841   -1.26  .2062    -.47849    .10327
--------+-------------------------------------------------------------------
--
***, **, * ==>  Significance at 1%, 5%, 10% level.
Model was estimated on Jan 12, 2023 at 08:10:48 PM
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```
|-> Reset
|-> read ; file = Data 20221205.csv$
Last observation read from data file was     972
|-> SAMPLE ; All $
|-> reject; profile < 1$
|->
REGRESS;Lhs=RATING;Rhs=one,ENER1,ENER2,WATER1,WATER2,MATER1,MATER2,ECOL1,EC
OL2$

---------------------------------------------------------------------------
--
Ordinary     least squares regression ............
LHS=RATING   Mean                    =        7.57716
             Standard deviation      =        1.97748
----------   No. of observations     =            324  DegFreedom   Mean
square
Regression   Sum of Squares          =        416.099            8
52.01235
Residual     Sum of Squares          =        846.972          315
2.68880
Total        Sum of Squares          =        1263.07          323
3.91044
----------   Standard error of e     =        1.63976  Root MSE
1.61682
Fit          R-squared               =         .32943  R-bar squared
.31240
Model test   F[  8,    315]          =       19.34407  Prob F > F*
.00000
--------+------------------------------------------------------------------
--
        |                  Standard            Prob.      95% Confidence
  RATING|  Coefficient       Error       t     |t|>T*         Interval
--------+------------------------------------------------------------------
--
Constant|    7.57716***      .09110    83.18  .0000     7.39861   7.75571
   ENER1|    -.09568         .12883     -.74  .4582     -.34818    .15683
   ENER2|     .87654***      .12883     6.80  .0000      .62404   1.12905
  WATER1|     .17284         .12883     1.34  .1807     -.07967    .42534
  WATER2|     .47840***      .12883     3.71  .0002      .22589    .73090
  MATER1|     .19136         .12883     1.49  .1385     -.06115    .44386
  MATER2|     .77469***      .12883     6.01  .0000      .52219   1.02720
   ECOL1|     .14506         .12883     1.13  .2610     -.10744    .39757
   ECOL2|     .22840*        .12883     1.77  .0772     -.02411    .48090
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--
***, **, * ==>  Significance at 1%, 5%, 10% level.
Model was estimated on Dec 13, 2022 at 07:54:52 PM
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```