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MASTER THESIS

THE DEVELOPMENT OF A DECISION SUPPORT SYSTEM TO DETERMINE THE SUITABILITY OF TARGET GROUPS FOR TRANSFORMING SOCIAL REAL ESTATE INTO HOUSING

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PREFACE

This master thesis is the completion of my master Construction Management and Engineering (CME) at the Eindhoven University of Technology (TU/e). The graduation project is conducted in collaboration with Arcadis.

I could not have completed my graduation project without the advice, support and cooperation of others. Therefore, I would like to thank the people and fellow students from the TU/e who made it possible to get my master's degree. Especially, I want to thank my supervisors Dr. Ing. P.J.H.J. van der Waerden and Dr. Q. Han for their guidance, advice and support during the last half year. Additionally, I would like to thank Arcadis, which enabled me to carry out my graduation project within their company, especially Joris Winters and Marjolijn Versteegden. Due to their support, advice and cooperation, this master thesis has been completed.

I would like to thank my family. My great inspiration, my sister, thank you for being my second-half and best friend. You always exactly know how to express what I think and feel, therefore also my word of thanks for and through her: 'My father for the life lessons he taught me, even though sometimes I wish we could have experienced thing differently. My mum for her courage and showing me that even in toughest times, life only gets as bad as you, yourself, allow it to be'. Finally, I want to thank my boyfriend for carrying the love and stress of me from over the past 7 years.

Thank you!

Nina Swelsen,

Eindhoven, 2020

SUMMARY

There has been a small decrease in vacancy in real estate in the Netherlands in the recent years. However, this vacancy remains a major problem. These vacant buildings have all kinds of functions, such as housing, shops, offices, industry, education, health, sports and meeting. In the past years, the vacancy of real estate, like shops and offices, have already received a lot of attention. This in contrast to social real estate, hardly anything is being done with this vacancy. Due to shrinkage, hazing, robotization and more home-based activities it is expected that the vacancy of social real estate will increase in the future. This will result in an increase from 2 million m² to 20 million m² vacancy in social real estate in the Netherlands in the next ten years. Demographic changes are another problem that contribute to the vacancy among social real estate. The Dutch population has increased to 17.2 million people and additionality the composition of the population is individualizing. This has led to a shortage of houses on the Dutch housing market. These two problems provide the scope of this research. Since there is an oversupply of social real estate and a shortage of houses in the Dutch housing market, this research has investigated if it is possible to combine these problems. This has resulted in the following research question: 'What to include in a Decision Support System to determine the suitability of target groups for transforming social real estate into housing?' The developed Decision Support System (DSS) determines the suitability of the target groups, based on their living preferences, for housing in transformed social real estate.

To understand the term 'social real estate' a literature study is conducted into the definition of social real estate. Social real estate is a collective name for buildings or objects with a health, education, sports, culture, government, welfare, religion or meeting function. However, to clarify the definition of social real estate, four main functions have been defined, namely: health, sports, education or meeting. In addition, a distinction can be made in social real estate based on ownership, service provider, public accessibility or use. Since this research focusses on all kind of social real estate, it is defined as: *Real estate that is used to provide social services and is related to health, sports, education or meeting.* The advantages of social real estate are that the buildings are mostly well located in the middle of a residential area and the capacity is generally high. However, the disadvantage of vacant social real estate is that it could lead to insecurity, pollution and an inhibiting effect on local economic growth.

During the decision process of transformation for social real estate, the challenge will arise to analyze the existing building. The analysis will consist of the original function, the physical character, the heritage value, the need of the district wherein the social real estate is located, sustainability and the financial feasibility. Besides analyzing the existing building, it is also important to look at the future potential of the building on a physical, economical, functional, environmental, political, social and cultural level.

The goal is to develop a DSS which determines the suitability of the target groups for housing in transformed social real estate. Different target groups have been considered and their living preferences are scientifically investigated. Only eight target groups have been selected to include in the DSS. It appears that most transformations of (social) real estate lead to small-scale housing in which mainly single-person households live. Therefore, the eight

target groups that are selected are characterized as single households and/or prefer to live in a small-scale house.

After all target groups and their living preferences have been investigated, it is able start with the development of the DSS. First, it is investigated what a DSS in general contains. A DSS can be developed through five 'Driven' categories, namely data-, model-, knowledge-, document- and communication-driven. For this research the principle of a model-driven DSS is used for the development. It uses quantitative models to assists decision makers in analyzing and deciding on situations. A decision analysis model is used as the quantitative model, which can separate facts form priorities. Several techniques can be used to develop a decision analysis model, for this research, the Weighted Sum Method (WSM) technique is used. By using the aforementioned techniques, the DSS helps decision makers to identify alternatives (target groups) and factors (living preferences of the target groups).

In general, a DSS contains of the communications-, the database-, the model- and the user interface component. The communications component is about the architecture, the network and the security of the DSS. The database component is formed by data retrieved from the investigation into the target groups and their living preferences. This data is transformed into the 'Evaluation matrix' and the 'Weighting matrix'. Additionality, the database component contains the 'Financial assessment model', which is created by an Arcadis cost expert. The database component ensures the input into the model component. The model component is structured into four consecutive parts. 'Part 1 - Preconditions' assesses the preconditions which contains procedural aspects, as well as a general assessment of the technical feasibility. 'Part 2 - Living Environment' assesses the living environment of the social real estate building based on the composition and facilities. In 'Part 3 - Building Potential', the potential of the building will be assessed; the current state of the social real estate building will be analyzed based on physical and functional aspects. 'Part 4 - Financial Assessment', that is developed by an Arcadis cost expert, shows a financial assessment of the value to cost ratio (> 30%) of transforming a social real estate building into apartments of either 20m², 40m² or 80m². The user interface component will ensure that the DSS is effective, intuitive, user-friendly and visually attractive.

Finally, four case studies have been conducted to conclude whether the DSS is capable of determining the suitability of the target groups. These case studies show that the younger target groups are most suitable for housing into transformed social real estate. This is probably due to the fact that the older target groups prefer a more lifecycle resistant house and private outside space, of which most social real estate buildings often have lack. Overall, this research has resulted into an accessible and easy to use DSS that provides a global inside into determining the suitability of target groups for transforming social real estate into housing.

SAMENVATTING

De afgelopen jaren is leegstaand vastgoed in Nederland licht gedaald. De leegstand blijft echter een groot probleem. Deze leegstaande gebouwen hebben allerlei functies, zoals huisvesting, winkels, kantoren, industrie, onderwijs, gezondheid, sport en bijeenkomst. In de afgelopen jaren heeft de leegstand van vastgoed, zoals winkels en kantoren, al veel aandacht gekregen. Dit in tegenstelling tot maatschappelijk vastgoed, waar met de leegstand nauwelijks iets gedaan wordt. Vanwege krimp, ontgroening, robotisering en meer thuisactiviteiten wordt verwacht dat de leegstand van maatschappelijk vastgoed in de toekomst zal toenemen. Dit zal de komende tien jaar leiden tot een toename van 2 miljoen m² naar 20 miljoen m² leegstand van maatschappelijk vastgoed in Nederland. Demografische veranderingen dragen ook bij aan de leegstand van maatschappelijk vastgoed. De Nederlandse bevolking is toegenomen tot 17,2 miljoen en de samenstelling van de bevolking is aan het individualiseren. Dit heeft geleid tot een tekort aan huizen op de Nederlandse woningmarkt. Deze twee problemen vormen de scope van dit onderzoek. Omdat er een overaanbod is van maatschappelijk vastgoed en een tekort aan huizen op de Nederlandse woningmarkt, is in dit onderzoek onderzocht of het mogelijk is om deze twee problemen te combineren. Dit heeft geresulteerd in de volgende onderzoeksvraag: 'Wat moet worden opgenomen in een Decision Support System om de geschiktheid van doelgroepen te bepalen voor het transformeren van maatschappelijk vastgoed in huisvesting?' Het ontwikkelde Decision Support System (DSS) bepaalt de geschiktheid van de doelgroepen, op basis van hun woonvoorkeuren, voor huisvesting in getransformeerd maatschappelijk vastgoed.

Om ‘maatschappelijk vastgoed’ te definiëren, is een literatuurstudie uitgevoerd naar de definitie van maatschappelijk vastgoed. Maatschappelijk vastgoed is een verzamelnaam voor gebouwen of objecten met een gezondheids-, onderwijs-, sport-, cultuur-, overheids-, welzijns-, religie- of bijeenkomstfunctie. Om de definitie van maatschappelijk vastgoed te verduidelijken, zijn er vier hoofdfuncties gedefinieerd, namelijk: gezondheid, sport, onderwijs en bijeenkomst. Daarnaast kan ook onderscheid worden gemaakt in maatschappelijk vastgoed op basis van eigendom, dienstverlener, openbare toegankelijkheid of gebruik. Aangezien dit onderzoek zich richt op alle soorten maatschappelijk vastgoed, wordt het gedefinieerd als: *Maatschappelijk vastgoed dat wordt gebruikt om maatschappelijke diensten te verlenen die gerelateerd zijn aan gezondheid, sport, onderwijs of ontmoeting*. De voordelen van maatschappelijk vastgoed zijn dat de gebouwen meestal goed gelegen zijn in het midden van een woonwijk en dat de capaciteit over het algemeen hoog is. Het nadeel van leegstaand maatschappelijk vastgoed is dat het kan leiden tot onveiligheid, vervuiling en een remmend effect op de lokale economische groei.

Tijdens het beslissingsproces van transformatie voor maatschappelijk vastgoed, zit de uitdaging in het analyseren van het bestaande gebouw. De analyse bestaat uit de oorspronkelijke functie, het fysieke karakter, de erfgoedwaarde, de behoefte van de wijk waarin het maatschappelijk vastgoed is gelegen, duurzaamheid en de financiële haalbaarheid. Naast het analyseren van het bestaande gebouw, is het ook belangrijk om naar de toekomstige potentie van het gebouw te kijken op fysiek, economisch, functioneel, milieu, politiek, sociaal en cultureel niveau.

Het doel is om een DSS te ontwikkelen die de geschiktheid van doelgroepen bepaalt voor huisvesting in getransformeerd maatschappelijk vastgoed. Verschillende doelgroepen zijn overwogen en hun woonvoorkeuren zijn wetenschappelijk onderzocht. Er zijn slechts acht doelgroepen opgenomen in de DSS. Het blijkt dat de meeste transformaties van vastgoed leidt tot kleinschalige woningbouw waarin voornamelijk eenpersoonshuishoudens wonen. Daarom zijn de acht geselecteerde doelgroepen gekenmerkt als eenpersoonshuishoudens en/of geven ze de voorkeur aan het wonen in kleinschalig huizen.

Na onderzoek naar de doelgroepen en hun woonvoorkeuren, is de ontwikkeling van de DSS gestart. Eerst is onderzocht wat een DSS in het algemeen bevat. Een DSS kan worden ontwikkeld via vijf 'gestuurde' categorieën, namelijk data-, model-, kennis-, document- en communicatie gestuurd. Voor dit onderzoek is het principe van een model-gestuurde DSS gebruikt. Deze maakt gebruik van kwantitatieve modellen om besluitvormers te helpen bij het analyseren en beslissen over situaties. Een beslissingsanalysemodel wordt gebruikt als het kwantitatieve model, wat feiten van prioriteiten kan scheiden. Verschillende technieken kunnen worden gebruikt om een beslissingsanalysemodel te ontwikkelen, voor dit onderzoek is de Weighted Sum Method gebruikt. Door de bovengenoemde technieken te gebruiken, helpt de DSS beslissers om alternatieven (doelgroepen) en factoren (woonvoorkeuren van de doelgroepen) te identificeren.

Over het algemeen bevat een DSS een communicatie-, database-, model- en gebruikersinterface component. De communicatiecomponent gaat over de architectuur, het netwerk en de beveiliging van de DSS. De databasecomponent wordt gevormd door gegevens die zijn opgehaald uit het onderzoek naar de doelgroepen en hun woonvoorkeuren. Deze gegevens worden omgezet in de 'Evaluatiematrix' en de 'Weegmatrix'. Daarnaast bevat de databasecomponent het 'Financiële beoordelingsmodel', wat is ontwikkeld door een Arcadis-kostenexpert. De databasecomponent zorgt voor de invoer voor de modelcomponent. De modelcomponent is gestructureerd in vier opeenvolgende delen. Deel 1 beoordeelt de randvoorwaarden die procedurele aspecten bevatten, evenals een algemene beoordeling van de technische haalbaarheid. Deel 2 beoordeelt de leefomgeving van het maatschappelijk vastgoed gebouw op basis van buurtsamenstelling en voorzieningen. In deel 3 zal het potentieel van het gebouw worden beoordeeld; de huidige staat van het maatschappelijk vastgoed gebouw zal worden geanalyseerd op basis van fysieke en functionele aspecten. Deel 4 toont een financiële beoordeling van de waarde-kostenverhouding voor het transformeren van maatschappelijk vastgoed in appartementen van 20m², 40m² of 80m². Het gebruikersinterface component zorgt ervoor dat de DSS effectief, intuïtief, gebruikersvriendelijk en visueel aantrekkelijk is.

Ten slotte zijn vier casestudies uitgevoerd om te concluderen of de DSS in staat is de geschiktheid van de doelgroepen te bepalen. Deze casestudies tonen aan dat de jongere doelgroepen het meest geschikt zijn voor huisvesting in getransformeerd maatschappelijk vastgoed. Dit komt doordat de oudere doelgroepen de voorkeur geven aan een meer levensloopbestendig huis en privé buitenruimte, waar het meeste maatschappelijk vastgoed vaak niet over beschikt. Dit onderzoek heeft geresulteerd in een toegankelijke en gemakkelijk te gebruiken DSS die een inzicht biedt in het bepalen van de geschiktheid van doelgroepen voor het transformeren van maatschappelijk vastgoed naar woningen.

ABSTRACT

There has been a small decrease in vacancy in real estate in the Netherlands in recent years. However, this vacancy remains a major problem. This research focusses on vacant social real estate, since hardly anything is being done with this vacancy. The vacancy of social real estate expects to increase from 2 million m² to 20 million m² in approximately 10 years. In contrast to this vacancy is the housing shortage in the Netherlands, especially for single households. What if there is a possibility of transforming vacant social real estate into housing? In this way two social problems in the Netherlands are tackled. During the transformation of buildings, it is important to keep the preferences of the end users central. During this research, residents will be the end users for the transformed social real estate. These residents will be divided into target groups and their living preferences will be investigated, to make it able to analyze the social real estate building and determine the suitability of the target groups.

Therefore, the goal of this research is to develop a Decision Support System (DSS) with which the suitability of target groups can be determined for housing in transformed social real estate. This research includes the development of a model-driven DSS consisting of a decision analysis model. The DSS will be structured into four consecutive parts, namely (1) preconditions, (2) living environment, (3) building potential and (4) financial assessment. Each part contributes to the determination of the suitability of the target groups for housing in transformed social real estate. As a result, an accessible and easy to use DSS is developed that provides a global inside into determining the suitability of target groups for transforming social real estate into housing.

Keywords: Social real estate, Decision Support System, Housing (shortage), Adaptive reuse, Living preferences

CONTENT

LIST OF ABBREVIATIONS

DSS	Decision Support System
AHP	Analytical Hierarchy Process
MAUT	Multi-Attribute Utility Theory
WSM	Weighted Sum Method
GIS	Geographic Information System
UFA	Usable Floor Area
GFA	Gross Floor Area
BIM	Building Information Model

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1 INTRODUCTION

There has been a small decrease in vacancy in real estate in the Netherlands in recent years. However, this vacancy remains a major problem. According to the latest figures from Statistics Netherlands (2018), almost 150,000 buildings (equals approximately 29,500,000 m²) are vacant, which is equal to 2% of all the buildings in the Netherlands. These buildings have all kinds of functions such as housing, shopping, accommodations for offices, industrial purposes, educational purposes, meeting centers or centers for health or sports (Statistics Netherlands, 2018). In order to solve this problem, the vacancy of commercial real estate, like shops and offices, generated a lot of attention since these buildings are of great economic importance for the municipalities (Leegstands Dokters, 2018). In addition, in the Netherlands these kinds of buildings demonstrate the highest vacant figures: just about 10% of the total amount of office buildings are vacant, equal to 8,710 buildings, representing an amount of approximately 3,600,000 m² (Statistics Netherlands, 2018).

However, about the vacancy of social real estate hardly anything is being done, because its economic importance is not immediately visible (Leegstands Dokters, 2018). According to the latest vacancy determination of the Statistics Netherlands (1 January 2018), approximately 4% of the social real estate is vacant in the Netherlands, which equals 4,600 buildings representing approximately 2 million m² (Statistics Netherlands, 2018). Currently, there are already too much social real estate buildings which is caused by two factors: (1) sectoral traditions, sharing spaces with other parties formerly was not done, now it is; and (2) it was assumed that there was constant growth, so that oversupply would be desired to prevent shortage. In the future, this vacancy will grow further due to shrinkage, hazing, robotization, more home-based activities, the possibility of working on smaller surfaces and people willing to share spaces. Therefore, the existing vacancy among social real estate will probably increase in the short term. This shall not only be caused by the factors mentioned above but also by the fact that still every year social real estate is being built, while there is hardly any demolition. This will result in an expectation of an oversupply in social real estate around 20 million m² in 2030 (de Moel, 2014).

One of the reasons for the changes in the use of social real estate is due to demographic changes. The Dutch population has increased to 17.2 million people in the last decades. It is expected that this growth will lead to a population growth of 18.5 million in 2050. The current housing shortage is equal to 279,000 houses, which is 3.6% of the total housing stock. This number is expected to fall to a shortage of 200,000 houses in 2030, which is 2.4% of the total housing stock (Kleinepier, Gopal, Omtzigt, van Leeuwen and Stuart-Fox, 2019). The mismatch between the population composition and the housing market is caused by the increase in the number of households, due to population growth and individualization within the household composition (Gopal, van Leeuwen, Omzigt, Kleinepier and Stuart-Fox, 2019). During 2019 the limit of 8,000,000 households will be passed. It is expected that by 2050 there will be 8,800,000 households in the Netherlands. Table 1 shows the developments of the household composition in the Netherlands and indicates that the single households will become the largest group among households by far (Kleinepier et al., 2019).

Table 1 - Increase in households on the Dutch housing market (based on: Kleinepier et al., 2019)

Household	2018	2030	2050	Increase in %
Single household	3,000,000	3,500,000	3,850,000	30%
Single parent household	572,000		639,000	12%
Couple with children	Stable around 2,000,000 and 2,200,000			-
Couple without children				

1.1 RESEARCH PROBLEM

Broadly speaking, the Netherlands have to deal with a housing shortage and on the other hand the vacancy of commercial and social real estate, both caused by demographic changes. The vacancy of social real estate will be the problem to be addressed in this research, since this is more interesting to investigate than commercial real estate because vacancy in commercial estate has already received a lot of attention. Vacancy of real estate was visible at first among commercial real estate, especially at offices (Leegstands Dokoters, 2018). There are three major differences between commercial and social real estate. The first difference is the financing. Commercial real estate is funded by investors or private owners, while social real estate is mostly funded by the municipalities or government. The vacancy of commercial real estate will lead to a loss of economic value for the owner, but with social real estate its economic importance is not immediately visible (Leegstands Dokters, 2018). However, social real estate still must deal with financial pressure. Because the municipalities always rent out the buildings at a cost price, they do not have extra spaces for investment, in contrast to commercial real estate. The second difference is the lack of an overview. The management of social real estate is fragmented, a good overview is missing. This overview most of the time does exist more for commercial real estate. Third difference is that social real estate is in general more complex than commercial real estate since social real estate consists of a mix of functions and building structures (Gebouwinzicht, 2015).

These three differences ensure that adaptive reuse of social real estate is more challenging compared to commercial real estate. For municipalities the vacancy of social real estate is nowadays an important issue, as this vacancy rate is increasingly seen as more urgent than the vacancy rate of commercial real estate. Where the commercial real estate, like the office stock, is concentrated in and around the big cities, smaller municipalities have to deal with vacant social real estate (de Vries, 2015). Moreover, the location of vacant social real estate has both an advantage and a disadvantage impact on future development. The advantage is that social real estate is often well located in the middle of a residential area, which is mostly not in case of commercial real estate, like offices (de Moel, 2014). Disadvantage is that the vacancy of social real estate is often caused due to shrinkage and aging (Moel, 2014). In addition, vacancy has consequences for the quality of life in the immediate vicinity. Unused space invites to debatable activities, unsafe feelings, reduced cohesion and vandalism in the environment of the vacant building (Mostert and Grooten, 2011). To guarantee the quality of life in a residential area, more attention should be paid to vacant social real estate, given the fact that social real estate usually is found in the middle of these areas.

A lot of studies already led to the adaptive reuse of buildings; these researches were mainly focused on office buildings (Heath, 2001; Bullen, 2007; Remoy and van der Voort, 2014). Furthermore, several Decision Support Systems (DSS) are already developed, unfortunately

none of them do focus on the future resident (Hek, Kamstra and Geraedts, 2004; Watson, 2008; Sfakianaki and Moutsatsou, 2015; Mohamed and Alauddin, 2016; Gade, Larsen, Nissen and Jensen, 2018). However, these previous studies still have some more gaps in the research field. As a result, three research gaps will be identified: (1) the lack of research into adaptive reuse of social real estate; (2) the lack of simple and holistic tools that can assist the building owners in prioritization and decision-making in the early stages of building transformation projects (Gade et al., 2018); and (3) the lack of a tool that could determine the future resident (Nielsen, Jensen, Larsen and Nissen, 2016). Besides research of the scientific gaps, there is also a practical gap. This research will be done in collaboration with Arcadis. In this company a problem was encountered concerning the reuse of social real estate. Frequently the question arises: what to do with a vacant social real estate? Within Arcadis there are no DSSs to decide effectively about a future reuse. Therefore, the firm is interested in the development of a DSS to make their decision process more effectively.

This research will regard the factors that are important to determine the suitability of target groups for housing in vacant social real estate buildings, in order to tackle the problem of the vacancy of social real estate and on the other hand the housing shortage.

1.2 RESEARCH QUESTION

The research question is stated as:

What to include in a decision support system to determine the suitability of target groups for transforming social real estate into housing?

During this research several sub questions will be answered in order to answer the main research questions. The sub questions are:

- SQ1. What are the advantages and disadvantages of adaptive reuse of a building?
- SQ2. What are the characteristics of a social real estate building?
- SQ3. Which target groups should be considered?
- SQ4. Which type of Decision Support System can best be applied?
- SQ5. Is the Decision Support System able enough to determine the suitability of target groups?

In order to answer the last sub question (Q5), different case studies will be conducted.

1.3 RESEARCH OBJECTIVES AND LIMITATIONS

The goal of this research is to develop a Decision Support System (DSS) to make the decision process for adaptive reuse of social real estate more effective. This DSS must be able to determine suitable target groups for housing in social real estate. The DSS will consider the characteristics of the building and its location, some regulations, a financial assessment and the living preferences of the future resident. In addition, case studies will be conducted with different social real estate buildings. The DSS will be used for these case studies to determine whether suitable target groups exist for housing in a social real estate building. Thereby it is possible to apply the DSS, to demonstrate the working of it and to interpret the results.

However, the research has some limitations. These limitations are based on and concluded from the literature study in Chapter 2. The limitations are:

- The DSS will only determine whether small-scale housing could function at adaptive reuse, other new functions, like large-scale housing, offices, shops or other social functions, are excluded
- The DSS only focus on factors concerning the suitability of future residents based on their living preferences and some political requirements of the government, factors for other stakeholders, like investors, producers, marketeers, regulators, policy makers, developers and owner, are not included;
- Due to the lack of financial expertise, a financial assessment model is created by an Arcadis cost expert, which can only be used for assessing transformations of social real estate either apartment of 20m², 40m² or 80m².

1.4 RESEARCH APPROACH

The research approach for this research is shown in Figure 1. It consists of 4 different stages, namely 'Literature study', 'Decision Support System', 'Case studies' and 'Finalize report'. During this research a qualitative research method will be used.

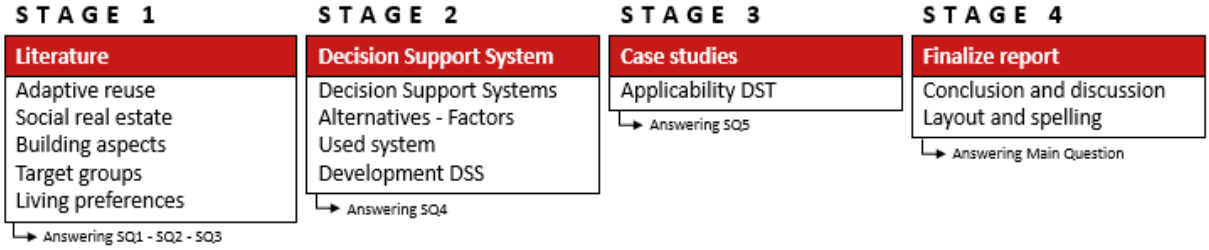


Figure 1 - Research method

In stage 1, topics, such as described in Figure 1, will be investigated in order to answer SQ1, SQ2 and SQ3. The findings of the topics will be scientifically substantiated based on literature. This stage is followed up by stage 2, in which the DSS will be developed. In order to answer SQ4, the overall Decision Support Systems will be investigated, and it will be concluded which system and appropriate technique can best be applied for this research. In addition, the factors that are important for the DSS will be described, which will be based on the findings of stage 1. The DSS will be tested on the applicability during stage 3, in order to answer SQ5. The DSS will be applied based on case studies to see if it functions well and if the included factors are enough to make a well based decision. Finally, in stage 4, the report will be finalized. A conclusion from all findings, a discussion about the findings and their limitations, and advice for future research will be described. The layout will be checked and adjusted where necessary, it will be checked for spelling and the final adjustments will be made to complete the report.

1.5 RELEVANCE OF THE RESEARCH

This research is resulted from limitations of existing research into adaptive reuse of vacant (social) real estate. In addition, the focus is on transforming vacant social real estate into housing, which tackles two social problems. On the one hand, the increase in vacant social real estate, which will lead to insecurity, pollution and an inhibiting effect on local economic

growth (Mostert and Grooten, 2011). On the other hand, the housing shortage of the Dutch housing market could be decreased. The research will contribute to the development of a Decision Support System, which is the scientific relevance of this research. As mentioned before, there is a lack of simple and holistic tools that can assist in setting priorities and decision making in early stages of transformation projects. As a result, struggles are encountered in determining the correct transformation project with a vacant social real estate, which is being recognized by Arcadis. The DSS makes it possible to analyze a vacant social real estate building and their surroundings in a structured and holistic way to find suitable target groups for housing in transformed social real estate. The results after using the DSS could lead to the start of transforming vacant social real estate. In addition, case studies will be conducted on vacant social real estate with the developed DSS. These results will provide insight into the applicability of the DSS at the opportunities for housing in social real estate.

1.6 READING GUIDE

This research is structured as follows. In Chapter 2 the literature research is conducted. Topics relevant to this research are being investigated. During Chapter 3, the general Decision Support Systems are investigated. Hereafter, it can be decided which technique can best be used for the development of the DSS. This development is done in Chapter 4. In Chapter 5, the DSS is applied based on case studies. Finally, the conclusion and discussion about the research will be drawn in Chapter 6.

2 LITERATURE STUDY

The results of the literature study are presented in this chapter. During this study various topics have been investigated and scientifically substantiated. The investigated topics are adaptive reuse, social real estate, aspects of a building, stakeholders and the target groups with their living preferences.

2.1 ADAPTIVE REUSE

Recycling is of great importance in modern society, since the enormous pursuit of ecological sustainability. With the aim of reducing, reusing and recycling waste, new life will be brought into all kinds of objects, such as bottles, clothing, vehicles and buildings (Department of the Environment and Heritage of Australia, 2004). Currently, there is clearly a trend visible in the built environment, namely the adaptive reuse of buildings. This is caused by the significant growth of new buildings and has created a wealth of built stock, which resulted in buildings that can be renovated and reused. However, these buildings have often been developed without taking the environment into account; therefore, these buildings are environmentally not as friendly as new buildings. Adaptive reuse addresses this 'gap' by trying to improve the performance of buildings (Bullen and Love, 2009). According to the Department of the Environment and Heritage of Australia (2004) adaptive reuse can be defined as: 'Adaptive reuse is a process that changes a disused or ineffective item into a new item that can be used for a different purpose.'

2.1.1 BENEFITS OF ADAPTIVE REUSE

There are several benefits of adaptive reuse of buildings. Environmental, economic and social benefits, and promoting innovation are recognized as the main benefits of adaptive reuse (Department of the Environment and Heritage of Australia, 2004; Bullen et al., 2009; De Silva and Perera, 2016; Misirlisoy and Günçe, 2016). The most important environmental benefit for the adaptive reuse of buildings is the preservation of the 'embodied energy' of buildings. Embodied energy can be described as all the energy required to produce a building, such as acquisition, manufacturing, transport and administrative functions (Department of the Environment and Heritage of Australia, 2004; Hek et al., 2004). Adaptive reuse leads to less consumption of materials, transport and energy, generates less waste, and ensures sustainable contributions (Bullen et al., 2009; De Silva et al., 2016; Misirlisoy et al., 2016). However, there are also adverse environmental effects. The lifespan of most buildings can have a detrimental effect due to inherent negative environmental effects. This makes the lifespan of a building an important factor when the choice must be made between adaptive reuse or demolition of a building (Hek et al., 2004; Bullen et al., 2009). The economic benefits are somewhat related to the environmental benefits. Adaptive reuse is often cheaper, the contract periods are shorter and the lower borrowing costs are lower due to retaining the embodied energy by not demolishing a building (Department of the Environment and Heritage of Australia, 2004; Bullen et al., 2009, De Silva et al., 2016). According to De Silva et al. (2016), adaptive reuse of a building, compared to the demolition and rebuilding of a building, will result in an average cost saving of 10-12%. Adaptive reuse also influences the social aspect of the environment: it reduces the negative visual impact of the poor quality of buildings (Hek et al., 2004; Bullen et al., 2009). The latter is also recognized by De Silva et al. (2019). According to them, it can significantly contribute to improving the living standards of people in neglected communities. With adaptive reuse, the

physical and social functions of a building can be extended or renewed with the aim of preserving the (historical) value (De Silva et al., 2016; Misirlisoy et al., 2016). However, if the preservation of historical values cannot be preserved, adaptive reuse is experienced as a disadvantage (Hek et al., 2004). According to the Department of the Environment and Heritage of Australia (2004), adaptive reuse offers opportunities for new housing and commercial property, in many cases due to its good location, access and public transportation. In addition, adaptive reuse will contribute to the promotion of innovations. It requires a genuine challenge for architects and designers to find a suitable solution (Department of the Environment and Heritage of Australia, 2004). However, many architects do not agree with this. According to the architects, the adaptive reuse of a building is less challenging than building a new one, since their creative possibilities are impeded. In contrast to the opinion of the architects, there are a lot of challenges and difficulties with adaptive reuse of buildings. As a result, they have to deal with existing grid sizes, perhaps a monument status and zoning plan that entails all kinds of challenges and requires an innovative solution (Bullen et al., 2009; Misirlisoy et al., 2016). Although there are many benefits of adaptive reuse, the process consists of a complex set of considerations that relate to location, architectural features, market trends and, where appropriate, a monument status (Hek et al., 2004; Misirlisoy et al., 2016).

2.1.2 Challenges and barriers adaptive reuse

A successful adaptive reuse depends critically on the adaptability of the existing space of the building. The more flexible the building is, the easier and quicker it is to apply adaptive reuse (Bullen et al., 2009). Not only the adaptive capacity of the building is crucial, but also other challenges and barriers shall arise with adaptive reuse. To make an adaptive reuse successful, it is important to know these challenges and barriers very well in advance. Some of these challenges have already been described briefly in the section *2.1.1 Adaptive reuse*. Several studies (Heath, 2001; Remoy et al., 2014; De Silva et al., 2016) have conducted research into the challenges and barriers of adaptive reuse. These challenges and barriers include physical restrictions, economic and social considerations, building codes and regulations, complexity and technical difficulties, inaccuracy of information and drawings, classification (zoning) change, poor state of the main structure and a mismatch with the appearance for the new function. In addition to the challenges and barriers of adaptive reuse, various factors can influence the decision-making process on adaptive reuse. Misirlisoy et al. (2016) described five factors that influence the decision process. These factors are (1) analysis of existing building; (2) conservation measures should be decided; (3) adaptive reuse of the architectural characteristics should be evaluated for the new use; (4) the functional changes and new use of the building should be decided; and (5) involved stakeholders (Misirlisoy et al., 2016).

2.1.3 Transformations in the Dutch housing market

In 2018, 13,000 residential houses have been created in the Netherlands due to transformations of existing buildings. This was nearly 14% of all residential houses added to the housing market in 2018. Of the transformed houses, most (42%) were realized in former office buildings and around 21% of the transformed houses were realized in former social real estate. The other houses were realized in former shops, industrial buildings or accommodations and others.

The transformations mainly create houses with a relatively small area. In most cases the houses have an area of less than 50 m² (43%), while more than a quarter of them have an area of 50 to 75 m². In addition, most of the transformed houses are rental properties. Furthermore, mostly single-person households (61%) and couples without children (27%) live in the transformed houses. The majority of the residents are young people between ages of 18 and 27 (47%), followed up by people between 28 and 45 years old (33%). Elderly people of 67 years and older live considerably less often in transformation houses (6%) (Swart, Goedhuys and van der Wal, 2019).

2.2 SOCIAL REAL ESTATE

Buildings can be viewed on different aspects. Functions, size, appearance, state and location of the building can be discussed. In this subchapter aspects of adaptive reuse of social real estate in relation to housing will be discussed.

2.2.1 EXISTING FUNCTION, ADVANTAGES AND DISADVANTAGES

At first the function of the buildings will be viewed in this research. As mentioned before, the vacancy of social real estate is in contrast with the housing shortage. But what kind of buildings are part of social real estate? Social real estate can be defined in different ways. Most studies (de Moel, 2014; Tennekes, van Amsterdam, Bijlsma, van Duinen, van der Linden and Vlak, 2017; Bouhuijs-Bos, Doove, Hendriks, Keller, Padding, Ströfer, Trouborst and Zuidema, 2018) define social real estate as a collective name for buildings or objects with a health, education, sports, culture, government, welfare, religion or meeting function. To clarify the meaning of all these functions, the 'Basisregistratie Adressen en Gebouwen' (BAG; English translation: Basic registration Addresses and Building) has defined four main functions of social real estate, which contain the previously mentioned functions (Bouhuijs-Bos et al., 2018). These main functions and their definitions are provided in Table 2.

Table 2 - Definitions of functions that are related to social real estate (adapted from: Bouhuijs-Bos et al., 2018)

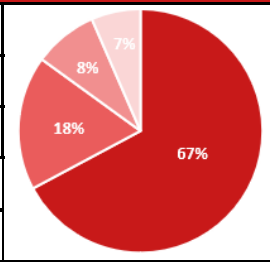
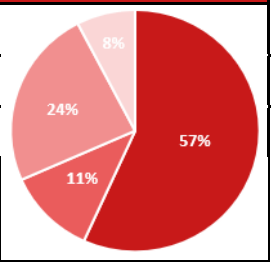
	Meeting	**Education**	**Health**	**Sports**
Definition BAG	Function for the coming together of people	Function for teaching	Function for medical research, nursing, care or cure	Function for practicing sports
Explanation	Think of a congress center, church, neighborhood building, cinema, theater, casino, restaurant, canteen, discotheque, museum, nursery, a stand in a sport building etc.	Think of the classrooms in a school building or a lecture hall of a university. A gymnasium belonging to a school is not an educational function but a sports function	Think of a room for the treatment or nursing of patients in a hospital, psychiatric institution or a practice room for a general practitioner, physiotherapist or dentist etc.	Think of swimming pools, gymnasiums, sports halls, fitness centers etc. A space for spectators in a sports hall is not a sport function but is a meeting function.

However, a distinction can be made in social real estate buildings based on ownership, service provider, public accessibility or use (de Moel, 2014; Tennekes et al., 2017). For instance, for some means social real estate is a building with a public function, financed from

public funds. Otherwise it can be defined as business real estate with added value for society (de Moel, 2014). In addition, another aspect, which is also of great importance when examining social real estate, is the diversity. Both in appearance and design, as well as in the regulations that apply to them, ownership and financing (Tennekes et al., 2017).

To find a good definition for social real estate depends on the context of the research in which social real estate is being discussed. In this research the vacant social real estate will be investigated. As mentioned earlier, 4% of social real estate is currently vacant. Table 3 shows the distribution of vacancy among social real estate by function (Statistics Netherlands, 2018). Since this research is focusing on all kinds of vacant social real estate, other aspects, such as ownership, financing, appearance or (non)public buildings, are not included for defining social real estate. Therefore, social real estate will be defined as: *Social real estate is real estate that is used to provide social services and is related to health, sports, education or meeting.*

Table 3 - Vacancy among social real estate in the Netherlands (based on: Statistics Netherlands, 2018)

Function	Vacancy – Objects		Vacancy – Surface	
Meeting	3,090		1,158,370 m²	
Education	820		236,680 m²	
Health	390		489,660 m²	
Sports	300		155,840 m²	
Total	**4,600**		**2,040,550 m²**	

As mentioned before, vacancy among social real estate will increase more and more in the future (de Moel, 2014). These vacant buildings can have a negative impact on the physical and social environment with the result of insecurity and pollution. This can have an inhibiting effect on local economic growth (Mostert and Grooten, 2011). In the case that social real estate functions disappear, but there is a lot of demand for spaces for other functions, will it be possible to use social real estate for other functions? Social real estate has various characteristics that can have potentials for new use. According de Moel (2014), social real estate buildings have several advantages, which could be advantageous and effective for other functions, namely (de Moel, 2014):

- The buildings are mostly well located, in the middle of a residential area;
- The accommodation capacity of the buildings is generally high;
- The technical condition is generally good;
- The state of maintenance is generally assessed as satisfactory, except for community centers and sports facilities;
- Problems with air quality (at many schools and nursing houses) are not a problem if the intensity of use decreases (for example, due to transformation into housing).

The better location, as social real estate is characterized, of social real estate and the negative effect of vacant buildings on both the physical and social environment is also recognized by Karatas, Uyterlinde, Jonker-Verkaart, van Dijk and van Leent (2018). It is exactly because of their favorable location that these locations can lend themselves to

adaptive reuse. However, adaptive reuse is not always easy in practice, due to the aforementioned challenges and barriers of adaptive reuse (Karatas et al., 2018). In addition to the location, the construction period is also an important characteristic of buildings. During the construction period you can get an indication of the condition (maintenance, build quality, sustainability, etc.) of the building. Not only the newest buildings are suitable for adaptive reuse, the older buildings may also be suitable. The degree of flexibility of the buildings is most important, precisely these buildings remain popular regardless of the building period. The last characteristic that will be discussed is the layout of social real estate. The various functions make transformation of social real estate complex, because each building has its own layout, which differs greatly from each other. Although there is often a pattern per function in the layout of the building and the capacity of the buildings is generally high (de Moel, 2014). Table 4 shows a broad description for various functions that belong to social real estate. For each function, it is shown what size of space they offer and whether they are located in the middle or the edge of a center. Small spaces could be, for example, office spaces, changing rooms or hotel rooms. A detailed description and some (average) dimensions of each function can be found in Appendix 1.

Table 4 - Broad description of various social real estate functions

Function	Large space > 150 m²	Multiple larger spaces; > 150m²	Multiple spaces; 50–150m²	Multiple small spaces; < 50m²	Common rooms	Location: Middle	Location: Edge
Primary school			X		X	X	
High school	X		X	X	X	X	
University	X	X	X	X	X	X	X
Academic hospital	X		X	X	X		X
Health center			X	X	X	X	
Sports hall	X			X	X		X
Theater		X			X	X	
Church	X					X	

2.2.2 ASPECTS OF THE BUILDING

As mentioned earlier, there are challenges in the decision process. One of these challenges is analyzing the existing building and adaptive reuse of the architectural characteristics. This should be evaluated for the new use. Several studies (Heath, 2001; Hek et al., 2004; Remoy et al., 2014; Misirlisoy et al., 2016; Mohamed et al., 2016) have done research on the criteria that are important to analyze a building. The analysis will consist of the existing structure, the original function, the physical characteristics, the adaptive reuse potential and the needs of the region. The lifespan of the adaptive reuse project depends on the new function that meets the needs of the neighborhood (Heath, 2001; Misirlisoy et al., 2016). Figure 2 shows the factors that must be analyzed in order to gain insight into the existing building, this overview is made by Misirlisoy et al. (2016).

Original function	Physical character	Heritage values	Needs of the district
-Residential buildings -Industrial buildings -Commercial buildings -Religious buildings -Military buildings -Agricultural buildings -Governmental buildings -Cultural buildings -Educational buildings -Health care buildings -Office buildings	-Location of the building -Style/period -Physical condition -Physical dimensions -Number of story -Structure system -Construction material -Location of the structural elements -Spatial organization -Formal characteristics -Façade characteristics -Natural lighting	-Architectural -Aesthetic -Historic -Documentary -Educational -Economic -Contextual -Social -Cultural -Symbolic -Spiritual -Emotional -Rarity	-Land use analysis -Socio-cultural analysis -Economic analysis -Environmental analysis -Policy analysis

Figure 2 - Analysis factors for existing buildings when considering adaptive reuse (adopted from: Misirlisoy et al., 2016)

Two factors are not included by Misirlisoy et al. (2016). One of these factors is the financial feasibility. The 'Herbestemmingswijzer' (English translation: Reallocation Guide) by Hek et al. (2004) includes a financial assessment. This determines the investment level and the rent level of the new functions. With this assessment the feasibility of adaptive reuse can be determined. Knowledge and understanding of the allocated number of square meters and the amount of reallocation costs per function are sufficient to form an opinion on the financial feasibility. A reliable assessment can be made with relatively little data. The financial assessment requires the number of square meters, financial key figures and investment costs for reallocation (Hek et al., 2004).

The other factor that is not included is sustainability. Since 2015 it is mandatory to show an energy label when selling or renting out a building. An energy label indicates with classes A (green, very efficient) up to and including G (red, very inefficient) how energy efficient a building is compared to similar buildings. An energy efficient house (label A or B) offers better living comfort and reduces energy costs (Energielabel, 2019). All owners of houses and users of buildings have to make things more sustainable for the future. Improving the quality of life with creating a better living comfort is one of the most important issues for households to make their decision about keeping their houses more sustainable. However, the lack of financial support and the lack of information are important barriers. It is therefore important for current Dutch policy to consider all relevant factors, such as reducing complexity, reducing the complexity of loans and subsidies, and facilitating access to information (Ebrahimigharehbaghi, Qian, Meijer and Visscher, 2019). In addition to improve living comfort, the housing market for owner-occupied houses also contributes to making a more energy-efficient energy label more attractive. The energy label influences the sale of houses in the Dutch housing market. It appears that a favorable energy label (A or B label) speeds up the sale of the house by more than 48 days. While an unfavorable energy label (F or G) delayed the sale of the house by 54 days. In addition to the selling time, the selling price will also be influenced. With a favorable energy label, an owner-occupied house could count on a price premium of more than € 6,300, while the selling price of owner-occupied houses with an unfavorable energy label can be worth less than €13,000. However, this effect is less in the four major cities of the Netherlands. The energy label is most of the times less weighted by house buyers, caused by the overheated housing market in the big city: here people currently pay the main price for a new house, regardless of the energy label (Brounen, 2018). The sustainability of houses in the rental sector differs from those in the owner-occupied sector. Tenants consider sustainable adjustments important, but they hardly invest money because they will lose their investment when they leave the rental house. This makes tenants depending on building owners, in most cases housing

corporations. Aim of the housing corporations is that tenants do not suffer financial loss during the sustainable adjustments to their house. Housing corporations have been working for a long time on making their houses more sustainable and are leading the way: the goal is that all houses will be CO2 neutral by 2050. In this way, tenants will get an energy-efficient and more comfortable house. However, it is not possible for the corporations to accelerate the sustainability process due to the financial scope (Hellebrekers, 2019).

With adaptive reuse, it is not only important to look at the existing situation, but also at the benefits that the adaptive reuse offers. Therefore, it is important to take the new situation and the potential that it entails for the neighborhood into account. Figure 3 shows an overview of the potentials that adaptive reuse can entail; this overview is made by Misirlisoy et al. (2016).

Physical	Economical	Functional	Environmental	Political	Social	Cultural
-Originality of architectural character -Aesthetics -Disability access -Human scale	-Site access -Population density in the location -Profits from market demand -Market opportunity -Financial resources for maintenance cost	-Spatial flow -Adaptability -Space/ structure relationship -Flexibility of spaces	-Site and location -Environmental quality of the surrounding -Neighbourhood relationships -Orientation of the building	-Conservation planning requirement -Building regulations -Urban master plan -Land use plan and zoning -Ownership	-Social meaning for the local community -Spirit of the building -Public interest to the building	-Cultural meaning for the local community -Historic significance -Authenticity

Figure 3 - Potentials of adaptive reuse of vacant buildings (adopted from: Misirlisoy et al., 2016)

2.2.3 STAKEHOLDERS

The decision-making process of adaptive reuse is described in the literature as a difficult process. This is because many different stakeholders are involved in adaptive reuse of a building, each with a different opinion (Mohamed et al., 2016). Therefore, it is important to know the various stakeholders who can influence the decision-making process for adaptive reuse. Table 5 shows the involved stakeholders and their description. Under this table some of the stakeholders will be explained in more detail.

Table 5 - Stakeholders involved in development projects (based on: de Boer, Carnal, Dijkstra, Henstra and van der Hoek, 2010; Misirlisoy et al., 2016; Mohamed et al., 2016; Restauratiefonds, 2018)

Stakeholder	Description
Investor	Company or independent investor who has capital to invest
Producers	Preparation and realization of the project
Marketeers	Company who investigates for suitable users for buildings
Regulators	Planning and local authorities
Policy makers	Federal, state and local government departments
Developers	Combines investment, production and marketing
Owner	Owner of the social real estate building; preservation or selling social real estate
Future users	The preferences and opinion of the future users
Residents	Involving residents to prevent dissatisfaction with transformation plans

The ownership of social real estate can be divided as follows: 50% is owned by non-profit organizations, 25% by the municipality or other government organizations and the remaining 25% by commercial organizations (Karatas et al., 2018). In general, the municipalities would like to retain ownership of their social real estate. However, in the future this will no longer be possible because of many vacancies and they will be forced to sell part of their social real estate. As soon as the municipality sells its social real estate, the municipality loses its direct influence on the position and the developments of the buildings. By means of public law, such as zoning plans, building regulations, welfare bills and building permits, they can still exert influence. The municipality can exercise a final direct influence by including agreements about future use in the purchase contract (de Boer et al., 2010). In addition, it is important to include the opinion and preferences of the future user, however this is mostly ignored in reuse projects. The chance of success of an adaptive reuse depends on the adaptability of the space within the existing building and the preferences of future users. Knowing these preferences, they can be used to determine how suitable the building is for future users. Therefore, it is important to see the future users as a stakeholder (Bullen et al., 2009; Misirlisoy et al., 2016). Furthermore, clear and good communication with the neighborhood and the residents is seen as a success factor for adaptive reuse. Ensure good interaction, be clear about developments and know what is going on in the neighborhood. This can prevent conflicts between the developing parties and the residents (Restauratiefonds, 2018).

2.3 LIVING PREFERENCES

Living pleasure is one of the most important factors of our happiness in life. This requires more than just living in a house. It also requires a living environment in which people feel at home and safe (Wisman, 2016). The potential new living environment is therefore of great importance in finding suitable target groups for housing in a vacant social real estate building. In this subchapter the living preferences of the target groups will be discussed.

2.3.1 TARGET GROUPS

The target group segmentation for this research is based on the research of BPD Mosaic by Wisman (2016). The target group segmentation was created from a survey conducted in 2015 among 15,000 respondents living in the Netherlands. This research created fourteen main target groups and fifty sub target groups. During this research, only the fourteen main target groups will be considered. These target groups have been divided based on demographic, psychological and lifestyle characteristics they have in common. A link is made between household and neighborhood characteristics (Wisman, 2016).

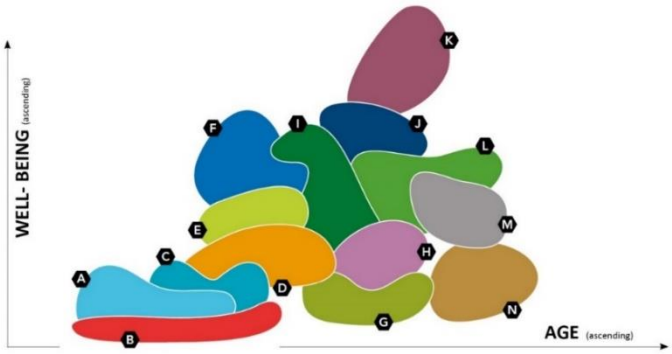


Figure 4 - Ratio well-being / age per target group (adapted from: Wisman, 2016)

Figure 4 shows all target groups that will be considered to be included in the DSS. The target groups are shown based on their age and their well-being. For example, target group D, called the 'Good City Life'. This group consists of highly educated singles, between the 25 to 40 years, who enjoy the city life. They can afford a private rental apartment within a price range of €700 to €1000 or an owner-occupied apartment within a price range of €100.000 to €500.000 (Wisman, 2016). A briefly description of most important characteristics, desired living environment and living preferences of each target group are described in Appendix 2.

2.3.2 LIVING PREFERENCES BY GENERATION

In every stage of life, people reconsider their housing options and make decisions based on the following factors: nature of the household, housing attributes, economic factors, living environment and psychological variables (Tazelaar, 2017). Before, the different target groups have been described based on their characteristics, living preferences and living environment preferences. However, these preferences are rather superficial, therefore additional research will be conducted based on scientific findings. Since it is possible to divide the target groups among four generations, namely Baby boomers, Generation X, Generation Y and Generation Z, the living preferences will be investigated per generation to gain more insight into the living preferences of these target groups.

2.3.2.1 Baby boomers

The baby boomer's generation, born between 1945 and 1960, are known as most vital and resilient people (Rooijkers, 2018). This generation (and the future Generation X) ensures that new developments must be made in the area of living for elderly people. This is caused by the increasing life expectancy, the growth of the dependent elderly population and the preference to grow old in a familiar environment (Demirkan, 2007; Costa-Font, Elvira and Mascarilla-Miró, 2009). Furthermore, 79% of the elderly living independently in the Netherlands indicate that they want to continue living at home, even if the need for care increases (Doekhie, de Veer, Rademakers, Schellevis and Francke, 2014). As people grow older, the desire to continue living in their own house increases (de Jong, Rouwendal, Hattum and Brouwer, 2012; Doekhie et al., 2014). If elderly nevertheless choose for a new house, it is because they need more care, the current house is too large or it is not a single - floor house (Doekhie et al., 2014). They are looking for a house where they can continue to live independently, that meets the need for daily activities and gives the feeling of satisfaction, safety, comfort and independence (Demirkan, 2007; Costa-Font et al., 2009; Doekhie et al., 2014). In addition, when they choose to move, they prefer an apartment, a senior house or a sheltered house (de Jong et al., 2012; Doekhie et al., 2014), and they want

to continue to live in their own environment (Costa et al., 2009). If elderly people want to live at home, housing conditions such as mobility and accessibility are essential to their quality of life (Costa et al., 2009). Various studies (Demirkan, 2007; de Jong et al., 2012; Doekhie et al., 2014; Hennink, 2018) have been conducted for the housing conditions for the Baby Boom generation. It is clear that elderly people prefer houses that require little maintenance and if maintenance is needed, they would like to use a handyman. They want their living room, kitchen, bathroom and at least one bedroom on the same floor and a balcony, most of the time no garden. Furthermore, they prefer to live on the ground floor, if this is not possible access with a lift is desirable (de Jong et al., 2012; Hennink, 2018). The floor space of an apartment must be around 100m², although above 80m² is also considered attractive. In addition to the apartment, the elderly are sometimes also interested in a common activity room, where activities will be organized, and outside facilities, such as a garden or gym. These common areas are considered to make a residential complex more attractive (Hennink, 2018). Most independently living elderly are not suffering from limitations or disability. Those people do not prefer the presence of accessible features, such as wide doors, enough clear space for wheelchairs, loop-type handles on hardware, grab bars in the bathroom or knee spaces under the sink. This is due to the clinical look and the space lost that these features entail. (Demirkan, 2007).

In addition to the house, the environment is also of great importance. The elderly indicate that they would like to live in a neighborhood with a mix of single people, families and older people. They also like it to live in a neighborhood with people of their own age which feeling becomes stronger when they get older (de Jong et al., 2012; Doekhie et al., 2014). They also attach great importance to facilities and social contacts in the neighborhood: their daily supplies, care facilities and public transport within a 15-minute walk. Furthermore, elderly do not want to live in a neighborhood at the edge of the city, because of the lack of facilities (de Jong et al., 2012; Doekhie et al., 2014; Hennink, 2018). However, nothing emerges from the research about the preferences of green areas in the area! Because of the fact that older people want to stay at home longer, it is important to try to improve their quality of life as much as possible. Research by Kemperman and Timmermans (2014) shows that green spaces make a major contribution to the quality of life of elderly. Green facilities ensure that people feel less lonely. It is of great importance for the social contacts between the residents in the neighborhood (Kemperman et al., 2014). That is why attention will be paid to the presence of green spaces, because the elderly like to have social contacts around them. All the previously mentioned preferences will be linked to the target groups with age of 60 years and older.

2.3.2.2 Generation X

Generation X, also known as the 'lost generation', represents people born between 1961 and 1980. Characteristics of this generation are putting things into perspective, reflecting, loyal and giving and receiving feedback (Rooijakers, 2018). Today larger cities can be seen as an interesting place of residence for singles and other small, childless households. Bigger families rank living in the city as the lowest level of satisfaction for their living conditions. Mostly these families are looking for larger houses and, if possible, owner-occupied single-family houses. The suburbs have been the main habitat of middle-class families (Karsten, 2010). According to de Jong et al. (2018), people over 40 take the next step in their living career: their households usually consist of a couple with children, who have already taken

the necessary steps in the work career. Then the next step to an owner-occupied single-family house can be made. It is therefore not surprising that in the Netherlands half of the main residents of an owner-occupied house are of middle age (de Jong et al., 2018).

The living environment that will be chosen is considerably based on the size of the household or the number and age of their children, and the price this household can afford. The type of house is an important factor and also the environment, because families and households are largely depending on the available facilities in the neighborhood. For middle-aged people work-related factors and cultural facilities have a determining influence on the choice of their living environment. Therefore, the location of a neighborhood is very essential. Neighborhoods in larger cities have some advantages and disadvantages for childless couples or families. Living here often means shorter commuting time and a wider range of facilities. However, they lack child friendliness, as less safe and attractive play spaces (Karsten, 2010). Because of these disadvantages, bigger families have often preference to a green and child-friendly living environment around the big cities (de Jong, van den Broek, Declerck, Klaver and Vernooij, 2008). In addition to the disadvantages mentioned above, having facilities 'in the neighborhood' does not always mean that they are 'easily accessible', which is seen as another disadvantage of an urban environment because people focus on optimizing the location of their living environment, considering the distance and time required to access facilities. Furthermore, households with children attach more value to build on social networks in their neighborhood than households without children. As a result, households with children will less quickly move compared to single or childless couples. Thereby, middle-aged people often value living in a neighborhood within a group of people to which they wish to belong (Karsten, 2010).

Despite the mentioned disadvantages and the fact that a lot of families are going to live in suburbs outside the big cities, more and more families still want to continue living in the city, even in case they can afford a house elsewhere. In this category of families, the interest in urban living expanded, caused by the fact that the advantages of living in a city are being considered of greater importance than the disadvantages. By choosing an urban living environment, families will be forced to look in a different way at the qualities of a house which means that they might be better looking at an apartment instead of a looking at a land-based family house. Middle-aged households are willing to live in apartments if the apartment will offer them the feeling of a home, for example an apartment with two floors. Above they think it’s important that the apartment will have flexible floor plans and heights, collective outdoor spaces, for each child its own place, a bicycle storage, extra storage space, peace and privacy (Klep, 2017). All the previously mentioned preferences will be linked to the target groups with the age between 40 and 60 years.

2.3.2.3 Generation Y

Generation Y, also called the millennials, who were born between 1980 and 1995 can be described as optimistic, entrepreneurial and flexible (Rooijakkers, 2018). Generation Y faces more choices compared to the previous generations. Those people are aware of needs for necessary changes, use social media to express their voice, have less to spend than the previous generations and owning a house is being delayed, they prefer to rent (Elzinga, Krebber, Treffers, van der Heide, Trip, Pasman, Otten and Prinsen, 2014). This generation covers approximately 25% of the Dutch population. About half of that group is living in an

urban area, the other half lives in a village or rural municipality. In general, most of them prefer to live around the place where they grew up, with some exceptions. This is evidenced by the fact that the preference for the city is stronger among those who grew up in a city themselves. (Nozeman, Grunder and Alves, 2019). This generation is a dynamic generation that likes to live close to their jobs and facilities and being social is one of the most important factors. Therefore, it is important for them to have private rooms. Bed- and bathrooms must be separated from social rooms, like the living room (Bruce and Kelly, 2013; Tazelaar, 207). They have high expectations of their house and environment. However, they are willing to make sacrifices and drop their high expectations if that could lead to an owner-occupied house. In addition, a house allows them to create and enhance their identity, they consider their house as an extension of their identity (Bruce et al., 2013) and if they do so it would feel like a lack of privacy when they would have to share facilities. About 74% of this generation does not want to share living facilities, things they prefer to share are a common area, gym, media room, game room, and a pool (Tazelaar, 2017). Furthermore, if they want to move to an urban area, they prefer to buy a land-based house. In the case of renting, they are interested in apartments. It appears that almost no one of this generation wants to rent in a village (Nozeman et al., 2019).

There are three important house related factors for Generation Y, when considering a new house. Factor one is the comfort of the house. Most people of Generation Y consider comfort as very important. It mostly is a basic condition, such as natural daylight and the indoor climate (Rigterink, 2017). Above they prefer a house that maximizes their comfort and privacy (Tazelaar, 2017). Low maintenance also seems an often-mentioned motivation to buy a new built house. The last important factor is sustainability. As described before, this generation is aware of a need of necessary environment changes. However, affordability always will be of more importance. Besides the three above mentioned important factors, some other factors such as floor plans (flexible for future needs), facilities, luxury (private and social space separated, outdoor space), and appearance are also being considered. In addition to the house related factors, there are also location and ownership related factors. The location related factors are the accessibility (ability to public transport, walk and biking trips, parking spots nearby home) and the neighborhood (facilities and feeling safe). The ownership related factors depend on the financial feasibility and attraction, it is considered as an investment (Rigterink, 2017). For this generation, the size and price ultimately determine the choice of housing (Tazelaar, 2017). Hoekman (2019) has conducted research into the more specific housing conditions that starters of Generation Y prefer. It appears that part of this generation thinks it is important that a house has a rental price of less than €700; they prefer a surface larger than 90m², a garden and location in the city center. If possible, located less than 1km from a train station and less then 3km from the highway (Hoekman, 2019). Regarding the young families of Generation Y, it appears that their living preferences correspond to the living preferences of the families of Generation X. They are looking for a spacious house with a child-friendly environment that offers them stability and safety. This preferred living environment can be found in the peripheral municipality and green-urban suburb. However, the same as with families of Generation X, families of Generation Y continue to live in the city more and more often. They are looking for a suitable housing offer on the outskirts of the cities, such as the Vinex neighborhoods. However, due to rising house prices, it appears that more and more of Generation Y families are leaving the city which contrasts with families of Generation X. This is because the families of Generation Y

often are starters on the (owner-occupied) housing market (Laarman and van Dam, 2018). However, this generation is facing some more bottlenecks. They have become victims of the highly regulated housing market as these regulations caused a limited offer of affordable houses for starters between the social rental and housing sector. Moreover, the problem only seems to be greater because also very attractive residential areas have limited housing available, there is a scarcity of access to the free rental sector and getting a mortgage is almost impossible (Rigterink, 2017). All the previously mentioned preferences will be linked to the target groups with age between 25 and 40 years.

2.3.2.4 Generation Z

Generation Z is the youngest generation of this research. This generation, also called post-millennials, who were born between 1995 and 2010, is multitasking, entrepreneurial, eager to learn, well-grounded digitally and technically (Rooijakkers, 2018). Generation X has many similarities with Generation Y in interest and living preferences. Therefore, in this research for Generation X only the living preferences of students will be considered. People belonging to Generation X, but not being students, will be linked to the living preferences that have been investigated for Generation Y.

In recent years, the needs and desires of students have changed more than ever. Compared to the previous generation, the students of the millennial generation set higher standards on their student accommodations. They expect more luxury, privacy, security and the availability of multiple facilities. Things that used to be considered luxurious, such as kitchen, private bedroom, private bathroom, laundry facilities, HVAC to be controlled in each room, social room and lounges, is nowadays expected as normal. Facilities students nowadays prefer to have are a private room and enough room for a double bed, a kitchen, a private bathroom, onsite parking, proximity to the campus, laundry, TV connection and internet access. Housing can have real deal breakers for the decision process. According to students, these deal breakers are no internet access, no laundry facilities onsite, no cable TV, no kitchen, sharing a bedroom and sharing a bathroom. However, some students have no problems with sharing a bathroom (La Roche, Flanigan and Copeland, 2010). When making their choice for a new house, students also include the place in the city where they will live as a decision criterion. As mentioned, the proximity of the campus counts for them and in addition the proximity of a supermarket and the city center are of great importance. Also, the accessibility to a train station and bus stops are great factors for students, as students usually use their bicycles as main transport and have no car. Therefore, students prefer a train station and bus stop in the neighborhood. Students hardly value the distance to green areas, sports centers and health centers. In addition, the student does not value population characteristics, like the average neighborhood age and the density. Furthermore, students are willing to pay approximately €400 per month (Corrales, 2017). All the previously mentioned preferences will be linked to the target groups with age of 25 years and younger.

2.3.3 LIVING PREFERENCES OF SINGLE HOUSEHOLDS AND MICRO APARTMENTS

As predicted, single households will increase in the coming years, therefore the living preferences of single households will be investigated and explained separately. BPD (Alves, 2015) has conducted a study into the living preferences of single households in general. There are different ages, education levels and income levels within the group of single households, which is the reason why living preferences of different age groups have been

considered, as discussed before. The study of Alves (2015) shows that in the Netherlands within the group of single people currently the majority of them is between 45 and 65 years old. Living rooms and bedrooms are often considered most important in their houses, and also a lot of natural daylight. They usually sleep in a double bed, so the dimensions of the bedroom must be enough. Single people attach great importance to storage spaces, they like a tidy and cozy apartment. A toilet or washing machine in the bathroom is not appreciated, the preference for a bath or shower is highly dependent on the type of respondent. Almost everyone thinks an outdoor space is necessary. In addition, everyone has or wants an extra room, which is paraded with hospitality. However, single households are not a fan of sharing their living functions. They feel it as a violation of their privacy, and they link it with their student time which makes them feel to take a step back. Although a tiny number of single households are yet interested in sharing living functions, only if it provides them benefits such as extra square meters in the kitchen in exchange for a shared laundry room. Besides the non-interest in sharing living functions, single households are not interested in micro apartments also. They do not want it smaller than 60 m². In addition, loft layouts are not appreciated, a classic three-room layout is the most popular (Alves, 2015).

However, the latter is contradicted by de Vries (2018) and Dopper and Geuting (2018). Micro houses fulfill an important need in the housing market, especially when it leads to affordable living in the city, the transformation of buildings and the flow into the housing stock (Dopper and Geuting, 2018). The study of de Vries (2018), shows that single households really do want micro-houses. This 'want' is explained by demographic and socio-economic characteristics. In demographic terms, the young households create the demand for micro apartments. And in the socio-economic field, low-income households create the demand for micro apartments. However, the demand for micro apartments from households with a medium income to high income is increasing (de Vries, 2018). The increase for micro-houses is increasing mainly in the very urban municipalities. This increase consists of 65% from the millennials, 20% from the elderly and 10% from others. A small group of 5% are interested in living in Tiny Houses, however, Tiny houses will not be discussed during this research. Micro apartments can be divided into 3 types of apartments, namely the simple, the luxury and the 2-person. Simple micro-apartments (20 to 25 m²) are best suited for students or starters, luxury micro-apartments (25 to 40 m²) are usually occupied by singles with a larger budget and 2-person micro-apartments (40 to 50 m²) are best suited for couples without children and the elderly (Dopper et al., 2018).

2.4 CONCLUSION

In the future the vacancy of social real estate will increase and might cause problems for the environment, such as unsafe feelings and effects on the local economic growth. Adaptive reuse of social real estate is becoming more popular to counteract these negative effects of vacant social real estate, which is mostly located at the middle of a residential area. With adaptive reuse of social real estate several functions can be considered such as offices, shops, housing or other social functions. However, this research only focusses on transforming social real estate into housing, other new functions will not be considered.

When transforming a social real estate building into housing, it is important to analyze the current situation of the social real estate building. Various aspects must be considered when analyzing the social real estate building. These aspects consist of the original function, the

physical character, the heritage value and the needs of the district. Besides analyzing the social real estate building, it is also important to consider the potentials of the adaptive reuse of the social real estate. These potentials can be achieved in physical, economical, functional, political, social and cultural terms.

Many different stakeholders are involved in a transformation project, such as investors, producers, marketeers, regulators, policy makers, developers, owner, future users and residents. When determining the included factors for the DSS, the preferences of the future residents are considered, since this research focusses on determining the suitability of target groups for transforming social real estate into housing. Therefore, the main stakeholder to be considered during this research will be the future users (future residents).

As the DSS focusses on future residents, it is important to make them and their living preferences clear. The BPD Mosaic research by Wisman (2016) is used to determine the target groups for this research. The BPD Mosaic research shows that the population of the Netherlands can be subdivided into fourteen main target groups and their living preferences. To substantiate these living preferences additional scientific literature study is conducted. However, as the target groups of the BPD Mosaic research are very detailed, the target groups are subdivided into generations to enable this scientific literature study. These generations are Baby Boomers, Generation X, Generation Y and Generation Z.

3 Decision Support System

It is important to understand a Decision Support System (DSS) in general. DSS contains large amounts of analytical information systems: DSS offers the possibility to control data, gives access to analytical tools and it has capabilities for advice and interaction. A DSS is a system that consists of various components (Power, 2002), so it will be important to pay attention to the benefits a DSS offers, which components a DSS consists of, what types of systems there are, and what kind of techniques can be used to develop a DSS. These topics will be discussed in this chapter.

3.1 Characteristics, benefits and limitations

In human nature making choices has always been an important issue and throughout history decision processes became a scientific research field. Many DSSs have already been developed to support these processes. However, DSS is hard to define, since the number of definitions keeps growing. This growth is caused by the amount of different and still growing systems, which often leads to confusion in the original definition of DSS (Nizetic, Fertalj and Milasinovic, 2007). Alter (1980) has defined the three main characteristics of a DSS: (1) DSS is designed specifically to facilitate decision process; (2) DSS should support rather than automate decision making; (3) DSS should be able to respond quickly to the changing needs of decision. In addition to these characteristics, Sprague and Carlson (1982) define DSS as follows: 'DSS is an interactive computer-based system that helps decision makers to utilize data and models to solve unstructured problems'. DSS can contain both data and models, which present internal and external facts, informed opinions, and forecasts to managers. In addition, DSS supports decision-makers in semi and unstructured situations by bringing together human opinion and automated information. The design must ensure that the decision-maker can effectively make a flexible choice and have a series of knowledge management activities. The goal of a DSS is to improve the effectiveness of a decision and the process itself, not the efficiency with which the decision is made (Power, 2002; Nizetic et al., 2007). The use of DSS has multiple benefits. The most recognized benefits consist of improving the individual productivity, the decision quality and speed up problem solving, the interpersonal communications, the decision-making skills and to increase organizational control. Besides the benefits, DSS has also some limitations. Limitations of DSS are that it might be structured for a specific purpose, it has a 'domain' of use, it has technological limitations and it has some form of behavioral engineering (Power, 2002).

3.2 Decision Support System framework

A framework has been designed to categorize the large number of automated systems that support decision-making. This framework specifies five 'Driven' categories of DSSs. 'Driven' refers to the DSS that offers dominant functionality for supporting decision making. These categories consist of data-, model-, knowledge-, document- and communication-driven DSSs (Power, 2002). A brief description of each category will be given based on Power (2002), Power and Sharda (2005) and Nizetic et al. (2007). Table 6 shows the five 'Driven' categories of DSSs which differ in terms of the dominant component of decision support.

Data-driven
In the data-driven DSS, the emphasis is on the analysis of large amounts of structured data. It contains file drawer, management, and analysis systems. These systems support decision-making problems by analyzing given time series of internal business and external data and by retrieving new information through that analysis. Examples of data-driven DSS are Executive Information Systems (EIS) and Geographic Information Systems (GIS).

Model-driven
Model-driven DSS provides systems that make use of accounting and financial models, representation models and optimization models. The data are provided by decision makers to assist in analyzing and deciding on a situation. The model-driven systems are usually not data-intensive, but data could be obtained from a large database. These systems support decision problems with the use of analysis and optimization DSSs and suggest actions. An example of model-driven DSS is choosing between many options.

Knowledge-driven
Knowledge-driven DSS is still evolving. These systems consist of specialized knowledge and suggest or recommend actions to managers to support decision making. The knowledge is stored in artificial intelligence or statistical DSSs. Examples of knowledge-driven DSS are medical diagnosis, equipment repair, investment analysis and financial planning.

Document-driven
Document-driven DSS is the newest type of this framework. It helps with collecting, retrieving, classifying and managing unstructured documents. With this system, the right documents can be retrieved and analyzed to support decision makers. An example of document-driven DSS are the search engines.

Communication-driven
Nowadays also Communication-driven DSS is referred to Group Decision Support Systems (GDSS). The system uses network, information and communication technologies to facilitate collaborations, making shared decision more effective. Examples of communication-driven DSS are chats software, document sharing, online collaboration and net-meeting systems.

Table 6 - Differences between the five 'Driven' categories (based on: Power, 2002)

'Driven' category	User Groups	Purpose General – Specific	Network needed
Data-driven DSS	Managers, staff and suppliers	Query a data - Warehouse	Usually
Model-driven DSS	Managers, staff and customers	Crew scheduling - Decision analysis	Sometimes
Knowledge-driven DSS	Internal users and costumers	Management advise - Choose products	Sometimes
Document-driven DSS	Specialists (user group is expanding)	Search web pages - Find documents	Usually
Communication-driven DSS	Internal teams (user group is expanding)	Conduct a meeting - Help users collaborate	Always

3.3 DECISION SUPPORT SYSTEM COMPONENTS

In general, a DSS is built based on four main components: (1) the database; (2) the models and analytic tools; (3) the DSS architecture and the network; (4) the user interface. These components, shown in Figure 5, help analysts to build a new DSS. In addition, the components are useful because they identify similarities and differences between types of DSS. Despite the differences between these types of DSS, they have similar technical components and a common goal: supporting decision making. Developing a DSS requires an appropriated process. A small, specialized model-driven DSS can be developed quickly, but when developing larger DSSs, it requires help from advanced tools, systematic structured system analysis and approach. Communication-driven DSSs are usually purchased as "off-the-shell" software packages, which is the reason why the literature does not emphasize that development but emphasizes the implementation of communication-driven DSS (Power, 2002). Each component will be explained based on Power (2002).

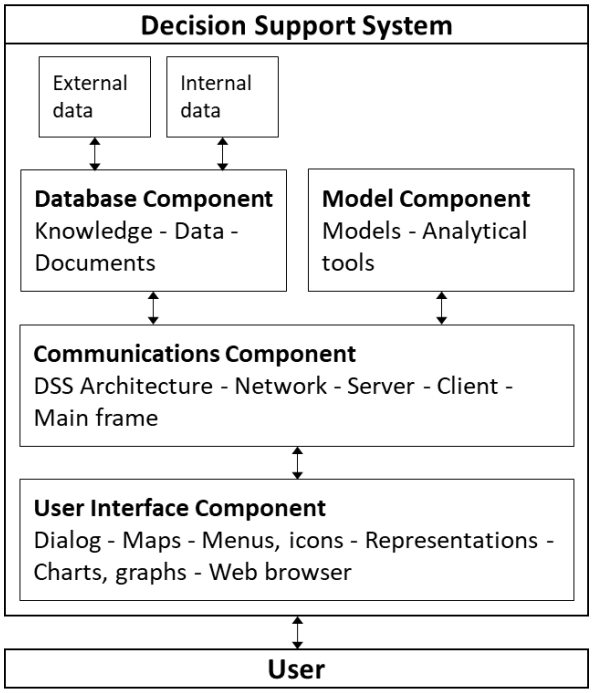


Figure 5 - DSS components (based on: Power, 2002)

3.3.1 COMMUNICATIONS COMPONENT

As described earlier, the development of a DSS consists of four components, these components together create the core of a DSS. This core of the DSS is described in the communications component. The communications component describes how the three topics architecture, network and security of the DSS will be organized. These topics are closely intertwined and important for building a DSS. The architecture and network refer to how hardware is organized, how software and data are distributed, and how networks are integrated and connected to the system.

The architecture defines the structures and operating elements that determine how the DSS can be used. It includes the hardware and software used to manage information, the tools used to process the information and the general settings that integrate the various components. The architecture varies for the five 'Driven' categories. The communication-

driven DSSs are highly dependent on network technologies. With a data-driven DSS, the emphasis is on scalability and database performance. A model-driven DSS stores the software on a server and distributes the software to their users.

The network consists of a collection of computers that are connected in a certain way that allows them to communicate and share information. These computers need an agreed language to communicate. However, sometimes a stand-alone computer can be enough, in cases no communication between different computers is required. Table 6 shows if a network is needed for each 'Driven' category. The goal of these networks is to provide access and storage for shared information.

Lastly, the communication component describes the security of the DSS. Securing the DSS is a very important issue, since computer crime is increasing by more than 150 percent a year. Securing a DSS consists of four phases: (1) evaluating security needs; (2) solving problems; (3) monitoring the operation of the system; and (4) staying informed about security issues. It is important to consider the importance of DSS availability and the managed data, a specialist is usually to be consulted to protect the DSS. However, security is not only the responsibility of the specialist, the DSS developer and decision makers must not underestimate the importance of security.

3.3.2 Database Component

The database component consists of a collection of data organized for easy access and analysis. Data-driven, document-driven and knowledge-driven DSS require a specialized database component. Conversely, a model-driven DSS may use a simple flat-file database. The database component of a data-driven DSS consists of a collection of current and historical structured documents that are organized for easy access and analysis. This database component can be expanded to include unstructured documents in document-driven DSS. Large database components with structured data are often called data warehouses or data marts. With knowledge-driven DSS, the database component consists of 'knowledge' in the form of rules.

3.3.3 Model Component

The model component predicts the output based on the input from the database component. This component contains the system or tool with which a DSS has been developed. For a model-driven DSS, the most important components are the mathematical and analytical models. Every model-driven DSS has a specific purpose and therefore it requires different models. Thereby, choosing suitable models is an important designers' problem. The software used for these model-driven models must be able to manage the required data and user interface. It must be possible to change the values of important factors in order to reflect possible changes. Knowledge-driven DSS models use special models, an inference engine. The software performs the reasoning function, for identifying relationships or processing rules. With data-driven and document-driven DSS, the model component is similar. Both DSSs require a system that can clean, extract and load the data. This requires a suitable data management system using an organized model.

3.3.4 User Interface Component

In many ways, the user interface component is the most important one of any DSS, therefore this component has to be emphasized. The tools used to create the user interface are also called DSS-generators. This component is important because the screens and displays in the user interface have a major influence on how a DSS is going to be used: a complex, difficult-to-use interface limits the use of a DSS. The easier it is to use a DSS, the greater the chance that the DSS will be used. Therefore, the general purpose of user interfaces is to make the design intuitive, user-friendly and visually attractive. Although, user-friendly is an evaluation term for someone's subjective impression of the user interface. It does indicate that decision makers rate the user interface as easy to learn, understand and use. An effective user interface is important to provide a context for human interaction and it will give directions to decision makers for desired actions. It will reduce errors, create a sense of user control, increase human processing speed and productivity. Decision makers prefer easy-to-use, functional interfaces, for example by using graphic images and other visual information displays; people quickly lose their attention when using "cute" user interfaces with funny graphic images. In addition, complex interfaces ensure increasing training costs. Overall, if the user interfaces improve, the usefulness and value of a new DSS will increase for decision makers. The user interfaces can be distributed to the decision maker in two ways: via "thick client" and "thin client". In case of a "thick-client" architecture, the DSS is on the decision maker's computer, but with a "thin-client" architecture the DSS can be used via a network using web pages.

3.4 Model-driven Decision Support System

This research will focus on determining the suitability of the target groups for housing in transformed social real estate. The results of the suitability of the target groups will be compared and eventually it will be possible to advise which target group would be the most suitable for housing in transformed social real estate. The principle of a model-driven DSS best fits this focus. As described before, model-driven DSS uses quantitative models, data are provided by decision makers to assist in analyzing and deciding on special situations. It supports decision problems by using analysis and optimization tools and suggests actions. It enables the decision maker to compare and choose between many options (Power, 2002). Compared to the other ‘Driven’ systems that focus on structuring data (data-driven), supporting management advice (knowledge-driven), finding the right documents (document-driven) and supporting and facilitating collaborations (communication-driven), a model-driven DSS will be the best system for this research (Power, 2002; Power and Sharda, 2005; Nizetic et al., 2007).

The computer support of a model-driven DSS that is used for a decision analysis is distinguished from the other ‘Driven’ DSSs by two characteristics: (1) the model of a model-driven DSS is made accessible to a non-technical specialist, and (2) the DSS is intended for repeated use in the same decision situation. The model component of model-driven DSS consists of quantitative models, these models include accounting and financial models, decision analysis models, forecasting models, network and optimization models, simulation models (Power and Sharda, 2005). Accounting and financial models can assist in cost-benefit analysis, break-even analysis, and capital budgeting. The goal of decision analysis models is to help decision makers to understand their problem, and to separate facts from priorities and preferences. With the help of network and optimization models, project planning and

control, location, allocation, distribution and transport problems can be formulated. Finally, simulation models can help evaluating complex, coherent decision problems (Power, 2002).

Looking at the supporting value of the various quantitative models, a decision analysis model will be developed during this research. The goal of this research is to determine the suitability of target groups (alternatives) based on their housing preferences (factors) and to help decision makers to understand problems better and to separate facts from priorities and preferences. Decision analysis models are a help for managers in decision situations to identify alternatives and factors. The alternatives are listed with the potential predicted contributions to the goal, the results are evaluated, and the best alternative is selected. The modeling philosophy is to only include the factors that are relevant to the decision-making situation and that help to distinguish the alternatives (Power, 2002). Decision analysis models can be developed with several techniques, most are known as multi-criteria decision analysis techniques. Some of these techniques are Analytical Hierarchy Process (AHP), decision tree, Multi-Attribute Utility Theory (MAUT), Weighted Sum Method (WSM), and outranking method (Power et al., 2005). To understand these techniques, they have been briefly researched and explained:

- Analytical Hierarchy Process (AHP)
  The AHP technique distinguishes itself from other multi-criteria techniques. With the AHP technique, the weights are not directly assigned to the factors, but are determined by pairwise comparisons. This means that factors are compared with each other and the decision maker makes a relative judgment between these two factors. The purpose of the AHP technique is to be able to rank the alternative and to determine the preferred alternative. When comparing in pairs it is up to the decision maker to answer a series of questions such as: "How important is factor A compared to factor B?" (Linkov and Moberg, 2012; Mateo, 2012). The advantages of AHP are ease of use, pairwise comparisons, scalability, adaptability and comparing the alternatives. The disadvantage, however, is that no factor can be assessed individually with the technique. This creates problems in the interdependence between factors and alternatives (Velasquez and Hester, 2013).
- Decision tree
  A decision tree uses three types of nodes: (1) the choice nodes at which a decision is to be made (represented by a square); (2) the chance nodes that shows uncertain outcomes (represented by a circle); and (3) the end node which indicates the outcome (represented by a triangle). The advantage of a decision tree is that it represents the graphical relationships between factors, and it can handle more complex situations in more compact forms. In addition, the decision tree can be used for unambiguous problems (Power, 2002; Lucidchart, n.d.).
- Multi-Attribute Utility Theory (MAUT)
  With the use of the MAUT, decision makers can be helped to assign utility values to the outcomes by evaluating multiple factors. In general, it combines the most important advantages of scoring techniques and optimization models. In addition, MAUT considers the preferences of the decision maker in the form of a utility-function. The utility-function is used to develop the relationship between the utility and the costs incurred as a result of a decision (Power, 2002; Linkov et al., 2012). A disadvantage of MAUT is that an incredible amount of input is needed to accurately record the decision maker's preferences. In addition, the preferences of decision

makers must be accurate and specific weights are required. This precision makes MAUT difficult to apply (Velasquez et al., 2013).

- Weighted Sum Method (WSM)
  The WSM is a multi-criteria decision analysis technique which is popular, well-known and easily implemented subjective decision-making method and mostly used for single dimensional problems. With the use of the WSM, it is important that the total value of each alternative is equal when all factors are adequate. With the WSM comparisons can easily be made between different alternatives after assessing the factors. The WSM is a technique that is often used with other techniques for determining the weighting factors. An easy, often used technique for determining the weighting factors during the WSM is the rating method, also known as the constant sum approach (Mateo, 2012; Sorooshian and Parsia, 2019).
- Outranking method
  The outranking method tries to organize alternatives by finding alternatives that dominate. The basis of this method is the pairwise comparison of alternatives based on factors, which means that one alternative will outrank another alternative if it outranks the important factors. The outranking method has two phases: (1) determining whether one alternative outranks another, and (2) combining all assessments into an overall preference ranking of the alternatives (Arentze, 2019).

3.5 Development process Decision Support System

Various steps need to be followed to develop a DSS. Power (2002) and Linkov et al. (2012) both have developed a process with various steps. Power (2002) developed a general process that involves seven steps to develop a DSS, and Linkov et al. (2012) briefly describe five steps for developing a decision analysis model. In this research, these steps are combined into one process in which six steps must be followed to develop the DSS. This process is shown in Figure 6. Every step of the process is important, considering decision making is more than deciding (Power, 2002). The steps of the process for developing the DSS will be explained below the figure, based on Power (2002) and Linkov et al. (2012).

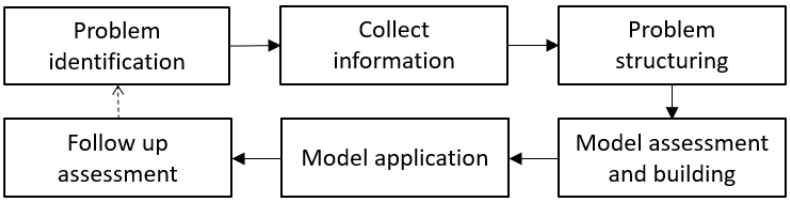


Figure 6 - The process for developing a DSS (based on: Power, 2002; Linkov et al., 2012)

1. Problem identification

According to optimists, problems create opportunities. Defending the problem is very important for a successful decision. A well-defined problem can be solved easier and reduces the chance of a solution for the wrong problem. The way of defending the problem influences the solution and the choice for the type of decision support.

2. Collect information

If the problem is defined, the relevant information can be collected. The collection of information is intended to determine the factors that influence and are related to the

problem. However, the information collected has not yet been described quantitatively, which is necessary for a decision analysis model.

3. **Problem structuring**

The most creative part of decision making is the identification of alternatives and factors. The problem is elaborated based on alternatives and factors. The alternatives define the potential options under which a decision maker decides. The factors are a group of properties that are used to choose between the alternatives. The alternatives and factors will be presented in an evaluation matrix.

4. **Model assessment and building**

The factors receive quantitative values, so that the alternatives can be scored based on the factors. In addition, a weighting factor can be assigned to the factors based on the importance attached to that factor by the alternatives. These weighting factors will be presented in a weighting matrix. By quantifying the factors and assigning weights, information can be obtained about how well each alternative score on each factor.

5. **Model application**

The input consists of the factors with the corresponding weighting factors and the alternatives. With a decision analysis model, the best alternative will be based on the input and the given data. The output can differ from an ordered list of alternatives to a set of probabilities whether an alternative is accepted or not.

6. **Follow up assessment**

Once the model is applied, the output can be used to decide the best alternative. It is important to evaluate the consequences that may arise after decision-making, new problems could arise. Which creates the decision cycle: define a problem which leads to a decision that will be implemented whereby new problems arise.

Step 1 ‘Problem identification’ has already been defined in Chapter 1. To clarify, the problem to be solved in this research is: the vacancy rate of social real estate in the Netherlands will increase in the coming years and, on the other hand, the housing shortage in the Netherlands will increase also. That is why a DSS will be developed to see if there is a way to match these two problems, resulting in the transformation of social real estate into housing.
Step 2 ‘Collect information’ has already been carried out in Chapter 2. In order to collect the right information for the development of the DSS, research was done into the factors that are important when analyzing buildings, into the target groups that can be included in the DSS and also research about the preferences of these target groups. In the Chapter 4 step 3 'Problem structuring' and step 4 'Model assessment and building' will be discussed. These two steps will be discussed by describing the components that are required to develop a DSS, namely communications, database, model, and user interface component. Eventually, step 5 'Model application' will be carried out in Chapter 5.

3.6 Examples of developed Decision Support System

To gain insight into the development of multi-criteria analysis and DSSs, a small analysis will be done in researches that uses multi-criteria techniques or developed DSSs. This analysis will help to substantiate the considerations that will be made during the development of the

DSS. Three studies will be analyzed, namely: ‘Herbestemmingswijzer’ (Hek et al., 2004); ‘Groenewijzer’ (Hennekeij, 2010); and ‘Student housing location preferences’ (Corrales, 2017).

Firstly, the 'Herbestemmingswijzer' tool developed by Hek et al. (2004) will be analyzed. This tool is constructed in four consecutive parts, divided into eight steps. It is not entirely clear how the factors included in the tool are determined. In the first part, the factors are assessed with a yes/no answer. If the answer is ‘no’ to one of the factors, the alternative is rejected and is no longer included in the following phases. In the remaining parts, the factors are assessed based on rating options. The rating varies from 1 to 5, with 1 being unsuitable and 5 being suitable. An explanation has been provided for each rating option so that the decision maker knows which rating to assign to the factors. Each factor in the tool is provided with a weighting factor. To make an objective assessment, all factors are counted equally, they receive a weighting factor of 1 (= 100%). However, a decision maker can choose to emphasize extra importance to a factor by changing the weighting factor, for example to 3 (=300%) (Hek et al., 2004). Furthermore, it is not clear how the ‘Herbestemmingswijzer’ is accessible to its decision makers.

Secondly, the ‘Groenewijzer’ tool developed by Hennekeij (2010) will be analyzed which provides a recommendation about investments in energy-efficient technologies. The tool is constructed in three consecutive parts and the factors included are determined based on scientific literature. During the first part of the tool the decision maker is asked to give information about their own living situation. In the second part, the decision maker is asked to give their preferred living situation. This preferred situation is created based on the assessment of five criteria. With each criterion, the decision maker can indicate the preferred situation based on a 5-point scaling, where 1 indicates that the residents want ‘to go up strongly’ and 5 indicates that the residents want ‘to go down strongly’, for example, with the housing costs. Ultimately, in the output phase, the best matches of energy-efficient technologies will be presented. The output consists of 96 different energy-efficient technology packages, only the 5 best matches will be presented at the output phase. These matches are based on the own situation of the residents and their wishes regarding the criteria. To present the tool to its decision makers, it has been converted into a digital tool. However, it is not clear if the tool is distributed through a 'thick-client' or 'thin-client' network (Hennekeij, 2010).

Finally, the research of Corrales (2017) will be analyzed. The goal of this research is to determine the location factors that are important and preferred by students and to include these factors in a land suitability analysis. To understand the importance and preferred location factors of students, a questionnaire is conducted and distributed among students to find out which location factors influence student’s decision making. The location factors are determined based on scientific literature. Respondents were asked to provide the location factors with a level of importance in their opinion, and to compare the factors pairwise to determine with the AHP method the weighting factor of the factors. With the results of the questionnaire it is possible to use the Logic Scoring of Preferences (LSP) method to develop suitability maps considering the factors and their importance. The LSP methods is a general multicriteria decision method that can model more complex suitability maps, whereby mandatory and non-mandatory factors can be considered without losing the significance for

GIS-based multicriteria methods (Corrales, 2017) It appears that no tool is developed during this research, however, a multi-criteria analysis is used to conduct the suitability analysis.

3.7 CONCLUSION

Some conclusions were already drawn in this chapter. The principles of a model-driven DSS fit best with this research and a decision analysis model will be used to develop the model-driven DSS. As described, there are various techniques for developing a decision analysis model, namely AHP, decision tree, MAUT, WSM and the outranking method. Every decision analysis technique has its advantages and disadvantages, but for this research, in which the suitability of the target groups for housing in social real estate is determined, the WSM will be the best technique to apply. It is an easy-to-implement subjective decision-making method, making it easy to implement a subjective assessment of the factors and weighting factors for determining the suitability of the target groups. The decision tree is not suitable for this research because it is meant for unambiguous problems determining one alternative as a result. The outranking method compares the alternatives based on the factors. This would be difficult during this research because each alternative (target group) attaches different importance to the factors, which makes comparisons between the alternatives difficult. The AHP and MAUT are two techniques that could possibly be suitable for this research. The AHP allows for pairwise comparisons between the factors, which focuses on determining the weighting factors. However, the purpose of this research is to develop the DSS in general. Therefore, the AHP will not be used, because this technique has a too specific focus on determining the weighting factors. Furthermore, the MAUT technique is not suitable for this research because the input of the model is too small.

In general, a DSS can be developed based on four components, the communications, database, model and user interface component. The communications component consists of the architecture, the network and security. A DSS can be distributed through a ‘thick-client’ (stand-alone computer) or a ‘thin-client’ (network) architecture. The database component provides the input for the model component, which in turn provides the output of the DSS. Furthermore, the user interface component ensures that the DSS is usable and user-friendly for the decision maker.

The three researches that have been analyzed show different ways of how to assign weighting factors to the various factors. The ‘Herbestemmingswijzer’ shows that the decision maker of the DSS can assign the weights himself to the factors before assessing these factors. The 'Groenewijzer' does not assign weights to the factors but allows the decision maker to assign weights to the factors by rating these factors. The research of Corrales (2017) assigns weights to the factors with the use of AHP, after a questionnaire has been carried out among the focus group. Both ‘Herbestmmingswijzer’ and ‘Groenewijzer’ are divided in consecutive parts, which offers structure and clarity to the decision maker. Furthermore, a multi-criteria technique can be used for an analysis or as an underlying technique for a DSS. The ‘Groenewijzer’ is a digital tool, which creates the user interface component of a DSS, making it easy to present to its decision makers. This in contrast with Corrales (2017), as he only uses the multi-criteria technique for conducting a suitability analysis. How the tools ‘Herbestmmingswijzer’ and ‘Groenewijzer’ are distributed among the decision makers is not clear.

4 DEVELOPMENT DECISION SUPPORT SYSTEM

In this chapter the four components of the Decision Support System (DSS) will be presented. First, the communications component will be described. It shows how the DSS is structured, how hardware is organized, how software and data are being distributed and how networks are integrated and connected to the system. Second, the database component will be formed during the 'Problem structuring' and 'Model assessment and building' steps, as described in the process for the development of a DSS. The database consists of an organized collection of data. This organized collection of data will be created by the determined alternatives and factors. In addition, the factors will be quantified, and weighting factors will be assigned. Third, the model component, which consists of the system by which the DSS is driven, will be discussed. The system predicts the output based on the input from the database component. Finally, attention will be paid to the user interface of the DSS.

4.1 COMMUNICATIONS COMPONENT

The communications component shows how the hardware is organized, how the software is arranged, how the networks are connected and how the system will be protected. The communications component consists of the architecture, the network and the security of the DSS. The architecture of the DSS is shown in the Figure 7. In the literature study, the data is collected based on the research of BPD Mosaic by Wisman (2016) and the additional scientific literature. The collected data will be structured in the database component. The database component provides the input for the model component. This model component offers a multi-criteria analysis that uses the WSM technique to perform the analysis. The DSS consists of four consecutive parts. In the user interface a clear distinction will be made between these consecutive parts, which creates a clear and user-friendly DSS. All components will be explained one by one in the following subchapters, in which the structure of the DSS will be explained also.

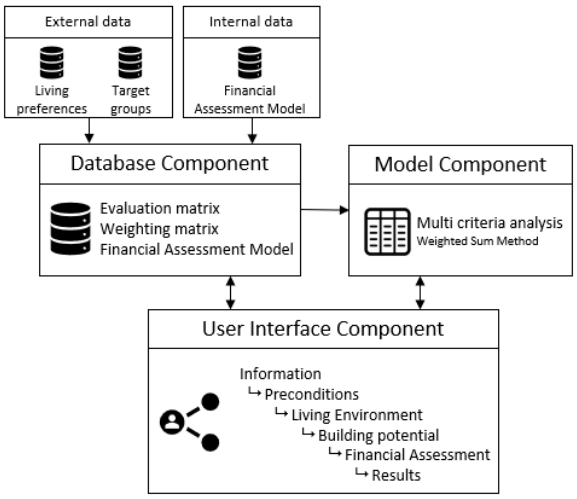


Figure 7 - Architecture of the DSS

The DSS will run on a stand-alone computer, therefore no network is required. But it is important that the product will be known by interested decision makers and distinguishes itself from competitive products. To ensure that it succeeds in having the attention of interested users, a brand name will be given to the DSS. The DSS will be named HouSRE,

Housing in **S**ocial **R**eal **E**state, since the DSS intends to determine the suitability of target groups for adaptive reuse of social real estate into housing. Furthermore, the security of the DSS will not be taken into consideration, because this is outside the scope of this research.

4.2 DATABASE COMPONENT

A lot of information has already been collected for the database component during the literature study in Chapter 2. However, this information is not yet structured. This subchapter focuses on which target groups are going to be included in the DSS and what their living preferences are. In addition, some factors that are needed to test these living preferences will be determined. In this research, the 'target groups' are the alternatives and the 'living preferences' are the factors as used in the decision analysis model.

4.2.1 ALTERNATIVES - TARGET GROUPS

With the developed DSS, a decision maker will be able to identify the suitability of target groups for housing in transformed social real estate. Therefore, the target groups are identified as the alternatives, since they are the potential option to decide between. Not all fourteen target groups will be included in this research. It appears that transformations of (social) real estate mostly create small-scale houses, in which mainly single households live (Swart et al., 2019). In addition, there will be a shortage of houses for single households in the future (Kleinepier et al., 2019). Therefore, the focus will be on the target groups that prefer to live in apartments and/or target groups that are characterized as single households. Furthermore, some target groups will not be included because they have higher expectations regarding their house, like detached, usually new build, (expensive) owner-occupied houses, and/or sometimes can afford more due to a better financial situation. In the research of BPD Mosaic, there is no target group specifically named 'Students'. Therefore, a target group 'Students' will be added. Table 7 shows the target groups included in this research.

Table 7 - Target groups included in the DSS

Generations	Target groups	Short description
Baby boomers	Aged Simplicity	People of the target group 'Aged Simplicity' have a simple existence and are quickly satisfied. They are 65 years and older, retired and live in a small apartment or terraced house alone or together with their partner.
	Well Deserved Enjoyment	People of the target group 'Well Deserved Enjoyment' are an active group of 55 years and older. They are usually retired, live together with their partner and have a fine financial budget to spend. They own a semi-detached house or corner house, sometimes an apartment.
	Mature Middle Class	People of the target group 'Mature Middle Class' are aged between 55 and 75, whose children have usually just left home. They usually live in an owner-occupied or private rental house together with their partner. They are happy people.

Generation X	Social Tenants	People of the target group 'Social Tenants' are people of middle-aged, between 45 and 65 years, living single or with a partner. They do not work or work part time and usually live in an apartment. As the name suggests, this target group lives in a social rental apartment or terraced house.
Generation Y	Good City Life	People of the target group 'Good City Life' are highly educated singles who enjoy the free city life. In some cases, they have a relationship and already children. They are ambitious and enjoy life. Some of them are still studying and the others already have a good career, since this group is between 25 and 40 years. They can afford a private rental or owner-occupied apartment.
	Urban Balancers	People of the target group 'Urban Balancers' live in a rental apartment in the middle of the city and mainly consist of people of non-Dutch descent. Material matters are not so important, a happy family and a slightly larger house is their main wish, since they live in a small rental house. This group is younger than 40 years and single, although in some cases they have a partner (with children).
	Young Digitals	People of the target group 'Young Digitals' follow an education, work part-time or are looking for work. In all cases this group can be found a lot on the internet, for arranging and keeping track of all daily activities. They usually live in a social rental house, are younger than 40 and single.
Generation Z	Students	People of the target group 'Students' are under the age of 25, study at the university, generally single and have a low monthly budget. Their means of transport is the bicycle and public transport, making the residential location important to them. They usually live in student houses or in social rental studios/apartments.

4.2.2 FACTORS - LIVING PREFERENCES

The living preferences of the target groups will be used to evaluate the suitability of each target group. Therefore, the living preferences have been identified as the factors of this research, since the factors are described as a group of properties that are to be used to evaluate the alternatives. The living preferences have been investigated during the literature study in Chapter 2. However, these living preferences have not yet been structured, subdivided into factors and described quantitatively. Figure 8 shows the structure of the DSS. The DSS consists of four consecutive parts: 'Part 1 - Preconditions', 'Part 2 - Living Environment', 'Part 3 - Building Potential' and 'Part 4 - Financial Assessment. Each part includes one or more aspects, for example in 'Part 1 - Preconditions' there are 'Procedural' and 'Technical' aspects. These aspects have various factors on which the building will be assessed. For each step, the aspects and their factors will be explained further in a subchapter.

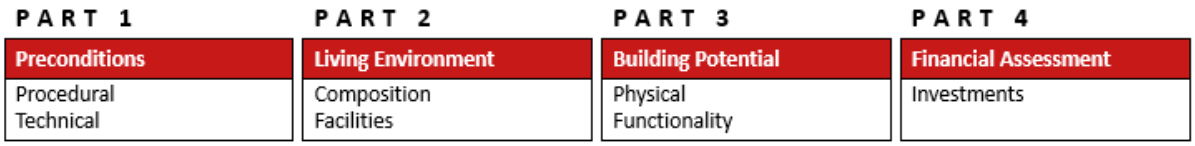


Figure 8 - Structure of the DSS

4.2.2.1 Part 1 - Preconditions

The vacant social real estate building is not only to be assessed based on target groups and their living preferences but also based on some preconditions, which are shown in Table 8. In this section 'Part 1 – Preconditions', some preconditions will be created for the location and the building, before it will be assessed based on the living preferences of the target groups. The preconditions are independent of the target groups, but they are necessary to see whether housing is allowed in the neighborhood anyway. Additionally, the DSS verifies if residential property is permitted and if the social real estate building is generally suitable for a residential function. The preconditions have been subdivided into two aspects, namely 'Procedural' and 'Technical', and each has its own factors. The 'Procedural' aspect will include factors that have to do with the law. When developing a project, it is important to know the future structural vision of the municipality and if the location has the right zoning for a new development. The 'Technical' aspect implies to make a general estimate of the suitability and feasibility of the social real estate building.

The 'Procedural' factors, 'Structural vision' and 'Zoning plan', are included in the DSS to determine whether transformation into housing is permitted and also is wanted at the location of the vacant social real estate building. The potentials of the location regarding the structural vision and zoning plan of the municipalities will be investigated. Naturally it will be an advantage if the location in the structural vision and zoning plan has specifically been designated as a potential living location. This information can be obtained from secondary research, such as information from policy and vision documents and the zoning plan of the relevant location.

The 'Technical' aspect considers the adaptability of the building, the monument status of the building and the floor height according to the building decree. For adaptive reuse, it is important to know whether the load-bearing construction can handle any expansion or change of load. By the load-bearing construction is meant the foundation, floors, walls, columns or beams and optional column plates. The current structural condition and the structure of the building largely determine the adjustments that are possible (Hek et al., 2014). The assessment factors for the 'Adaptability' have been adopted from Hek et al. (2004), which are shown in Table 8.

The 'Monument status' will also be considered as a factor. In the Netherlands there are several different statuses that can be assigned to a building. Buildings can be designated as a National monument, which means that the building is protected by the government for its national monument status. Furthermore, buildings can also be designated as a Provincial or a Municipal monument; these buildings have no national value but have a provincial or municipal value. In case of the National monuments, a permit must be applied for almost every change to the building, both exterior and interior. This often also applies to Provincial and Municipal monuments, although this may differ per province or municipality. If a building has one of these three monuments statuses, many extra procedures will have to be followed. That is why these three monuments statuses, 'National, provincial or municipal monument', are considered as disadvantageous during a transformation project. Furthermore, buildings can have a protected city or village view monument status. When a building has this status, certain building activities on the rear facade cannot be carried out without a special permit. A permit will be required as soon as construction activities will take

place in the front or side facade of a building and in case construction works, such as a garage for example, are being built next to such buildings. Since this aforementioned monument status makes it possible to carry out more building activities without a permit, a 'Protected city or village view' status is considered less disadvantageous than the other monument statuses (Monumenten, n.d.). If none of these statuses are assigned to a building, the building does not have a monument status and the standard procedures have to be followed, the building needs to be rated with 'No monument status'. Information about the monument status of a building will be done based on secondary research from https://www.monumenten.nl/monumenten.

The Building Decree contains all the requirements that a building with a certain function must meet. These requirements will not yet be included in this DSS, they will be tested at a later stage of the development. However, one requirement will be included, namely the free height above the floor of an occupied room. The 'Free height' is included because it requires a lot of adjustment when this does not meet the requirements. For other requirements of the Building Decree solutions can be found, such as requirements that apply to usability, daylight, ventilation and fire safety. Nevertheless, the quantity and scope of these solutions have a major impact on the process and financial feasibility. The DSS will be used for vacant social real estate, which means that in this case the requirements of the Building Decree for existing buildings are applying to the social real estate building. According to art. 4.4 of the Building Decree, a free height of at least 2.1 meters applies to existing buildings. As soon as a building has a free height less than 2.1 meters, this building will be unsuitable. (Ministery of Internal Affairs, 2019).

Table 8 - Part 1 - Preconditions: aspects and their factors which are included in the DSS

Aspect	Factors	Rating	Description
Procedural	Structural vision	Unsuitable	The municipality has no plans for housing development
		Neutral	The municipality has plans for housing development, but in a different neighborhood than the neighborhood of the social real estate building
		Suitable	The municipality has plans for housing development in the neighborhood of the social real estate building
	Zoning plan	Unsuitable	In conflict with specific zoning plan
		Neutral	In conflict, but municipality is willing to change the zoning plan
		Suitable	Suitable for specific zoning plan

Technical	Adaptability	Unsuitable	Strip building and change load-bearing construction
		Negative	Stripping to load-bearing construction
		Neutral	Adjust façade, interior walls and installations
		Positive	Adjust facade and interior walls
		Suitable	Adjust interior walls
	Monument status	National, provincial or municipal monument	Disadvantageous, adjustments to the outside and inside of the building are very hard to achieve
		Protected city or village view	Less disadvantageous, adjustments to the outside of the building are very hard to achieve
		No monument status	No disadvantageous
	Floor height	< 2.1 meter	Does not meet the requirements of the Building Decree
		> 2.1 meter	Meets the requirements of the Building Decree (for existing buildings)

4.2.2.2 Part 2 - Living Environment

'Part 2 – Living Environment' contains the assessment of the characteristics of the living environment of the vacant social real estate building. The living environment aspects and their factors, shown in Table 9, are fixed and that's why it is rather difficult for a developer to invest in since these factors are influenced by demographic aspects and governmental development. Living environment is subdivided into two aspects, namely 'Composition' and 'Facilities' with their associated factors. The literature study in Chapter 2 shows that the target groups attach importance to the composition of the neighborhood and to the range of facilities they will find in their neighborhood. That is why these two aspects, 'Composition' and 'Facilities', will be included in the DSS.

The 'Composition' aspect is divided into three different factors: 'Degree of urbanity', 'Majority of residents' and 'Insecurity in the neighborhood'. Each neighborhood or municipality has been assigned to an urbanity class by the Statistics Netherlands (2019), based on the environmental address density. The determination of the urbanity class is shown in Table 9 under 'Degree of urbanity'. Some target groups indicate that they prefer living in an environment with other people having some similar characteristics, like their ages. Therefore, a factor is created that regards the composition of the neighborhood based on generations, called 'Majority of residents'. The 'Majority of residents' means that there is a difference of 1000 people between the largest and second largest generation. If this is the case, the largest generation is in the majority, if not, the 'Mix' option must be chosen. For each neighborhood or municipality the data for the 'Degree of urbanity' and the 'Composition' can be found via https://www.cbs.nl/nl-nl/dossier/nederland-regionaal/wijk-en-buurtstatistieken/kerncijfers-wijken-en-buurten-2004-2019.

The Statistics Netherlands provide insight to the developments of social insecurity in the Safety Monitor. Various target groups indicate that they think it is important to feel safe in their living environment. Therefore, the data from the Safety Monitor will be used to assess the safeness of neighborhoods in which a vacant social real estate building is located. The

monitor indicates whether the feeling of insecurity in a neighborhood is higher than national average ('Unsafe feeling'), national average ('Safe feeling') or lower than national average ('Safest feeling') (Akkermans, Gielen, Kloosterman, Knoops, Linden and Moons, 2018). The Safety Monitor can be found via https://www.cbs.nl/nl-nl/publicatie/2018/09/veiligheidsmonitor-2017, in which the safety is represented per police unit and districts.

The proximity of the facilities is assessed on the 'Walking distance', 'Cycling distance' or 'Distance by car'. The acceptable walking- and cycling distance depends on each person, on the purpose and on the quality of the route, which makes it very difficult to determine an acceptable walking and cycling distance. De Haan and Oostenbrink (2016) have performed an analysis to determine the average acceptable walking distance. The analysis, based on various studies, shows that 0.5 km is considered as an acceptable walking distance (de Haan and Oostenbrink, 2016). The acceptable cycling distance has been determined in a study by the 'Kennisinstituut voor Mobiliteitsbeleid' (KiM; English translation: Knowledge Institute for Mobility Policy). The KiM has looked at both the acceptable cycling distance for a normal bicycle and an electric bicycle. For this research, only the acceptable distance for a normal bicycle has been considered. According to the KiM, this distance is approximately 7.5 km (Schaap, Harms, Kansen and Wüst, 2015). If the distance is more than 7.5 km, it is assumed that this will be covered by car (or another motorized vehicle). Information about the distance from the building to the various facilities can be obtained by using a geographic information system (GIS).

Table 9 - Part 2 - Living Environment: aspects and their factors which are included in the DSS

Aspect	Factors	Rating	Description
Composition	Degree of urbanity	Not urban	< 500 addresses per km²
		Little urban	500 – 1,000 addresses per km²
		Moderately urban	1,000 – 1,500 addresses per km²
		Strong urban	1,500 – 2,500 addresses per km²
		Very urban	≥ 2,500 addresses per km²
	Majority of residents	Baby boom	> 60 years
		Generation X	40 – 60 years
		Generation Y	25 – 40 years
		Generation Z	< 25 years
		Mix	Mix of ages
	Insecurity in the neighborhood	Unsafe feeling	Higher than average
		Safe feeling	Average
		Safest feeling	Lower than average
Facilities	Proximity to supermarket and drugstore	Walking distance	< 0.5 km
		Cycling distance	0.5 – 7.5 km
		Distance by car	> 7.5 km
	Proximity to healthcare and pharmacy	Walking distance	< 0.5 km
		Cycling distance	0.5 – 7.5 km
		Distance by car	> 7.5 km
	Proximity to daycare, primary or high school	Walking distance	< 0.5 km
		Cycling distance	0.5 – 7.5 km
		Distance by car	> 7.5 km

	Proximity to university campus	Walking distance	< 0.5 km
		Cycling distance	0.5 – 7.5 km
		Distance by car	> 7.5 km
	Proximity to public transport	Walking distance	< 0.5 km
		Cycling distance	0.5 – 7.5 km
		Distance by car	> 7.5 km
	Proximity of green facilities	Walking distance	< 0.5 km
		Cycling distance	0.5 – 7.5 km
		Distance by car	> 7.5 km
	Proximity to playground	Walking distance	< 0.5 km
		Cycling distance	0.5 – 7.5 km
		Distance by car	> 7.5 km

4.2.2.3 Part 3 - Building Potential

In contrast to the living environment, it is surely possible making investments in the social real estate buildings. As a result, 'Part 3 - Building Potential' will be approached differently than 'Part 2 - Living Environment'. This part will regard what the existing social real estate building has to offer and how achievable it is to realize the preferences of the target groups. Building potential is subdivided into two aspects, namely 'Physical' and 'Functionality', each has its own factors which are shown in Table 10. The factors for these two aspects have been determined based on the literature and they are often mentioned as important by the different generations.

The 'Physical' aspects consist of the factors 'Energy rating', 'Lifecycle resistant' and 'Building accessibility'. Energy rating is considered as important from two different points of view: sustainability and cost-saving. The younger generation, such as generation Y, is increasingly aware that sustainability can no longer be avoided. This generation is fully engaged in living as sustainable as possible, which is the reason why they believe it is important that their house will be energy efficient. Generation X and the Baby Boomers consider having an energy-efficient house important from the point of view of energy saving and therefore lower monthly energy costs. In addition, it appears that all generations label their living comfort as important. Energy label B or higher ensures a comfortable living environment and a considerable saving on energy costs (Energielabel, 2019). Therefore, the social real estate building will be upgraded to energy label B or higher.

The other two factors 'Lifecycle resistant' and 'Building accessibility' are especially important for the older generation, the Baby Boomers. The elderly prefer a lifecycle resistant apartment that is preferably located on the ground floor. If not, they will only consider the apartment as attractive if the building is equipped with a lift. In addition, it is important for the Baby Boomers that the main entrance of the social real estate building is easily accessible in case they will become disabled. In the factor 'Building accessibility' will be investigated which adjustments should be required to gain easy access to the main entrance. Such entrances are considered easy to access if they are accessible for elderly as well as for disabled people without any steps or obstacles, easy to access with wheelchairs and walkers.

The 'Functionality' aspect shows two factors: 'Type of apartment' and 'Outside space'. All target groups have living preferences regarding their type of apartment. It is indicated how many square meters they would like to have and what kind of facilities they would prefer for

their own use. These living preferences have been translated into five different apartment types and the factor ‘Outside space’. The apartment types are assessed with the 'Type of apartments' factor. The different types of apartments are based on a literature review and rental brochure. The apartments 'Single micro-apartment', 'Luxury micro-apartment' and '2-person micro apartment' have been adopted from the research by Dopper et al. (2018). The other two apartments, '2-person apartment' and 'Luxury 2-person apartment' are based on data in the rental brochures of the new-build project Cadenza, in Amersfoort (Cadenza, 2019). The different types of apartments, whereby the number of square meters is shown in usable floor space (UFA), are:

- Simple micro-apartment
  - Floor surface of ± 20m²
  - Studio
  - Open kitchen
  - Bathroom
  - Primary target group: Students
- Luxury micro-apartment
  - Floor surface of ± 40m²
  - One bedroom
  - Open kitchen
  - Bathroom
  - Primary target group: Young Digitals
- 2-person micro-apartment
  - Floor surface of ± 50m²
  - One bedroom
  - Half open kitchen
  - Bathroom
  - Storage space
  - Primary target group: Urban Balancers; Good City Life; Social Tenants
- 2-person apartment
  - Floor surface of ± 80m²
  - Two bedrooms
  - Half open kitchen
  - Bathroom
  - Storage space
  - Primary target group: Aged Simplicity
- Luxury 2-person apartment
  - Floor surface of ± 100m²
  - Three bedrooms
  - Half open kitchen
  - Bathroom
  - Storage space
  - Primary target group: Mature Middle Class; Well Deserved Enjoyment

The preferences of 'Outside space' will be considered. All target groups indicate that they would like to have an outside space. However, there is a difference between wishes of the target groups whether they want to have a private or shared outside space.

Table 10 - Part 3 - Building Potential: aspects and their factors which are included in the DSS

Aspect	Factors	Rating	Description
Physical	Energy rating	Energy label A	If the building has the preferred energy label of a target group, the maximum number of points is awarded to the target group. The score is lower for each less energy-efficient energy label.
		Energy label B	
		Energy label C	
		Energy label D	
		Energy label E	
		Energy label G	
		Unknown	
	Lifecycle resistant	Lifecycle resistant	Ground floor or multi-floor with lift facility
		Not lifecycle resistant - Achievable	The building has a clear location (lift shaft) for the lift facility
		Not lifecycle resistant - Hard to achieve	The building has no clear location (lift shaft) for the lift facility
		Not lifecycle resistant - Very hard to achieve	The building has a national, provincial or municipal monument status, making it very difficult to install a lift installation
	Building accessibility	Good accessibility	The entrance to the building is easily accessible for people with disability
		No good accessibility - Achievable	The entrance to the building is not easily accessible for people with disabilities; minor adjustments are needed
		No good accessibility – Hard to achieve	The entrance to the building is not easily accessible for people with disabilities; major adjustments are needed
		No good accessibility - Very hard to achieve	The building has a national, provincial, municipal, or protected city or village view monument status; making adjustments to the entrance for people with disabilities will be very hard
Functionality	Type of apartment Simple micro Luxury micro 2-person micro 2-person Luxury 2-person	Easily achievable	Small adjustments needed; the building generally complies with the layout for the realization of the type of apartment
		Achievable	Adjustments are needed to realize the type of apartment; these adjustments do have influence on the load-bearing construction
		Hard to achieve	Adjustments are needed to realize the type of apartment; these adjustments do have influence on the load-bearing construction
		Very hard to achieve	Adjustments to the building structure are necessary for the realization for the type of apartment, but due to the national, provincial or municipal monument status these adjustments are not allowed

	Outside space Shared … Private …	Achievable	Adjustments are needed to realize the type of apartment; these adjustments do have influence on the load-bearing construction or cannot make use of the existing (installation) systems
		Hard to achieve	Adjustments are needed to realize the type of apartment; these adjustments do have influence on the load-bearing construction or cannot make use of the existing (installation) systems
		Very hard to achieve	Adjustments to the building structure are necessary for the realization for the type of apartment, but due to the national, provincial or municipal monument status these adjustments are not allowed

4.2.2.4 Part 4 - Financial Assessment

Due to the lack of financial knowledge, 'Part 4 - Financial Assessment' has been outsourced to an Arcadis cost expert. The data of 'Bouwkostenkompas' is used to develop the financial assessment model. 'Bouwkostenkompas' always considers the most recent key figures and the location of the project (Bouwkostenkompas, 2020). According to the Arcadis cost expert, the key figures of the 'Bouwkostenkompas' predict higher financial costs than reality. Therefore, the financial assessment model is developed based on the key figures of the location Limburg, since the key figures for Limburg are generally lower than those for the Randstad. In this way an attempt is made to give a rough, average financial assessment, since the DSS does not consider the location of the building. Based on the key figures of 'Bouwkostenkompas' it is possible to determine the real estate value and construction costs. The key figures depend on the location of the social real estate building, the condition of the building, its current function and the type of apartments to be realized. Therefore, a different financial assessment must be made for each social real estate building in combination with the type of apartments to be realized. In addition, a monument status also has a lot of influence on the financial assessment.

Since the key figures are not known for the realization of each type of apartment, a financial assessment model will be developed which makes it possible to assess three type of apartments with the DSS. The financial assessment model contains the data and calculations for making a financial assessment for transforming social real estate into either (1) 'Simple micro 20m²', (2) 'Luxury micro apartment 40m²' or (3) '2-person apartment 80m²'. The financial assessment model has been developed by an Arcadis cost expert, therefore the development of this model will not be explained further. Data is necessary to run the financial assessment model. These data indicate the maximum rent that different target groups are willing to pay and the preferred type of apartment per target group. These data are based on the living preferences of the target groups as investigated in Chapter 2 and shown in Table 11. However, the model can only provide a financial assessment for the transformation of social real estate into apartments of either 20m², 40m² or 80m². Therefore, a financial assessment can only be determined for the target groups 'Students', 'Young Digitals', 'Good City Life', 'Social Tenants' and 'Aged Simplicity' based on their living preferences.

Table 11 - Part 4 - Financial Assessment: data input based on the preferences of the target groups for the financial assessment (Wisman, 2016; Corrales, 2017; Hoekman, 2019)

Target group	Preferred maximum rent per month	Preferred type of apartment	
Students	€400	Simple micro apartment	20m²
Young Digitals	€600	Luxury micro apartment	40m²
Urban Balancers	€700	2-person micro apartment	50m²
Good City Life	€700	2-person apartment	80m²
Social Tenants	€700	2-person apartment	80m²
Mature Middle Class	€850	Luxury 2-person apartment	100m²
Well Deserved Enjoyment	€800	Luxury 2-person apartment	100m²
Aged Simplicity	€800	2-person apartment	80m²

4.2.3 Evaluation Matrix

An evaluation matrix will be designed to organize the target groups, factors and living preferences. The evaluation matrix reflects the characteristics of a given set of alternatives that are determined by a set of factors. The evaluation matrix itself gives a clear picture of the general differences between the alternatives, sometimes these differences are so clear that a choice can be made immediately (Voogd, 1982). The evaluation matrix will be designed based on the previously determined target groups and factors. The living preference for each target group and their factors can be determined based on the literature study in Chapter 2. To clarify, an example and a brief explanation of how, “proximity to facilities” is been interpreted per target group. As previously described, the acceptable walking and cycling distance per person differs. That is why the characteristics of the target group have been considered after assessing whether a target group prefers 'Walking distance' or 'Cycling distance'. If a target group prefers to have the facility 'close by', this is interpreted as 'Cycling distance' for the younger generations, such as generations Z and Y, but as 'Walking distance' for the older generations, such as generation X and baby boom. Only if clear 'Walking distance' or 'Cycling distance' was indicated by the target group, this interpretation is not applied. This way, the evaluation matrix creates a clear overview of the living preferences of each target group. The ‘Evaluation Matrix’ is shown in Figure 9, a clearer overview is shown in Appendix 3.

EVALUATION MATRIX								
	Target groups							
Factors	Students	Young Digitals	Urban Balancers	Good City Life	Social Tenants	Mature Middle Class	Well Deserved Enjoyment	Aged Simplicity
PART 2 - LIVING ENVIRONMENT								
Composition: Degree of urbanity	Strong urban	Strong urban	Very urban	Very urban	Moderately urban	Little urban	Little or strong urban	Little urban
Composition: Majority of residents		Mix	Mix	Mix	Generation X	Baby boom	Baby boom	Baby boom
Composition: Insecurity in the neighborhood	Safe feeling	Safe feeling	Safe feeling	Safe feeling	Safe feeling	Safest feeling	Safest feeling	Safest feeling
Facilities: Proximity to supermarket and drugstore	Cycling distance	Cycling distance	Cycling distance	Cycling distance	Walking distance	Walking distance	Walking distance	Walking distance
Facilities: Proximity to healthcare and pharmacy	Cycling distance	Cycling distance	Cycling distance	Cycling distance	Walking distance	Walking distance	Walking distance	Walking distance
Facilities: Proximity to daycare, primary or high school			Cycling distance	Cycling distance				
Facilities: Proximity to university campus	Cycling distance	Cycling distance						
Facilities: Proximity to public transport	Cycling distance	Cycling distance	Walking distance	Walking distance	Walking distance	Walking distance	Walking distance	
Facilities: Proximity of green facilities	Cycling distance	Cycling distance	Cycling distance	Cycling distance	Cycling distance	Walking distance	Cycling distance	Walking distance
Facilities: Proximity to playground			Walking distance	Walking distance			Cycling distance	
PART 3 - BUILDING POTENTIAL								
Physical: Energy rating	Energy label B	Energy label B	Energy label A	Energy label B	Energy label A	Energy label A	Energy label A	Energy label A
Physical: Lifecycle resistant						Lifecycle resistant, elevator is required if there are multiple stories	Lifecycle resistant, elevator is required if there are multiple stories	Lifecycle resistant, elevator is required if there are multiple stories
Physical: Building accessibility						Good	Good	Good
Functionality: Type of apartment in m²	20	40	50	80	80	100	100	80
Functionality: Outside space	Shared	Shared	Privately	Shared	Shared	Privately	Privately	Privately
PART 4 - FINANCIAL ASSESSMENT								
Budget per month	€ 400,00	€ 600,00	€ 700,00	€ 700,00	€ 700,00	€ 850,00	€ 800,00	€ 800,00

Figure 9 - Evaluation Matrix used as input for the DSS

4.3 MODEL COMPONENT

The model component has been structured in four consecutive parts ‘Part 1 - Preconditions’, ‘Part 2 - Living Environment’, ‘Part 3 - Building Potential’ and ‘Part 4 - Financial Assessment’ as shown in Figure 8. This chapter explains the interaction with the database component, the techniques used to process the data and the way the output is determined. Techniques are applied to determine the suitability of the target groups for housing in social real estate. The database component ensures the input of the living preferences and the importance of these living preferences for each target group. As described earlier, the financial assessment model was developed by a cost expert from Arcadis, therefore 'Part 4 - Financial Assessment' will not be discussed in this section.

4.3.1 PART 1 - PRECONDITIONS

‘Part 1 - Preconditions’ is divided in two aspects: ‘Procedural’ and ‘Technical’. For the ‘Procedural’ aspect, a 'GO' / 'NO GO' procedure applies; if one of the two factors is ‘Unsuitable’, the advice is not to continue with the development of housing. The ‘Technical’ aspect is to be implemented to create awareness, these factors reflect in case development will become complicated and will have a major impact on the process and financial feasibility. The advice 'Development will be complicated' will be given if 'Adaptability' is ‘Unsuitable’ or ‘Negative’, or if 'Monument status' is ‘National, provincial or municipal monument’, or if 'Floor height' is ‘< 2.1 meter’. Based on a drop-down menu, a choice can be made for each factor between the various rating options described in Table 8.

Figure 10 shows how the preconditions have been designed in the DSS including two possible outcomes; two negative variants of possible outcomes are shown too. However, it can also be that both aspects are positive and a 'GO' is given in both cases. The left side of the figure indicates that the development will be complicated, since the building has been designated as a ‘National, provincial or municipal monument’. The right side of the figure

indicates that factor 'Zoning plan' is 'Unsuitable', which immediately indicates that it seems better to stop the development, because of the fact that the location is not intended for housing; other developments would probably fit better.

PART 1 - PRECONDITIONS		
	Factors	Rating option Explanation rating option
Procedural	Structural vision	Suitable
	Zoning plan Search option	Neutral
	GO	
Technical	Adaptability	Neutral
	Monument status Search option	National, provincial or municipal monument
	Floor height	> 2.1 meter
	Development will be complicated	

PART 1 - PRECONDITIONS		
	Factors	Rating option Explanation rating option
Procedural	Structural vision	Neutral
	Zoning plan Search option	Unsuitable
	NO GO	
Technical	Adaptability	
	Monument status Search option	
	Floor height	

Figure 10 - Design 'Part 1 - Preconditions' of the DSS with two examples of possible outcomes

4.3.2 PART 2 - LIVING ENVIRONMENT

For 'Part 2 - Living Environment', the Weighted Sum Method (WSM) will be used to determine the suitability of the living environment factors for each target group. As described before, the WSM is a multi-criteria decision analysis technique which is popular, well-known and an easily implemented subjective decision-making method (Mateo, 2012; Sorooshian and Parsia, 2019). If there are i target groups and j factors, the suitability of the target groups can be calculated using the following formula:

$$A^*_{wsm} = \sum_{i}^{j} a_{ij} w_j$$

In this formula A^*_{wsm} is the weighted sum score of the target group, a_{ij} is the value of the i^{th} target group in terms of the j^{th} factor. The value w_j indicates the weight of importance of the j^{th} factor. If all factors meet the desired preferences, the sum of each target group is equal (Mateo, 2012). The target group with the highest value for A^*_{wsm} is the most suitable target group for housing in the considered social real estate.

The value of a_{ij} can be 1 or 0. The value is equal to 1 when the factor meets the preferences of the target group. In addition, there is an exception for the factors of the aspect 'Facilities'. In case a target group indicates that facilities should be within cycling distance, but the facilities are within walking distance, the value of a_{ij} is also assigned with 1. In all other cases, the value of a_{ij} is equal to 0.

The value of w_j is per factor specific for each target group. This value indicates how important the factor is for the target group. The use of the constant sum approach ensures that the sum of the alternatives is always equal. The constant sum approach means that per

target group 100 points will be distributed among the factors. The higher the number of points a factor is to be awarded, the more important this factor is for the target group (Voogd, 1982). The weighting factors are assigned to factors for each target group and shown in the 'Weighting Matrix' in Figure 11. For a clearer overview, the 'Weighting Matrix' can be found in Appendix 4. The weighting factors are determined based on the literature study mentioned in Chapter 2. Disadvantage of using these methods is that weighting factors are determined by the interpretation of scientific literature. The 'Weighting Matrix' indicates, for example, that the target group 'Students' finds the distance to the supermarket and drugstore, the university, and public transport very important. They hardly attach any value to the distance to healthcare and pharmacy, and to green facilities. The other facilities, like daycare, primary or high school and the playground, seem not important to them also, because they do not (yet) use these facilities.

WEIGHTING MATRIX									
		Target groups							
	Factors	Students	Young Digitals	Urban Balancers	Good City Life	Social Tenants	Mature Middle Class	Well Deserved Enjoyment	Aged Simplicity
Composition	Degree of urbanity	6	16	16	16	16	18	18	18
	Majority of residents	0	4	10	4	8	8	8	8
	Insecurity in the neighborhood	6	4	4	6	4	6	6	6
Facilities	Proximity to supermarket and	24	20	22	20	22	28	26	30
	Proximity to healthcare and pharmacy	8	4	20	18	22	28	26	30
	Proximity to daycare, primary or high school	0	0	2	2	0	0	0	0
	Proximity to university campus	24	12	0	0	0	0	0	0
	Proximity to public transport	24	20	20	18	22	2	2	0
	Proximity of green facilities	8	20	4	14	6	10	10	8
	Proximity to playground	0	0	2	2	0	0	4	0
	sum	100	100	100	100	100	100	100	100

Figure 11 - 'Weighting Matrix' used as input for the DSS

The design of ‘Part 2 - Living Environment’, shown in Figure 12, is similar to the design of ‘Part 1 - Preconditions’. The factors have been listed and a drop-down menu can be used to make a choice between the rating options per factor. Each factor has its own rating options as described in Table 9. The chosen rating option will be compared with the living preferences from the 'Evaluation Matrix' and by means of a formula the results will be calculated. The formula uses the ‘IF’ function by which logical comparisons can be made. A comparison can show two results: the comparison is ‘True’, or the comparison is ‘False’. The ‘IF’ function will be ‘True’, if the social real estate meets the desired living preferences of the target group. With an exception for the factors of the aspect ‘Facilities’: if a target group indicates that facilities should be within cycling distance, but these are within walking distance, the ‘IF’ function will also be ‘True’. If it appears that the ‘IF’ function is ‘True’, a_{ij} will have a value of 1. In all other cases, if the ‘IF’ function is ‘False’, a_{ij} will have a value of 0. The outcome of the ‘IF’ function will be multiplied by the weighting factor as determined in the 'Weighting Matrix'. The formula will be entered in Excel as follows:

$$= (IF('Living\ Environment'!\#cel = 'Evaluation\ Matrix'!\#cel; 1; 0)) * 'Weighting\ Matrix'!\#cel$$

For clarification, the mentioned WSM formula has been used here, where the ‘IF’ function determines the value of a_{ij} and the 'Weighting Matrix' factor determines the value of w_j.

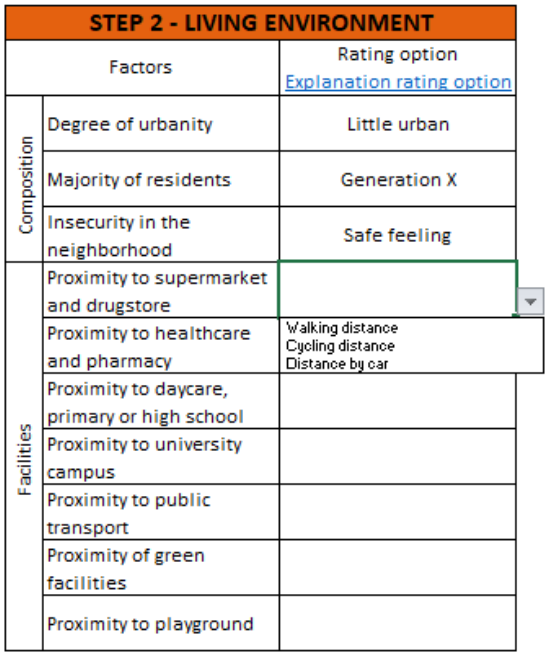


Figure 12 - Design 'Step 2 - Living Preferences' of the DSS

4.3.3 PART 3 - BUILDING POTENTIAL

Compared to the previous two parts, this part shall be designed slightly different. In 'Part 3 - Building Potential' the potential of the building has to be investigated. The current situation of the social real estate building will be analyzed. Afterwards it will be assessed how the facility as stated by the factor can easily be realized if the building does not have this facility. If the rating options have been expressed qualitatively, a comparison between the target groups will be difficult. Therefore, the rating options will be quantified and to ensure consistency, the rating method will be used to assign scores to the rating options. This means that a maximum of 100 points can be achieved for 'Part 3 - Building potential'. Because 'Part 3 - Building Potential' has two aspects, a maximum of 50 points can be divided between the two aspects. The 'Physical' aspect consists of three factors and the 'Functionality' aspect consists of two factors, which means that the factors of the 'Functionality' aspect will count more heavily. This also corresponds to the literature: target groups attach higher value to their type of apartment and the availability of outside space.

As mentioned above the 'Physical' aspect consists of three factors, which means that each factor can achieve a maximum score of 16.67 (= 50/3). With the assessment of the 'Energy rating' factor, the decision maker must indicate what the energy rating of the building is. The DSS will determine the achievability for the preferred energy label. If the building has the preferred energy label of the target group or higher, the maximum number of points of 16.67 is awarded. For example, in the case that a target group prefers energy label B, energy label A is also awarded with 16.67. To ensure that the effort of upgrading to a higher energy label remains the same, the same formula for calculating scores between energy labels is used, which is shown in Table 12.

Table 12 - Score per rating option to determine the achievability of the 'Energy rating' factor of the 'Physical' aspect during 'Part 3 - Building Potential'

Energy rating	Formula	Preference for energy label A	Formula	Preference for energy label B
Energy label A	50/3	16.67	50/3	16.67
Energy label B	16.67 – (16.67/7)	14.29	50/3	16.67
Energy label C	14.29 – (16.67/7)	11.90	16.67 – (16.67/7)	14.29
Energy label D	11.90 – (16.67/7)	9.52	14.29 – (16.67/7)	11.90
Energy label E	9.52 – (16.67/7)	7.14	11.90 – (16.67/7)	9.52
Energy label F	7.14 – (16.67/7)	4.76	9.52 – (16.67/7)	7.14
Energy label G	4.76 – (16.67/7)	2.38	7.14 – (16.67/7)	4.76
Unknown	0	0	0	0

The assessment of the other two factors, 'Lifecycle resistant' and 'Building accessibility' of the 'Physical' aspect, will be slightly different. The decision maker analyzes the current state of the social real estate building. If the building is not lifecycle resistant and/or the entrance has no good accessibility for people with a disability, the decision maker has to estimate the achievability of realizing these facilities. The rating options of the factors 'Lifecycle resistant' and 'Building accessibility' and their scores are shown in Table 13.

Table 13 - Score per rating option to determine the achievability of the 'Lifecycle resistant' and 'Building Accessibility' factors of the 'Physical' aspect during 'Part 3 - Building Potential'

Factors	Rating	Score	Determination score
Lifecycle resistant	Lifecycle resistant	16.67	50/3
	Not lifecycle resistant - Achievable	11.11	16.67 – (16.67/3)
	Not lifecycle resistant - Hard to achieve	5.56	11.11 – (16.67/3)
	Not lifecycle resistant - Very hard to achieve	0	5.56 – (16.67/3)
Building accessibility	Good accessibility	16.67	50/3
	No good accessibility - Achievable	11.11	16.67 – (16.67/3)
	No good accessibility - Hard to achieve	5.56	11.11 – (16.67/3)
	No good accessibility - Very hard to achieve	0	5.56 – (16.67/3)

The 'Functionality' aspect consists of two factors, which means that each factor can achieve a maximum score of 25 (= 50/2). The assessment of the 'Type of apartment' and 'Outside space' factors is the same as the assessment of the 'Lifecycle resistant' and 'Building accessibility' factors. The decision-maker first analyzes the social real estate building, then gives an assessment of the achievability to realize the facilities as stated by the factor. The rating options of the factors 'Type of apartment' and 'Outside space' and their scores are shown in Table 14.

Table 14 - Score per rating option to determine the achievability of the 'Type of apartment' and 'Outside space' factors of the 'Functionality' aspect during 'Part 3 - Building Potential'

Factors	Rating	Score	Determination score
Type of apartment	Easily achievable	25	50/2
	Achievable	16.67	25 – (25/3)
	Hard to achieve	8.33	16.67 – (25/3)
	Hardly to achieve	0	0
Outside space	… outside space available	25	50/2
	… outside space achievable	12.50	25 – (25/2)
	… outside space very hard to achieve	0	12.50 – (25/2)

The design of 'Part 3 - Building Potential' is shown in Figure 13. The factors have been listed and a drop-down menu can be used to make a choice of the rating options per factor. Each factor has its own rating options as described in Table 10. Multiple assessments must be made for the 'Type of apartment' and 'Outside space' factors. Because five different apartment types are designed based on living preferences, the achievability must be assessed per type of apartment. The living preferences of the target groups indicate that they prefer shared or private outside spaces, therefore the achievability of a shared or privately outside space must also be assessed separately. If the achievability has been determined per factor, the 'Results' will show the scores as previously determined per factor. Ultimately, the scores of both the 'Physical' and 'Functionality' aspects are added together, which determines the final score of each target group for 'Part 3 - Building Potential'. The target group that is closest to 100 will need the least adjustments to meet their living preferences.

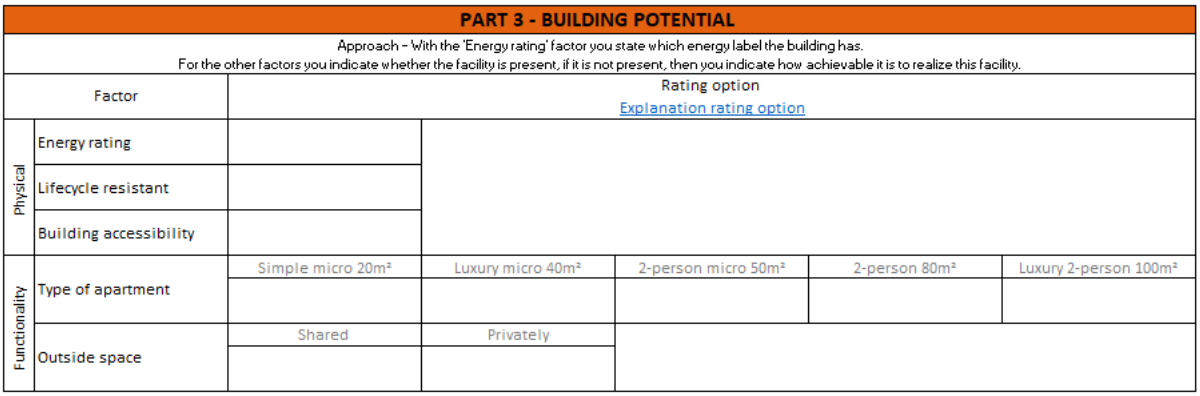


Figure 13 - Design 'Step 3 - Building Potential' of the DSS

4.3.4 PART 4 - FINANCIAL ASSESSMENT

The financial assessment is developed by an Arcadis cost expert and shown in Appendix 5. Therefore, the development and the underlying calculations of this model will not be discussed. However, a brief explanation will be given of the design of 'Part 4 - Financial Assessment' in the DSS. To perform the financial assessment, data is necessary from the decision maker. To be able to make a financial assessment it is important to know how many apartments of each type of apartment, in this case only the apartments with an UFA of 20m², 40m² and 80m², can possibly be developed in the social real estate building. The decision maker needs to enter the total number of gross floor area (GFA) in square meters of the social real estate building. The GFA is the floor area including everything such as facades, load-bearing walls, stair holes, elevator shafts and voids. After that the decision maker will

have to estimate what percentage of this GFA will be used for corridors, technical rooms and other rooms beside the apartments. If multiple floors are identical in terms of m² GFA, the decision maker must enter the number of floors, in order to make the calculation of the number of apartments more accurate. The design of 'Part 4 - Financial Assessment' is shown in Figure 15. As described before, the financial assessment will only be carried out for the target groups 'Students', 'Young Digitals', 'Good City Life', 'Social Tenants' and 'Aged Simplicity'. The financial assessment includes the calculations of the real estate value after transformation and the total construction costs for these target groups, it does not include the purchase and land costs. With the calculated real estate value and construction costs it is possible to calculate the 'value to cost ratio'. The formula used to calculate the value to cost ratio is $(\text{Real estate value} - \text{Construction costs}) / \text{Construction costs}$. The value to cost ratio can indicate whether the transformation is financially feasible for a target group. If the value to cost ratio is higher than 30%, the transformation can be considered financially feasible, although it remains a rough estimate.

PART 4 - FINANCIAL ASSESSMENT			
	Assessment		
m² GFA Social Real Estate Building			
% m² GFA for corridors and others			
m² GFA for realization apartments	0		
If the floors are identical in terms of m² GFA, enter the number of floors			
Number of floors			
m² GFA per floor for realization apartments			
	Simple micro 20m²	Luxury micro 40m²	2-person 80m²
Number of apartments	0	0	0

Figure 14 - Design 'Part 4 - Financial Assessment' of the DSS

4.3.5 Users input in Decision Support System

To be able to use the DSS, it is up to the user, also known as the decision maker, to collect the necessary information as input for the DSS. When a decision maker wants to use the DSS, it is assumed that he/she wants to investigate the suitability of target groups for housing in transformed social real estate. The decision maker must collect the information as shown in Figure 15 in the 'Users input' box to be able to assess the consecutive parts of the DSS. When all the consecutive parts are assessed the DSS will process this information into the results for each part.

'Part 1 – Preconditions' will show a 'GO' or 'NO GO' for the 'Procedural' aspects and a 'GO' or 'Development will be complicated' for the 'Technical' aspect. An initial assessment of difficulties for the transformation at first sight will be made. When the 'Procedural' aspect displays a 'NO GO' as result, the advice is not to continue with the development of housing.

The results of 'Part 2 - Living Environment' and 'Part 3 - Building Potential' will be presented together, whereby a target group can achieve a maximum number of 200 points. The two target groups with the highest number of points will be considered as most suitable. For these two target groups the results of 'Part 4 - Financial Assessment' will be interpreted.

The results of 'Part 4 - Financial Assessment' will determine the most suitable target group(s), whereby the value to cost ratio needs to be higher than 30%. A target group will not be considered as suitable when the value to cost ratio is lower than or equal to 30%.

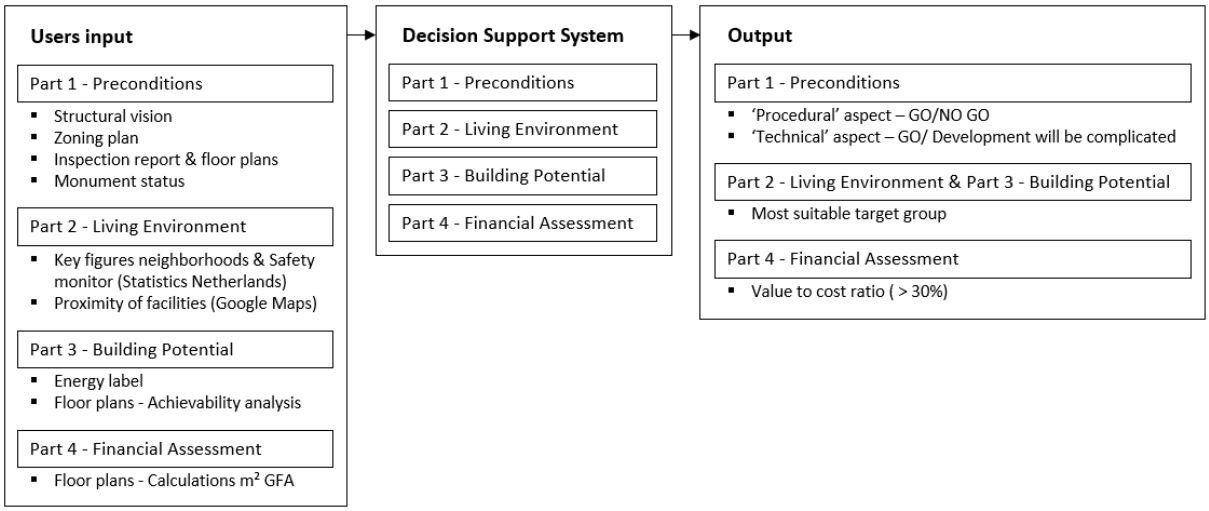


Figure 15 - Users input in DSS & The output provided by DSS

4.4 USER INTERFACE COMPONENT

As discussed earlier, the user interface component is very important and has a major influence on how a DSS is used. The general purpose of user interfaces is to make the design effective, intuitive, user-friendly and visually attractive. An effective user interface provides a context for human interaction and gives directions to decision makers for desired actions. The structure of the user interface is shown in Figure 16.

Figure 16 - Structure user interface component of the DSS

The DSS starts with an intro page where the purpose and structure of the DSS is explained to ensure that the decision maker understands the importance of the DSS. The introduction page is provided with a start button, by clicking on 'Start' the decision maker is redirected to 'Part 1 - Preconditions' and the assessment of the DSS factors can start. While assessing the factors, the decision maker must make a choice between different rating options, which differ per factor. This will result in many various rating options and involves the danger that they will be interpreted differently per decision maker. To ensure that every decision maker of the DSS interprets the rating options in the same way, each part of the DSS is provided with an 'Explanation rating option' link, as shown in Figure 17. By clicking on the 'Explanation rating option' link, the decision maker will be linked to the 'Explanation rating option' sheet and can read here an explanation of each rating option. When the decision maker finishes consulting this sheet, he has the option to return to the step he visited before. Therefore, the 'Explanation rating option' sheet is provided with a 'Go back to Part …' link, by clicking on this link the decision maker will be sent back to the previous part.

Figure 17 - Option in the DSS to consult 'Explanation rating option' during the execution of the DSS

Information must be gathered for all factors to be able to assess that factors and to determine the rating option. For some factors, such as ‘Zoning plan’, ‘Monument Status’, ‘Degree of urbanity’, ‘Majority of residents’ and ‘Insecurity in the neighborhood’, it is possible to retrieve this information from a certain websites on the internet, regardless of the location of the social real estate building. That is why these factors have been provided with a 'Search option' link, as shown in Figure 18. By clicking on this 'Search option' the decision maker will be redirected to a website where information can be found about that factor. Information about the other factors depends on the building and her location. Therefore, these factors cannot be provided with a 'Search option' and the decision maker of the DSS will have to collect information about these factors himself.

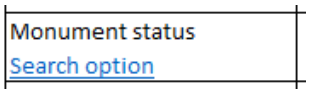


Figure 18 - Option in the DSS to search for information that is needed to assess the factors

When the decision maker has finished filling in one part, it will be necessary to continue filling in the following parts. To make this as clear and easy as possible, every step has been provided with an option as shown in Figure 19. By clicking on 'NEXT' the decision maker will automatically be redirected to the next step. This figure shows that there is also an option to go back to an earlier step by clicking on ‘PREVIOUS’, in case the decision maker wants to change something.

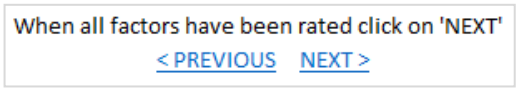


Figure 19 - Option in the DSS to continue to the next step or to go back to the previous step

After having completed all the steps, the decision maker finally arrives at the ‘Results’ sheet. This sheet provides an overview of the finally achieved score that the target groups show. The results of 'Part 1 - Preconditions' have an advising function. The results of 'Part 2 - Living Environment' and 'Part 3 - Building Potential' are reflected in the number of points achieved per target group. In total, the target groups can achieve 200 points, 100 points per step. Finally, the results of 'Part 4 - Financial Assessment' will be displayed. As described earlier, this part represents a rough estimate of the financial budget. These results are taken into consideration when a decision has to be made about the suitability for housing in transformed social real estate of special target groups. These results together ensure that an abundance of information can be seen on the 'Results' sheet. To make all these results clear, a sheet is created where results will be shown structured and where a comparison is made between the results of each target group. To consult this sheet, the option as shown in Figure 20 is included in the 'Results' sheet. To give a clear overview of the design of the DSS the entire DSS is shown in Appendix 6.

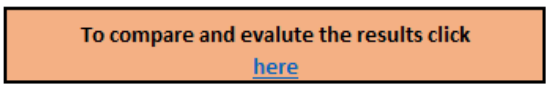


Figure 20 - Option in the DSS to consult the comparison sheet of the results

4.5 CONCLUSION

This chapter shows how the DSS has been developed. The DSS intends to determine the suitability of target groups for adaptive reuse of social real estate into housing. The model component consists of four consecutive parts: 'Part 1 - Preconditions', Part 2 - Living Environment,' Part 3 - Building Potential 'and' Part 4 - Financial Assessment. Each part contributes to determining the suitability of the target groups for housing in social real estate and the research was based on the input from a database component and on the use of decision analyses techniques. The database component includes all the factors and associated rating options that must be assessed. In addition, it contains the living preferences of the target groups which preferences are incorporated in the 'Evaluation Matrix'. It also shows the importance that the target groups attach to the factors that are incorporated in the 'Weighting Matrix'. Finally, the user interface component will ensure that the DSS is effective, intuitive, user-friendly and visually attractive.

'Part 1 - Preconditions' assesses the preconditions that are set. It contains procedural aspects, as well as a general assessment of the technical feasibility. 'Part 2 - Living Environment' assesses the living environment of the social real estate building based on the composition and facilities. In 'Part 3 - Building Potential', the potential of the building will be assessed; here the current state of the social real estate building will be analyzed based on physical and functional aspects. 'Part 4 - Financial Assessment', that is developed by an Arcadis cost expert, shows a financial assessment of the costs and revenues in case of transforming an education building into apartments of either 40m² or 100m². This financial assessment is only intended for social real estate buildings with the current function of education. After having assessed all factors, the results will be calculated and being displayed. 'Part 1 - Preconditions' has an advisory role; an initial estimate has to be made about the possibility of continuing the development. If the outcome of one of the factors as shown in Table 8 is 'Unsuitable', 'Negative', 'National, provincial or municipal monument' or '< 2.1 meter', the transformation will become a difficult and expensive process. If this is the case, it is recommended to reconsider whether the social real estate building is worth the investment. In 'Part 2 - Living Environment' and 'Part 3 - Building Potential' numbers of points, based on the assessment of the factors are awarded to the target groups: 100 points can be collected per part, which means that the maximum number of points a target group can achieve is 200. The target group with the highest number of points is the most suitable for housing in the social real estate building where this DSS is about. 'Part 4 - Financial Assessment' gives a rough indication of the financial assessment per target group.

5 CASE STUDIES

In this chapter four case studies are to be investigated and the developed DSS will be applied to see if the living preferences of the target groups will match the mentioned social real estate buildings. For this the DSS will be applied, to demonstrate how it works and to interpret the results. It is not always possible to obtain all types of information of a social real estate building that are necessary for case studies, due to privacy; however for the four case studies in this chapter, it worked, which is the reason to choose for these four cases. The assessment and application of the DSS will be explained in detail per part in one of the case studies. The other three case studies will only show the assessments of each part and the results of the DSS. Furthermore, two case studies concern vacant social real estate buildings that are for sale or have recently been sold; the other two cases are about buildings that were social real estate buildings before but they already have been transformed into housing or are currently being transformed.

5.1 FORMER SCHOOL BUILDING 'GEWOON LAGER ONDERWIJS'

In this case study, a social real estate building in Rotterdam, shown in Figure 21, is going to be analyzed. This social real estate building previously served as a school, that was known in the area as the 'Gewoon Lager Onderwijs' school. The school has been built in 1912 and is surrounded by a residential building in the Blazoenstraat, the Boudewijnstraat, the Abcoudestraat and the Zwederstraat in the neighborhood called Bloemhof that belongs to a pre-war residential area in the Feijenoord city district of Rotterdam.

The school building contains a gross floor area (GFA) of approximately 960m². Furthermore, the building currently is for sale and plans are being sketched to transform this school building into one that can be used for housing, because of the suitable layout of the building and the convenient and excellent location (Kolpa, 2019). The application of the DSS will be explained for each consecutive part.

Figure 21 - Previously 'Gewoon Lager Onderwijs' (Kolpa, 2019)

5.1.1 PART 1 - PRECONDITIONS

Information must be gathered about the factors of the 'Procedural' and the 'Functionality' aspects which information makes it possible to assess 'Part 1 - Preconditions'. To assess the factors of the ‘Procedural’ aspect, the structural vision of the municipality of Rotterdam and the zoning plan of the location (Zwederstraat 16) have to be investigated. In the structural vision of the municipality of Rotterdam about the future housing developments of the city is stated: "We want to build 50,000 new houses in the period up to 2040" (Gemeente Rotterdam, 2018). This means that the municipality wants to expand their housing stock with 50,000 houses. As the location does not fall within one of the designated development areas, the factor 'Structural vision' will be rated as 'Neutral'. The current zoning plan for the location of this study is the 'Bloemhof', irrevocably established on 22-02-2018. In this zoning plan, the location got the zoning 'Gemengd - 5' and the dual zonings 'Waarde - archelogie 2' and 'Waarde - cultuurhistorie 2'. Within zoning 'Gemengd - 5' living and social facilities are allowed (Ruimtelijkeplannen.nl, 2018). Therefore, the factor ‘Zoning plan’ will be rated as ‘Suitable’. The assessment of the ‘Procedural’ aspect resulted in a ‘GO’, which indicates that there are no difficulties regarding the factors of the ‘Procedural’ aspect at first sight. Since the result is ‘GO’ the assessment of the social real estate ‘Gewoon Lager Onderwijs’ can be continued.

To assess the factors of the 'Functionality' aspect, an inspection report, the monument register and some building plans are to be consulted. Commissioned by Urban Development Rotterdam, a third party has carried out an inspection investigation to review the condition of the building. This report shows that the building is in reasonably good condition. By maintaining the building and carrying out repairs and improvements and also by replacing parts of the building such as the facade, some interior walls, the installations, water drainage, the foundations, the fire ways and the green areas around the building, it can be put into excellent condition. Therefore, the factor ‘Adaptability’ will be rated with ‘Neutral’. The monument register shows that the building does not have a monument status, therefore the 'Monument status' factor will be rated with 'No monument status'. Finally, the 'Floor height' factor will be rated with ‘> 2.1 meter’, since the floor plans show that all floors of the building have the minimum height of 2.1 meters. The assessment of the ‘Technical’ aspect resulted in a ‘GO’, which indicates that there are no difficulties regarding the factors of the ‘Technical’ aspect at first sight. The assessment of 'Part 1 - Preconditions' is shown in Figure 22.

PART 1 - PRECONDITIONS		
	Factors	Rating option Explanation rating option
Procedural	Structural vision	Neutral
	Zoning plan Search option	Suitable
	GO	
Technical	Adaptability	Neutral
	Monument status Search option	No monument status
	Floor height	> 2.1 meter
	GO	

Figure 22 - Assessment 'Part 1 - Preconditions' of the previously 'Gewoon Lager Onderwijs'

5.1.2 PART 2 - LIVING ENVIRONMENT

Information must be collected about the factor 'Composition' and about the 'Facilities' aspects. With this information it is possible to assess 'Part 2 - Living Environment'. All information needed to assess the factors of the 'Composition' aspect can be found via Statistics Netherlands. As described earlier, the information for the 'Degree of urbanity' and 'Majority of residents' factors can be found by consulting the 'Key figures for neighborhoods' investigated by Statistics Netherlands (2019). This shows that the Bloemhof district is situated in a very urban environment, which means that there are more than 2500 addresses per km². Therefore, the factor 'Degree of urbanity' will be rated with 'Very urban'. Furthermore, the generation structure of the Bloemhof district is shown in Table 15. As described before, the 'Majority of residents' means that there is a difference of 1000 people between the largest and second largest generation. The table shows that the difference between the largest generation and the second largest generation is 1,175 people (= 4,500 - 3,325). Therefore, the 'Majority of residents' factor will be rated with 'Generation Y'.

Table 15 – Generation structure of the Bloemhof neighborhood (Statistics Netherlands, 2019)

Factor	Number of residents on January 1, 2019
Baby boom	1,420
Generation X	3,325
Generation Y	4,500
Generation Z	2,875
Total	12,120

The Safety Monitor must be consulted to assess the 'Insecurity in the neighborhood' factor. This monitor shows that the residents of the Feijenoord city district judge their district as unsafe. Here the feelings of insecurity score higher than the average feeling of insecurity does in the rest of the Netherlands (Akkermans et al., 2018). Therefore, the 'Insecurity in the neighborhood' factor will be rated with 'Unsafe feeling'. The proximity of facilities is determined based on Google Maps. The distance to the nearest facility as described by the factor is investigated, the results are shown in Table 16. In addition, the table shows which rating option should be entered in the DSS for each factor. The assessment of 'Part 2 - Living Environment' is shown in Figure 23.

Table 16 - Proximity to facilities from the Zwederstraat (GoogleMaps, 2020)

Factor	Distance to nearest facility	Rating
Proximity to supermarket and drugstore	0.3 km	Walking distance
Proximity to healthcare and pharmacy	0.5 km	Walking distance
Proximity to daycare or primary school	0.2 km	Walking distance
Proximity to university campus	4.0 km	Cycling distance
Proximity to public transport	0.3 km	Walking distance
Proximity to green facilities	1.6 km	Cycling distance
Proximity to playground	0.1 km	Walking distance

PART 2 - LIVING ENVIRONMENT		
Factors		Rating option Explanation rating option
Composition	Degree of urbanity Search option	Very urban
	Majority of residents Search option	Generation Y
	Insecurity in the neighborhood Search option	Unsafe feeling
Facilities	Proximity to supermarket and drugstore	Walking distance
	Proximity to healthcare and pharmacy	Walking distance
	Proximity to daycare or primary school	Walking distance
	Proximity to university campus	Cycling distance
	Proximity to public transport	Walking distance
	Proximity of green facilities	Walking distance
	Proximity to playground	Walking distance

Figure 23 - Assessment 'Part 2 - Living Environment' of the previously 'Gewoon Lager Onderwijs'

5.1.3 PART 3 - BUILDING POTENTIAL

To assess the 'Physical' and 'Functionality' aspects, the current building must be analyzed, and information must be collected. With this analysis and relevant information, it will be possible to assess 'Part 3 - Building Potential'. The factors of the 'Physical' aspect will be assessed by investigating which energy label the building has, if the building is lifecycle resistant and if the entrance of the building has good accessibility. Sales data show that the building has energy label G. Therefore, the factor 'Energy rating' will be rated with 'Energy label G'. From the floor plan, as shown in Figure 24, it appears that the building only has a staircase; however, the building does have enough space to provide the facility of an elevator. In figure 24 this space is indicated by a red cross. As the building is not lifecycle resistant, but does have space to install an elevator, the factor 'Lifecycle resistant' will be rated with 'Not lifecycle resistant - Achievable'. The photo in Figure 21 shows that the entrance is easily accessible and that there is no need for stairs or other obstacles to enter the building. Therefore, the factor 'Building accessibility' will be rated with 'Good accessibility'.

To assess the factors of the 'Functionality' aspect, the floor plans of the building will be analyzed. The school building measures approximately 960 m² GFA and has three floors: the ground floor, the first and the second floor. These three floors have all the same layout of rooms and corridors, Figure 24 shows the floor plan of the first floor. Each floor counts four classrooms of approximately 40m² UFA. Since it is not clearly visible in the floor plans which walls are the load-bearing walls, it is assumed that the walls of 400 and 340 mm thick are the load-bearing walls. These load-bearing walls are indicated by a red line in Figure 24. As mentioned, the classrooms measure approximately 40m² UFA; this means that the factor 'Type of apartment - Luxury micro 40m²' will be rated with 'Easily achievable', because these apartments will have the same m² UFA as the classrooms. The factors 'Type of apartment - Simple micro 20m²' and 'Type of apartment - 2-person 80m²' will be rated with 'Achievable'. In case of realization of the simple micro apartment 20m², the classrooms have to be split up by adding partition walls. In addition, when designing these apartments, the windows and the location of the front doors have to be considered.

For the realization of the 2-person apartment 80m² two classrooms will be merged, realized by demolition or partly demolition of the partition wall between those classrooms, naturally considering the stability of the building. To guarantee this stability, it is most optimal to leave at least one meter of a partition wall being connected to the outside facade. For the realization of the other apartments, the 2-person micro apartment 50m² and the luxury 2-person apartment 100m², more adjustments will be required, given the layout of the school. The location of the load-bearing walls shows for sure that the optimum number of apartments cannot be realized along the length of the building. For example, with retention of the load-bearing walls between the corridor and the classrooms, two apartments of 50m² or only one of 100m² could possibly be realized along the length of each floor. In the remaining space, another type of apartment could be realized. However, DSS does not include combining different types of apartments. As for the 'Type of apartment - 2-person micro 50m²' and the 'Type of apartment - Luxury 2-person 100m²' the optimum number of apartments cannot be realized, these factors will be rated with 'Very hard to achieve'.

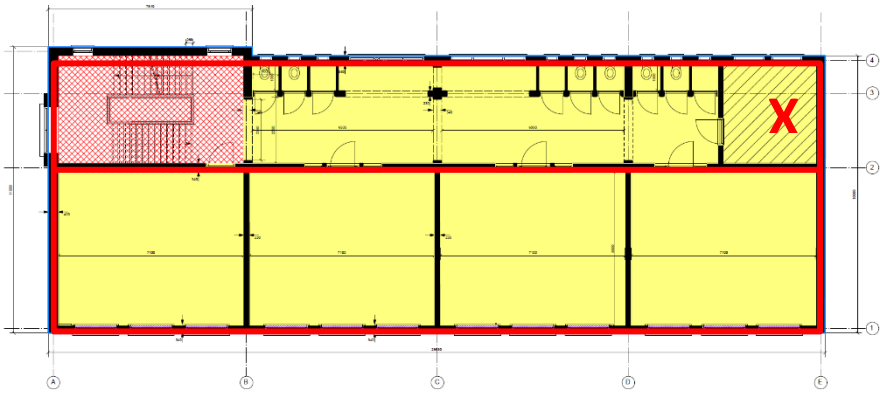


Figure 24 - Floor plan of the previously 'Gewoon Lagere School'

Finally, the 'Outside space' factor will be assessed. This factor has been divided in 'Shared outside space' and 'Privately outside space'. The building is located in the inner area of a housing block, as described earlier, which offers sufficient space for the realization of a shared outside space. Therefore, 'Shared outside space' will be rated with '... outside space available'. However, the building has no private outside space. This possibly can be realized by making an extra construction against the facade on which balconies can be built. Realization of this option requires considering laws and regulations for the necessary permits. Therefore, the factor 'Privately outside space' will be rated with '... outside space achievable'. The assessment of 'Part 3 - Building Potential' is shown in Figure 25.

PART 3 - BUILDING POTENTIAL						
Approach - With the 'Energy rating' factor you state which energy label the social real estate building currently has. For the other factors you indicate whether the facility is present, if it is not present, then you indicate how achievable it is to realize this facility.						
Factor		Rating option Explanation rating option				
Physical	Energy rating	Energy label G				
	Lifecycle resistant	Not lifecycle resistant - Achievable				
	Building accessibility	Good accessibility				
Functionality	Type of apartment	Simple micro 20m²	Luxury micro 40m²	2-person micro 50m²	2-person 80m²	Luxury 2-person 100m²
		Achievable	Easily achievable	Very hard to achieve	Achievable	Very hard to achieve
	Outside space	Shared	Privately			
		... outside space available	... outside space achievable			

Figure 25 - Assessment 'Part 3 - Building Potential' of the previously 'Gewoon Lager Onderwijs'

5.1.4 PART 4 - FINANCIAL ASSESSMENT

To assess the 'Part 4 - Financial Assessment', the current building must be analyzed for the amount of m² GFA. As described in 'Part 3 - Building Potential', the school building contains approximately 960 m² GFA, so 'm² GFA Social Real Estate Building' will be assessed with 960. After this the percentage of this m² GFA that is intended to corridors and others can be assessed in order to be able to determine how many m² GFA remains for realization of the type of apartments. This assessment is based on the layout as shown in Figure 24. In the assessment of the type of apartments it is assumed that the layout of the load-bearing walls does not change, and the walls are being retained. This means that the current corridor and staircase will be preserved. The percentage of m² GFA that is meant for the corridors and others is calculated by dividing the number of m² GFA of the corridors and others by the total number of m² GFA of the social real estate building. The number of m² GFA for the corridors and others is calculated based on Figure 24. It appears that the entire social real estate building contains approximately 380 m² GFA of corridors and others. Therefore, '% m² GFA for corridors and others' will be assessed with 40% (= 380/960). As a result, 576m² GFA remains for the realization of the type of apartments, as shown in Figure 26.

Because the building has three floors with the same layout of rooms and corridors, it is possible to assess 'Number of floors'; therefore, 'Number of floors' is assessed with 3. The DSS automatically calculates how many m² GFA per floor is available for the realization of the type of apartments. Given that the financial assessment only shows calculations for the type of apartments of either 20m², 40m² or 80m², only the number of apartments to be realized for these types will be calculated. As Figure 26 shows, either the type of apartment 'Simple Micro 20m²' could be realized 24 times. 'Luxury Micro 40m²' could be realized 12 times and '2-person 80m²' could be realized 6 times. The assessment of 'Part 4 - Financial Assessment' is shown in Figure 26.

PART 4 - FINANCIAL ASSESSMENT			
	Assessment		
m² GFA Social Real Estate Building	960		
% m² GFA for corridors and others	40%		
m² GFA for realization apartments	576		
If the floors are identical in terms of m² GFA, enter the number of floors			
Number of floors	3		
m² GFA per floor for realization apartments	192		
	Simple micro 20m²	Luxury micro 40m²	2-person 80m²
Number of apartments	24	12	6

Figure 26 - Assessment 'Part 4 - Financial Assessment' of the previously 'Gewoon Lager Onderwijs'

5.1.5 RESULTS

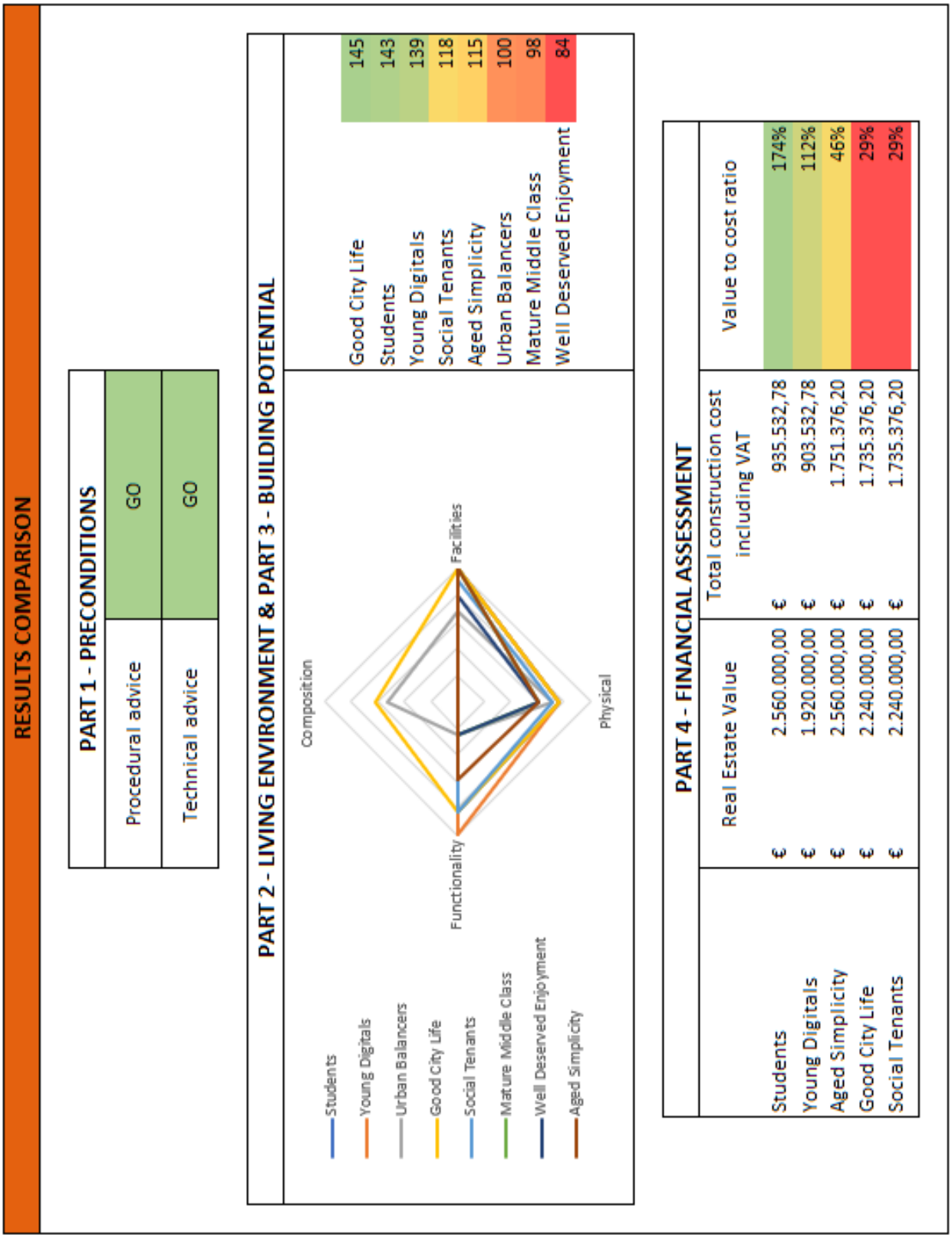


Figure 27 - Results of the assessment 'Gewoon Lagere School' with the DSS

After having assessed all consecutive parts, the results can be interpreted. These results are presented in a clear overview to make comparisons between the target groups easily possible, as shown in Figure 27. As described earlier, the results of 'Part 1 - Preconditions' show an advantageous result. At first sight, both 'Procedural' and 'Technical' do not seem to create any problems for the transformation of the social real estate building 'Gewoon Lager Onderwijs' into housing.

The results of 'Part 2 - Living Environment' and 'Part 3 - Building Potential' indicate that the younger generations are most suitable for housing in this social real estate building, since the social real estate building and its location have a lot of facilities they prefer to have. The reason why the older generations do not achieve these number of points, is because the social real estate building does not have a lift facility and no private outdoor space. Older generations attach higher importance to these facilities compared to the younger generations. From the results of ‘Part 2 - Living Environment’ and ‘Part 3 - Building Potential’ it can be concluded that the target groups ‘Good City Life’ (145/200) and ‘Students’ (143/200) are considered as most suitable target groups.

The results of 'Part 4 - Financial Assessment' can be interpreted that the target group ‘Good City Life’ has a value to cost ratio of 29% and the target group ‘Students’ has a value to cost ratio of 174%. Because the value to cost ratio must be higher than 30% for the financial feasibility of the transformation, the 'Good City Life' target group is not considered feasible for the transformation of ‘Gewoon Lager Onderwijs’. Therefore, the target group 'Students' is most suitable for the transformation of ‘Gewoon Lager Onderwijs’ into housing.

5.2 FORMER SCHOOL BUILDING 'R.K. LAGERE PAREDISSCHOOL'

For this case study, a social real estate building in Roermond, shown in Figure 28, will be analyzed. This building previously served as a school building and is known in the area as the 'R.K. Lagere Paredisschool'. The school building, located in the Begijnhofstraat, has already been transformed into twelve studio apartments commissioned by Rendiz. The transformation started in November 2016 and the apartments have been completed in November 2018 (Rendiz, n.d.). The assessment of the 'R.K. Lager Paredisschool' is based on the floor plans with the original layout of the building when it was still in use as a school. An assessment of each part and the results will be presented.

Figure 28 - Previously 'R.K. Lagere Paredisschool'(Stichting Ruimte Roermond, 2013)

5.2.1 PART 1 - PRECONDITIONS

The information required for assessing 'Part 1 - Preconditions' is collected; after that the factors will be rated as shown in Figure 29. Regarding all factors it appears that the social real estate building has a national monument status. For that reason, to transform this social real estate building and to make adjustments, it will be more difficult to realize and definitely will require permits. Therefore, a warning is given that the development might be complicated.

PART 1 - PRECONDITIONS		
	Factors	Rating option Explanation rating option
Procedural	Structural vision	Neutral
	Zoning plan Search option	Suitable
	GO	
Technical	Adaptability	Neutral
	Monument status Search option	National, provincial or municipal monument
	Floor height	> 2.1 meter
	Development will be complicated	

Figure 29 - Assessment 'Part 1 - Preconditions' of the previously 'R.K. Lagere Paredisschool'

5.2.2 PART 2 - LIVING ENVIRONMENT

The information required for assessing 'Part 2 - Living Environment' is collected, after which the factors will be rated as shown in Figure 30.

PART 2 - LIVING ENVIRONMENT		
Factors		Rating option Explanation rating option
Composition	Degree of urbanity Search option	Strong urban
	Majority of residents Search option	Mix
	Insecurity in the neighborhood Search option	Unsafe feeling
Facilities	Proximity to supermarket and drugstore	Walking distance
	Proximity to healthcare and pharmacy	Cycling distance
	Proximity to daycare or primary school	Cycling distance
	Proximity to university campus	Distance by car
	Proximity to public transport	Walking distance
	Proximity of green facilities	Walking distance
	Proximity to playground	Cycling distance

Figure 30 - Assessment 'Part 2 - Living Environment' of the previously 'R.K. Lagere Paredisschool'

5.2.3 PART 3 - BUILDING POTENTIAL

The floor plans are analyzed for assessing 'Part 3 - Building Potential', after which the factors will be rated as shown in Figure 31.

PART 3 - BUILDING POTENTIAL						
Approach - With the 'Energy rating' factor you state which energy label the social real estate building currently has. For the other factors you indicate whether the facility is present, if it is not present, then you indicate how achievable it is to realize this facility.						
Factor		Rating option Explanation rating option				
Physical	Energy rating	Unknown				
	Lifecycle resistant	Not lifecycle resistant - Achievable				
	Building accessibility	No good accessibility - Achievable				
Functionality	Type of apartment	Simple micro 20m²	Luxury micro 40m²	2-person micro 50m²	2-person 80m²	Luxury 2-person 100m²
		Hard to achieve	Very hard to achieve	Easily achievable	Very hard to achieve	Achievable
	Outside space	Shared	Privately			
		... outside space available	... outside space very hard to achieve			

Figure 31 - Assessment 'Part 3 - Building Potential' of the previously 'R.K. Lagere Paradisschool'

5.2.4 PART 4 - FINANCIAL ASSESSMENT

The floor plans are analyzed for assessing 'Part 4 - Financial Assessment, after which the required m² GFA are entered, as shown in Figure 32.

PART 4 - FINANCIAL ASSESSMENT			
New situation	Assessment		
m² GFA Social Real Estate Building	1030		
% m² GFA for corridors and others	33%		
m² GFA for realization apartments	690		
If the floors are identical in terms of m² GFA, enter the number of floors			
Number of floors	3		
m² GFA per floor for realization apartments	230		
	Simple micro 20m²	Luxury micro 40m²	2-person 80m²
Number of apartments	27	12	6

Figure 32 - Assessment 'Part 4 - Living Environment' of the previously 'R.K. Lagere Paredisschool'

5.2.5 RESULTS

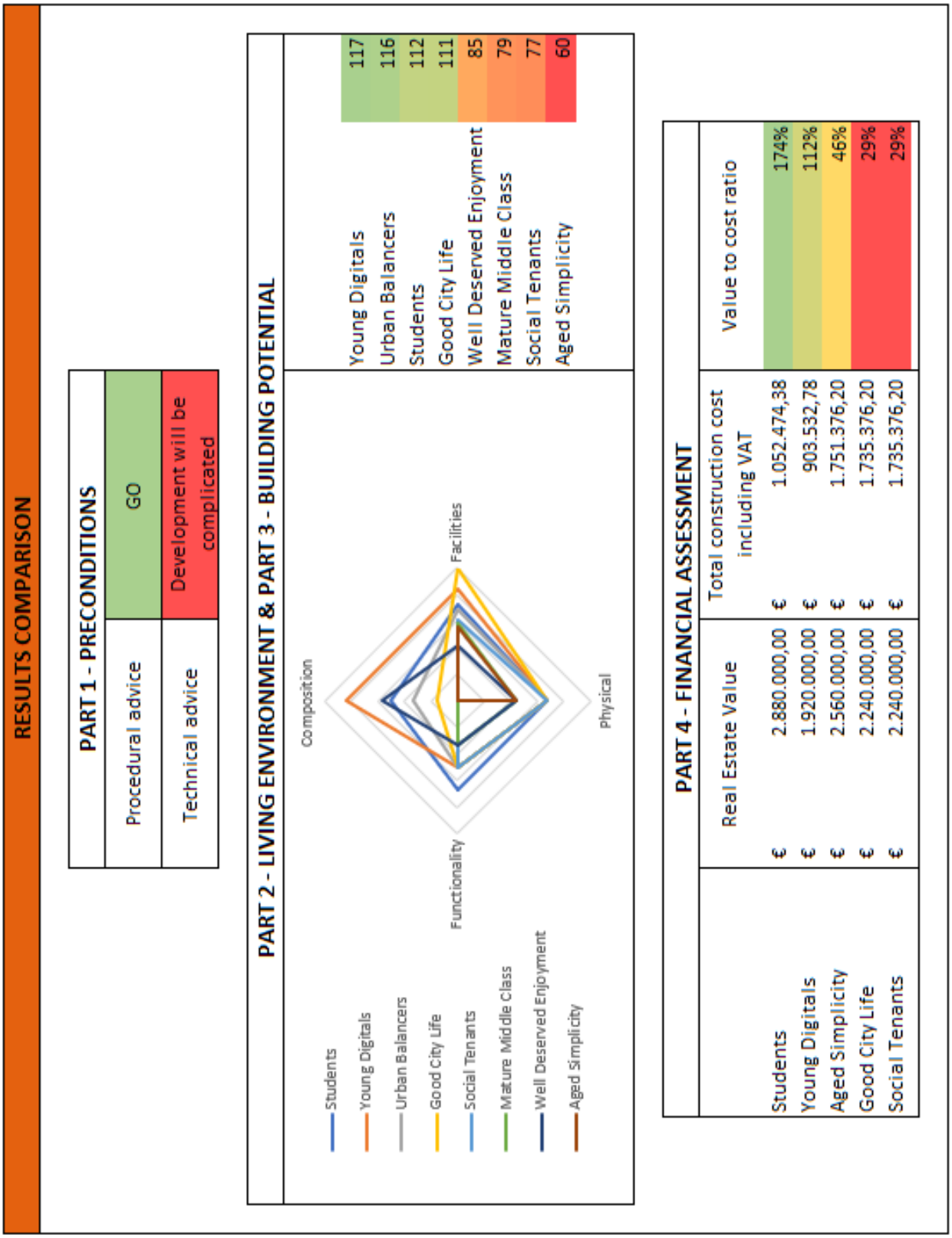


Figure 33 - Results of the assessment 'R.K. Lagere Paredisschool' with the DSS

After having assessed all consecutive parts, the results can be interpreted. They are presented in a clear overview, so that comparisons between the target groups can be made, as shown in Figure 33. As described earlier, the results of 'Part 1 - Preconditions' indicate that the development will be complicated, due to the national monument status attached to the social real estate 'R.K. Lagere Paredisschool'. This monument status entails additional requests for permits and the risk that not all intended adjustments to the building will be permitted.

The younger generations achieve the highest points for ‘Part 2 - Living Environment’ and ‘Part 3 - Building Potential’ in this case study, since the social real estate building and its location have a lot of facilities they prefer to have. However, since there is no university campus within walking or cycling distance and the district does not have the preferred degree of urbanization the younger generations do not score as high as the previous case study. The reason why the older generations do not achieve these number of points, is because the social real estate building does not have a lift facility and has no private outdoor space. Older generations attach higher importance to these facilities compared to the younger generations. From the results of ‘Part 2 - Living Environment’ and ‘Part 3 - Building Potential’ it can be concluded that the target groups ‘Young Digitals’ (117/200) and ‘Urban Balancers (116/200) are considered as most suitable target group.

The results of 'Part 4 - Financial Assessment' show that the target group ‘Young Digitals’ has a value to cost ratio of 112%. Unfortunately, it is not possible to interpret the value to cost ratio for the 'Urban Balancers' target group, as no financial assessment has been carried out for this target group, since they prefer the type of apartment of 50m². After an extensive financial assessment for the target group 'Urban Balancers', it can be considered whether this target group can be seen as most suitable. For now, it will be concluded that the target group 'Young Digitals' is the most suitable for the transformation of ‘R.K. Lagere Paredisschool’ into housing.

Since the ‘R.K. Lagere Paredisschool’ already has been transformed, it is possible to reflect the results of the case study with the current situation of the building. As described before, the previously ‘R.K. Lagere Paredisschool’ is transformed into twelve studio apartments. This corresponds with the results of the case study. The target group ‘Young Digitals’ prefer to live in an apartment of 40m² and as the assessment of ‘Part 4 - Financial assessment’ shows in Figure 32, that twelve apartments of 40m² can be developed. In addition, the current residents of these studio apartments are mainly people of the younger generations, such as generation Y and Z (including the target group ‘Young Digitals’).

5.3 FORMER HOSPITAL 'MILITAIR HOSPITAAL'

In this case study, a social real estate building in Amersfoort, shown in Figure 34 will be analyzed. This social real estate building previously served as a hospital that was known in the area as the 'Militair Hospitaal'. The 'Militair Hospital' has been built in 1877. It is a stately, imposing main building with barracks connected to it, everything together with a floor space of approximately 3,856 m², located in a beautiful neighborhood near the city center of Amersfoort in the Kruiskamp district. Currently this building is for sale and nothing is known yet of any further developments. The building has the status of a national monument and according to the zoning plan, the location is assigned as 'Office' location. In cooperation with the Municipality of Amersfoort, there are possibilities to change the current zoning plan, for example into 'accommodation' (Bieboek Rijksvastgoedbedrijf, 2019). For this case study, the assessment and the results of each part concerning the 'Militair Hospitaal' will be presented.

Figure 34 - Previsouly 'Militair Hospitaal' (Bieboek Rijksvastgoedbedrijf, 2019)

5.3.1 PART 1 - PRECONDITIONS

The information required for assessing 'Part 1 - Preconditions' is collected, and after that the factors will be rated as shown in Figure 35. Assessing the factors show that the social real estate has not the right zoning plan and has a national monument status. The social real estate building has not the right zoning plan to offer possibilities for transforming the building into suitable for housing. However, the municipality is willing to cooperate in changing the zoning plan in a way that the building could possibly be transformed into a building with a housing function. When transforming this social real estate building with monument status, it has to be taken in account that making adjustments will be extra difficult and often requires permits. Therefore, a warning is given that the development might become complicated.

PART 1 - PRECONDITIONS		
	Factors	Rating option Explanation rating option
Procedural	Structural vision	Neutral
	Zoning plan Search option	Neutral
	GO	
Technical	Adaptability	Neutral
	Monument status Search option	National, provincial or municipal monument
	Floor height	> 2.1 meter
	Development will be complicated	

Figure 35 - Assessment 'Part 1 - Preconditions' of the previously 'Militair Hospitaal'

5.3.2 PART 2 - LIVING ENVIRONMENT

The information required for assessing 'Part 2 - Living Environment' is collected, after which the factors will be rated as shown in Figure 36.

PART 2 - LIVING ENVIRONMENT		
Factors		Rating option Explanation rating option
Composition	Degree of urbanity Search option	Very urban
	Majority of residents Search option	Mix
	Insecurity in the neighborhood Search option	Safe feeling
Facilities	Proximity to supermarket and drugstore	Cycling distance
	Proximity to healthcare and pharmacy	Cycling distance
	Proximity to daycare or primary school	Cycling distance
	Proximity to university campus	Cycling distance
	Proximity to public transport	Walking distance
	Proximity of green facilities	Cycling distance
	Proximity to playground	Cycling distance

Figure 36 - Assessment 'Part 2 - Living Environment' of the previously 'Militair Hospitaal'

5.3.3 PART 3 - BUILDING POTENTIAL

The floor plans are analyzed for assessing 'Part 3 - Building Potential', after which the factors will be rated as shown in Figure 37. Due to the complexity of the floor plans of the social real estate 'Militair Hospitaal', only the main building is analyzed and assessed.

PART 3 - BUILDING POTENTIAL						
Approach - With the 'Energy rating' factor you state which energy label the social real estate building currently has. For the other factors you indicate whether the facility is present, if it is not present, then you indicate how achievable it is to realize this facility.						
Factor		Rating option Explanation rating option				
Physical	Energy rating	Unknown				
	Lifecycle resistant	Not lifecycle resistant - Hard to achieve				
	Building accessibility	No good accessibility - Very hard to achieve				
Functionality	Type of apartment	Simple micro 20m²	Luxury micro 40m²	2-person micro 50m²	2-person 80m²	Luxury 2-person 100m²
		Easily achievable	Achievable	Achievable	Very hard to achieve	Very hard to achieve
	Outside space	Shared	Privately			
		... outside space available	... outside space very hard to achieve			

Figure 37 - Assessment 'Part 3 - Building Potential' of the previously 'Militair Hospitaal'

5.3.4 PART 4 - FINANCIAL ASSESSMENT

The floor plans of the main building are analyzed for assessing 'Part 4 - Financial Assessment, after which the required m² GFA are entered, as shown in Figure 38.

PART 4 - FINANCIAL ASSESSMENT			
	Assessment		
m² GFA Social Real Estate Building	1085		
% m² GFA for corridors and others	22%		
m² GFA for realization apartments	846		
If the floors are identical in terms of m² GFA, enter the number of floors			
Number of floors	3		
m² GFA per floor for realization apartments	282		
	Simple micro 20m²	Luxury micro 40m²	2-person 80m²
Number of apartments	33	15	6

Figure 38 - Assessment 'Part 4 - Financial Assessment' of the previously 'Militair Hospitaal'

5.3.5 RESULTS

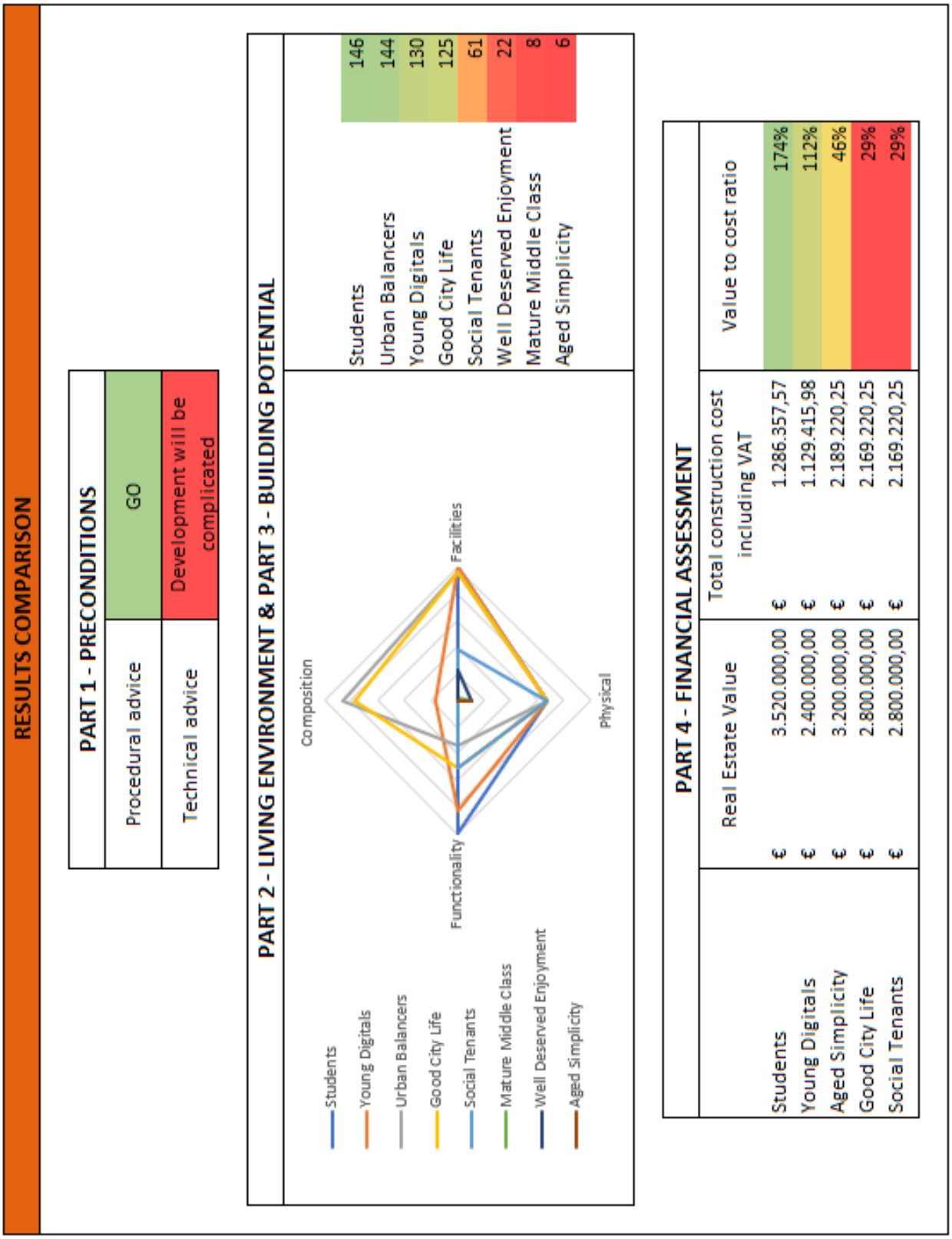


Figure 39 - Results of the assessment of the previously 'Militair Hospitaal'

After having assessed all consecutive parts, the results can be interpreted. The results are presented in a clear overview, which makes it possible to compare between the different target groups. This is shown in Figure 39. As described earlier, the results of 'Part 1 - Preconditions' indicate that the development will be complicated, due to the national monument status attached to the social real estate ‘Militair Hospitaal’. This monument status can give rise to additional requests for permits and to the risk that not all intended adjustments will be permitted.

In this case study the younger generations also achieve the highest points for ‘Part 2 - Living Environment’ and ‘Part 3 - Building Potential’, since the social real estate building and its location have a lot of facilities they prefer to have. In contrast to the other case studies, the older generations achieve very low points for 'Part 2 - Living Environment' and 'Part 3 - Building Potential'. This is due to the fact that almost all facilities are within cycling distance and the building needs many adjustments to become lifecycle resistant and to provide a private outside space. These adjustments will become a challenge due to the monument status that is attached to the building. From the results of ‘Part 2 - Living Environment’ and ‘Part 3 - Building Potential’ it can be concluded that the target groups ‘Students’ (146/200) and ‘Urban Balancers’ (144/200) are considered as most suitable target groups.

The results of 'Part 4 - Financial Assessment' show that the target the target group ‘Students’ has a value to cost ratio of 147%. Unfortunately, it is not possible to interpret the value to cost ratio for the 'Urban Balancers' target group, as no financial assessment has been carried out for this target group, since they prefer the type of apartment of 50m². After an extensive financial assessment for the target group 'Urban Balancers', it can be considered whether this target group can be seen as most suitable. For now, it will be concluded that the target group 'Young Digitals' is the most suitable for the transformation of ‘Militair Hospitaal’ into housing.

5.4 FORMER HOSPITAL 'OUDENRIJN ZIEKENHUIS'

In this case study, a social real estate building in Utrecht, shown in Figure 40 will be analyzed. This social real estate building has previously been used as a hospital, known in the area as the 'Oudenrijn Ziekenhuis'. Plans to transform the building into housing already have been developed for this vacant 'Oudenrijn Hospital. A joint venture of KKR and Round Hill Capital bought the buildings and intends to realize 750 houses for students and starters. The former 'Oudenrijn Ziekenhuis' will be transformed into 114 short-stay houses, of approximately 20m² or 40m² UFA each. On site the remaining houses will be realized with new construction projects (Utrechtnieuws, 2018). As this case study is not about a social real estate building with the function of education, 'Part 4 - Financial Assessment' is not carried out. The assessment of the 'Oudenrijn Ziekenhuis' is based on the floor plans with the original layout of the hospital, so when the building still was in use as a hospital. For this case study, the assessment and results of each part concerning the 'Oudenrijn Ziekenhuis' will be presented.

Figure 40 - Previously 'Oudenrijn Ziekenhuis' (Did Vastgoedontwikkeling, 2018)

5.4.1 PART 1 - PRECONDITIONS

The information required for assessing 'Part 2 - Living Environment' is collected, and after that the factors will be rated as shown in Figure 41. This shows that both the 'Procedural' and 'Technical' aspects receive a 'GO' and that there are no difficulties for the development at first sight.

PART 1 - PRECONDITIONS		
	Factors	Rating option Explanation rating option
Procedural	Structural vision	Neutral
	Zoning plan Search option	Suitable
	GO	
Technical	Adaptability	Neutral
	Monument status Search option	No monument status
	Floor height	> 2.1 meter
	GO	

Figure 41 - Assessment 'Part 1 - Preconditions' of the previously 'Oudenrijn Ziekenhuis'

5.4.2 PART 2 - LIVING ENVIRONMENT

The information required for assessing 'Part 2 - Living Environment' is collected, after which the factors will be rated as shown in Figure 42.

PART 2 - LIVING ENVIRONMENT		
	Factors	Rating option Explanation rating option
Composition	Degree of urbanity Search option	Very urban
	Majority of residents Search option	Generation Y
	Insecurity in the neighborhood Search option	Unsafe feeling
Facilities	Proximity to supermarket and drugstore	Cycling distance
	Proximity to healthcare and pharmacy	Walking distance
	Proximity to daycare or primary school	Cycling distance
	Proximity to university campus	Cycling distance
	Proximity to public transport	Walking distance
	Proximity of green facilities	Cycling distance
	Proximity to playground	Cycling distance

Figure 42 - Assessment 'Part 2 - Living Environment' of the previously 'Oudenrijn Ziekenhuis'

5.4.3 PART 3 - BUILDING POTENTIAL

The floor plans are analyzed for assessing 'Part 3 - Building Potential', after which the factors will be rated as shown in Figure 43. Due to the column structure, the social real estate building 'Oudenrijn Ziekenhuis' has a great adaptability.

PART 3 - BUILDING POTENTIAL						
Approach - With the 'Energy rating' factor you state which energy label the social real estate building currently has. For the other factors you indicate whether the facility is present, if it is not present, then you indicate how achievable it is to realize this facility.						
	Factor	Rating option Explanation rating option				
Physical	Energy rating	Unknown				
	Lifecycle resistant	Lifecycle resistant				
	Building accessibility	Good accessibility				
Functionality	Type of apartment	Simple micro 20m²	Luxury micro 40m²	2-person micro 50m²	2-person 80m²	Luxury 2-person 100m²
		Achievable	Achievable	Hard to achieve	Achievable	Hard to achieve
	Outside space	Shared	Privately			
		... outside space available	... outside space achievable			

Figure 43 - Assessment 'Part 3 - Building Potential' of the previously 'Oudenrijn Ziekenhuis'

5.4.4 PART 4 - FINANCIAL ASSESSMENT

The floor plans of the main building are analyzed for assessing 'Part 4 - Financial Assessment, after which the required m² GFA are entered, as shown in Figure 44. Due to the different m² GFA per floor, the social real estate 'Oudenrijn Ziekenhuis' will be assessed based on the total number of m² GFA.

PART 4 - FINANCIAL ASSESSMENT			
New situation	Assessment		
m² GFA Social Real Estate Building	10120		
% m² GFA for corridors and others	30%		
m² GFA for realization apartments	7084		
If the floors are identical in terms of m² GFA, enter the number of floors			
Number of floors			
m² GFA per floor for realization apartments			
	Simple micro 20m²	Luxury micro 40m²	2-person 80m²
Number of apartments	301	150	75

Figure 44 - Assessment 'Part 4 - Financial Assessment' of the previously 'Oudenrijn Ziekenhuis'

5.4.5 RESULTS

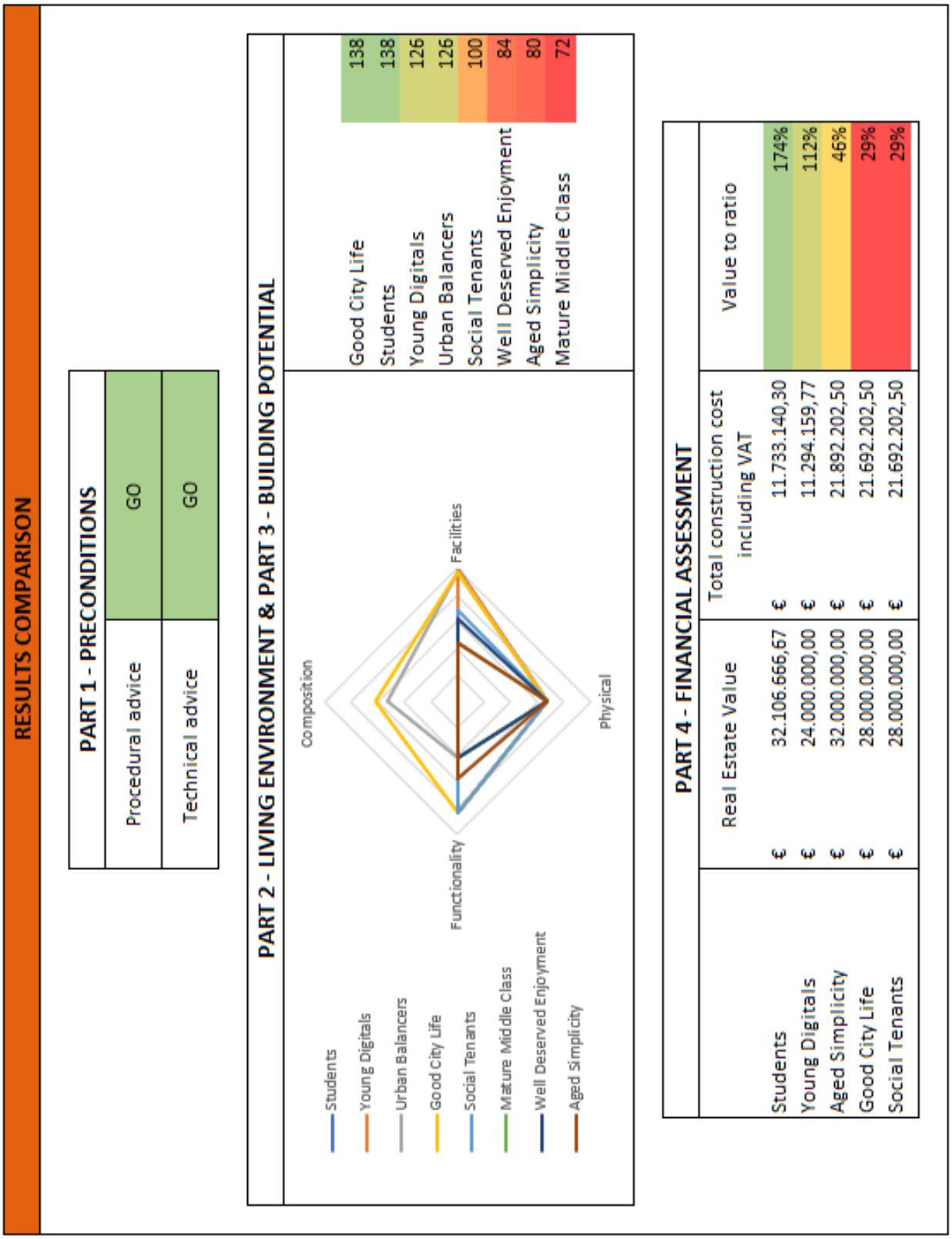


Figure 45 - Results of the previously 'Oudenrijn Ziekenhuis'

After having assessed all consecutive parts, the results can be interpreted. The results are presented in a clear overview that makes it possible to compare between the target groups, as shown in Figure 45. As described earlier, the results of 'Part 1 - Preconditions' show a favorable result. At first sight, both 'Procedural' and 'Technical' do not seem to create any problems for transformation of the social real estate building ‘Oudenrijn Ziekenhuis’ into housing.

In the case study the younger generations also achieve the highest points for ‘Part 2 - Living Environment’ and ‘Part 3 - Building Potential’. This is mainly due to the fact that the social real estate building is not in a residential area with the right urbanization in which the older generations would like to live and that the proximity of some of the facilities is within cycling distance, while they would like to have the facilities within walking distance. From the results of ‘Part 2 - Living Environment’ and ‘Part 3 - Building Potential’ it can be concluded that the target groups ‘Good City Life’ (138/200) and ‘Students’ (138/200) are considered as most suitable target groups.

The results of 'Part 4 - Financial Assessment' show that the target group ‘Good City Life’ has a value to cost ratio of 29% and the target group ‘Students’ has a value to cost ratio of 174%. Because the value to cost ratio must be higher than 30% for the financial feasibility of the transformation, the target group 'Good City Life' is not considered suitable for the transformation of ‘Oudenrijn Ziekenhuis’. Therefore, the target group 'Students' is most suitable for the transformation of ‘Oudenrijn Ziekenhuis’ into housing.

Since the ‘Oudenrijn Ziekenhuis’ is currently being transformed into housing, it is possible to reflect the results of the case study with the current plans for the ‘Oudenrijn Ziekenhuis’. As described before, in the previously ‘Oudenrijn Ziekenhuis’, 114 short-stay houses for students of approximately 20m² or 40m² are currently being developed. This corresponds with the results of the case study for the most suitable target group. The target group ‘Students’ prefer to live in an apartment of 20m². Furthermore, the future resident for the houses are students, which correspondents with the target group ‘Students’. However, as the assessment of ‘Part 4 - Financial assessment’ shows in Figure 44, 301 apartments of 20m² can be developed. This does not correspond to the 114 houses that will be realized in the ‘Oudenrijn Ziekenhuis’. This is caused by the fact that the transformation plans for the 'Oudenrijn Ziekenhuis' include common facilities. Almost the entire ground floor will be developed as common facilities. In addition, various houses with different square meters are being realized. Both options for considering common facilities and combining different types of apartments, are not included in the DSS.

5.5 CONCLUSION

The present case studies are generally easy to perform with the DSS. For 'Part 1 - Preconditions' and 'Part 2 - Living environment' the corresponding information must be collected. In general, collecting the required information is easy to do. For some factors the DSS has the source where the information can be found, these factors are provided with a 'Search option' button. The factors that are not provided with this button are dependent on the location of the social real estate building, such as the factors structural vision and the proximity to facilities. The structural vision can easily be found for each municipality via their website and the proximity to facilities can be retrieved with 'Google Maps'. The sources from which the required information is obtained contain literally the needed information for assessing the factors, which makes this an easy process.

Regarding 'Part 2 - Living environment' however, there can be doubt about the assessment of some factors in the 'Facilities' aspect. For example, when assessing the 'Distance to healthcare and pharmacy', it may happen that the distance to healthcare is within walking distance, while the distance to a pharmacy shows cycling distance. This causes doubt about which rating option must be entered in the DSS. In such case, the facility that is furthest away will be considered and the rating of ‘Cycling distance' will be entered in the DSS.

Using 'Part 3 - Building Potential' there were difficulties in assessing some of the factors. Assessing the factors of the 'Physical' aspect can be done reasonably well. If it is possible to assess the factors of 'Functionality' in a simple way depends on the complexity of the social real estate building, which is especially true for the 'Type of apartment' factor. If the social real estate building features a simple, clear layout, it will be easy to assess the achievability per type of apartment, as can be seen in the assessments of the buildings of the first two case studies in Chapter 5. However, assessing the achievability of types of apartments in buildings showing rather complex layouts is more difficult. Furthermore, it is relatively simple using DSS to assess the 'Outside space' factor; both for the ‘Shared outside space’ and the ‘Privately outside space’.

To assess 'Part 4 - Financial Assessment' is in general easy. The total number of m² GFA and the percentage m² GFA intended for corridors and others must be calculated and being entered in the DSS: the DSS calculates the required information for the financial assessment itself. For a more accurate calculation the number of floors can be assessed; however, success of such an assessment depends on the complexity of the social real estate building, for more complex buildings, having different types of floors, it will not work. If the building is not complex and the different floors are equal, it is easy to assess the number of floors to get more accurate calculations.

Furthermore, the results of the case studies show that, in general, the younger generations are most suitable for housing in transformed social real estate. This is probably due to the fact that older generations prefer a more lifecycle resistant house and private outside space, of which most social real estate buildings often have lack. This corresponds to the literature, which shows that houses developed by transformed (social) real estate are mainly inhabited by the younger generations, such as generation Y and Z.

6 CONCLUSION AND DISCUSSION

The structure of this research emerged from answering the pre-formulated main question with associated sub-questions. This led to the development of a Decision Support System (DSS) that determines the suitability of target groups for housing in transformed social real estate. In this chapter the answers to the main question and to the associated sub-questions will be formulated, the limitations of the research will be discussed, and recommendations will be made for further research.

6.1 CONCLUSION

This research aims to answer the following question: 'What to include in a decision support system to determine the suitability of target groups for transforming social real estate into housing?' The complexity of the research question ensures that multiple other questions will arise, which is the reason that sub questions have been formulated in order to find the most complete answer to the main question. These sub questions are: 'what will be the advantages and disadvantages of adaptive reuse of a building?', 'which are the characteristics of a social real estate building?', 'which target groups should be considered?' and 'which type of Decision Support System can best be applied?' and last 'Is the Decision Support System suitable enough for usage?'

As main benefits of adaptive reuse can be recognized advantages in the field of environment, economy, in the social field and also in promoting innovations. However, these advantages depend on the lifespan and condition of the social real estate building. In case of adaptive reuse, it is important to know in advance all possible challenges and barriers in order to prevent most of them. Furthermore, besides the importance of lifespan, success of adaptive reuse depends on flexibility and adaptability and off course of the needs of the market.

Nowadays adaptive reuse of social real estate is worth to be considered. The increasing vacancy rate of social real estate is in strong contrast with the housing shortage in the Netherlands. It is important to first know the characteristics of social real estate in order to derive benefits for possible adaptive reuse of social real estate into housing. Social real estate can be characterized by a bundling of many different functions, such as for meeting, for education or for health and sports. A main characteristic of social real estate that can be recognized as an advantage, is that usually most of the buildings are situated in the middle of the residential area and that most of them have a (highly) large capacity. However social real estate buildings also show disadvantageous characteristics, as for example the diversity of functions social real estate can have, which ensures a great diversity in the layout of the various buildings. Those different functions will make a transformation of that kind of social real estate more complicated, although there often is a pattern per function in the layout of the building and of the capacity of the buildings also.

The intention of the research is to determine the suitability of target groups for housing in transformed social real estate. To find out that it is important to identify the target groups and their living preferences. It might be possible to consider several kinds of target groups in the DSS, but only target groups that prefer to live in apartments or that are characterized as single household will be included in this DSS. These selected target groups are to be divided

into generations: the Baby Boomers (60 years and older), Generation X (40 to 60 years), Generation Y (25 to 40 years) and Generation Z (25 years and younger). The distinction between the target groups and their living preferences has been formed by the specific living preferences per target group provided by the research of BPD Mosaic.

To find out which DSS can best be used for this research, a short analysis is conducted to make the choice which 'Driven' category, model and technology can best be applied. A DSS can be developed in different ways using five different 'Driven' categories. These five 'Driven' categories have been analyzed; it can be concluded that a model-driven DSS can best be applied for this research. It uses quantitative models where the data are being provided by decision makers to assist in analyzing and deciding on situations. Model-driven DSSs can be developed using various quantitative models, which all have different supporting values. The supporting value of a decision analysis model, separating facts form priorities, fits best for this research. It helps decision makers in decision situations to identify alternatives (target groups) and factors (living preferences of the target groups). Various techniques can be used to develop a decision analysis model, these techniques have all been analyzed. It can be concluded that the WSM technique can best be applied for this research. It is an easy-to-implement subjective decision-making method, making it easy to implement a subjective assessment of the factors and weighting factors for determining the suitability of the target groups.

When developing a DSS, it is also important to know the four components a DSS has. In general, a DSS contains the communications-, the database-, the model-, and the user interface component. The communication component is about the architecture, the network and the security of the DSS. With ‘the architecture’ the structure of the DSS is being explained, it shows how the interaction between the database component, the model component and the user interface component proceeds in the DSS. It is decided that the DSS will run on a stand-alone computer, therefore no network is required and the DSS will serve by a 'thick-client' architecture. Furthermore, no attention has been paid to the security of the DSS, as this does not fall within the scope of the research. The database component is formed by the 'Evaluation matrix', the 'Weighing matrix' and the 'Financial assessment model'. The evaluation and weighting matrix are based on data collected from the literary study in Chapter 2; these data are processed as external data. The financial assessment model has been developed by an Arcadis cost expert; these data are processed as internal data. The model component is structured in four consecutive parts. 'Part 1 - Preconditions' assesses the preconditions which contains procedural aspects, as well as a general assessment of the technical feasibility. ‘Part 2 - Living Environment’ assesses the living environment of the social real estate building based on the composition and facilities. In ‘Part 3 - Building Potential’, the potential of the building will be assessed; the current state of the social real estate building will be analyzed based on physical and functional aspects. ‘Part 4 - Financial Assessment’, that is developed by an Arcadis cost expert, shows a financial assessment of value to cost ratio (> 30%) of transforming a social real estate building into apartments of either 20m², 40m² or 80m². The user interface component will ensure that the DSS is effective, intuitive, user-friendly and visually attractive.

Finally, due to the conducted case studies it can be concluded whether the DSS is capable to determine the suitability of the target groups for housing in transformed social real estate.

The DSS is easy to use when carrying out these case studies. Each consecutive part can be assessed properly, which results in a clear overview of the suitability of each target group. Furthermore, by conducting four case studies it is possible to show the differences in suitability of the target groups for different social real estate buildings. Overall, the DSS is able to determine the suitability of the target groups for housing in transformed social real estate.

The development of a DSS can be effectuated in several ways. For this research, a well-founded decision was made to develop a DSS with a model-driven system consisting of a decision analysis model and developed with the WSM technique. The DSS includes the alternatives (target groups), the factors (living preferences of the target groups), a weighting matrix which indicates the importance of each factor for an alternative, and a financial assessment model to provide a financial assessment for some alternatives. The DSS arranges the alternatives with the calculated suitability and provides a financial assessment. The results can be evaluated and the alternative with the highest suitability can be selected. In this way this research resulted into an accessible and easy to use DSS that provides a global inside into determining the suitability of target groups for transforming social real estate into housing.

6.2 DISCUSSION AND RECOMMENDATIONS

The DSS will only determine whether small-scale housing might have a function as adaptive reuse for vacant social real estate. More possible new functions can be considered for adaptive reuse; if, after using the DSS, it appears that a social real estate building is not suitable for small-scale housing, it may still be suitable for adaptive reuse but in that case for other functions, such as large-scale housing, offices, shops or other social functions.

Also, some limitations of this research have been determined. The first limitation is that the DSS only considers the end users, the future residents. However, more stakeholders like investors, producers, marketeers, regulators, policy makers, developers and owners, are involved in a transformation project of a social real estate building. These people are briefly mentioned in the research but are not considered and/or included in the DSS, while they still can influence the development of a transformation project a lot. Therefore, it would be important having a good overview in advance of these influences on the project, in the most ideal situation the DSS includes them.

Another limitation identified in advance is the financial assessment model. Due to the lack of financial expertise, a financial assessment model is created by an Arcadis cost expert. The limitation of this financial assessment model is that it currently only applies to transformations of social real estate into either apartments of 20m², 40m² or 80m². In addition, the key figures used are those of the province of Limburg; if the social real estate building is located in another province, the key figures might differ. Furthermore, information regarding the condition of the social real estate buildings, a monument status or other unforeseen circumstances are not taken into consideration. It is recommended to develop a more extensive financial assessment which integrates this information. This more extensive financial assessment could differ significantly from the financial assessment of this DSS.

The conclusion is that there are some points of improvement for the DSS. Currently, the decision maker has to collect its own data before the assessment can be made with the DSS. In the most ideal situation, all data can be retrieved automatically from an enormous database. To make the DSS more automated, various adjustments will be necessary; a data-driven DSS would perhaps be better for 'Part 1 - Preconditions' and 'Part 2 - Living Environment'. For example if the database would offer general information about the location of the social real estate building, such as the zoning plan, the monument status, the degree of urbanity, the generation structure of the residents, the safety in the neighborhood and the proximity of facilities. If a DSS has such a database, the decision maker only needs to enter the zip code or address of the social real estate and all the required information will be displayed automatically.

Automating 'Part 3 - Building Potential' could be achieved by using a Building Information Model (BIM). With a BIM model it would be possible to have the building analyzed automatically and to retrieve more detailed information about the construction of the building. For improving 'Part 3 - Building Potential', a more detailed DSS needs to be developed. More detailed factors should be created for the existing social real estate buildings, to make the assessment of the achievability of the types of apartments more accurate. If more information is requested and will be available about the layout of the building, as about the load-bearing and partition walls and the size of rooms, a better prediction could be made about the achievability of an apartment type. An interaction should be developed between the BIM model of a social real estate building and the DSS, so that the information from the BIM model can be used as input for the DSS.

The limitations and improvements of 'Part 4 - Financial assessment' have already been discussed. It is very important that the decision maker understands that the financial assessment is a rough estimate of the final real estate value and construction costs.

Furthermore, the living preferences and weighting factors in the 'Evaluation Matrix' and 'Weighting Matrix' are based on scientific literature. For a more accurate approach of the living preferences, it is recommended offering questionnaires to the target groups to get their opinion about living preferences and the degree of importance they attach to it. The results of the questionnaires create better opportunity to determine factors and their weighting factors using the Analytic Hierarchy Process technique.

At last a recommendation for Arcadis. If they would like to use the DSS in the future via a 'thin-client' architecture, it is important to pay attention to the network and security part of the communications component. As this research uses a 'thick-client' architecture, there is no network. In addition, in this research no attention has been paid to the security of the DSS. It is advisable first resolving these limitations before usage of the DSS towards clients. However, in case Arcadis is going to use this DSS, they will be able to provide adequately a general insight into determining the suitability of target groups for housing in transformed social real estate.

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APPENDICES

Appendix 1 Detailed description of various social real estate building functions
Appendix 2 Characteristics - Living preferences - Living environment preferences
Appendix 3 Evaluation Matrix
Appendix 4 Weighting Matrix
Appendix 5 Financial Assessment Model
Appendix 6 DSS HouSRE

APPENDIX 1 - DETAILED DESCRIPTION OF VARIOUS SOCIAL REAL ESTATE FUNCTIONS

Function	Characteristics	Dimensions	
Primary school [1, 2, 3]	Number of classrooms; central hall; sports and play hall; outdoor playground; auditorium; study rooms; copy rooms; office workplaces	Floor height	3.6 – 4.2 m
		Average amount stories	Max. 2
		Surface per scholar	9.8 m²
		Average amount scholar	225
		Average amount school	2205 m²
High school [1, 2]	Number of classrooms; central hall; sports hall; canteen; outside place; auditorium; study rooms; copy rooms; office workplaces; library	Floor height	2.9 – 4.4 m
		Average amount stories	2.9
		Surface per scholar	13.6 m²
University [1, 2]	Located on a campus; multiple buildings; lecture halls; presence of special rooms such as laboratories; canteen; auditorium; study rooms; copy rooms; office workplaces; library; single, double and multiple room; silence workplaces; open workplace	Floor height	3.9 – 4.6 m
		Average amount stories	2.8
		Surface per student	6.3 m²
Academic hospital [1, 4]	Large-scale hospital for specialist medical treatment; operating rooms and outpatient clinics are on different layers; waiting rooms; high-quality air treatment installations; many open façades with sun protection	Floor height	3.8 – 4.1 m
		Average amount stories	4.4
		Operation room (minimal)	40 m²
		Amount of beds	> 600
		Average surface per bed	90 m²
Health center [1]	Various disciplines employed (physical therapist, pharmacists, general practitioner, etc.); central entrance; ratio of different spaces; amount of different functions; treatment rooms; office spaces for administration; waiting rooms	Floor height	3.1 – 4.2 m
		Average amount stories	2.2
Sports hall [1, 5, 6]	Free height; amount of sports hall; amount of dressing rooms; presence of other spaces such as grandstand and canteen	Floor height	4.2 – 7.0 m
		Average amount stories	1.3
		Min. surface of one sports hall	308 m²
		Min. L x B x H	22 x 14 x 5.5 m
		Min. surface dressing room	20 m²
		Average amount stories	5.1
Theater [1]	Large halls with a number of seats; décor; good sound insulation; amount of technical installations	Floor height	4.6 – 8.3 m
		Average amount stories	1.9
Church [7]	A church can differ in size, shape, construction period or style period; the shape can consist of basilica (church consisting of a tall nave with low side aisles), central structure (the main shape consists of a round or polygonal volume), cross shape (nave and transept cross each other with approximately equal arms), box shape (floor plan and elevation have a rectangular shape) and others	Surface type small	< 250 m²
		Surface type medium size	250 – 500 m²
		Surface type large	500 – 1000 m²
		Surface type very large	> 1000 m²
		Church tower	< 112.3 m

See next page for footnotes →

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APPENDIX 2 - CHARACTERISTICS - LIVING PREFERENCES - LIVING ENVIRONMENT PREFERENCES

A short description of each target group is given, followed up with three tables. Table 1 shows the characteristics of the target groups, table 2 shows the living preferences of each target group and table 3 shows the living environment preferences of each target group. In addition, the figure shows the ratio between the different target groups of their well-being and age. All information is obtained from the BPD Mosaic study by Wisman (2016).

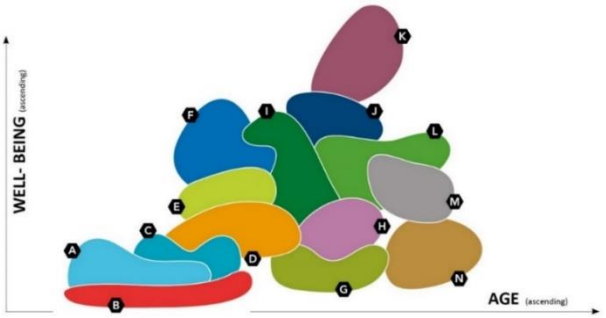


Figure - Ratio well-being / age per target group (adapted from: Wisman, 2016)

A Young Digitals

People of the target group 'Young Digitals' follow an education, work part-time or are looking for work. In all cases this group can be found a lot on the internet, for arranging and keeping track of all daily activities. They usually live in a social rental house, are younger than 40 and single.

B Urban Balancers

People of the target group 'Urban Balancers' live in a rental apartment in the middle of the city and mainly consist of people of non-Dutch descent. Material matters are not so important, a happy family and a slightly larger house is their main wish, since they live in a small rental house. This group is younger than 40 years and single, although in some cases they have a partner (with children).

C Start Together

The people of the target group 'Start Together' have a low level of education, stand simple in life and are between 25 and 45 years. A career is not their ambition, they often have a part-time job and live in a social rental house.

D Good City Life

People of the target group 'Good City Life' are highly educated singles who enjoy the free city life. In some cases, they have a relationship and already children. They are ambitious and enjoy life. Some of them are still studying and the others already have a good career, since this group is between 25 and 40 years. They can afford a private rental or owner-occupied apartment.

E Model Buying Families

Family life is central to the people of the target group 'Modal Buying Families'. They have an owner-occupied house or terraced house, at least two children and a middle-class car. They often make trips or visit family during the weekends. People within the target group 'Model Buying Families' are between 25 and 45 years.

F Child and Career

The people of the target group ‘Child and Career’ live in between work and private life at an age between 30 and 55 years. They assure themselves of enough income to be able to afford a pleasant life with their family. A good balance between work and quality time is of great importance. They can afford an owner-occupied house.

G Social Tenants

People of the target group ‘Social Tenants’ are people of middle-aged, between 45 and 65 years, living single or with a partner. They do not work or work part time and usually live in an apartment. As the name suggests, this target group lives in a social rental apartment or terraced house.

H Mature Middle Class

People of the target group ‘Mature Middle Class’ are aged between 55 and 75, whose children have usually just left home. They usually live in an owner-occupied or private rental house together with their partner. They are happy people.

I Freedom and Space

The people of the target group ‘Freedom and Space’ live in rural municipalities and own a spacious house, where the kids can play outside. They have a good life, with an age between 40 and 60 years.

J Golden Border

The people of the target group ‘Golden Border’ are doing well financially. They enjoy life, even though they work hard. Moreover, they own a detached or semi-detached house and they are between 45 and 65 years.

K Elite Top Class

The people of the target group ‘Elite Top Class’ are at the top of the social ladder, which they are aware of. This group enjoys the good life and owns a detached house. They are 45 years and older.

L Rural Life

The people of the target group ‘Rural Life’ enjoy the rural area. They are 50 years and older, and own a detached house, usually with a farm.

M Well Deserved Enjoyment

The target group ‘Well Deserved Enjoyment’ is an active group of 55 years and older. They are usually retired, live together with their partner and have a fine financial budget to spend. They own a semi-detached house or corner house, sometimes an apartment.

N Aged Simplicity

People of the target group ‘Aged Simplicity’ have a simple existence and are quickly satisfied. They are 65 years and older, retired and live in a small apartment or terraced house alone or together with their partner.

CHARACTERISTICS										
Target group	**Age**	**Household composition**	**Number of children**	**Education**	**Career**	**Income**	**Type of house**	**Living surface**	**Year of construction**	**Car ownership**
A Young Digitals	< 40 years	Single	None	Secondary education	Student with part-time job or unemployed	Below average	Social rental home (apartment)	< 90m²	1945 - 1969	No car
B Urban Balancers	< 40 years	Single or living together	None or in some cases young	Low to secondary education	Student or unemployed	Below average	Rental home	< 90m²	1900 - 1969	No car, but a moped or scooter
C Start Together	25 to 45 years	Living together	One or more children up to 19 years	Low to secondary education	Part-time job or unemployed	Low to average	Social rental home (terraced house)	90 - 135m²	1945 - 1989	No car
D Good City Life	25 to 40 years	Single	None	High or university education	Fulltime job or student	Twice average	Private rental or purchase apartment	< 90m²	1900 - 1944	No car
E Model Buying Families	25 to 45 years	Married or living together (three to four person households)	One or more children up to 12 years	Secondary or high education	Fulltime job	Average to twice average	Owner-occupied house (corner or townhouse)	90 - 135m²	1900 - 1999	One or two cars
F Child and Career	30 to 55 years	Married or living together (three to four person households)	One or more children up to 19 years	High education	Fulltime job	Twice average or more	Owner-occupied house	90 - 135m²	1990 to the present	One or two cars
G Social Tenants	45 to 65 years	Married, living together or single	None	Low education	Part-time job or unemployed	Below average	Social rent, terraced house or apartment	< 90m²	1945 - 1989	No car
H Mature Middle Class	50 to 75 years	Married or living together	None or adult children	Secondary education	Fulltime job or retired	Average	Owner-occupied house or private rental	90m² - 135m²	1945 - 1989	One car
I Freedom and Space	40 to 60 years	Married or living together	One or two children between 6 to 18 years	Secondary to high education	Fulltime job	Twice average or more	Owner-occupied house, detached or semi-detached house	90 - 135m²	1900 - 1994	One or two cars
J Gold Border	45 to 65 years	Married or living together (three to four person households)	One or two children between 6 to 19 years	High to university education	Fulltime job	More than twice average	Owner-occupied house, detached or semi-detached house	> 135m²	1900 - 1944 or 1990 - 2005	Two cars
K Elite Top Class	> 45 years	Married or single (one to four person household)	None or two children from 6 years	University education	Fulltime job	More than twice average	Owner-occupied house (detached)	> 135m²	Before 1994	Two cars
L Rural Life	> 50 years	Married or living together	Teenagers or adult children	Secondary to university education	Fulltime job or retired	Average to more than twice average	Owner-occupied house (detached)	> 135m²	Before 1994	One or two cars
M Well Deserved Enjoyment	> 55 years	Married or living together	None or adult children	Secondary to high education	Retired	Average to twice average	Owner-occupied house (semi-detached or corner)	90 - 135m²	1970 to the present	One car
N Aged Simplicity	> 65 years	Married or single	None or adult children	Low education	Retired	Below average	Apartment or terraced house	< 135m²	1945 to the present	Sometimes one car

LIVING PREFERENCES					
Target group	**Rent or owner**	**Rental price**	**Purchase price**	**New construction**	**Housing type**
A Young Digitals	Rental or owner-occupied home	€400 to €600 per month	€150.000 to €250.000	No preference	Very different, a small apartment or a terraced house, depending on location and budget
B Urban Balancers	Owner-occupied home	€500 to €700 per month	Cheap owner-occupied home	Expressed preference for new construction	Apartment or terraced house
C Start Together	Rental or owner-occupied home	€400 to €600 per month	€150.000 to €250.000	One in five prefers new construction	Terraced or corner house
D Good City Life	Prefer purchase apartment	€400 to €700 per month	€100.000 to €500.000	Great preference for existing construction	Apartment
E Model Buying Families	Prefer owner-occupied home	€700 to €1000 per month, many free sector renters	€200.000 to €250.000	Great preference for existing construction	Terraced or corner house
F Child and Career	Prefer owner-occupied home	-	€200.000 to €600.000	Great preference for new constructions	Chic terraced house in a good neighborhood or a detached house
G Social Tenants	Prefer rental home, mostly apartment	€400 to €700 per month	-	Slight preference for new construction	Very different and depending on location and budget a small apartment or terraced house
H Mature Middle Class	Rental or owner-occupied home	Cheap to mid-priced rental or owner-occupied homes		Prefer existing constructions	Terraced house, sometimes apartment
I Freedom and Space	Prefer owner-occupied home	-	Medium to expensive up to €450.000	Prefer existing constructions	Detached house
J Gold Border	Prefer owner-occupied home	> €1.000	Medium to expensive up to €600.000	Prefer new constructions	Detached house or luxury apartment or penthouse
K Elite Top Class	Prefer owner-occupied home	-	Very expensive > €700.000	Prefer new constructions	Detached house, penthouse or multi-layer apartments
L Rural Life	Prefer owner-occupied home	Very wide price range that is highly dependent on the location and the type of		Lowest preference for new construction	Detached house
M Well Deserved Enjoyment	Rental or owner-occupied home	Social and free sector up to € 800 per month	Medium and expensive	Prefer new constructions	Ground-level house or apartment
N Aged Simplicity	Prefer rental home	Social and free sector up to € 800 per month	-	Prefer existing renovated constructions or new constructions	Apartment with an elevator

LIVING ENVIRONMENT PREFERENCES	
Target group	**Preferred living environment**
A Young Digitals	Pre-war neighborhoods around the center of the city
	Mixed environments
	Park in the neighborhood
	Facilities relatively unimportant
	Accessibility by public transport and car
B Urban Balancers	Diverse composite neighborhoods
	Neighborhoods must have straight streets
	Pronounced against water nearby
	Lots of private space
	Environment with offices and shops
	Facilities focused
	Pharmacy and health center
	Accessibility to public transport
C Start Together	Around the center
	Post-war neighborhoods built before 1990 with lots of green and water
	Neighborhood shopping center within walking or cycling distance
D Good City Life	City centrum
	Mixed residential areas with shops, restaurants and offices
	When they have children, a daycare center is a must
	Center urban facilities and places to go out
	Good accessibility by public transport
E Model Buying Families	Suburb of a city or town
	Nearby playground, supermarket, daycare center and/or school
	'Our kind of people'
F Child and Career	Suburb of a city or town
	1930s home
	Village character
	Car accessibility is important
	Enough parking space
G Social Tenants	Neat neighborhood with land-based owner-occupied and rental homes
	Facilities within walking distance, such as neighborhood or neighborhood shopping center
	District nursing center, pharmacy and physiotherapist
	Good accessibility by public transport
H Mature Middle Class	Center of village residential environment
	Ground floor rent apartment, anticipating a deteriorating health
	Near a shopping area
	Near a healthcare and pharmacy
I Freedom and Space	Villages and rural area
	Attached value to greenery in the area
	Everything by car
	Proximity to facilities not very important
J Gold Border	Attractive neighborhood in the city or village close to the city
	Some opt for an apartment in a city center or village center environment
	Others prefer to live in a detached house in a residential area
K Elite Top Class	Both city center and very rural
	The most beautiful places in the living environment
	Preference for various types of architecture
	Property must be unique
	Culture is very important
	Relatively little value to all other facilities, since they are used to the neighborhood offering everything
L Rural Life	Preferred detached house the largest
	Rural area outside the village
	Facilities do not have to be close
M Well Deserved Enjoyment	Center urban and center village living environments
N Aged Simplicity	Near a shopping center, preferably within walking distance
	Shopping is a form of social contact

Appendix 3 - Evaluation Matrix

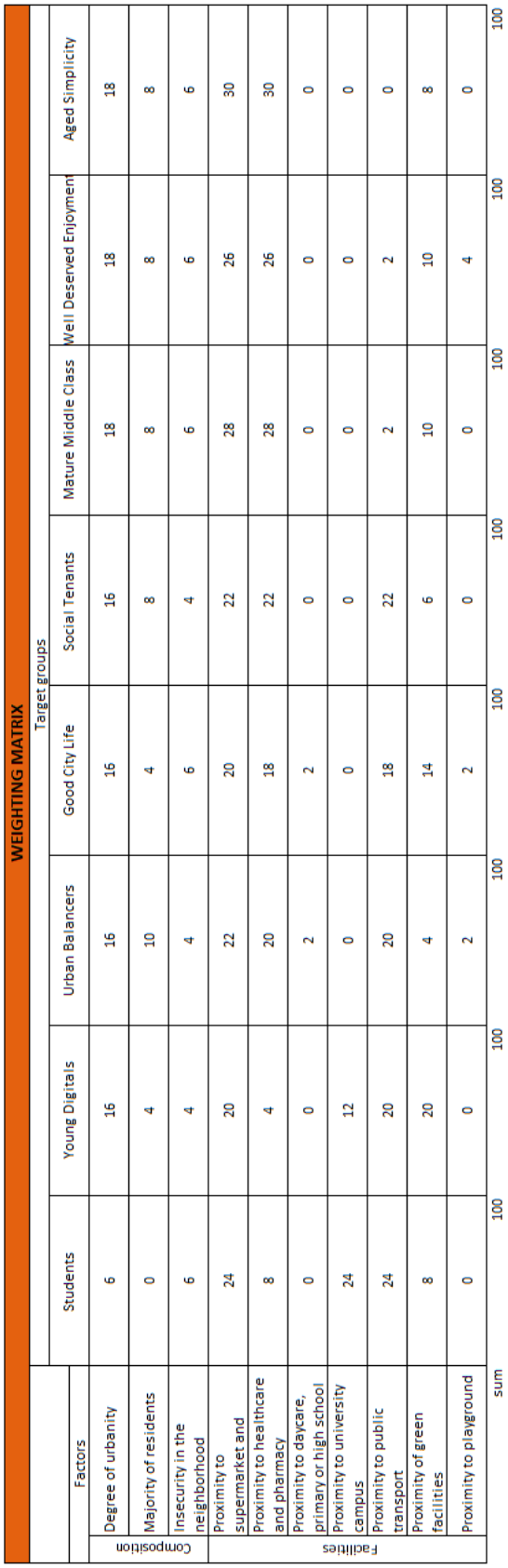
The evaluation matrix shows the target groups included with their living preferences for each factor.

EVALUATION MATRIX

	Factors	Students	Young Digitals	Urban Balancers	Good City Life	Social Tenants	Mature Middle Class	Well Deserved Enjoyment	Aged Simplicity
		Target groups							
PART 2 - LIVING ENVIRONMENT									
Composition	Degree of urbanity	Strong urban	Strong urban	Very urban	Very urban	Moderately urban	Little urban	Little or strong urban	Little urban
Composition	Majority of residents		Mix	Mix	Mix	Generation X	Baby boom	Baby boom	Baby boom
Composition	Insecurity in the neighborhood	Safe feeling	Safe feeling	Safe feeling	Safe feeling	Safe feeling	Safest feeling	Safest feeling	Safest feeling
Facilities	Proximity to supermarket and drugstore	Cycling distance	Cycling distance	Cycling distance	Cycling distance	Walking distance	Walking distance	Walking distance	Walking distance
Facilities	Proximity to healthcare and pharmacy	Cycling distance	Cycling distance	Cycling distance	Cycling distance	Walking distance	Walking distance	Walking distance	Walking distance
Facilities	Proximity to daycare, primary or high school			Cycling distance	Cycling distance				
Facilities	Proximity to university campus	Cycling distance	Cycling distance						
Facilities	Proximity to public transport	Cycling distance	Cycling distance	Walking distance	Walking distance	Walking distance	Walking distance	Walking distance	
Facilities	Proximity of green facilities	Cycling distance	Cycling distance	Cycling distance	Cycling distance	Cycling distance	Walking distance	Cycling distance	Walking distance
Facilities	Proximity to playground			Walking distance	Walking distance			Cycling distance	
PART 3 - BUILDING POTENTIAL									
Physical	Energy rating	Energy label B	Energy label B	Energy label A	Energy label B	Energy label A	Energy label A	Energy label A	Energy label A
Physical	Lifecycle resistant						Lifecycle resistant, elevator is required if there are multiple stories	Lifecycle resistant, elevator is required if there are multiple stories	Lifecycle resistant, elevator is required if there are multiple stories
Physical	Building accessibility						Good	Good	Good
Functionality	Type of apartment in m²	20	40	50	80	80	100	100	80
Functionality	Outside space	Shared	Shared	Privately	Shared	Shared	Privately	Privately	Privately
PART 4 - FINANCIAL ASSESSMENT									
	Budget per month	€ 400,00	€ 600,00	€ 700,00	€ 700,00	€ 700,00	€ 850,00	€ 800,00	€ 800,00

APPENDIX 4 - WEIGHTING MATRIX

The weighting matrix shows for each target group the importance that they attach to the factors. These weighting factors are determine based on the literature study in Chapter 2.



WEIGHTING MATRIX		Target groups							
	Factors	Students	Young Digitals	Urban Balancers	Good City Life	Social Tenants	Mature Middle Class	Well Deserved Enjoyment	Aged Simplicity
Composition	Degree of urbanity	6	16	16	16	16	18	18	18
	Majority of residents	0	4	10	4	8	8	8	8
	Insecurity in the neighborhood	6	4	4	6	4	6	6	6
Facilities	Proximity to supermarket and	24	20	22	20	22	28	26	30
	Proximity to healthcare and pharmacy	8	4	20	18	22	28	26	30
	Proximity to daycare, primary or high school	0	0	2	2	0	0	0	0
	Proximity to university campus	24	12	0	0	0	0	0	0
	Proximity to public transport	24	20	20	18	22	2	2	0
	Proximity of green facilities	8	20	4	14	6	10	10	8
	Proximity to playground	0	0	2	2	0	0	4	0
	sum	100	100	100	100	100	100	100	100

APPENDIX 5 - FINANCIAL ASSESSMENT MODEL

This appendix shows the financial assessment model of the calculations for the type of apartments of 20m², 40m² and 80m².

Simple micro 20 m² UFA - Students

Number of apartments		0
m² GFA		24
From factor		85%
m² UFA		20
Rental income per month	€	400,00
Rental income per year	€	4.800,00
Gross initial yield		5%
Real Estate Value per apartment	€	106.667
Total Real Estate Value	**€**	-

Construction costs for transformation

	m² GFA	Price m² GFA	New construction	Total
Substructure	0	€ 222	25%	€ -
Superstructure	0	€ 181	50%	€ -
Façade	0	€ 362	100%	€ -
Roof	0	€ 80	75%	€ -
Finishing	0	€ 72	100%	€ -
Fixed facilities	0	€ 54	100%	€ -
W-installations	0	€ 77	100%	€ -
E-installations	0	€ 89	100%	€ -
Climate installations	0	€ 109	100%	€ -
Surtax BENG	0	€ 89	100%	€ -
				€ -
General execution costs	10%			€ -
General costs contractor	7%			€ -
Profit & risk contractor	3%			€ -
Unforeseen	5%			€ -
Total construction costs				€ -
Additional construction costs	15%			€ -
Architect, constructor, fees, insurance, connection costs, consultants				
General cost developer	4%	Construction and additional costs		€ -
Profit & risk developer	5%	VON-price excluding VAT		€ -
Total construction costs excluding VAT				€ -
Total construction costs including VAT				**€** -

Luxury micro 40 m² UFA - Young Digitals

Number of apartments		0
m² GFA		47
From factor		85%
m² UFA		40
Rental income per month	€	600,00
Rental income per year	€	7.200,00
Gross initial yield		5%
Real Estate Value per apartment	€	160.000
Total Real Estate Value	**€**	-

Construction costs for transformation

	m² GFA	Price m² GFA	New construction	Total
Substructure	0	€ 222	25%	€ -
Superstructure	0	€ 181	50%	€ -
Façade	0	€ 362	100%	€ -
Roof	0	€ 80	75%	€ -
Finishing	0	€ 72	100%	€ -
Fixed facilities	0	€ 54	100%	€ -
W-installations	0	€ 77	100%	€ -
E-installations	0	€ 89	100%	€ -
Climate installations	0	€ 109	100%	€ -
Surtax BENG	0	€ 89	100%	€ -
				€ -
General execution costs	10%			€ -
General costs contractor	7%			€ -
Profit & risk contractor	3%			€ -
Unforeseen	5%			€ -
Total construction costs				€ -
Additional construction costs	15%			€ -
Architect, constructor, fees, insurance, connection costs, consultants				
General cost developer	4%	Construction and additional costs		€ -
Profit & risk developer	5%	VON-price excluding VAT		€ -
Total construction costs excluding VAT				€ -
Total construction costs including VAT				**€** -

2-person 80m² UFA - Good City Life

Number of apartments		0
m² GFA		94
From factor		85%
m² UFA		80
Rental income per month	€	700,00
Rental income per year	€	8.400,00
Gross initial yield		5%
Real Estate Value per apartmen	€	186.667
Total Real Estate Value	**€**	-

Construction costs for transformation

	m² GFA	Price m² GFA	New construction	Total
Substructure	0	€ 215	25%	€ -
Superstructure	0	€ 171	50%	€ -
Façade	0	€ 322	100%	€ -
Roof	0	€ 79	75%	€ -
Finishing	0	€ 75	100%	€ -
Fixed facilities	0	€ 35	100%	€ -
W-installations	0	€ 51	100%	€ -
E-installations	0	€ 72	100%	€ -
Climate installations	0	€ 108	100%	€ -
EPC 0,0	0	€ 151	100%	€ -
				€ -
General execution costs	10%			€ -
General costs contractor	7%			€ -
Profit & risk contractor	3%			€ -
Unforeseen	5%			€ -
Total construction costs				€ -
Additional construction costs	15%			€ -
Architect, constructor, fees, insurance, connection costs, consultants				
General cost developer	4%	Construction and additional costs		€ -
Profit & risk developer	5%	VON-price excluding VAT		€ -
Total construction costs excluding VAT				€ -
Total construction costs including VAT				**€** -

Welcome to HouSRE

HouSRE stands for **Hou**sing in **S**ocial **R**eal **E**state. This Decision Support System (DSS) is intended to determine the suitability of target groups for adaptive reuse of social real estate into housing. The DSS is structured in four consecutive parts as shown below. Each part contributes to determining the suitability of the target groups for housing in social real estate and considering decisions for the following phases of the development project.

PART 1 PRECONDITIONS	→	PART 2 LIVING ENVIRONMENT	→	PART 3 BUILDING POTENTIAL	→	PART 4 FINANCIAL ASSESSMENT
Procedural Technical		Composition Facilities		Physical Functionality		Investments

Part 1 assesses the preconditions that are set, which contain procedural aspects, as well as a general assessment of the technical feasibility. Part 2 assesses the living environment of the social real estate building based on the composition and facilities. During part 3, the potential of the building will be assessed, whereby the current state of the social real estate building will be analyzed based on physical and functional aspects. Part 4 consists of a financial assessment of the costs and revenues for the transformation. This financial assessment is only intended for social real estate buildings with the current function of education.

As described, various factors will be assessed at each step based on rating options. While using DSS there is the possibility to consult the explanation of the rating options, this can be done by clicking on 'Explanation rating option'.

After assessing all factors, the results will be calculated and displayed. Part 1 consists of an advisory role; an initial estimate is made of whether to continue with the development. In parts 2 and 3, points are awarded to the target groups based on the assessment of the factors. 100 points can be collected per step, which means that the maximum number of points a target group can achieve is 200. The target group with the highest number of points is the most suitable for housing in the social real estate building used during this DSS. Part 4 gives a rough indication of the financial assessment per target group.

START

PART 1 - PRECONDITIONS		
Factors		Rating option Explanation rating option
Procedural	Structural vision	
	Zoning plan Search option	
Technical	Adaptability	
	Monument status Search option	
	Floor height	

When all factors have been assessed click on 'NEXT'

< PREVIOUS NEXT >

PART 2 - LIVING ENVIRONMENT		
Factors		Rating option Explanation rating option
Composition	Degree of urbanity Search option	
	Majority of residents Search option	
	Insecurity in the neighborhood Search option	
Facilities	Proximity to supermarket and drugstore	
	Proximity to healthcare and pharmacy	
	Proximity to daycare, primary or high school	
	Proximity to university campus	
	Proximity to public transport	
	Proximity of green facilities	
	Proximity to playground	

When all factors have been rated click on 'NEXT'

< PREVIOUS NEXT >

PART 3 - BUILDING POTENTIAL

Approach - With the 'Energy rating' factor you state which energy label the social real estate building currently has.
For the other factors you indicate whether the facility is present, if it is not present, then you indicate how achievable it is to realize this facility.

	Factor	Rating option Explanation rating option				
Physical	Energy rating					
	Lifecycle resistant					
	Building accessibility					
Functionality	Type of apartment	Simple micro 20m²	Luxury micro 40m²	2-person micro 50m²	2-person 80m²	Luxury 2-person 100m²
	Outside space	Shared	Privately			

When all factors have been rated click on 'NEXT'

< PREVIOUS NEXT >

PART 4 - FINANCIAL ASSESSMENT

	Assessment
m² GFA Social Real Estate Building	
% m² GFA for corridors and others	
m² GFA for realization apartments	0
If the floors are identical in terms of m² GFA, enter the number of floors	
Number of floors	
m² GFA per floor for realization apartments	

	Simple micro 20m²	Luxury micro 40m²	2-person 80m²
Number of apartments	0	0	0

When all factors have been answered click on 'NEXT'

< PREVIOUS NEXT >

RESULTS

PART 1 - PRECONDITIONS	
Procedural advice	
Technical advice	

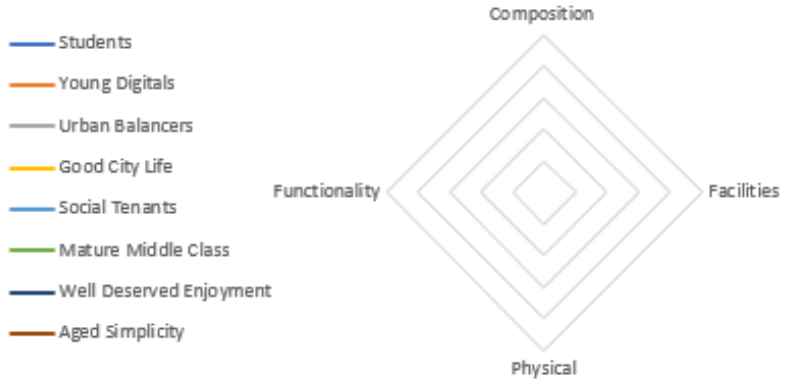
To compare and evaluate the results click here

	Factors	Students	Young Digitals	Urban Balancers	Good City Life	Social Tenants	Mature Middle Class	Well Deserved Enjoyment	Aged Simplicity
PART 2 - LIVING ENVIRONMENT									
Composition	Degree of urbanity	0	0	0	0	0	0	0	0
	Majority of residents	0	0	0	0	0	0	0	0
	Insecurity in the neighborhood	0	0	0	0	0	0	0	0
Facilities	Proximity to supermarket and drugstore	0	0	0	0	0	0	0	0
	Proximity to healthcare and pharmacy	0	0	0	0	0	0	0	0
	Proximity to daycare or primary school	0	0	0	0	0	0	0	0
	Proximity to university campus	0	0	0	0	0	0	0	0
	Proximity to public transport	0	0	0	0	0	0	0	0
	Proximity of green facilities	0	0	0	0	0	0	0	0
	Proximity to playground	0	0	0	0	0	0	0	0
	SUB TOTAL	0	0	0	0	0	0	0	0
PART 3 - BUILDING POTENTIAL									
Physical	Energy rating	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	Lifecycle resistant	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	Building accessibility	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Functionality	Type of apartment	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	Outside space	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	SUB TOTAL	0	0	0	0	0	0	0	0
	TOTAL	0	0	0	0	0	0	0	0
PART 4 - FINANCIAL ASSESSMENT									
Investments	Real Estate Value	€ 0	€ 0		€ 0	€ 0			€ 0
	Total construction costs including VAT	€ 0	€ 0		€ 0	€ 0			€ 0

RESULTS COMPARISON

PART 1 - PRECONDITIONS	
Procedural advice	
Technical advice	

PART 2 - LIVING ENVIRONMENT & PART 3 - BUILDING POTENTIAL



Students	0
Young Digitals	0
Urban Balancers	0
Good City Life	0
Social Tenants	0
Mature Middle Class	0
Well Deserved Enjoyment	0
Aged Simplicity	0

PART 4 - FINANCIAL ASSESSMENT

	Real Estate Value	Total construction cost including VAT	Value to cost ratio
Students	€ -	€ -	0%
Young Digitals	€ -	€ -	0%
Good City Life	€ -	€ -	0%
Social Tenants	€ -	€ -	0%
Aged Simplicity	€ -	€ -	0%

EXPLANATION RATING OPTION			
	Factors	Rating option	Description
PART 1 - PRECONDITIONS			
Procedural	Structural vision	Unsuitable	The municipality has no plans for housing development
		Neutral	The municipality has plans for housing development, but in a different neighborhood than the neighborhood of the social real estate building
		Suitable	The municipality has plans for housing development in the neighborhood of the social real estate building
	Zoning plan	Unsuitable	In conflict with specific zoning plan
		Neutral	In conflict, but municipality is willing to change the zoning plan
		Suitable	Suitable for specific zoning plan
Technical	Adaptability	Unsuitable	Strip building and change load-bearing construction
		Negative	Stripping to load-bearing construction
		Neutral	Adjust façade, interior walls and installations
		Positive	Adjust facade and interior walls
		Suitable	Adjust interior walls
	Monument status	National, provincial or municipal monument	Disadvantageous, adjustments to the outside and inside of the building are very hard to achieve
		Protected city or village view	Less disadvantageous, adjustments to the outside of the building are very hard to achieve
		No monument status	No disadvantageous
	Floor height	< 2.1 meter	Does not meet the requirements of the Building Decree
		> 2.1 meter	Meets the requirements of the Building Decree (for existing buildings)

PART 2 - LIVING ENVIRONMENT			
Composition	Degree of urbanity	Not urban	< 500 addresses per km²
		Little urban	500 – 1,000 addresses per km²
		Moderately urban	1,000 – 1,500 addresses per km²
		Strong urban	1,500 – 2,500 addresses per km²
		Very urban	≥ 2,500 addresses per km²
	Majority of residents *The 'Majority of residents' means that there is a difference of 1000 people between the largest and second largest generation, if not, the 'Mix' option must be chosen.*	Baby boom	> 60 years
		Generation X	40 – 60 years
		Generation Y	25 – 40 years
		Generation Z	< 25 years
		Mix	Mix of ages
	Insecurity in the neighborhood	Unsafe feeling	Higher than average
		Safe feeling	Average
		Safest feeling	Lower than average
Facilities	All factors of the aspect 'Facilities' have the same rating options	Walking distance	< 0.5 km
		Cycling distance	0.5 - 7.5 km
		Distance by car	> 7.5 km

PART 3 - BUILDING POTENTIAL			
Physical	Energy rating	Energy label A	If the building has the preferred energy label of a target group, the maximum number of points is awarded to the target group. The score is lower for each less energy-efficient energy label.
		Energy label B	
		Energy label C	
		Energy label D	
		Energy label E	
		Energy label F	
		Energy label G	
		Unknown	
	Lifecycle resistant	Lifecycle resistant	Ground floor or multi-storey with lift facility
		Not lifecycle resistant - Achievable	The building has a clear location for the lift facility
		Not lifecycle resistant - Hard to achieve	The building has no a clear location for the lift facility
		Not lifecycle resistant - Very hard to achieve	The building has a national, provincial or municipal monument status, making it very difficult to realize a lift facility
	Building accessibility	Good accessibility	The entrance to the building is easily accessible for people with disabilities
		No good accessibility - Achievable	The entrance to the building is not easily accessible for people with disabilities; minor adjustments are needed
		No good accessibility - Hard to ahieve	The entrance to the building is not easily accessible for people with disabilities; major adjustments are needed
		No good accessibility - Very hard to achieve	The building has a national, provincial, municipal, or protected city or village view monument status; making adjustments to the entrance for people with disabilities will be very hard
Functionality	Type of apartment	Easily achievable	Small adjustments needed; the building generally complies with the layout for the realization of the type of apartment
		Achievable	Adjustments are needed to realize the type of apartment; these adjustments do not affect the load-bearing structure
		Hard to achieve	Adjustments are needed to realize the type of apartment; these adjustments do have influence on the load-bearing construction
		Very hard to achieve	Adjustments to the building structure are necessary for the realization for the type of apartment, but due to the national, provincial or municipal monument status these adjustments are very hard to achieve
	Outside space	... outside space available	The building has a shared or private outside
		... outside space achievable	The building has no shared or private outside space, realizing shared or private outside space will be achievable
		... outside space very hard to achieve	The building has no shared or private outside space, realizing shared or private outside space will be very hard to achieve (for example, a monument status is assigned to the building)