Recycling the woonerf

A testcase for a circular woonerf

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1 Introduction

1.1 Revitalising New Heritage

This graduation project is set in the wider context of the Graduation Studio Revitalising Heritage. The studio centres around two case studies, the Bijlmerplein neighbourhood in the expansion area Amsterdam Zuid-Oost and the neighbourhood Goedewerf in the new town Almere-Haven, with the assumption that they will be regarded as future heritage. The residential stock built between 1965 and 1985 requires a design solution that deals with the technical and social problems that are generally found in these residential areas. The students are asked to explore the potential of the existing urban structure and buildings in the case studies and find design solutions to create future-proof neighbourhoods while harbouring potential heritage. In short, the studio aims to "discover the qualities of what could be new heritage and to use these qualities in a sustainable redesign" (New Heritage Studio Text, 2022, pp.2).

1.2 A test case of a circular woonerf

A large portion of my generation, including myself, have grown up in a woonerf neighbourhood. The labyrinthic layout and the green area were the perfect environment to grow up in. Now almost 50 years old, the woonerf is challenged with social and technical deterioration, poor energy performance, misalignment of demographics and typology and an overall negative image. Because the housing stock consists of 20% of woonerf residents, there is considerable reason to seek for a solution to make this type of neighbourhood future-proof. In this national task to renovate and adapt entire neighbourhoods, there is a bigger issue to consider: our linear consumption. In 1972 it was concluded in the report for the club of Rome that the unlimited growth of the world population, the economy and the associated use of energy and materials would ultimately lead to a catastrophe (Meadows, et al., 1972). The report awakened the world, leading to increased awareness of environmental pollution and sustainable energy consumption. Meanwhile, resource consumption stayed mostly linear, meaning that it follows a 'take-make-dispose' pattern (Ellen MacArthur Foundation, 2013). This pattern not only further depletes natural resources, but also leads to emissions of pollutants and disposal of waste into water, air and soil. To address these issues, the concept of circular economy (CE) has gained increasing attention in business models as well as in political agendas (Ellen MacArthur Foundation, 2013; European Commission, 2020; UNEP, 2016). On the Dutch political agenda, the government aspires to make the Dutch economy completely circular by 2050, meaning that only renewable resources are used and the waste sum is brought back to zero (Rijksoverheid, 2016). Especially the construction industry plays a big role in resource consumption and waste. The sector is responsible for 50% of raw material consumption, 40% of the total energy consumption and 30% of the total water consumption in the Netherlands. In addition, 40% of all waste in the Netherlands comes from construction and demolition, and the sector is responsible for approximately 35% of CO_2 emissions (PBL, 2021; Rijksoverheid, 2016).

This project combines the challenge of future-proofing the woonerf and the transition to circular consumption into a test case that aims to experiment with the woonerf as a circular neighbourhood. The final product is a research-informed design for the neighbourhood Goedewerf in Almere Haven, for which a circular strategy is developed and values and characteristics of potential heritage are conserved. The objectives that lead the research have been formulated into the following main question.

How can the woonerf, such as Goedewerf, be redesigned to create a circular neighbourhood, while still maintaining potential heritage?

1.3 Definition circularity

For the definition of circularity, this research will refer to the definition Kirchherr et al. (2017) formulated, because it touches upon all aspects of sustainability. In their analysis of 114 circular economy definitions, Kirchherr, Reike, and Hekkert conceptualized their findings in a single definition: "A circular economy describes an economic system that is based on business models which replace the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, thus operating at the micro-level (products, companies, consumers), meso-level (eco-industrial parks) and macro-level (city, region, nation and beyond), with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations" (Kirchherr et al., 2017, p. 224-225). The core principle contains the R framework, which is essentially the how-to of the CE. Furthermore, the framework has a waste hierarchy, that indicates the order of ranking of the mentioned Rs. Although many varieties of the R framework exist, the research and design holds on to the 9R by Potting et al. (2017). The R framework operates on three different scales (micro, meso, and macro), which encourages the integration of circularity in all building scales. Lastly, the definition also touches upon the subject of the three p's: people planet, and prosperity, involving all aspects of sustainability.

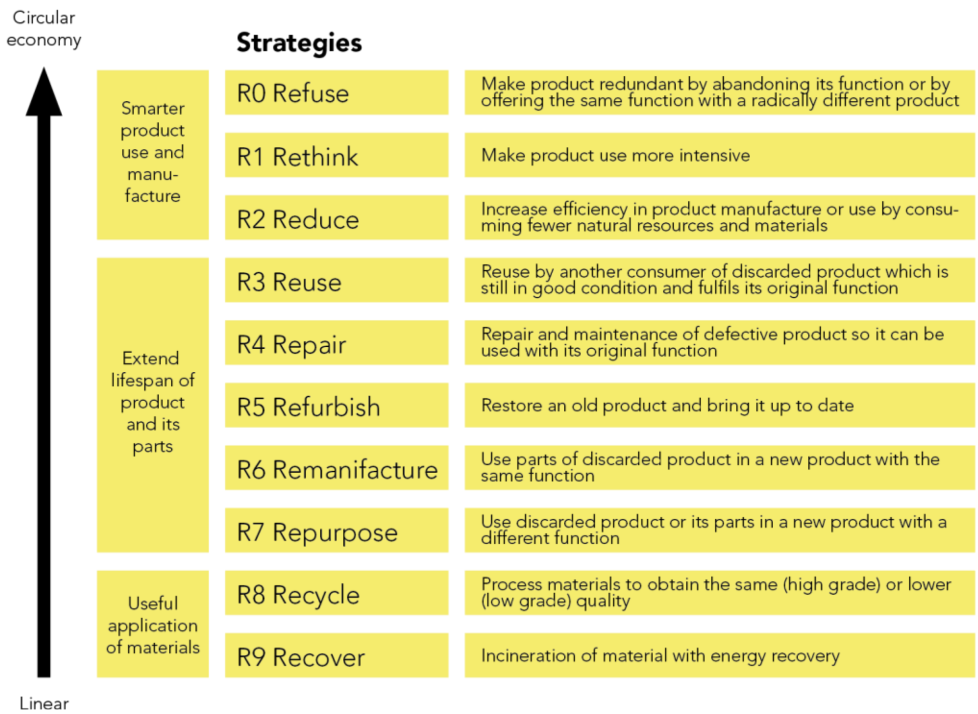


Figure 1a *R-ladder adapted from Potting et. al 2017*

2 Methodology

2.1 Research by design

During the first phase of the studio, the students had the work in a group to establish the values of the case studies. These values and attributes were shown in an adjusted version of the Kamari wheel, which is a holistic sustainability decision-making support framework for building renovations (Kamari, Corrao & Kirkegaard, 2017). This value assessment formed the basis for the individual research and design. The two outer rings are the positive values, and the inner The wheel itself is divided into 18 value tags that are split into 3 pillars of sustainability: accountability (yellow), functionality (red) and feasibility (orange). To establish whether circular interventions in the redesign of Goedewerf are adding value, the end results are measured again in a value map. But instead of the value map by Kamari, the Circular Value Flower method, developed by Els Leclercq and Mo Smit, will be used. The Circular Value Flower focuses specifically on circular interventions on a neighbourhood scale.

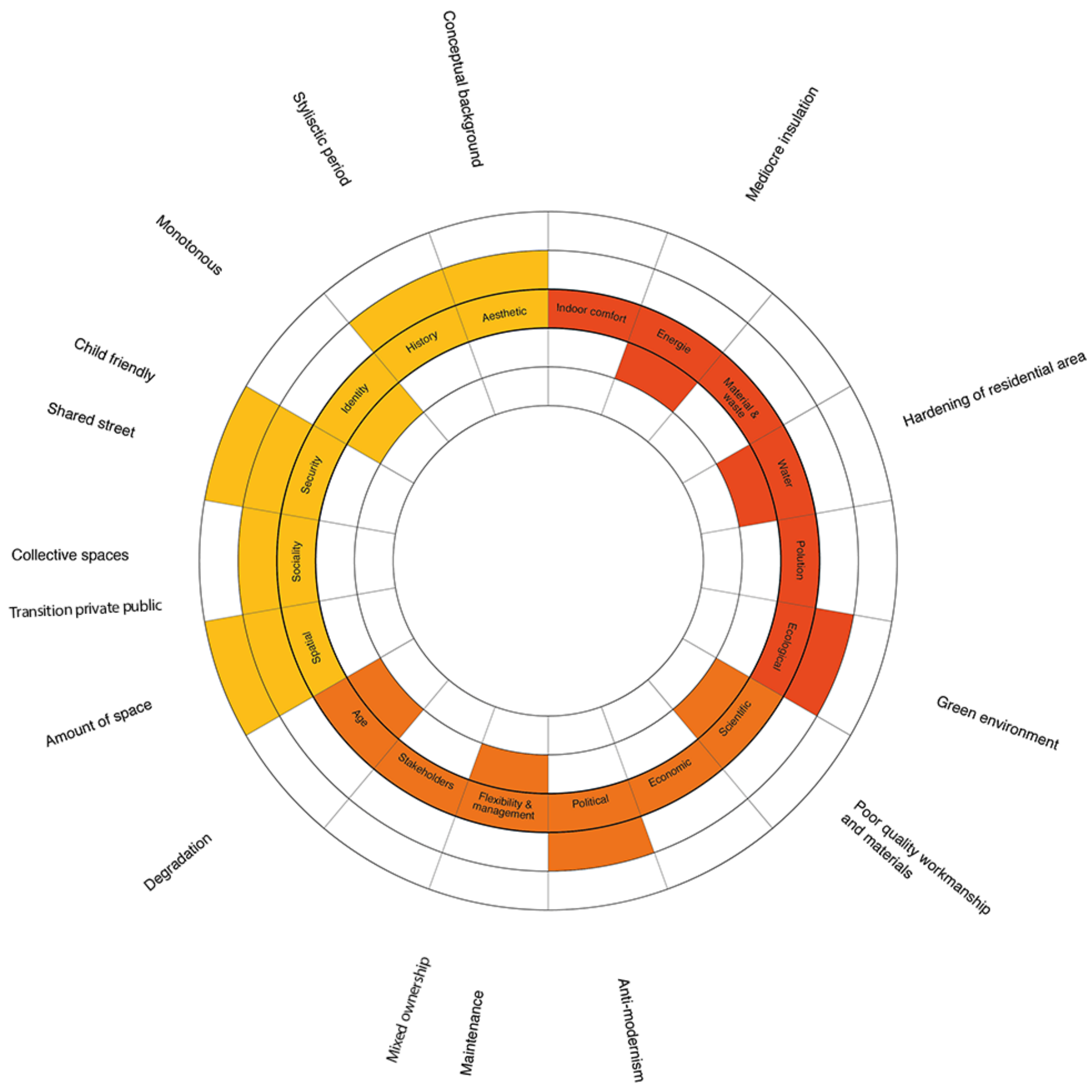


Figure 1 *Adapted Kamari value map of Goedewerf*

2.2 Literature studies

The individual work in the studio started with the investigation into the potential heritage of the woonerf. To make an assumption about the potential heritage, the origin and the characteristics of the woonerf were researched, for which a literature study was conducted. The most elaborate publication on the subject is the report published by Jaap Evert Abrahamse, commissioned by the Rijksdienst voor het Cultureel Erfgoed (2019). The report Opkomst en ontwikkeling van de bloemkoolwijk: Het ontwerp van woonwijken in Nederland en de zoektocht naar identiteit covers the historical and political context of the woonerf, but also goes into depth about the form and function of the woonerf. The report concludes with a challenge, stating that the woonerf neighbourhoods require a different approach from older post-war neighbourhoods which is yet to be found. Spatial-typological and sociological research into the woonerf is done by Ivan Nio, Nynke Jutten, and Willemijn Lofvers. The focus of this research is laid on the transition zone between the dwelling and the outdoor space. The first phase of the research was published in Lay-Out 08 (2009), and Het Woonerf Leeft (2010). In the second phase of the research, spatial and sociological research was done into the qualities of woonerf neighbourhoods, using case studies in Lunetten. The results were published in Studie Woonerven Lunetten (2011). The future task that lies ahead of the woonerf neighbourhoods is defined by Martijn Ubink and Thijs van der Steeg in their publication Bloemkoolwijken: Analyse en perspectief (2011). They provide spatial and socio-economic insights into the gradual downward dynamics of bloemkoolwijken, by analysing 35 neighbourhoods. The goal of the literature studies was therefore not to bring new information to light, as there is a lot of research done already on the background of the woonerf, but to give a summarized overview so that it can support the answer to the main question of the research. From the literature studies, I concluded that the existing literature on the woonerf predominantly focuses on the history of the woonerf. While some authors do locate the problems of the woonerf and state that solutions need to be sought to make the woonerf future-proof, the subject of the future of the woonerf is still unexplored.

2.3 Case studies

The third phase of the research contains the exploration of several other case studies, with the objective to draw up an inventory of circular tools that can be used in a circular strategy in a woonerf. The case studies have helped to get an overview of the most commonly used techniques in neighbourhoods. Furthermore, the practice of certain circular systems in the case studies also gave insight into techniques that are less fit for a (woonerf) neighbourhood because of expenses or the maturity of the technology. The case studies that contributed to the research were Ecodorp Boekel, Superlocal in Kerkrade, Schoonschip in Buiksloterham, Eva Lanxmeer in Culemborg, and De Loskade in Groningen. Each case study had circular strategies that focussed on specific themes. In Ecodorp Boekel and Eva Lanxmeer the emphasis lies on the use of circular materials and a circular water system. Schoonschip is a floating neighbourhood that has a dominant theme of circular water systems and a sharing economy. Superlocal is one of the most innovative case studies that experiments with newer technologies to close the water and material cycle even further. De Loskade has a strong focus on reusable materials and building elements.

		WATER	ENERGY	MATERIALS	GREEN
Eva Lanxmeer, Culemborg 1990		-Helofyte filters -Wadis -Rainwater pond -Drinkwater extraction	-Solar energy -Thermal storage	-Biobased materials -Shared cars	-Permaculture -Local food production
Schoonschip, Amsterdam 2009		-Greywater recycling -Rainwater use	-Solar energy -Biogas from blackwater	-Biobased materials -Material passport	
De Loskade, Groningen 2019			-Solar energy	-Modular building	
Superlokal, Kerkrade 2020		-Grey- and black water recycling -Rainwater use	-Biogas from blackwater	-Urban mining	
Ecodorp Boekel, Boekel 2022		-Passive house		-Biobased materials	-Permaculture -Local food production

2.3 Circular strategies matrix

The outcome of the research on circular tools in the case studies is summarized in a circular strategy matrix, which intends to give an overview of tools that can be used and combined in a woonerf neighbourhood to form a circular strategy. Though it must be noted that the matrix is certainly not complete because new technologies are invented every day and some tools might have been overlooked. The matrix is categorised into four circular themes: water, energy, material and green, and vertically divided into the 9 Rs of the R ladder. Each tool is supplemented with requirements and the positives and negatives that might motivate the selection of that particular tool in the circular strategy of a woonerf neighbourhood. In the conclusion of this research, the chosen circular strategy for Goedewerf is motivated by the outcome of the research on the potential heritage value of the woonerf and the most suitable tools that align with the characteristics of the woonerf and its residents.

3 Origin

3.1 A time of renewal and change

During the ’60s, the views of the modernists began to clash with the changing society which set in motion a time of renewal and change. The population had become more diverse, the economy had grown and the call for democratization had advanced. At the same time, the housing shortage also worsened. With the anticipated further growth of the population, several municipalities were assigned as growth cores (also known as New Towns), to absorb the overflow from the cities in suburban neighbourhoods (Ubink & Van der Steeg, 2011). Among urban planners and architects, new ideals emerged for the design of these neighbourhoods. Neighbourhoods were to be more humane, varied, complex, recognizable, and most importantly human-scaled (Abrahamse, 2019). Evident is, that these ideals are a reaction to the post-war modernist neighbourhoods, which were mainly criticized for their monotone architecture, large-scale planning, and the dominant position of the car. A concept that was preserved from the post-war neighbourhoods, and had a central position within these new ideals, is the ‘wijkgedachte’. The concept resembles the idea of community building and is based on stimulating social contact in public space, creating a feeling of togetherness, identity, security, and stability through physical design (Ubink & Van der Steeg, 2011). At the same time, a new appraisal of the street arises. The social function of the street as a meeting place had been lost in the post-war neighbourhoods due to the rise of the car (Abrahamse, 2019). Urban planner Niek de Boer was an early advocate for the return of the street as a living space. In his lecture in 1966, Niek de Boer advocates the social significance of the street as a meeting place and living environment. In his lecture he describes how the street is the core of a neighbourhood community:

“Vroeger had de straat een heel andere betekenis voor de mensen dan nu. Ik denk daarbij dan aan een heel gewone straat, een woonstraat. Er was verkeer, maar dat was zo weinig en zo goedaardig, dat men elkaar in de straat ontmoette, dat men er op zomeravonden buiten ging zitten, dat een ambachtsman z’n zaakje op de stoep zette en voor de deur z’n bedrijf uitoefende. Kinderen speelden op straat. Om de groentekar vormde zich een soort huisvrouwensociëteit. Kortom naast een zeer beperkte verkeerstaak had de straat de veel belangrijker functie een ‘erf’ te zijn. De straat was ontmoetingsruimte.” (De Boer, 1966).

3.2 The first woonerf neighbourhoods

It was in the late ’60s when De Boer introduces the term and concept ‘woonerf’ with his design of the neighbourhood Emmerhout in Emmen, in which he aimed to bring back the original function of the street as a meeting place (De Boer, 1982). The neighbourhood is designed as cul-de-sacs, sequences of squares varying in function and character. To give social contact a place on the street again, cars were completely separated from the pedestrian area in assigned parking lots. The woonerf became an important design tool in the large-scale development of the growth cores. The woonerf was the smallest unit that related to the human scale and acted as a building block in a larger neighbourhood structure, the ‘bloemkoolwijk’. De Boer’s apprentice, Joost Vahl, presented a variation on De Boer’s woonerf with the neighbourhood Tanthof in Delft. His vision on the woonerf incorporated cars in the neighbourhood, but he discarded any hierarchy in roads and traffic flows (Nio, 2010; Van der Leun, Jutten & Lofvers, 2009). With the expansion of the woonerf in the Netherlands, the concept of a car-free woonerf by De Boer was let go of.

Figure 2 *Emmerhout, Emmen. From Emmerhoutspringlevend.nl*

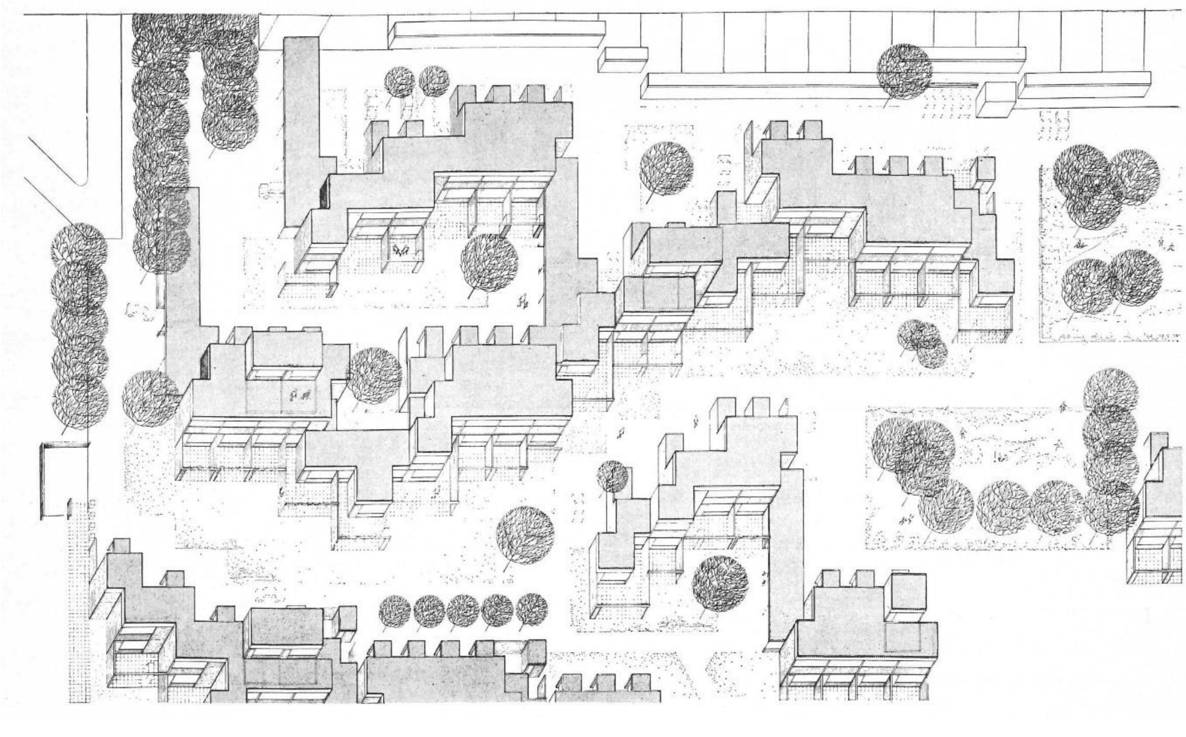


Figure 3 *Design for Emmerhout, Emmen by Niek de Boer, 1969-1973. From Experimentelewoningbouw.nl*

Figure 4 *Perspective drawing of a woonerf in Tanthof, Delft. From Het Nieuwe Insituut.*

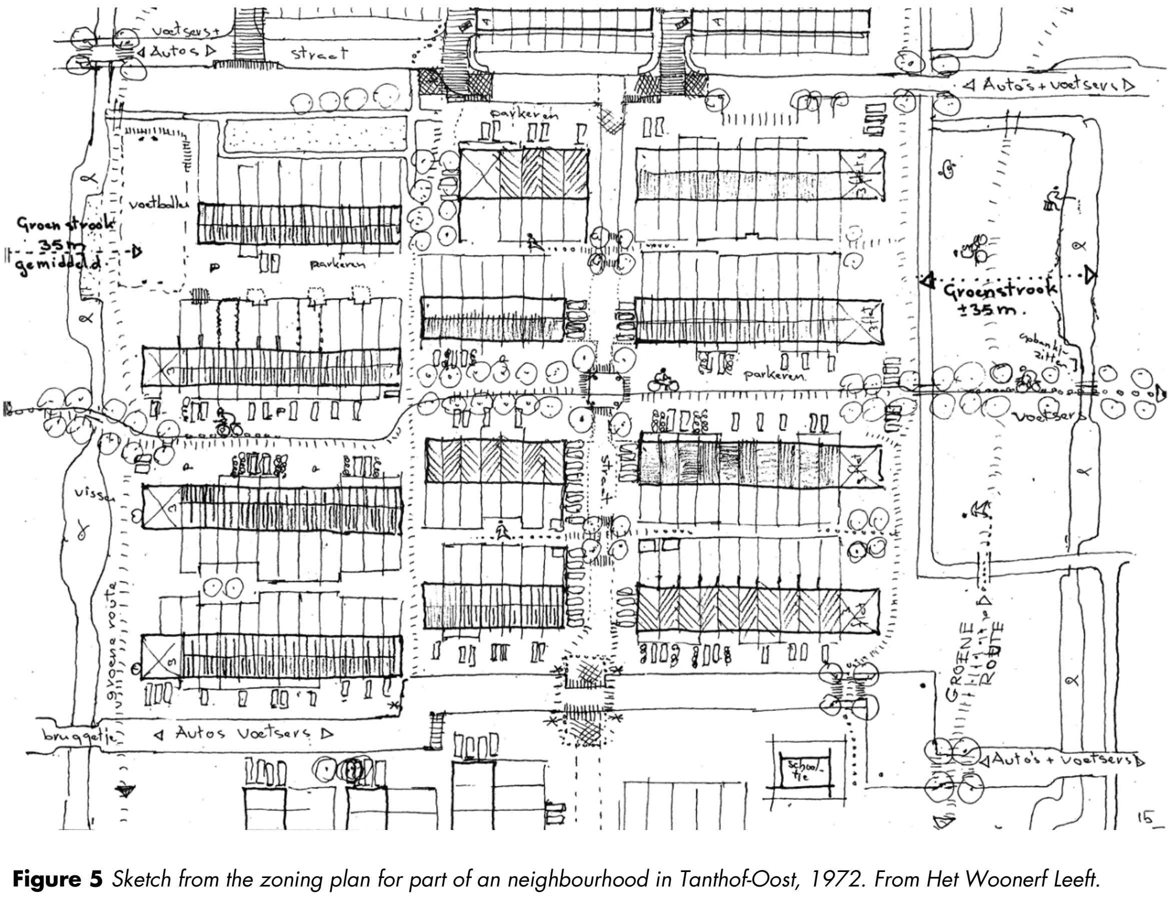


Figure 5 *Sketch from the zoning plan for part of an neighbourhood in Tanthof-Oost, 1972. From Het Woonerf Leeft.*

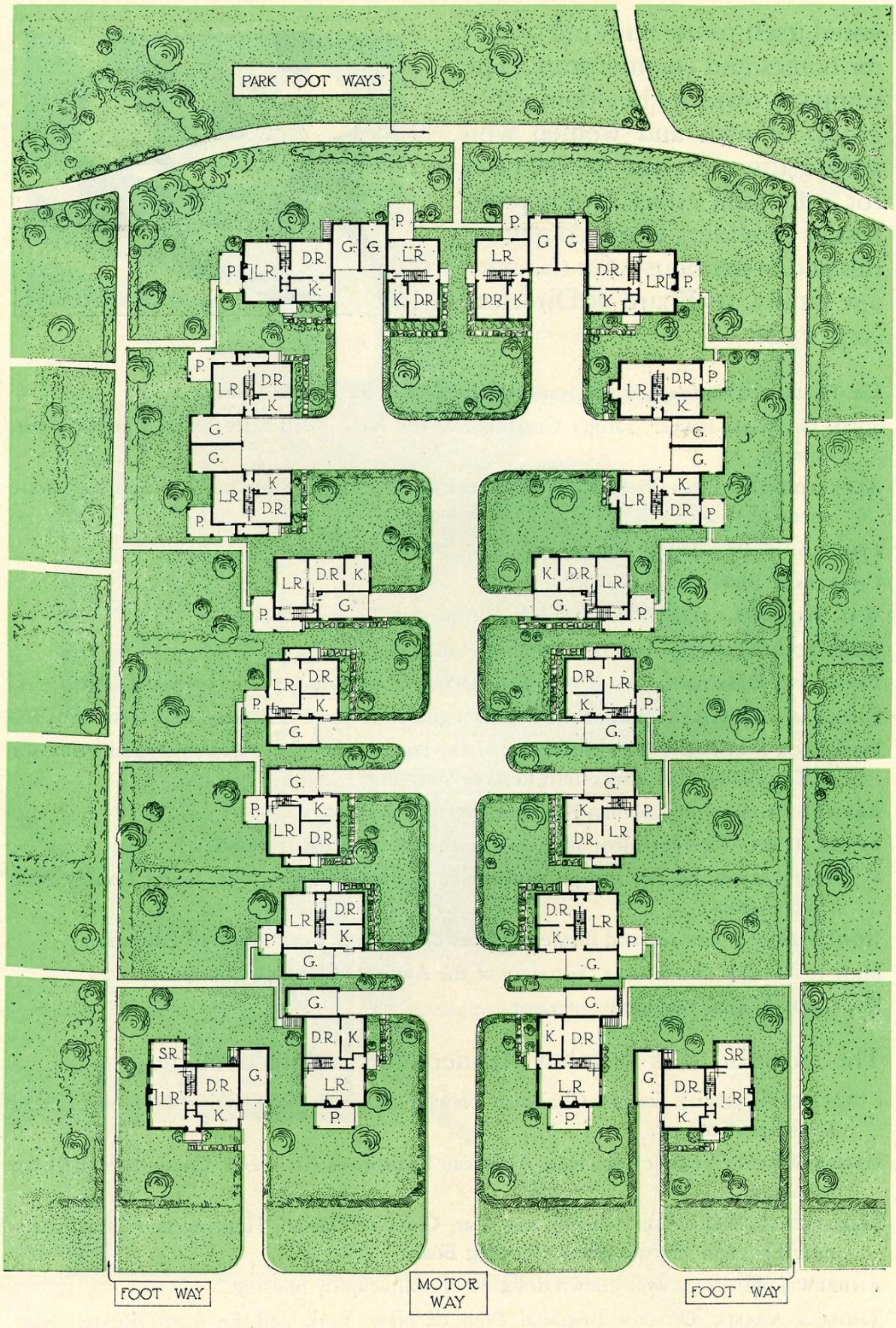
Instead, the variation by Vahl was favoured and developed into the woonerf neighbourhoods we see throughout the whole of the Netherlands. While the woonerf did not have a singular spatial translation or form, all shared the social objective of the woonerf to stage the encounter between neighbours, stimulate self-development, and increase appropriation of and identification with the immediate living environment. The success of the woonerf and the renewed importance of the living environment lead to the initiative from the Dutch government to formalize the concept of the woonerf in 1976. But the initiative was also mostly pragmatic because the woonerf was a functional solution for the improvement of traffic safety in residential neighbourhoods. With the formalization of the woonerf, minimum requirements for the design of the residential area and traffic rules were established by law in 14 articles (Van der Leun, Jutten & Lofvers, 2009). This formalization caused a shift in the woonerf neighbourhoods built after 1976, which were more practical and less focused on the social function of the street.

3.3 Historical and international parallels

With the introduction of the term 'woonerf' Niek de Boer makes a historic parallel to a typical Dutch concept: the erf, which is a farmyard with several buildings and a variety of outdoor spaces that together form a unity (Van Gameren & Mooij, 2010). Besides the analogy in the name, the woonerf also shares the same characteristics as the erf. In some farming villages, the erf had a communal function. Several farming buildings would be lined up along a road, and the road itself would be used to stack harvest or gather cattle. With the farm functions in front of the buildings, the living quarters would move to the back away from the erf. The backside would often have greenery in the form of an ornamental garden as protection from the wind, and the spaces in between the buildings would also be used as gardens. This same configuration can be seen in the development of the woonerf.

Not only are there historical parallels to the woonerf, but there are also international ties to be found. First of all, there is an obvious link to Ebenezer Howard's views on the garden city movement in the experimentation with green suburban neighbourhoods. The garden city is a model for the urban development of self-sufficient satellite cities. More specifically, de Boer's design for Angelslo en Emmershout in Emmen correlates with the Radburn concept that originated in Radburn, New Jersey, which stemmed from the garden city movement. Promoted as 'a town for motor age', Radburn was designed to include the car in a way that does not compromise on the quality of the residential area. The houses are clustered in a cul-de-sac that is connected to a road system. The car is parked at the backside of the house, and the front side is facing a green and car-free pedestrian area (Van Gameren & Mooij, 2010).

Another interesting linkage is with a well-known image of what the Dutch call a 'bloemkoolwijk'. It depicts a non-uniform neighbourhood made out of smaller units, closely resembling the structure of a cauliflower with its florets growing out of the main stem. This image has always been thought to be designed by Niek de Boer but was actually published by the german urban planner Walter Schwagenscheidt in 1957 in his book *Ein Mensch wandert durch die Stadt.* The linkage to de Boer is also contradictory because the woonerf neighbourhoods in the bloemkoolwijk deviate from his idea of a woonerf neighbourhood. De Boer's woonerf has, first of all, a linear structure, much like the Dutch 'stempelbouw'. The structure of the woonerf neighbourhoods in a bloemkoolwijk on the other hand is irregular and seeks variety. Secondly, in de Boer's woonerf, the collective residential area is completely car-free, while most of the woonerf neighbourhoods in a bloemkoolwijk have incorporated cars into the collective area by designing bending and twisting roads with bumps to slow traffic down. It is therefore peculiar that these opposite versions of the woonerf were thought to be related.



TYPICAL CLOSED-END STREET

Showing how houses are grouped. One end opens on a wide traffic avenue; the other on the park, which forms the center of each block. Motor ways give easy access for vehicles, while the footways connecting with park walks provide for pedestrian traffic.

[3]

Figure 6 *Plan of Radburn Garden Homes. From Rockefeller Archive Center.*

3.4 Conclusion

The woonerf can be seen as the result of social and political changes. The diversified and emancipated society needed a living environment that enabled individuality and stimulated self-development, and increase appropriation of and identification with the immediate living environment. The woonerf was furthermore a large-scale solution for not only the growing population but also the growing amount of cars. The woonerf provided a stage for the social goals to flourish, while also being a pragmatic solution for traffic safety. Many varieties were explored within the concept of the woonerf. The first woonerf was completely car-free, but soon woonerf neighbourhoods followed that compromised and incorporated the car, making it a domain for all users.

4 Demographics

Society is everchanging. And so are the type of people living in the woonerf neighbourhoods. Making a futureproof woonerf includes making a suitable home for people living there now and in the future. That is why a closer look is needed at the demography.

4.1 Shifting demographics

In the ’70s and ’80s, there was a substantial migration from the cities to the New Towns in the Netherlands. This was driven by the desire for more living comfort, space, and greenery. It was predominantly standard families that moved to the woonerf neighbourhoods in the New Towns. This was a result of the fact that the neighbourhoods were mainly designed for this target group, by building single-family homes at a time when suitable family homes were scarce (Ubink & Van der Steeg, 2011). Now, forty years later, the woonerf neighbourhoods have undergone a demographic change, as the original population still living in the woonerf neighbourhoods is ageing. Is this the end of the woonerf as a family neighbourhood? Admittedly, after decades of migration due to suburbanization, the city has regained its appeal. Especially young families and couples from the higher income class are attracted by the urban living environment in the cities (PBL, 2017). Furthermore, from 1990 residential areas (Vinex neighbourhoods) were built on the fringes of the cities. As a result, higher-income class families with suburban preferences choose the Vinex over the woonerf (Van Dam & Manting, 2015). Whereas during the ’80s and ’90s the woonerf neighbourhoods in the new towns consisted of 44% of the higher-income class, this number has now shrunk to 29%. On the other hand, the amount of lower-income households in the woonerf neighbourhoods has increased. As a result of the selective migration of the higher-income class and the high pressure on the urban housing market, the homes in the woonerf neighbourhoods have become affordable for the middle and lower-income classes (Ubink & Van der Steeg, 2011; Van Dam & Manting, 2015). For this same reason, the woonerf has also become more multicultural. The share of non-western immigrants has increased in the woonerf neighbourhoods due to the lack of affordable housing in the cities (Van Dam & Manting, 2015).

Among the households living in the woonerf neighbourhoods, today are not only standard families, like the original focus group, but also one and two-person households. The prognosis of the central bureau of statistics is that one and two-person households will have stronger growth than family households. The continuing ageing of the population, fewer pairs, an increased risk of divorce, and young couples delaying family expansion all play a role in this (Stoeldraijer, Te Riele, Van Duin & Van der Reijden, 2021). Aligning to this trend, the current household average in Goedewerf is 2,1 persons (Kadastralekaart, n.d.) It is also expected that there will be a strong growth of the population in the suburbs in the coming years (De Jong & Van Duin, 2011; Van Dam & Manting 2015). And with the general growth of the number of households, more than the cities can hold, it is very likely that the migration of young couples and families to the suburbs will be set in motion again (Van Dam & Manting, 2015).

It is the end of the woonerf solely as a family neighbourhood. The population within the woonerf has diversified, but the housing types are still very monotonous. With the growing population in the suburbs and the expected migration from the cities, it could be an opportunity to densify the woonerf. But simultaneously it is also an opportunity to redevelop the woonerf to a suitable and attractive living environment and to diversify the housing types for its diverse residents. At the same time, this densification within the woonerf addresses the national housing shortage.

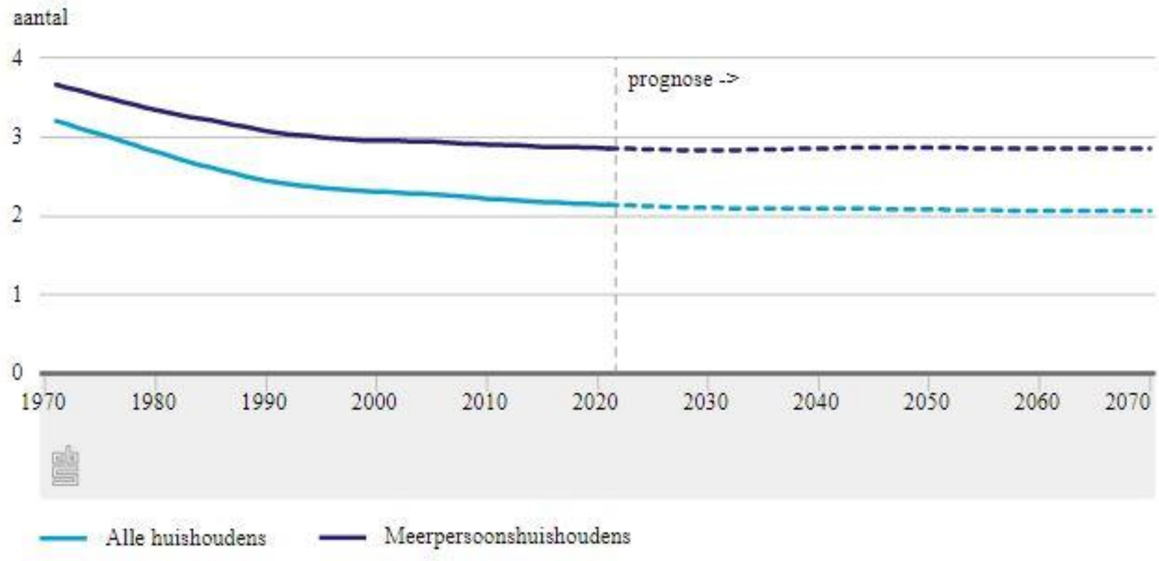


Figure 7 *Prognoses of household sizes. From CBS, 2021.*

Figure 8 *Prognoses of household composition. From CBS, 2021.*

4.2 Business owners

Goedewerf seems to have a large number of self-employed residents with businesses varying from construction to nail care. This became very apparent during a site visit when many construction vans could be spotted. According to several other publications, the large number of self-employed residents is a trend in other woonerf neighbourhoods as well (Uyterlinde & Oude Ophuis, 2012). During the first phase of the studio, group analysis was conducted on Goedewerf. This analysis also included an inventory of businesses that are registered in the KvK. The results show a wide variety of businesses owned, ranging from construction to nail salons and healthcare.

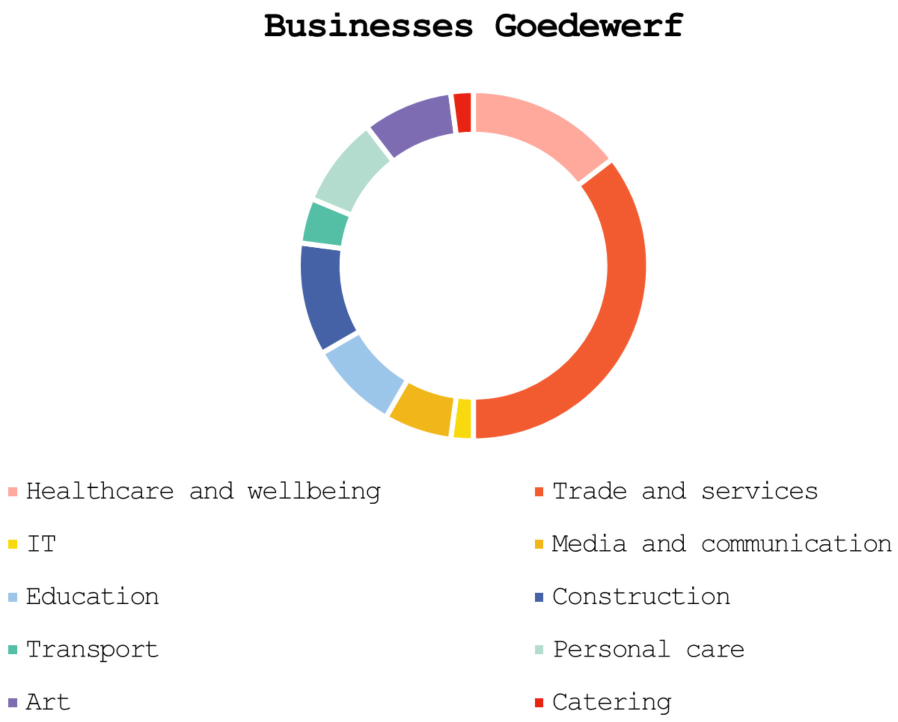


Figure 9 *Diagram of businesses in Goedewerf. Data from KvK register.*

4.3 Ownership situation and neighbourhood renovation

Most woonerf neighbourhoods typically contain owner-occupied homes and rental homes. The ratio of private and rental homes has been shifting in the last decennia due to the selling of rental homes by housing corporations (Ubink & Van der Steeg, 2011). The ownership situation does create difficulties in the renovation of a woonerf neighbourhood. Private owners could choose not to participate in the renovation, or could simply not have the financial means to do so. Similar cases have sought to find a solution to this problem. To renovate an apartment complex, housing corporation Wonen Zuid has been buying back apartments from private owners for their market value and renting them back to the residents that want to stay. HEEMwonen sought the same strategy, but in a phased repurchase of private homes (Baggerman, 2020).

This graduation project will be designed for the scenario in which a phased renovation of the neighbourhood would take place, but in which full building blocks or streets would be renovated. To renovate a full housing block or street:

- private home owners would have to participate in the renovation;
- a housing switch would take place where home owners that are willing to participate are moving to the to be said housing block
- a housing corporation buys houses out to renovate them

5 Characteristics

Although there is no lack of literature on woonerf neighbourhoods, an overview of its characteristics is missing. Therefore, in the next section, descriptive terms on the physical and experiential characteristics of a woonerf are listed from different publications. From this list, a set of characteristics could then be derived that summarize the descriptive terms that are being used in literature to relate to a woonerf. This technique derives from the coding technique in social sciences, which is used to analyze and categorize data.

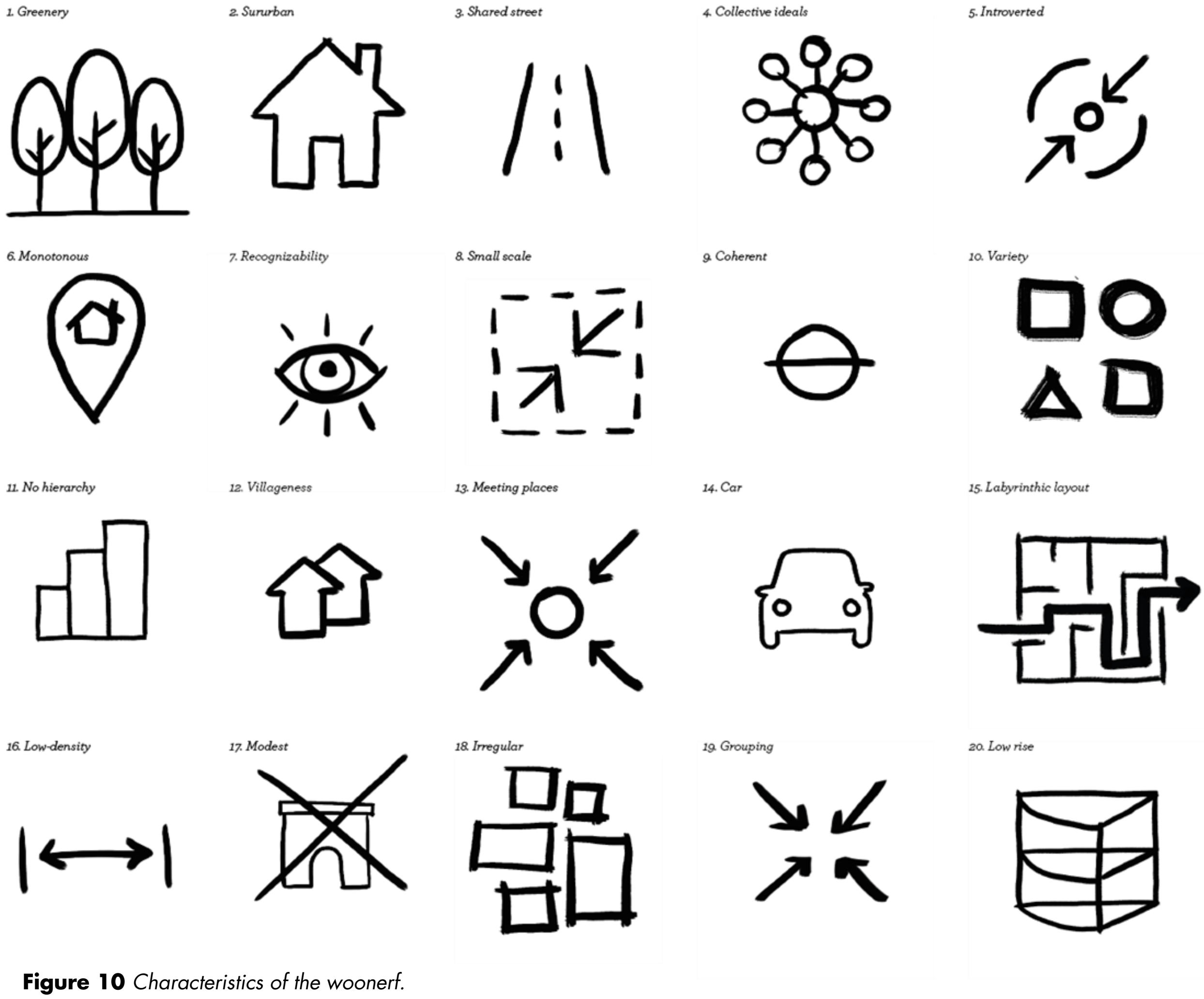


Figure 10 *Characteristics of the woonerf.*

	Physical characteristics		**Experience**	
Nio, 2010	culs-de-sac	p.5	"tweeslachtig karakter: uitdrukking van vooruitgang, maar ook heimwee naar wat verloren is gegaan"	p.5
	wooneilanden	p.5	socialiserende betekenis	p.5
	kleinschaligheid	p.11	"straat als een collectieve ruimte"	p.6
	diversiteit	p.11	collectief domein	p.6
	collectieve opzet	p.11	niet-hiërarchisch en collectief karakter	p.8
			gedemocratiseerd suburbaan woonlandschap	p.8
			woonerf als een tussenzone	p.8
			informele karakter	p.8
			"een afspiegeling van een stadsgewestelijke stedelijkheid"	p.8
			traditioneel woonprogramma	p.9
Van Gameren & Mooij, 2010	"ruimte aan de toegangszijde […] als uitloopgebied van de woning"	p.21	informele karakter	p.21
	verspringende configuratie	p.27	introvert karakter	p.27
			enclaves	p.28
Frijters & Klijn, 2010	meanderende structuren	p. 61	weinig uitgesproken architectuur	p.61
Van der Leun & Oskam, 2008	grillige vorm	p.2	geïsoleerd	p.24
	laagbouw	p.2	introverte karakter	p.24
	kleinschaligheid	p.3	woonbuurten	p.24
	gedifferentieerd	p.3	gebrek aan helderheid en uitstraling	p.24
	variatie	p.3		
	grootschalige groen- en waterstructuur om en in de wijk	p.24		
	"verschillende verkavelingsvormen, plattegronden en type openbare ruimte"	p.24		
	intern gericht	p.24		
	"vermijden van herhaling in de verkaveling"	p.24		
	meanderende verkavelingen	p.24		
	verschillen in oriëntatie	p.24		
Van der Leun, Jutten & Lofvers, 2009	achtertuinen aan hoofdgroenstructuur	p.2	collectieve ruimte	p.2
	kleinschaligheid	p.2	alle verkeersstromen gelijk	p.2
	diversiteit	p.2	gebrek aan hierarchie	p.2
	laagbouw	p.2	ontbreken van oriëntatie	p.2
	eclectische vorm van architectuur	p.2	beslotenheid	p.3
	grillige stedenbouwkundige structuur	p.2	collectief domein	p.4
	ruimtelijke eenheid	p.2	niet-hiërarchisch	p.4
	woning als schakelelement voor het grotere geheel	p.3		
	willekeurig 'gehusselde' huisjes	p.3		
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6.1 Water

There is no denying the importance of water. But it is being used as if it were an infinite source. Nonetheless, the reality is different. Climate change is causing extreme droughts and rainfall. This we are already experiencing in the Netherlands. Therefore, we need to rethink our water system and find ways to transition from a linear water system to a circular one. And as a case study for a circular neighbourhood, Goedewerf is a good place to start thinking about such a system. According to the circularity goals the government has set, the water system needs to be circular within 30 years. Therefore the Dutch water companies set up a research program called WiCE (Water in the Circular Economy) in collaboration with Kiwa Water Research (KWR) and Belgium water companies, to explore the possibilities of a closed water system (KWR, 2021). By nature water is a circular system, meaning it will never be lost. When referring to a closed water system in a circular economy, water is not directly discharged to the sewers, but wastewater is reused and the resources contained in it are recovered (KWR, 2021). To find realistic and fitting solutions for a circular water system in the woonerf, in this subchapter an inventory is made of current and newer techniques implemented in several projects. The solutions are explored in the hierarchical order of the r-ladder.

Reducing

Rainwater collection

Valuable drinking water can be saved by substituting drinking water for rainwater where possible. Having been put into practice for thousands of years, rainwater harvesting is one of the simplest methods to supply water. In Ecodorp Boekel this system is being put into practice, and by doing they claim to save up to 40% on drinking water (Ecodorp Boekel, 2020). Rainwater is collected and stored in three collective 10m3 underground tanks, that can store a month's worth of water for 12 houses. The collected rainwater is then used to wash clothing and flush toilets.

The potential to harvest rainwater in Goedewerf is high because there is a large amount of roof surface. The total roof surface on which rainwater could be collected comes down to about 6835 square meters. In 2021 there was an average of 806 mm of rainfall in the Netherlands (Huiskamp, 2022). Considering 1 mm of rain equals 1 litre per square meter, that translates to 806 litres per square meter (KNMI, n.d.). With the roof surface available in Goedewerf, this would result in 5.509.010 litre (5.509 m3) of collected rainwater per year. With currently 156 households living in Goedwerf and an average of 2,1 persons per household, which consumes about 93 m3 per household, the collected rainwater could provide for about 38% of the total use (Nibud, n.d.). Naturally, with the densification in the neighbourhood, the percentage will decrease, but every drop counts. This technique is therefore a viable solution to decrease the use of drinking water.

Turning rainwater into drinking water

Consumption of drinking water could even further be reduced by making rainwater safe for consumption. The Dutch National Insitute for Health and Environment (RIVM) however states that rainwater is not pure enough for consumption. Rainwater has an unstable quality and could contain bacteria, viruses, and other contaminations (Van Driezum, Van der Aa, & Van den Berg, 2020). Technically it is possible to purify rainwater so that it complies with the criteria of drinking water. But a few questions arise concerning the woonerf. One of which is mainly how financially feasible is it to purify rainwater for the residents living in the neighbourhoods.

Although still in its test period, project Superlocal collaborated with drinking water company WML to see if they can produce drinking water from rainwater of sufficient quality for 125 homes. The costs of the drinking water supply during the trial amount to approximately half a million euros (Hooijmeijer, 2018). On top of that, to provide water in periods of drought the rainwater reservoirs have to be big enough. The price of water is so inexpensive that the investment for a reservoir does not recoup itself (Ecodorp Boekel, n.d.).

As a pioneer of this system, Superlocal will have to prove if it's a viable system. For the woonerf, this system is perhaps better left for the future when techniques to filter rainwater are more established and it is financially attractive to do so. Even so, rainwater should still be collected for other uses than consumption.

Recycle

Recycling wastewater

Project Superlocal is even taken it further and is experimenting with the reuse of greywater. After the greywater is filtered through an 85 m2 reed field (Phytoair), which functions as a natural filtration system, the water is treated with an activated carbon filter and UV filter. The water would then be clean enough to be used as washing water in the local carwash and the laundry service. Subsequently, water from the laundry service can go through the cycle again (Hooijmeijer, 2018; Rietland, n.d.).

The natural filtration system is certainly not a new technique and was even already been used on a neighbourhood scale since 1994. Lanxmeer, Drielanden, and Polderdrift were the first to treat their grey water with a helophyte filter. It functions through purification by plants and filter substrate.
In 2011 extensive research was done by Nanninga on these three neighbourhood water systems to shed light on the general performance and costs of helophyte filters. His research showed that even during lower temperatures in winter, helophyte filters would still perform sufficiently. Odour nuisance was only experienced due to poor infiltration during summer but could be solved by adjusting the timer of the pump. Financially, the construction costs were covered by the municipality, as the helophyte filters are considered part of the sewage system in the neighbourhood. Moreover, operation and maintenance costs were also paid for by the municipalities, which would be passed on in the annual rioolheffing fee. Overall the helophyte filter was perceived as positive in all three neighbourhoods (Nanninga, 2011).

In terms of space, a conventional helophyte system requires 3 m2 per person (Wetlandtec, n.d.). For Goedewerf this would require a helophyte coverage of at least 2.496 m2. Newer systems, like the one installed in Superlocal, are more compact.

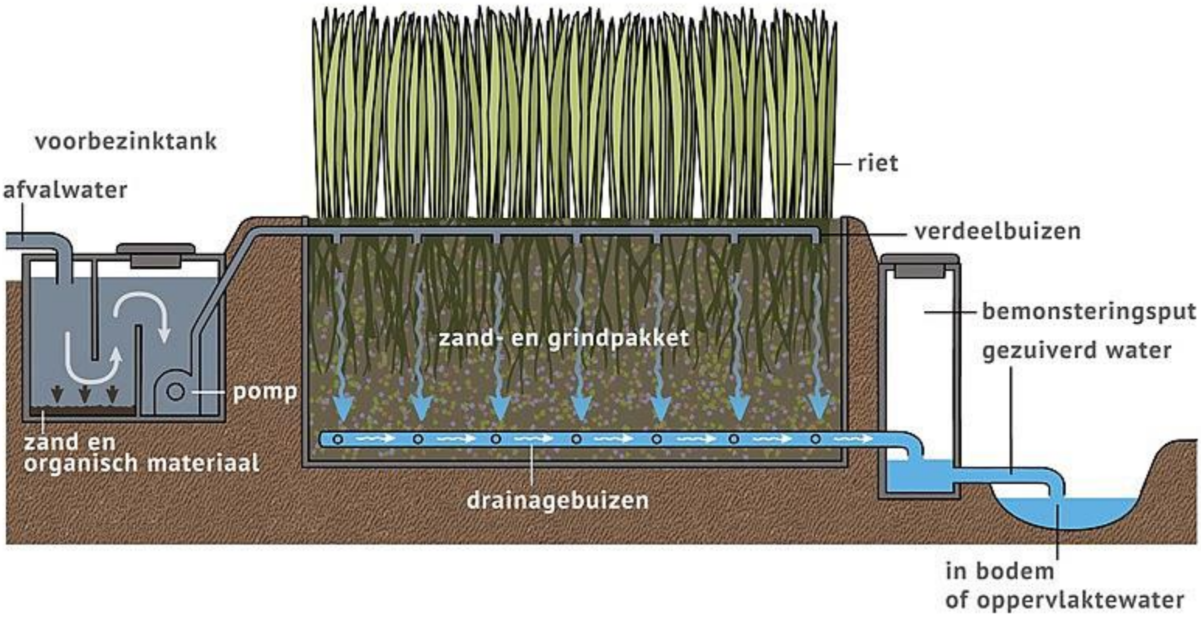


Figure 11 *Conventional helophyte filter. From Saniwijzer.*

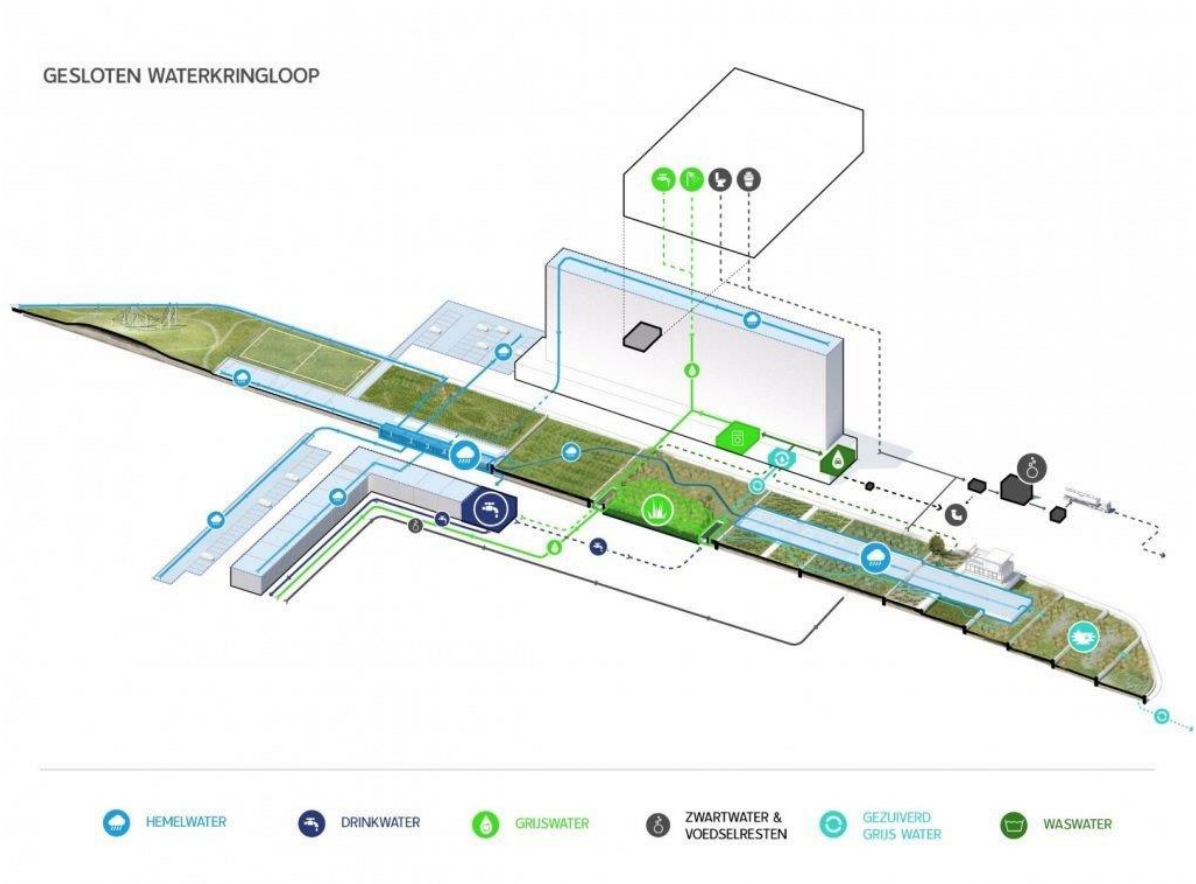


Figure 12 *Closed water system Superlocal. From Superlocal.eu/gesloten-waterkringloop*

6.2 Energy

Reduce

Passive house

By designing a passive house, no extra energy is required to heat or cool a home, reducing the ecological footprint of the house. A passive house meets the following criteria: Heating and cooling do not exceed the annual limit of 15 kWh/m2. Primary Energy Demand does not exceed the annual limit of 60kWh. And lastly, the airtightness is lower than 0,6 air changes per hour (Passive House Institute, 2022).

Recover

Extracting heat (from wastewater)

Heating buildings and water in households account for approximately 40% of the total energy consumption (Stowa, 2011). After being used, warm water ends up in the sewage. Instead of being disposed of, this energy may well be retrieved.

Watercycle Research Insitute KWR and Stowa, have been researching the possibilities of heat retrievement from wastewater on a larger scale. Both institutes concluded that heat retrievement is most fruitful when close to the users (Bloemendal et al., 2015; Stowa, 2011). Therefore, in the scenario where the neighbourhood would have its wastewater treatment, it would be beneficial to have a heat exchanger. In Buikslotermeer, the municipality is preparing to realize such a system. The plan is to install a 300-meter bypass on the existing sewer system, that has a heat exchanger on the pipe wall. Most of the heat would be retrieved in summer and stored in underground thermal storage (Winnovatie, 2020).

Another option is to have the heat exchanger installed in every household. Heat exchangers that are installed in showers to retrieve warmth from shower water have already been in practice in the Netherlands. Recent techniques now also allow warmth to be retrieved from all wastewater. HeatCycle embraces this exact concept, by storing the recovered heat in a boiler inside the system. A built-in heat pump then raises the residual heat to 60 degrees Celsius. The recycled heat can then be used as hot tap water or to warm a house. With this system HeatCycle claims to provide 40% of the total heat requirement of a four-person family (Zimmerman, 2020).

Producing biogas from waste(water)

Wastewater can still be valuable. This is the fundamental idea behind the concept of New Sanitation. It aims to restore the nutrient cycle between agriculture and sanitation, by applying anaerobic purification to wastewater and kitchen waste, which not only produces fertilizer but also biogas. Biogas can then be used in its original form or transformed into electricity. In the Netherlands, a New Sanitation project that uses DESAH technology in combination with vacuum toilets has been set up in 232 homes in the neighbourhood Waterschoon in Sneek since 2007. In 2018, another New Sanitation project started for 46 homes in the case study Schoonschip Buiksloterham, Amsterdam (Van Tuijn, 2022).

The pilot in Sneek has been monitored, and the results conclude that New Sanitation on a scale of 1000-1500 people would have the same costs as conventional sanitation. The research has also shown that the residents were generally satisfied and that the installation, which is located in the middle of the district, did not cause any nuisance (Stowa, 2014). Although the research has shown that such an installation is only profitable at a scale that is bigger than Goedewerf, the municipality of Almere has the ambition to start testing New Sanitation on a city scale. However, the cost of the maintenance of the city sewage is high due to soil subsidence and a decentralized sewage system with a biogas transformer might prove to be financially feasible when the techniques are more mature.

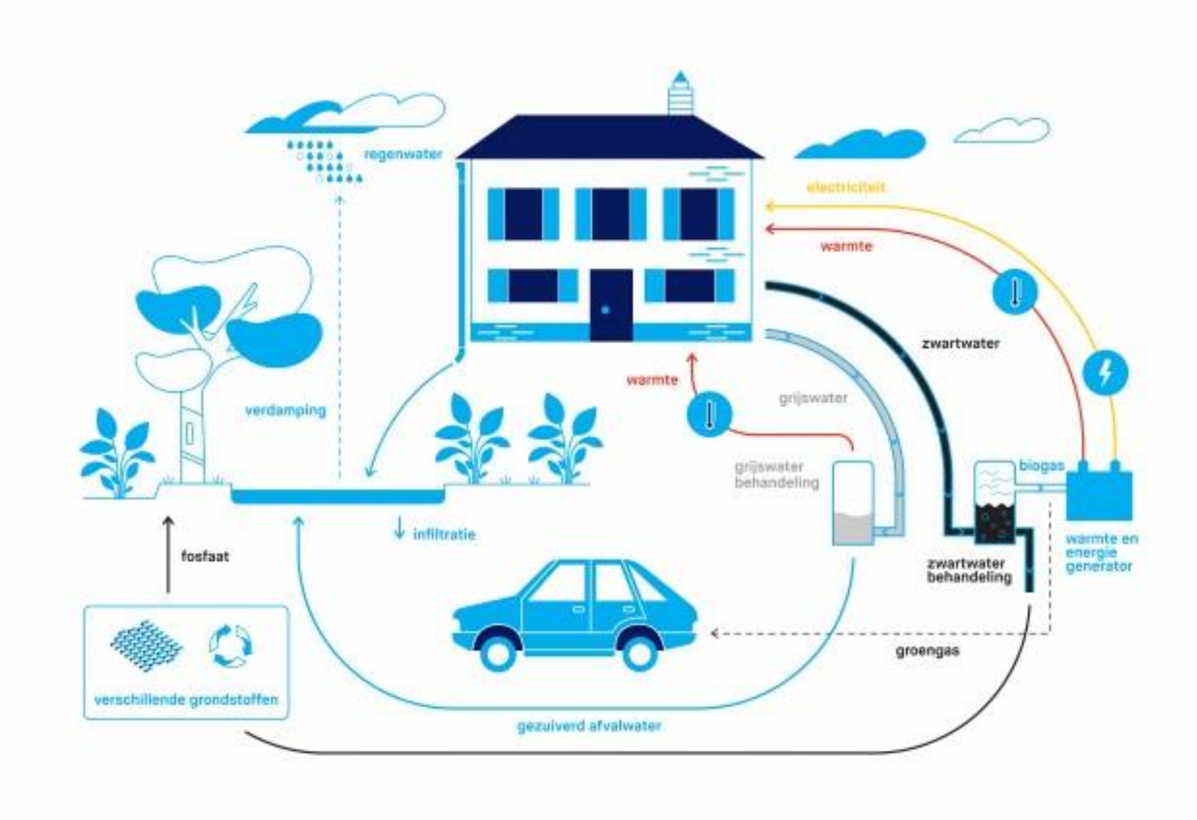


Figure 13 *New Sanitation diagram. From Waternet.nl*

6.3 Materials

The traditional take-make-use-dispose approach is no longer of this time. The negative side effects on the environment of this linear material flow, like resource depletion emissions and pollution, are urgent reasons to convert to a circular approach to materials management. This chapter, therefore, sums up methods concerning building materials and material consumption, that contribute to a circular material flow.

Refuse/rethink

Sharing hub

Sharing is the new owning. By creating a sharing economy within the neighbourhood, where for example equipment and transport are shared, less waste is created. On top of that, higher investments could be made into better quality products with a longer life span.

Material passport

"Waste is material without an identity", as said by Dutch architect and founder of materials database Madaster Thomas Rau (Madaster Foundation, n.d.). A material passport documents the materials present in a building to maximize the potential reuse of the materials in urban mining. A material passport also holds information on the source of the material, the supplier, and the environmental impact (Luscuere, 2017).

One of the case studies, Schoonschip in Amsterdam, applied this concept in their project as a decision-making tool, sorting different options of materials by ecological footprint. In reality, compromises had to be made for more affordable options rather than more sustainable ones (Schoonschip, n.d.)

Reduce

Biobased materials

In almost all of the case studies, biobased materials have been used. In the European Standards (EN) a bio-based product is described as "A product wholly or partly derived from biomass, […] excluding material embedded in geological formations and/or fossilized" (EN 16575:2014). Biobased thus refers to the source of a product. The advantage of the source being biotic is that the source is renewable and that in most cases biobased resources absorb CO_2 from their environment and retain the CO_2 until their life cycle has ended. It must be noted that biobased materials are only climate neutral if the resource is sustainably managed and the amount of CO_2 emission during production and transport does not exceed the amount that is stored within the material. Temporarily storing carbon in building materials, can contribute to mitigating climate change. With the reuse and recycling of materials, carbon emissions can even be further deferred (Fraanje & Nijman, 2021).

Local materials

By using local materials the ecological footprint can be reduced by minimizing transport. Clay and reed are prime examples of local materials, that have been used for centuries already. With the growing demand for local biobased materials, initiatives have sprouted to explore the production of building materials from Dutch soil and sea. Flax, hemp, and grass are available insulation materials, grown on our Dutch soil (Van den Breemer, 2021). Though, some essential materials such as wood, are scarce or even unavailable in the Netherlands and have to be transported from abroad or reused from demolished structures.

Reuse

Modular building

Modular building is a building method that is designed to be taken apart and reused. The majority of the construction takes place in the factory. Case study De Loskade in Groningen uses this modular construction method so that the neighbourhood can be deconstructed and rebuilt elsewhere. In collaboration with Fijn Wonen, the neighbourhood was realized and constructed in a short time, as the building elements were already built in the factory.

Figure 14 *Modular building used in De Loskade, Groningen. Photo by Lucas Kemper.*

Urban mining

Urban mining is the reuse and recycling of building waste from building demolitions. In the case study Superlocal, materials from the to be demolished appartment building on the site are extracted and reused in the new buildings. Their ambition is to construct new buildings that for 90% consist of the extracted building elements and materials. From the existing building, complete appartment structures are hoisted out of the building and used as a base for the to be constructed houses. Concrete is then recycled and made into concrete blocks. For the façade recycled bricks are used from the old building. Window frames as well as the roof structure is made from recycled wood (Superlocal, n.d.).

Figure 15 *Appartment structure reuse in project Superlocal. From Superlocal.eu*

Figure 16 *Newly constructed buildings from reused and recycled materials. From Superlocal*

Repair

Repair shop

In the daily lives of the residents, waste can be reduced by having defective objects repaired. Initiatives like the Repair Café could provide a place for residents to come to when they are unable to repair the objects themselves (Repair Café, n.d.). Simultaneously, this repair shop could stimulate community building and provide job opportunities, as the analysis of Goedewerf has shown that there are a considerable amount of residents that have technical and mechanical knowledge.

Refurbish/remanufacture

Reusing building elements

In some cases, existing building elements can be reused and even refurbished or remanufactured into more energy-efficient elements. Wooden windows can often be refitted with new glass, or even be deconstructed and processed to produce new window frames (Van der Meijs, n.d.).

Regarding possible upgrades in Goedewerf, the current window frames containing double glazing could be upgraded to triple glazing by installing a modified glazing bead to create sufficient space for triple glazing (Van Rijnback, 2019). This method improves the insulation value of the windows without wasting building elements that are still in good condition. Possible impediments to this method are the weight of the triple glazing, as not all window frames will support the weight. Together with the possible thermal bridges in the existing window frames, this might in some cases lead to choosing new window frames over modified frames.

The exterior walls of the homes in Goedewerf exist, like in many woonerf neighbourhoods in the Netherlands of brickwork. With the priority to reduce material consumption and make use of what is already there, it is sensible to find a way to reuse the existing brickwork. Even so, the reuse of individual bricks is made difficult by the use of portland cement mortar, which was often used in the '70s. Unlike lime mortar, which is a soft mortar and therefore easily removable, portland cement is a hard mortar. This makes it very hard, if not impossible, to separate from the brickwork (Lendager Group, n.d.). Cutting out modules of brickwork, like the way it was done for the construction of Resource Rows in Copenhagen, is a viable option if only parts of the wall were to be reused. The difficulty of this procedure is the labour-intensive and customized process, which is not fit in.

Figure 17 & 18 *Reuse parts of brick wall. From Lendager Group*

Reusing building rubble

Another approach concerning the reuse of materials is the use of building rubble. For example, Atelier cnS reused the building rubble from the demolition of the previous structure in the construction of public toilets in the Zuzhai Village. By filling wire cages with crushed rubble, bricks, roof tiles, and stones, a new building was erected, while reducing the use of new materials (Barandy, 2020). This way, the material heritage continues to live on in a new form.

Figure 19 *Reuse building rubble by Atelier cnS. From World Architecture Community.*

Recycle

Recyclable materials

At the end of their life cycle building materials have four possible destinations. Material is either reused, recycled, incinerated (with or without heat recovery), or ends up in a landfill. In the last scenario, the embodied energy in the materials is wasted and there is a contamination risk of soil, water, and air (Thormark, 2001). That is why it is important to consider the potential reuse or recycling of the material after the end of its life cycle. Reuse is preferred over recycling. However, if a building element or material does not correspond to the new demand, recycling can be considered.

Designing with a building material or element with the end of life in mind aligns with the concept of cradle-to-cradle by Braungart and McDonough (2008). This concept regards waste as food, which feeds into the next cycle. It distinguishes two material flows: the biological cycle and the technical cycle. The biological cycle is a natural process of materials or products designed to return to the earth by biodegradation. Whereas the technical cycle contains materials or products that are industrially processed into raw materials for new materials or products.

To increase the recyclability of a building material or element in the technical cycle, a few points need to be taken into consideration. Most importantly, the material itself needs to be recyclable, and toxic or hazardous parts should be easy to remove. Some materials are easier to recycle and consume less energy doing so. Furthermore, the building material or element should be dismantlable, and parts that cannot be recycled together must be easy to separate (Thormark, 2001). All in all, the type of material, the design, and the construction method all play a role in the recyclability.

Recycled building materials

The neighbourhood Goedewerf has a variety of candidates that could be recycled: wood, concrete, brick, and glass. However, recycling is only sustainable if the energy and emissions during the recycling process are not higher than with the production of virgin materials (Saghafi & Teshnizi, 2011). Therefore, these calculations need to be taken into account when striving for the most sustainable option.

6.4 Ecology

The side effects of our linear consumption like overexploitation of resources, pollution, and most of all climate change, have had a direct impact on the loss of biodiversity worldwide (IPBES, 2019). Especially the loss of pollinators is threatening global food production (IPBES, 2016). In this chapter, several methods are shortly explained that could create suitable conditions to regenerate biodiversity and create a green cycle within the scale of a neighbourhood.

Refuse/rethink

Ecosystem service

Environmentalists define ecosystem services as "the benefits human populations derive, directly or indirectly, from ecosystem functions" (Costanza et al., 1997, p. 253). Some of these services could serve the circular systems of the neighbourhood beneficially, keeping out species that are harmful to the local food production and attracting species that pollinate the crops.

Permaculture

Case study EVA Lanxmeer facilitates biodiversity in its design by using the concept of permaculture. Permaculture design is a design method that works with nature, rather than against it. The design method is aimed at creating resilient and stable agricultural ecosystems, that can facilitate all forms of life (Mollison, 1979)

Reduce

Local food production

Even though being fully self-reliant on local food production might not be realistic for most neighborhoods, as there is simply not enough space or labor force, local food production could contribute to biodiversity. Community gardens that provide variety in vegetation, vegetation structure, landscape structure, and floral diversity can increase biodiversity (Lhin, Philpott, Jha, 2015).

Recycle

Composting green waste

Organic waste is part of the natural cycle mentioned in the cradle-to-cradle concept. To make this cycle more effective on a neighborhood scale, green waste could be collected and locally composted for later use as fertilizer.

7 Circular strategies

	Water	Energy	Materials	Green
Refuse/ rethink	Rainwater collection Turning rainwater into drinking water		Sharing hub Material passport	Ecosystem services Permaculture Nature inclusive building
Reduce		Passiv haus Green energy production	Biobased materials Local materials	Local food production
Reuse			Modular building Urban mining	
Repair			Repair shop	
Refurbish/ remanufacture			Reusing building elements Reusing building rubble	
Recycle	Recycling greywater Recycling wastewater		Recyclable materials Recycled materials	Composting green waste
Recover		Extracting heat from wastewater and air Producing gas from waste(water)		

Figure 20 *Circular strategy matrix*

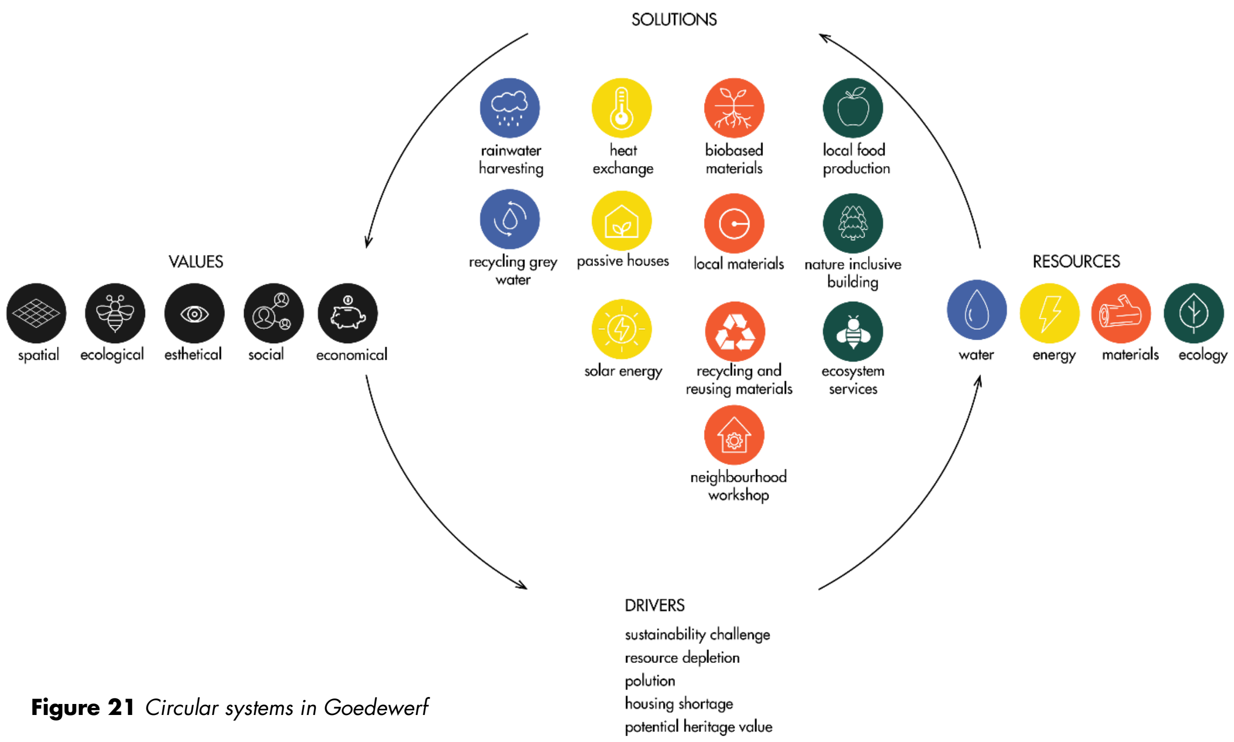


Figure 21 *Circular systems in Goedewerf*

Water

The current water system in Goedewerf exists of a conventional separated sewer system, in which rainwater is separated from domestic wastewater and drained to the closest surface water. Domestic wastewater is treated in a wastewater treatment centre, where wastewater is cleaned and drained back to surface water. For the redesign of Goedewerf, the proposal is to close the water system by harvesting rainwater and recycling domestic wastewater locally to reduce drinking water use. Rainwater is drained from roof surfaces and stored in underground rainwater tanks. By harvesting rainwater, a housing unit containing 4 households can save 23% on regular water use (with a harvest of 43 m3 per year). Because rainwater doesn't meet the criteria of drinking water, rainwater would only be used for irrigation, toilets and washing machines. The cycle is further closed by recycling domestic wastewater for the use of non-drinking water. The current wastewater sewer would be connected to a water purification system that is integrated with the parking lots of the neighbourhood. Here, wastewater is purified through a biological process similar to a helophyte system. One parking spot has the capacity to filter the wastewater of 15 residents.

With the densification the maximum number of households in Goedewerf is 170, which amounts to an average of 510 residents. This would mean that the wastewater of the neighbourhood could be treated with 34 parking spots. In comparison to a conventional helophyte filter, which would require about 1500 m2 in Goedewerf, this system saves a substantial amount of space. By closing the water system (for non-drinking water) the use of drinking water can be reduced by 37% (waternet, n.d.).

Energy

Goedewerf like most woonerf neighbourhoods has poor energy performance. Therefore, to reduce energy use to warm and cool the house, the proposal is to adjust the houses to a passive house standard. To achieve this, a new layer of insulation needs to be added to the current exterior to reach an Rc-value of 8. Furthermore, to reduce the need for cooling shading would need to be created on the south façade of the buildings. For additional heating and cooling, a ground source heat pump will provide passive cooling in summer and heating in winter. The heat pump itself is powered by solar energy.

Materials

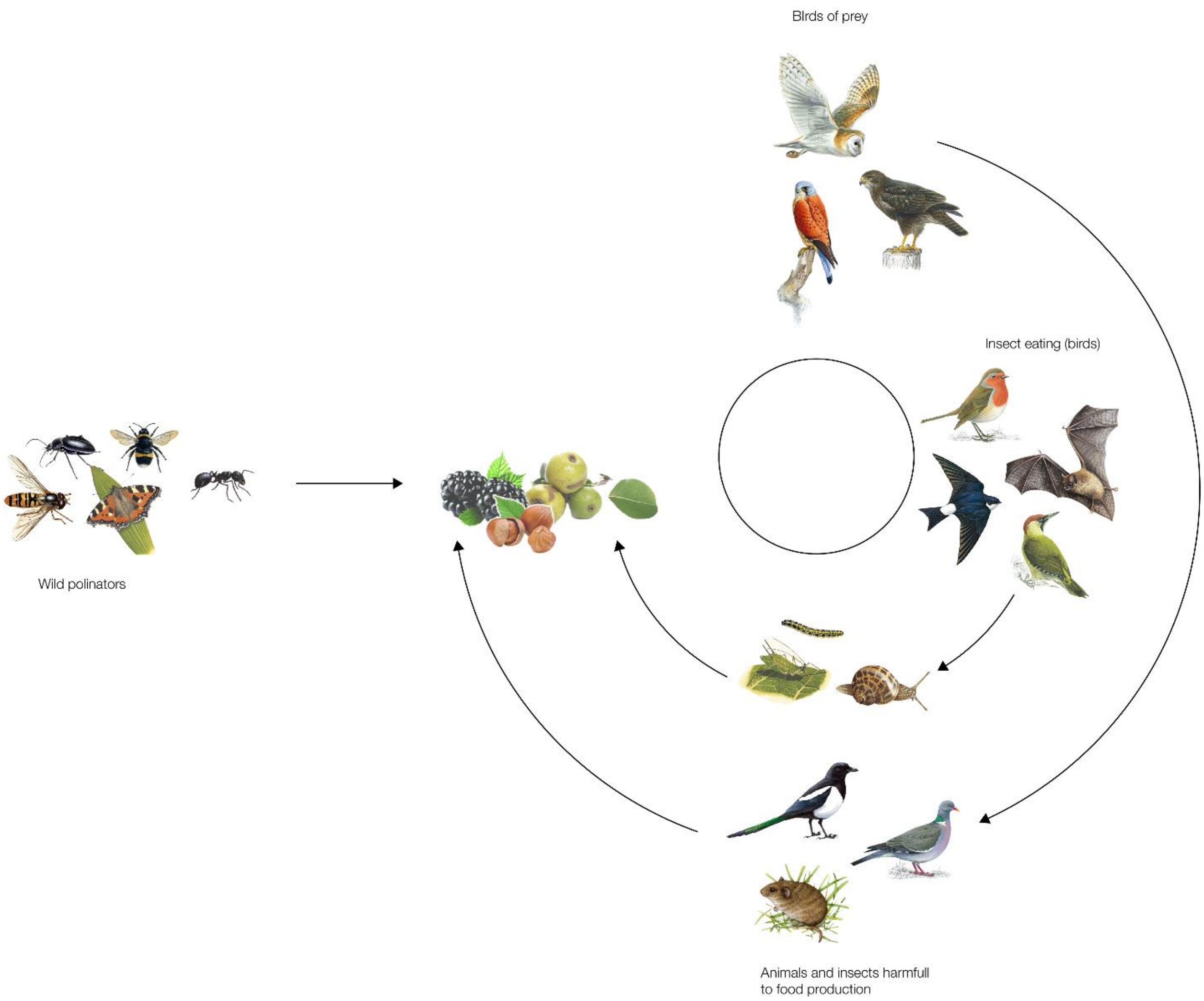
The interventions of transforming the houses into passive houses, splitting houses and creating more usable living space by building roof extensions will inevitably require the movement of material in and out of the neighbourhood. Therefore, to reduce the ecological footprint of adding more insulation, only biobased and locally produced insulation will be used. Furthermore, because the outer layers of the exterior walls are removed to create more space for the insulation, the brickwork is recycled and formed into dry stack bricks. By doing this the reusability of the brickwork is increased. With the extension of the roof, the removed wood is reused in the new building structure.

Within the neighbourhood, the parking garages that become available with the construction of parking lots, are transformed into workshops. Here repairs of household items and bikes can be done, and equipment can be shared to further reduce waste.

Ecology

The ecological cycle is closed by creating an ecosystem service, that will benefit local food production. To achieve this buildings and landscapes must be nature inclusive. This means, including nesting possibilities and providing variation in landscape and vegetation. Food production on site will take place in the form of fruit trees and vegetable gardens.

Figure 22 *Ecosystem services*



8 Conclusion

How can the woonerf, such as Goedewerf, be redesigned to create a circular neighbourhood, while still maintaining potential heritage?

The first part of the research investigated the potential heritage of the woonerf. Its characteristics and values were established and the conclusion is that its potential heritage can be found in the concept of the woonerf. Even though the woonerf comes in many shapes and forms, and doesn't have one appearance, the motivation behind a woonerf is the same: to bring back the street as a living space and to enable individuality, stimulate self-development, and increase appropriation of and identification with the immediate living environment. In the redesign of Goedewerf this concept is improved on by creating a collective garden that forms the centre of the neighbourhood. Furthermore, spaces are created in garage boxes where business owners can establish their businesses. As was seen in the analysis of business owners in Goedewerf, a variety of skilled people are available that could contribute to the circular economy in the neighbourhood, such as a workshop.

The redesign to a circular neighbourhood was conducted with a circular strategy matrix that resulted from the case study research. With this matrix, a circular strategy was developed that formed the basis for the design of the neighbourhood. The strategy was developed by combining different tools from the matrix that were categorized by the hierarchy of the R-ladder and circular theme. The circular strategy was then combined with the concept of the woonerf in the resulting design, which is translated to a value map with the Circular Value Flower method. The resulting value map shows that all resource cycles and values were improved upon, even though some resource cycles and values had more focus. The project shows it is worthy of further investigation in which the circular strategy matrix is further developed and more circular design models can be investigated. It could prove to be interesting to investigate circular design models that have an emphasis on different resource cycles and values or to find a model that is balanced in all cycles and values.

Recommendations

The project also brought to light some weaknesses that need further investigation. The phenomena of 'gespikkeld bezit' needs to be further looked into. A neighbourhood renovation requires management and cooperation with the users. Different approaches towards this situation exist and need to be taken into consideration. Secondly, the densification of the neighbourhood in the project aims at the addition of 14 apartments by splitting 7 single-family homes. Further research has to show whether this is a feasible number.

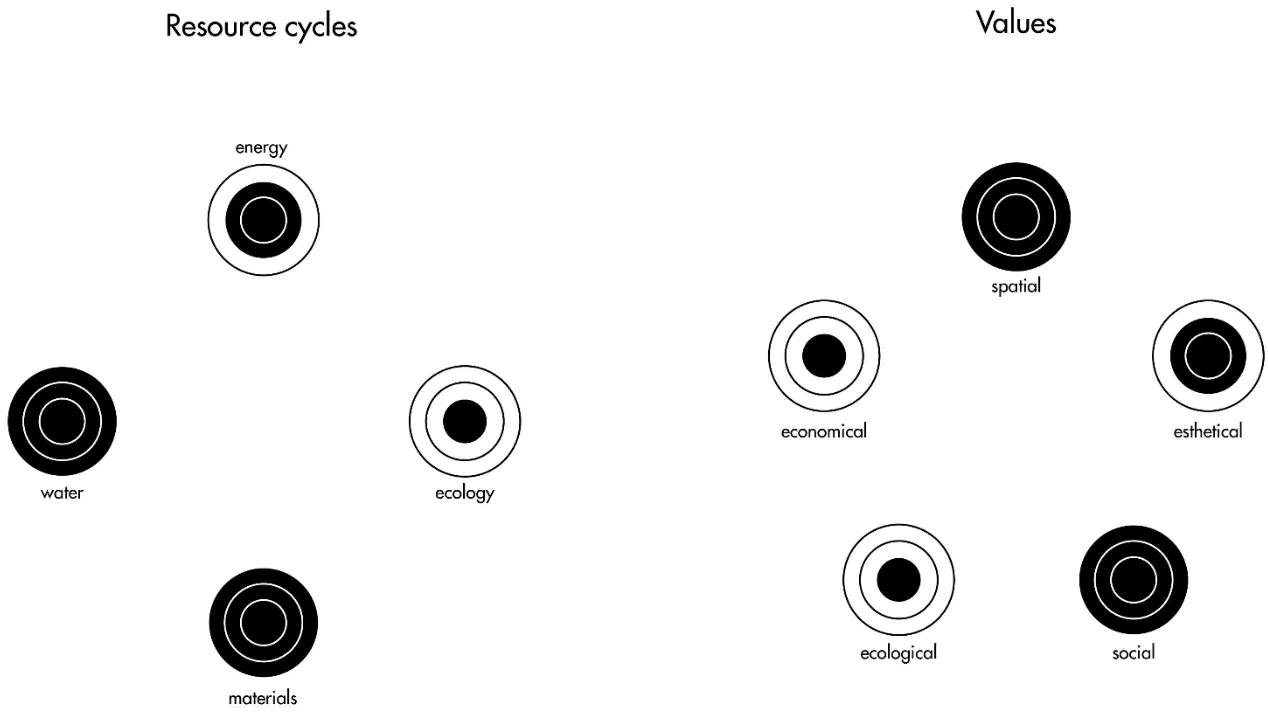


Figure 23 *Circular Flower Value map of the design for Goedewerf*

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