



RHENEN DENSIFIES

AN INTEGRATIVE SOLUTION FOR A GROWING CITY

COLOPHON

Final report Group 9

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ABSTRACT



This report identifies different possibilities and strategies for a transition towards densification instead of expansion in the municipality of Rhenen. Rhenen wants to build around 500 extra houses until 2028. Inhabitant group 'de Vrienden van Lijstereng' would rather see these houses built within the boundaries of the build area, instead of expanding the city on the outside. There are different aspects which should be taken into account while densifying like e.g. public services, traffic increase, and greenspace. The interventions will address these challenges using the compact city concept. Out of different analyses, locations that are possible for densifications are identified. Three main strategies for densification have come up with; building from scratch, building on top and transforming. The five overarching principles that are used for designing are conscientious densification, green corridor, slow transport, urban quality and livability, and spatial context. These principles must be kept in mind while designing the densified area. Multiple interventions that lead to a more densified Rhenen are proposed according to the strategies and the principles. To involve the public in making the transition towards more densification a success, a participation process is proposed. The results show that creating 500 houses is possible by only densifying within the municipality of Rhenen.

Keywords; densification, transition, compact city, green corridor, participation, slow transport, urban quality, spatial context

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Figure 1 *The locations that fall within the municipality of*

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For many people living in Rhenen, building more houses within the municipality is a sensitive topic. Therefore, the public needs to be involved in the process of new housing plans. If the public is involved, the chances for a publicly accepted plan are greater.

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Rhenen Municipality has been growing a lot over

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1. INTRODUCTION

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Rhenen is a small city within the province of Utrecht in the Netherlands within the area of the Utrechtse Heuvelrug. The municipality of Rhenen has roughly 20.000 inhabitants and consists of the city of Rhenen, the two villages Achterberg and Elst and neighbourhoods Laareind, Remmerden and (a part of) Nude (Centraal Bureau voor de Statistiek, 2019a; Plaatsengids, 2019) (Figure 1).

The Province wants the municipality to build more houses in the future, mainly in the segment of social housing, elderly care homes and starters' housing. Currently, there is a gap in the housing stock regarding those categories (Gemeente Rhenen, 2017). The

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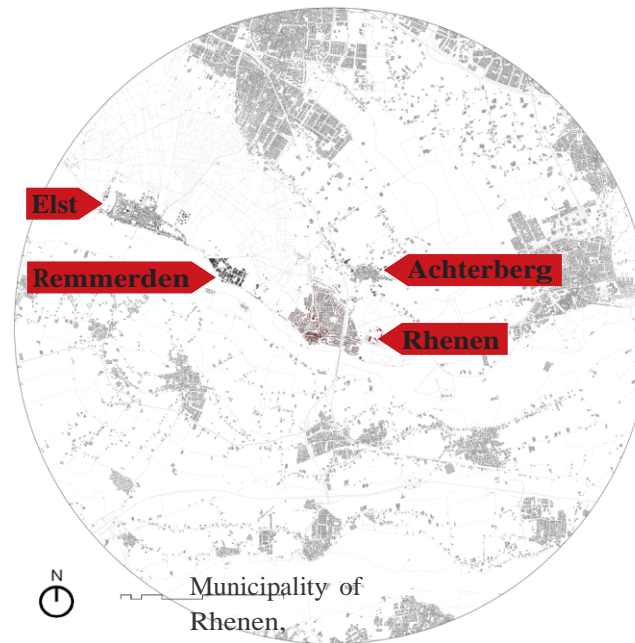


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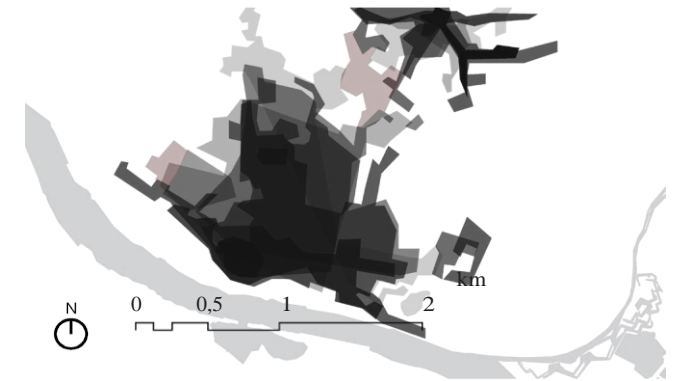


Figure 2 The urban expansion of the city of Rhenen over the last decades (in black and grey) and the expected expansion when densification doesn't happen (in red).

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therefore, wants to expand the city. However, the citizens' group 'Stichting Vrienden Behoud Lijsterengh' (the commissioner) would rather

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the last decades. It seems to be a trend that the city of Rhenen mainly expands rather than densifies (Figure 2). Rhenen is known for living close to or within

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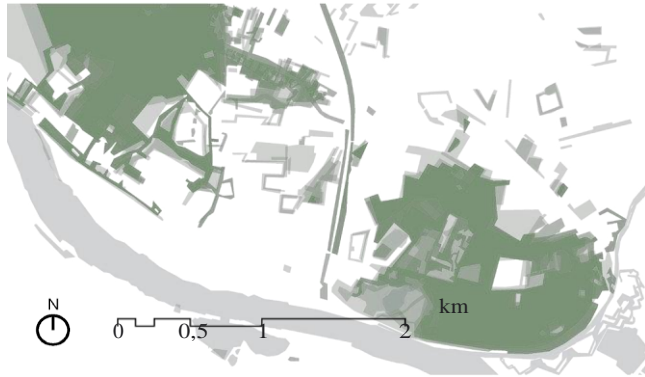


Figure 3 *The decrease of the natural landscape over the last decades (in light green).*

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of this study is to help find the potentials for publicly accepted densification options within the municipality of Rhenen.

This results in the following main **research question**:

'Where lie the potentials for publicly accepted

densification in the municipality of Rhenen?'

To specify more, the main research question is subdivided into the following sub-questions:

RQ1: 'What are suitable areas for densification within the existing urban tissue in the municipality of Rhenen?'

RQ2: 'What are potential strategies for densification in the municipality of Rhenen?'

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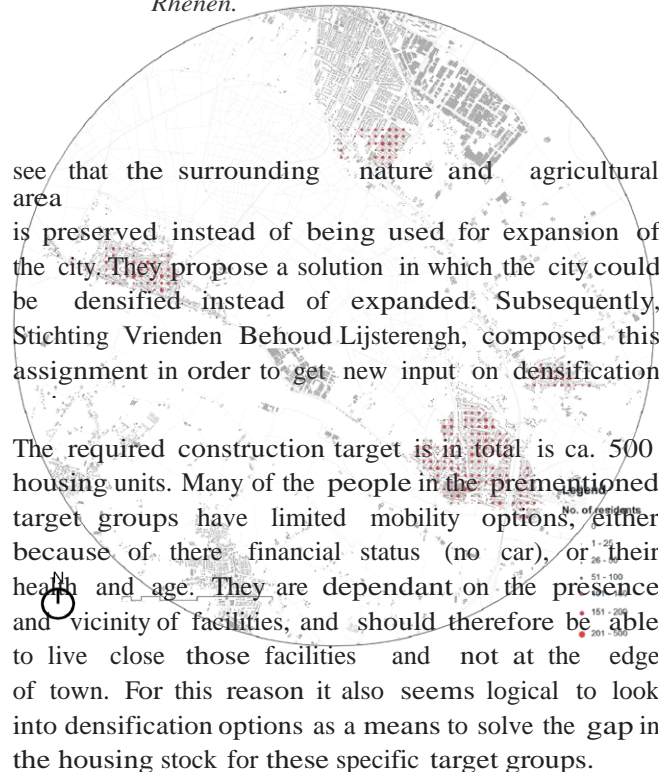
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Q :

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Figure 4 The current living density in the municipality of Rhenen.



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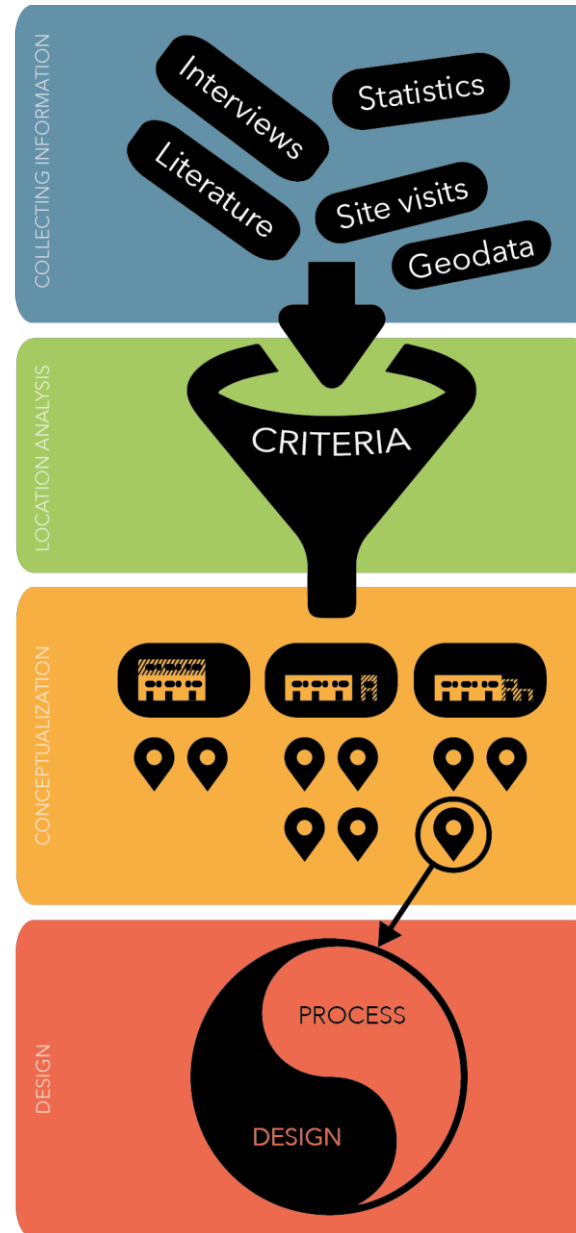
2. METHODS & MATERIALS

In order to find out the potentials for densification in the municipality of Rhenen, the project will be divided into four phases (Figure 5). Firstly, there will be a data collection phase with an aim to find out which locations might be suitable for densification. that, the different locations that came out of the data collection phase will be analysed according to different criteria. When the most suitable locations have been decided upon, the plan will be conceptualized. In the final phase, the most important sites of our plan will be designed and visualized. In this chapter, the methods and materials of the previous phases will be described in detail.

After completing these four phases, we will discuss the results in the discussion part. In this part, things we might have missed or that we were not able to do will be discussed. Besides that, we discuss what impact our plan could have for the municipality of Rhenen. We will end the discussion with reflection upon the theme of the Atelier: 'Transition in place'.

2.1. DATA COLLECTION

The data collection phase consists of different elements. Firstly, site visits are being used to get our first impression of the area, as well as to look for possible locations within the area. These site visits are useful in order to look at the area with an open mind, not yet being influenced by other data. Next to site visits, interviews will help us in getting knowledge from people who live or work in the area. It is important to understand the different perspectives. Multiple interviews are conducted with 'De vrienden van Lijstereng'. Next to this group, an interview is also held with Karin Wortelboer, who works for the municipality of Rhenen. From these interviews,



we gather different viewpoints on the subject, but also information about different plots, which might be suitable for densification. It would be interesting to also talk to the housing corporation called Rhenam and also, to someone from the inhabitant group in the village of Elst, however, neither of them were able to meet in the available time due to holidays.

Next to the research in the field, online research is done as well. This includes literature, statistical data and geodata. The literature will be used to gather information about densification. Examples of such information are densification strategies, densification challenges and densification examples. This kind of information can help us understand better what sustainable densification actually is and how this project of ours can become a success. Statistics of the municipality of Rhenen are used to get a better insight on, for example, the people who live there and the trends that are happening. Important aspects are demographic statistics of the current inhabitants, housing types and growth trends. Geodata is used in order to analyse locations. These analyses concern for example accessibility, green areas, ground space index and floor space index, land-use mix index and population density. All this information helps tremendously when exploring the most suitable locations for densification.

2.2. SPATIAL ANALYSIS OF LOCATIONS

After gathering all the data, it is then used to limit the initial number of possible locations to more specific and realistic building locations that we describe as the most suitable locations. Additionally, the geodata will be used to see what the characteristics of these plots are. After the different locations are analysed we will

Figure 5 *Project breakdown structure.*

2. METHODS & MATERIALS

based on their surroundings, determine the building size, height and functions for the future development on these locations. This step will form the conclusion of the analysis phase. It will serve as the start of our concept phase.

2.3. CONCEPT PHASE

In the previous phase, different typologies and dwelling sizes have been assigned to the most suitable locations. In the concept phase, this will be used to come up with a concept, which could help Rhenen in making the densification a success. In the concept phase, different design principles will be created for densifying the locations that are most suitable. The design principles will serve as a tool for the final design phase. In the concept phase, there will also be a focus on the research question: How can we involve the public to legitimize the plan? A participation process will be created as a tool for the municipality to involve the public. This participation process will help in creating awareness as well as support for the densification within the city of Rhenen. Such awareness and support amongst the citizens are necessary to make the densification a success.

2.4. DESIGN PHASE

In the final phase, the concepts and ideas from the design phase will be visualized. using Adobe InDesign, Photoshop, Illustrator, Google SketchUp and Lumion. The visualisations will be shown to the municipality of Rhenen, in order to give them an idea of what densification within the city could look like. The designs will focus on some specific sites of the plan, as it would be too time-consuming to visualize every suitable location in detail. Also, the design will be limited to the building volumes, and will not describe the materials or

architectural details. The commissioner is planning on asking a structural architect to further develop the final product of this project. Rather than final solutions, our designs should be seen as an inspiration and starting point for discussions that will broaden the range of growth options at the table of the Municipality of Rhenen. The design will be accompanied by a short movie. In this movie, the participation process that we propose to involve the citizens will be explained.

3. THEORY & ANALYSIS

3.1. STAKEHOLDERS

Many different people and organisations have an interest in the process of densification in Rhenen. Amongst them are the municipality of Rhenen, the residents and the companies and organisations that own or use the buildings and plots that will be affected by the densification plan.

The residents, represented partly by our commissioner, *Stichting Vrienden Behoud Lijsterengh*, have an interest in keeping the attractiveness of their surroundings. It is crucial that they support the plan for densification in order to prevent larger protests later on in the process.

Housing corporations like Rhenam Wonen and project developers could not be interviewed, but are expected to value high quality and profitability of the developments. Their cooperation is needed to implement the densification plan as well.

The main decision power, however, lays with the Municipality of Rhenen. Although the commissioner of this project is *Stichting Vrienden Behoud Lijsterengh*, our indirect target group is the Municipality of Rhenen. The commissioner will use our project to convince the municipality that there are alternatives to extending the city. Therefore, the project will have to address the municipality's interest as well. We expect the municipality to have an interest in a solution with a comparable effort and cost as the proposed expansion plans.

For detailed design for different locations, it is important to know the ownership of the plots. However, this information is not publicly available. As we focus on making an overall plan and vision for a more densified

Rhenen, it was not feasible to contact all parties. With diving into the ownership of small plots, it becomes

hard to find be accurate and often results in small scale solution rather than one big solution.

Thus, the focus of this research will not lie on the stakeholders, as ownership is a large part of this. Ownership information is important in the future, therefore it is recommended to gather this information when the concrete plans will be made when densification in Rhenen will be realised.

3.2. THEORY ON DENSIFICATION

The residential density of cities and villages is changing. Urban densification has become increasingly popular in the Netherlands. In almost all regions of the country, types of densification are present because of population growth. Densification within built areas became preferable to expansion to open plots of land (Broitman & Koomen, 2015).

In the past, many cities and communities have developed by growing outwardly. This has led to the loss of natural and agricultural land, as is also the case of Rhenen. Densification is seen as a strategy for building houses in cities without the disadvantages of spreading out and claiming valuable land. Jabareen (2006) describes density as one of the seven design concepts of sustainable urban forms. Density is hereby referred to as the ratio of people or dwelling weighted to the land area.

However, densifying in its most simple understanding also implicates several risks that have to be taken into consideration. There are different aspects that are important for healthy and comfortable environments, which are challenged by densification (Boverket, 2017). One could think of the following aspects:

3. THEORY & ANALYSIS

- **Public services** (e.g. green space, sports facilities, schools and doctors). Growing inwards in cities challenges the space for public services, as with densification, the competition for land will increase (Arvidson, 2017).
- **Traffic increase.** Densifying alone does not guarantee a more sustainable city development in terms of decreased energy use for transportation. In areas that are badly connected to the public transport network, more buildings immediately only mean more people putting pressure on the street network (Center for Urban Planning, Royal Danish Academy of Fine Arts, 2009).
- **Greenspace.** Vegetation in the city serves several different functions and can be highly varied in appearance. However, the risk of densification is that the amount of greenspace might decline, despite the fact that the climate-smart role of vegetation becomes more important in a densified city (Wingren, 2017). Green space of good quality in the inner city, as well as a greater diversity, is desired. When more people live in a specific place, more and better quality of green is needed. The challenge is to expand the current green space and complement it with new qualities (Tillie et al., 2012).
- **Daylight.** There are limits to how densely we can build. When designing buildings, it is really important to keep the amount of daylight within the area in mind (Rogers, 2017).
- **Noise.** When cities are densified, there are more people, more buildings and more functions in the same place. This means that there will be higher levels of noise. Also, in this case, building design

3. THEORY & ANALYSIS

could influence the amount of sound, which should be kept in mind, while densifying the city. Densification requires that acoustics are actively incorporated in the planning process (Hellström, 2017).

While the issues of noise, daylight and greenspace can be solved by the design of the individual buildings, issues of lacking services and increasing traffic have to be tackled on a larger scale. A refined concept has, therefore, been developed: the Compact City.

The Compact City concept adds several requirements to the concept of the dense city. Most importantly, good accessibility by public transport, bike, walkability and a mix of land-uses (Neuman, 2016). Joint use of space could be a solution for the latest. This notion refers to the fact that the premises and outdoor space are not to be used for one function only, but for other functions as well. An example of this is a schoolyard that could also

become a public playground. Space should be used flexible, in order to provide enough public services.

However, collaboration is hereby very important, joint use must be discussed at the planning stage between different parties (Arvidson, 2017).

Concerning the issue of increased traffic, the Danish/Norwegian researchers Peter Hartoft-Nielsen and Petter Næss discovered that travel time and distance

to a centre structure are closely related (Næss, 2012). Therefore, they propose that new centre developments and workplaces should be built around public transport

When we apply the aforementioned theory specifically to the case of Rhenen itself, densifying alone would only mean adding more buildings to the city. However, this would also increase the number of people commuting to work in Utrecht and Veenendaal using a personal car. However, improving the accessibility of those cities by public transport and adding service functions and workplaces to Rhenen, might actually lead to a noticeable decrease in car traffic. Also, the infrastructure for slow transport (i.e. biking and walking) within the city should be improved. Moreover, it is important to site less mobile citizens (e.g. the elderly and the starters, who do not own a car) in the areas that are more easily accessible by public transport. Given that these conditions are kept, the densification would indeed help to reach critical support for public transport to run (Boverket, 2017).

3.3. LANDSCAPE ANALYSIS

3.3.1. POTENTIAL LOCATIONS

As mentioned before, the focus lies on finding empty locations or potentially empty locations. This includes areas that are already empty, parking lots or buildings that have almost reached their lifespan. The locations in Figure 6 are the ones that we suppose could potentially be used for densification.

This is the first inventory of possible locations, however, stations, in order to make it easier for commuters to access their workplaces by public transport. This development around public transport connections is also called Transit-Oriented Development (Still, 2002).

because of the low floor space index, suggesting lots of open space and enough room to build, however these areas are not yet used as building locations, therefore, the result would be an urban expansion by the nature of the intervention, rather than densification, which is the actual overarching topic.

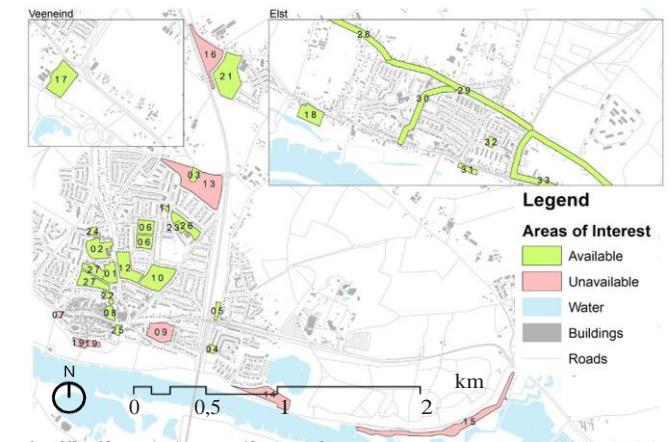


Figure 6 All potential building locations. (For information about the numbers, see Table 1.

3.3.2. DENSITY

The density map (Figure 7) shows that Rhenen is not very dense. The average density of the municipality is 469 people per km^2 (Centraal Bureau voor de Statistiek, 2019b) compared to the average density of the whole Netherlands, i.e. 488 people per km^2 (Holland.com,

a few have been excluded after a short discussion. Location 13 has been excluded because it concerns a large villa park. This would be a suitable location to densify because the

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gardens are very large and there is a lot of space around the houses. However, it is not realistic or feasible to propose building on the private grounds of the owners of the villas. Additionally, locations 7, 9, 14, 16 and 19 have been highlighted

2018). There are just a few hotspots marked in the red colour, where the density is higher. Most of the potential building locations are mostly in less dense areas marked in the green colour. Therefore, the potential building locations are considered good options for densification from this point of view.

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Table 1 Information about the location numbers.

Nr.	Place	Extra info
1	Gezondheidscentrum near the old church	Doctors Berg & Hofmeier, Upholster shop
2	Sportcentrum 't Grasland	Bowling
3	Beukenlaan stormwater storage	
4	Car dealer at Zwarteweg	New potential landmark
5	Spoorgat at the railway	Pro-Rail, Spoorgat Rhenen (local inhabitants)
6	Neighborhood block near Meidoornlaan	Already being renovated, small space
7	De Westpoort building & area	Repair-café
8	De Etalage near Jumbo	Management issue in centre (shop owners - residents)
9	Gedachtenis kerk nearby park	Religious community Sint-Cunera
10	Gereformeerde gemeente kerk	
11	Valleiweg near ontmoetingskerk	Shopowners: De Kappershoek hair salon, Apotheek Rhenen
12	Between the Venendaalseweg en Achterbergseweg	Already being renovated
13	De Helling	Expansion, not densification
14	Cunera inc., area near Rhine	Cunera Inc. (make carpets)
15	Grebbseluis	
16	Achterberg	Expansion, not densification
17	Veeneind, near Venendaal	bert Henken
18	Damkro area, Elst	Old caravanland, public participation underway
19	Buitenwal, near the Rhine	Expansion, not densification
20	Het bosje, Elst	Rhenam wonen (senior housing), already realized
21	De Linde complex, Achterberg De	Rhenam wonen
22	Bakken parking, near centre	Incorporate parking in IT
23	Lijsterberg, near Montessori	Rhenen municipality
24	Sprinkplank, at Platanenlaan	Rhenen municipality
25	Buitenomme parking Rhenen	Incorporate parking in IT
26	Lijsterberg 2, existing buildings	Building extra floor(s)
27	Doktor Wallerstraat, near the mosque	Building extra floor(s)
28	Paardekopstraat, Elst	
29	Franseweg, Elst	
30	Schoolweg, Elst	
31	Rijksstaatweg, Elst	Fire station
32	Prinsenweg, Elst	Former school
33	between Rijksstraatweg and Zwijsbergen, Elst	

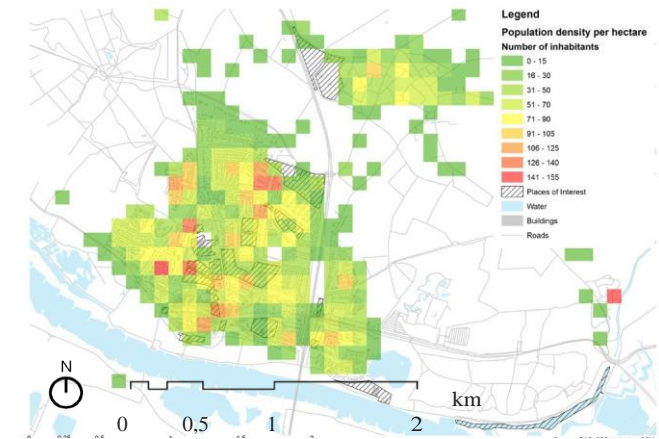


Figure 7 Density map.

3.3.3. ACCESSIBILITY

Good accessibility of public transport is important when considering densifying. Especially for young starters, accessibility to bus stops (Figure 8) and the train station (Figure 9) can be very helpful. These people often commute between home and work. With a diminishing focus on the car and increasing focus on soft transport (biking and walking), public transportation becomes indispensable for longer distances. Both the accessibility maps show the areas closer to the centre of Rhenen have good accessibility to the public transportation system. Therefore, most of the potential building locations also have a good accessibility. This is especially true for the bus, as most locations have a good connection. For the train connection, some places are further away.

3.3.4. GROUND AND FLOOR SPACE INDEX

The analysis has been performed calculating the Ground Space Index (Figure 10), which shows the ratio between the built-up and the unbuilt area of a

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plot. However, even more relevant is an additional calculation that also includes the number of floors of

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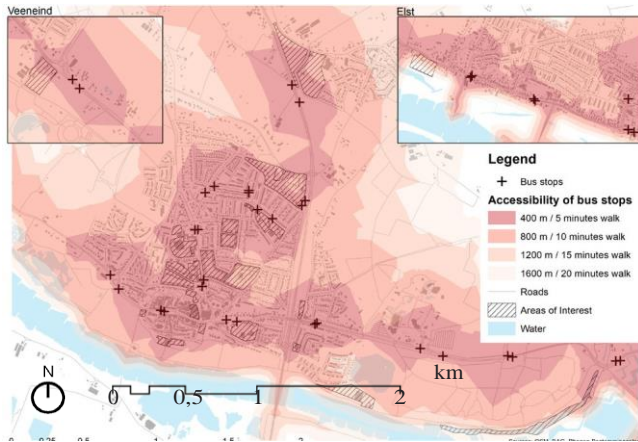


Figure 8 Accessibility to the bus stops, based on the travel time.

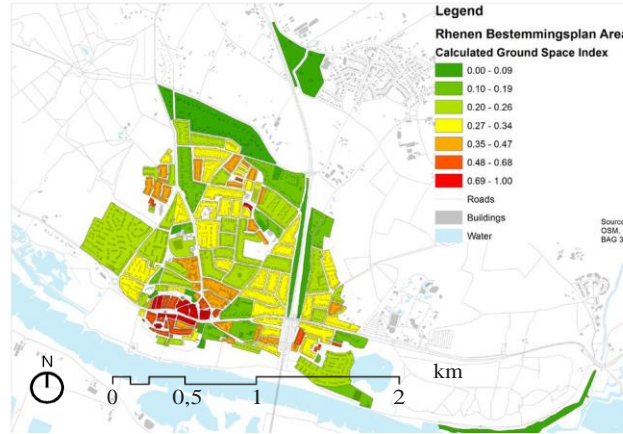


Figure 10 The Ground Space Index map.

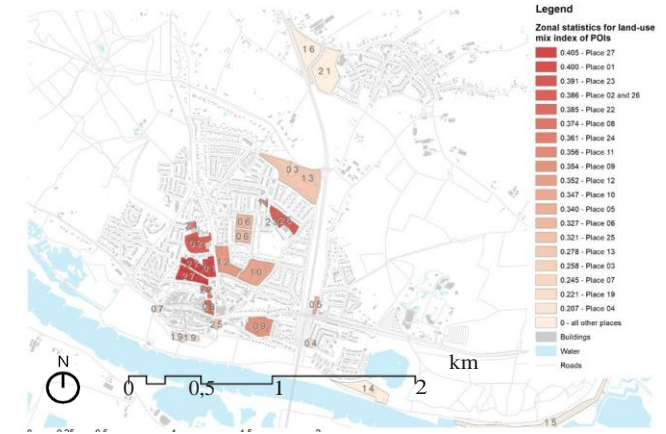


Figure 12 The Land-use Mix Index for the city of Rhenen.

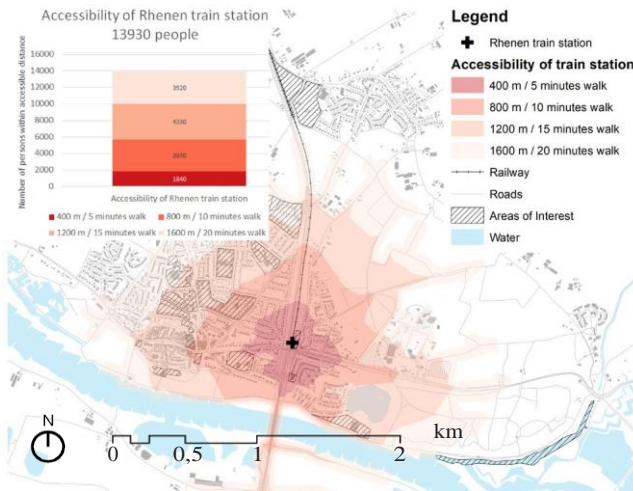


Figure 9 Accessibility to the train station, based on the travel time.

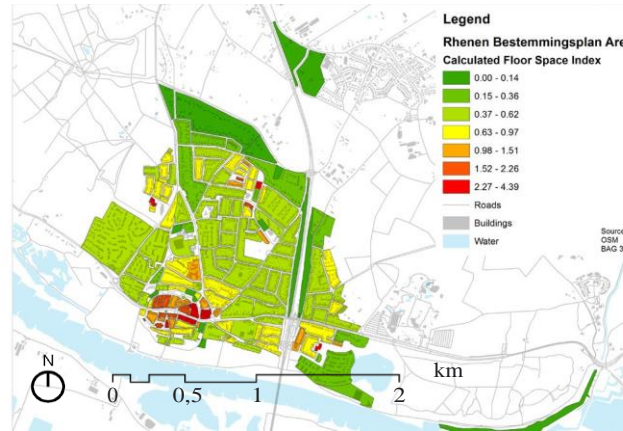


Figure 11 The Floor Space Index map.

These areas show less promise for further densification and some of them are even considered to be made

3.3.5. LAND-USE MIX INDEX

The areas represented by the darkest shades of red in the following Land-use mix index map (Figure 12) are the locations where the land-use is the most diverse on the same area. These areas are characterised by high accessibility of public services, which is a desirable quality. Land-use mix index was calculated using the following types of land-use: residential, commercial and greenery.

3.3.6. AGE OF THE BUILDINGS

The municipality of Rhenen has been built gradually, thus featuring houses of many different ages. Figure 13 shows a map of the age of the buildings.

Many of the potential building locations are currently built-up, with old houses that are or soon will be up for

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the building in question into the calculation, resulting in another index called the Floor Space Index (Figure 11). On this resulting map, it can be seen where the hotspots that are relatively more built-up are located.

more open. However, on the other hand, the areas with very low Floor Space Index show great potential for densification.

renewal. For example, many of the rental houses are from the 1960s and these are now being renovated. Therefore, these rental houses are not the best locations for densification in the near future, however,

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they show great potential in another decade or two, when these renovations have met their lifespan and the reconstruction will be required.

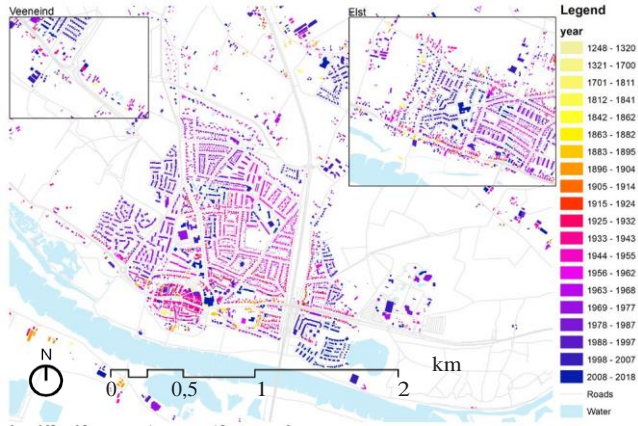


Figure 13 The age of the buildings.

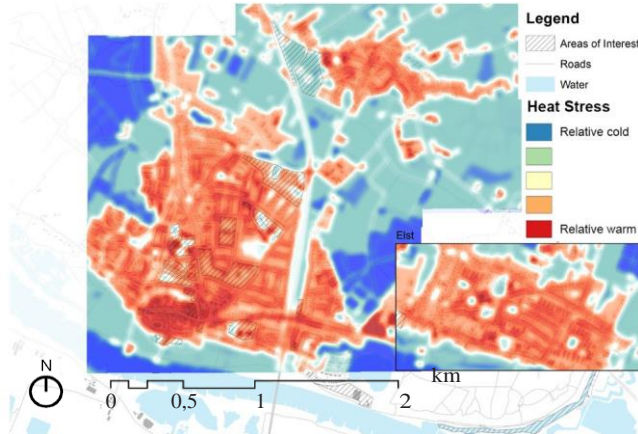


Figure 14 Heat stress map.

3.3.7. URBAN HEAT

Many cities face issues with urban heat, not unlike

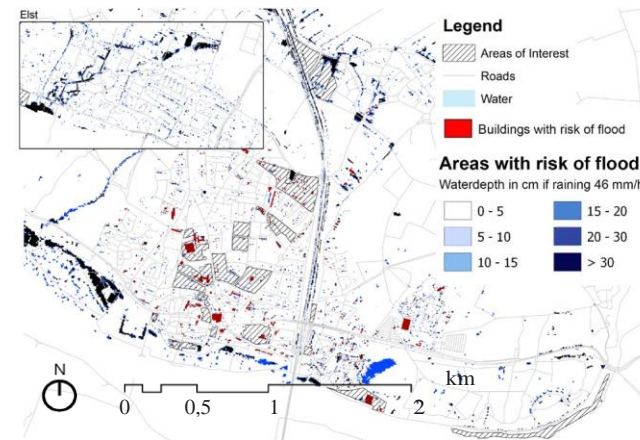
building locations are located in the dark-red areas of the urban heat map (Figure 14). These locations should receive higher priority for tackling heat stress issues than the others. With good city-planning and a climate-adaptive design in mind, these areas will have a better living climate in the future.

3.3.8. FLOOD RISK

Rhenen is a city close to the river, with different height levels. Therefore, some locations can have to deal with the risk of flooding (Figure 15). When designing for a more dense Rhenen, the risk of flooding needs to be incorporated in the design. Due to climate change, it seems likely that more peak-rain events will occur in the future, so the design should include climate-adaptive measures.

3.3.9. WIND CONDITIONS

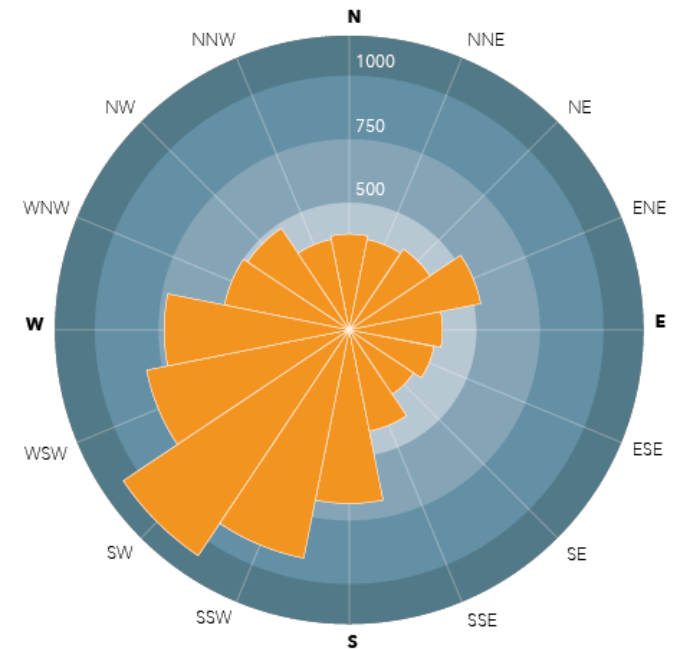
In order to be able to create an urban design that mitigates heat stress, it is important to analyse the wind conditions in Rhenen. If in summer the wind is steered



through the city, it can help cooling off public spaces.

The wind rose (Figure 16) shows, that the wind in Rhenen predominantly moves from southwest to northeast. According to the Royal Netherlands Meteorological Institute, KNMI (2019), in winter, the wind comes from the southwest. In summer, however, the wind directions are more scattered and rather weak. This is connected to the relief of Rhenen and its surroundings (Figure 17). Rhenen lies in the slipstream of the Utrechtse Heuvelrug, i.e. the wind, that goes over the hills from the northeast does not sink down fast enough to reach Rhenen. Also, buildings situated higher up on the hill cause turbulence and weaken the wind.

With these wind conditions, the wind cannot effectively



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Rhenen, which also has some hotspots. Several potential

Figure 15 *Flood risk map.*

Figure 16 *The wind rose.*

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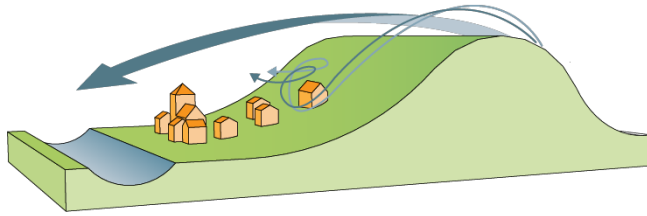


Figure 17 The slipstream of Utrechtse Heuvelrug.

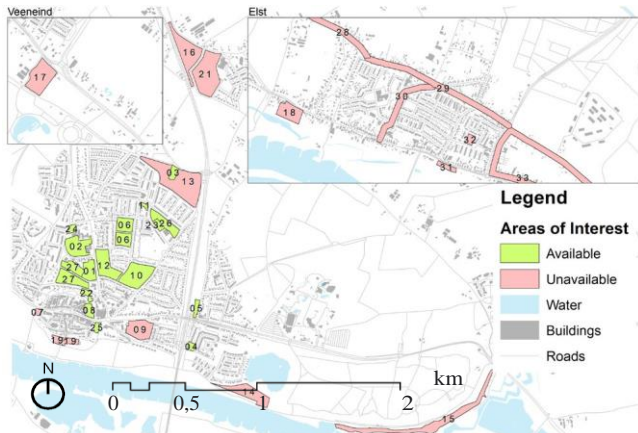


Figure 18 The most suitable building locations.

be used to cool down the city in summertime. In winter, the buildings should block off the cold wind coming from southwest in order to avoid the appearance of unpleasant, windblown public spaces.

3.4. MOST SUITABLE LOCATIONS

The landscape analysis resulted in a new set of locations that are shown on the following map of the potential building locations. Locations in Elst and Achterberg are not included because they often result in expansion rather than densification. And the largest opportunity

Table 2 Point of attention for the most suitable building locations (green means already good, dark red needs most attention).

Nr.	Place	Build-up Index Ground space index/ floor space index	Area (ha)	Land-use mix index	Water problems	Heat stress	Accessi- bility
24	Springplank	0/0	0,3184	1	3	2	4
2	Sportcentrum	0,22/0,43	1,874	1	4	4	4
27	Dokter Wallerstraat	0,26/0,63	2,4182	1	2	3	3
1	Church	0,33/1,33	1,117	1	3	4	3
22	De Brakken	0/0	0,3271	1	3	4	3
8	De etalage	0,89/2,64	0,4977	1	2	5	2
25	Buitennomme	0/0	0,2547	2	2	3	2
3	Water Storage	0/0	0,4293	4	5	1	5
11	Valleiweg (empty shops)	0,82/1,85	0,1609	2	3	5	3
23	Lijsterberg (empty plot)	0/0	0,3229	1	2	2	3
26	Lijsterberg (apartments)	0,13/0,53	1,26	1	3	3	3
6,10,12	Neighborhood (tiny houses)			2	3	4	3
5	Cunera Restaurant			2	1	4	1
4	Car dealership	0,43/1,26	0,2527	5	3	4	1

lies in making one big solution for the housing problem. These opportunities lie in Rhenen itself, where clusters

of potential building locations can be combined for an overall vision for a new and densified Rhenen. So for this report, we only focus on locations in Rhenen, however, this does not mean that the locations in Achterberg, Elst and Veeneind are not suitable at all.

Figure 18 shows the map with all the initial potential building locations. The locations in red are the ones excluded for the next steps, the locations in green are the ones that will be used. Table 2 shows the points of attention for the most suitable building locations according to the analysis. The data shown in the table is mostly the result of the landscape analysis.

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3.5. NUMBERS ON HOUSING

3.5.1. CURRENT SITUATION RHENEN

The brief for the Rhenen densification project, mentions that the to-be-constructed housing is primarily aimed at starters/young families and elders. These dwellings generally fall into the lower size range of housing: 65 - 90m² (NU.nl, 2019; Centraal Bureau voor de Statistiek, 2013). This vision corresponds with the current trend in the construction sector, as is demonstrated by the new construction stock overview from the Province of Gelderland, as shown in Appendix 1.1.

The most recent data on the housing stock in the

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municipality of Rhenen stems from 2012 (Centraal Bureau voor de Statistiek, 2012). This dataset is more elaborate and includes -amongst others- data on real estate typologies, functions, construction years, and userspace.

When analyzing the housing stock by type and function, immediately a striking observation can be made: the multi-functional use of real estate, with regards to living space, is very low within the municipality; only 125 (which translates to 1,67 %) of the total housing stock of 7.491 buildings incorporate a double function with living. Moreover, of these mixed-use buildings, only 14 shops are accounted for (Appendix 1.2.). This means that many of the city centre shops either have vacant floors above them or use suitable living space for storage. This indicates a strong potential for densification. However, since further required data (such as ownership data) is not publicly available, we will leave this lead for now. That said: it is strongly recommended to dedicate more resources towards the research of this hidden potential in the foreseeable future.

The current housing stock is for a large part constructed between the years 1955 and 1975. In that period of 20 years, Rhenen underwent rapid urban expansion. For your reference: 36 percent (that is: 2.697 dwellings) of the current housing stock was constructed in that particular period (Appendix 1.3.). This means, however, that in all likelihood a lot of the (partly poor quality early post-war) housing stock will be eligible for renovation, or demolition in the coming years (Nunen, 2010; Nunen & Mooiman, 2012).

Currently, roughly 35,0 percent of the housing stock falls within the much needed 65-90 m² size-category mentioned previously (Appendix 1.4.). That being said,

when we compare the distribution of dwelling-sizes with adjacent municipalities such as Wageningen and Veenendaal, the percentage of large size dwellings is noticeably higher (Appendix 1.5.).

When compared to the national average, we can indeed support the municipalities vision and conclude that Rhenen severely lacks starter housing options and has an abundance of high(er)-end, large(r) dwellings. Regarding the housing stock ratio for dwellings up to 75 m², this even goes as far as a 9% share against

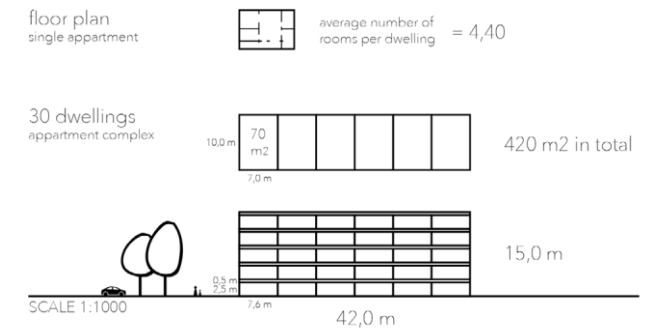


Figure 19a Apartment complex with small single household apartments.

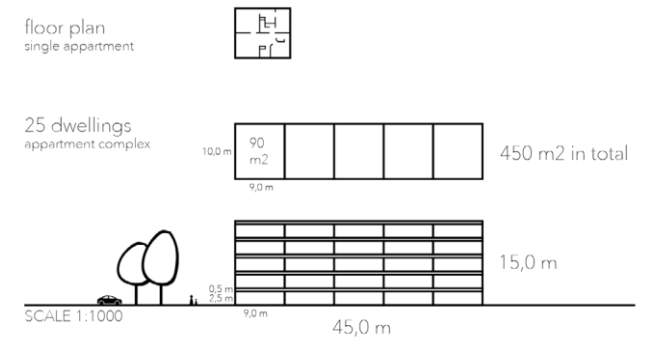


Figure 19b Apartment complex with small family apartments.

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the national average of 24% (Appendix 1.6). This misalignment in the housing stock is also illustrated by the average cost per house in Rhenen. For Rhenen this is currently €303.161 per house, in comparison to the Dutch national average of €263.000 per house. (Centraal Bureau voor de Statistiek, 2018).

3.5.2. BUILDING TYPOLOGIES

In order to crystalize the different building typologies, examples of each category will be presented in Figure 19a-d (Kools, Klaase, & Vlek, 2014).

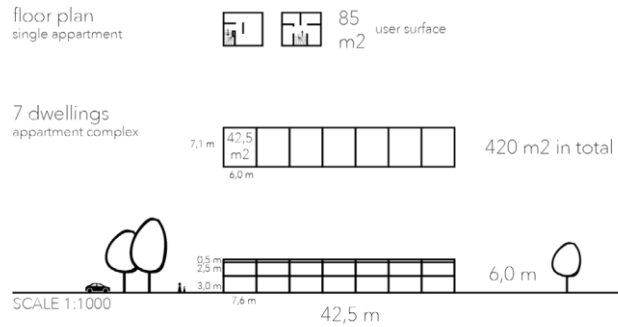


Figure 19c Small family row houses (flat roof).

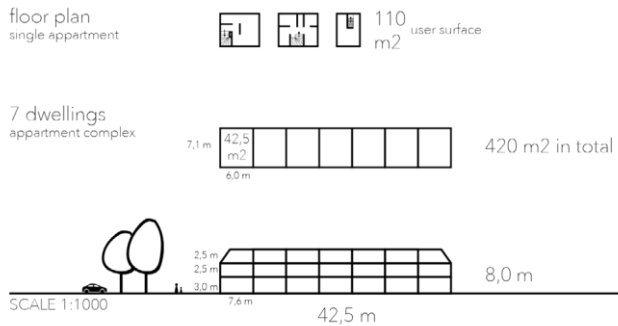


Figure 19d Small family row houses (slanted roof).

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3.5.3. FINANCIAL VIABILITY

With regards to social housing, it should be taken into account that there are tight restrictions to the construction costs for these projects, in order for them to be economically viable for project stakeholders and investors (Kools, Klaase, & Vlek, 2014). For social housing, these costs have been examined, as commissioned by the Ministry of Internal Affairs, and schematized as shown in Figure 20 and 21.

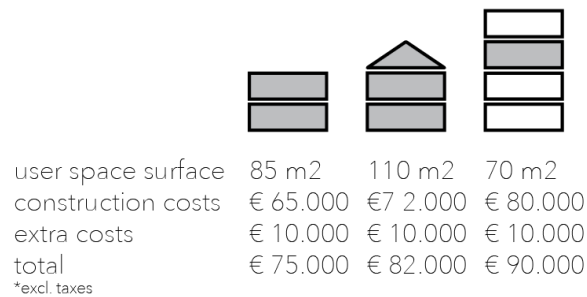


Figure 20 Costs for different social housing typologies.

3.5.4. PARKING

The parking norm for Rhenen prescribes between 1,4 to 2,2 parking spots per apartment that are built outside the city centre, i.e. north of Bantuinweg. Hereby, 1,4 is the minimum for parking spots for cheap apartments, while 2,2 is the maximum for parking spots for expensive apartments (Appendix 2). As our housing offer will be mixed, we will apply a parking norm of 1,8 parking spots per apartment to our development. If other functions are incorporated in the planned buildings, we will comply with the parking norms as stated in Appendix 2.

The size of a parking spot is defined as 2,4m x 5m. For underground parking and parking garages, the usual space needed for each parking spot + access route is

The cheapest option for building parking lots is placing them in front of the buildings. This solution will be chosen where possible. Additionally, underground parking will be installed directly under larger buildings.

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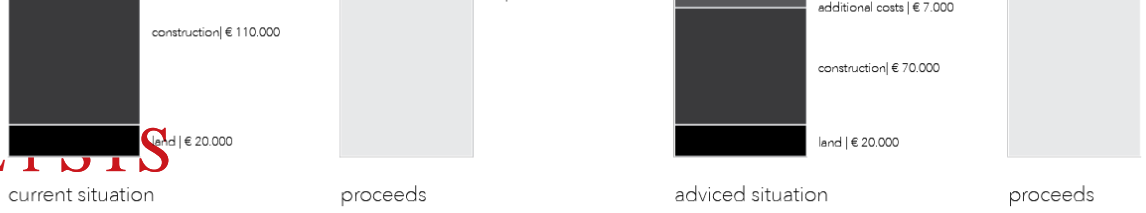


Figure 21

Cost-composition for social housing.

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4.1. STRATEGIES

4.1.1. BASIC DENSIFICATION OPTIONS

Based on the theory and analysis from the previous chapter the number of possible building locations was narrowed down to the most suitable locations. The following design phase will be based on the concept strategy presented in this chapter. We will first describe three different densification strategies that can be applied to the level of single buildings. Afterward, the strategy that forms the basis of the concept of the final Masterplan will be elaborated on.

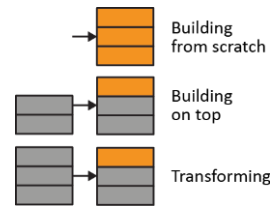


Figure 22 3 strategies.

Based on Beurden, et. al. (2013), we identified the following three basic strategies for densification (Figure 22):

1. **Building from scratch** on empty plots within the city.
2. **Adding additional floors** on existing buildings.
3. **Transforming** the use of existing buildings to residential use

4.1.2. CONCEPT STRATEGY

The overall strategy for densifying the city of Rhenen should include overarching principles on the larger scale that interconnect the individual approaches on a smaller scale. No matter how the specific interventions will be realized exactly in the local



Figure 23 Green corridor map.

context, each of them must follow the overarching principles, in order to fit into the overall strategy.

amplifying the aforementioned issues and, therefore, unsatisfactory results.

The second principle is the **green corridor** (Figure 23). The key idea behind it is to interconnect the Koerhevel throughout the city all the way to the river Rhine in the South. This will be made possible using the array of continuous public space stretching alongside this corridor, making it wholly accessible for the citizens of Rhenen that could make use of this new axis passing through their city without needing to worry about cars, pollution and heat stress.

The third principle concerns **slow transport** (i.e.

One of those principles is the **conscientious densification**, which requires each intervention to be based on the analyses performed in Chapter 3.3, in order to fully comprehend the circumstances at their specific locations and work in compliance with this information. This includes:

- **Land-use mix index.** At the areas of a low index, other land-use must be included.
- **Heat stress.** The areas with high heat stress must include a higher share of cooling.
- **Water problems.** The areas that are prone to flooding must include water retention.

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- Accessibility of public transport. Localize the housing for the disadvantaged at the areas of high accessibility.

Disregarding these guidelines could, in turn, lead to

walking and cycling). As mentioned in Chapter 3.2, densification increases the pressure on the existing transport infrastructure. On the scale of the city of Rhenen, we see a solution to this issue in the form of extending and improving current infrastructure for slow transport, i.e. bike lanes and pedestrian paths, at the expense of current car lanes. This would incentivize the public to use those kinds of transport and, at the same time, discourage them to use the car.

The fourth principle ensures that the sites where densification takes place do not decline in their **urban quality and livability**. This means that every function that has been provided by the specific place must be kept at least and more preferably other functions should be added on top of those in order to increase the quality and livability. Some examples of added value to those places might be:

- Using roofs and lower floors for additional functions such as urban agriculture, green terraces, medical

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services, sports centres, etc.

- Tackling urban heat island effect
- Extending the number of parking places when replacing parking that has been taken away by new development.
- Improving the public environment (public space network and public amenities).
- Improving infrastructure (a reference to the previous principle about slow transport).

And the fifth principle refers to the **spatial context**, requiring new buildings to correspond spatially and materially with the surrounding buildings, in order not to disrupt the visual character of the densified neighbourhoods. Emphasis is about to be taken specifically in the height of the buildings and their position in relation to existing infrastructure. These concept principles have been spatialized on the map in Figure 24. Next to each location are icons, showing:

- Which functions have to be replaced or added.
- Which climate challenges have to be taken into account.
- Which of the 3 basic densification options applies.
- Which building height and shape would fit to the surroundings of the specific location.

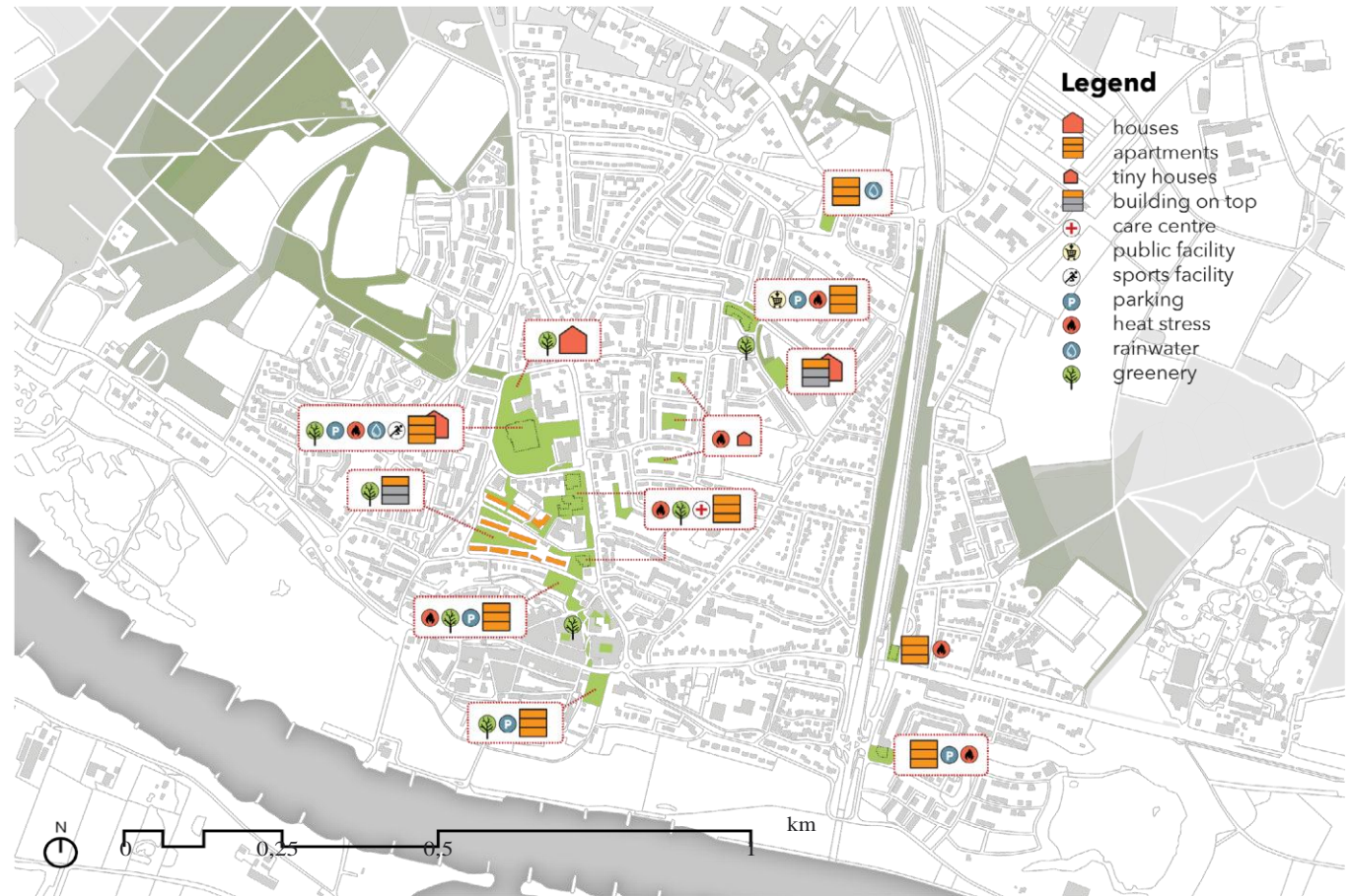


Figure 24 The concept map.

This map will serve as a basis to develop more

detailed design proposals but can also be used by the municipality to develop their own designs with its help.

4.2. MASTERPLAN

The masterplan (Figure 25) summarizes all the interventions that were developed based on the concept map above. The area of the cluster is designed in more detail: it shows proposed building volumes and

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designs for the open space in-between the buildings. Locations outside the cluster have not been designed in detail. Figure 26 shows the volume study of the masterplan within the existing urban fabric.

4.3. DETAILED DESIGN AND PHASING This chapter will present the detailed design proposals for each location and the time plan (phasing) for

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Figure 25 The masterplan.

implementing the developments. The numbers in front of the paragraphs refer to the numbers on the masterplan (Figure 27). Within the map, numbers in orange represent projects of densification phase 1

while numbers in red represent projects of densification phase 2. In Figure 28, the phasing map is shown, the locations per phase are shown in this map.



Figure 26 Volume study of the masterplan.

4.3.1. PHASE 1

In order to create 500 houses in Rhenen before 2028, different locations are proposed for densification. The locations, where densification is realistic before 2028, are in the first phase. This first phase includes empty plots, plots where renovating or rebuilding in the next few years is realistic, and plots where the transformation of the area on the short term might be profitable. The site-specific problems resulting from Table 2 are also taken into account in the strategy description. For the plots in the green corridor, the exact number of houses and parking spots is calculated. For the remaining plots, only a rough estimation of the potential amount of houses is given.

Plots within the green corridor:

01 Nieuwe Veenendaalseweg

The Nieuwe Veenendaalseweg will have to be redeveloped in order to be able to handle the growing pressure caused by an increasing population. The bike lane will be taken out and moved to the green corridor which will allow the municipality to broaden the car lane and make car and bus traffic more fluent.

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Figure 27 Numbers of the action locations. Orange represent projects of densification phase 1, Red represent projects of densification phase 2. On the small map on the right, the parking

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*types can
be seen.*

4. RESULTS

02 Springplank

On the empty plot north of Basisschool de Springplank, a terraced building can combine the functions of housing and schoolyard: its green rooftop can be used partially as private gardens and as a green school garden while catching rainwater during heavy rainfalls (Figure 29, for more see Appendix 3.1.).

- # 37 Households (10 \geq 100m², 27 <100m²)
- # 80 Parking spots (48 underground, 32 in front of the building)



Figure 29 Impression of the terrace building.

03 Green corridor

The green corridor will stretch from the Koerheuvel to the city centre and the floodplains next to the Rhine, providing Rhenen with a new bike connection to the train station, away from the busy Nieuwe Veenendaalseweg, while mitigating the urban heat island effect and providing permeable surfaces for storing rainwater (Figure 30).

Phasing map.

Figure 28

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Groeneweg
The old
bowling hall
will be
replaced by a
building
complex with
mixed
apartment
sizes and a
new sports



- Current Green
- Before 2028
- After 2028
- Threatened land

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Figure 30 Green corridor cluster map.

center on the lower floors. On the parking lots apartment buildings will be placed. Parking for the sports center and the houses will be situated underground and between

6 buildings with 121 households (47 $\geq 100m^2$, 75 $< 100m^2$)

413 parking spots (380 underground, 33 in front)

05 Old church/ medical centre

The unused church and old medical centre will be replaced by new dwellings. Green rooftops that can be used as a park by the elderly people will be included in the building design. The elderly will benefit from living on top of a medical centre situated in the ground floor of their building. Also, empty spots will be used for rowhouses with their own gardens (Figure 31 and 32, for more see Appendix 3.2.).

4 buildings with 90 households (20 $\geq 100m^2$, 70 $< 100m^2$)

195 parking spots (165 underground, 30 in front)

06 Pharmacy

The old pharmacy will be replaced by a terraced building with mixed apartment sizes. A new pharmacy can move in on the ground floor.

34 household (6 $\geq 100m^2$, 28 $< 100m^2$)

77 parking spots (34 in front, 43 underground)

07 De Brakken

A terraced building with green rooftop gardens replaces the parking spot that was a source for urban heat in the past. To provide the city centre of enough

parking space, the parking will be underground. On top of the parking are apartments.

the buildings. Green should be added between and on the buildings to reduce heat and water stress.



Figure 31 Impression of green roof next to care home.



Figure 32 Impression from inside.

08 Buitenomme

A building will replace the large parking lot, consisting of terraced apartments in the south and a parking garage in the north. The building will be attached to

the city wall that now forms a viewpoint. This viewpoint will be extended to the rooftop of the garage, which

24 households (2 $\geq 100m^2$, 22 $< 100m^2$)

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2-storey underground parking with 156 spots, covering the 100 spots that have been removed.

can be used as a public space as well (Figure 33 and 34, for more see Appendix 3.3.).

9 households $\geq 100\text{m}^2$

90 parking spots in the building, covering the 70 that have been removed.

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Figure 33 Impression of rooftop park with viewpoint.



Figure 34 Rhine-facing impression of the viewpoint, with parking below.

Plots outside of the green corridor:

09 Bergweg

For the former water storage site, the strategy is to build from scratch. Waterproof design should have priority when building in the water storage, as water that flows to this area must be processed.

20-25 apartments

10 Valleiweg

The empty shops can be transformed into apartments with temporal rent contracts while adding an additional storey during the renovation. If in the future there is a demand for facilities, some apartments can be transformed back to other facilities. Greenery should be included in the design to reduce heat stress.

5-7 apartments

11 Lijsterberg (empty plot)

Build from scratch on the empty plot in front of the Larikslaan to create houses. No extra functions will be added to this location.

6-10 houses

12 Tiny houses

Tiny houses will be implemented within large gardens and open spaces in the old neighbourhood, to increase the density of this neighbourhood. It serves as a temporary solution until the neighbourhood reaches the end of its lifespan, and thus could be rebuilt. In the design of the tiny houses, heat stress reduction should be an important theme. Therefore, roofs with a high albedo or green space around it should be taken

account in the design (Figure 35 and 36, for more see Appendix 3.4.).

Next to the old neighbourhood, this innovative way of densifying could be used on other plots as well. Citizen involvement is important in implementing the tiny houses.

10-35 tiny houses



Figure 35 Impression of the tiny houses.



Figure 36 Impression of the border between the gardens and the tiny houses.

13 Cunera-restaurant

The restaurant and its parking lot can be rebuilt and transformed into apartments. It could be a building of a larger size which could serve as a landmark at the entrance of Rhenen. Green has to be included to reduce heat stress.

5-10 apartments

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14 Vogelenzang

Rebuild and transform the car dealership into

apartments. Reallocate the car dealership somewhere else. It could be a building of a larger size which could serve as a landmark at the entrance of Rhenen. Green has to be included to reduce heat stress.

10-20 apartments

4.3.2. PHASE 2

Phase two is created to provide a plan for the municipality after 2028. It is likely that Rhenen still has to grow, or that the actual created amount of houses before 2028 doesn't provide enough dwellings. For further densification after 2028 some more interventions have been come up with. We assume that these interventions are not realistic in the short term, as whole buildings where people already live in have to be renovated or rebuilt. If possible, only rough estimates of the number of dwellings are provided.

15 Dokter Wallerstraat

When the building has to be renovated, add one or two storeys on top during this renovation.

30-40 apartments

16 Lijsterberg (apartments)

When the building has to be renovated, add an extra storey on top during this renovation.

15-25 apartments

17 Old neighbourhood between Nieuwe Veenendaalseweg and Achterbergse Weg

Remove the temporary solution of tiny houses

rebuild the neighbourhood in a more densified way when the end of its lifespan is reached. Include green

to reduce heat stress.

115-600 houses (Appendix 4).

4.4. IMPLEMENTATION RECOMMENDATIONS

4.4.1. GOVERNANCE

If we want the proposed interventions to get off the ground, a recent study has shown the need for strong governance. This includes intertwining the top-down and bottom-up approaches, with the top-down hierarchy having a prominent role in the coordination of efforts across policy levels and sectors (Mees, et.al., 2013).

Yet another study concerning governance has shown, that in order to gain enough public and private support, which is critical for the successful delivery of the planned interventions, there is the need for the mixed approach of all the different types of governance (Bulkeley & Kern, 2006). These types of governance are defined in the study as follows:

- **Self-governance;** the capacity of local government to govern its own activities;

An example of this type could be in our case densifying on the gemeente owned plots; or pilot projects like greenification of public buildings' roofs.

- **Governance by provision;** the shaping of practice through the delivery of particular forms of

service and resource;

This type could be incorporated by the municipality effort to trade-off and aggregate smaller plots onto larger ones where dense development will be implemented;

Another example is the provision of bike lanes and pedestrian paths at the expense of car lanes.

- **Governance by authority;** use the traditional forms of authority such as regulation and direction;

Following this type means ordering densification by municipal laws, for example by setting the zones of required minimal floor space index for new developments; or ordering mixed land-use at certain locations.

- **Governance by enabling;** refers to the role of local government in facilitating, coordinating and encouraging action through a partnership with private- and voluntary-sector agencies;

For example, the plot owners could be encouraged by different incentives to build tiny houses in their gardens, when another example might be to provide the citizens with a subsidy for a new e-bike.

4.4.2. PARTICIPATION

Experience has shown that densification projects often involve major implications. Therefore, the participation process connected to them should get a lot of attention. In Berlin, which is experiencing a shortage of approximately 150.000 apartments (Holm 2017), densification projects as the plans for building apartments on an empty airfield near the city centre

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and public transport opportunities, met tremendous protests and were finally blocked entirely by a citizens' vote (Mallwitz 2018) (Hackenbruch 2018). Also, municipal employees working on densification in Aarhus, Denmark, are reporting problems. They claim that instead of involving the citizens from project project, it would save them a lot of time and trouble to involve them in an even earlier phase of the densification plans and on a higher scale (Svith 2017).

Finally, our commissioner, Geoffrey Gaspersz stated as well that planning processes in Rhenen are lacking possibilities for citizen involvement on a higher level (G. Gaspersz, personal communication, June 07, 2019).

Based on these insights, we decided to design a citizen participation process that will cover different scales and levels of involvement. The process will be divided into two parts: one on the city level, concerning the potential locations for densifying, and one about the actual implementations per neighbourhood. This participation process will decrease the risk of conflicts later on in the process as the citizens get the chance to mentally prepare for change.

Firstly, we propose to kick-off the whole process with an organized event for the public, where the preliminary information about the need for densification would be covered and where the contextual analyses would be presented for the first time. Afterwards, we propose to prepare and operate several informational stands within the city of Rhenen that will be open to everyone passing by, showing posters with our analyses and the map including all the preliminary location proposals

possibility for anybody who knows of any other feasible location for densification, to include this location into the interactive map as a new point of interest for the rest of the participants.

This will result in an interactive map of the whole city, where citizens can localize their densification proposals and also discuss the ideas of others. However, we also suggest limiting the number of areas that citizens can propose for densification. For example, the areas where densification is not feasible (e.g. graveyard, listed buildings, etc.) could be displayed in red colour and that will prevent the citizens from getting false hopes and unrealistic expectations to building alternatives.

that we have developed during the atelier. However, besides those preselected places, there is also a

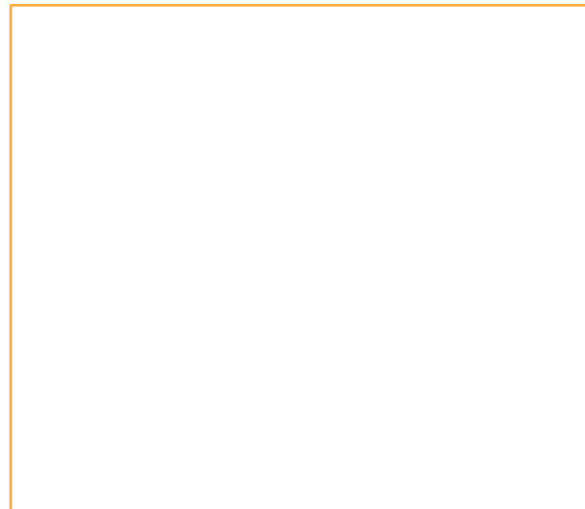


Figure 37 *Impression of the CityScope project.*

In order to reach as many citizens as possible, this set-up can be moved around, especially into the neighbourhoods where we expect the highest densification potentials.

Inspiration for the interactive map could be the CityScopes tool, developed by HafenCity Universität Hamburg (2016). It has earlier been used to involve citizens in finding possible locations for refugee camps within the city of Hamburg. A city map is here projected on a transparent table and model blocks (e.g. refugee camps) (Figure 37). A computer can read the location of the model blocks from beneath and conducts a spatial analysis, showing – in real-time – the consequences, which different locations would have for the surrounding traffic, demographics etc.

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The second part of the participation process will focus

on the specific interventions in the neighbourhoods. The main target group for this process are the current residents and people that are expected to move in the affected area, but also the users of the area are welcome to join. The level of participation will be considerably higher than in the first phase. This second phase of the participatory process is actually giving them the power to co-create plans about how their neighbourhood will develop.

Firstly, ideas will be collected during the participatory session about what the participants value in the neighbourhood, i.e. which of the functions and features they want to keep and also, what they would like to add or change. Here, the focus should be on reaching out to as many people as possible – both young and old, rich and poor, residents, but also organizations and entrepreneurs. All the inputs should be collected in order to make a common vision for its development. This will be done in the form of kick-off discussions, further dialogues, questionnaires, online forms, guided walks with the stakeholders and the participatory game that



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has the overall rules modified and the shape of the game board redesigned for the specific neighbourhood only. As a reference, we learned about a similar participatory session that took place in Antwerp, Belgium (URBACT, 2019), where they also used these methods resulting in successful negotiations with stakeholders.

Based on the aforementioned various inputs, a prototype design will be created and proposed to the citizens in yet another participatory meeting. For this next step, we would suggest limiting the number of participating stakeholders. In Århus, Denmark, good experiences have been gained with creating a citizens' panel, consisting of representatives of the kind of residents that were expected to move into the newly developed area (Christina, 2017).

The process iteration of design-discussion-change can be repeated several times, we would, however, suggest keeping the number of repetitions low in order to make it less time consuming for people with a busy schedule. Figure 38 gives an overview of this second step of the participation process.

To show the different steps of the participation process, an animation has been made to help explain (Figure 39). This animation can be seen by scanning the QR-code in Figure 40.



Figure 40 QR-code with a link to the animation.

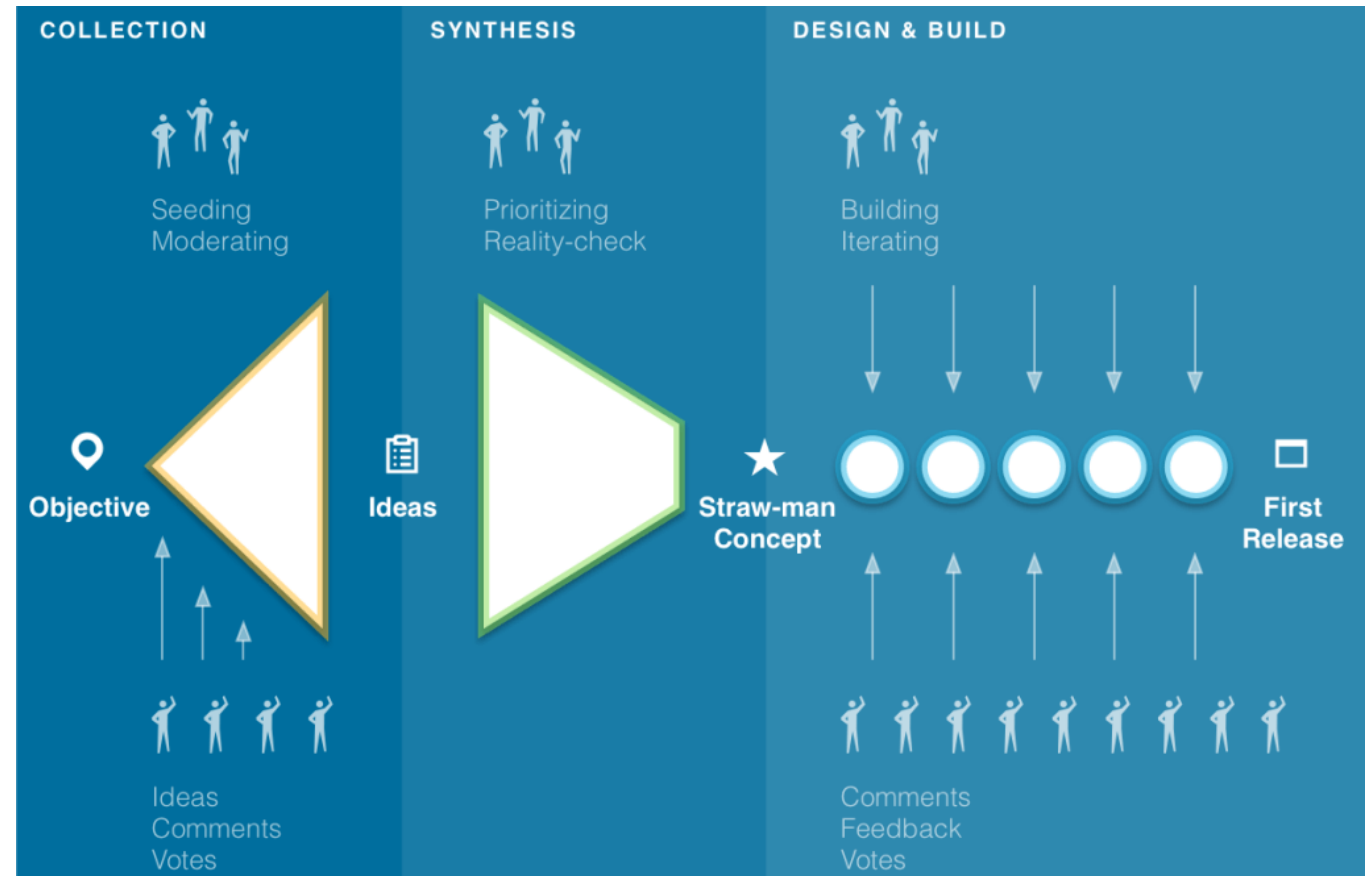


Figure 38 Overview of 2nd step of participation process.

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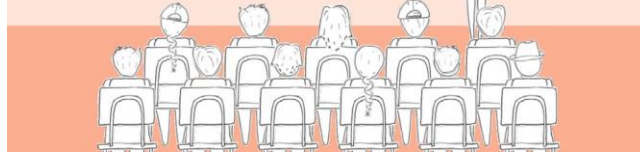


Figure 39 Screenshot of the animation.

5. DISCUSSION & CONCLUSION

5.1. DISCUSSION

5.1.1. ACHTERBERG, ELST, VEENEIND

In this report, in order to densify the city of Rhenen, interventions are proposed. However, the task to build 500 houses is for the whole municipality of Rhenen, meaning that the residential areas of Elst, Achterberg and Veeneind are also included. Therefore, the municipality of Rhenen could also look at options to densify here. During the analysis, different locations in Achterberg, Elst and Veeneind were shown where densification could be possible. Locations we looked into were:

- **Elst:** Paardekop, Franseweg, Schoolweg, Rijksstraatweg (plot next to the fire station), Prinsenweg (former school Woudmees), former Dorpshuis, and the area between Rijksstraatweg and Zwijnsbergen (possible place for tiny houses). Note: the information for Elst was also provided by Wim van Zanten, from the inhabitant group of Elst.
- **Achterberg:** De Linde.
- **Veeneind:** Next to Cuneraweg.

After coming up with possible locations, we decided that for any further analyses, the masterplan and the design to only focus on locations in Rhenen. The reason for this was the time constraints and the fact that the best opportunities are in Rhenen. Because of these two things, it was easier for us to focus on Rhenen and come up with one bigger concept plan instead of multiple, more scattered, plans in multiple residential areas. Besides that, multiple options in Elst, Achterberg, and Veeneind are rather an expansion of the residential area, than densification.

However, the proposed densification design for Rhenen could serve as an example for densification in the other residential areas within the municipality of Rhenen. The different strategies that are described in Chapter 4.1, could be used in order to densify several places in other residential areas. The design principles that are used for designing the buildings could be used for designing buildings in the three residential areas as well.

5.1.2. STAKEHOLDERS

In order to make the plan a success, it is necessary to talk with the different stakeholders to solve different potential problems for densifying. Some plots are already empty and municipality-owned, For these locations, we do not expect much trouble for densification projects. However, there are also plots, which are owned by other stakeholders, such as housing corporation Rhenam Wonen, the owner of the car dealership or the current owner of the Cunera restaurant. There will probably be more stakeholders, which are of relevance to us for making the plan a success, however, we could not get our hands on the information, which could show us the owners of all the different plots that could be of interest. The municipality did not have one available, and looking at the Kadaster would be costly.

We tried to get in contact with Rhenam Wonen as they own multiple plots of interest, however, they were not able to meet before the end phase of this project, due to holidays. We also decided not to interview the other stakeholders because otherwise, it would become too time-consuming given the fact that we only have eight weeks of time and a lot of different locations. The municipality could play a role in negotiating with landowners in order to create possibilities for densification.

The plots that are not owned by the municipality could not be considered as certain locations for our plans. When an owner of a plot that is considered for densification decides not to sell it and is also not willing to create housing over there, this situation would cause problems. Densification plans could be delayed or forced into being canceled. Therefore, it is important that conversations with landowners take place from the very beginning of the project life span. This is considered crucial in order to come to mutually supported agreements and consensus between the different parties.

5.1.3. FEASIBILITY UNCERTAINTIES

There might be more constraints regarding the feasibility of the proposed plan, due to the uncertainties that will be presented in the following paragraph. In our project, some uncertainties occurred due to the constrained time to research or due to the lack of tools or knowledge we possess. We mentioned before that different interests of stakeholders could lead to uncertainties in our plan. Another uncertainty is the issue with funding. In this report, some general information on housing costs is calculated, however, we did not have enough time for further research on the estimated costs of our whole plan. Therefore, we were not able to make any calculations on the expected costs of the whole plan or parts of the plan. This is something for the municipality to be taken into account when the plans become more concrete after the public participation phases. Another limitation of our proposal is the calculations used to determine the actual prices of the proposed housing. This limitation is due to the fact that we can only approximate this number according to the size of the living spaces and it is not feasible, from the

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aforementioned reasons, to also include the price differences of the specific locations. Further uncertainty

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is the precise number of dwellings and parking spots. We made some estimations on how many dwellings and parking spots our densification plan could provide, however, due to lack of expertise in this subject, the estimations could deviate from the realistic amount that could be created. This could be caused for example by regulations, infrastructural constraints or other situations we have not foreseen, for example when some plots turn out not to be suitable for densification. If these deviations lead to a shortage of dwellings, the proposed plots in Achterberg, Elst or Veeneind could compensate for this shortage. Yet another compensation could be found within the plans for the next phase after 2028. However, the numbers that could be created by these plots are also not estimated precisely.

5.1.4. CONTINUATION AFTER 2028

The municipality wants to build around 500 houses before 2028 and we tried to deliver the plans to come to this number. However, the sufficiency of the number of houses that are proposed by our plan is not definite because of the two following uncertainties. Firstly, the exact amount of houses that will be created is hard to estimate, as mentioned before. And secondly, because by 2028, there will be a whole different situation on the housing market and, therefore, many more houses might be needed. This is the reason why we also propose the plan for the continuation of the densifying project after 2028, in order to give the municipality also some continuation plans for densification. In our opinion, these plans are not feasible in the short term because of administrative and regulative reasons, as these interventions are quite radical, as is, for example, the complete renovation of buildings or rebuilding of neighbourhoods. Additionally, the plan would also not be efficient in the short term. The buildings that are proposed to be renovated or rebuilt are not too old

before 2028, so in this case, it would be more efficient to do this only after 2028.

5.1.5. FURTHER POTENTIALS FOR DENSIFICATION

Next to the locations that we came up with in Rhenen, Elst, Achterberg, and Veeneind, there might be additional locations on which densification is possible. For example in the city centre of Rhenen. There are some empty shops and the percentage of those grew steadily in Rhenen in the last couple of years, towards 15.4% on the 1st of October 2018 (Planbureau voor de Leefomgeving, 2019). In these buildings, there is a great opportunity to use the transformation strategy to create apartments in these empty shops. However, we did not look into this, because then it would have become more of a management plan instead of a design for the area. But still, it is a good opportunity for densifying Rhenen and it should not be forgotten by the municipality. Therefore, we recommend them to look at the opportunity to create housing in the city center in these empty shops as well.

Another possibility which we did not explore much, is the option of relocating commercial enterprises currently placed within the city to move outside of it, in order to create a win-win situation when providing the enterprises with potentially more appropriate locations and, at the same time, creating feasible space for densification. One example of this approach is the car dealership that could function outside the city with the same effectivity and benefit from larger premises. At the same time, the prominent location as the entrance into the city and near the train station would be very opportune for housing. We got the information and the name of the car dealership from

one of our commissioners, however, besides that, not much research was done on additional enterprises,

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which could be moved somewhere else. Therefore, this could be another additional opportunity to focus further research on.

It could also be the fact that we have missed some locations, which would be good places for densifying. This would be because we only know Rhenen for eight short weeks of this project, and, therefore, we do not know the city as good as anyone who has been working or living here for years. Because of this, the participation game we proposed will help in finding even more locations for densifying. It might be the case that people who know the area for a longer time have more insight into what is going on behind the scenes of that particular area and what additional plots could serve the need for densification. The participation game could also bring forward unforeseen coalitions and other opportune deals that have been missed.

5.1.6. CLIMATEADAPTIVE DESIGN In the design phase, we have taken into account different problems that might be amplified by densification, e.g. water problems and heat stress. We tried to include different measures in the overall design, which could tackle these problems. This is done by using our analysis to define different problems of the specific plots. For example, at places where heat stress or water retention is a problem, we tried to reduce that using surfaces with low albedo and high permeability. The public space we design will take into account these problems as well. However, when talking about heat stress, there is much more potential within the building design itself. We did not focus on detailing the building

design, concerning for example building materials. The reason for this is, that these designs could be better done by the structural architect, who will make the designs for the exact buildings, however, the architect can make use of

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our preliminary analysis showing the potentials of the building location.

5.1.7. FURTHER IMPACTS ON RHENEN

Densification of Rhenen will have multiple impacts on the city. There are some requirements, which should be taken into account for making the densification a success. The compact city concept, as described in the theory part, mentions good accessibility by public transport, slow transport and mix of land-use as some of the important requirements for a compact city concept implementation.

Firstly, increasing slow transport and densification are mutually dependent in the compact city theory because without densification, there are not enough points of interest to make the walking/biking worthwhile and vice versa, without slow transport, the space required for densification would need to be used to build roads and parking lots to accommodate for the transportation needs. Our plan, therefore, enables densified Rhenen proposing a new slow transport connection within the green corridor, as presented in the previous chapters. Additionally, there is the possibility to extend this corridor further to the North-East during the second phase of the densification project, while interconnecting the corridor also with the locations at Lijsterberg.

An additional impact of densification for the whole municipality of Rhenen is driven by the increased number of its inhabitants. The theory of microeconomics suggests that a growing number of customers increases both market threshold and market range of any service (Rodrigue, et.al., 2017). In practice, this could mean unforeseen opportunities. As one example of those opportunities, we can envision an influx of commercial activities bringing additional capital into the region.

Another example might be the increased demand for public transport. This increase could result not only in adding more vehicles but also in building more transit stations, especially train stations. New locations of those stations would be an excellent opportunity for Transit-Oriented Development as previously elaborated in the theory Chapter 3.2. We explored these opportune locations for such developments in our preliminary phases of location analysis. Those places were considered to become Transit-Oriented Development centres and, thus, very desirable for densification because of the implicitly excellent accessibility to public transport. However, as we have further elaborated upon, we have eventually removed those locations because such developments would be against the densification character of our project.

Densification of Rhenen will also change different urban infrastructures within the city. In a densified city for example, the energy demand per capita decreases, as densification leads to more efficiency (Barresi, 2018). However, when more people live in one particular area, the energy and water demand, as well as waste production, will increase in absolute numbers. This is especially the case in the cluster of densification locations, where some adjustments to the urban infrastructure might be required. Further research should focus on how to improve the urban infrastructure in a way that it can provide the new demand for energy and water, and that it can handle the amount of generated waste.

Our plan will also have an impact on the parking space in Rhenen. A lot of parking space is created for future inhabitants. Beneath the ground as well as between buildings, parking spaces are provided. In general, we used the average number of 1.8 parking spots per

dwelling for deciding the amount. In the future, it might be that less parking space is needed because the use of more sustainable modes of transport has substituted the use of cars. If this transition takes place, Rhenen will have a lot of unused parking spots. In order to use this potential space, a plan could be created to use the purposeless parking spots for another purpose.

5.1.8. TRANSITION IN PLACE

The transition that should take place in Rhenen is about changing the mindset of the municipality from the expansion of the city towards the densification of the city for creating houses. With our design, we try to give inspiration on what a densified Rhenen could look like. By giving inspiration, we try to give new insights into the difficult subject of densification within the city. Next to the plan and design, we also recommend extra tools to manage the transition towards densification, by proposing a participation process and introducing different modes of governance to govern the project. Especially the participation process might influence the way of working of the municipality. By involving inhabitants from the municipality of Rhenen, more power is given to the inhabitants in creating a densified Rhenen. This might be a change in the way of working, but it is a necessary step to make the transition towards more densification a success.

A transition towards more densification instead of expansion of the city could lead to multiple advantages within the municipality of Rhenen. With densification, the area green areas around Rhenen will be preserved. The transition will help in preventing the green areas around Rhenen, including the floodplains, the forests in the East and West, and the valuable agricultural land in the north, from being diminished for the purpose of building houses. The values in the outlying area will

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contribute to the liveability and attractiveness of Rhenen.

More densification could also provide a transition in the use of sustainable modes of transport. In 2017, car use in the municipality of Rhenen was higher than the average car use of the Netherlands (Crow Databank, 2017). As densification could lead to the use of more sustainable modes of transport as described before, the number of car use could decrease. Besides that, the green corridor will provide a safer slow traffic infrastructure in Rhenen. Improved safety could stimulate people to use slow traffic modes instead (Pucher & Dijkstra, 2003).

5.2. CONCLUSION

This report has shown that there are multiple densification options within the city of Rhenen. According to calculations and estimates of the plan, the phase until 2028 can provide between 371 and 422 dwellings. Until 2028, the number of 500 will probably not be reached within the city of Rhenen by the

proposed interventions, however, further densification options are available in Elst, Achterberg, and

Veeneind. Thereby, the transformation or reallocating of commercial businesses in the city (centre) is still an option as discussed in Chapter 5.1. So keeping this in mind, it seems realistic to provide Rhenen of a number of houses close to 500 by 2028 by only densification. The results are shown in numbers in Table 3.

A plan for densification is proposed for after 2028 as well. As it might be possible that Rhenen does not stop growing after phase one. The results are shown in Table 4. The range of the estimations are larger, especially for the rebuilding of the old neighbourhood, as many

Table 3 *Netto number of created homes before 2028.*

Phase 1 (Until 2028)	
Location # and name	Number of created dwellings (net)
02 Springplank	37
04 Groeneweg	121
05 Old church/ medical center	90
06 Pharmacy	34
07 De Brakken	24
08 Buitenomme	9
09 Bergweg	20-25
10 Valleiweg	5 - 7
11 Lijsterberg	6 - 10
12 Tinyhouses	10 - 35
13 Cunera-restaurant	5 - 10
14 Vogelenzang	10 - 20
Total	371 - 422

Table 4 *Netto number of created homes after 2028.*

more uncertainties are present for these interventions in the long term.

Next to the interventions which provide densification

tool to create citizen awareness and support for the

densification plans in Rhenen as well as to gather more qualitative data about locations.

Further research could be conducted after this report. As said, a structural architect could design the plans more into detail. Other important things to know are the price ranges of dwellings and the predicted costs of the whole plan for densification. One of the most important things that were missing in this report was the land ownership of different plots. Further research should also give more information about this subject to create possibilities for densification.

This report serves as inspiration for the municipality of Rhenen of what a densified Rhenen could look like, and how the transition towards a densified Rhenen could be started. Therefore, it is not a final solution, but more an incentive to start a discussion about how to deal

with the growth of Rhenen in a densifying way. This report could also be interesting for other municipalities

Phase 2 (After 2028)

Location # and name	Number of created dwellings (net)
15 Dokter Wallerstraat	30-40
16 Lijsterberg	15-25
17 Old neighbourhood between Nieuwe Veenendaalseweg and Achterbergseweg	115-600
Total	160-665

options for creating houses, recommendations for implementation are done as well. The modes of governance as described in Chapter 4.4.1. could help in

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coming up with different ways to start the transition towards more densification. In Chapter 4.4.2. a participation process is provided. This process is a

who want to focus on densification. The strategies and designs that are shown could serve as an inspiration for other densification projects as well.

6. REFERENCES

6.1. IN-TEXT REFERENCES

- Arvidson, K. (2017). *More housing increases the need for public space*. In *Boverket*. (2017). *Urban density done right - ideas on densification of cities and other communities* (pp. 15 - 18). Retrieved June 5 2019 from <https://www.boverket.se/globalassets/publikationer/dokument/2017/urban-density-done-right.pdf>
- Barresi, A. (2018). Urban densification and energy efficiency in Smart cities - the VerGe project (Switzerland). *Journal of Technology for Architecture and Environment*, 1, 28–32. <https://doi.org/10.13128/Techne-22713>
- Broitman, D., & Koomen, E. (2015). Residential density change: Densification and urban expansion. *Computers, Environment and Urban Systems*, 54, 32–46. <https://doi.org/10.1016/j.compenvurbsys.2015.05.006>
- Beurden, J. B. V., Doepel, D., & Tillie, N. (2013). Sustainable densification and greenification in the inner city of Rotterdam. In *13th International Conference on Computers in Urban Planning and Urban Management, CUMPUM 2013, 2 July 2013 through 5 July 2013, Utrecht, 1-17*. CUPUM.
- Bulkeley, H., & Kern, K. (2006). Local Government and the Governing of Climate Change in Germany and the UK. *Urban Studies*, 43(12), 2237-2259. [doi:10.1080/00420980600936491](https://doi.org/10.1080/00420980600936491)
- Boverket. (2017). *Urban density done right - ideas on densification of cities and other communities*. Retrieved June 5 2019 from <https://www.boverket.se/globalassets/publikationer/dokument/2017/urban-density-done-right.pdf>
- Center for Urban Planning, Royal Danish Academy of Fine Arts. (2009). *Den Tætte By*. The Danish Nature Agency.
- Centraal Bureau voor de Statistiek. (2012). *Woningoppervlakte in Nederland. Voorraad woningen naar type, functie, bouwjaar en oppervlakte per provincie en gemeente*. The Hague, South-Holland, Netherlands.
- Centraal Bureau voor de Statistiek. (2013). *Twee derde van alle woningen eengezinswoning*. Retrieved May 28 2019, from <https://www.cbs.nl/nl-nl/achtergrond/2013/04/twee-derde-van-alle-woningen-eengezinswoning>
- Centraal Bureau voor de Statistiek. (2018). *Regionale verschillen huizenprijzen*. Retrieved May 28 2019, from <https://www.cbs.nl/nl-nl/nieuws/2018/06/regionale-verschillen-huizenprijzen>
- Centraal Bureau voor de Statistiek. (2019a). *Regionale kerncijfers Nederland*. Retrieved May 21, 2019, from <https://statline.cbs.nl/StatWeb/publication/?>
- Centraal Bureau voor de Statistiek. (2019b). *Bevolkingsontwikkeling; regio per maand*. Retrieved June 24 2019, from <https://opendata.cbs.nl/statline/#/CBS/nl/dataset/37230NED/table?fromstatweb>
- Christina, S. (2017). *Amtssygehusgrunden bliver ny, gammel og grøn*. Retrieved June 13 2019, from Aarhus Lokalavisen: <http://aarhus.lokalavisen.dk/nyheder/2017-10-25/SE-ALLE-BILLEDERNE-Amtssygehus-grunden-bliver-ny-gammel-og-gr%C3%B8n-939581.html>
- Crow Databank. (2017). *Vervoerswijze - Duurzaamheidsscore*. Retrieved June 27 2019 from <https://crow.databank.nl/dashboard/Vervoerswijze>
- Gemeente Rhenen. (2017). *Woonvisie Kiezen voor Rhenen*. Retrieved May 17 2019 from <https://www.rhenen.nl/mozard/document/docnr/591636,,589536,/Woonvisie%20Kiezen%20voor%20Rhenen%20-%20januari%202018.pdf>
- Hackenbruch, F. (2018). *Flughafen Berlin-Tempelhof "Als Bauland bleibt das Feld begehrt"*. Retrieved January 15 2019, from Der Tagesspiegel: <https://m.tagesspiegel.de/berlin/flughafen-berlin-tempelhof-als-bauland-bleibt-das-feld-begehrt/23235776.html>
- HafenCity Universität Hamburg. (2019). *CityScope*. Geraadpleegd June 14 2019, van <https://www.hcu-hamburg.de/en/research/citysciencelab/research/cityscope/>
- Hellström, B. (2017). Include vegetation. In *Boverket*. (2017). *Urban density done right - ideas on densification of cities and other communities* (pp. 24- 28). Retrieved June 1 2019 from <https://www.boverket.se/globalassets/publikationer/dokument/2017/urban-density-done-right.pdf>
- Holland.com. (2018). Facts and figures about the Netherlands. Retrieved June 24 2019, from <https://www.holland.com/global/tourism/information/facts-figures.htm>
- Holm, A. (2017). Berliner Wohnungsfragen seit 1990. In H. Bodenschatz, & K. Brake, *Wohnungsfrage und Stadtentwicklung: 100 Jahre Gross-Berlin* (pp. 179-191). Berlin: Lukas Verlag. Jabareen, Y. R. (2006). Sustainable Urban Forms. *Journal of Planning Education and Research*, 26(1), 38–52. <https://doi.org/10.1177/0739456X05285119>
- KNMI (Royal Netherlands Meteorological Institute). (2019). Historische daggegevens van het weer in Nederland : weerstation Soesterberg. [etmgeg_265.txt](https://www.knmi.nl/nederland-nu/klimatologie/daggegevens). Soesterberg, Utrecht, Netherlands. Retrieved June 27 2019, from <https://www.knmi.nl/nederland-nu/klimatologie/daggegevens>
- Kools, J., Klaase, D., & Vlek, P. (2014). *De rendabele sociale huurwoning*. Rotterdam, South-Holland,

6. REFERENCES

- Netherlands: Ministerie van Binnenlandse Zaken. Mallwitz, G. (2018). Vor zehn Jahren hoben die letzten Flieger von Tempelhof ab. Retrieved March 15 2019, from <https://www.morgenpost.de/berlinerwoche/bezirke/tempelhof/article215665681/Freiraum-oder-Wohnungen-Der-Streit-ums-Tempelhofer-Feld.html?service=amp>
- Mees, H. L., Driessen, P. P., Runhaar, H. A., & Stamatelos, J. (2013). Who governs climate adaptation? Getting green roofs for stormwater retention off the ground. *Journal of Environmental Planning and Management*, 56(6), 802-825. doi:10.1080/09640568.2012.706600
- Næss, P. (2012). *Byplanlægning og bæredygtighed*. Aalborg University.
- Neuman, M. (2016). The Compact City Fallacy. *Journal of Planning Education and Research*, 25(1), pp. 11-25.
- Nunen, van H. (2010). Assessment of the sustainability of flexible building: the improved factor method: service life prediction of buildings in the Netherlands, applied to life cycle assessment. Bostel: Aeneas Publishers DOI: 10.6100/IR691287.
- Nunen, van H. & Mooiman, A. (2012). *Improved service life predictions for better life cycle assessments*. Retrieved from http://www.irbnet.de/daten/iconda/CIB_DC23028.pdf
- NU.nl. (2019, May 27). *Nederlander heeft gemiddeld 65 vierkante meter woonoppervlakte*. Retrieved from NU.nl: <https://www.nu.nl/wonen/5294174/nederlander-heeft-gemiddeld-65-vierkante-meter-woonoppervlakte.html>
- Plaatsengids. (2019). *Rhenen*. Retrieved May 27 2019, from <https://www.plaatsengids.nl/rhenen>
- Planbureau voor de Leefomgeving. (2019). *Leegstand van winkels 2004 - 2018*. Retrieved 21 June 2019, from <https://www.pbl.nl/infographic/leegstand-van-winkels#gemnr=340&year=2018&type=winkels>
- Rodrigue, J., Comtois, C., & Slack, B. (2017). *The geography of transport systems*. London: Routledge
- Rogers, P. (2017). Include vegetation. In *Boverket. (2017). Urban density done right - ideas on densification of cities and other communities (pp. 32 - 36)*. Retrieved June 5 2019 from <https://www.boverket.se/globalassets/publikationer/dokument/2017/urban-density-done-right.pdf>
- Still, T. (2002). Transit-oriented development: Reshaping America's metropolitan landscape. *On Common Ground*, 44-47.
- Svith, M. (2017). Byudvikling: Og hvordan synes politikerne selv, at det går?. Retrieved June 12 2019, from <https://stiften.dk/aarhus/Byudvikling-Og-hvordan-synes-politikerne-selv-at-det-gaar/artikel/482076>
- Tillie, N. M. J. D., Aarts, M., Marijnissen, M., Stenhuijs, L., Borsboom, J., Rietveld, E., ... Visschers, J. (2012). Rotterdam- People make the inner city: densification + greenification = sustainable city (1ste editie). Rotterdam: Mediacenter Rotterdam.
- TU Delft. (2019). *Parkeren*. Retrieved June 20 2019, from <https://ocw.tudelft.nl/course-readings/parkeren/URBACT>.
- URBACT. (2019, January 24). New urban planning: Long-lasting innovation or just a temporary illusion. Retrieved from <https://www.blog.urbact.eu/2019/01/new-urban-planning-part-2/>
- Wingren, C. (2017). Include vegetation. In *Boverket. (2017). Urban density done right - ideas on densification of cities and other communities (pp. 19 - 23)*. Retrieved June 5 2019, from <https://www.boverket.se/globalassets/publikationer/dokument/2017/urban-density-done-right.pdf>
- ### 6.2. FIGURES
- Cover:** Made by author, using ArcMap.
- Colophon/ Abstract:** Houdu, van J. (2009). Luchtfoto "Ruimte voor de Rivier", Neder-Rijn. Picture. Retrieved June 15 2019 from https://nl.wikipedia.org/wiki/Bestand:Luchtfoto_deel_Rhenen,_op_voorgrond_Cuneratoren.jpg
- Figure 1:** Made by author, using ArcMap.
- Figure 2:** Made by author, based on: Kadaster. (2019). 200 jaar topografische kaarten. Retrieved May 14, 2019, from <https://www.topotijdreis.nl/>
- Figure 3:** Made by author, based on: Kadaster. (2019). 200 jaar topografische kaarten. Retrieved May 14, 2019, from <https://www.topotijdreis.nl/>
- Figure 4:** Made by author, using ArcMap.
- Figure 5:** Made by author.
- Figure 6:** Made by author.
- Figure 7:** Made by author, using ArcMap.
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- Figure 11:** Made by author, using ArcMap.
- Figure 12:** Made by author, using ArcMap.
- Figure 13:** Made by author, using ArcMap.
- Figure 14:** Made by author, based on: Gemeente Rhenen. (2018). Hitte. Retrieved June 24, 2019, from <https://klimaatanalyserhenen.nl/effecten/hitte/>
- Figure 15:** Made by author, based on: Gemeente Rhenen. (2018). Wateroverlast. Retrieved June 24, 2019, from <https://klimaatanalyserhenen.nl/effecten/wateroverlast/>
- Figure 16:** Made by author, based on: Meteoblue. (2019). Klimaat (model) Rhenen. Retrieved June 27, 2019, from <https://www.meteoblue.com/nl/>

A P P R E N D I X E N C E S

www.veer.nl/history/climate/climatemodelled/rhenen_nederland_2748185

Figure17: Made by author.

Figure18: Made by author.

Figure 19a: Made by author, based on: Kools, J., Klaase, D., & Vlek, P. (2014). De rendabele sociale huurwoning. Rotterdam, South-Holland, Netherlands: Ministerie van Binnenlandse Zaken.

Figure 19b: Made by author, based on: Kools, J., Klaase, D., & Vlek, P. (2014). De rendabele sociale huurwoning. Rotterdam, South-Holland, Netherlands: Ministerie van Binnenlandse Zaken.

Figure 19c: Made by author, based on: Kools, J., Klaase, D., & Vlek, P. (2014). De rendabele sociale huurwoning. Rotterdam, South-Holland, Netherlands: Ministerie van Binnenlandse Zaken.

Figure 19d: Made by author, based on: Kools, J., Klaase, D., & Vlek, P. (2014). De rendabele sociale huurwoning. Rotterdam, South-Holland, Netherlands: Ministerie van Binnenlandse Zaken.

Figure 20: Made by author, based on: Kools, J., Klaase, D., & Vlek, P. (2014). De rendabele sociale huurwoning. Rotterdam, South-Holland, Netherlands: Ministerie van Binnenlandse Zaken.

Figure 21: Made by author, based on: Kools, J., Klaase, D., & Vlek, P. (2014). De rendabele sociale huurwoning. Rotterdam, South-Holland, Netherlands: Ministerie van Binnenlandse Zaken.

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Figure23: Made by author.

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Figure29: Made by author. **Figure30:** Made by author.

APPENDICES

APPENDIX 1

thor. **Figure 33:** Made by author. **Figure34:** Made by author. **Figure35:** Made by author. **Figure36:** Made by author.

Figure 37: Observatory of Public Sector Innovation. (2016). CityScope FindingPlaces: HCI Platform for Public Participation in Refugees' Accommodation Process. Geraadpleegd 14 juni 2019, van <https://oecd-opsi.org/innovations/cityscope-findingplaces-hci-platform-for-public-participation-in-refugees-accommodation-process/>

Figure 38: Casali, D. F. (2013). Co-design and participatory design: a solid process primer. Geraadpleegd 14 juni 2019, van <https://intenseminimalism.com/2013/co-design-and-participatory-design-a-solid-process-primer/>

Figure39: Made by author.

Figure40: Made by author, using: QR Code Generator. (2019). *QR Code Generator*. Geraadpleegd 1 juli 2019, van <https://www.qr-code-generator.com/>

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APPENDICES

APPENDIX 1

APPENDIX 1.1. *Completed new-build homes by property type and number of rooms, 2013 (Het ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2016).*

Provence	Newly built	Type		User space			
	Total	Single family	Milti-family	<90 m ²	90-119 m ²	120-149 m ²	>150 m ²
Gelderland	6.194	2.924	3.270	2.499	1.643	1.077	975
Netherlands	49.311	19.347	29.964	22.562	13.414	7.187	6.137

APPENDIX 1.2. *Housing stock by type and function, 2012 (Centraal Bureau voor de Statistiek, 2012).*

Region letter	Region code	Region name	Housing stock											More than two functions
			Total	Type		Function	Double function							
				Single family	Multi-family	Living	Living Meeting	Living Healthcare	Living Industry	Living Office	Living accomodation	Living Shop	Living Remaining (education, sport, etc.)	
GM	0340	Rhenen	7.491	6.105	1.386	7.355	12	-	99	-	-	14	-	-

APPENDIX 1.3. *Housing stock by construction year and type, 2012 (Centraal Bureau voor de Statistiek, 2012).*

Region letter	Region code	Region name	Housing stock															
			Total	Until 1850			1850-1905			1905-1925			1925-1945			1945-1955		
				Total	Single family	Milti-family	Total	Single family	Milti-family	Total	Single family	Milti-family	Total	Single family	Milti-family	Total	Single family	Milti-family
GM	0340	Rhenen	7.491	-	-	-	150	139	11	128	115	13	987	920	67	770	723	47

Housing stock

1955-1965			1965-1975			1975-1985			1985-1995			1995-2005			2005 and later		
Total	Single family	Milti-family	Total	Single family	Milti-family	Total	Single family	Milti-family	Total	Single family	Milti-family	Total	Single family	Milti-family	Total	Single family	Milti-family
1.204	870	334	1.493	1.163	330	642	578	64	889	751	138	867	577	290	353	261	92

APPENDIX

APPENDIX 1.4. Housing stock by user space and type, 2012 (Centraal Bureau voor de Statistiek, 2012).

Region letter	Region code	Region name	Housing stock															
			Total	<15 m ²			15-50 m ²			50-75 m ²			75-100 m ²			100-150 m ²		
				Total	Single family	Multi-family	Total	Single family	Multi-family	Total	Single family	Multi-family	Total	Single family	Multi-family	Total	Single family	Multi-family
GM	0340	Rhenen	7.491	-	-	-	92	22	70	603	290	313	2.030	1.399	631	2.919	2.596	323

Housing stock

150-250 m ²			>250 m ²		
Total	Single family	Multi-family	Total	Single family	Multi-family
1.418	1.385	33	421	405	16

APPENDIX 1.5. Percentage of large dwellings per municipality, 2012 (Centraal Bureau voor de Statistiek, 2012).

Municipality	Total dwellings	Large dwellings			As percentage of whole stock
		150-250 m ²	>250 m ²	Total	
Rhenen	7.491	1.418	421	1.839	24,55 %
Wageningen	14.486	1.974	584	2.558	17,66 %
Veenendaal	26.663	2.885	330	3.215	13,04 %

APPENDIX 1.6. Percentage of households by user space, 2017 (Centraal Bureau voor de Statistiek, 2017; Centraal Bureau voor de Statistiek, 2012).

Scale	<75 m ²	75-100 m ²	100-150 m ²	>150 m ²
Netherlands	24,8 %	22,3 %	35,8 %	17,0 %
Rhenen	9,3 %	27,1 %	39,0 %	24,5 %

References:

Centraal Bureau voor de Statistiek. (2012). Woningoppervlakte in Nederland. Voorraad woningen naar type, functie, bouwjaar en oppervlakte per provincie en gemeente. The Hague, South-Holland, Netherlands.

Centraal Bureau voor de Statistiek. (2017). Woonoppervlakte Nederland 2017. *Woonoppervlakte Nederland 2017*. Retrieved from <https://www.cbs.nl/nl-nl/maatwerk/2018/22/woningoppervlakte-in-nederland>

Centraal Bureau voor de Statistiek. (2018). Regionale verschillen huizenprijzen. Retrieved from CBS: <https://www.cbs.nl/nl-nl/nieuws/2018/06/regionale-verschillen-huizenprijzen>

Het ministerie van Binnenlandse Zaken en Koninkrijksrelaties. (2016). *Cijfers over Wonen en Bouwen 2016*. The Hague, South-Holland, Netherlands.

APPENDIX

APPENDIX 2

PARKING NORMS OF RHENEN MUNICIPALITY

Reference:

Gemeente Rhenen. (2011). *Beleidsnota parkeernormen en parkeerfonds actueel 2011*. Geraadpleegd van https://www.planviewer.nl/imro/files/NL.IMRO.0340.BPbergwegvanrijn-ON01/b_NL.IMRO.0340.BPbergwegvanrijn-ON01_rb2.pdf

Functie	Parkeernorm centrumgebied (minimum)	Parkeernorm centrumgebied (maximum)	Parkeernorm buiten centrumgebied (minimum)	Parkeernorm buiten centrumgebied (maximum)	opmerkingen
Woningen					
woning duur	1,5	1,7	2,0	2,2	woning
woning midden	1,3	1,5	1,8	1,9	woning
woning goedkoop	1,2	1,3	1,4	1,7	woning
serviceflat/aanleunwoning	0,3	0,6	0,3	0,6	woning (zelfstandige woning met beperkte zorgvoorzieningen)
kamer verhuur	0,2	0,6	0,2	0,6	kamer
Winkels					
wijk-, buurt- en dorpscentra	3,0	4,5	3,0	4,5	100 m2 bvo, 1 arbeidsplaats = 40 m2 bvo
grootschalige detailhandel	-	-	6,5	8,5	100 m2 bvo, 1 arbeidsplaats = 40 m2 bvo
(week)markt	3,0	4,5	3,0	4,5	100 m2 bvo, 1 m = 6 m2 (indien geen parkeren achter kraam dan + 1,0 pp per standhouder)
Bedrijven					
(commerciële) dienstverlening (kantoren met baliefunctie)	2,3	2,5	3,0	3,5	100 m2 bvo (1 arbeidsplaats = 25-35 m2 bvo)
kantoren (kantoren zonder baliefunctie)	1,2	2,0	1,7	2,5	100 m2 bvo (1 arbeidsplaats = 25-35 m2 bvo)
arbeidsintensieve/bezoekerintensieve bedrijven (loods, opslag, groothandel, transportbedrijf)	0,5	0,6	0,8	0,9	100 m2 bvo (1 arbeidsplaats = 25-35 m2 bvo)
arbeidsintensieve/bezoekerintensieve bedrijven (industrie, garagebedrijf, laboratorium, werkplaats, transportbedrijf)	1,2	1,7	2,5	2,8	100 m2 bvo (1 arbeidsplaats = 25-35 m2 bvo)
arbeidsintensieve/bezoekerintensieve bedrijven (showroom)	1,0	1,2	1,6	1,8	100 m2 bvo (1 arbeidsplaats = 25-35 m2 bvo)
bedrijfsverzamelgebouw	0,8	1,7	0,8	1,7	100 m2 bvo (1 arbeidsplaats = 25-35 m2 bvo)
Horeca					
cafe/bar/discotheek/cafetaria	5,0	7,0	6,0	8,0	100 m2 bvo
restaurant	10,0	12,0	14,0	16,0	100 m2 bvo
hotel	0,5	1,5	0,5	1,5	kamer
museum/bibliotheek	0,5	0,7	1,0	1,2	100 m2 bvo
bioscoop/theater/schouwburg	0,2	0,3	0,3	0,4	zitplaats
Sport/vrije tijd					
sporthal (binnen)	1,7	2,2	2,5	3,0	100 m2 bvo, gymlokalen met alleen schoolfunctie hebben geen extra parkeervraag. Bij sporthal met wedstrijdfunctie + 0,1-0,2 99 per bezoekersplaats
sportveld (buiten)	13,0	27,0	13,0	27,0	ha. netto terrein
dansstudio/sportschool	3,0	4,0	4,0	5,0	100 m2 bvo
squashbanen	1,0	1,5	1,0	1,5	baan
tennisbanen	2,0	3,0	2,0	3,0	baan
golfbaan	-	-	6,0	8,0	hole
bowlingbaan/biljartzaal	1,5	2,5	1,5	2,5	baan/tafel
stadion	0,04	0,2	0,04	0,2	zitplaats
evenementenhal/beursgebouw/congresgebouw	4,0	6,0	6,0	8,0	100 m2 bvo
zwembad	8,0	10,0	10,0	12,0	100 m2 opp. Bassin
themapark/pretpark	4,0	12,0	4,0	12,0	ha. netto terrein
overdekte speeltuin/hal	3,0	12,0	3,0	12,0	100 m2 bvo
manege	-	-	0,3	0,5	box
cultureel centrum/wijkgebouw	2,0	4,0	2,0	4,0	100 m2 bvo
Verzorging					
ziekenhuis	1,5	1,7	1,5	1,7	bed, bij vaste bezoektijden bovengrens hanteren
verpleeg-/verzorgingstehuis	0,5	0,7	0,5	0,7	wooneenheid
arts/maatschap/kruisgebouw/therapeut	1,5	2,0	1,5	2,0	behandelkamer met een minimum van 3 parkeerplaatsen per praktijk
Onderwijs					
WO/HBO - dag	20,0	20,0	20,0	20,0	parkeervraag = collegezalen + leslokalen
MBO (ROC)/WO/HBO - dag	5,0	7,0	5,0	7,0	leslokaal (= circa 30 zitplaatsen), totale parkeervraag = collegezalen + leslokalen
voorbereidend beroeps onderwijs (VWO, HAVO, VBO) - dag	0,5	1,0	0,5	1,0	leslokaal (= circa 30 zitplaatsen)
avondonderwijs	0,5	1,0	0,5	1,0	student
basisonderwijs	0,5	1,0	0,5	1,0	leslokaal (= circa 30 zitplaatsen)
creche/peuterspeelzaal/kinderdagverblijf	0,6	0,8	0,6	0,8	arbeidsplaats (maximaal gelijktijdig aanwezig aantal werknemers)
Overig					
volkstuin	0,3	0,3	0,3	0,3	perceel
religiegebouw	0,1	0,2	0,1	0,2	zitplaats
begraafplaats/crematorium	15,0	30,0	15,0	30,0	gelijktijdige begrafeniscapaciteit

Centrumgebied: gedeelte tussen Nieuw Veenendaalseweg en Veerweg ten zuiden van de Bantuinweg.
Buiten centrumgebied: alles wat buiten het centrumgebied valt.

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APPENDIX 3

3.1. EXTRA VISUALISATION OF LOCATION 02; SPRINGPLANK

Figure A and B show extra visualisations for the implementation of the proposed design.

3.2. EXTRA VISUALISATION OF LOCATION 05; OLD CHURCH/ MEDICAL CENTRE

Figure C-H show extra visualisations for the implementation of the proposed design.



Figure A *Appartment complex with playground.*



Figure C *Impression of park.*



Figure D *Overview of green roof.*

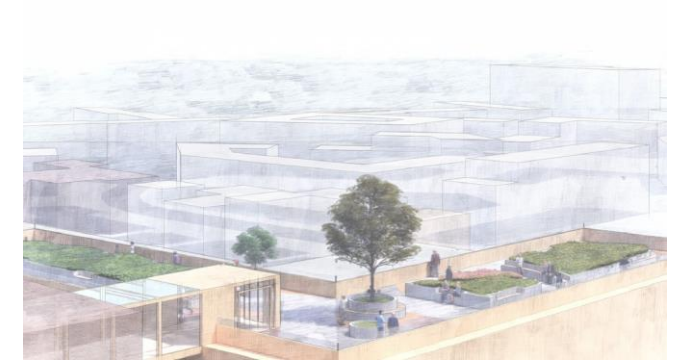


Figure F *Overview of green roof.*



Figure G *Impression of park.*



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Figure B *Impression of apartment complex 'Springplank'.*

Figure E *Overview of green roof.*

Figure H *Impression of park.*

APPENDIX

3.3. EXTRA VISUALISATION OF LOCATION 08; BUITENOMME

Figure I-M show extra visualisations for the implementation of the proposed design.

3.4. EXTRA VISUALISATION OF LOCATION 12; TINY HOUSES

Figure N-R show extra visualisations for the implementation of the proposed design.



Figure K *Buitennomme street opposite of viewpoint.*



Figure N *Tiny houses courtyard.*



Figure I *Streetview from a passing car.*



Rooftop park in winter. **Figure L**

Rooftop park by night.
Rooftop park by night.



Figure J



Figure M

APPENDIX

Figure O *View from backgarden into the courtyard.*



Figure P *Tinyhouses courtyard by night.*



APPENDIX



Figure Q *Tinyhouses courtyard.*



Figure R *Tinyhouses courtyard by night.*

Reference:

All figures: Made by author.

APPENDIX

APPENDIX 4

ESTIMATION OF AMOUNT OF HOUSES

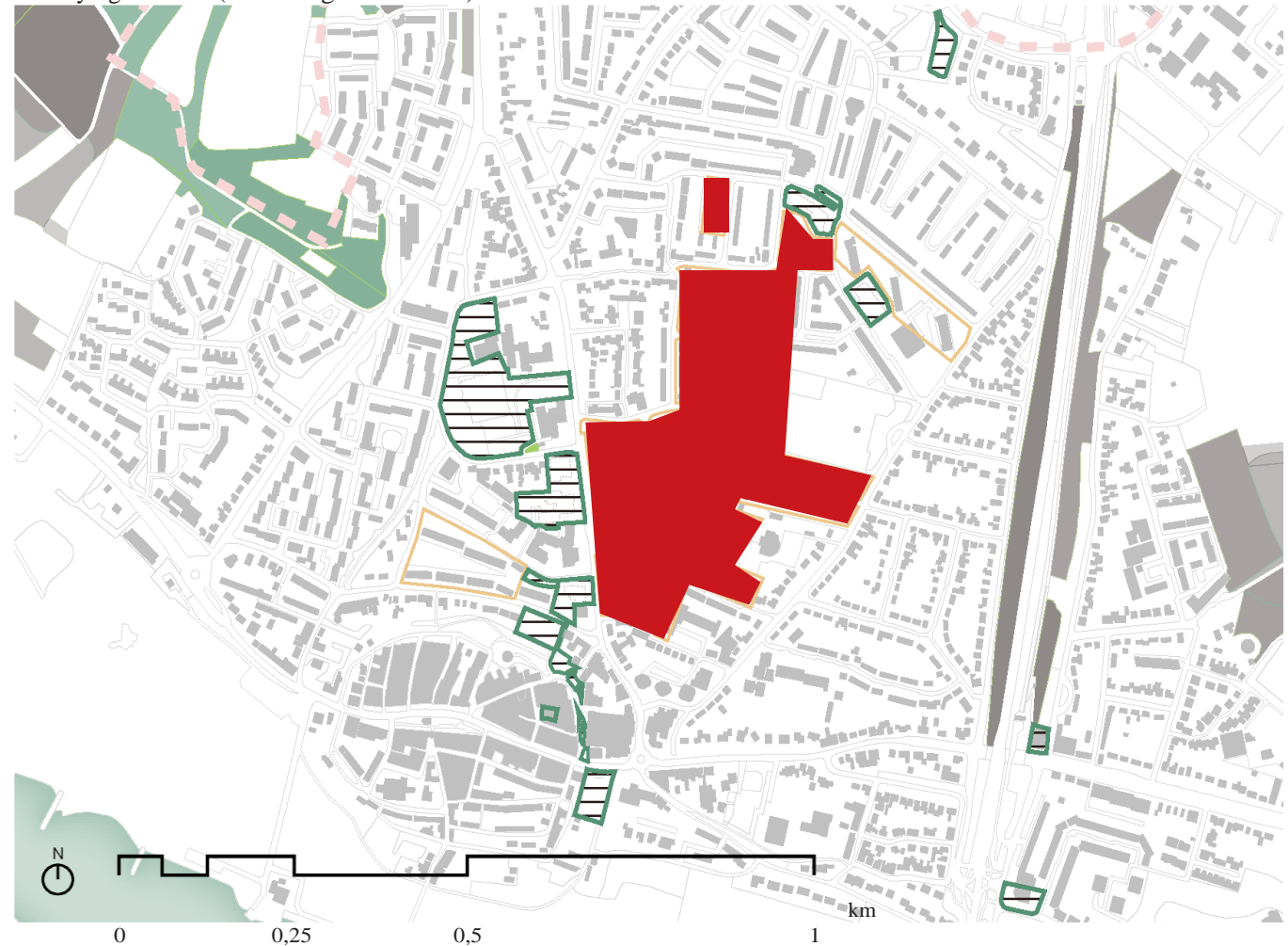
	Estimated amount of houses	Area size (m ²)	Area size (km ²)	Density (houses/km ²)
Old neighbourhood (current)	369	120273,00	0,120273	3068.020254
Created green corridor	315	39112,00	0,039112	8053.794232

In the table above the number of houses per location, the area size and the density are estimated of the old neighbourhood (current situation) and the newly created green corridor. The number of houses in the old neighbourhood is estimated by just counting houses, a small deviation could be possible. The area size is measured based on the size of the plots shown in the map. The number of houses in the green corridor is based on the calculations from our plan.

	With half the density of the green corridor	With same density as green corridor
# houses after rebuilding and densifying the old neighbourhood	484	969
# net created houses (subtracting the old ones)	115	600

For making estimations about the amount of created houses in the old neighbourhood, the area size of the

current amount of houses in the old neighbourhood. For creating a range, the estimated density of the green corridor after densifying is used (on average ± 4 stories), and half the density of the green corridor after densifying is used (on average ± 2 stories).



APPENDIX

old neighbourhood is multiplied by the density of the created green corridor. For calculating the net amount of newly created houses, this number is subtracted by the

The red area on the above map shows the area used for calculating the estimated amount of houses.

