Building resilience

design strategies in planning for a densified Gelderland

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GRADUATION THESIS

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ABSTRACT

With the ongoing impact of climate change on inhabitation patterns in the Netherlands, the region of Gelderland will play a crucial role in accommodating a growing population while facing ecological and socio-economic pressures. Proper planning and design practices that prioritize long-term resilience are necessary to prevent the loss of opportunities and qualities in Gelderland. This design project aims to offer an alternative pathway for the future by identifying opportunities outside of the highly vulnerable Randstad region and envisioning potential developments in safer areas. Through the study of urban form across different scales, time frames, and scenarios, the project combines the concepts of resilience and densification, benefiting both Gelderland and the Netherlands as a whole.

The project centres around the shared framework of space in response to the uncertainties that we are faced with. Though these uncertainties impact various processes and elements within complex systems, the spatial conditions of a location play a crucial role in determining the functioning of the systems that are embedded within it. Recognizing the significance of (the alteration of) space offers an opportunity to address processes on different layers and promote resilience in a holistic manner.

By categorizing areas based on potentials and vulnerabilities, and employing different scenarios, the research identifies suitable locations for densification and develops strategies for improving connectivity, efficiency, modularity, redundancy, and diversity in urban environments. The multiscalar approach involves diverse and phased developments to answer to the pressure on space. By designing with higher densities with resilience as a starting point, urban environments can benefit from the transformation and the negative effects of climate change and densification can be mitigated.

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ULEES+CO
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01 INTRODUCTION

1.1 PROBLEM DEFINITION

Climate change

Climate change is forming an increasingly pressing problem to the condition of our planet and its habitats and its consequences have already begun showing in a multitude of ways and environments (United Nations, 2015). It is thus becoming evermore evident that it will have a changing effect on the way humans inhabit the planet. Whether it is due to droughts and rising temperatures, floods caused by the rising sea level, storms and extreme weather or other difficulties, it is clear that a changing climate inherently means changing living conditions. There are multiple ways to respond to this crisis and in some cases, adaptation might be possible and logical. In other instances, however, the change will be so extreme that adaptation on location will be beyond human capabilities or simply unwise. In those cases, relocation might be the only (sensible) option.

Migration to the Netherlands

To be able to prepare for the possible consequences of a changing climate, predictions have been made of where and how many people might move to other areas. In a study conducted by researchers from various countries and institutions, the predictions about the number of displaced people by 2070, based on multiple demographic and climate scenarios, range from 1.06 billion people in the most 'optimistic' scenario to 3.64 billion people being displaced in case of a population growth of 3.88 billion people and a mean projected global temperature rise of about 3.2 degrees Celsius (Xu et al., 2020).The latter would mean that about a third of the world population would have to migrate to more suitable areas for living. In 2020, the percentage of international migrants was estimated at only 3.6% (McAuliffe & Triandafyllidou, 2021). With the difficulties that many countries, including the Netherlands, already have regarding immigration, we can only begin to imagine what a tenfold increase of the number of global migrants would mean. The research on the future of the human climate niche (Xu et al., 2020) displays the Netherlands as a location where the suitability of living remains enough to sustain human life and therefore, in most cases, a likely area for relocation (Figure 1.1). Therefore, it would be wise to take a trend of increasing immigration into account when planning and designing for the future of the Netherlands.

Migration within the Netherlands

Naturally, the effects of climate change will not stop at our borders; something we experience more and more. The flooding in parts of the Netherlands, Germany and Belgium during the summer of 2021, but also the periods of drought in three consecutive years, starting in 2018, showed us that 'extreme' weather, as caused by climate change, is not something of the far future. With a large part of the Netherlands already being below sea level, the issue of sea level rise will add another risk to our way of living. The estimations divert substantially: the sea level could rise as mildly with 30 centimetres or as much as 2 meters by 2100 (KNMI, 2021). Despite there being uncertainty about climate change, as with any aspect of the future, the question seems to no longer be if the sea will take back parts of the land, but only when. Accompanied by problems such as subsidence and salinisation, the question which locations will remain suitable for living becomes more relevant. Locations that will become unfavourable to live in due to water management issues and subsidence will take up increasingly more space up to 2100 and the percentage of dwellings situated in those areas was already 8,3 percent in 2021 (Kuiper & Spoon, 2022). Unfortunately, the provinces with the highest densities are also the ones facing more risks (Figure 1.2). It is therefore plausible that part of those inhabitants will have to or want to move to other parts of the country, such as Gelderland.

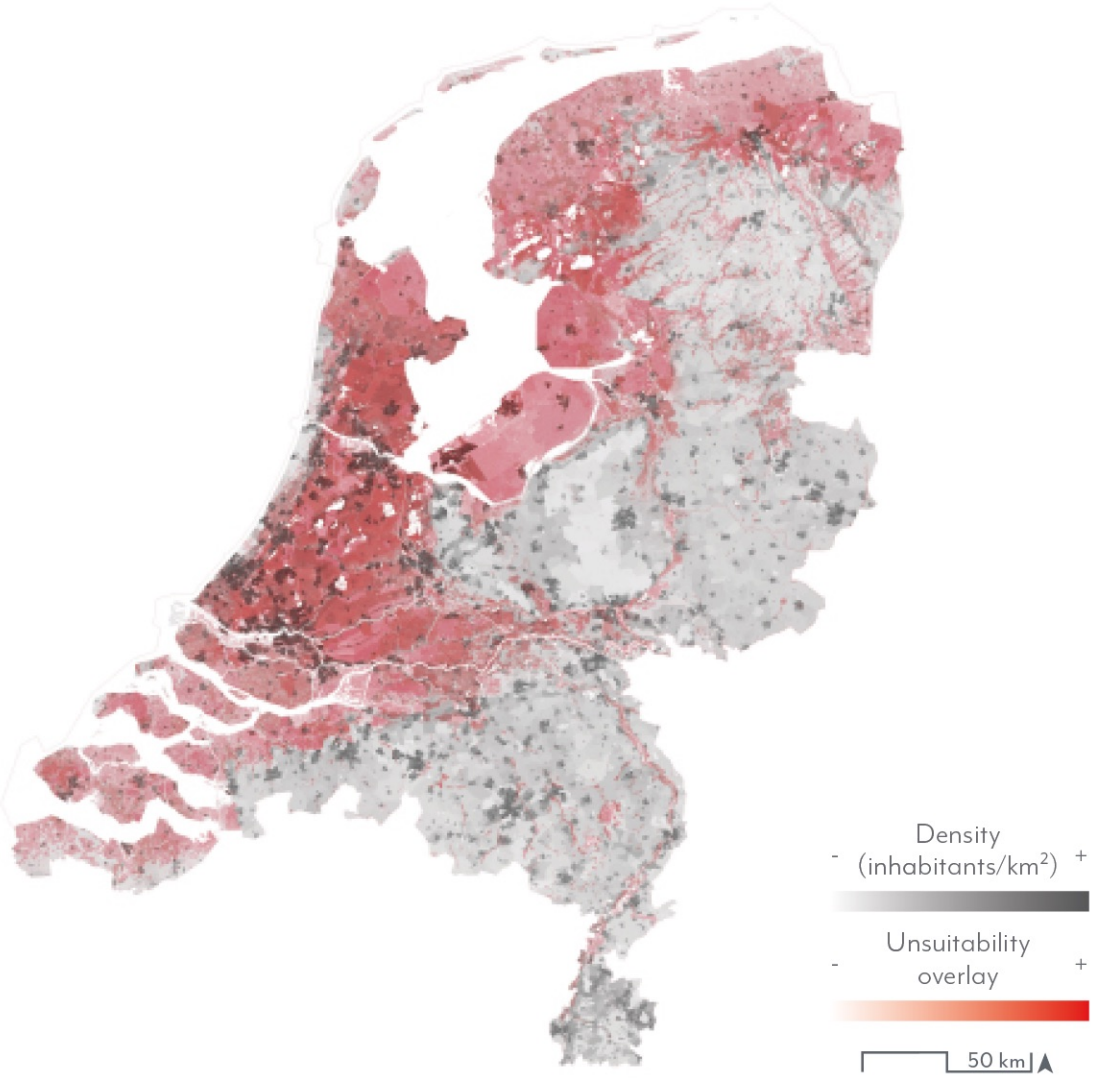

Figure 1.2.Population distribution superimposed by risks and unsuitability. Data from Centraal Bureau voor de Statistiek, 2021; Klimaateffectatlas, n.d.

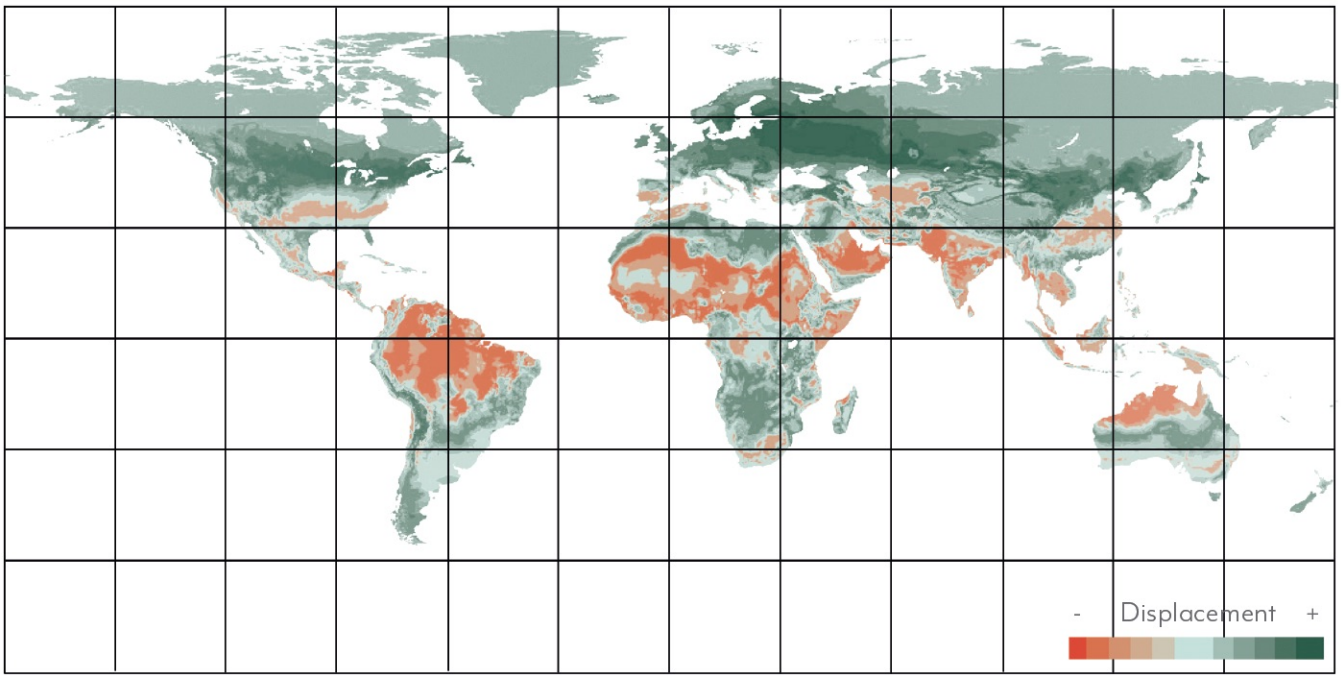

Figure 1.1.Possible global displacement of people by 2070. Adapted by author from Xu et al., 2020.

I.2 IDENTIFYING UNCERTAINTIES

To be better able to respond to future change, it helps to identify and line out the different uncertainties that cities will have to deal with. The different kinds of uncertainties can be categorized into three types: uncertain developments, enforced uncertainties and exposure to uncertainties (Roggema, 2016). Uncertain developments are characterized as phenomena that are so complex in itself that their trajectories are uncertain. An example of this is climate change, the other uncertain developments are elaborated on and described as the drivers of change. Enforced uncertainties are those that are brought about by development towards specific goals, as described under trends and transitions. Exposure to uncertainties is not focused on the origin of uncertainty, but the fact that more and more elements or people will be exposed to it, as discussed in the problem field.

I.2.1 DRIVERS OF CHANGE

Demographic changes

The continually increasing amount of people that will migrate due to climate change, will cause changes in demographic changes in most countries, as in many cases, it will not be feasible for people to stay close to home. How these changes will take form in the demographic composition of countries is difficult to predict, however, because of multiple aspects. Firstly, the different scenarios have heavily ranging results. Because the time frames lie very far into the future, there is an increasing the level of uncertainty. Lastly, other factors, such as political and socio-economic circumstances, also play a role in to which countries people migrate to.

However, even without taking the displacement of people caused directly by climate change into account, the prognosis is that the Dutch population will grow and that it will become more diverse. According to research carried out by CBS, by 2070, our population will likely have grown to 20.4 million people, of which 42 percent will have a migration background (Stoeldraijer et al., 2020). In 2020, that number was 25 percent.

Increased pressure on space

It is obvious that the expected population growth and a decreasing amount of inhabitable land pose serious consequences for the field of urbanism. As the housing crisis is already a very pressing problem today, one could wonder whether this will not remain a crisis that we have to deal with the coming decade, but if this eventually will become our problem of the century (along with many others). The present lack of available housing is partly due both to the qualities of the supply not meeting the demands of the users, as well as the fact that the Dutch use a substantially bigger amount of living space in both comparison to neighbouring countries (College van Rijksadviseurs, 2022) as well as when compared to the usage of space a century ago (Berghauser Pont & Haupt, 2021). The deficit of the current housing supply might therefore not be due to so much a lack of space, but rather an inappropriate use of it. If we want to formulate durable solutions to the continually increasing pressure on space, it is clear that these should be sought in new ways of planning and designing.

Changes in occupation of the land

The displacement of people within the Netherlands will provide both opportunities as well as challenges as the occupation of the land changes. Those areas that will see a decrease or even complete absence in population, might be used for other purposes, such as water reserves, natural environments, energy production, etc. The remaining land will then become more densely inhabited, which could cause shifts in density distribution, network, centrality, and so on. The way the Netherlands operates as a system will change and whether this has a positive or negative impact is also depending on whether we plan in room for this to happen or whether it is something that happens *to* us.

1.2.2 TRENDS AND TRANSITIONS

Naturally, climate change and migration are not the only uncertainties that we should consider when thinking about and designing for the future of the Netherlands. With the continuation of technology becoming ever more advanced, we can only imagine what the coming century holds for us. There is a variety of trends and transitions, however, that we can already identify. As some seem particularly important in current policy documents and in the field already, it is wise to also take them into account in this project. Those illustrated in the study De Lage Landen 2020-2100 (Architecture Workroom Brussels et al., 2018) seem to be the ones that will have largest impact in spatial terms, which is why the project takes these as the themes which should be included (Figure 1.3).

Renewable energy

An important condition for a sustainable society, is renewable energy. It is evident that this has spatial implications, we can see this already by looking at the landscape. But aside from wind turbines and solar panels in the fields, it also has or should have spatial implications in terms of where and how cities are built. To make efficient use of the energy system, it is important for the users to be located close to the source. This also means that more densely built neighbourhoods are more energy efficient. The energy transition could also be a catalyst for urban development, as the largest gain is to be found in neighbourhoods that are now least sustainable. One principle applicable but not limited to the energy transition, is that areas should be used for exactly those purposes, that they are most suitable for. Some locations are more convenient to produce wind energy, others might be better used for solar energy. This also translates into a multi-scalar approach. Not every region might be able to arrive at an energy balance of zero, so it is vital for regions to work together in an effective and solidary manner.

A circular economy

The transition towards renewable energy naturally has consequences for the economy in many ways, one being that the diminishing use of fossil-fuels, together with a decrease in trade activity, will come with opportunities to reprogram our ports and industrial zones. Our cities have become places of consumption without production. This is problematic in many ways, but the solution should not be sought in an easy fix. If we want to become more sustainable and make the transition to a circular economy, we must ensure that processes can be monitored from start to finish and move towards a ‘think-and produce-economy’. The new productive city provides more jobs for people from all socio-economic backgrounds and could create a new-found sense of pride in making. This symbiosis between thinkers and makers could also bridge existing social contradictions, as people understand and support each other more. A reintroduction of the manufacturing industry should also come with a reinterpretation or renewed design of the decentralised system. Underutilized water networks and industrial sites, but also the introduction of newer concepts such as ‘fablabs’, small, local manufacturing centres and an increase of collective property are likely to play essential roles in this transition.

Healthy agriculture and farming

As 54 percent of the available land was used for agriculture in 2015 (CBS, 2020), any changes in this sector will have a large impact on the overall use of land. As the technology for the efficient and organic cultivation of foods continues to improve and receive more attention, there are opportunities for a revision of the use of space. An important aspect of this new way of agriculture is that it often is not 'ground-bound', which means it does not exhaust the soil and that it could also be located in areas with less fertile soil. Again, the principle of using the land for its most suitable function is apt.

Durable agriculture should, however, also entail finding synergies between agriculture and the preservation of nature. Complementary agriculture means that it is no longer merely about the production of foods, but also about the maintenance of ecosystems and landscapes. An existing and successful example of this is agro-forestry. In shaping these new landscapes, it is important to remember that industrial agriculture and monocultures form barriers and ecological islands just as much as large-scale infrastructure and urban areas, as they are almost ecological deserts. Therefore, multi-scalar diversification is important for biodiversity and agricultural activity.

A shift in the agricultural sector should not only be felt in peripheral areas, as healthy farming is also about diminishing the literal and metaphorical distance between the production and consumption of goods. Urban farming lends itself as a perfect tool for enhancing social cohesion, improving our relationship with food and dealing with ecological issues within cities such as biodiversity and urban heat island effect. What a shift in this sector also needs is a new and more extensive logistic system, including more local distribution points. Foodhubs and market places could become the new public places within cities, providing more jobs and places for encounter.

Shared mobility

As congestion and air pollution are ever-increasing problems for the Netherlands, changes in our infrastructural system are needed if we want to become more efficient and sustainable. The technological advancements to change our ways of moving are essentially already there, as autonomous vehicles and shared mobility systems are already being implemented. What is yet still missing to activate the transition has more to do with the societal and governmental side of it, as it is a social choice, too. It is therefore important that in making plans for the future, we create designs in which these advancements are embedded. It is expected that the core elements of our future shared mobility system contain new service stations and more integrated infrastructure that focuses at creating a complementary instead of a parallel system. This would have to be embedded into urban forms that are more organised via a polycentric city model that is more densely inhabited. The service stations are then connected to the energy grid and become charging points, intermodal transfer stations and places for social interaction. A gradual shift towards more automated mobility could make our infrastructural network more efficient, also in spatial terms, meaning there would be more room for other functions than transport.

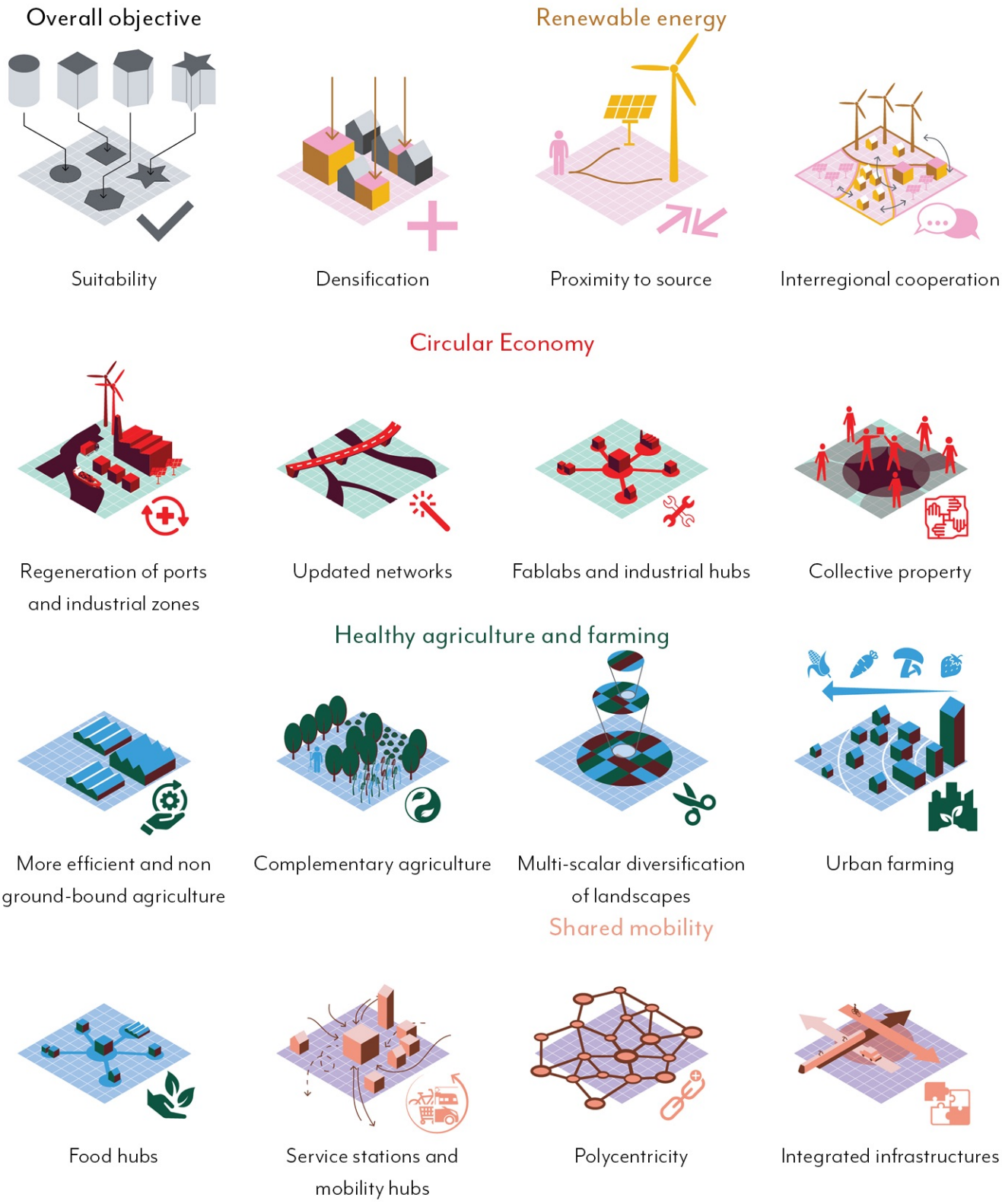

Figure 1.3. Spatial implications of foreseen trends and transitions as mentioned in de Lage Landen 2020-2100 (Architecture Workroom Brussels et al., 2018)

1.3 WHY GELDERLAND?

Bridging gaps

Even though the majority of policy documents and designs take sustainability as one of their core values, it seems that often, the widely accepted notion of sustainability does not shine through in the totality of the plans. If we see sustainability "as meeting the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations Brundtland Commission, 1987), looking no further than 20 or 30 years into the future can hardly be seen as sufficient. Nonetheless, governmental documents often take 2050 or even earlier as their point on the horizon and pay little attention to what would come after (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2020; Ministerie van Binnenlandse Zaken en Koninkrijksrelaties & Volkshuisvesting en Ruimtelijke Ordening, 2022a, 2022b). This is not to say that there are no plans or designs established that focus on a longer time frame. What many of these projects have in common, however, is that they picture the landscape of the Netherlands and the way it is inhabited distinctly different from the current situation (Baptist et al., 2019; Deltares et al., 2021; Doodeman, 2022; H+N+S Landschapsarchitecten et al., 2022). Most treat sea level rise as the inescapable problem that it is, accepting that our current way of living meters below sea level is not maintainable in the long run. To aid in paving the way for more research and design that takes multiple generations into account, this project is focused on Gelderland: a location which will remain more suitable for inhabitation for at least the life span of buildings in the possible developments.

Besides time, there are also gaps to be found in research and design regarding the scale of the subject. When a larger time frame is considered, it is often more focused on the national or very local scale. Regional policy is often-times not made spatial or is represented in a diagrammatic map or drawing, even though regional regulations have very spatial effects. In order to be able to translate the needs of the (far) future to the necessary changes of today, we need to use the power of imagination on all scale levels.

Focusing on the province of Gelderland is therefore a way of helping to bridge the temporal and scalar gaps in current research and design practices.

An existing framework

Another reason for why Gelderland has great potential, is the established internal and external connections. The already extensive road, rail and water-networks make it a logical location for urban expansion and densification. The province is already important for north-south connections within the Netherlands, but it is also the link to Germany and further eastern neighbours. Focusing on Gelderland could therefore be an opportunity to strengthen the ties between different regions.

The landscape

As the Rhine enters the country in Gelderland, the way in which it flows in the landscape there has consequences for the rest of the Netherlands. The delta landscape is one of the most influential features for the organisation of our country, making Gelderland an important region for the exploration of possible future development. What makes the province especially interesting, however, is the diversity of the landscape. It consists of rivers, polders, heather, dunes, forests, meadows, croplands and so on. The long history of inhabitation has continually developed to present day, leaving it built by cities, castles, farms and villages of diverse sizes, shapes and characters. Its richness makes Gelderland not only an interesting case study, but also ensures better transferability of the solutions found in the project.

1.4 KEY CONCEPTS

Resilience

Though there are clear indicators of the ways in which our world could change during the coming century, precisely predicting the future remains impossible. To be able to deal with these uncertainties, the concept of resilience is a way of understanding how our systems can be prepared for change. If the resilience of our society and cities is increased, the chances of them remaining operational after a shock, disturbance or any form of change are increased too, even if we cannot yet predict exactly what this change will look like.

As the previously mentioned uncertainties that the Netherlands will have to deal with influence many different processes, this project focuses on the framework that they share, which is space. The spatial conditions of a location dictate the way in which systems can operate within it, so even while there are many other factors controlling their activities, socio-economic and ecological systems could be made more resilient in a holistic manner if we focus on creating a supporting spatial environment (Barthel et al., 2013).

Morphology

As there are many different spatial elements that make up the environment in which systems operate, it is important to distinguish in which elements the relationship between resilient socio-economic and ecological systems and the spatial conditions is sought. The project attempts to paint a picture of possible trajectories of urban environments, using the power of design to visualise what yet seems unimaginable. Following the words of Christopher Alexander:

> 'the ultimate object of design is form' (1964)

the focus lies on the analysis and design of form and therefore on morphology, defined as the study of form. In most cases, densification implicitly means an alteration of urban form, which makes morphology a logical field for exploration.

Though the study of form can only happen as the documentation of the environment at one or multiple points in time, at best as a diachronic analysis, urban form is all but static. Urban morphology is not merely about analysing physical characteristics, but also about understanding what the catalysts for change were that made them repeatedly transform in order to serve the needs of its inhabitants in a better way (Karl Kropf, 2018 as mentioned in Romice et al., 2020). Urban form is not something that exists in solitude, but in relation to rules and regulations (Barthel et al., 2013), as well as to ecosystems and (human) life. The relationship between living beings and their environment was described in the article 'Of Other Spaces' as:

> "The space in which we live, which draws us out of ourselves, in which the erosion of our lives, our time and our history occurs ... is ... a set of relations that delineates sites which are irreducible to one another and absolutely not superimposable on one another" (Foucault, 1984).

By studying form, we can reveal a multitude of informational layers, because cities as they are today are also a product of time, society and other spatial features, such as geographic conditions. Urban form therefore plays a key role in both informing the analysis of options for densification as well as being altered by it. By incorporating the line of work called space syntax, we can analyse the relationships between urban form and patterns of activity (Hillier, 2007).

1.5 RELEVANCE

Densification

As the issue of an increased pressure on space indicates, it is important we use the available space carefully and efficiently. Therefore, densification is seen as an indispensable strategy for further urban developments by both designers as well as policymakers in the Netherlands. Densification is not merely the most sensible remaining strategy due to the lack of space, however, but also offers great opportunities in improving existing urban areas. New developments can be catalysts for attracting new businesses, improving infrastructural networks, increasing sustainability, enhancing liveability and so on (College van Rijksadviseurs, 2022). We should therefore treat it not only as a solution for shortages in the housing stock, but as a possible tool for the improvement of urban environments.

Scientific relevance

The research project aims at further development of the existing research on resilience theory within the field of urbanism, because while the foundations for resilience theory have been laid some time ago, applying it within the context of urban development is relatively new and unexplored territory. There are examples which use resilience as a basis for design, but these are often limited to the urban scale. By also incorporating it in regional design, new knowledge might be uncovered. The research also aims at adding to the relatively small body of literature that does not just look at either ecological, social or economic resilience, but seeks holistic solutions by approaching it through the framework that they share. This integral approach and nuanced view on the layer model might shine light on new opportunities in regional and urban design. The practical approach, taking Gelderland as a case study, could then be especially valuable, as this region has not been used as a location for examining and attempting to increase resilience through design. Apart from the theoretical framework and finding synergies between resilience, morphology and densification, the study of Gelderland itself could be a beneficial asset in the revaluation of regions outside of the Randstad. The body of literature on (historical) urban development in Gelderland is rather limited, or so specialised that it falls short in giving a complete overview. This research also aims at providing a better understanding of Gelderland and its characteristics and qualities, so that further research and/or design may be easier carried out.

1.6 ETHICAL CONSIDERATIONS

Societal relevance

Increasing the understanding of and resilience to what we will have to face in the future, can mean the difference between an overwhelmed, unprepared and exhausted society or an innovative and optimistic one. The struggle of turning the numbing fear of the consequences of climate change into a hope that things can change can be helped by showing how they could change. Getting more people on board of the transitions towards a more sustainable future is very difficult without giving them some evidence or examples with which this hope can be encouraged. If people have no hope for the future, it is unlikely for them to go out of their way to try to change it for the better.

With inclusivity and the interests of future generations of inhabitants being at the core of this research, it deals with the question of (in)justice in many ways. The aim is to show the possibility of a more just society, so it is also important to take the current inhabitants and nature into account. In planning and designing for the future, it is only logical that in some instances, we will have to make sacrifices today to be able to build a secure future. It is important, however, that both the compromises as well as the gains are balanced between all groups and stakeholders. In order to avoid some groups paying the price for others to benefit, an analysis of stakeholders and their needs, resources and power should be included in the assessment of the proposals, alongside other criteria, such as urban and environmental qualities, quantities (amount of people) and resilience.

The notion of risk also always comes with ethical questions, as it difficult to objectively decide at which point a certain risk is acceptable. The people or elements exposed to the risk have different vulnerabilities and capital, so the costs of a disastrous event would never be borne in an equal or just way. By taking a larger timeframe and trying to respond to risks over the long term, however, the hope is that risk will be averted in a tempered and manageable pace before it is too late. By basing the decision for where to densify on scientific research and by making insightful which risks are accepted and which are not, the research attempts to make risks better averted and visible.

Even though densification is thought to aid in reaching sustainability goals in most cases (Berghauser Pont & Haupt, 2021; College van Rijksadviseurs, 2022; Salat & Bourdic, 2012; Sharifi, 2019), urban development and construction takes a heavy toll on the environment and is very costly. Therefore, the project should take into consideration that any proposed design would need to weigh against this and other negative side effects it causes. Therefore, nature-based solutions should, alongside the focus on resilience, be taken into account.


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02 METHODS

2.1 PROBLEM STATEMENT

As climate change will continue to impact inhabitation patterns in the Netherlands, it is logical that we will become more and more dependent on areas that are less exposed to its consequences. Gelderland is one of the regions which inevitably will have to house more people, but at the same time, its ecological and socio-economic qualities will be under pressure. Without planning ahead properly and in a way that suits Gelderland, opportunities could be missed and qualities lost.

2.2 AIM

The proposed design project is aimed at offering a possible alternative pathway into the future, in which planning, design and construction practices are focused on more long-term resilience. By highlighting opportunities outside of the Randstad and in areas that are less prone to flood risk, and by sketching an image of how developments could take place there, possibilities of a brighter future come to surface. The aim of this project is to develop a strategy and a design that works in favour of both Gelderland as well as the Netherlands as a whole, in which resilience is increased and the region is densified. This is done by studying urban form on multiple scale levels and through different time frames and scenarios.

2.3 RESEARCH APPROACH

As the largest knowledge gap seems to be in the actualisation of policies or research results focused on sustainability and resilience into multi-scalar design, that is where the focus of the project will lie. All three of the design research categories as defined by Frankel and Racine will be incorporated in order to create a multi-facetted understanding of the challenge and to provide an extensive answer to it (2010) (Figure 2.1). Research about design, or basic research, is continually, but in a gradually reduced amount, used to develop the design problem alongside with the solution. This way, knowledge that will appear in a later stage of the process, but that is however inherently important, can still find its way into the organisation and structure of the project. To be able to find the common ground between the different goals and theories, research through design, or applied research, is used. It also ensures that (part of) the results of the project will be transferable to other locations or situations. Applied research can aid in creating synergies between different fields, that can then be tested in clinical research, or research for design. As this project aims at proposing a strategy and design specifically for Gelderland, research for design is used to actualise the assembled knowledge for the test location. Clinical research can therefore also be seen as contextualised research.

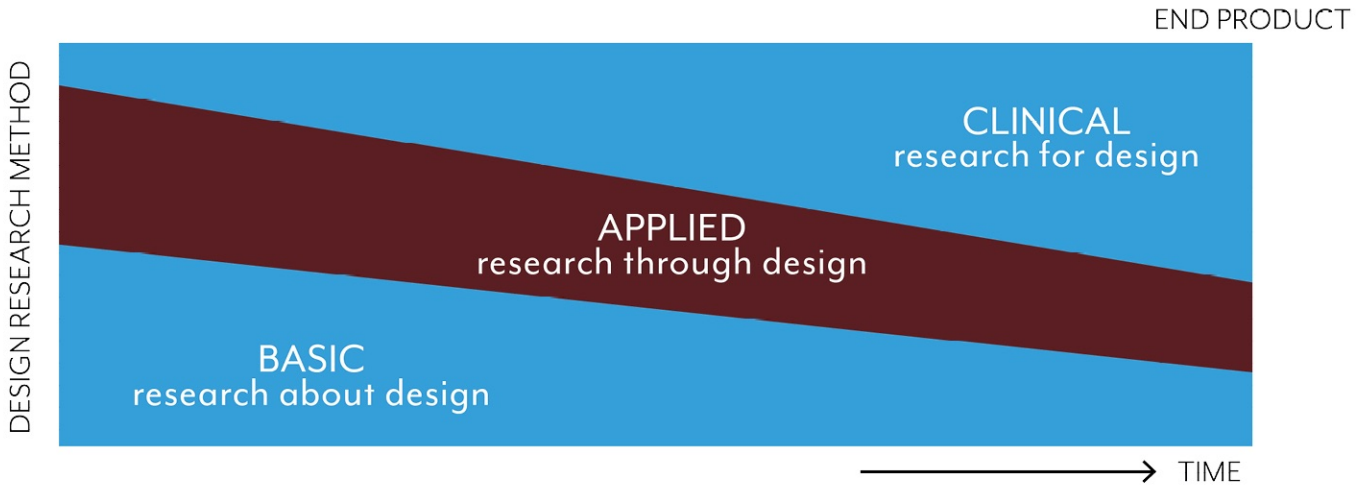
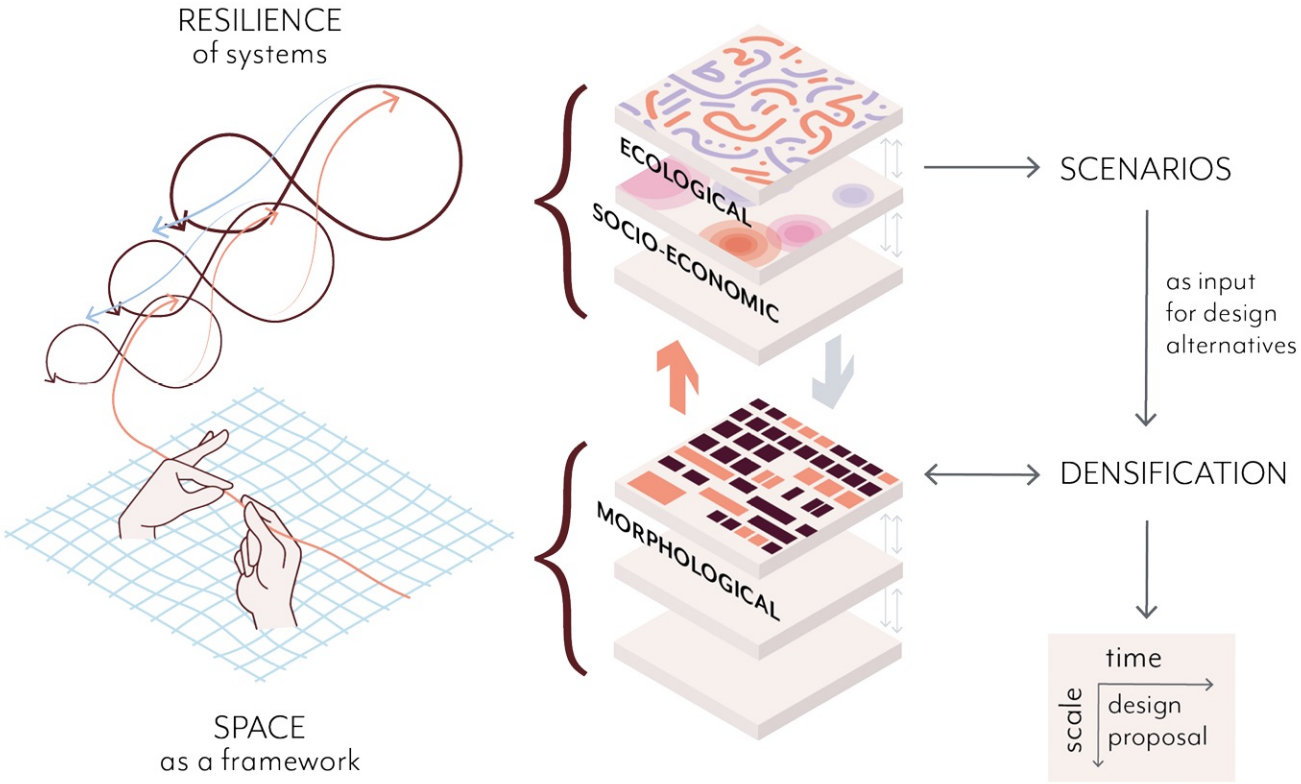


Figure 2.1. Chosen project approach following the categories as mentioned by Frankel and Racine (2010).

2.4 CONCEPTUAL FRAMEWORK

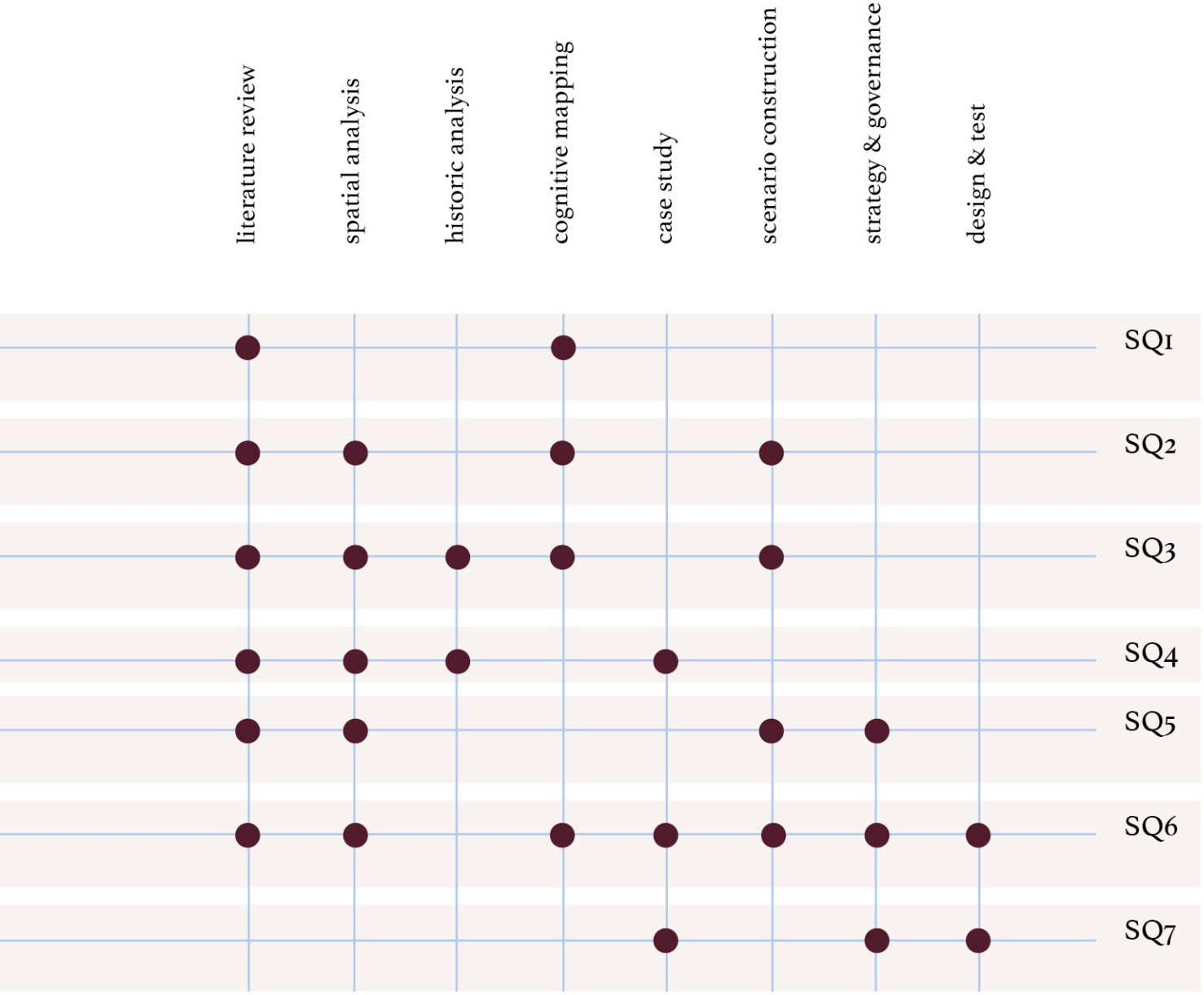
The aim of the project involves a strategy and design to increase the resilience of the socio-economic and ecological systems in Gelderland, accomplishment of this is sought in the alteration of the shared framework in which these systems are embedded. Alterations of the spatial condition need a certain (economic) impulse, as spatial and/or urban development is costly. Densification is needed to answer to the future pressure on space and expected housing demand, but as it alters urban environments, it could also be used as a tool for increasing resilience of urban form and the systems that rely on it. Because the ways in which socio-economic and ecological systems will evolve are uncertain, different scenarios that offer variations of potential urban development are used. The possible trajectories into the future are analysed and designed on different scales of space and time, resulting in a collection of proposals.



2.5 RESEARCH DESIGN

RQ: Which morphological transformations and multi-scalar densification strategies can be employed to increase resilience and answer to the future pressure on space in Gelderland?

PROJECT FOUNDATIONS	SQ1	How are resilience, morphology and densification connected and how can this interrelationship be used as input for design?
	SQ2	Which scenarios should be considered to be able to answer to the possible pressure on space?
	SQ3	What is the current relationship between the use of space and societal conditions and how could societal transitions lead to a change in the pressure on space?
CONTEXT	SQ4	What is the historical, governmental and spatial context of the project?
THE MEANING OF DENSIFICATION	SQ5	What could be the different meanings of densification depending on the different contextual conditions?
DESIGNING WITH DENSITY	SQ6	Which multi-scalar densification strategies and morphological transformations can increase resilience in Gelderland?
	SQ7	Which strategies and transformations could be employed to answer to the future pressure on space?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spatial analysis
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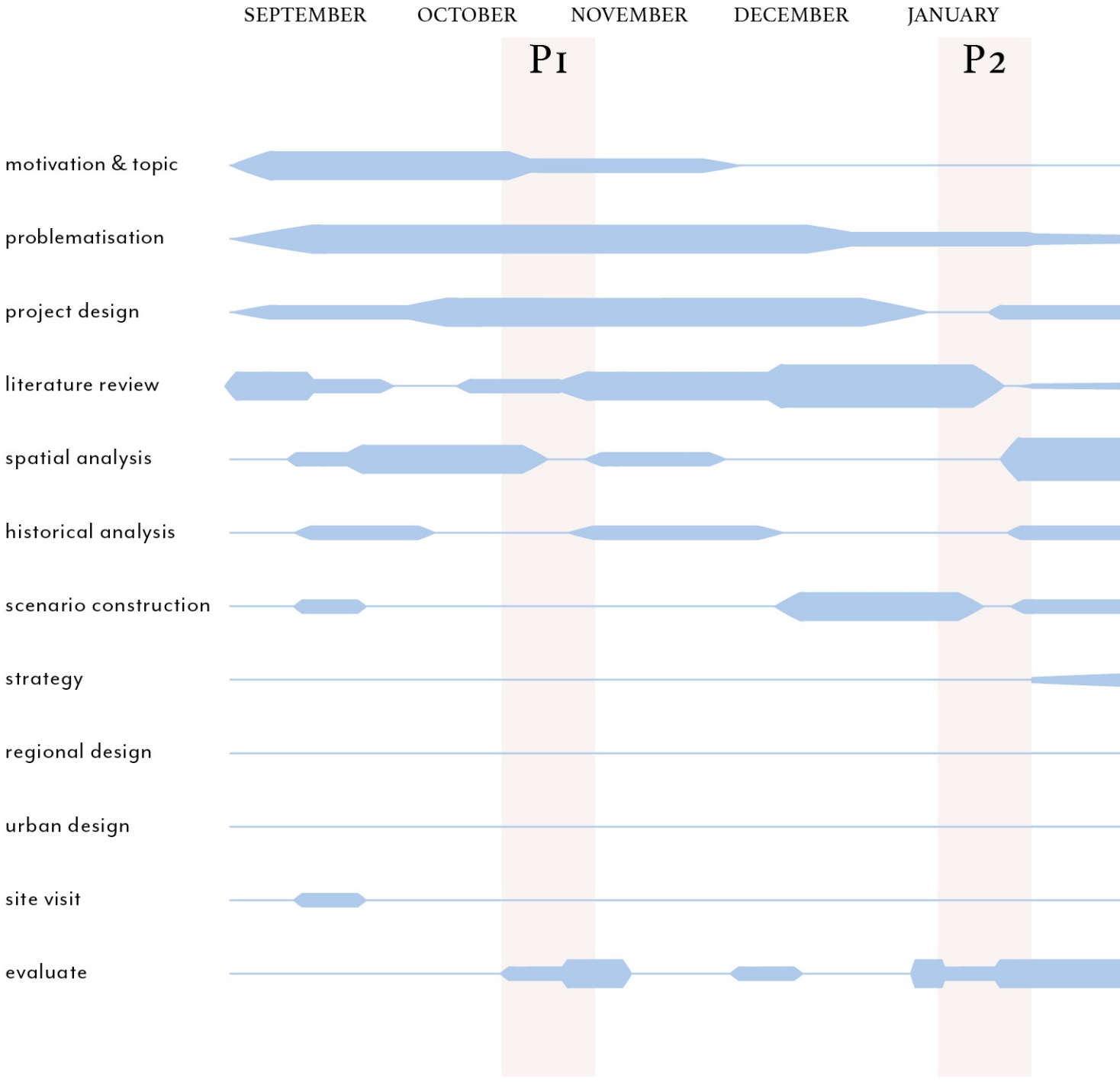
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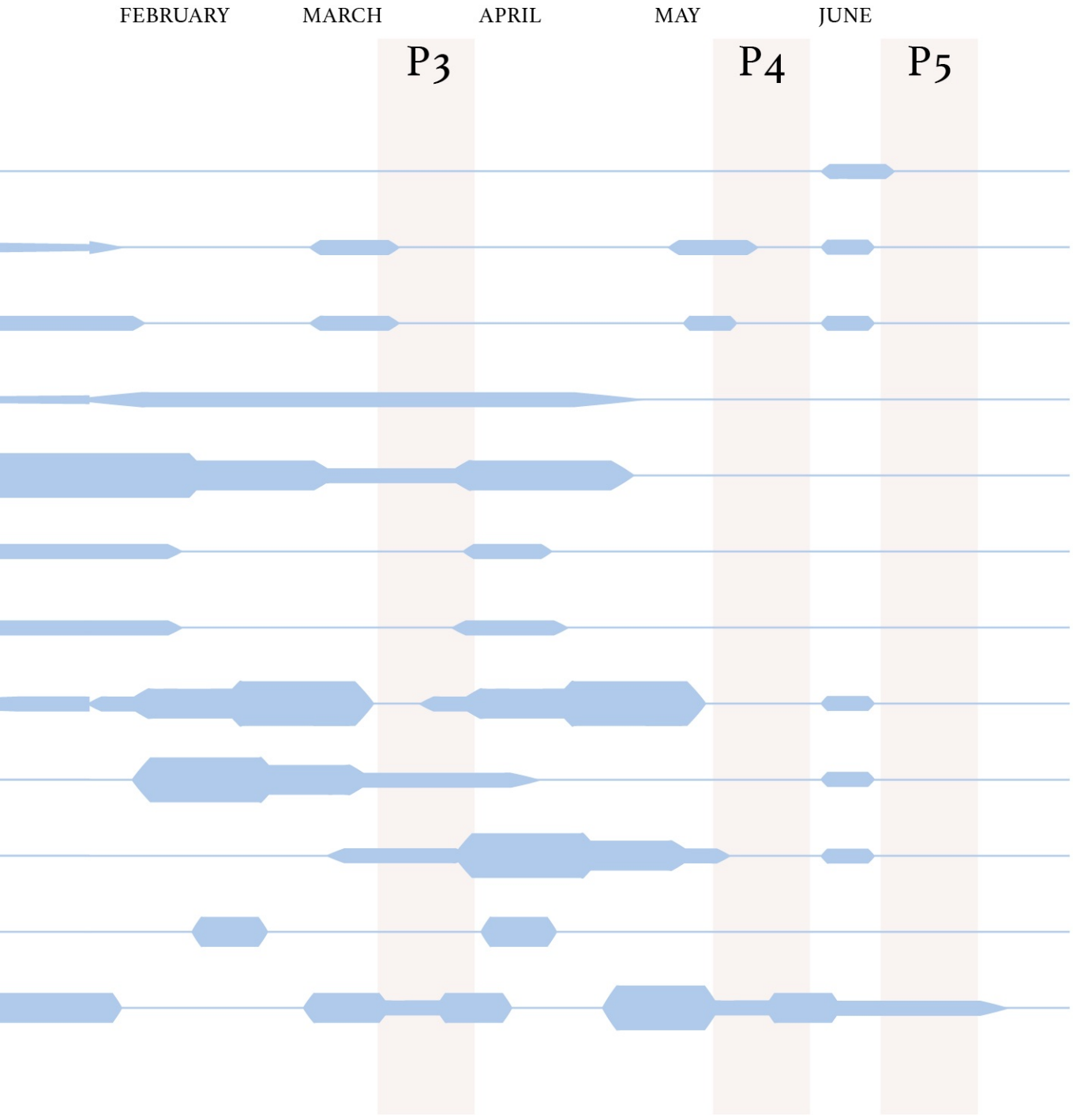
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2.6 METHODOLOGY

Literature review

To position the project within the broader context of existing knowledge, an overview and analysis of relevant findings, theories and gaps in literature is given. It provides the base of knowledge on which the remainder of the research can be built. The project seeks value in finding synergies or overlap between theories and applying them in a specific context.

Spatial analysis

To understand the geographic distribution of phenomena and variables and the relationships and patterns that exist between them, spatial analysis is used. This is carried out predominantly with the use of Geographic Information Systems (GIS) and with a multi-scalar approach. The most commonly used scales are identified as national, regional, municipal, urban, neighbourhood, district, fabric, island, lot and building (Figure 2.2).

Historical analysis

This method is used to understand past events, trends and patterns that have shaped the present and inform the future. In order to make sense of urban areas that exist in Gelderland today and their physical, social and cultural characteristics, it is crucial to recognise the processes that were that formed the basis for it. This is done by archival research and the analysis of historical maps, photographs and written documents.

Cognitive mapping

Cognitive mapping is applied for the explanation of different concepts and lines of thought through visualisation. It is also helpful as a first step in the process of translating theorical or abstract concepts into the spatial dimension, or vice versa: presenting spatial conditions or processes in a diagrammatic way, to reveal an understanding of its systematic or metabolic properties.

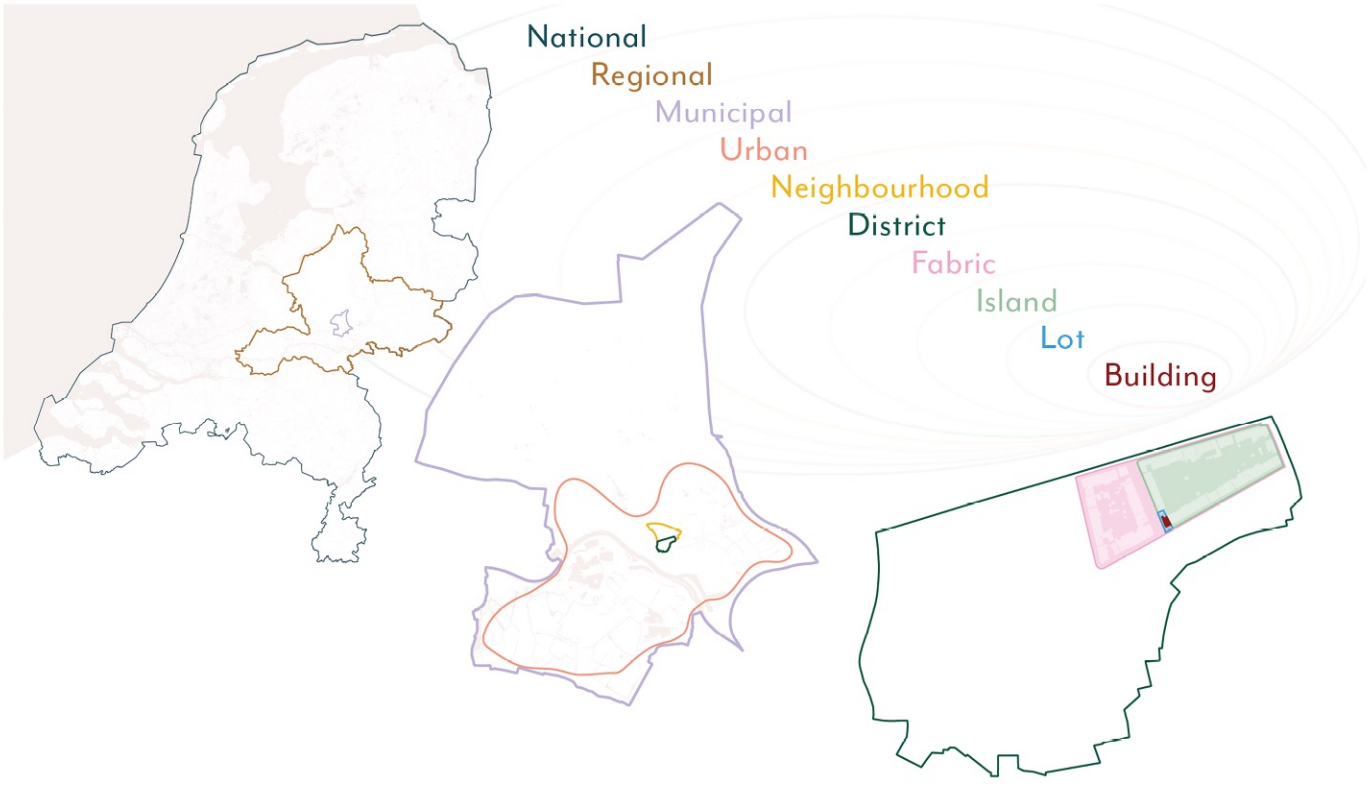


Figure 2.2.Representation of the levels in the multi-scalar approach with the example of a test location in Arnhem

Case study

Though the location of the research is very central in the project, Gelderland is still used as a case study to analyse and test processes and design options in practice. The multi-scalar approach allows for the method of using case studies to be able to compare between locations, to see if and how application of theory has different outcomes in different locations and circumstances. It is also used to test how desirable design and strategy alternatives may be in the various proposed scenarios.

Scenario construction

The construction and exploration of different scenarios is a method to deal with uncertainties and potential future states of a system. Scenario construction allows for the exploration of a wide range of possibilities, providing a more comprehensive understanding of the potential impacts of different design and planning decisions. It can be used as a tool for strategic urban planning, helping to identify potential challenges and opportunities for future urban development. The focus is hereby not necessarily on predicting a plausible future, but on drawing up an image of a possible one (C. M. Salewski et al., 2010). By imagining multiple variants of the future, we can also uncover similarities between them, parallels that reveal opportunities or threats that prevail no matter what the trajectory is.

One of the attributes of complex systems and therefore also of cities, is that they are seen as something of which it is almost impossible to determine all the elements of which they exist (Batty & Marshall, 2012). Our understanding of them will always remain incomplete, which makes it very difficult to make predictions of how they will evolve over time and prevents us from defining any optimal states. This does not mean, however, that we should not intervene, as planning and design can still aid in preparing for problems that we can see coming. It only means that this should be done in a conscious manner, accepting that unexpected change is inevitable (Batty & Marshall, 2012). This is where scenario-making can be of help, as it allows us to construct multiple images of a future, based on some specified trends or drivers of change. The scenario does not predict the future, but it shows us what the implications would be if some crucial conditions were to change. In elaborating on desirable outcomes and strategies within each scenario, but also by looking at how we would arrive in such a situation, threats and opportunities can be uncovered. In a way, constructing scenarios is a perfect tool for using design for what it can help us do best: envisioning futures.

Strategy & governance

Though the research is mostly focused on the spatial conditions that dictate the functioning of systems, strategy and governance are important tools in providing a complete proposal. The research and design of strategic and regulatory interventions can provide insight into the decision-making processes, policies and regulations that shape the urban environment, as well as the distribution of power and resources of different actors. This method is used to evaluate the effectiveness of existing governance structures, and to identify potential opportunities for improving decision-making and fostering more inclusive and sustainable urban development.

Design & test

Designing and subsequently testing the design are important methods to bring the project to a more practical or pragmatic level. It allows for evaluation of the effectiveness and usability of solutions in a specific urban environment. When designing and testing is employed as an iterative process and is combined with the other methods described, it can be the basis of innovative and unexpected solutions.

03 PROJECT FOUNDATIONS

3.1 THEORETICAL BACKGROUND

Resilience

There are many different definitions of resilience, but for resilience of urban systems, the notion of panarchy is imperative. More traditional definitions of resilience, such as in physics, describe it as the ability to bounce back to a former state after a change or shock, whereas panarchy focuses on how a system remains the capacity to function after such an impact (Gunderson & Holling, 2002). Panarchy starts to describe a form of resilience that is better able to describe and aim for resilience of urban environments, because change is a necessity in the survival of them. Returning to an original state is most often undesirable, as societies or socio-economic systems hardly ever do so too. For cities to support the needs of its inhabitants, development is crucial. For complex systems such as cities, development is neither simple nor at once and bouncing backward or forward are neither an accurate description of how change is instigated. Therefore, evolutionary resilience is better suited here, as it encapsulates the flexible and unpredictable character of change, acknowledging that the system can evolve through both internal and external factors (Romice et al., 2020). As summarised by Romice et al. in Masterplanning for change, the definition of evolutionary resilience is twofold:

> 'The ability of complex socio-ecological systems to change, adapt, and, crucially, transform in response to stresses and strains.' (Davoudi et al., 2012)

> 'Evolutionary resilience broadens the description of resilience ... to incorporate the dynamic interplay between persistence, adaptability and transformability across multiple scales and timeframes.' (Davoudi et al., 2013).

This view on resilience could be seen as closely linked to antifragility, as described by Taleb (2012, as cited in Cañizares et al., 2021). A system is regarded to be antifragile if it benefits from change or disturbance, as it uses it as fuel for improvement. Taleb describes antifragility as something distinctly different from resilience, as his definition of it disregards the notion of panarchy. When the adaptive cycle is taken into account, however, antifragility seems to be just the superlative of resilience, or it might even relate more to the process of 'bouncing forward', which makes it an inappropriate concept for characterising urban systems.

Figure 3.1 represents an interpretation of the integration of different concepts and theories related to resilience. The four possible responses of systems to change are perceived as innovation, adaptation, resistance and breakdown. Fragile systems are unable to remain operational after a disturbance, because they have a breakdown in the process. Regardless of the alternative outcome, this project aims most importantly at the prevention of fragility. The remaining three facilitate a continuation of activity or existence, though in different forms. Robustness is a characteristic that can be very valuable, buildings or infrastructural networks should, for example, be robust to be able to remain usable in

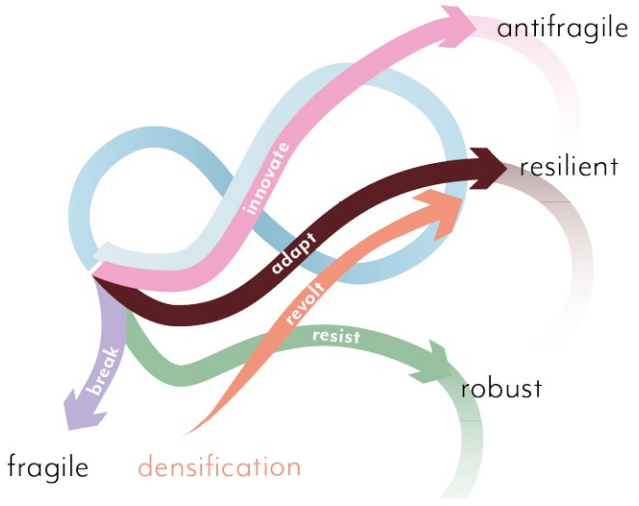


Figure 3.1. An integrated representation of approaches to resilience

case of extreme weather events. Robustness seems most apt when change comes in the form of an individual shock or disturbance, as it is sufficient to remain stable, without changing the way in which the system works. When change does not manifest as a singular event, however, the inability to adapt or innovate will eventually most probably result in breakdown, as the circumstances have changed too much for resistance to preserve the system. That is why, in response to the continuous and irreversible process of climate change (and its consequences), adaptation and innovation are crucial. Though innovation in some sectors is essential in the coming decades, e.g., the energy transition and building technology, it is not what the ambitions for this project are focused on. Besides (evolutionary) resilience being a more appropriate concept to apply to complex systems, antifragility is also less desirable because it implies a complete renewal of a system. It is not the aim to redefine or redesign the elements which make up (urban) morphology, but mainly to use existing knowledge in such a way that the spatial framework becomes more adaptive. The strategy and design should respectfully consider the existing conditions and qualities of Gelderland and avoid treating it as a 'tabula rasa'.

Noteworthy is how the concept of panarchy relates to historical urban development. The idea is that with every cycle, after a disruption has led an urban system to revolt, the city automatically becomes more efficient and resilient (Romice et al., 2020). Normally, the more historical layers a city has, the greater are its diversity, modularity and efficiency. These environments have stood the test of time and have therefore proven their adaptive capacities. This is exactly why densification could work as a tool for improving resilience (alongside liveability), as it is an opportunity to add another temporal layer onto existing urban areas. Densification could be the revolt the spatial framework needs in order to improve its adaptive capacities.

Morphology

The project focuses on morphology as the spatial component within which design can aid in increasing the resilience of the systems that are embedded within space. As previously mentioned, (urban) form is not the only element which influences this, however, as has also been made clear through the numerous takes on the layer model. The Dutch layers approach has been a central element in planning practices in the Netherlands since 1998, but not without critique (van Schaick & Klaasen, 2011). The model organises three different layers, the substratum, networks and the occupation pattern, all with their own time scales, design and planning tasks and approaches. These layers are meant to be held together by the element of coherence, which in some later representations of the original approach seems lost. Some propose that the Dutch layer approach only works well if the occupation and network layers both correspond to the substratum, such as the document 'Op Waterbasis', on the basis of water (Deltares et al., 2021). Other layer models have a different focus, such as the network approach as developed by Dupuy (Dupuy, 2008). In his model, three layers of networks, and their interrelations, are described: production networks, consumption networks and personal networks. Though this model seems focused more on the systematic functioning of different layers rather than their physical configuration, they are closely linked and can be described using three criteria: the topological criterion, the kinetic criterion and the adaptive criterion (Caso (1999) and Rooij (2005) as described in Wandl et al., 2017). It is also proposed that Dupuy's model could be expanded to include layers and elements that fit within the aim of a specific project, such as governance and green infrastructure (Wandl et al., 2017). As a main driver of this project is the need for densification, the focus will be on built urban form. The layer approach is used to remember that and how built urban form stands in relation to other concrete physical

conditions, but also how it influences and is influenced by systems and networks, such as the ones described by Dupuy. A difference in approach is the clearer divide between physical and systematic layers (Figure 3.2). The project does not stop, however, at proposing an alteration of the urban form up to the point that the expected housing demand is met, it should be designed and then assessed in such a way that the built form is in logical correspondence with the limitations and opportunities that the other physical layers offer, while providing the different layers of systems with opportunities to become more resilient. The focus on morphology is therefore not a dismissal of the aforementioned methods of the use of the layer approach, nor does it disregard the importance of a metabolic approach in planning for resilient regions, it is merely more focused on some elements of the model to make the use of it more tangible and appropriate for the scope of this project.

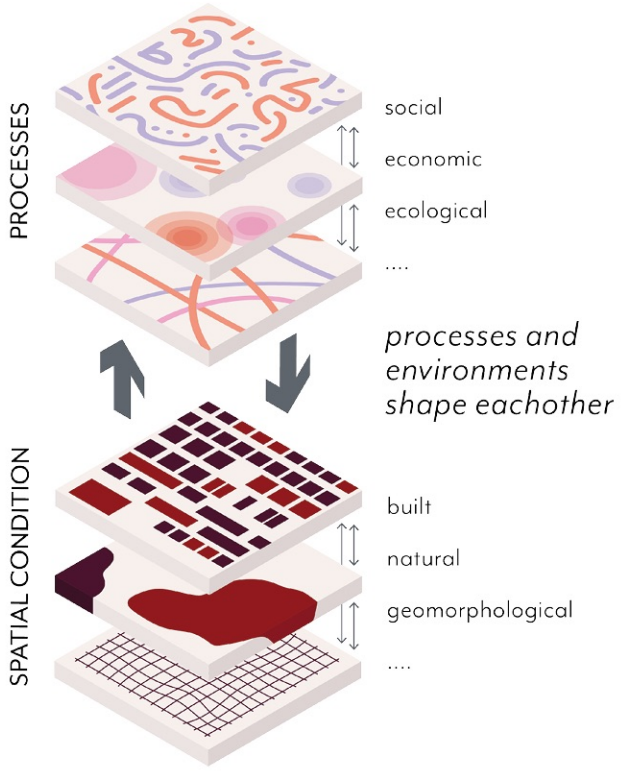


Figure 3.2. Space as a shared framework

Densification

Density is not an absolute concept, as it can describe attributes of almost any physical measurable element. To measure, compare and design with densities in a consistent manner, the project applies the components of physical density as described in Space Matrix consists of (Berghauser Pont & Haupt, 2021), namely: population and dwelling density, land use intensity, coverage, building height and spaciousness. The use of multiple components simultaneously while working with densities is essential for developing a complete understanding of the selected urban fabric. As is shown in Space Matrix, built form can be very different and still have the same amount of relative floor space, ground space, open space or number of levels. Therefore, a multivariable approach is helpful when densities are used to describe form.

To be able to correctly compare between locations, a clear understanding of scale levels is also required, because density differs per scale level. For this project, the ones proposed by Berghauser Pont and Haupt will be used. The characteristics of density on the different scale levels is most visibly indicated by Tare (T), which is also often distinguished by net and gross base land area. Other characteristics can also be measured and calculated as indicated in Figure 3.3.

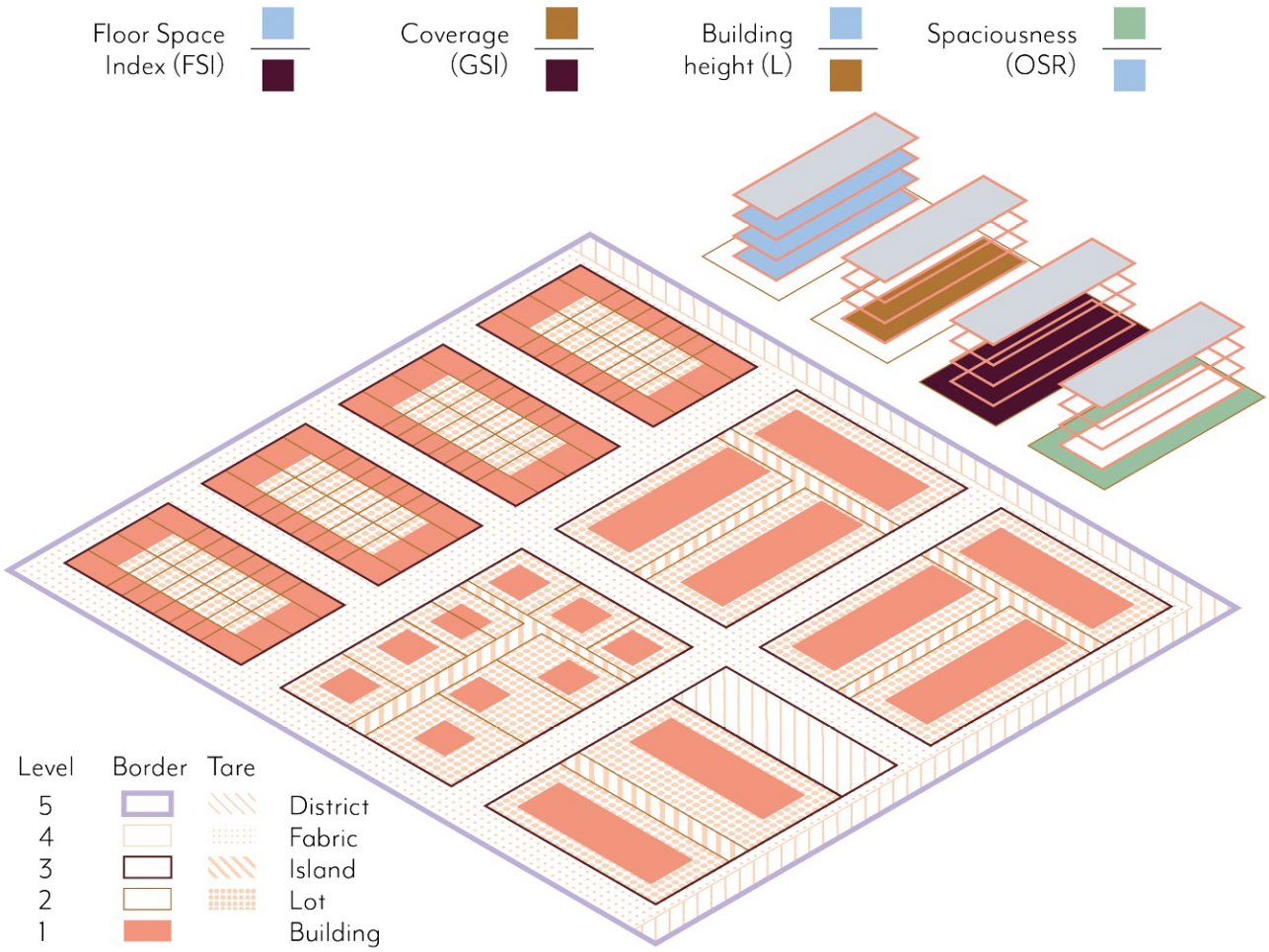


Figure 3.3. Representation of the components of density and accompanying calculations as described by Berghauser Pont & Haupt, 2021

3.2 DESIGN PILLARS

Resilience and Urbanism

How resilience theory could be applied within the field of urbanism has been explored from different starting points. Because theory of panarchy originates from ecological studies, some start from analysing the parallels between ecosystems and urban systems. The centuries-long development of the separation between humans and nature has now become an obstacle in obtaining goals regarding sustainability, so focusing on resilience could be what we need in order to close this gap (Barthel et al., 2013). As described earlier, both cities and ecosystems are complex systems which have a common framework that constitutes them, physical space. This can be divided in the a-biotic spatial structure (non-living) and the biotic dimension, the living elements (Romice et al., 2020), . Their systemic qualities inherently mean that they consist of elements that both evolve at different paces and are of different scales. Without establishing the connection with panarchy theory, Christian Salewski described that the temporal characteristics of urban structures should be taken into account, as some are more static than others and that aggregates of selected elements can also be more static or diverse than the individual parts of which they consist (2014).

General resilience

There is no established consensus of all the characteristics that make a system resilient, but there are five core concepts to be found that play an important role in increasing resilience in multiple disciplines, which are diversity, connectivity, redundancy, modularity and efficiency (Feliciotti et al., 2016; Masnavi et al., 2019). What should not be forgotten, is that these elements may have different effects on different scale levels, as is also indicated by the multiple studies done by Ayyoob Sharifi (2019a, 2019b, 2019c). Further explanation of the five attributes and examples of their meaning in spatial terms are given in the book Masterplanning for Change: designing the resilient city (Romice et al., 2020). These five attributes can form a basis for planning and designing more resilient cities, as they are transferable across locations. Therefore, they can be categorised under general resilience, one of the two levels of resilience. The distinction between general resilience and specific resilience is made in whether it is clear what exactly a system should be resilient towards (Masnavi et al., 2019). While specific resilience plays an important role in being able to respond to enforced uncertainties and partly to uncertain developments, or any type of specified disturbance, general resilience is crucial to ensure that the resilience of the system as a whole is safeguarded from yet unknown shocks.

Specific resilience

To increase specific resilience of a system and identify potential vulnerabilities or links within or between systems, it can be helpful to formulate answers to four questions about resilience: 'resilience (in the context) of what? Resilience to what? Resilience for what? And resilience at what stage?' (Sharifi, 2019b). This can also aid in revealing the essential drivers within a system, as was proposed by Holling (2001, as described in Lang, 2011). One mechanism often standing in the way of resilience is that of path dependency and the related concept of lock-ins, because path dependencies can make systems maladaptive (Lang, 2011; Röhring & Gailing, 2011). Path dependencies are established through developments in which certain actions generate a recurrent process of positive results, making it more and more logical to carry on in a similar line of action. Because of the resources that are invested, the system at a certain point becomes dependent on this way of functioning, which diminishes the opportunities for alternatives to be implemented, even if the system becomes less satisfactory in fulfilling the needs (Röhring & Gailing, 2011). If the path dependency continues on the long-term and becomes deep-rooted in the larger system, the tools or methods used first

used to achieve a goal may ultimately become the goal themselves (Wilson, 2014).

Escaping the lock in by deviating from the original decision making processes is also described as de-locking (Röhring & Gailing, 2011). It is emphasised, however, that when de-locking from the path dependency, all the elements, other systems, scales and layers that relate to the specific system should be considered, too. Diverging from a continuous line of action and changing ingrained mechanisms may influence the functioning of elements that might seem distant from the original mechanism, as can be illustrated by the butterfly effect, first explained by Edward Lorenz (Wilson, 2014).

To avoid excessive (negative) consequences from de-locking, alteration of a path-dependency can also be sought on lower levels of the system, which improve the resilience of the system itself without changing too much about the essential ways in which it operates. An example of how this can be done is by building in 'natural breakpoints' into the system, to ensure that if a disturbance were to take place, it happens firstly in the breakpoint, where it is expected. These breakpoints can serve as a buffer, as they allow change to take place in such a way that the systems do not break down in their entirety. A project that incorporates this concept are the 'Room for the River' measures taken by the Dutch government. By reserving some areas or polders next to the rivers that are not inhabited, in case of high tide, extreme rainfall or flooding, these can work as buffer zones, into which the excess water can enter. This takes the pressure off the entire system, reducing the risks for surrounding areas. This concept can even be enhanced to become antifragile, as is done in the case of wisselpolders: the sediment that stays behind after a flood elevates the surface little by little, which makes it a natural way of flood protection and an alternative to building dikes.

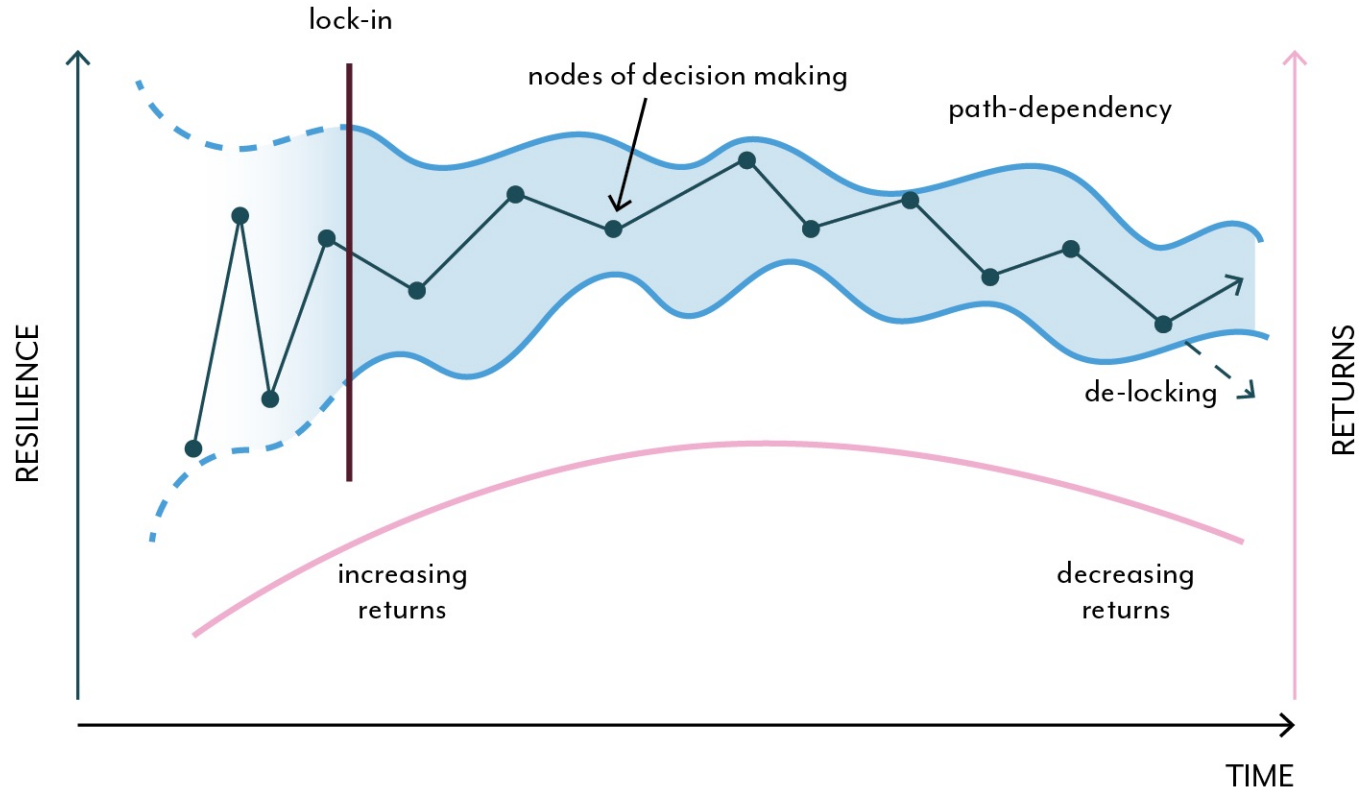


Figure 3.4. The mechanism of path dependency, based on Röhring & Gailing, 2011

3.3 SCENARIOS

For this project, two types of circumstances that are central to urban development are juxtaposed along two axes, which results in four quadrants, each representing a scenario. The first is the pressure on space, caused by climate change and changes in the size and distribution of populations, as explained under the drivers of change. The other variable is the socio-economic condition, which includes whether the focus and/or outcome means growth or de-growth (Figure 3.5). The further into the future, the more uncertain it becomes and the larger the differences between the scenarios (C. M. Salewski et al., 2010)(Figure 3.6).

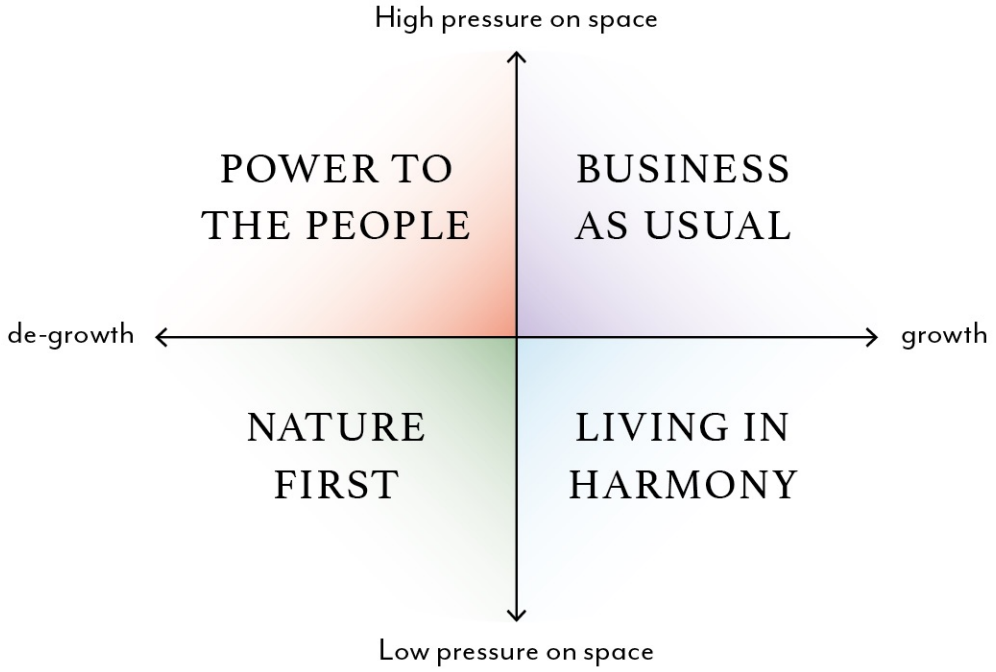


Figure 3.5. The scenarios used throughout the project

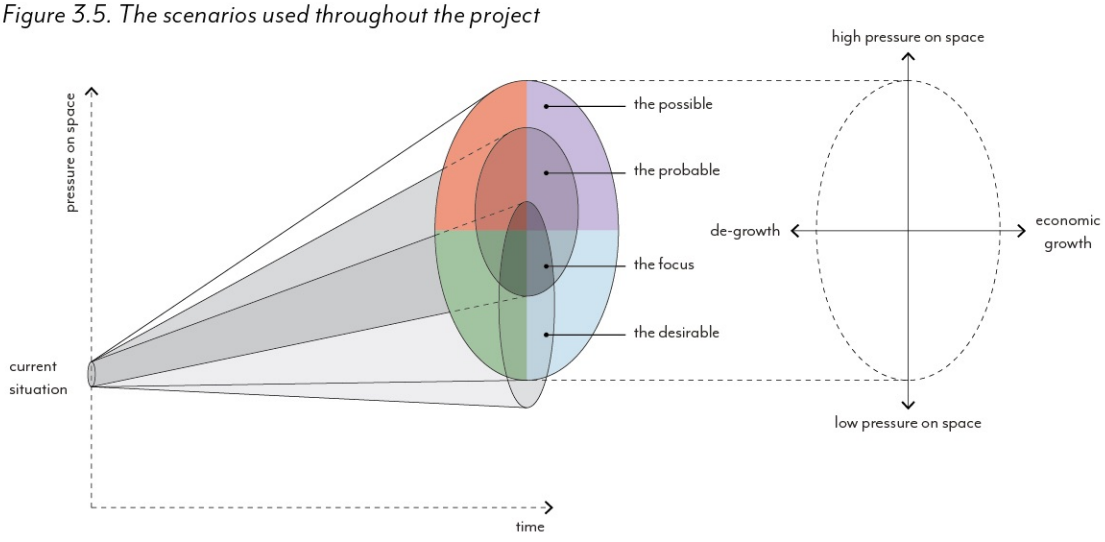


Figure 3.6. The cone of possibilities

In order to have an indication of the magnitude of the amount of people that will have or will want to move within the Netherlands, the maps show which areas are most vulnerable. Four different themes were selected, all related to flood risk and/or suitability for building. The upper maps display the neighbourhoods most affected and indicate how many people are currently living there (in millions).

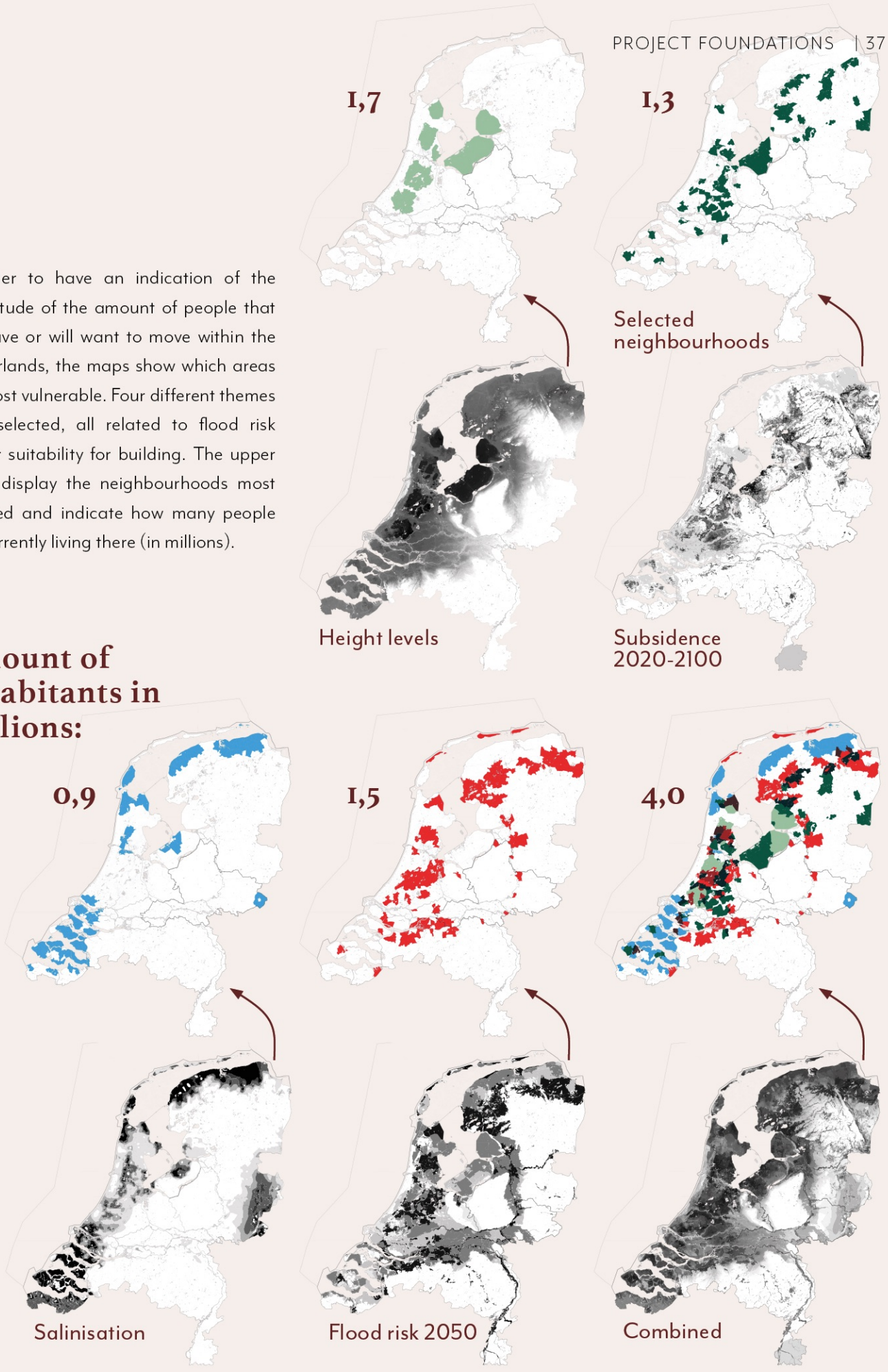
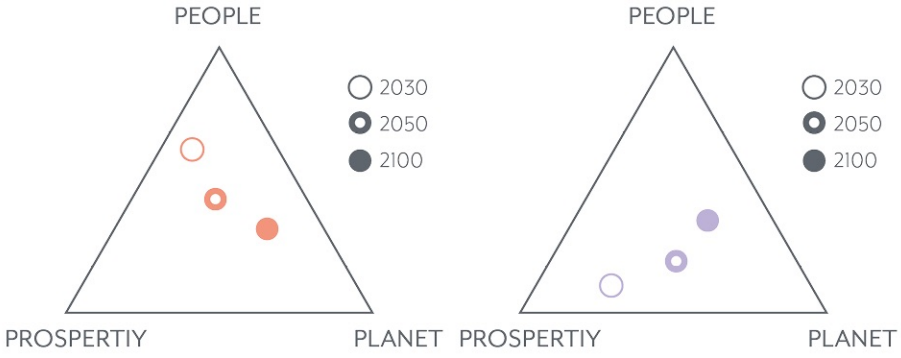
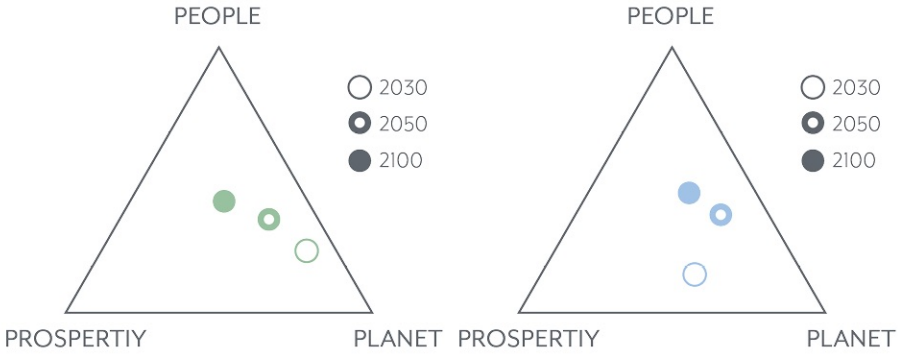


Figure 3.7. Analysis of the possible displacement of people in the Netherlands. Data from Actueel Hoogtebestand Nederland, n.d.; Centraal Bureau voor de Statistiek, 2021; Klimaateffectatlas, n.d.

Theme	Change	Power to the people	Business as usual
Pressure on space	Population growth	+ 3 million people	+ 3.5 million people
	Sea level rise	+ 1.75 meters	+ 2 meters
	Climate change mitigation	Slow, people and communities do not have the means to live more sustainably, but companies get somewhat restricted. Focusing on regional development to decrease transport. Medium energy demand and consumption level.	Slow, sought through technological advancements (electrification, hydrogen, nuclear energy) High energy demand and consumption level.
	Climate change adaptation	Local solutions, not the means to stop areas from flooding	Reinforcing dykes, using new and improved technology to handle flooding and drought, floating buildings
	Climate change	Fast	Fast
Society	'P' of sustainability	People	Prosperity
	Distribution of wealth	Medium wealth gap	Large wealth gap
	Lifestyle	People rely on themselves and their communities to deal with change, as circumstances force them to. Communities and regions adapt to climate change	People do not want to give up their current lifestyle, circumstances force them to change. Economic prosperity is used to adapt to climate change.
	Governmental involvement	Medium control, government serves people	Little control, government serves companies
Economy	Condition	Recession	Growth at first, recession later
	Work patterns	Companies spread out more, daily urban systems become smaller	Larger cities remain more important, daily urban systems become larger.
	Economic developments	Investing in social infrastructure & economy. Due to a smaller purchasing power, material use decreases, self sufficiency	Investing in economy & technology. Large companies dominate the economy, 'green growth'
Spatial	Network	Improving regional networks, improving existing public transport	Extending and improving networks within large cities and to the in between
	Pattern of urbanisation and densification	Micropolis, focus on smaller cities and regional development, sprawl	Megalopolis, extension of the Randstad towards the east, cities grow together, existing cities become very dense
	Character of urban development	Small scale, parcel-based, bottom-up, local focus	Multi-scalar, high quality, market-driven



Nature first	Living in harmony	Change	Theme
+ 1 million people	+ 1.5 million people	Population growth	Pressure on space
+ 0.5 meters	+ 0.75 meters	Sea level rise	
Fast, through rigid government control. Low energy demand and consumption level. Local and nature-based/ 'clean' production.	Relatively fast, through an integrated approach and cooperation between government and companies. Using digitalisation to decrease transport. Medium energy demand and consumption level.	Climate change mitigation	
Nature-inclusive developments, more room for nature, welcoming water in	Strategic freeing of land for nature and water, using technological developments for climate resilience	Climate change adaptation	
Slow	Relatively slow	Climate change	
Planet	Prosperity *for* Planet & People	'P' of sustainability	Society
Medium wealth gap	Small wealth gap	Distribution of wealth	
People live with more respect and care for nature and for eachother. 'Growth' is given a new definition, human activitiy / intervention is restricted.	People use their knowledge and energy for technological development to mitigate (or adapt to) climate change. The focus is on building with nature.	Lifestyle	
Much control, top-down, government bonds people and companies	Medium control, cooperative, government bonds people and companies	Governmental involvement	
Recession at first, growth later	Relatively stable	Condition	Economy
People live closer to work, daily urban system becomes smaller	Digitalisation plays a larger role, more people work from home or close to home	Work patterns	
Investing in nature & technology, degrowth, self sufficiency, complete change of agri-food and industry sector.	Investments in technology for the sake of nature and later for people. Smaller companies, start ups and sustainable companies dominate economy	Economic developments	
Improving public transport within and between cities	Improving existing networks, focus on shared mobility, electrification, improving electric and data networks	Network	Spatial
Ecopolis, existing cities are densified and interwoven with nature	Smart city, constrained to preserve nature but with densification spread more evenly	Pattern of urbanisation and densification	
Large scale planning, top-down, preference for small scale interventions, adaptation of existing structures	Large scale, innovative & cooperative	Character of urban development	



3.4 SOCIETY & SPACE

Over the past century, the allocation of space per individual has witnessed a significant growth (Berghauser Pont & Haupt, 2021). During a time when the country was still rebuilding cities after the war, the popularity and widespread use of the motorcar gave rise, technological advancements were accelerating and the family was still the cornerstone of society, it was quite logical that the country was soon built with homogenous housing with private gardens or in green, open spaces. However, as spatial constraints now intensify and the population diversifies, it becomes increasingly evident that this trend must be brought to a halt. Determining the extent and means by which to address this challenge presents a complex dilemma. Exploring the various scenarios can aid in imagining what other and new relationships between society and space could look like, as the different circumstances in the scenarios lead to and ask for different ways of living together and fundamentally, a different distribution of functions, people and buildings.

How much space is used per person can be calculated in different ways: by focusing on the land use (Figure 3.8) or by looking merely at floor space (Figure 3.9). There are many different ways of using a certain amount of space per person as guidelines or design rules, each with their own benefits and limitations. It is becoming a method that is used more, an example is the so-called 'barcode' the municipality of Utrecht developed for their new spatial strategy. This focuses not so much on the exact amount of space, but defines which and how many services should be present or added when realising 10.000 dwellings (Gemeente Utrecht, 2021). This also raises questions, however, as one could ask if the amount and size of services is not also dependent on the (population) density, and whether this amount per person changes or diminishes if cities become denser.

As a first exploration, the project focuses on the amount of (internal) floor space that might change under the different circumstances, as the amount of external floor space per person is more difficult to make rules for, as this is more irregular and dependent on specific landscape features of a location (Figure 3.8).

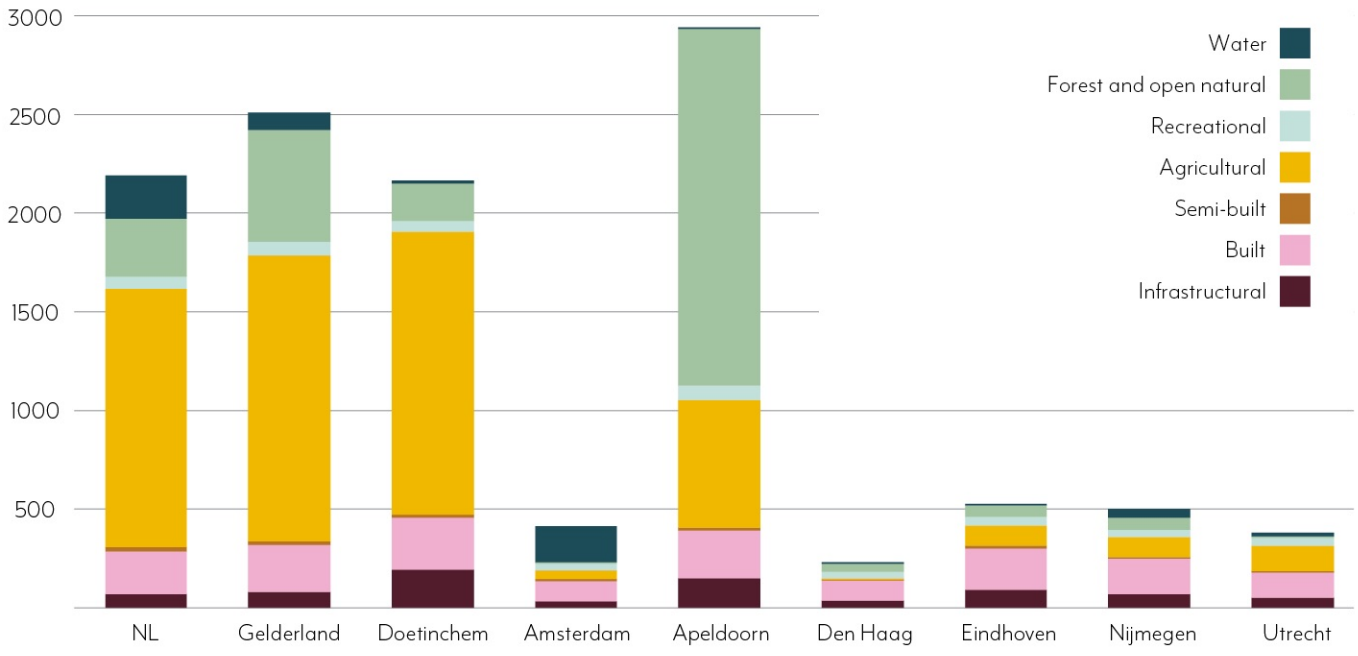


Figure 3.8. Square meters of a certain landuse per person, calculated per administrative boundary object. Data from Centraal bureau voor de statistiek (CBS), 2022

New amount of floor space per scenario:

Power to the people

Average dwelling size / person for new dwellings: 45 m^2

Added amount of floor space / person other uses: 50 m^2

New average footprint:

109 m2 per person

Business as usual

Average dwelling size / person for new dwellings: 55 m^2

Added amount of floor space / person other uses: 50 m^2

New average footprint:

113 m2 per person

Nature first

Average dwelling size / person for new dwellings: 40 m^2

Added amount of floor space / person other uses: 40 m^2

New average footprint:

112 m2 per person

Living in harmony

Average dwelling size / person for new dwellings: 45 m^2

Added amount of floor space / person other uses: 45 m^2

New average footprint:

112 m2 per person

Figure 3.9. Current average floor space per person in Gelderland, per function. Data from Planbureau voor de leefomgeving, 2022

04 CONTEXT

4.1 HISTORICAL

As can be seen from the palaeographic landscape (Figure 4.1), the province of Gelderland is host of many different kinds of landscapes: the moraine landscapes in combination with the river plains and marshes result in substantial height differences, which are atypical for the Dutch landscape. Though the administrative borders of the province have been the same for a long time, the distinct differences in the landscape make that the province can be divided in different historical geographic subregions (Figure 4.2). The diversity of the landscape do not only make it enjoyable to visit today, but are what have made it suitable for inhabitation for many centuries.

The higher grounds of the Veluwe were sparsely populated until the 19th century due to its poor soil and limited surface water availability. However, despite its scarcity, the region has been inhabited for a long time the Veluwe has a long history of human habitation, with archaeological finds dating back 300,000 years.
The IJsselvallei, on the other hand, is marked by a strong division of the landscape into higher and lower parts, reflecting its soil usage. It features scattered settlements on terpen (artificial mounds), castles, estates, and waterways parallel to the IJssel river. The IJsselvallei experienced regular flooding during high water levels, leading to the construction of farms on elevated spots known as a terp.

De Graafschap, also known as Achterhoek, is an ancient cultural landscape situated between the river area of the Oude IJssel and the IJssel, and the Eastern Dutch plateau in the east, near Winterswijk. The topography of the region has influenced the formation of large contiguous complexes of “es” fields in some areas, while in other places, the small-scale relief has led to the development of small encampments or single-person farms. The ownership of large estates has played a significant role in the landscape development of the region.

The regions in the south-western part of the province exhibit cultural-historical landmarks such as river dikes, breakthrough pools, watercourses, terpen, castles, linear villages, and remnants of the New Dutch Waterline.
As can be seen from the map displaying settlements and

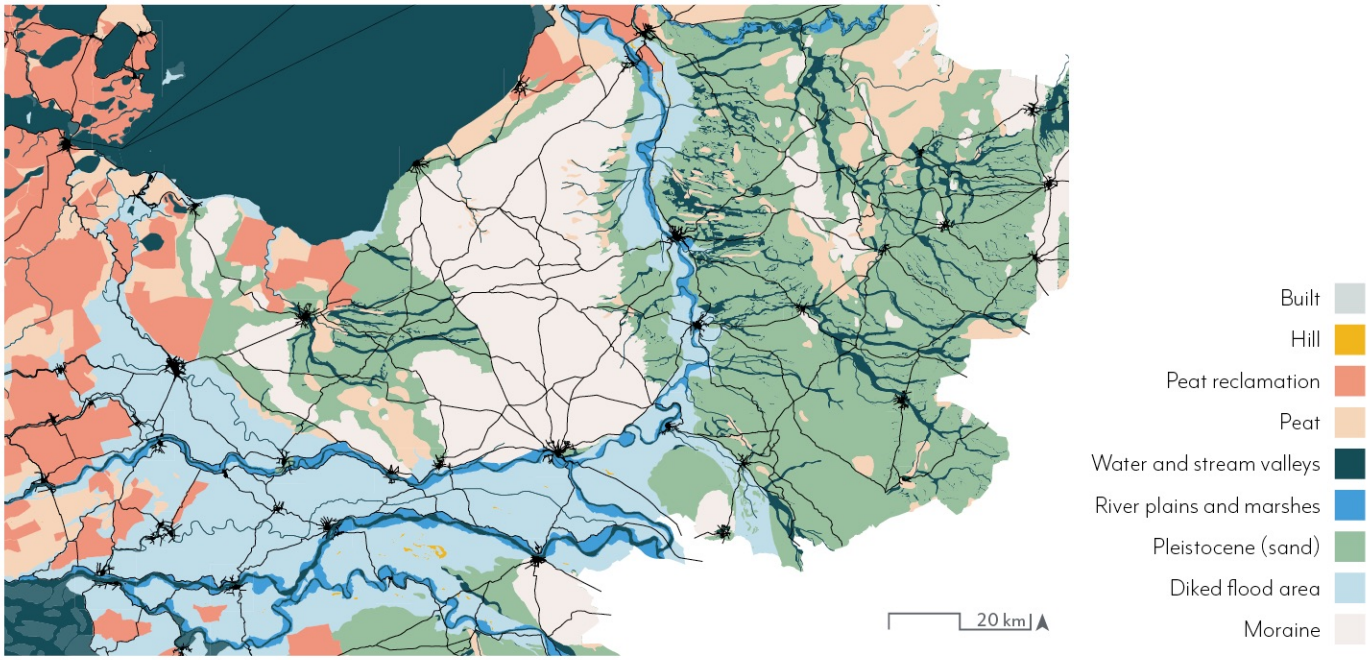


Figure 4.1. Palaeographic landscape, cities and networks in 1575 Nationaal Georegister, n.d.

networks in 1820 (Figure 4.3), many of the villages that exist today have existed for centuries before, with some even dating back to roman times, like Arnhem. By taking a closer look at the different types of villages, however, we can see that the way in which or the reason why they were founded differs quite a lot (Figure 4.2). When investigating how densification could take place at a specific location, it is therefore important to understand the underlying story behind the formation of a settlement, as most have a very distinct character and place in the system.

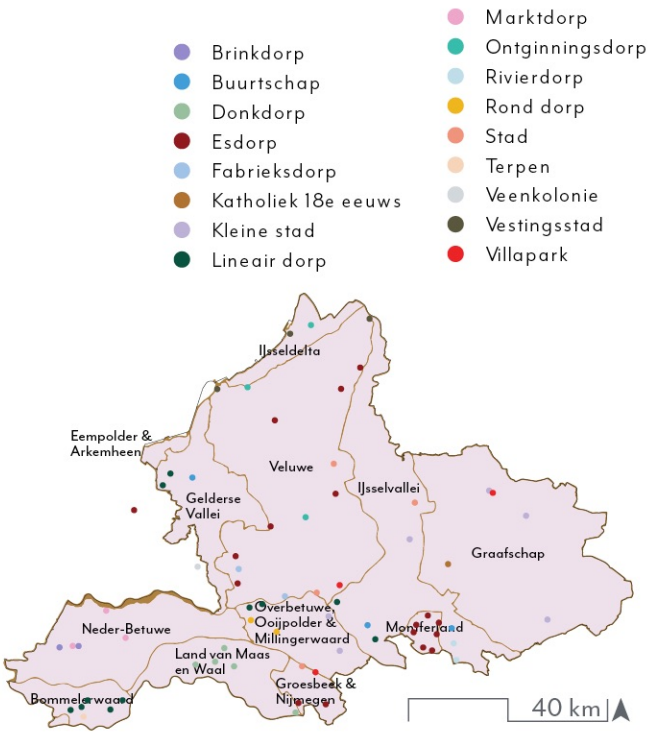


Figure 4.2. Mapping of settlement types and historical geographic regions as described by Haartsen, 2009

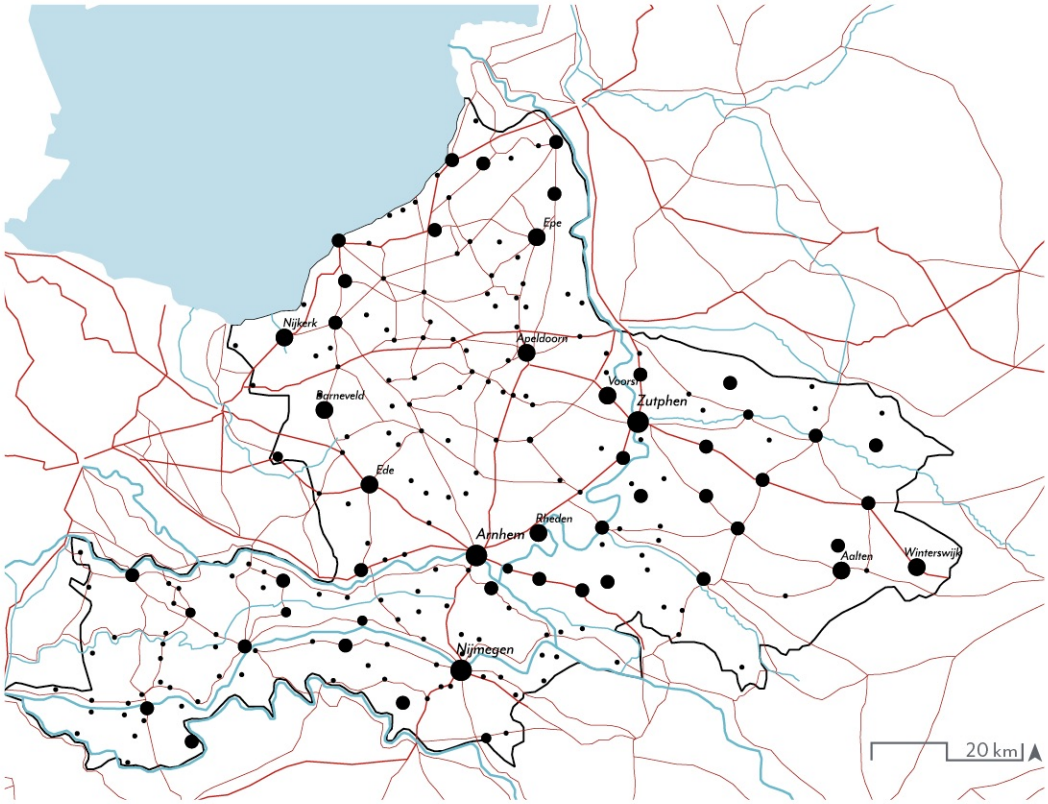


Figure 4.3. Mapping of settlements and networks in 1820. Data from Kadaster, n.d.

Despite their differences, the different regions share commonalities in their history. They have all experienced the impact of rivers on their landscapes, evident in features like river dikes and watercourses. They have a rich cultural history, with castles and estates dotting the landscapes. Over time, human inhabitation and interventions have shaped the landscapes, with artificial elevations like terpen and floodplains constructed to mitigate flood risks and improve agricultural productivity.

When we examine historical developments on a smaller scale and from a different perspective, we can see how different social and technological developments and events have a spatial outcome. The historical trajectory of Arnhem becomes clear through the comparison of photographs and reveals the different temporal layers of which the city is composed. It was only in the early 20th century that the city experienced significant growth, yet this progress was soon followed by widespread destruction during the bombings of World War II. In the aftermath, developments appeared to prioritize the repair and expansion of the city rather than the reconstruction of its central core. Nevertheless, the city centre remained vibrant, characterized by bustling streets adorned with prominent shop signs throughout the 1980s. Interestingly, the advent of online shopping and delivery services had not yet signified the demise of activity and public life in the city centre, despite the expansion of monofunctional housing redevelopment areas. When we observe the present-day city centre, however, its allure as a welcoming entrance has diminished. Concealed behind bridges and roads, the once-preserved buildings have gradually given way to modern structures with closed-off facades.

Figure 4.4. Biographic mapping of Arnhem, Rijnstraat. Photos from Gelders Archief, 2019

4.2 URBANISM IN GELDERLAND

The development of urban areas and national regulations in the Netherlands can be traced through several key policy documents, known as "nota's ruimtelijke ordening." These documents demonstrate the changing priorities and challenges faced by the country over time. The first nota, together with the nota 'Westen des Lands', aimed to address congestion in the western part of the Netherlands by promoting economic development in the north and east, discouraging migration to the west. It proposed a growth model for the Randstad, emphasizing a central green area called the Groene Hart, surrounded by separate cities to maintain safe and manageable living environments (Figure 4.5). The second nota, issued in 1966, focused on the projected (explosive) population growth and sought to prevent uncontrolled expansion of the Randstad. It advocated for 'concentrated deconcentration', establishing growth centres ('groeikernen') away from the cities and buffer zones between them. The policy also emphasized the need for an expanded highway network. The third nota, spanning from 1973 to 1983, responded to revised population projections and the trend of urban dwellers moving to suburban areas. It continued the approach of concentrated deconcentration, designating new growth centres and implementing urban development measures. The policy also addressed the disproportionate growth of smaller towns and initiated urban renewal projects. The fourth nota, issued in 1988, prioritized spatial qualities and emphasized the advantage of coherent urban structures. It considered a timeline until 2015 and advocated for expanding the economic core of the Randstad, including cities in North Brabant and East Gelderland, and highlighted the need for new housing. The Vinex policy document in 1994 focused on environmental concerns, promoting compact urbanization and accessibility through public transportation. It encouraged development within existing cities and cooperation with regions and provinces to provide housing, transportation, and green spaces.

The Nota Ruimte, published in 2005, emphasized a decentralized approach and involvement of stakeholders in area-based development. It prioritized strengthening urban networks and preserving ecological areas and national landscapes. The Structuurvisie Infrastructuur en Ruimte (2012) acknowledges the decreasing need for offices and the challenge of aging and vacant buildings. The government emphasizes revitalization and transformation through functional changes, with

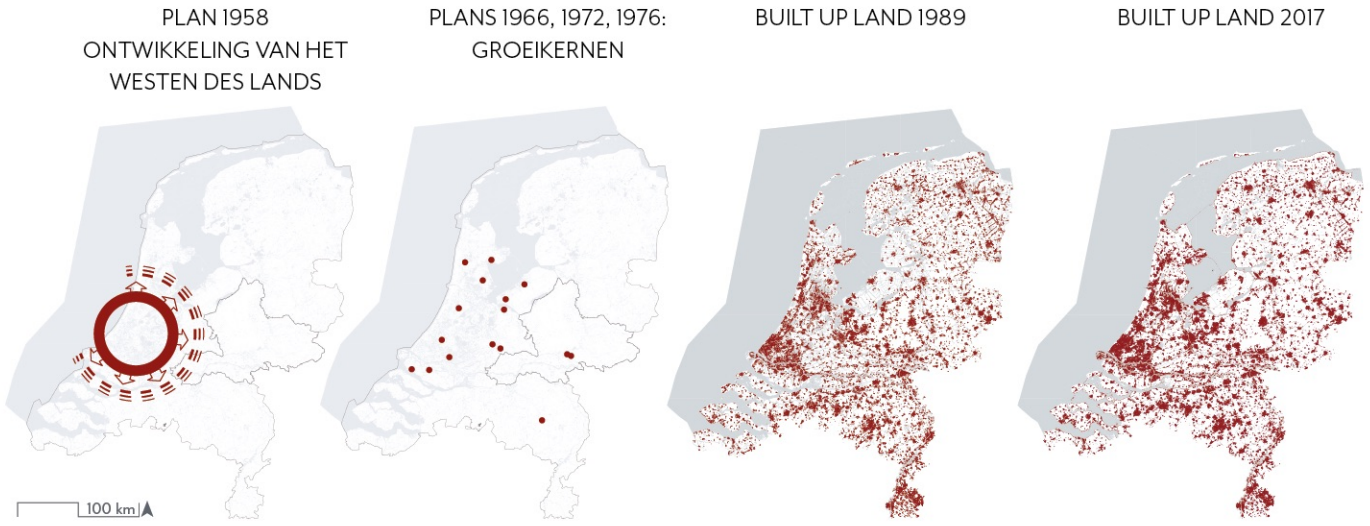


Figure 4.5. Visualisation of the different national urban development plans since the 1950s and the resulting built up land (roads excluded) Centraal bureau voor de statistiek (CBS), 2022

responsibility shared by provinces, municipalities, and the market. This also meant the government as a national apparatus was less and less involved with spatial planning from then on (Bruinsma & Koomen, 2018a; van der Wouden, 2016).

Whether the planning concepts and policies were successful in reaching their goals, is debatable. On one hand, it is said that without the urban development plans, the area of urbanised land would have been even larger, the usage of the car higher and the fragmentation of ecological reserves worse (van der Wouden, 2016). Nevertheless, the current existing environment can be characterised by sprawl, which was to be avoided from the outset of the spatial regulations.
One question to ask is why this concept of a ring of urbanisation around the green heart, and then the founding and development of the growth centres eventually did not yield the desired results. Perhaps, these visually and conceptually strong, but practically oversimplified doctrines did not have enough flexibility built into them, leading all the solutions that came after to have to abide to this 'set in stone' principle. What can be the role of strategic planning and expertise once such a strong concept has been formed, or is their role the formulation of the (new) doctrine? (Faludi, 2000) What could be learned from half a century of planning, is that strong concepts can indeed steer development, but not be so controlling that they hinder research, design and planning that follow other trajectories if the circumstances ask for it. It also shows the importance of thinking the consequences of certain policies, concepts, and designs through over longer periods of time.

Now that the scarcity of space and a lack of sufficient dwellings have become a more urgent problem again, new national and regional planning policies are in place, as part of the program 'beautiful Netherlands' ('mooi Nederland') (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2022). Some of the areas that have the focus within this program also concern Gelderland (Figure 4.6), but most are still focused on the existing denser areas.

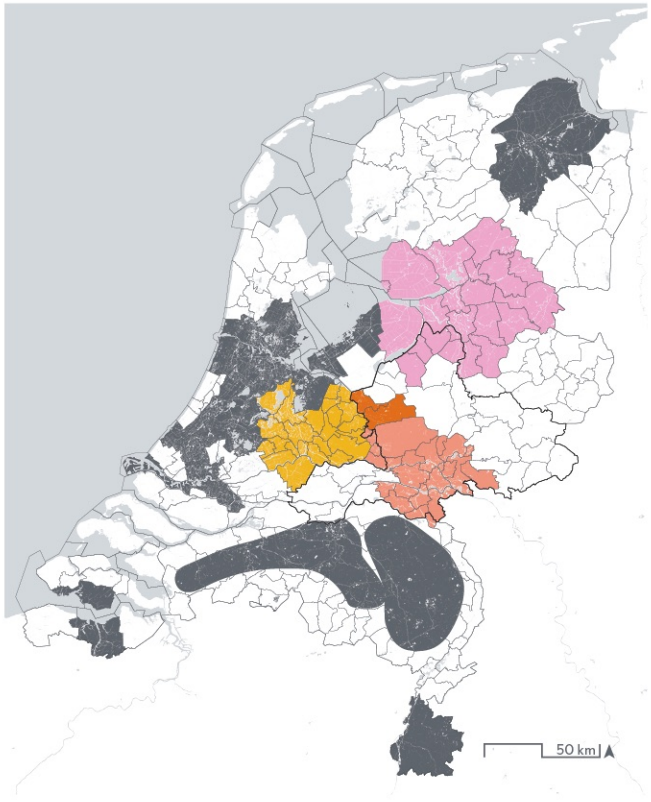


Figure 4.6. The different NOVEX-areas. (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, n.d.)

4.3 THE CURRENT ENVIRONMENT

Gelderland still is host of many different types of environments and landscapes (Figure 4.7), with the most prominent one being the Veluwe, which is one of the largest nature reserves of north-western Europe and is often praised for its rich biodiversity. Nevertheless, also Gelderland struggles with problems such as drought, flood risk and subsidence. As we can learn from the historical analysis, this is nothing new, but due to the higher population density, urbanisation and climate change, the pressure on the landscape is ever growing.

To be able to start to form an idea of the possibilities for densification in the province, it is helpful to not merely divide the land into 'built' and 'unbuilt', but to categorise urban environments in a way that says something about the type of urban environment that it is (). The type of environment seen on the provincial level dictates how dense environments can become and if (and how much) they could potentially expand. They also determine certain urban qualities that should be found within the environment: being in a city should feel differently from being in a town, village, etc. and vice versa. Of course, over time, locations could grow or shrink into a different type. The categorisation is made based on the amount of inhabitants, the population density, the urban character and age of the settlement and the presence of a train station.

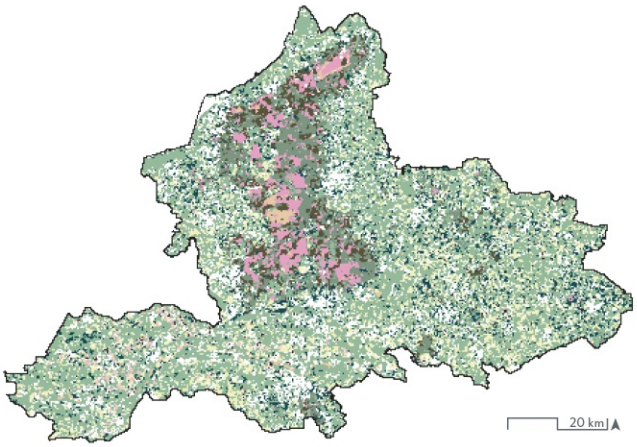


Figure 4.7. The physical landscape (Kadaster, 2020)

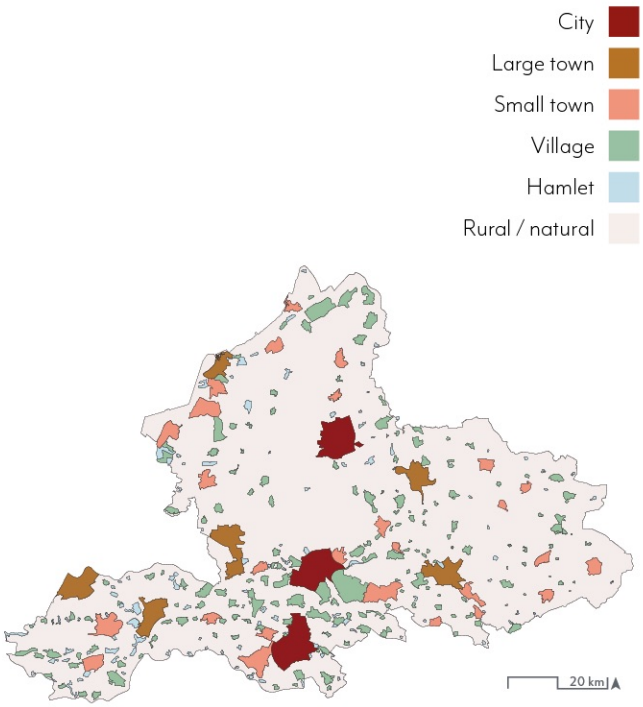


Figure 4.8. Levels of urbanity


Simons

05 THE MEANING OF DENSIFICATION

5.1 SPATIAL OPPORTUNITIES

That densification can provide an answer to the increasing pressure on space is quite logical, but to see if and how it could also aid in improving urban and/or environmental qualities, it is important to understand the meaning of it in different types of urban environments. To establish different strategies in terms of where and how to densify, we take a closer look at some of the characteristics that prescribe and describe urbanity.

Public services

In order to achieve a high liveability standard, presence of public services is crucial. Proximity to services is what makes environments with higher densities remain liveable, as areas that have a high population density but are lacking in service provision have a higher chance of becoming congested. Vice versa, a high population density is one of the conditions under which services can and businesses could start and thrive. The focus on the proximity of services is also a means of de-locking and/or avoiding an aggravation of the path dependency on the car that exists in Gelderland today, like in many other (sprawled) environments (Figure 5.1, Figure 5.2). A Dutch study from 2020, carried out under 1293 people, showed that only 30 percent of the respondents said to not feel more and more dependent on their car

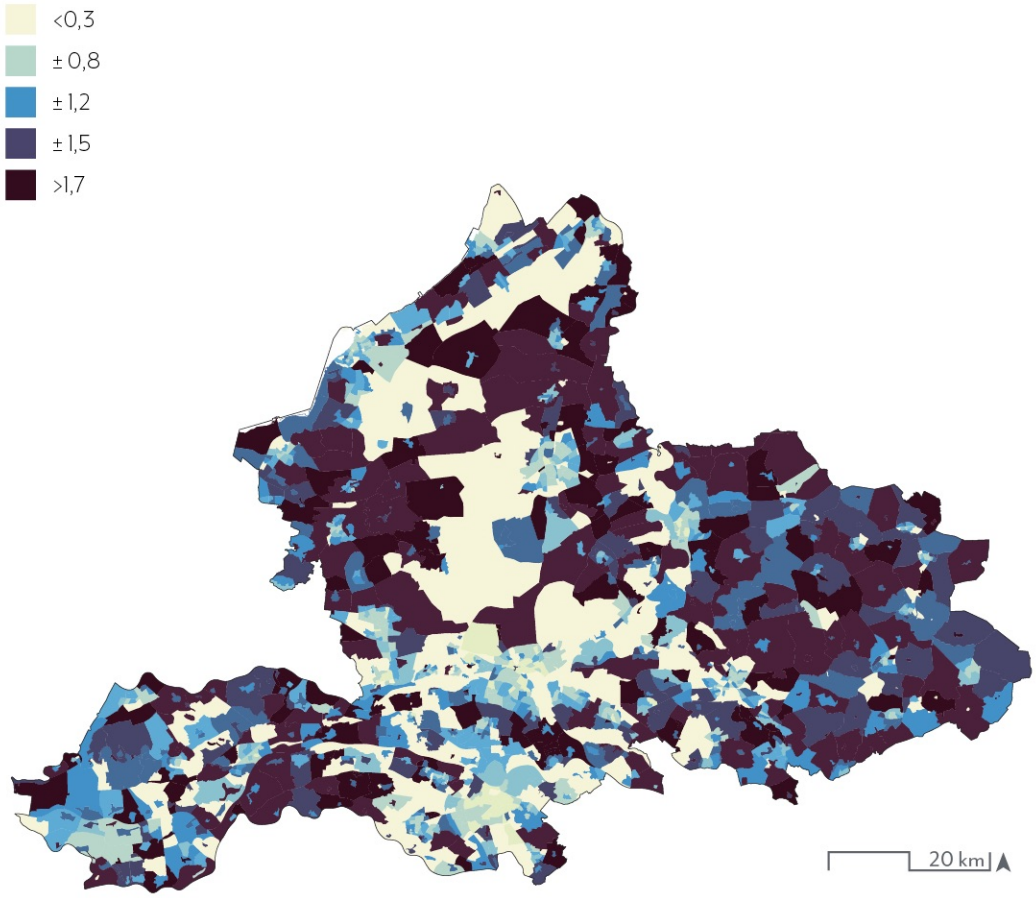


Figure 5.1. The amount of cars per household, per neighbourhood. Data from Centraal Bureau voor de Statistiek, 2021

(Kennisinstituut voor Mobiliteitsbeleid Jan-Jelle Witte Toon Zijlstra Stefan Bakker, 2022). The importance of this is underlined by the introduction and popularity of the "15-minute city" concept, which is closely linked to sustainability, resilience and place identity. The 15-minute city was introduced by Carlos Moreno, advocating for an urban lifestyle where locals have easy access to all their basic needs within a 15-minute walk or bike ride, which is based on his idea of a "living city" that aims to improve urban and social aspects and allows for a higher quality of life for residents (Moreno et al., 2021).

Though the 15-minute city is a good start for analysing and describing the qualities of (urban) life on a neighbourhood or city scale, it might not be a concept that can or should be applied throughout regions. This would not only disregard the quality of diversity of urban environments, but also is unattainable or even unwanted in some cases. As there hardly are any parts of Gelderland left that are uninhabited, applying the 15 minute city concept on the complete province would most likely result in the construction of a mega-city, which goes against many of the needs and goals set within the project.

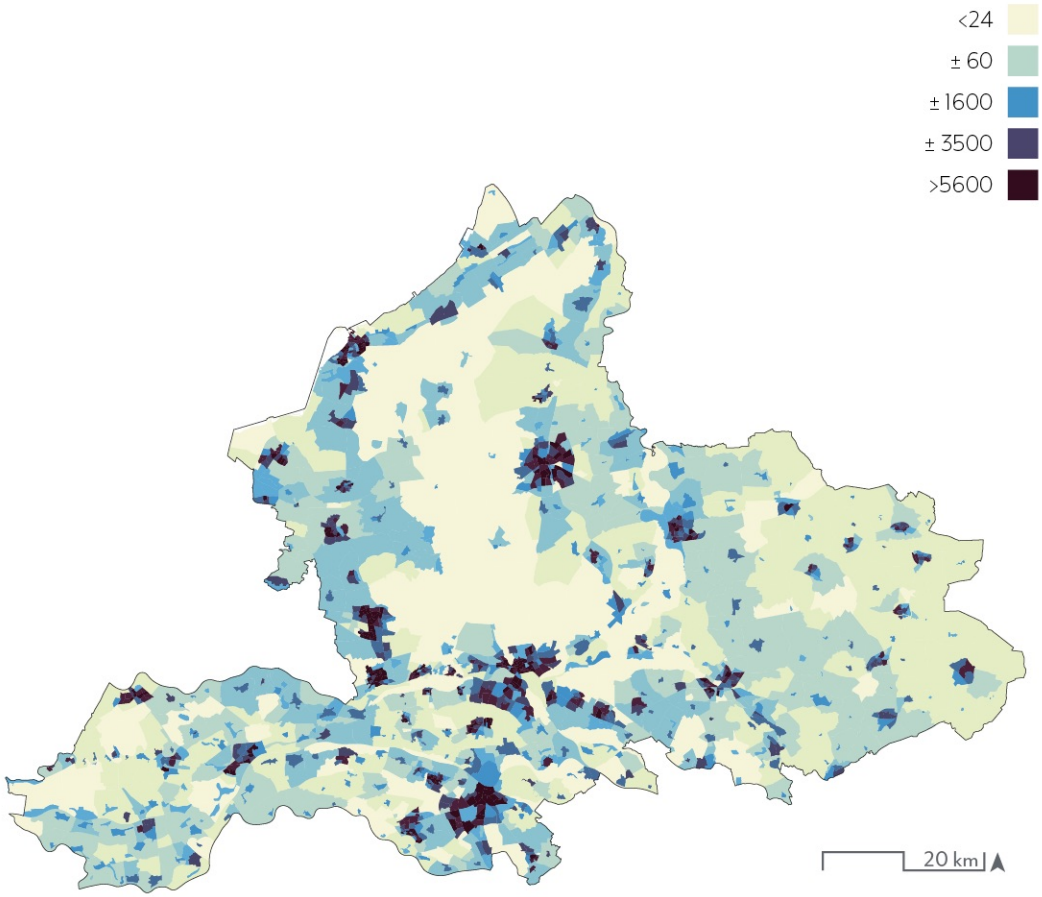


Figure 5.2. The population density per km2, per neighbourhood. Data from Centraal Bureau voor de Statistiek, 2021

Besides the fact that not every neighbourhood should become so dense that the 15-minute city concept can be sustained, there is also a distinction to be made between the necessity and needed proximity of services. Some services can be labelled basic (daily) necessities, without the presence of which even smaller settlements do not function properly, other services are ordinarily present in more densely populated areas or can be marked a luxury: these services do improve the quality of urban life and make for a more vibrant city, but are less important. Then, different to the 15-minute city model, the project also makes a distinction in the proximity of these services. Some should be located closer to home than others, as all functions have a different place in daily life. This is also dependent on cultural-historical, socio-economic and personal preferences and conditions, which makes it difficult to give an objective and absolute conclusion on which functions should be how close. In order to be able to make a spatial analysis of service provision levels in Gelderland, however, a credit system based on the proximity and necessity of a function is made (Figure 5.3). The idea is that there is a minimum number of credits a neighbourhood should score in order to be ranked sufficient on liveability. The table makes insightful which average distance within a neighbourhood (calculated from each building in the neighbourhood to the closest instance of a specific function) is deemed reasonable and how many credits are acquired with a specific distance. The credits are then used to make a legend of the service provision level of a neighbourhood (Figure 5.4).

	Available within						
Service	1 km	3 km	5 km	10 km	20 km	Reasonable	Maximum
Supermarket or other stores for daily supplies	12	9	6	3	0	9	12
Primary school	12	9	6	3	0	9	12
GP or GP centre	12	9	6	3	0	9	12
VMBO	12	12	9	3	0	9	12
HAVO / VWO	12	12	9	3	0	9	12
Pharmacy	12	9	6	3	0	9	12
Fire station	12	9	6	3	0	9	12
Total						63	84
Kindergarden	8	6	4	2	0	6	8
After school care	8	6	4	2	0	6	8
Library	8	6	4	2	0	6	8
Swimming pool	8	6	4	2	0	6	8
Cafe	8	6	4	2	0	6	8
Cafetaria	8	6	4	2	0	6	8
Restaurant	8	8	6	4	0	6	8
Cinema	8	8	6	4	0	6	8
Total						48	64
Warehouse	4	3	2	1	0	3	4
Hotel	4	4	3	2	1	3	4
Ice skating	4	4	3	2	1	3	4
Total						9	12
Total						**120**	**160**

Figure 5.3. Service provision level credit system

The resulting map, displaying the service provision level per neighbourhood in Gelderland (Figure 5.5), may not be surprising, as the most urbanised areas are also the ones with better accessibility to services. What is good to note, however, is that almost all the smaller settlements also suffice or even fall in the highest category. The map presents which areas in the province have the already are or have the potential to become a 15 minute city and those in which the goal of a 15-minute city would require more drastic developments.

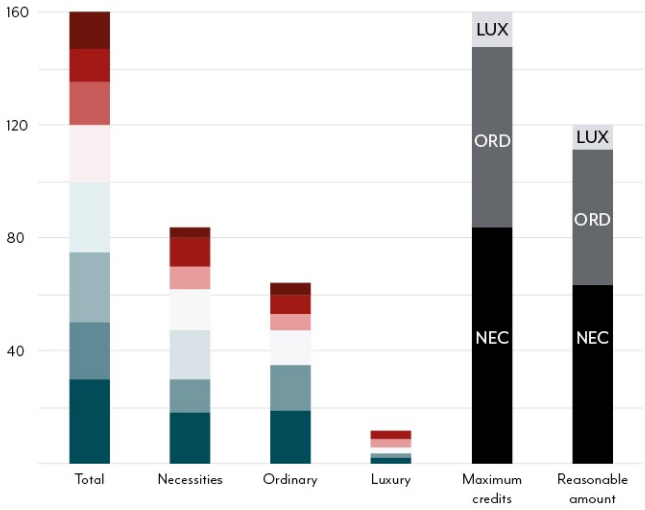


Figure 5.4. Legend of the service provision level credit system

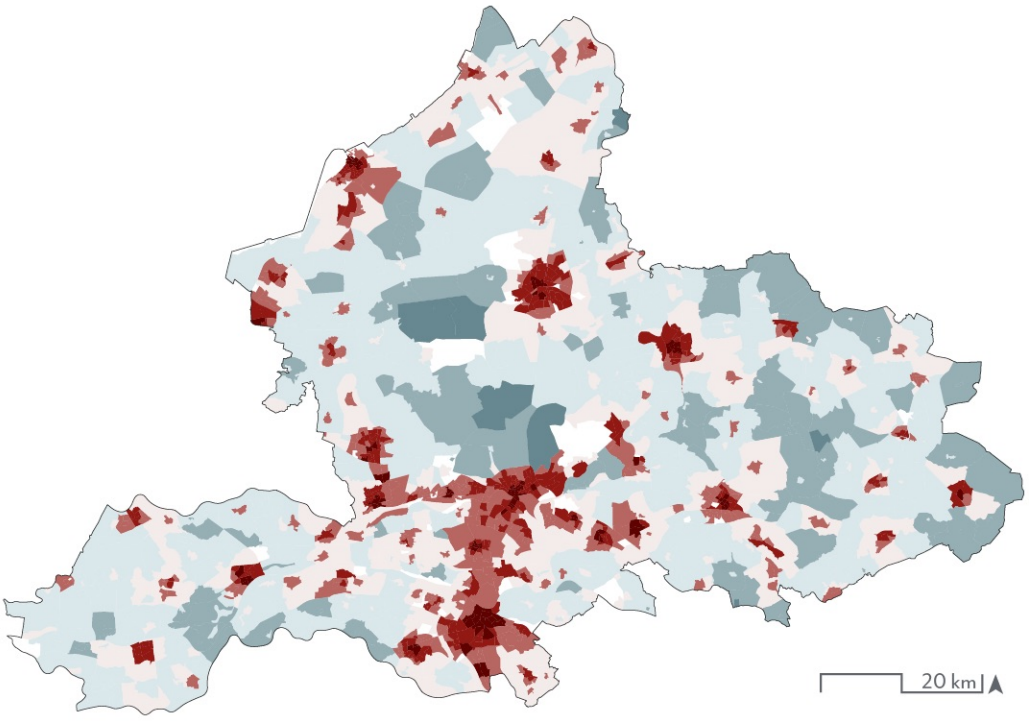


Figure 5.5. Total service provision level per neighbourhood. Data from Centraal Bureau voor de Statistiek, 2021

Public transport

What this analysis does not take into account, however, is the fact that people's daily lives do not stay within the boundaries of one city. Ever since the increasing mobility of the population due to the rise of various forms of transportation such as bicycles, trains, and later cars, as a result of industrialization, daily urban systems have become substantially larger. Before the 20th century, the daily action radius was limited to about 5 kilometres, but as the distance someone could cover within the same timeframe continuously grew, so also did the average

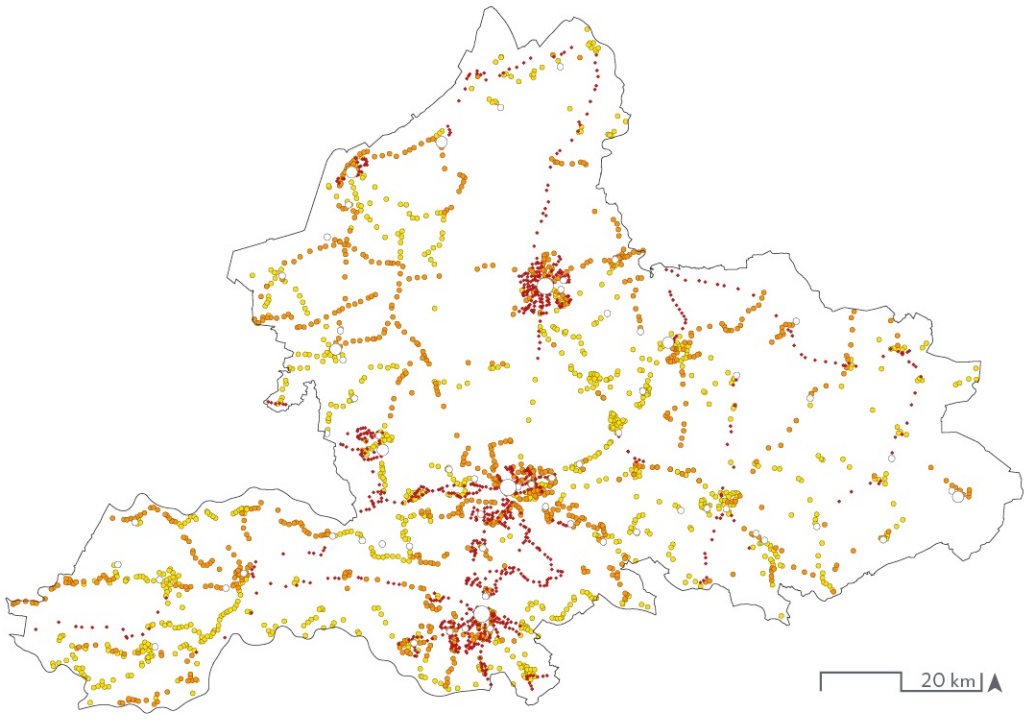


Figure 5.6. Public transport nodes. Data from Stichting OpenGeo, 2021

		Available within					
	type	1 km	3 km	5 km	10 km	Reasonable	Maximum
Regional	large train station	12	9	6	3	6	12
	medium train station	8	6	4	2	6	8
	small train station	6	4	3	1	4	6
Local	other transport, frequent (>30x per day)	6	4	2	1	4	6
	other transport, semi frequent (16 - 30x)	4	2	1	0	4	4
	other transport, non frequent (< 16x)	2	1	0	0	3	3
	Total					10	18

Figure 5.7. Public transport accessibility credit system

distance between one's home and their workplace (Bruinsma & Koomen, 2018). This freedom and lifestyle are not something that can or should necessarily be easily changed, even when services are close by, as exchange and interconnections between cities is also what can make a region stronger (Nadin & Zonneveld, 2020). To not worsen the dependency on the car even further, the presence of public transport is essential. Of course, an improvement or extension of the existing infrastructure could be realised if the potential and resources are there, but as this as this is very costly and yet unpredictable, the analysis first focuses on how well locations are connected to the existing public transport infrastructure. This is done through an attraction distance analysis from each building block to the closest bus or train station (Figure 5.6), via the existing road network. To rank each block on accessibility, a similar credit system is used as for the service provision level, which is based on the distance to a transport stop as well as the frequency of a train or bus stopping at such a location (Figure 5.7). The resulting map shows which areas have high connectivity to other locations through public transport and which locations are either more reliant on the car or have a smaller daily urban system (Figure 5.8).

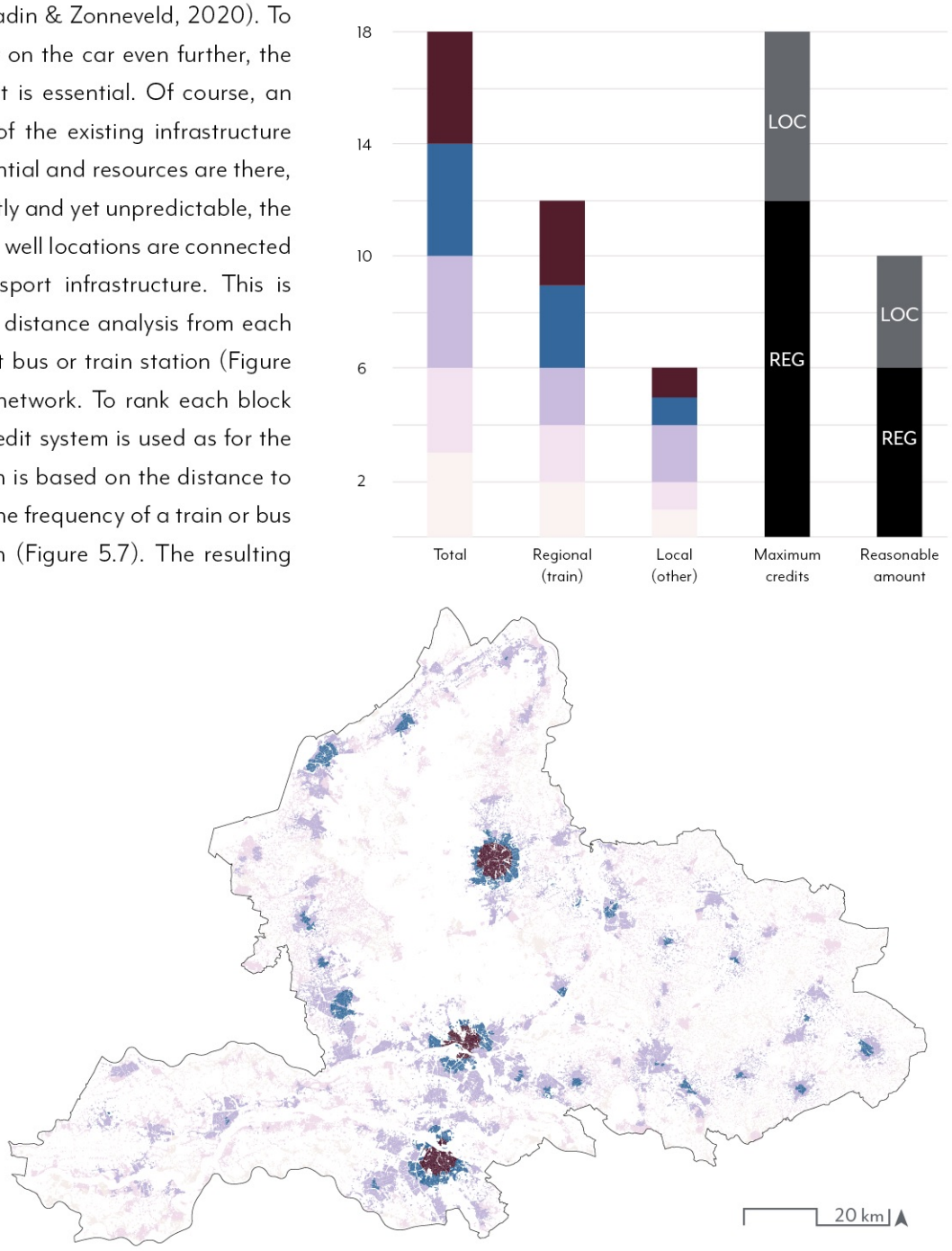
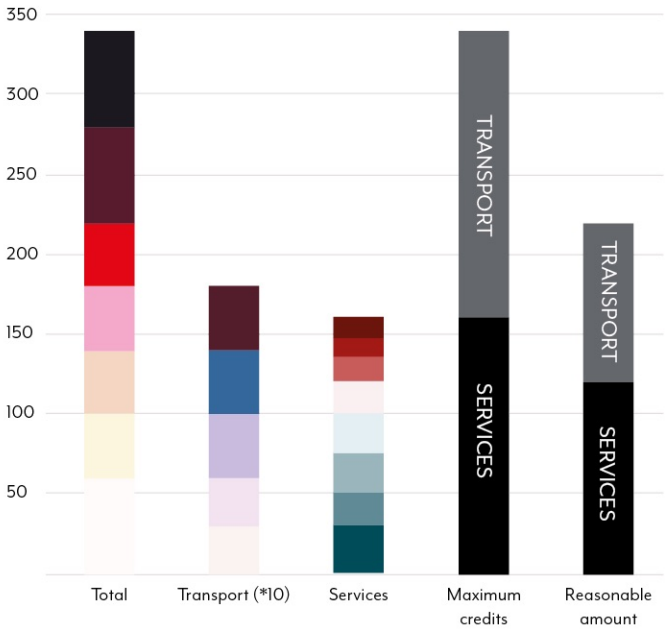


Figure 5.8. Total amount of accessibility credits per block. Data from Planbureau voor de leefomgeving, 2022.



To be able to distil from these analyses the locations that have the potential to be further densified in terms of services and transport, the credit systems are combined and again, represented in a map (Figure 5.9).

Existing density types

Naturally, another factor that has to be taken into account is the current density of a location. As described earlier, density is best analysed by considering multiple characteristics, as in the Space Matrix graph (Berghauser Pont & Haupt, 2021). By analysing the FSI and GSI of all building blocks in Gelderland, some distinct types can be made, in this case done with the help of GeoDa (Figure 5.10).

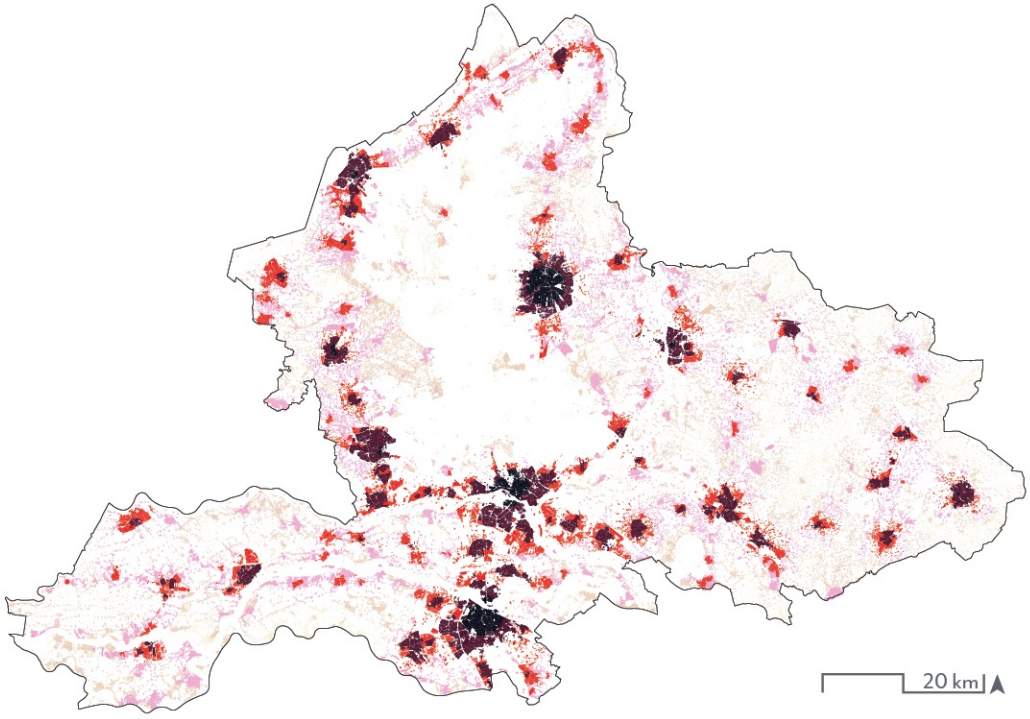
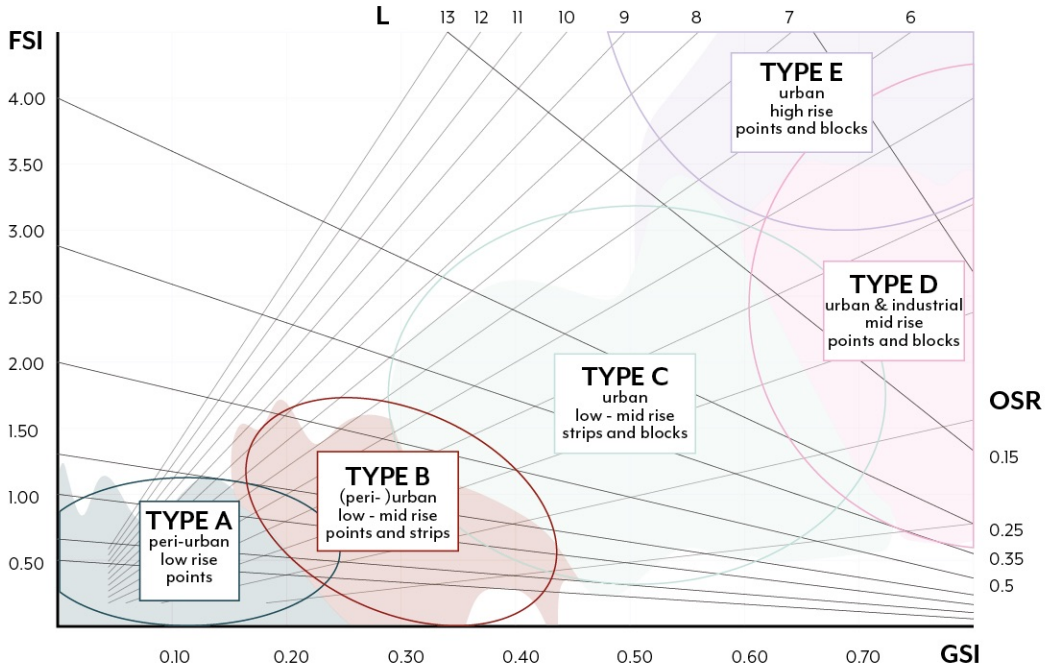


Figure 5.9. Total amount transport and service credits per block.



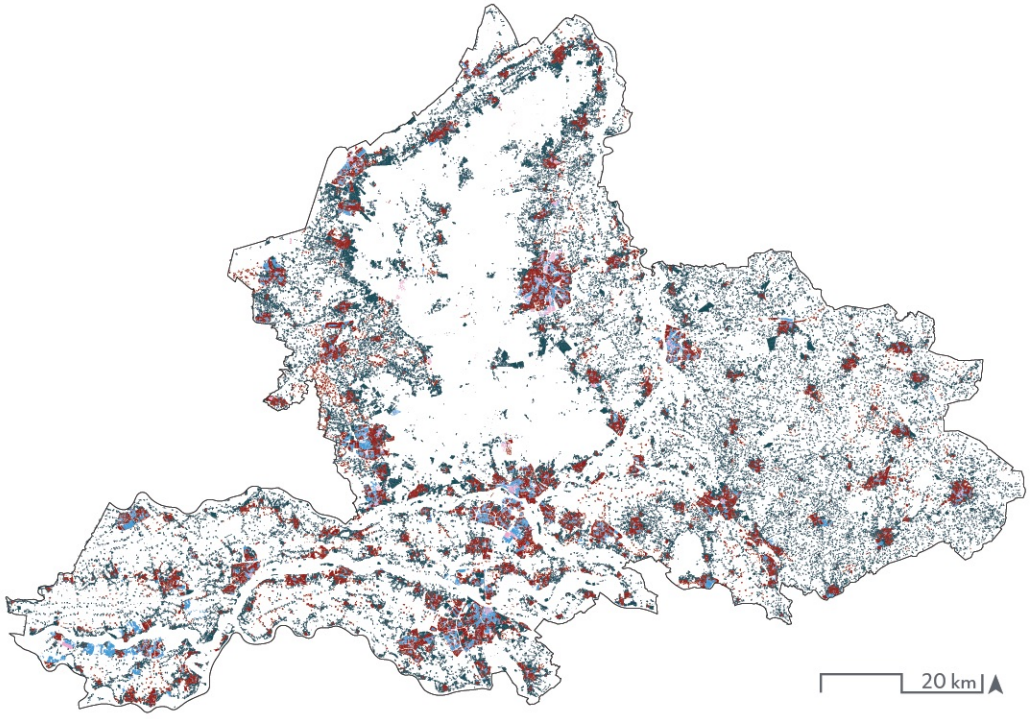


Figure 5.10. Density type per block. Data from Planbureau voor de leefomgeving, 2022

By combining the service and accessibility levels with the density types, strategies for densification can be made. The most logical places for densification would be those that are not yet very dense (type A and type B), but do score high on service provision (>220 or >180 credits). Then there are also locations which are already relatively dense, (type C), but do not have services and/or public transport closeby (<180 credits). The map presents those locations in which densification would mainly mean an unlocking of potential (in green) and areas in which densification could be the catalyst for an improvement or addition to existing service and transport systems (orange)(Figure 5.12).

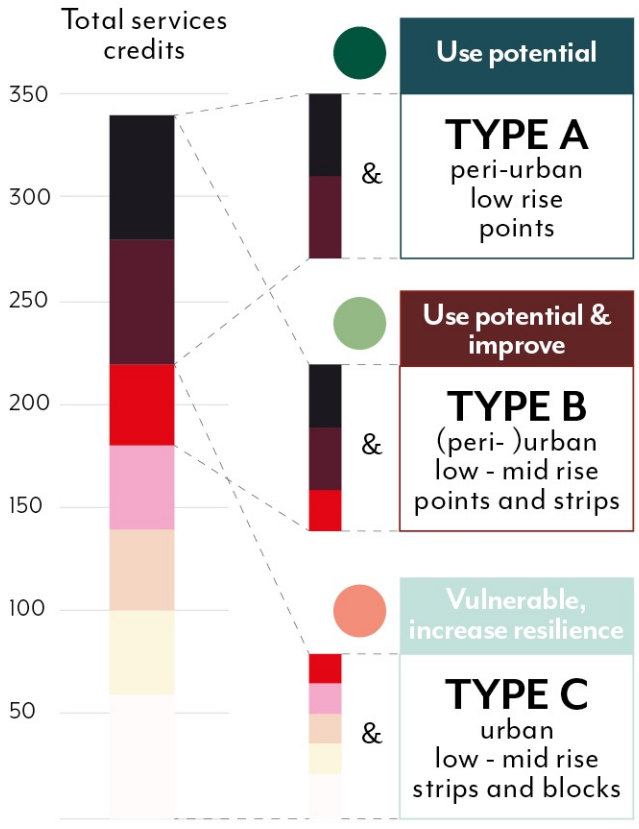


Figure 5.11. Strategy based on service and accessibility levels and density type

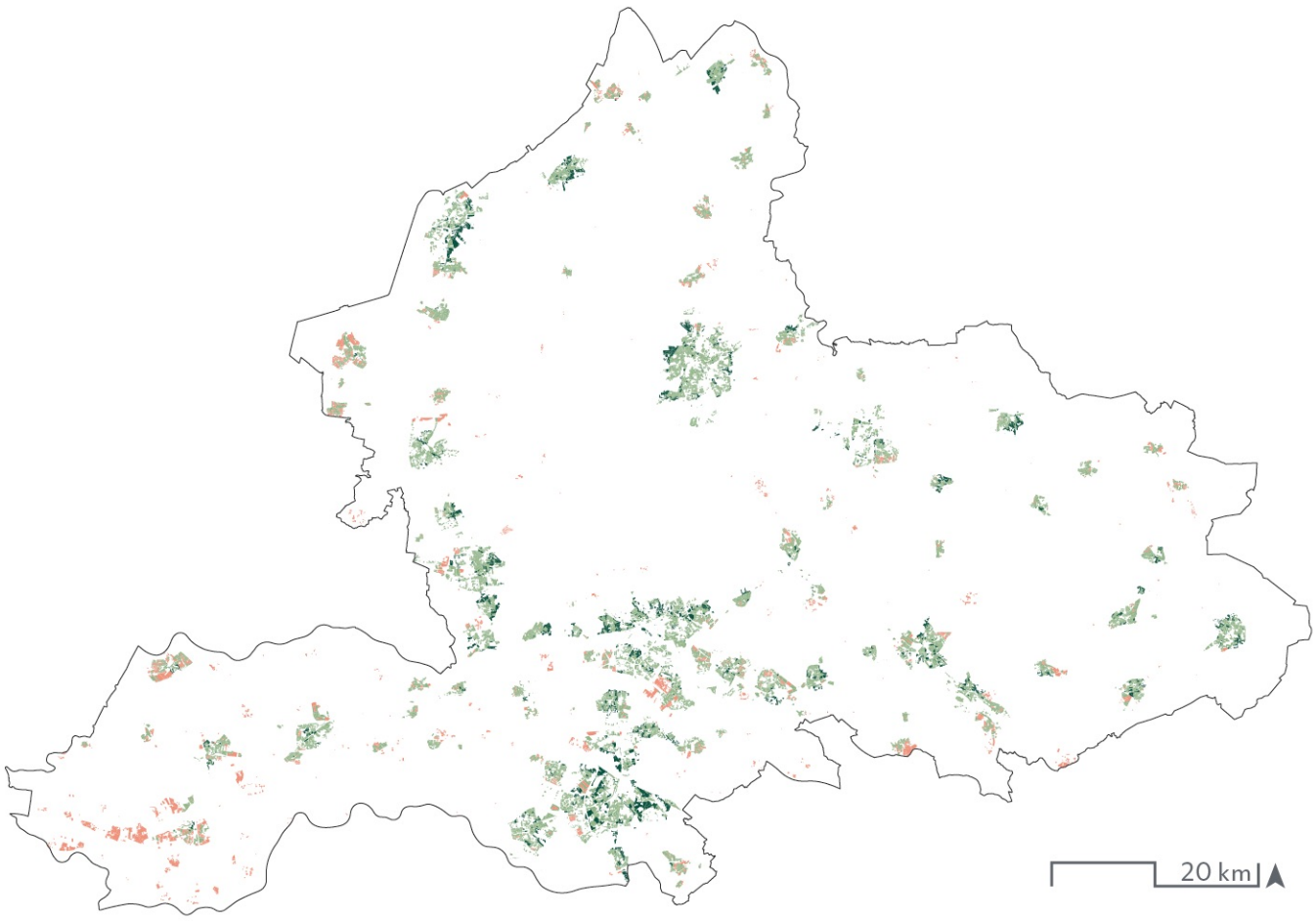


Figure 5.12. Net building blocks per densification strategy

5.2 RISK ASSESSMENT

The notion of risk

Following the problematisation for the project, it is clear that we should not only look at the opportunities for urbanisation, but also at the weaknesses and threats, if we want to avoid history to repeat itself in a negative manner in the coming decades and centuries. Therefore, the notion of risk is important. What densification would mean also depends on the risks that come with building in a certain location, and vice versa. Dealing with risk is complex on many levels: the technical, methodological and ethical approaches are diverse, which makes it even more important that decisions that involve risks are made insightful. The next section therefore explains how the project involves flood risk, bearing capacity and sea level rise in the selection of locations for densification. Other issues, such as drought and salinisation, are also important in sustaining liveability, but are not included exploration, because those either do not pose immediate threats for inhabitation or are issues that could actually be dealt with through urban renewal.

Flood risk

The risk of flooding, akin to various other hazards, can be characterized as the product of the probability and the impact, or alternatively, as a combination of probability, exposure and vulnerability, or as the geographical overlap of hazard and vulnerability (Pieterse et al., 2013). Because the project is not (only) focused on the areas in which people already live, but also explores which areas would be suitable for inhabitation, exposure to flood risk is relatively irrelevant. The risk is thus visualised as the flooding depth in meters combined with the probability of a flood happening (Figure 5.13). This also makes insightful which risks are deemed extreme, and should be avoided at all costs, and which ones are seen as low or minimal.

Suitability

Whether land can then be characterised as suitable for inhabitation, does not only depend on flood risk, however. The bearing capacity of the soil is another aspect that should be taken into consideration (Deltares et al., 2021). Because a low bearing capacity is something that already

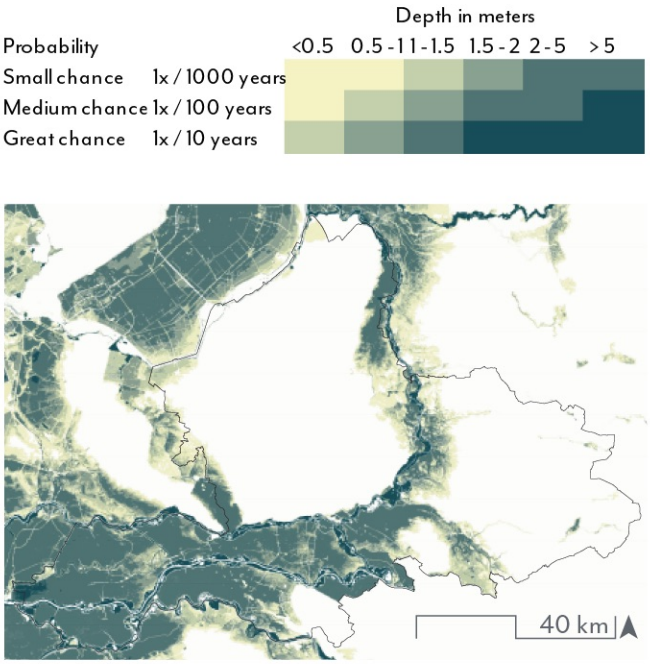


Figure 5.13. Flood risk analysis. Data from Klimaateffectatlas, n.d.

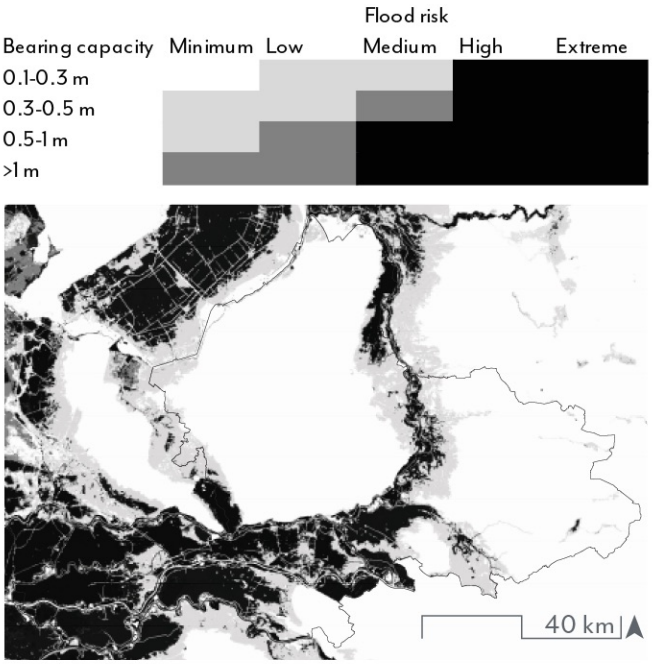


Figure 5.14. (Un)suitable land for building based on flood risk and bearing capacity. Data from Klimaateffectatlas, n.d.

accounts for many complications and high costs in existing urban areas, densification of locations with poor soil conditions is not sustainable. The suitability is therefore conceptualised in a new matrix, using the bearing capacity and flood risk as input. The resulting legend shows which areas are a 'no-go' (black), not suitable (dark grey) or possible (light grey) for densification. The idea is that certain flood risks can only be accepted if the bearing capacity is higher, because the higher the amount of possible complications, the less logical it is to densify a certain location.

Sea level rise

The previous explorations show the suitability for densification based on existing and projected conditions, but depending on different scenarios, the conditions for inhabitation also differ. As the goal is to make our patterns of inhabitation more sustainable, and thus more resilient, another aspect that should be considered is sea level rise. One of the major path dependencies that urbanisation in the Netherlands operates within, is the polder landscape. Despite the fact that being able to create a landscape below sea level that is inhabitable has brought us many things, the difficulties that too come with this man-made landscape are becoming more and more apparent. Remembrance of the quote "One day, we will surrender this land to the waves with a sigh of relief" by Johan van Veen, who founded the so-called 'Deltaplan', becomes more and more relevant and important. In the end, building higher dykes in response to higher water levels only enlarges the risks (Rijcken, 2015), which is why the project also takes existing height levels into account for determining which land should (not) be built, as those, together with the sea level (rise), dictate the pressure on the dykes and the water management system.

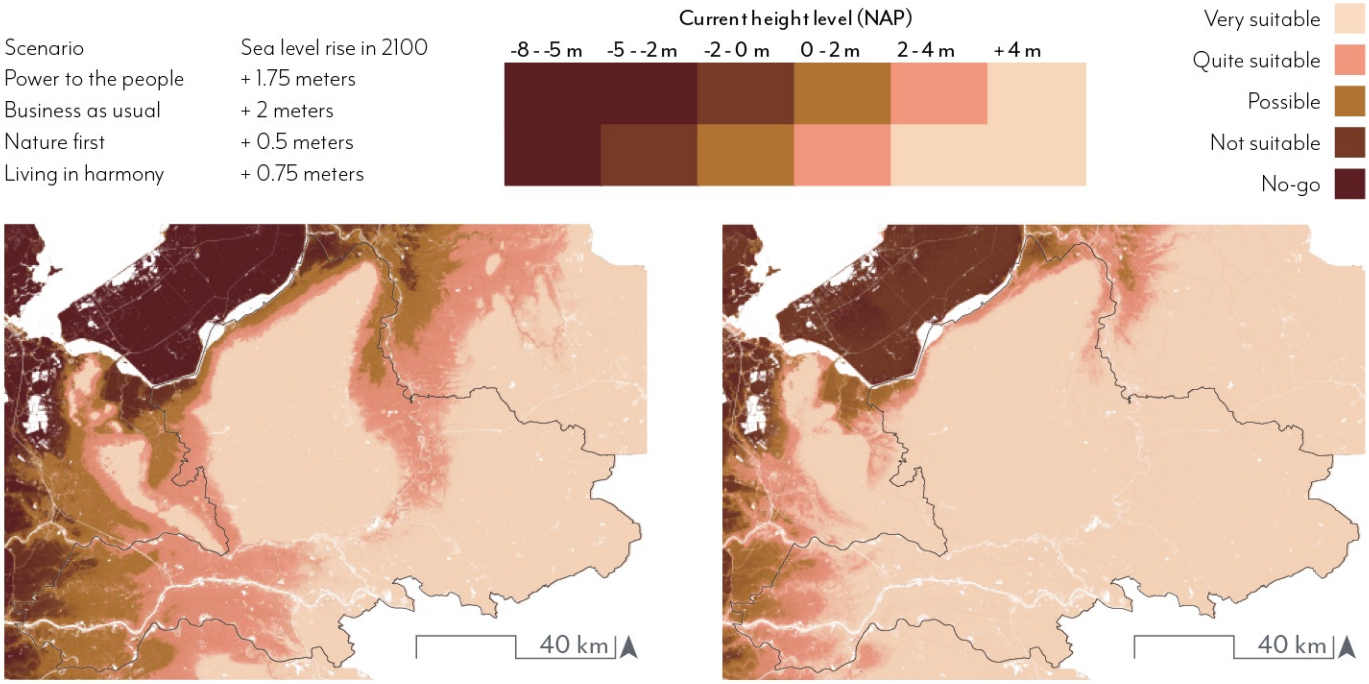


Figure 5.15. Suitability for building based on height levels and possible trajectories of sea level rise within the scenarios. Left: Power to the people & Business as usual, right: Nature first & Living in harmony. Data from Actueel Hoogtebestand Nederland, n.d.

5.3 PROTECTING NATURE

In order to mitigate the negative consequences of urban growth, it is crucial to not only consider the possibilities, limits and risks of densification for human activity, but also how it affects the natural environment. As urban growth is known to pose threats to biodiversity and ecosystem services, vulnerable locations in the province are mapped. Whether these locations are respected, however, depends heavily on the dominating paradigm in respect to nature. As the scenarios sketch different meanings of this relationships, these are also used to establish which areas would likely be free of urbanisation, if a certain scenario is prevalent.

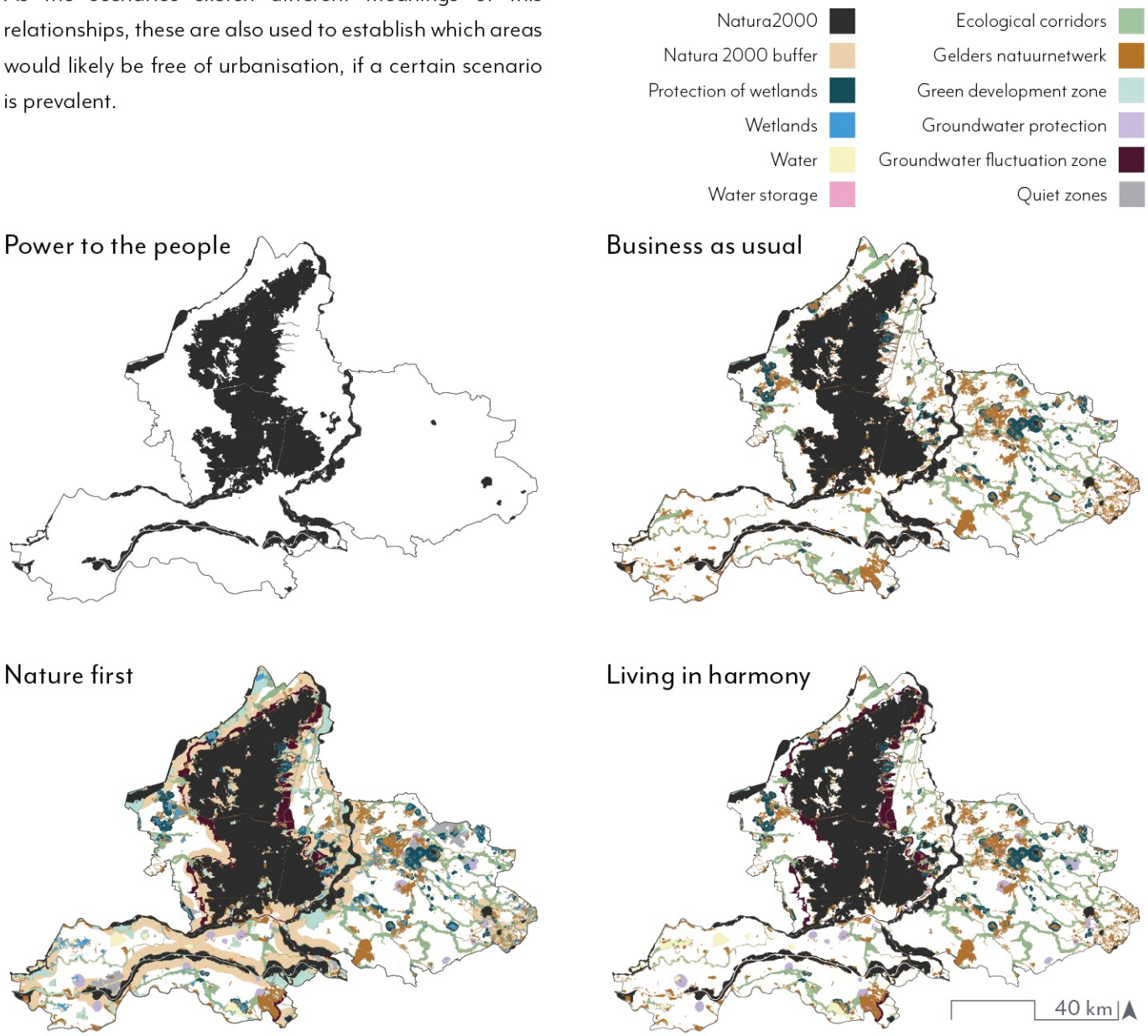


Figure 5.16. Areas that should be exempt of construction to protect nature following each of the scenarios. Data from Provincie Gelderland, n.d.

5.4 SUITABLITY

By deducting the opportunities for densification with the areas in which urbanisation should be avoided, we are left with a map indicating where it could take place and what it could mean. Because the scenarios vary heavily, the maps indicate not only which locations would merely be suitable for densification under certain circumstances, but also where densification could take place, no matter the conditions.

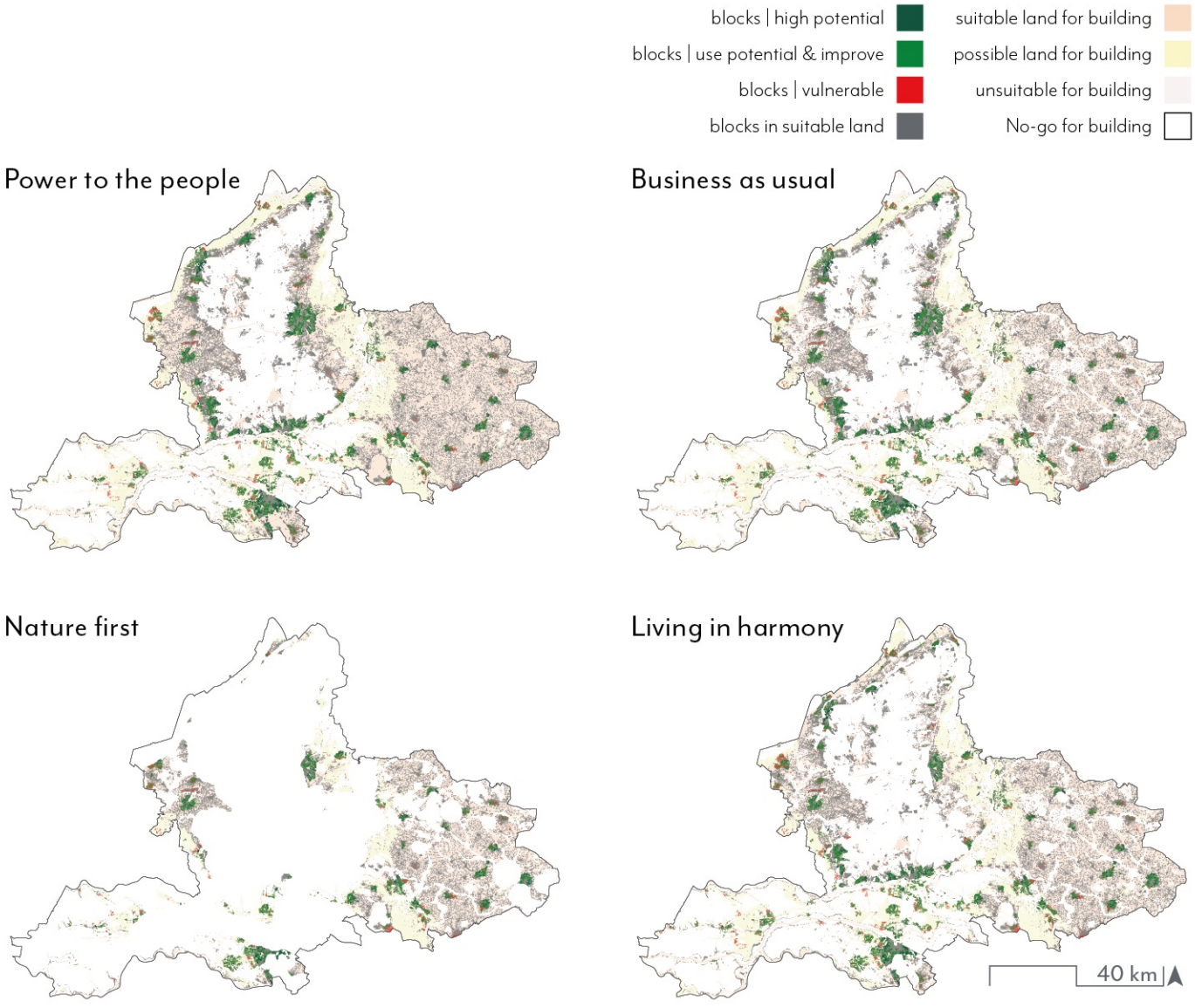


Figure 5.17. The meaning of densification of blocks and urbanisation of land

06 DESIGNING WITH DENSITY

6.1 URBANISATION PATTERNS

The problem is not solved by merely exploring which locations are suitable to densify, because the demand can only be answered to sufficiently if the degree of densification is made explicit. Because the density of an urban environment importantly dictates its characteristics and qualities, there should then also be a linkage between the amount and the way of urban growth. For that reason, this chapter is focused on answering the three basic, main questions in parallel: *where*, *how much* and *how* to densify? Because the answer to each question cannot be found within a specific scale level, they alternate each other while zooming in, to finally conclude by projecting the findings on the larger scale again.

How densification should take place does not only depend on the local conditions that were used in the suitability assessment, such as access to services, risks and the presence of vulnerable nature. It should also be examined in relation to the urban characteristics and the connections between urban environments. As stated in the premise of the research, densification could be the revolt needed to make (urban) environments more resilient. Whether this will be accomplished or not goes beyond the local characteristics and is also reliant on the relative position and character of each settlement. Cities that are surrounded by many other settlements or have a strong cooperation or network with other cities operate entirely differently than cities which exist more as an island. For this reason and due to its polycentric character, the Randstad has become a much discussed and studied region (Nadin & Zonneveld, 2020). Because the different cities that are situated within in function in cooperation with each other and because the travel distances between the larger cities can be compared to those of many metropolises abroad, many people view the region as being one whole rather than merely a collection of smaller cities. Whether the Randstad really

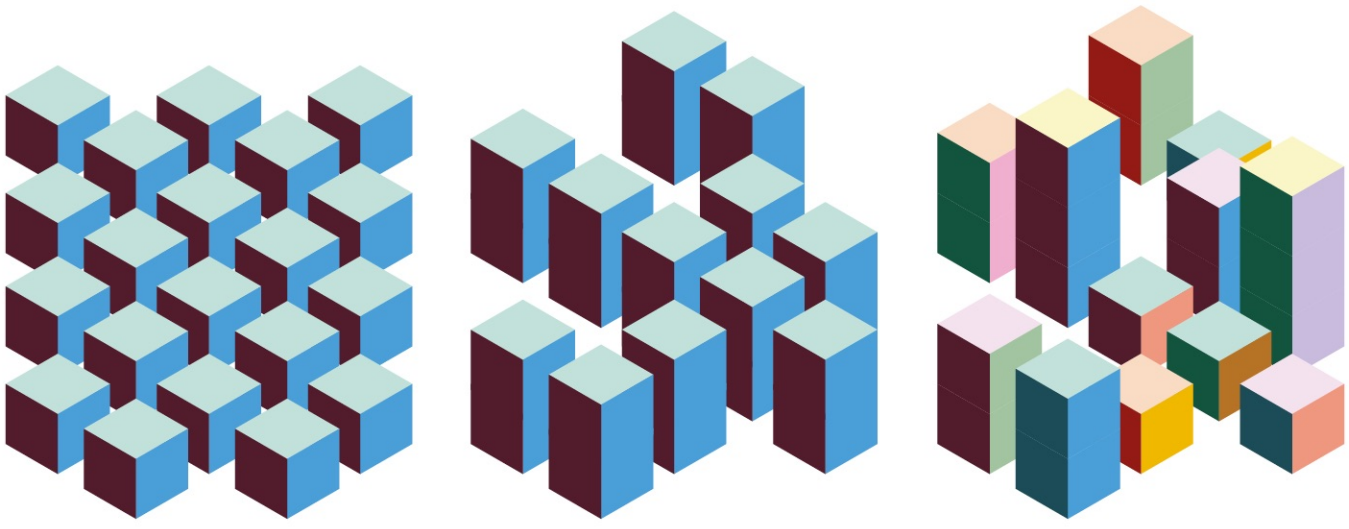


Figure 6.1. How much, where and how to densify?

operates as one, if the whole is greater than the sum of its parts and if that could be accredited to urban design and planning practices can be debated, but that urban areas often benefit from proximity to other settlements has been endorsed by the 'borrowed size' (Burger et al., 2015) concept. When cities establish alliances in such a way that they form a united system, it increases the economic success of the whole (Meijers et al., 2018). This is in line with the beforementioned characteristics which increase resilience of a system. When cooperation between the elements of a system is enhanced, the elements often become better interconnected.

What should not be forgotten, however, is that it also matters what the individual elements are like and how they relate to the rest of the system. Design and planning, especially on the larger scales, should happen in such a way that it improves, or at least is accordance with the structure in which the changed element exists. As Willems Jan Neutelings described the Randstad as a patchwork metropolis in 1989, each element in the patchwork operates as part of a system, which also means that urban transformations should be done with an awareness of the way it could alter this system (Neutelings, 2022). For the system to be(come) resilient, not only connectivity, but also diversity, efficiency, redundancy and modularity should also be thought of. While cities require a base level of certain attributes, cities that carry different specific qualities and functions often work well together. Striking is how, especially in the Randstad and in the Netherlands as a whole, many cities take a certain position in providing a service for the entire system, one which often also gives them a typical character or is used as a kind of 'branding' for the city. Of course, functions that are crucial for the performance of the system should not be carried out by one instance or city solely, as this only creates an Achilles' heel for the whole. Therefore, diversity should always go hand in hand with redundancy.

Particularly interesting for the way in which the region should densify, is the concept of efficiency. This characteristic can be described through the relationship of the quantity and the size of elements (Romice et al., 2020). Usually, the higher the ubiquity of an element, the more it is common and the smaller its size. This can be linked back to the levels of urbanity that are present in Gelderland and in many urban regions today, as there are many more smaller settlements than there are larger cities. This is important to acknowledge and consider in designing with densities, because where new developments are planned impact the size and quantity of certain (types of) settlements. The risk is that densification happens only or first in places where there is hypothetically more than enough room for it, in villages that are not so dense yet. If this were to happen, however, the distribution of the levels of urbanity that have formed through the 'natural' historical built-in efficiency could be changed in such a way that the resilience of the region could actually be decreased.

Taking these five concepts of resilience into account automatically has an influence on the way in which densification can still be carried out and different patterns emerge than if this was not the steering force behind development. If we relate resilience to the way in which urbanisation patterns have typically emerged in the past century, it becomes clear that in order for the goals for Gelderland to be met, a new path has to be forged. In many parts of the world, and especially in the Netherlands, sprawl has transformed large parts of regions into a new kind of environment, one which has been given many names, labels and characterisations. Whether we describe it with terms such as 'nor rural, nor urban', the horizontal metropolis, isotropy or the in-between city, the different definitions and discussions of the subject illustrate that when designing with(in) these types of environments, one should attempt to understand

and relate to the way in which it occurs (Barcelloni Corte & Viganò, 2022). While sprawl is a logical effect of the introduction and widespread use first of public transport and then of the motorcar, one could argue that it makes urban environments less resilient for multiple reasons.
When large stretches of land are transformed into environments of similar (lower) densities, built by similar types of housing, often without some kind of centrality, the environment transforms into a kind of homogeneous "mush" (Secchi, 2022). Perhaps partly due to the much more rapid transformation of the environment than the historically predominant incremental way of urbanisation, sprawled areas lack the diversity and efficiency that can be seen in older or denser settlements. Due to the homogeneous character, one would think the redundancy is very high, but in this case, the homogeneity actually puts more pressure on those elements or housing types of which there are less. The overrepresentation of single family homes (64% of the housing stock in the Netherlands, 74% in Gelderland (Centraal bureau voor de Statistiek (CBS), 2022)) is the result of planning practices in a time in which the family as a unit was the cornerstone of society, but as the population and the way in which people live together has changed and diversified over time, so should the buildings in which we live. The lack of suitable dwellings for a large part of the population, combined with the fact that continuation of sprawl worsens the dependency on the car, a good which less and less people can afford and want to and should use, makes that the search for new kinds of urbanisation is important.

What makes this search particularly essential in the case of Gelderland, and also for the Netherlands for that matter, is the scarcity of space. One quite basic and obvious reason why unlimited sprawl is unsustainable, is because it treats space as if that is unlimited as well, as many societies handle other resources similarly. The truth is, however, that space is a very limited and an increasingly scarce resource, and by using it in ways as if it is not leaves us with literally less room for answering to possible future demands and unforeseen circumstances. Scarcity of essential goods leads to vulnerabilities and a diminish of the adaptive capacities of a system and could only aid in increasing resilience if the (eco)system learns how to use resources in a different, more efficient manner. This also seems to be the task we, as urbanists, have laid out in front of us.

Therefore, the project proposes the formulation of a regional strategy which aims at retaining a balanced distribution of levels of urbanity. One logical way of moving forward with this is the creation of new levels of urbanity and adaptation of existing levels to one level higher. This can be done in different ways (Figure 6.2), but in which way this could and should be planned for and with, should also be informed by what kinds of transformations are possible and desirable on a smaller scale.

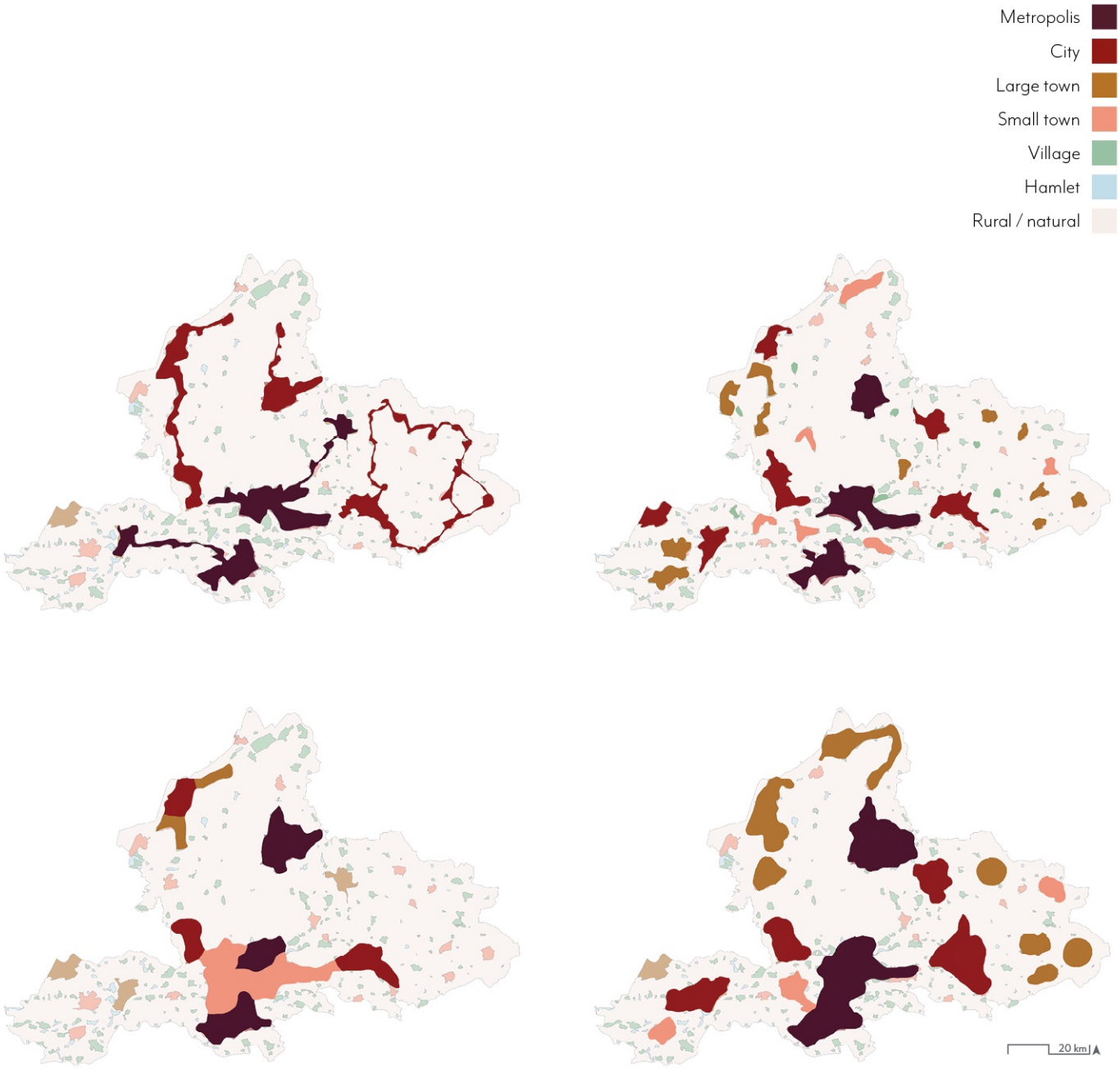


Figure 6.2. Design sketches: how the level of urbanity could change

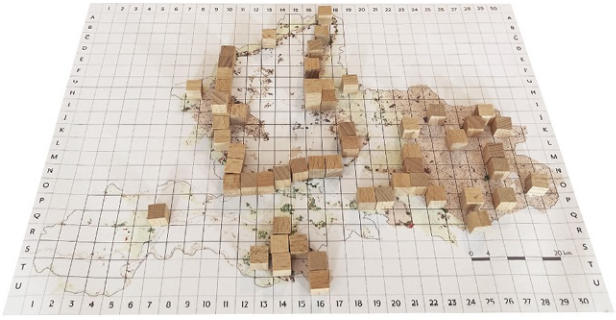
Distributing density

To start to develop an idea of what kinds of densities will be necessary in which locations, a physical model with small blocks is used to test different distributions of density. The blocks are placed within a grid that is laid over the maps representing the meaning of densification for each of the scenarios from the previous chapter. Each block represents an addition of 50.000 people and as each grid cell is 4 by 4 km, the added population density per block would be 3125 residents per square kilometre. For comparison: the population density of the municipalities of Utrecht is about 3900, in Amsterdam 5300 and for Den Haag it is around 6700 people / km2. Adding a block would thus mean a quite significant increase in density, one which seems quite extreme at first. When placing all the blocks necessary to fulfil the demand that is required within the scenarios, however, it becomes clear that most of the areas that were identified as suitable for densification are needed to answer to the needs. Of course, this test represents just an abstract simplification of how the population could be distributed and there would also live more people in areas that are not marked with a block, but the exercise did make clear which locations will be important and about which kinds of densities we should think when zooming in.

1 block: + 50.000 people
added population density = 3125 / km^2

2 blocks: + 100.000 people
added population density = 6250 / km^2

Business as usual



Overlay of all scenarios

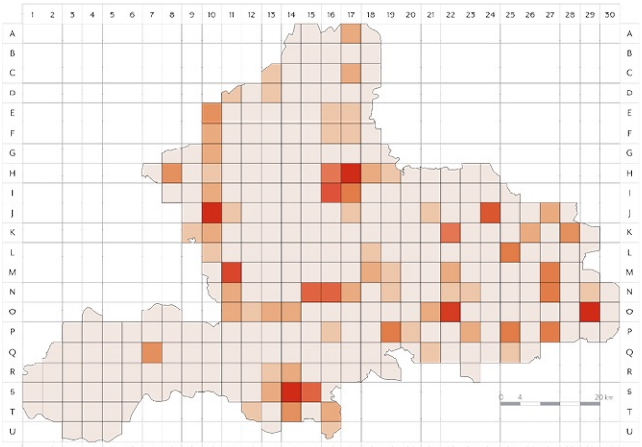
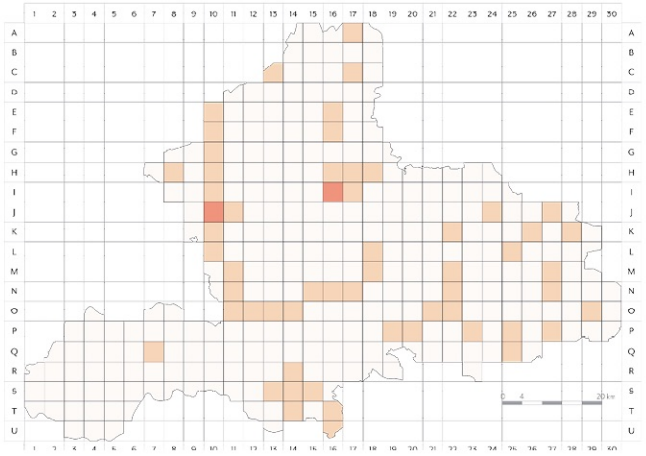


Figure 6.3. Testing with density distributions, test setup and result of all scenarios

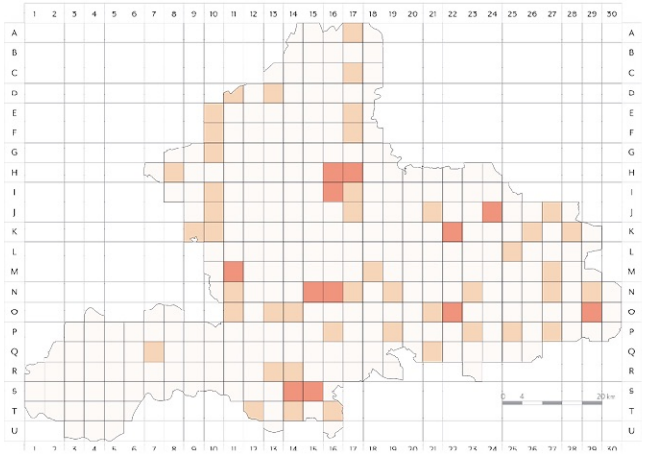
1 block: + 50.000 people
added population density = 3125 / km²

2 blocks: + 100.000 people
added population density = 6250 / km²

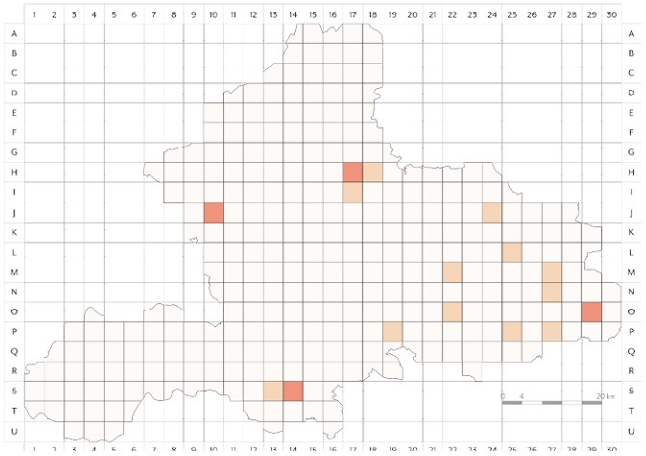
Power to the people



Business as usual



Nature first



Living in harmony

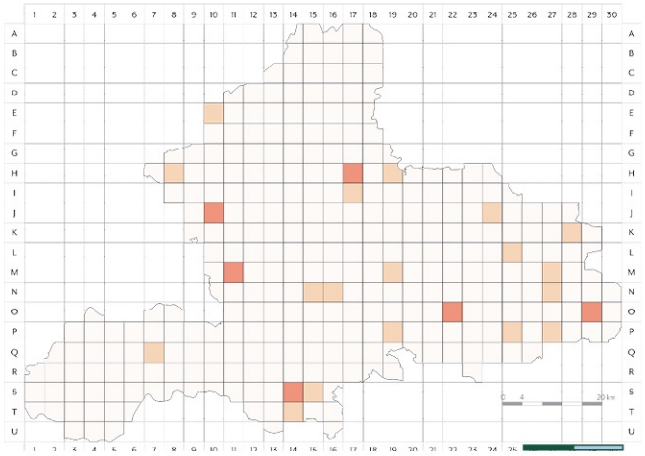


Figure 6.4. Testing with density distributions, outcome per scenario

Connectivity

As mentioned, one of the important elements in creating a resilient region, is connectedness. For this reason, an improvement and extension of the rail network is necessary. Currently, many locations are actually quite close to a train station, but most of the connections are focused on bringing people from smaller settlements to the closest larger town or city. Before the region can begin to operate as an efficient, interconnected system, and become greater than the sum of its parts, more connections have to be established. Especially before Doetinchem (and other towns and cities) can grow to support surrounding settlements, it is important that people from around the region can reach them quite directly. As this is something that has implications for how and where transformations could take place on the smaller scale levels, an updated version of the rail network is already proposed (figure x). The change is mostly an extension of what is there: better linkages between settlements in de Achterhoek (from Doetinchem and Varsseveld through Zelhem and Hengelo to Vorden, an extra line from Terborg via 'S Heerenberg to Zevenaar) and an extra line to connect the northern and middle-eastern part of Gelderland (from Putten to Barneveld).

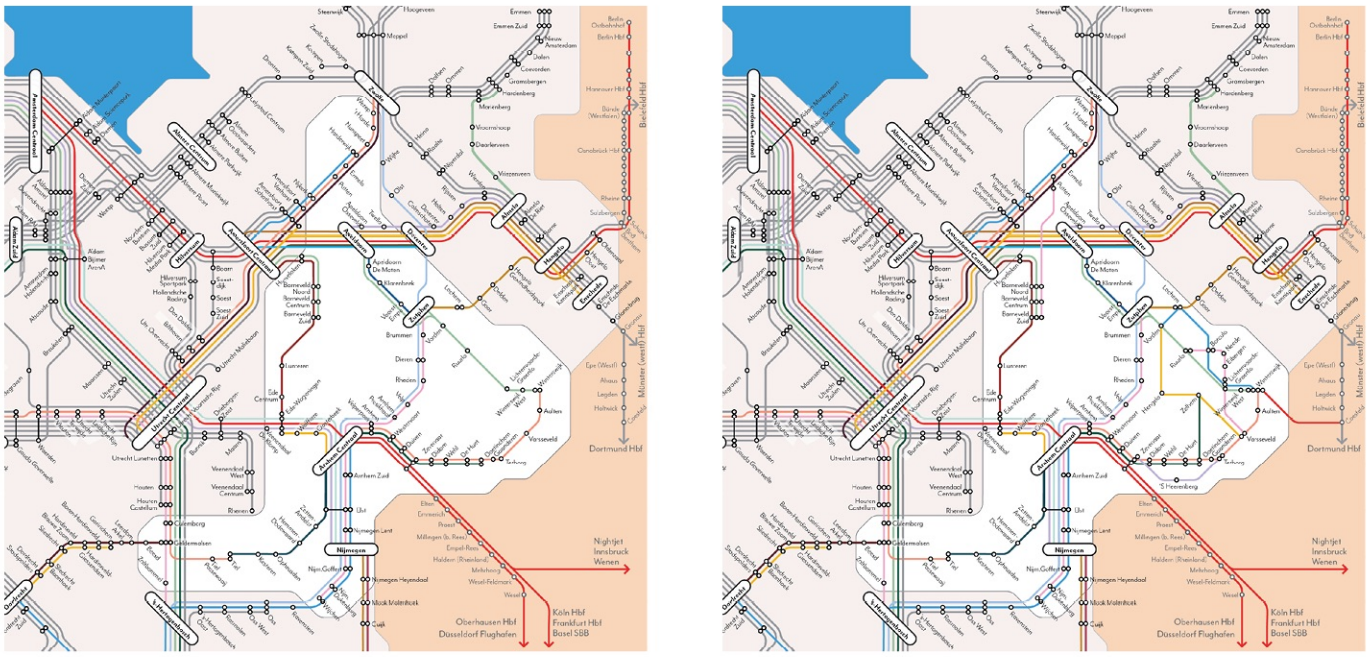


Figure 6.5. The current and the newly proposed rail network

One of the locations that pops up in the testing is the region around Doetinchem, a city that is situated on the boundary of three historical geographic regions (IJsselvallei, Graafschap and Montferland). The municipality of Doetinchem is no part of a NOVEX-area, and thus no part of any national or regional planning policies. As it is the most eastern situated large town of the province, however, it is an important link from the larger cities Arnhem, Apeldoorn and Nijmegen and the Randstad to de Achterhoek and Germany (Figure X). As can be seen from the overlay of the density test of all the scenarios, the Achterhoek could prove to be an important region in looking for ways to answer to the future pressure on space. As this region momentarily constists mostly of very small settlements and has very low levels of density, it seems logical to see Doetinchem as a possible instigator of change. Once Doetinchem grows in size and becomes a city, it could start to support growth in the surrounding region as well.

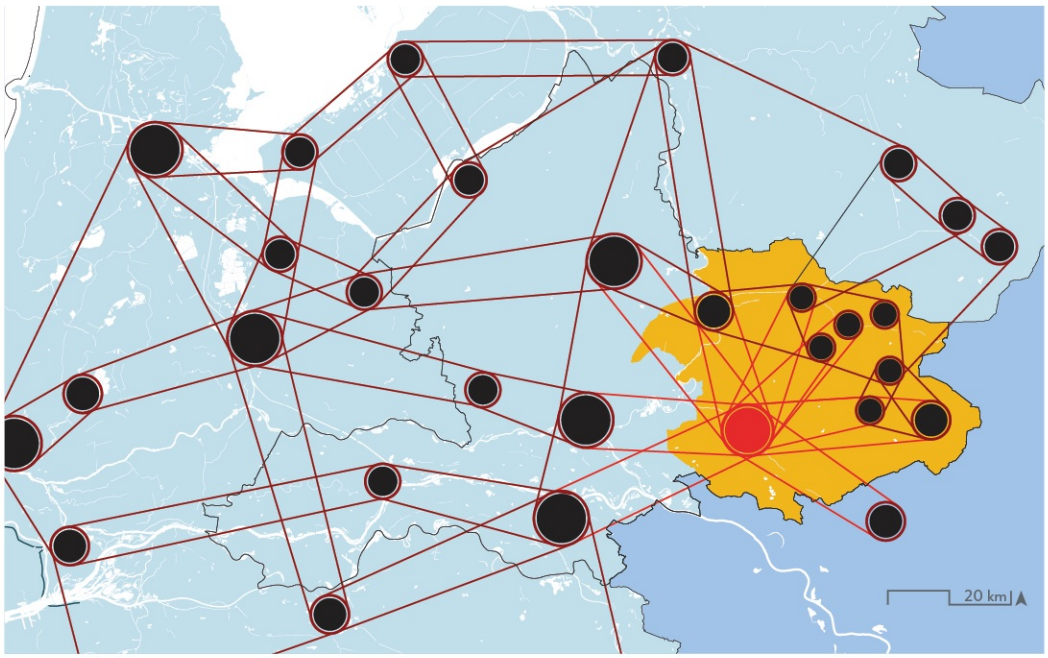


Figure 6.6. Doetinchem and its place in the system

6.2 REGIONAL DEVELOPMENT

To see what kind of population growth is possible in the region, it helps to compare population sizes and physical dimensions with other cities. The maps show different cities projected onto the map of the Doetinchem region in the same scale. Even though a 4-,6 or 9-fold increase in population for a city of 60.000 inhabitants seems disproportionate, the maps reveal that there is not that much extra space needed to house many more people. Of course, these cities grew slowly over a large amount of time, and the question remains if attempting to have Doetinchem grow to these kinds of proportions is desirable. Nevertheless, it shows that it could be done, if the circumstances require it, especially when one considers the fact that Dutch cities are not yet nearly as dense as many cities abroad. Figure 6.9 shows how (population) density can be linked to other characteristics, like spaciousness and height levels of buildings. More people mostly means that buildings have to become higher, but not all neighbourhoods should have the same characteristics. Becoming more dense therefore also means a differentiation of urban environments.

Doetinchem: 60.000 inhabitants

Eindhoven: 243.000 inhabitants

Figure 6.7. Net building blocks within municipal borders projected onto the aerial view of the Doetinchem region. Data from Centraal Bureau voor de Statistiek, 2021; Planbureau voor de leefomgeving, 2022

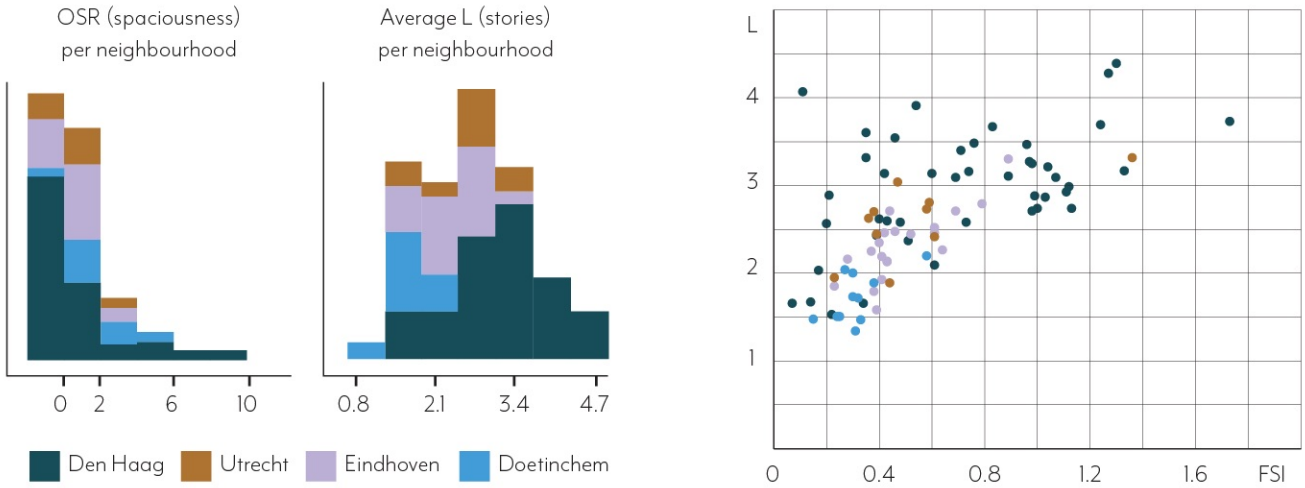


Figure 6.9. Attributes of density per neighbourhood. Data from Centraal Bureau voor de Statistiek, 2021; Planbureau voor de leefomgeving, 2022

Utrecht: 368.000 inhabitants

Den Haag: 562.000 inhabitants

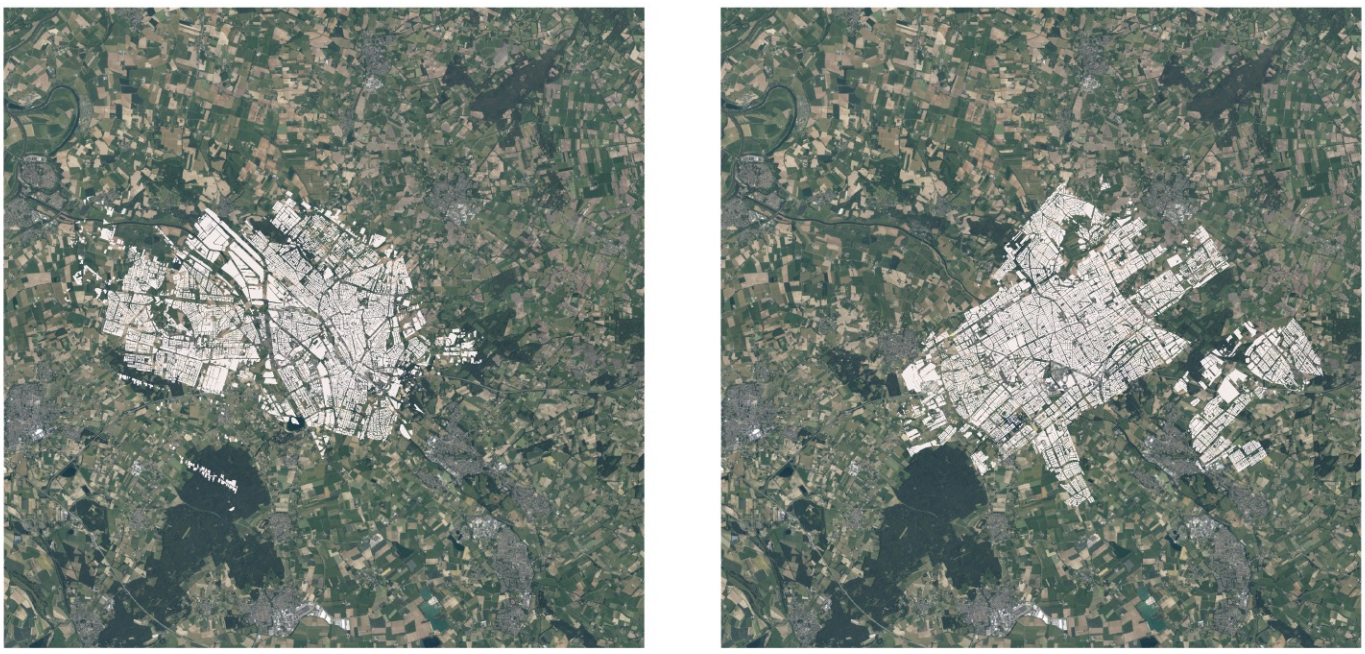


Figure 6.8. Net building blocks within municipal borders projected onto the aerial view of the Doetinchem region. Data from Centraal Bureau voor de Statistiek, 2021; Planbureau voor de leefomgeving, 2022

The region around Doetinchem is a collection of smaller villages and towns scattered around the city. While most are historical settlements that lie isolated in the landscape, the settlements around Doetinchem have started to grow together more (Figure 6.10).

Figure 6.11 shows the types of existing environments one scale level lower, a categorisation which was made through analysis of the MXI, GSI and FSI. It reveals that only larger settlements show the urban residential type and contain a larger diversity of environments.

Relating the level of urbanity to the situation in the landscape reveals that the larger settlements are all located along or close to the water. Even though this region has a long history of dealing with floods (Figure 6.12), it also was a key to success and growth, as water has always been a requirement for (urban) life. Now that our relationship with water has changed tremendously over the past centuries, and even more so in the last decades, it is also important to establish what the new relationship with water will be, if and how this should shape urban growth.

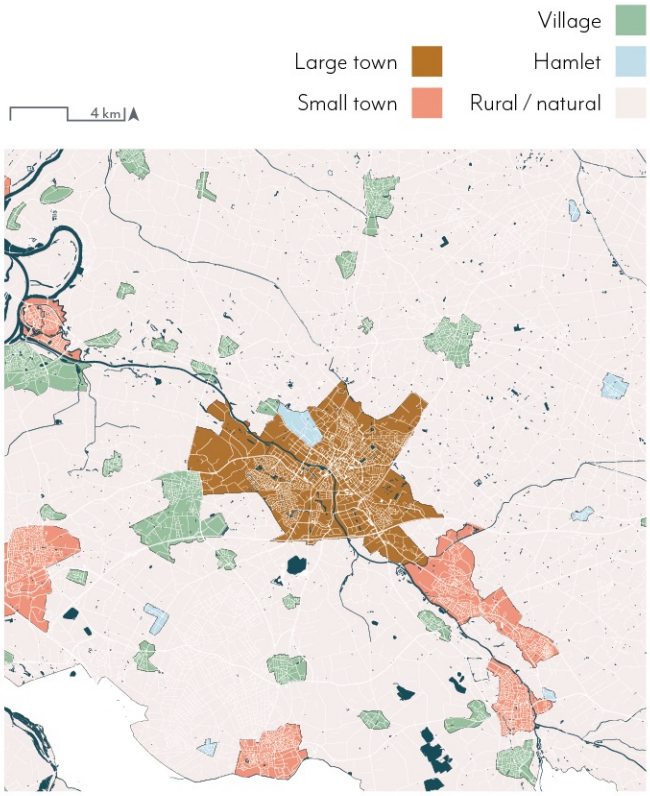


Figure 6.10. Level of urbanity

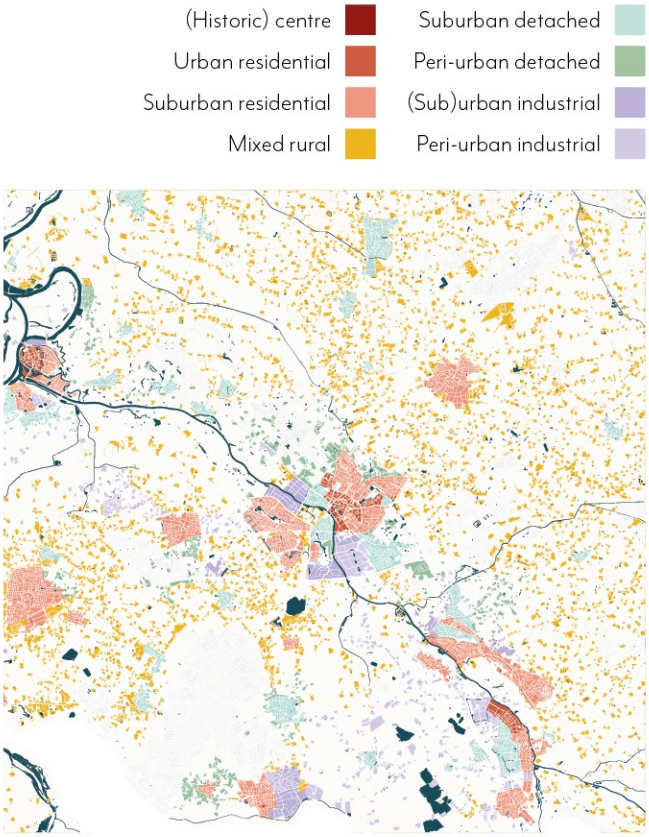


Figure 6.11. Type of environments. Data from Centraal Bureau voor de Statistiek, 2021; Planbureau voor de leefomgeving, 2022

When comparing the historical landscape with which areas are suitable for densification now (Figure 6.13), we can see that the features that were problematic for urbanisation then, are still what dictates where we could and should not build. Though the Dutch have interacted with the landscape as if it is completely malleable for a long time, it is important to realise that our way of inhabiting the landscape is a mere snippet of time in comparison to the time that the original landscape has been there and the time that it took to be formed in this way. The geological and ecological processes that exist have a longer cycle than we can often grasp, therefore it is helpful to acknowledge them and define how we relate to them. Analysing the structures that have existed for a long time can help us in determining how to move on into the future, as these elements of a higher time and space scale are also intrinsically of a more stable nature.

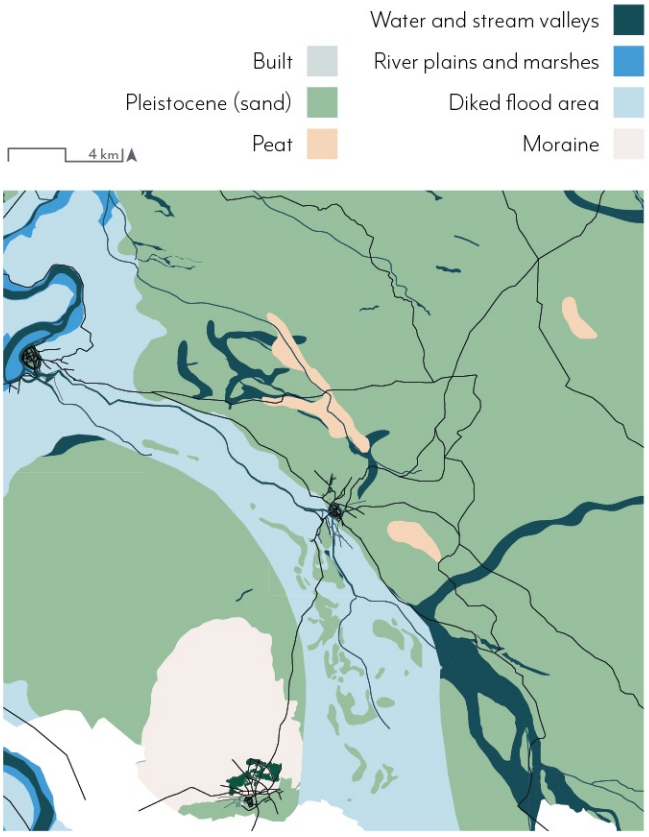


Figure 6.12. Paleographic landscape, cities and networks in 1575. Data from Nationaal Georegister, n.d.

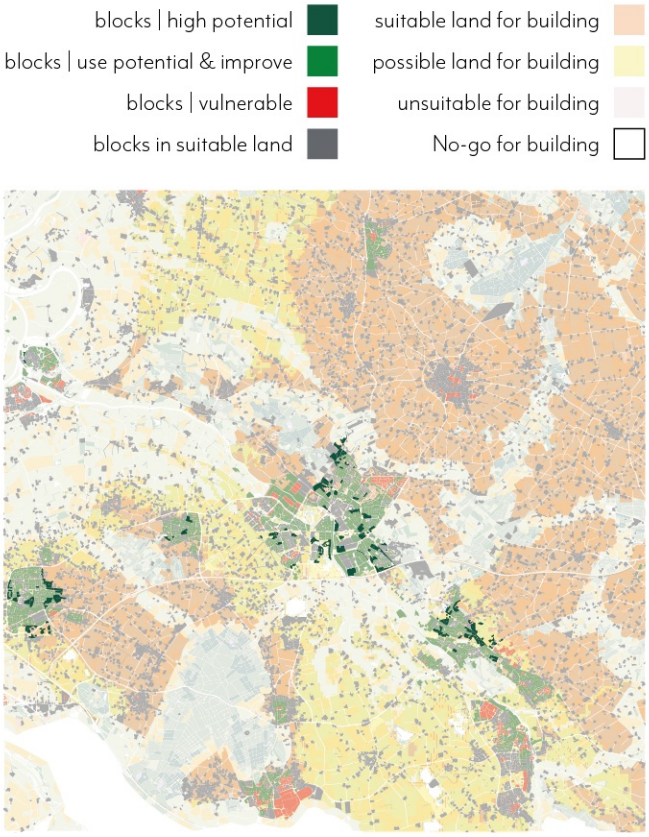


Figure 6.13. The meaning of densification of blocks and urbanisation of land

One way of starting to describe and design where densification could take place is to first establish those locations where it should not. Deciding which (natural) structures should be kept, protected and/or extended can aid in the formation of a regional plan and strategy, as its negative form is something we can work with as matter. By looking at projects such as OMA's example of the masterplan for Melun Senart (OMA, n.d.), we can see how this definition of the void can steer a creative process.

By reserving extra space for nature over time and taking the inverse form of the latest phase as the space we can build on/with, the project can be not only an instigator of change for urban environments, but it can also be assured that ecosystems are not further confined. Because it is yet unsure which scenario will be closest to reality, the form that should be exempt from urban development is not considerate of these possible futures. There are certain resolutions that would be the wiser ones no matter how big the pressure on space is or what the economic and societal circumstances are, and the decision that we should be protective of ecological zones is one of them.

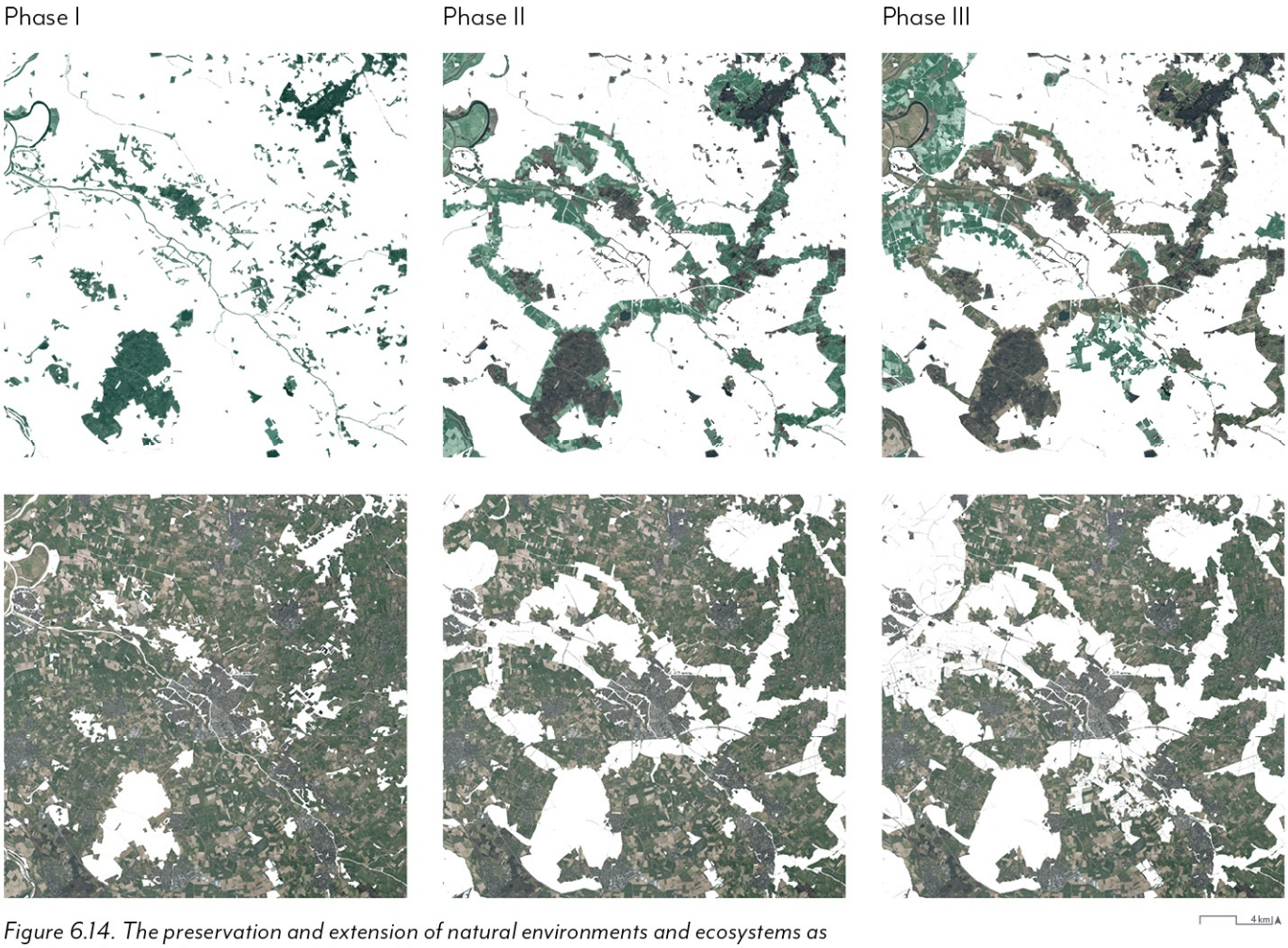


Figure 6.14. The preservation and extension of natural environments and ecosystems as guidance for densification possibilities and strategies.

By combining the levels of urbanity, the existing type of environments, the possibilities for densification, the averting of risks and the ecological system into a plan, we can come to solutions that are durable and in line with the vision and goals for the whole province. The resulting map shows that many existing settlements should densify in some way, but there are also areas into which these settlements could further extend if it is needed. Another important element is the formation and accumulation of small built-up areas into new, small settlements. These newly emerging hamlets and villages should be included in the strategy, because they ensure that the variety and diversity of settlements and environments stays intact or is elaborated, and that the efficiency of the system as a whole does not become imbalanced. Of course, these places do not have to look, feel or function in the same way as places of a comparable size do today. These places are actually a great opportunity to test how people could live together in different ways; more harmoniously with nature, in different kinds of collective communities, around certain kinds of work, etc. Due to the new rail road and train stations, these new places can still be formed in places that are easily reachable by public transport and bike.

Of course, not all settlements should be densified or extended in the same way or to the same extent. To determine what the options for and limits to urban growth are, we have to zoom in to the urban scale, first.

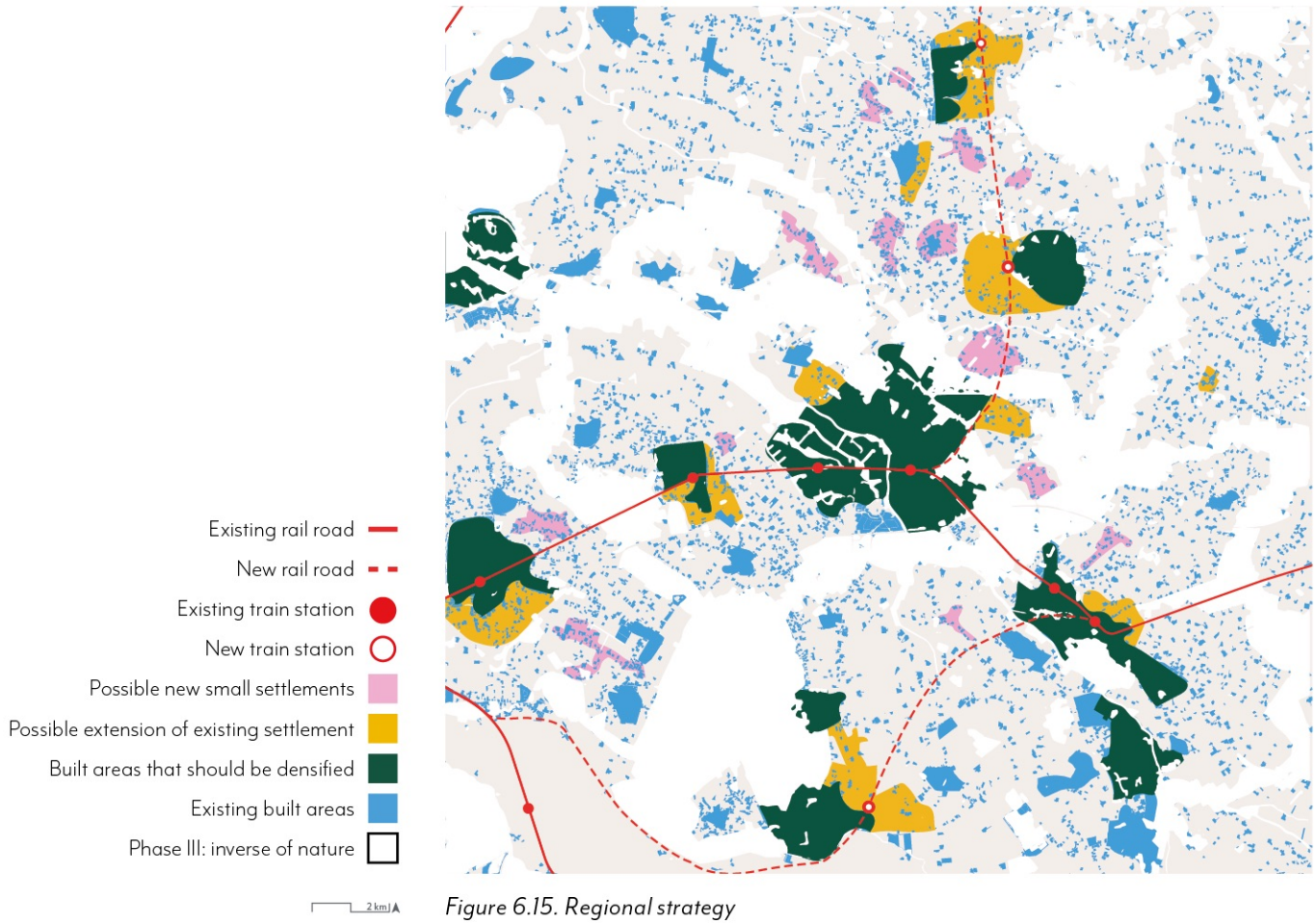


Figure 6.15. Regional strategy

6.3 SPATIAL STRUCTURES

What are the existing physical elements in the current urban environment?

To be able to start to form an idea of which kinds of transformations could be possible, it is important to first look at which physical structures exist within the environment. For this reason, a categorisation is made of the existing buildings and possible drosscapes. Whether these elements will really be suitable for transformation, is dependent on many factors, but the ones identified do form a good base to start with. The drosscapes that are shown represent places that either have a relatively little ecosystem services, such as the scattered patches of grass, could become obsolete, such as parking lots, or could have a change in use, such as public facilities, sports fields and industrial zones.

The buildings are categorised based on different qualities. Some are easier to transform in small ways, such as buildings with a flat roof. Others are important to identify because they make up a very large part of the housing stock, like row houses. (Semi-)detached houses and sheds are included because these are often built in environments of very low densities, and could be relatively easily extended, split or given a new meaning. Buildings with a large footprint but that are very low, such as supermarkets, are a missed opportunity because having dwellings on top of these kinds of buildings is often a win-win.

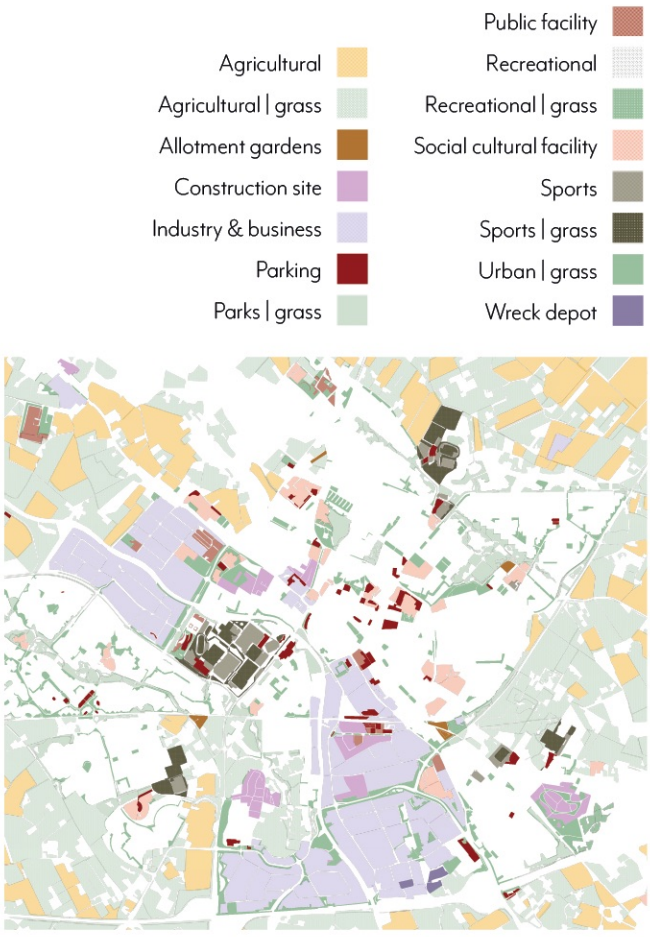


Figure 6.16. Possible drosscapes Data from Centraal bureau voor de statistiek (CBS), 2022; Kadaster, 2020

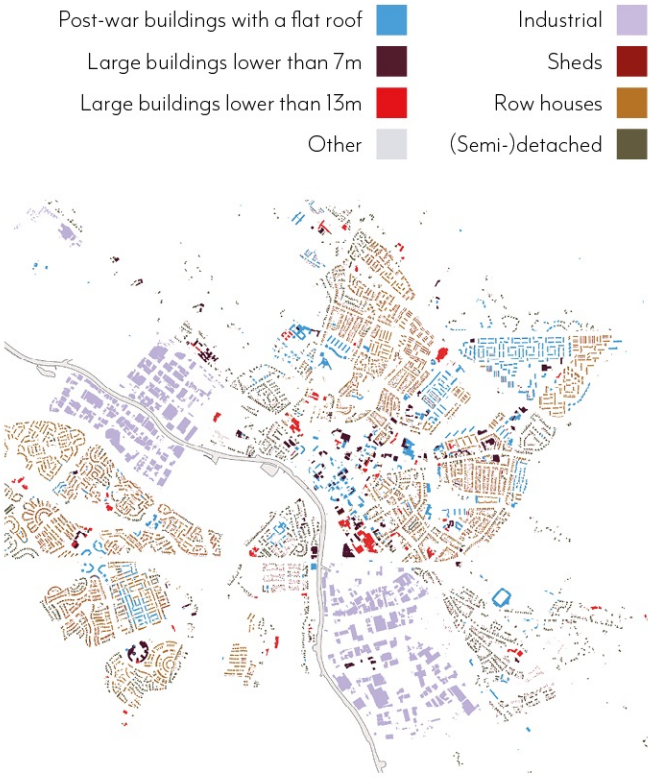


Figure 6.17. Building types. Data from Kadaster, 2020; Planbureau voor de leefomgeving, 2022; tudelft3d, n.d.

Which structures, locations and buildings have potential for densification?

The identified physical elements can be further filtered on whether they would be suitable for densification by including what the meaning of densification would be in case they were transformed. When they are merged into one image, it becomes clear that in the most part of the city there are possibilities for densification and that many elements are grouped within one block or even within a neighbourhood. Some locations are part of a type, as they exist in many parts of the city, make up a large part of it or are probably also located in many other cities throughout Gelderland.

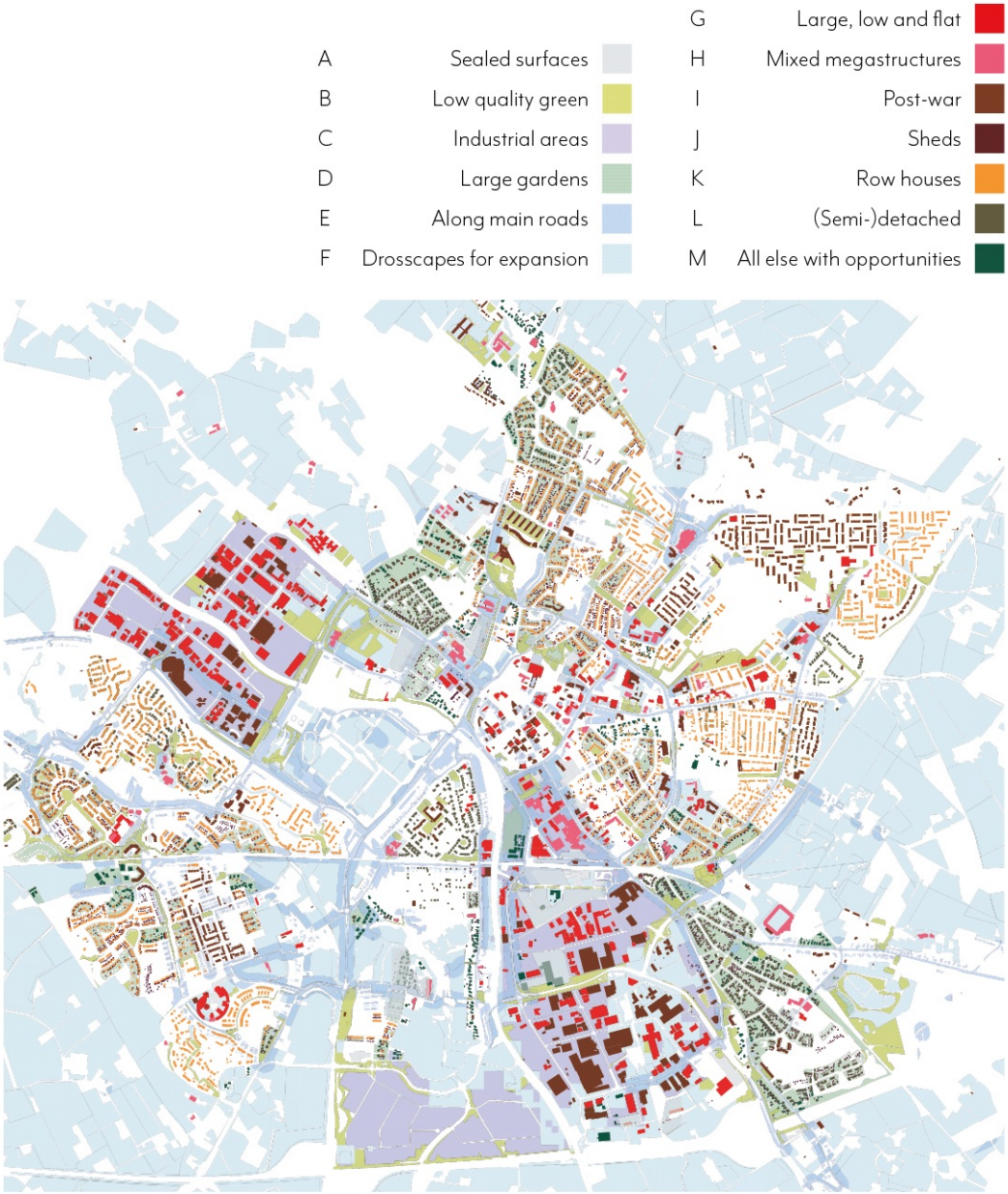


Figure 6.18. Elements with certain potential for densification

Characteristics \ Name		A Sealed surfaces	B Low quality green	C Industrial areas	D Large gardens	E Along main roads	F Drosscapes for expansion
Description	Type of structure	Drosscape: construction site / parking / extraction site / semi-paved / wreck depot	Drosscape: grass in urban and semi-urban areas	Drosscape: industrial zone	Drosscape: open space within a building block	Any structure within the 80m buffer zone around the 10% most central streets and main roads > 4 m wide	Parks, allotment gardens, forest and natural terrains
Scale level							
District	Type of neighbourhood						
	Services credits				> 100		
Block	L			< 2		< 3.5	
	FSI			< 0.6		< 2	
	GSI				< 0.35	< 0.6	
	MXI				> 0.8		
	Transport credits	>= 100	>= 80	>= 80	> 60	<2500 m to a train station	> 50
	Densification strategy						
Building	Height						
	Footprint						
	Roof type						
	Year of construction						

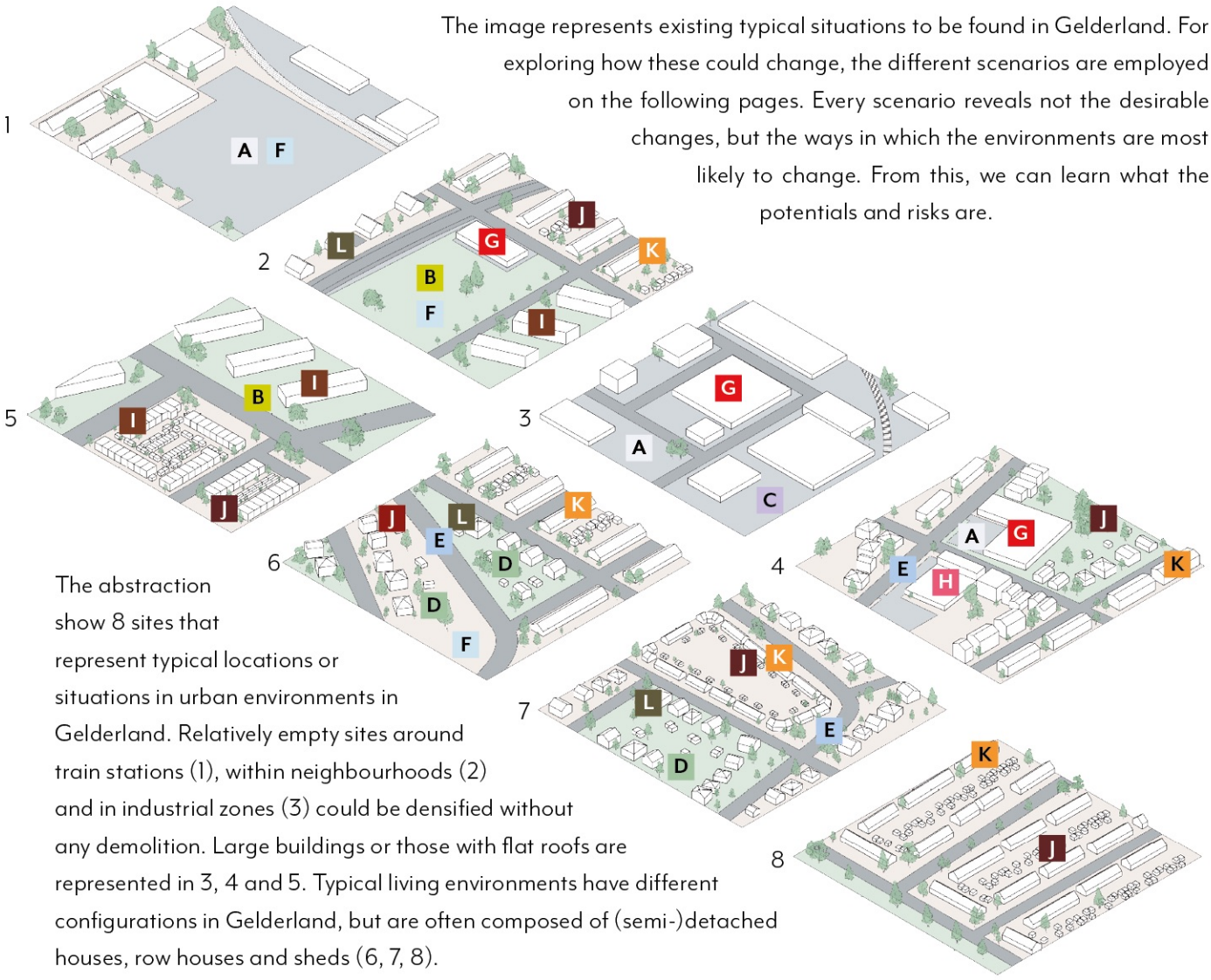
Figure 6.19. An overview of the characteristics on which the different elements with potential for densification are based

G Large, low and flat	H Mixed megastructures	I Post-war	J Sheds	K Row houses	L (Semi-)detached	M All else with opportunities	
Large buildings in blocks with more than 100 m2 of shopping: supermarkets, shopping centres, etc.	Other large buildings that are not dwellings and not in industrial sites: schools, hospitals, etc.	Post-war buildings with a flat roof	Sheds and small buildings in gardens in urban environments	Row houses in urban environments	(Semi-)detached housing in urban environments	All other buildings that have opportunities for densification	Type of structure
Non-rural	Non rural, non industrial		Non-rural	(Sub)urban residential	(Sub)urban residential and detached		Type of neighbourhood
			> 120				Services credits
	< 3.5						L
	< 1.5			< 0.8	< 0.8		FSI
			< 0.4				GSI
< 0.95	< 0.8						MXI
>= 80	>= 60	>= 60	>= 80				Transport credits
				Potential / improve / vulnerable	Potential / improve / vulnerable	Potential	Densification strategy
< 7 m	< 13 m	< 11 m	< 7 m	< 10 m	< 12 m		Height
> 300 m2	> 300 m2	> 40 m2	< 30 m2	between 30 and 90 m2	between 50 and 250 m2		Footprint
Flat		Flat					Roof type
		1945 - 2000					Year of construction

A	Sealed surfaces	G	Large, low and flat
B	Low quality green	H	Mixed megastructures
C	Industrial areas	I	Post-war
D	Large gardens	J	Sheds
E	Along main roads	K	Row houses
F	Drosscapes for expansion	L	(Semi-)detached
		M	All else with opportunities

The places that pop up as typical from the map with the elements with potential for densification are abstracted to be able to work with them on a conceptual and methodological level, without worrying about the possible very local or unique constraints that a certain location may have. Through the abstraction we can learn about possible transformations that can be applied to many locations, with alterations that fit the specifics of the site. This increases the transferability of the solutions that are found.

The image represents existing typical situations to be found in Gelderland. For exploring how these could change, the different scenarios are employed on the following pages. Every scenario reveals not the desirable changes, but the ways in which the environments are most likely to change. From this, we can learn what the potentials and risks are.



The abstraction show 8 sites that represent typical locations or situations in urban environments in Gelderland. Relatively empty sites around train stations (1), within neighbourhoods (2) and in industrial zones (3) could be densified without any demolition. Large buildings or those with flat roofs are represented in 3, 4 and 5. Typical living environments have different configurations in Gelderland, but are often composed of (semi-)detached houses, row houses and sheds (6, 7, 8).

What kind of transformations and densification methods can be thought of?

Starting to imagine how densification could take place, it is helpful to have an overview of the possible methods. Whether a method has a large impact on the physical structure, defines if it can be characterised as 'hard' or 'soft' densification. Soft densification often happens on a very small or local scale and consists mostly of incremental changes. Hard densification is more often than soft densification part of a larger (master)plan and has the power to completely change the character and layout of an environment. Hard densification also often has a larger environmental impact, especially when buildings first have to be demolished.

When we relate the different methods to the concept of resilience, it might look as if hard densification is not the way to go. Resilience emphasizes the importance of change being either relatively slow and incremental, or to happen on a small scale. As this is exactly what soft densification is about, one might wonder whether we should abandon the concept of hard densification altogether. When the pressure on space becomes as high as expected within the illustrated scenarios, however, the amount of small densification interventions necessary becomes so high that not it not only is unfeasible, it is also often less space-, cost-, and resource effective. The approach should be viewed similarly as with the construction of a building: it might seem more sustainable to refrain from the use of concrete and steel structures, but with certain dimensions and types of structures, timber is just not a suitable material.

Especially when we review the many advantages and disadvantages of the different ways in which densification could take place (Pelczynski & Tomkowicz, 2019), it becomes clear that there is not one correct or best way. As with many design solutions, it is about finding a suitable solution for the specific location and circumstances. Most likely, the solution that will lead to an increase of resilience in the province is a diverse one. What the different methods do clearly show, however, is that some methods are more obvious for some buildings or environments than others. Vertical extension, for example, is a lot easier to be done when the building has a flat roof and in environments where there are hardly any buildings, hard densification is often the only (sensible) option.

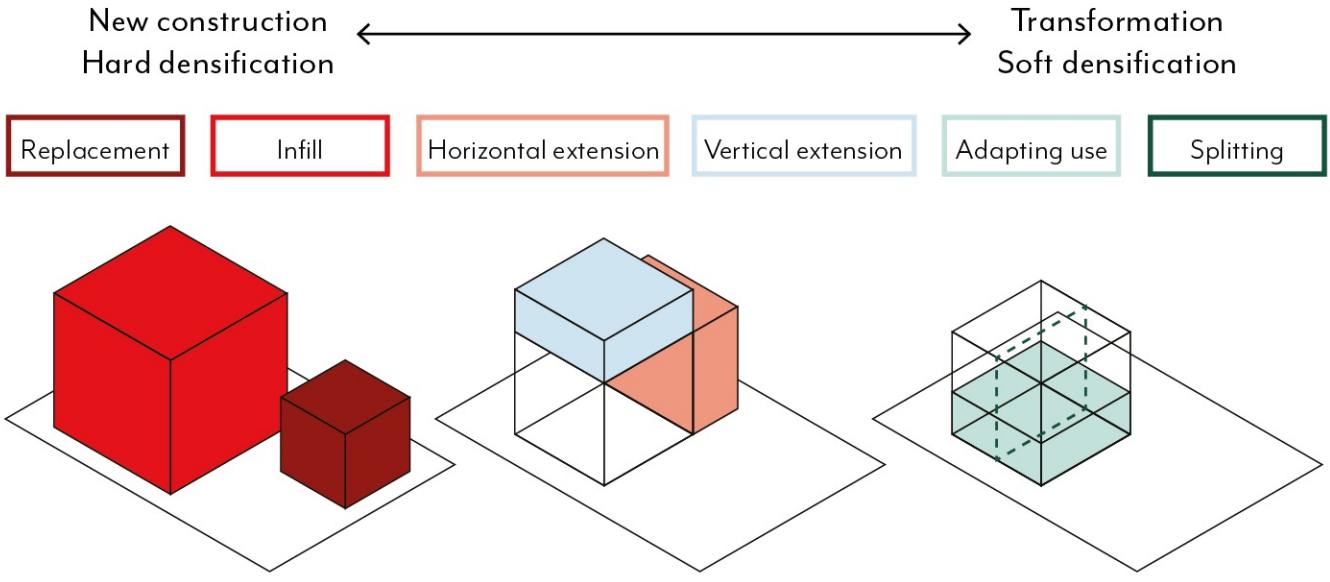
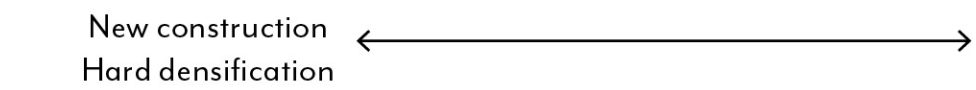


Figure 6.20. Methods of densification

Scenario: power to the people

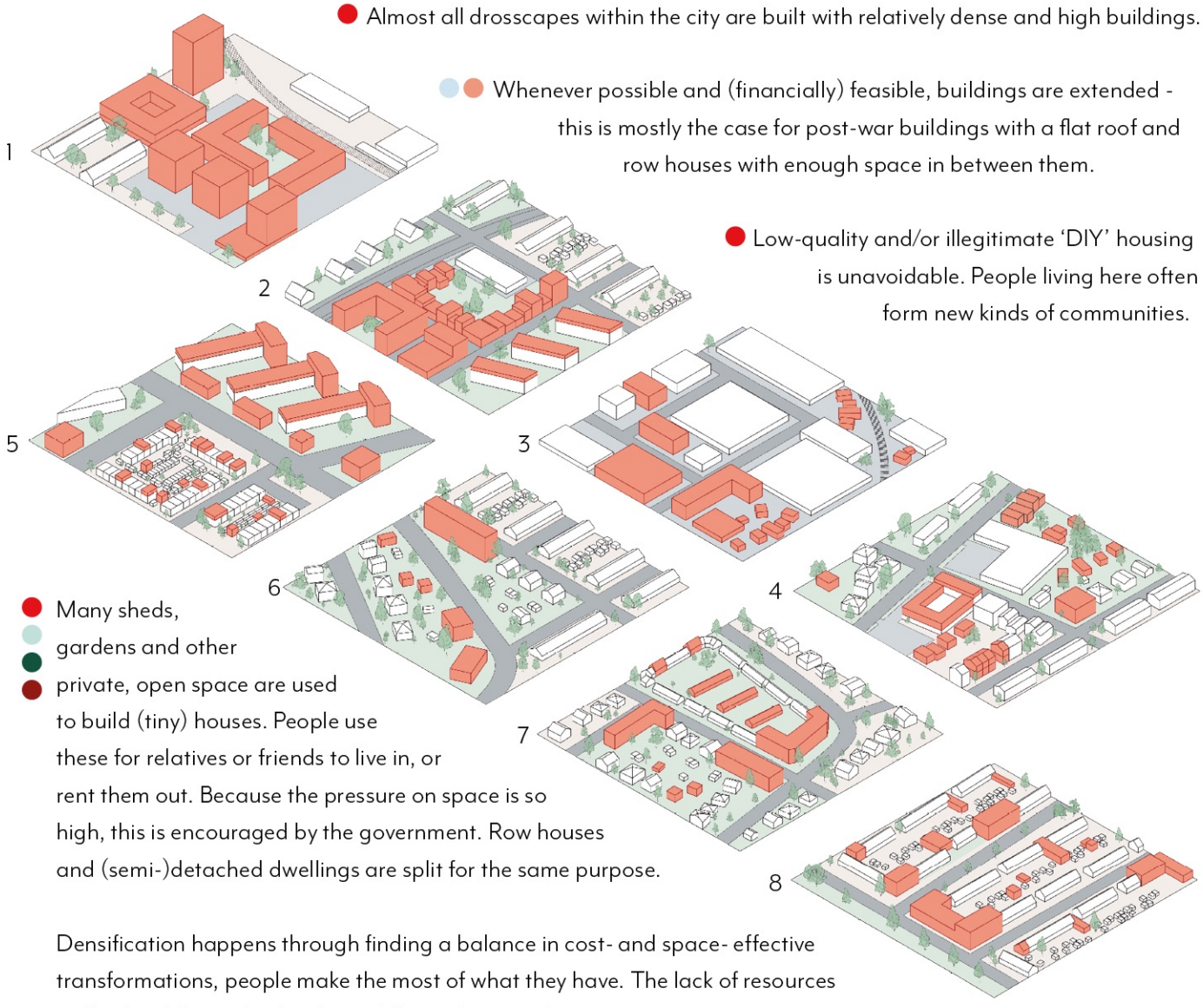
New construction
Hard densification



Transformation
Soft densification

Replacement | Infill | Horizontal extension | Vertical extension | Adapting use | Splitting

Development is steered both bottom-up as well as top-down: people demand more (social) housing, housing corporations and the government do everything they can to fulfil the demand. Because the pressure on space is so high, many people are forced (or stimulated through funds) to split their home or build extra space for housing on their property.



- Almost all drosscapes within the city are built with relatively dense and high buildings.
- Whenever possible and (financially) feasible, buildings are extended - this is mostly the case for post-war buildings with a flat roof and row houses with enough space in between them.
- Low-quality and/or illegitimate 'DIY' housing is unavoidable. People living here often form new kinds of communities.
- Many sheds, gardens and other private, open space are used to build (tiny) houses. People use these for relatives or friends to live in, or rent them out. Because the pressure on space is so high, this is encouraged by the government. Row houses and (semi-)detached dwellings are split for the same purpose.

Densification happens through finding a balance in cost- and space- effective transformations, people make the most of what they have. The lack of resources makes for different kinds of social dependency and communities.

Due to a lack of (financial) resources, people (have to) make the most of what they have. This leads to creative solutions, such as people extending their own homes or building on their private property. Because the demand for (social) housing becomes high enough, there is an incentive to build relatively dense: the construction of (detached) single family homes is brought to a halt, and buildings with a medium-high density arise. Due to the fact that developers and housing cooperations investing in social housing have limited resources, these developments are relatively incidental. Buying and demolishing or transforming existing buildings is very expensive and therefore often unfeasible, which means that the densification does not necessarily happen in the best or most logical places.

To avoid negative consequences of these kinds of development and use the potential, it would be helpful to not allow densification just anywhere and in any way. To ensure housing standards remain acceptable, the government should inform and aid in the ways of how people can create extra living space. By reserving subsidies for the extension of buildings or the construction of tiny houses in gardens, there can also be more supervision and control.

Figure 6.21. Amount of space needed in the 'power to the people' scenario. Calculations to be found in the appendix.

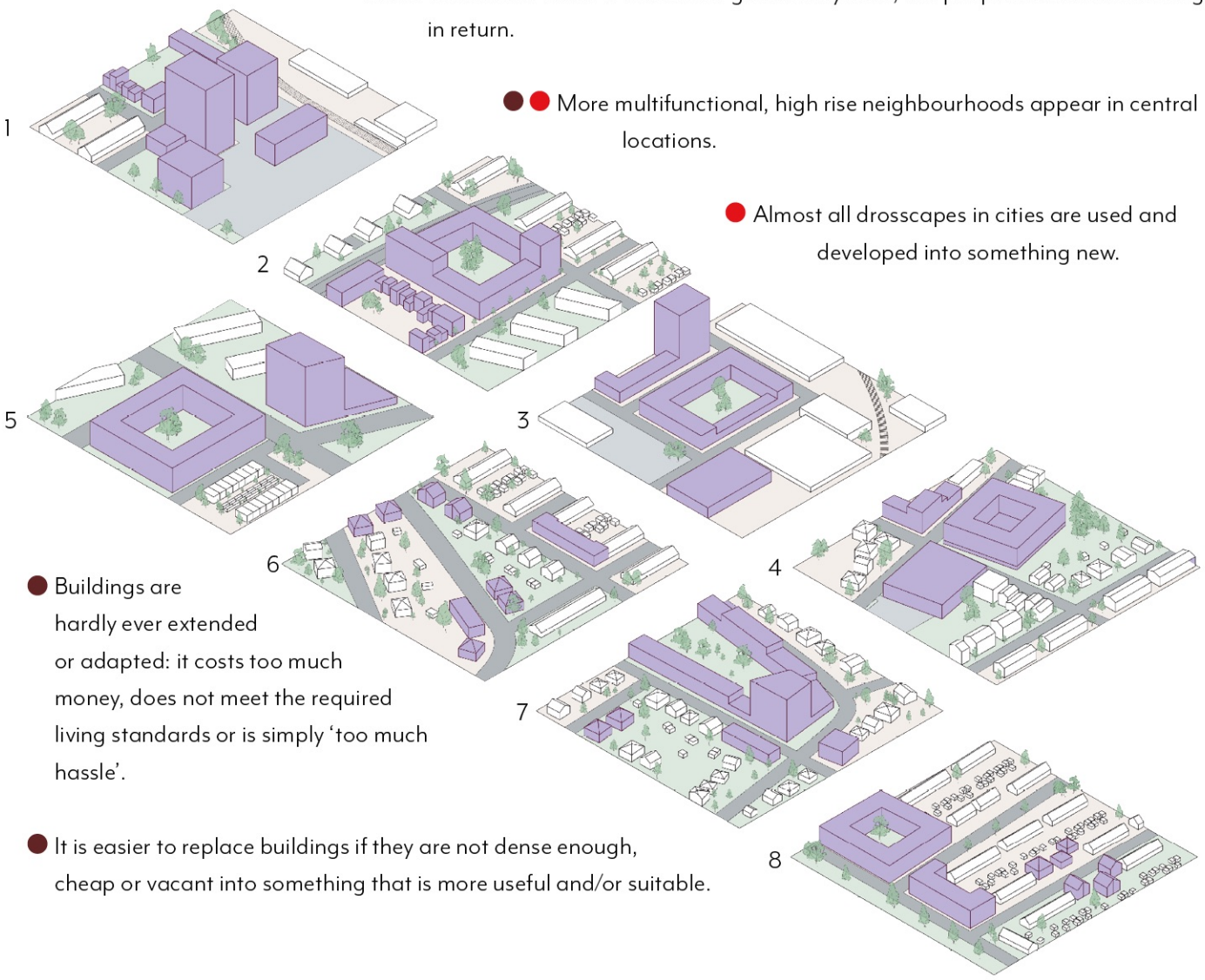
Scenario: business as usual

New construction
Hard densification

Transformation
Soft densification

Replacement | Infill | Horizontal extension | Vertical extension | Adapting use | Splitting

Development is mostly focused on prosperity: the free market is unrestricted, and the government helps companies to thrive. Densification projects are not aimed at being in tune with the demand, but provide larger, more luxurious and more detached dwellings than necessary. Cities are transformed to become denser, however, because the pressure on space and available financial resources make it possible for high-quality high rise projects to be realised. Not everyone wants or needs to live in a villa with a garden anymore, but people do want something in return.



● ● More multifunctional, high rise neighbourhoods appear in central locations.

● Almost all drosscapes in cities are used and developed into something new.

● Buildings are hardly ever extended or adapted: it costs too much money, does not meet the required living standards or is simply 'too much hassle'.

● It is easier to replace buildings if they are not dense enough, cheap or vacant into something that is more useful and/or suitable.

In order to be able to realise projects of high density and quality, it is necessary for dwellings in the higher segments to also be realised. To ensure that everyone can afford a place to live, there should of course be a healthy balance between social and free market housing, which is why it is important that there are regulations in place to make sure that developments are in line with how many and which types of dwellings are needed. Other risks of developments through hard densification only are gentrification, functional diversity, loss of character and identity, water management issues, UHI, loss of biodiversity, etc. As mentioned before, the densification methods should be a mix of hard and soft densification, or else the toll on the environment will be too high and the province will not become more resilient. There should therefore be strict regulations that dictate under which circumstances demolition or infill is acceptable or not.

Figure 6.22. Amount of space needed in the 'business as usual' scenario. Calculations to be found in the appendix.

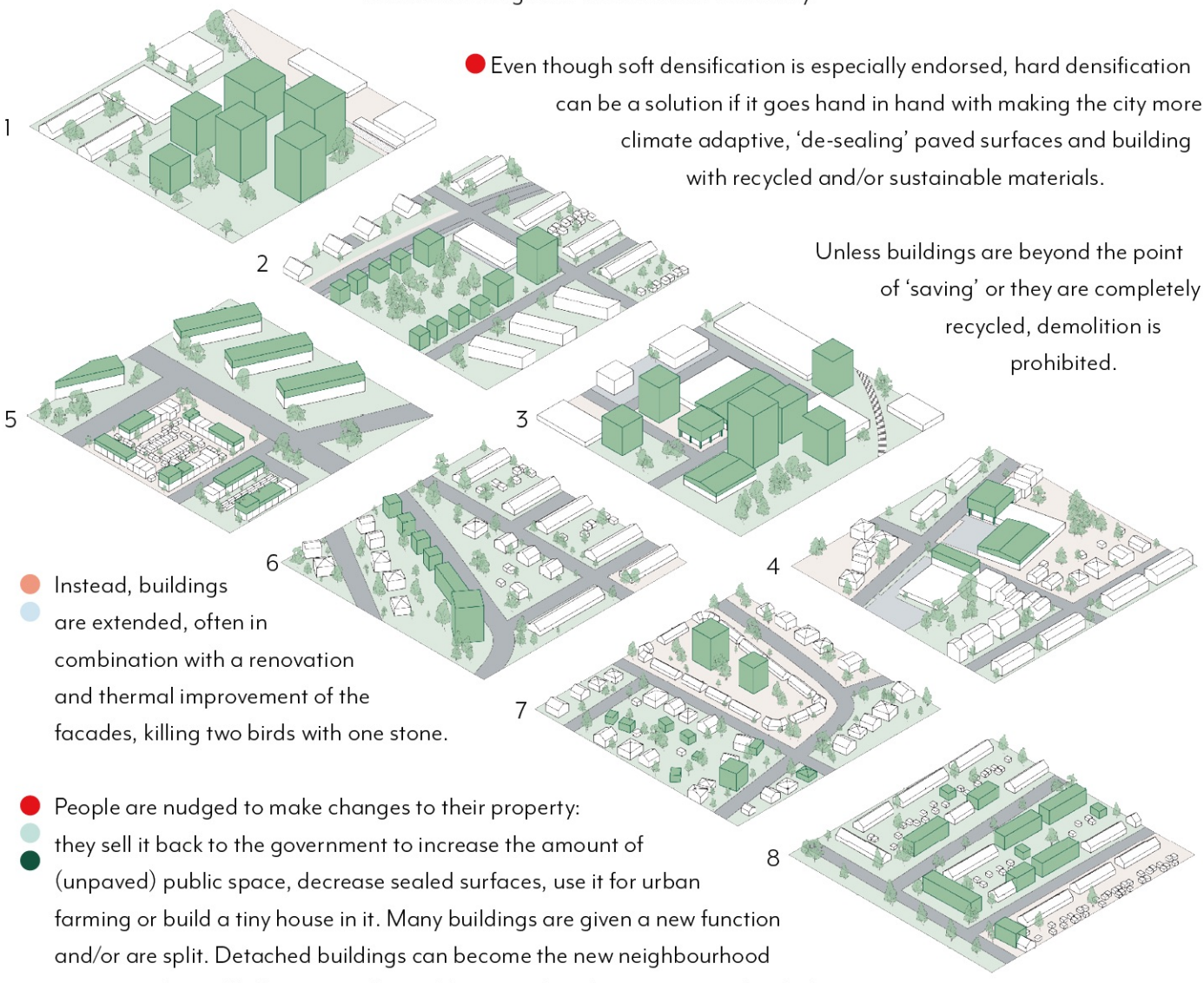
Scenario: nature first

New construction
Hard densification

Transformation
Soft densification

Replacement | Infill | Horizontal extension | Vertical extension | Adapting use | Splitting

In the nature first scenario, all densification methods are employed in order to create urban environments that are dense enough to ensure that cities do not have to expand to answer to the pressure on space. The preference for the use of timber for the construction of buildings puts a limit on how tall and large a building can be, often resulting in medium to high-density neighbourhoods. Both the economy as well as society change drastically, which also has an influence of which kinds of buildings and functions are necessary.



● Even though soft densification is especially endorsed, hard densification can be a solution if it goes hand in hand with making the city more climate adaptive, 'de-sealing' paved surfaces and building with recycled and/or sustainable materials.

Unless buildings are beyond the point of 'saving' or they are completely recycled, demolition is prohibited.

● ● Instead, buildings are extended, often in combination with a renovation and thermal improvement of the facades, killing two birds with one stone.

● ● ● People are nudged to make changes to their property: they sell it back to the government to increase the amount of (unpaved) public space, decrease sealed surfaces, use it for urban farming or build a tiny house in it. Many buildings are given a new function and/or are split. Detached buildings can become the new neighbourhood centres, industrial halls are transformed for agricultural use or as recycling hubs.

As demolition is avoided in this scenario, where the densification takes place is again relatively unplanned and random, because it is very dependent on the specifics and circumstances of a location and the people who own the building. It is therefore important to identify key drosscapes where infill can take place and define which role they could play in the larger system. The aim of being more mindful of planetary health should not be seen as something that only comes with restrictions, but as an opportunity to form more integrated communities, improve the living comfort both inside as well as outside buildings and increase overall liveability. If these things are not interrelated in policies and planning practices, the risk is that the threat of climate change and thus the priorities of future generations are put first at the expense of people currently living there, which is not just either. By enabling people to become more sustainable together, it will be easier to share the space they own or live on and the pressure on space will be decreased.

Figure 6.23. Amount of space needed in the 'nature first' scenario. Calculations to be found in the appendix.

Scenario: living in harmony

New construction
Hard densification

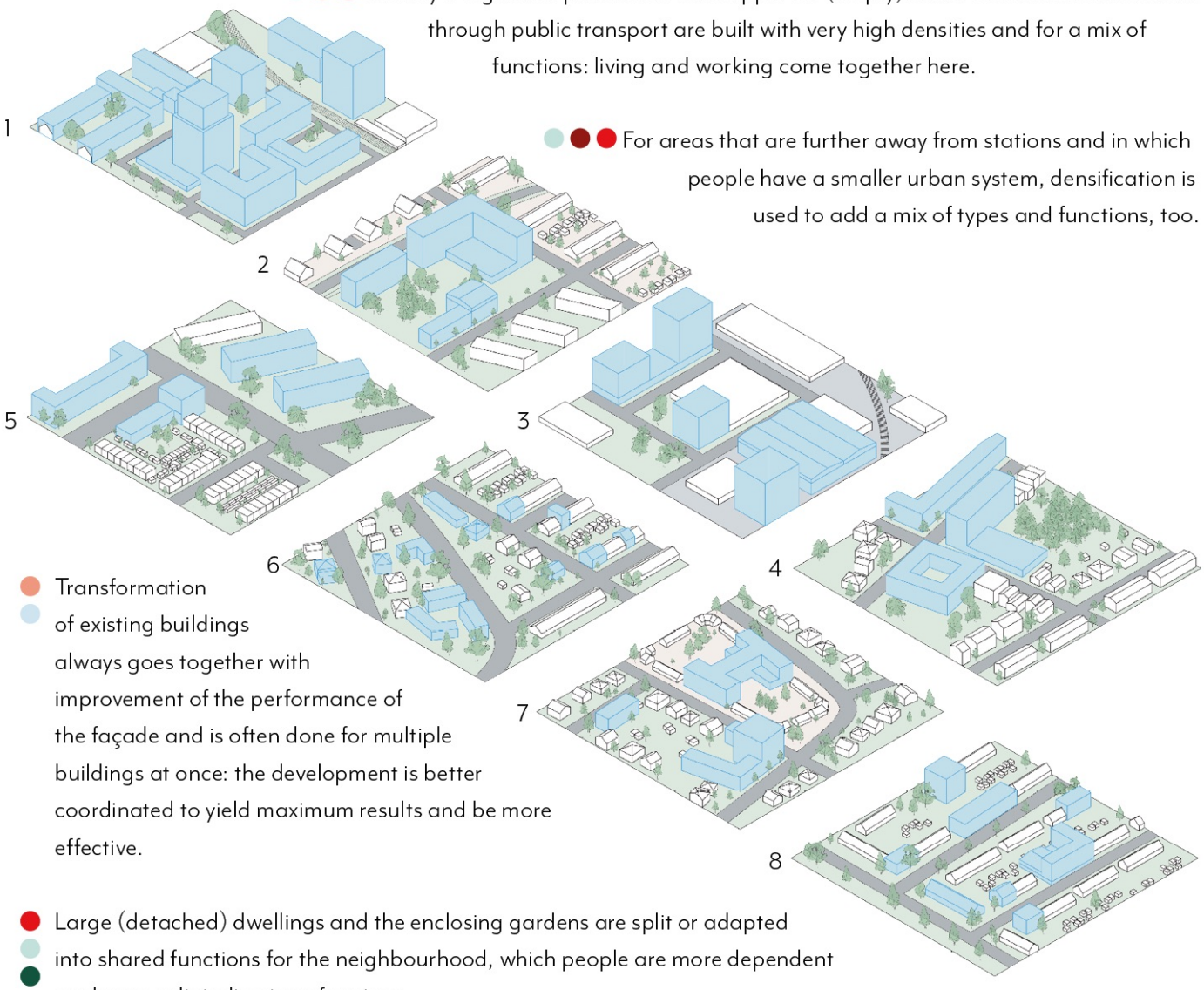
Transformation
Soft densification

Replacement | Infill | Horizontal extension | Vertical extension | Adapting use | Splitting

In the living in harmony scenario, the technological developments employed to in an attempt to enhance planetary health and human wellbeing come with different ways of living and urban development. It resembles elements from the other scenarios but is distinct because solutions are more balanced.

Density is highest in places that can support it: (empty) areas that are well connected through public transport are built with very high densities and for a mix of functions: living and working come together here.

For areas that are further away from stations and in which people have a smaller urban system, densification is used to add a mix of types and functions, too.



Transformation of existing buildings always goes together with improvement of the performance of the façade and is often done for multiple buildings at once: the development is better coordinated to yield maximum results and be more effective.

Large (detached) dwellings and the enclosing gardens are split or adapted into shared functions for the neighbourhood, which people are more dependent on due to a digitalisation of society.

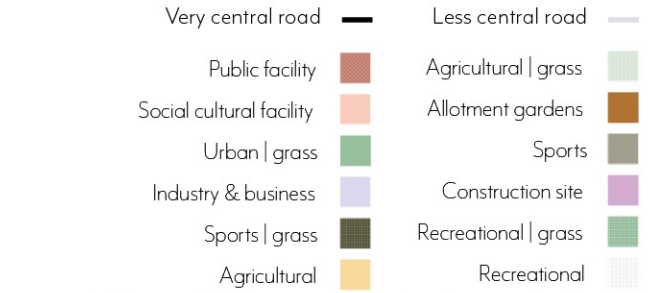
Because the densification method is tailored to every specific type of place, the potential for these strategies to increase resilience is quite big. The most important things to learn from this exploration are that, if possible, different opportunities should always be connected and that densification should be used to not only make the entire building stock diverse, but to also apply that mechanism on a neighbourhood level. If developments are regulated to always include services for the neighbourhood, the 15 minute city-concept has a chance to be successful. People then need less space within the boundaries of their own home, because they can find services or space to work, garden, do their laundry, eat together, and so on within, walking distance.

A possible risk within this scenario, is that if all development should be coordinated from higher up, it leaves little room or incentive for individuals to take matters into their own hands to help solve the problem, or people are dependent on their neighbours in becoming more sustainable and extending their home. This does not only leave enormous untapped potential, but also makes the people whose homes are not updated more vulnerable. Therefore, development should always be about getting as many people as possible on board, but should also provide opportunities for individuals to respond to the issue as they see fit.

Figure 6.24. Amount of space needed in the 'living in harmony' scenario. Calculations to be found in the appendix.

6.4 DESIGN TESTS

As can be seen in the different scenarios, how densification can take place differs depending on the socio-economic conditions. Despite the abstraction being helpful to think about densification on a more conceptual level, it is important to also always take the specific circumstances into account. The reality of the conditions of a location always come with limitations and difficulties, but they can just as well be full of potential and should give guidance to a design. For the first design tests, a neighbourhood in the northern part of Doetinchem is taken. As the majority of dwellings in Gelderland is a single family home, testing with densities in this neighbourhood, which consists mostly of row houses and (semi-)detached dwellings, can uncover possibilities for many similar locations around the province.



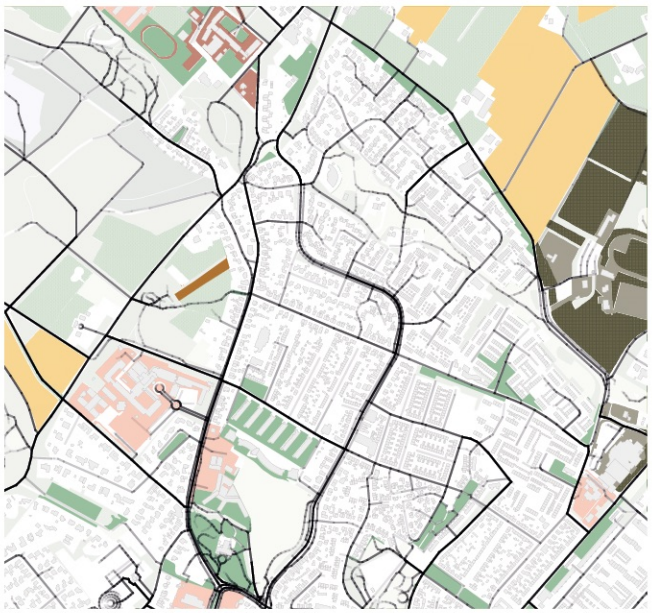


Figure 6.26. Possible drosscapes and most central roads. Data from Centraal bureau voor de statistiek (CBS), 2022; Kadaster, 2020; OpenStreetMap, n.d.

Existing situation

GSI	0.18	Footprint (FP)	43.000 m²
FSI	0.31	Floor space (FS)	74.000 m²

MXI	0.86	Inhabitants	1115
OSR	2.64	Households	565
L	1.72	Av. hh. size	2

Figure 6.25. Aerial

Even though the types of dwellings in the neighbourhood are very homogenous, there are many services available close by. Supermarkets and shops, day care, primary and secondary schools, a pharmacy, GP and a hospital can all be found within a kilometre distance. It is also situated at a walkable distance from the historic city centre and only a 10-minute bike ride away from the station, which make it a very suitable location to be densified.

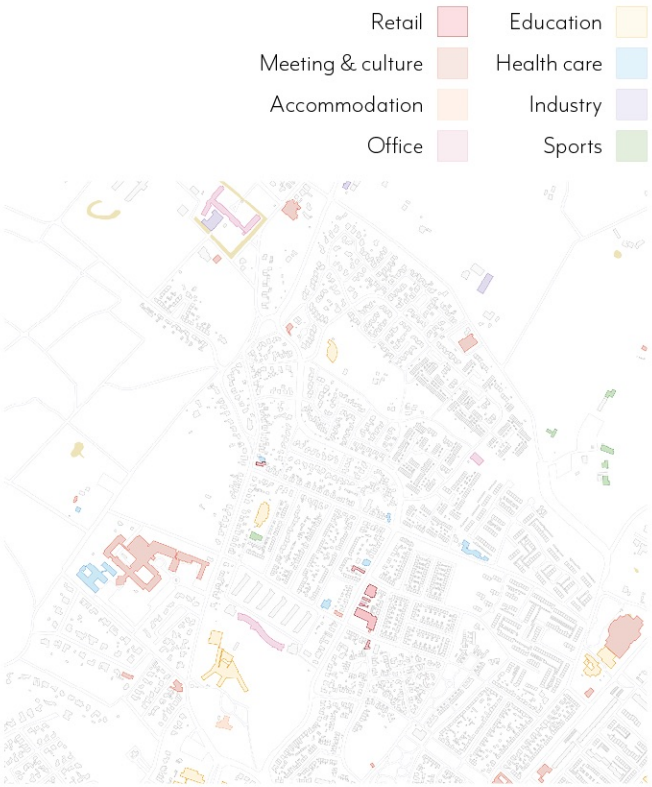
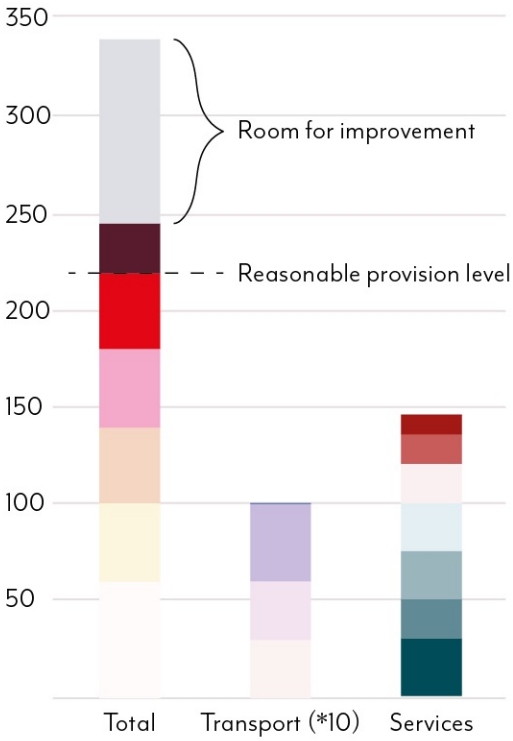


Figure 6.27. Programmatic functions. Data from Kadaster, 2020



Credits regional transport	4
Credits local transport	6
Total transport credits	10
Credits necessary services	81
Credits ordinary services	58
Credits luxurious services	7
Total service credits	146
Total credits	**246**

Test 1

GSI	0.19
FSI	0.33
FP	+6%
FS	+8%

The development is relatively incidental and parcel based, but coordinated in such a way that it happens at corners or along main roads. Each development produces a building of maximum capacity at the parcel, which can host diverse types of dwellings and functions.

Test 2

GSI	0.19
FSI	0.33
FP	+6%
FS	+7%

Densification happens along one main road, and in a way of being a 'cornerstone' to the existing row houses. This way, the development can be focused around one location, while having to demolish the least buildings.

Test 3

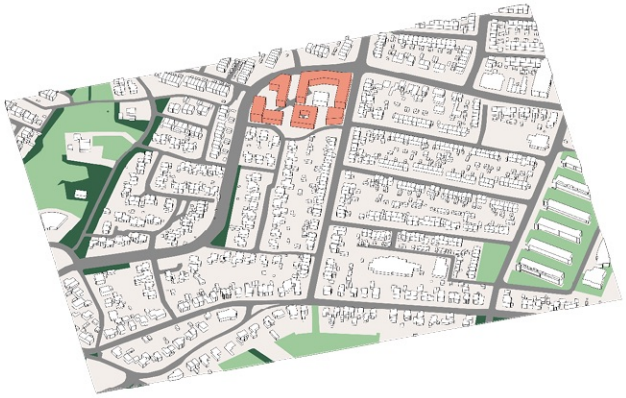
GSI	0.20
FSI	0.37
FP	+11%
FS	+19%

Development is incidental, but is aimed at merging 2 parcels or making the most of the space on one. The test shows what the result would be of making shared courtyards at this scale, as this could retain the appreciation of the garden in the neighbourhood.

Test 4

GSI	0.19
FSI	0.35
FP	+6%
FS	+13%

To be able to also establish new characters within the neighbourhood and perhaps provide services for the surrounding areas, a new, small centre along the main roads is developed.



** The added floor space (+ FS) and added footprint (+ FP) are always calculated in relation to the current situation*

Combination of 1, 2, 3 and 4

GSI 0.23
FSI 0.52
FP +25%
FS +68%

As all the design tests add only a limited amount of floor space while the amount of inhabitants in Doetinchem is expected to double or triple in size. Combining all the different methods does add substantially more floor space, but also is unclear in terms of centrality and added qualities.

Test 5

GSI 0.21
FSI 0.53
FP +19%
FS +72%

The development is places along the main road, at the border of the two adjacent neighbourhoods. By developing in this location, the added benefits and qualities can be enjoyed by a larger number of people and also reframes the function of the main road, which is now mostly used for through traffic.

Test 6

GSI 0.24
FSI 0.77
FP +31%
FS +147%

The development from test 5 is expanded to see how much space would be needed to answer to the possible future demand. When the floor space is more than doubled and dwellings become substantially smaller, even the larger expected needs could be met.

Test 7

GSI 0.19
FSI 0.48
FP +5%
FS +54%

To see what the result of would be of trying to get much added floor space without a substantial increase of the footprint, as in the nature first scenario, the development is more central and of higher density, allowing more high rise. Whether this really fits within this neighbourhood is questionable.

** The added floor space (+ FS) and added footprint (+ FP) are always calculated in relation to the current situation*

6.5 URBAN DEVELOPMENT

Test results

The design tests are a good start to see what certain kinds of developments mean in terms of (added) density, and how the character changes when certain goals need to be met. They also show, however, that in order to fulfil the possible future demand for extra dwellings, quite drastic changes will have to be made. Changing only a few buildings per neighbourhood helps, but would mean that in other locations, there has to be a complete redevelopment of the environment. Now that we have an idea of the magnitude and dimensions of the needed transformations, it is possible to delve deeper into which elements should be the steering forces behind the development. The tests took a first step of in having a (logical) driving force or concept behind a development, but these are still relatively basic and/or specific for the very local scale.

The spatial condition

To be able to link densification to improved liveability, resilience and urban qualities of the whole city and region, it is important to first analyse the existing situation in more detail and identify to which opportunities the developments could link and of which risks it has to be mindful. Where and how cities should densify in order to become more resilient, is not only reliant on the very local conditions under which it is possible to add floor space. To reach the goals set out by the project, development projects should not merely be used as a solution to the shortages in the housing stock, but as a possible tool for the improvement of urban environments. Therefore, it is important to view these possible transformations within their context and the network, and see how they could be linked to existing spatial structures as well as the possible changing conditions within which they could take place.

The network

A space syntax analysis is done to calculate the distance from a street to the train station (Figure 6.28). Whether people are able to walk or cycle to the train station within reasonable time partly dictates their dependency on the car, thus also whether a street could (eventually) be transformed to be car-free.

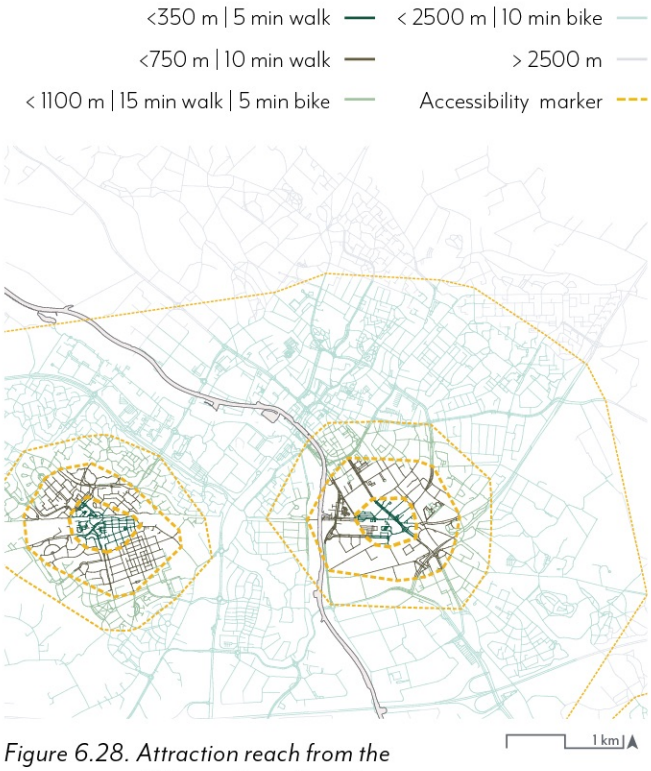


Figure 6.28. Attraction reach from the train station of Doetinchem. Data from OpenStreetMap, n.d.

The existing type of streets also prescribe the opportunities for transformation. Especially larger roads that are situated within the boundaries of what would become a dense, car-free centre have the potential to introduce or restore urban qualities (Figure 6.29). Following the principle that towns should evolve to obtain the character and density of a city before they can expand further, it is important that the network of streets is altered to become more urban.

Many roads existed long before the introduction of the car, and could be used as a main connector for slow traffic again, bringing back their original and new qualities (Figure 6.30). Other roads were built specifically to serve the car, but do not have to anymore when the city becomes more car-free. Revitalising these streets should create a clearer differentiation within the network and therefore also generate potential for different urban characters and qualities to form.

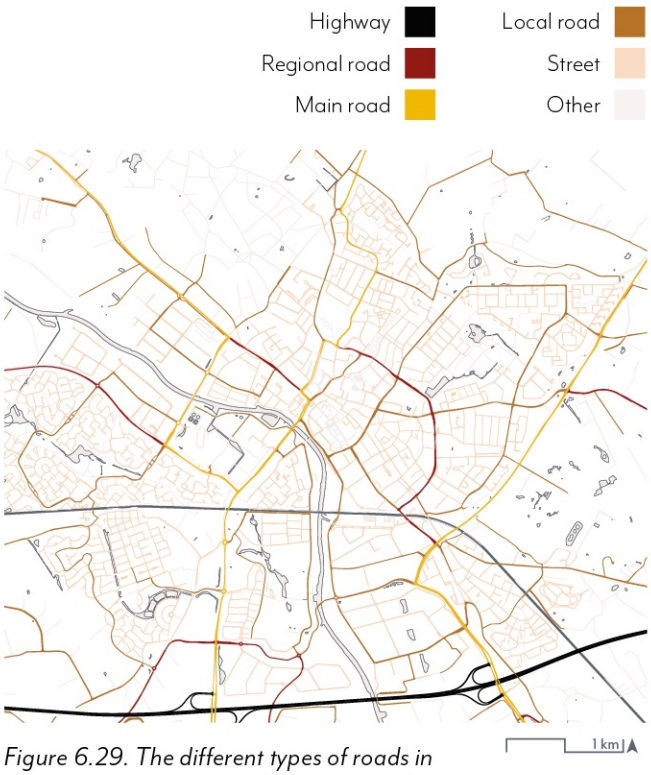


Figure 6.29. The different types of roads in Doetinchem. Data from Kadaster, 2020

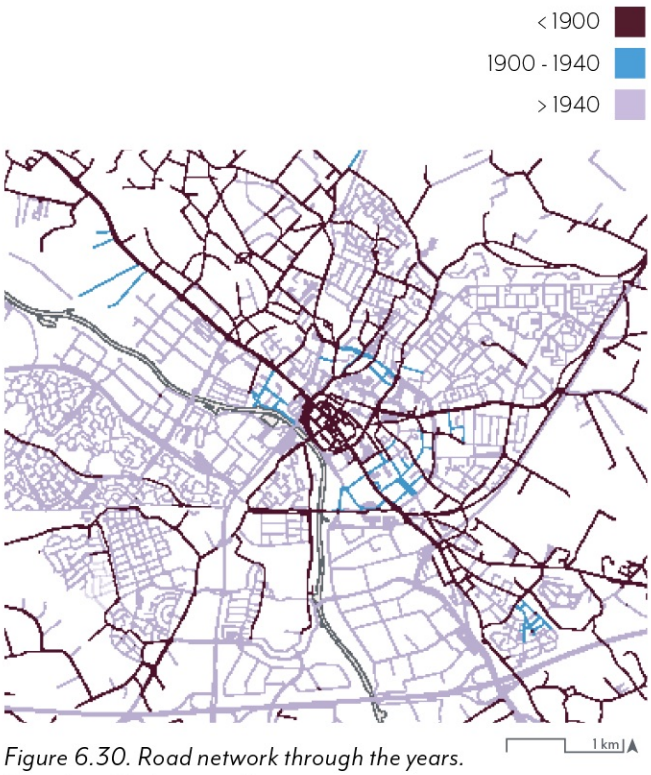


Figure 6.30. Road network through the years. Data from Kadaster, n.d.

Which structures could be transformed to be given a meaning and function that supports densification?

Lower the pressure

Roads that are situated more towards the edges of the city are reserved or improved to serve predominantly motorised traffic, which takes the pressure off other streets in the centre. Multifunctional mobility hubs with parking spaces are added near these roads, so the city remains accessible for those people living far away from public transport. The mobility hubs are all at a walkable distance from the city centre.

A new rail road

In order for Doetinchem to be able to fulfill the new role it will be assigned once it becomes more dense, the infrastructural connections to surrounding places need to be strengthened and updated, too. The east-west connection is already established, but the new rail road should also provide one in the north-south direction. As this also takes up space, urban development should be considerate of it.

Synthesis drawing: regional connectivity

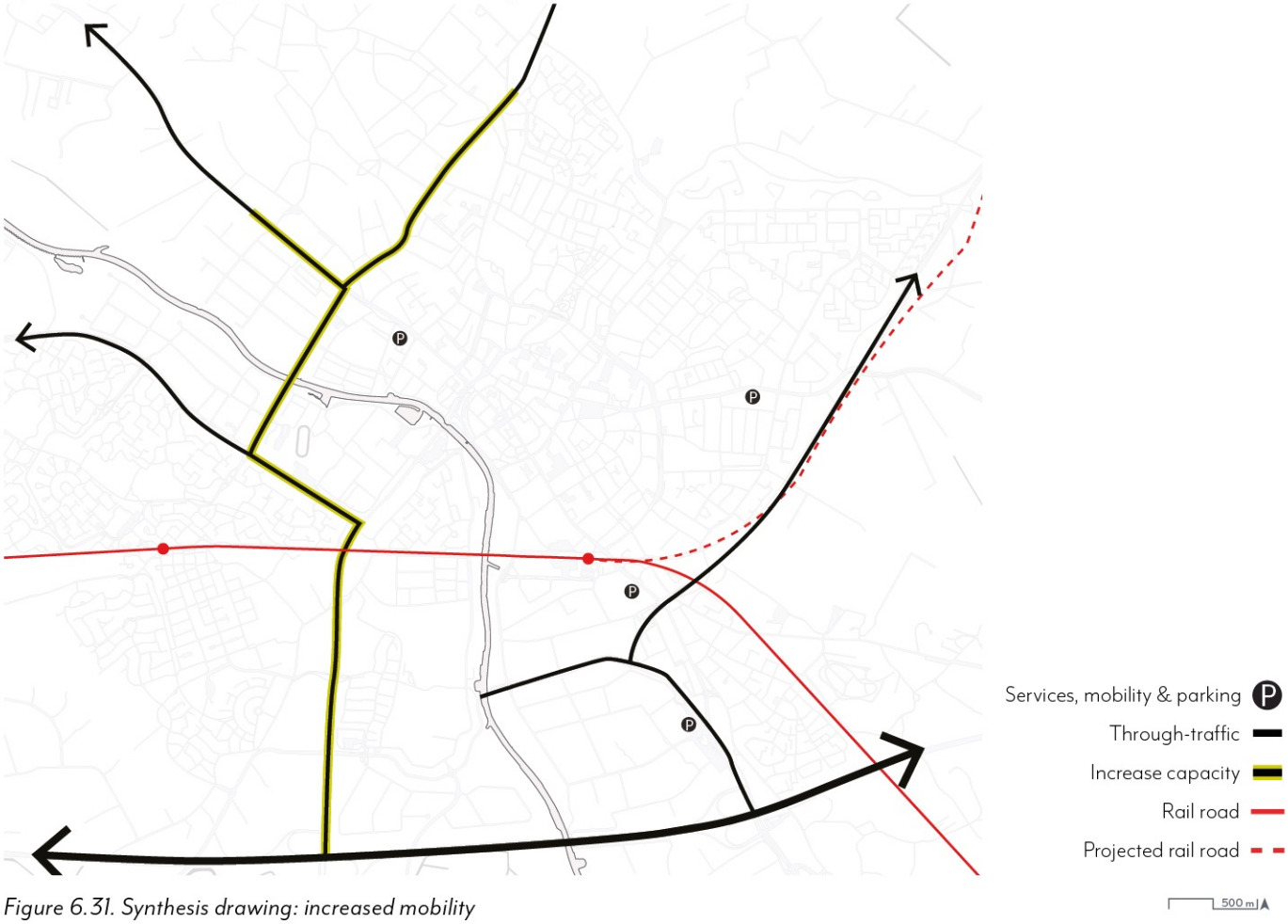


Figure 6.31. Synthesis drawing: increased mobility

Restrict the car

When the pressure on and congestion in the streets in the centre is lowered, it becomes more and more possible to restrict the car from the centre. This does not have to be done all at once or completely, but can be done gradually over time and by nudging people to not drive their car into the centre. The use of one way vehicular traffic, giving priority to pedestrians and cyclists and the creation of zones for destination traffic only can already go a long way in diminishing car traffic.

Revitalise streets

When the car has less and less access to the centre, a lot of space opens up that can be used for other functions or to reach goals to improve the urban qualities, liveability, and the character of the street. Therefore, the development starts by defining the main structures that can be adapted to support the needed densification.

Synthesis drawing: local connectivity

Figure 6.32. Synthesis drawing: transforming streets

Building with nature

With the risks of climate change being at the core of the problem steering the project, it is crucial to take into account the factors which impact planetary health as well as the consequences of aggravated climate change. Including nature in the city, decreasing unsealed surfaces, improving biodiversity and linking ecological zones are some of the measures which can aid in diminishing the effects and risks of droughts, floods, extinction of species, UHI, and so on. To ensure that these problems do not become worse before they have to be adapted to again, mitigation should happen before densification takes rise. In order to do so, one first has to understand the existing conditions.

Doetinchem is surrounded by different kinds of natural environments, such as wetlands, forests and heather It is situated along the river Oude IJssel, a tributary of the river IJssel, which starts in Germany. The landscape around the city is relatively fragmented and a large part of it is used for agricultural purposes. Within the borders of the city, however, the landscape is even more fragmented and scattered. Apart from some parks, the connected green structures on the northern side of the city and the patches of green to be found along main roads, there is not much qualitative green to be found. The grassland situated south of the river seems extensive, but as these are also used as sports fields, its ecosystem services are rather low. The areas that should be exempt of construction are helpful in preserving and protecting nature on a larger scale, apart from the buffer zone around the wetlands that has already been built. To improve the performance of nature within the city as well, however, there needs to be more attention to the green and blue within the city.

Figure 6.33. The existing unbuilt landscape. Data from Kadaster, 2020

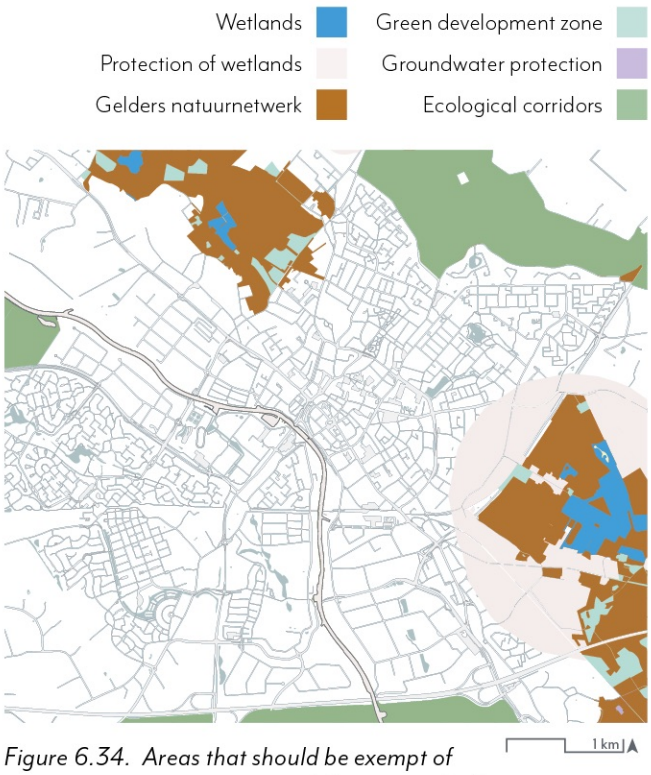


Figure 6.34. Areas that should be exempt of construction to protect nature following each of the scenarios. Data from Provincie Gelderland, n.d.

As we saw from the analysis on the regional scale, looking at the historical landscape can be an inspiration for future development, as this shows us which structures were changed. The structure of the centre of Doetinchem and its characteristic oval shape have been around since the 13th century (Gemeente Doetinchem, n.d.). The canal surrounding the centre was filled in in the second half of the nineteenth century, when the city began to expand (Pronk, 2010). As the new roads were built on top of were the canal used to be and the centre still has this distinctive shape, it might be possible for the old structure to be reintroduced.

The original larger stream of water on the northern side of the city that was connected to the peat soil is also barely recognisable in the current landscape. To increase the water storage capacity, the remaining fragmented water structures could be linked, which often also improves the quality of the water and the biodiversity. As Doetinchem is situated along the water, it is important to take possible risks concerning flooding into account. By reserving extra space for water, creating a new blue structure, decreasing or limiting the amount of sealed surfaces and perhaps building in new ways which are mindful of the water, the risks can be mitigated.

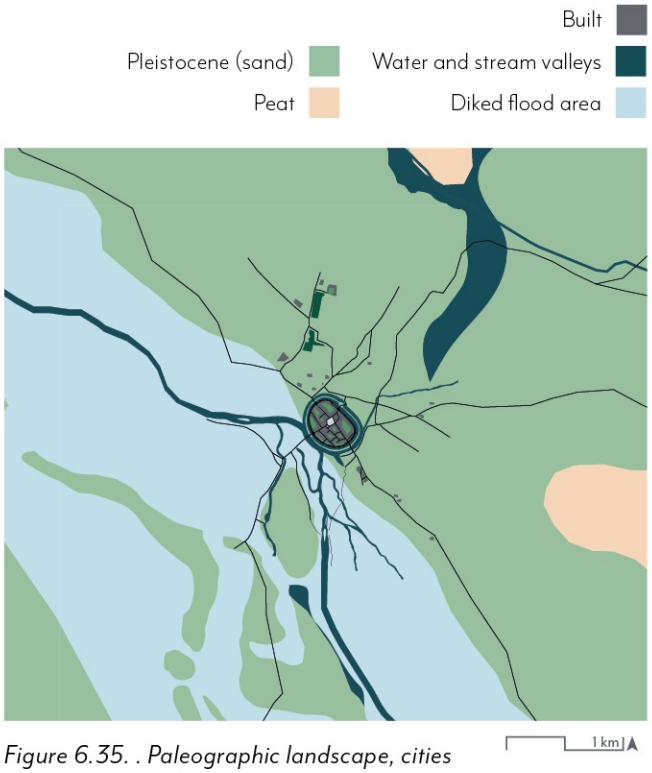


Figure 6.35. . Paleographic landscape, cities and networks in 1575. Data from Nationaal Georegister, n.d.

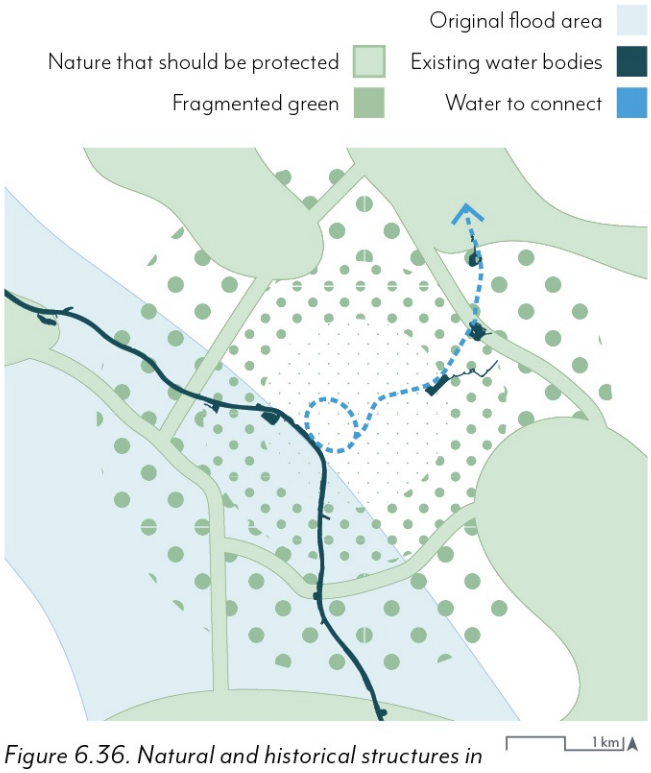


Figure 6.36. Natural and historical structures in the landscape

Which original and/or natural structures should inform the design and how?

Connecting green structures

The reimagined street network is used to tie fragmented pieces of nature together, improving their ecosystem services and increasing climate resilience as well as making green spaces more accessible.

Bring back the blue

Now that the focus is on making liveable and adaptive cities, reintroducing the old 'gracht' around the city does not only restore the cultural-historical image, but also makes the city more climate adaptive. The outer water structure is one of the identified roads that for the most part did not exist until it was built for motorized traffic, but lies within the perimeter of the area in which vehicles should be restricted. The space that is freed provides potential for the structure to be transformed into a 'singel'.

Most parts of the area that should allow more room for water have already been urbanised, so a redevelopment should be done in such a way that water is taken as a starting point.

Synthesis drawing: nature in the city

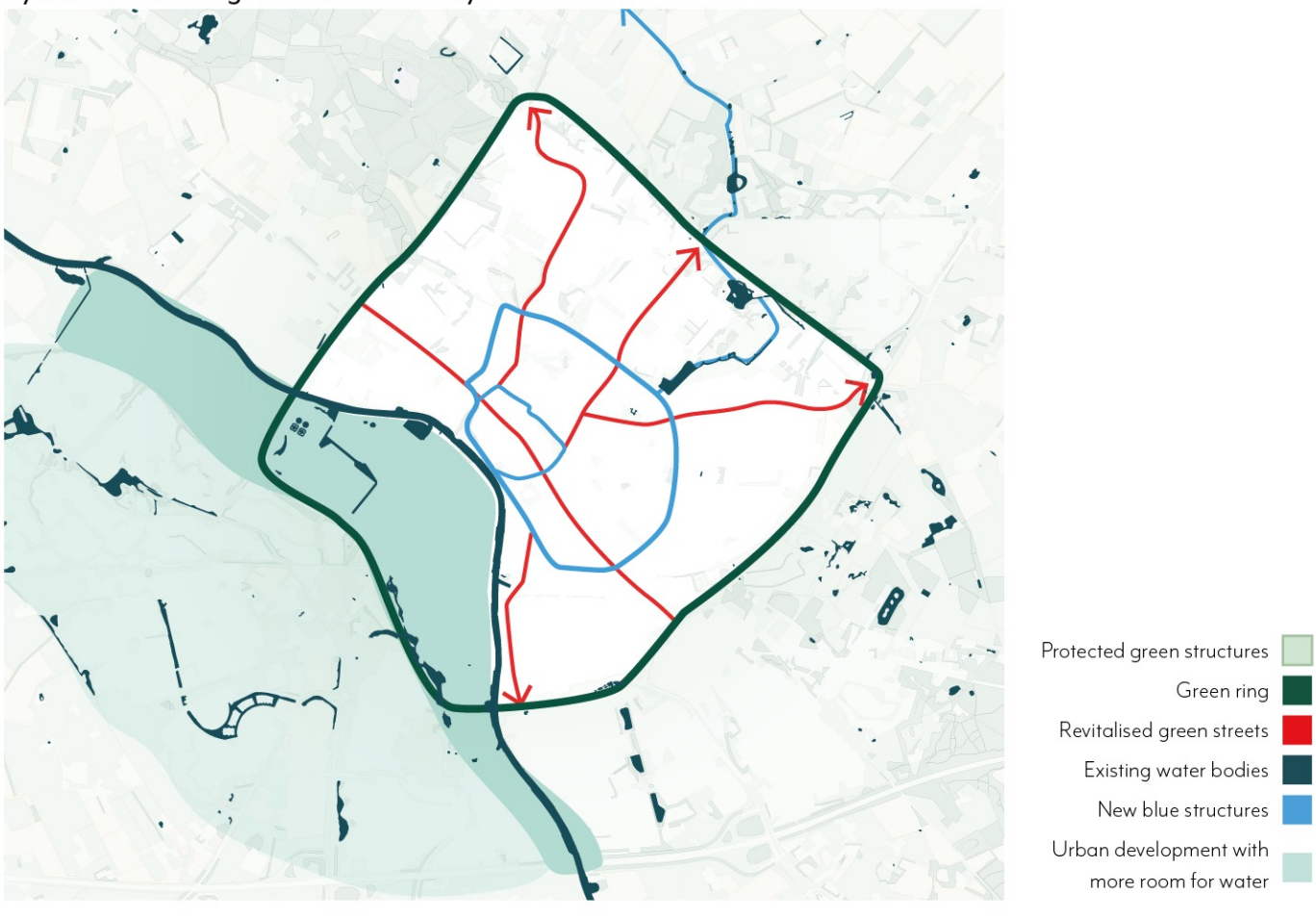
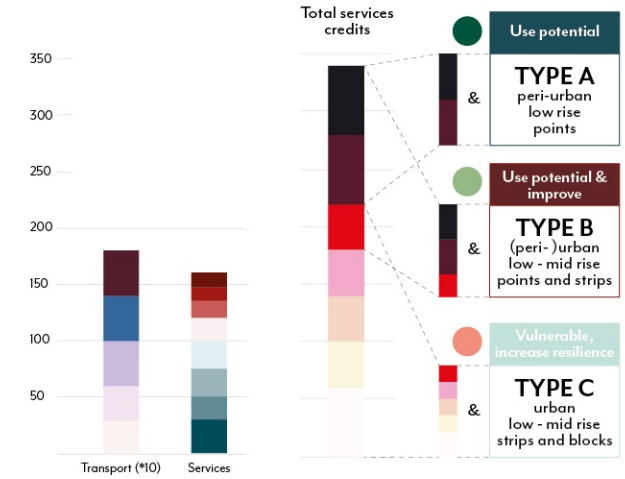


Figure 6.37. Synthesis drawing: designing with nature

Access to services and transport

While Doetinchem was highlighted as a place with much potential for densification in all the scenarios, it is helpful to have another look at the characteristics that define this potential on the urban scale, too. While the (historic) city centre and the surrounding neighbourhoods have the highest access to services, the highest potential in terms of transport is centred around the train station, which is not very dense yet. This shows that different parts of the city need different elements to be updated or benefited from for densification to be an improvement of the neighbourhood and the city as a whole.



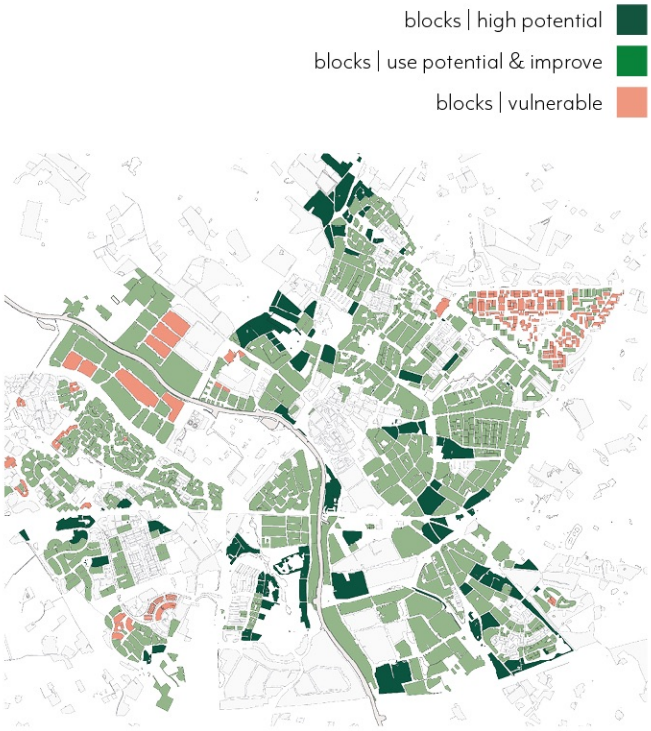


Figure 6.38. The meaning of densification of blocks and urbanisation of land. Data from Planbureau voor de leefomgeving, 2022

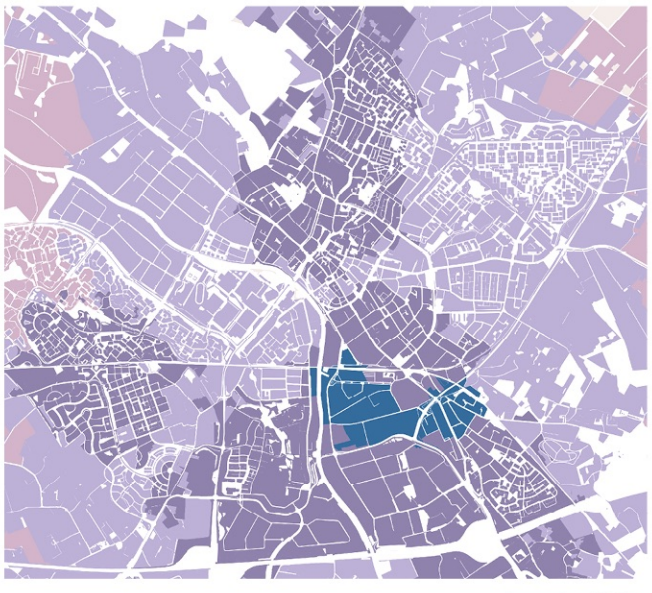


Figure 6.39. Total amount of accessibility credits per block. Data from Planbureau voor de leefomgeving, 2022.

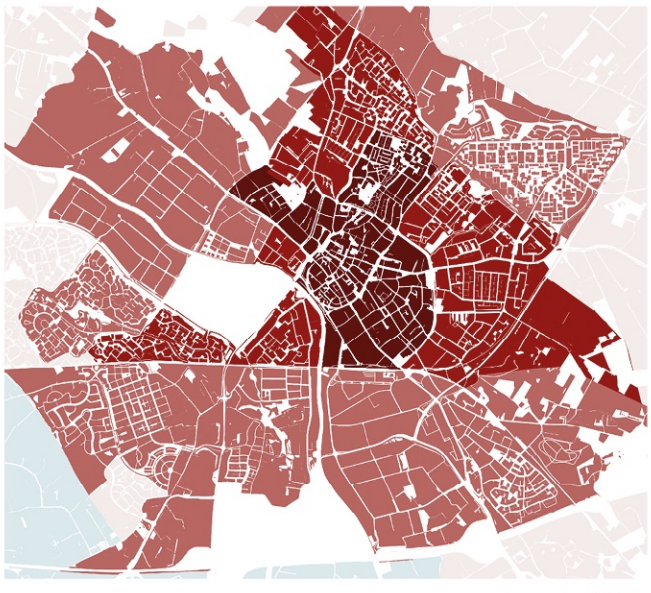


Figure 6.40. Service provision level per neighbourhood. Data from Centraal Bureau voor de Statistiek, 2021

Functions and character

The map displaying the functions to be found in the city display quite distinctively the way in which most public services are clustered in the historic city centre and along some of the main roads identified in the network analysis. The industrial areas make up quite a substantial part of the city and, like most of the other neighbourhoods in the city, can be characterised as relatively monofunctional. Most neighbourhoods do have some small shops or a supermarket and a school nearby, but are still very much purely residential areas, as can also be seen from the MXI.

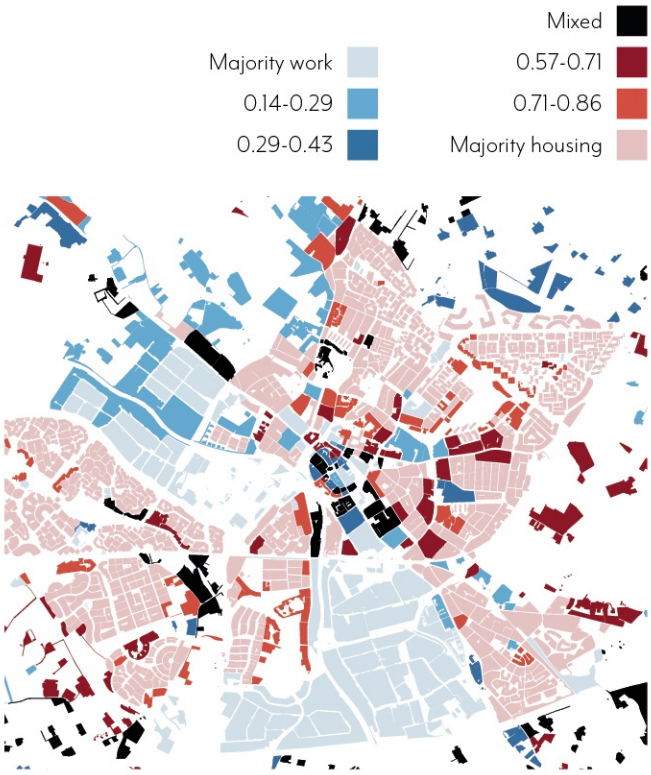


Figure 6.41. MXI per block. Data from Planbureau voor de leefomgeving, 2022

Figure 6.42. Building functions. Data from Kadaster, 2020

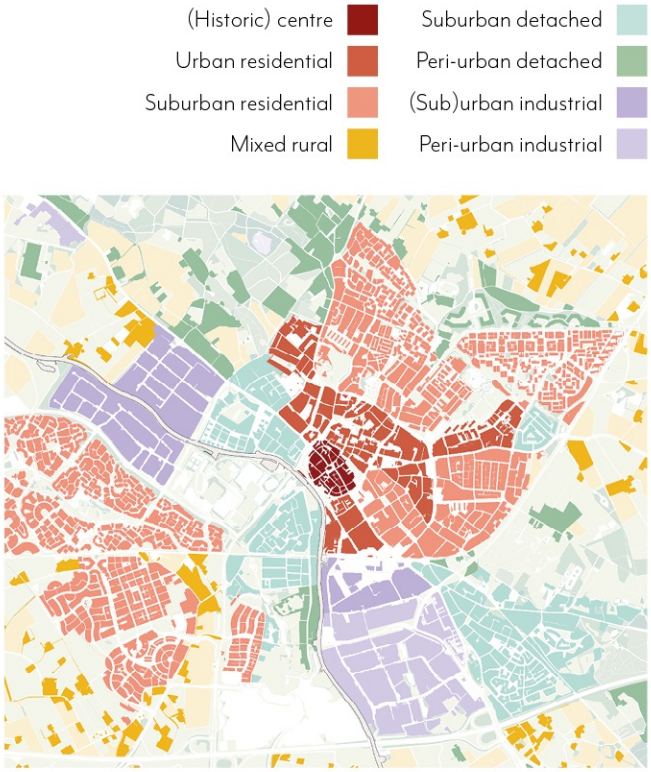


Figure 6.43. Type of urban environments per neighbourhood

Which (new) types of urban environments can be formed through densification?

New kinds of urban

As the densification of Doetinchem should also happen with the aim of supporting growth of the surrounding region, new and more functions and services will have to be introduced. This is an opportunity for new kinds of urban environments to be introduced into Doetinchem, which increases the diversity and therefore, improves resilience of the fabric. These kinds of urban could resemble environments as exist in larger cities today, or be of a completely new kind, with different qualities. The character of an environment and how it looks and feels depends on much more, but a good start is to define the kinds of densities, functions and building types that should exist within it. These characters are then the elements which can be both the constraints as well as the driver behind developments and designs for densification.

Synthesis drawing: urban environments and characters

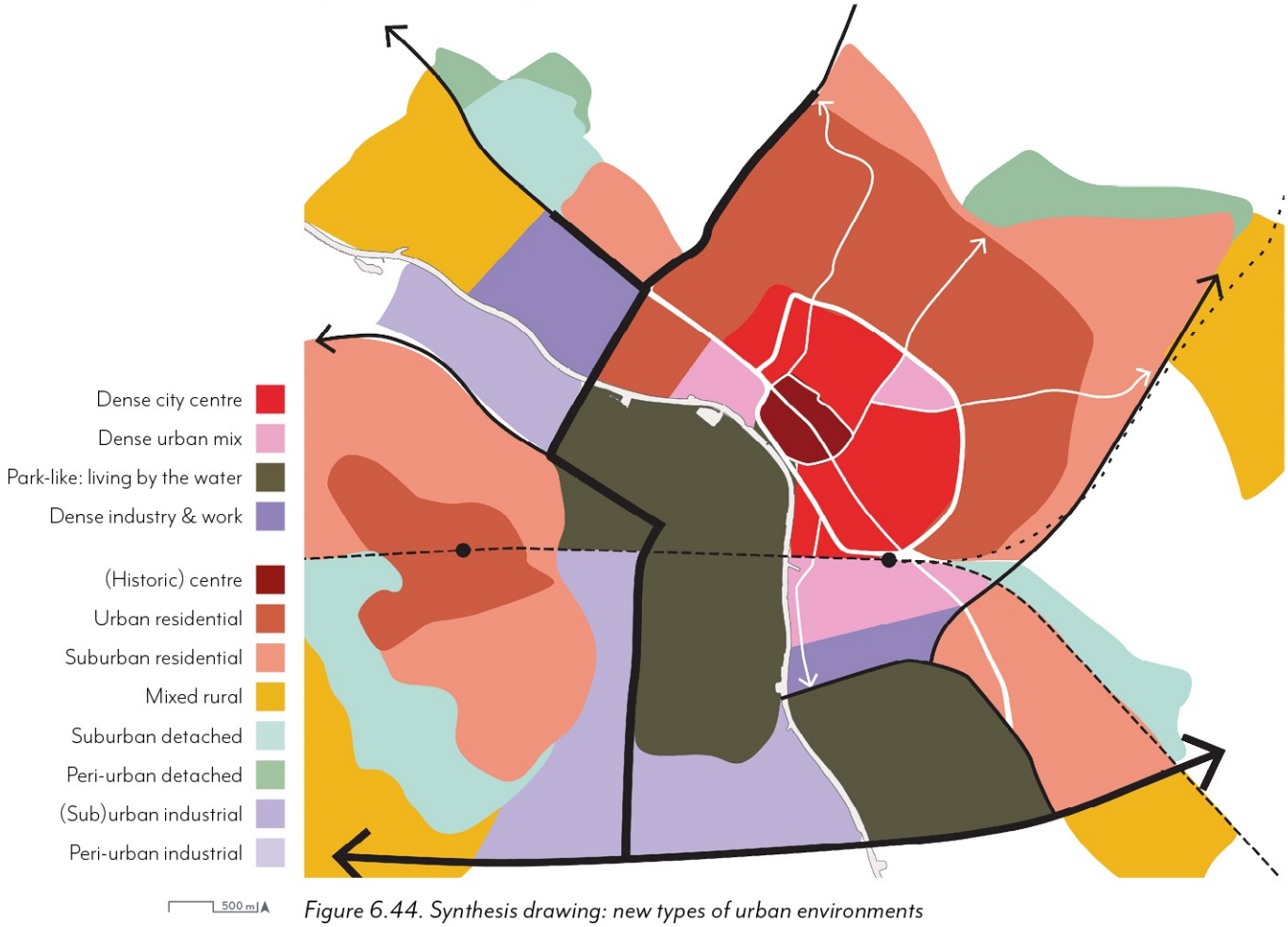


Figure 6.44. Synthesis drawing: new types of urban environments

A new urban network

The resulting map shows how the design interventions in the network link together and how they relate to the different functions and types of environments that are established. The revitalised streets are often at the edge of two different kinds of neighbourhoods, which means the reimagined network and the buildings that are developed and densified adjacent to it can be a catalyst of change for the rest of the neighbourhood.

Vision map: networks

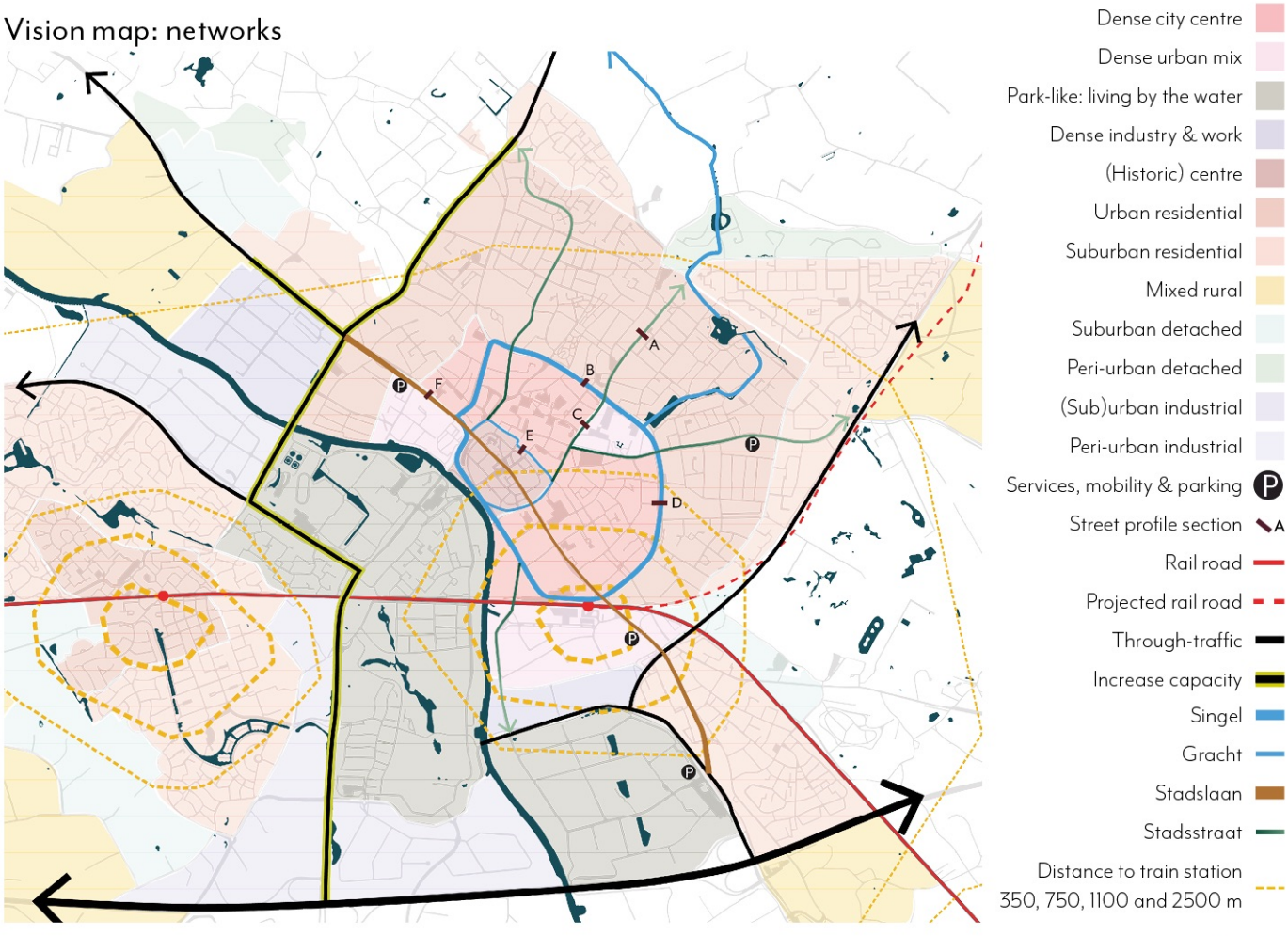


Figure 6.45. A new urban network

A nature-inclusive city

By integrating the green and blue structures into the main (functional) network, the city can benefit as much as possible from the added ecosystem services as the busiest streets are also the ones with the most pleasant climate. Reserving space for nature to thrive in key public space means liveability is increased and mitigates issues that would otherwise become bottlenecks before the densification takes place. Because this also means a reorganisation of the street profile, the project includes a proposal of how these streets could be transformed.

Vision map: nature

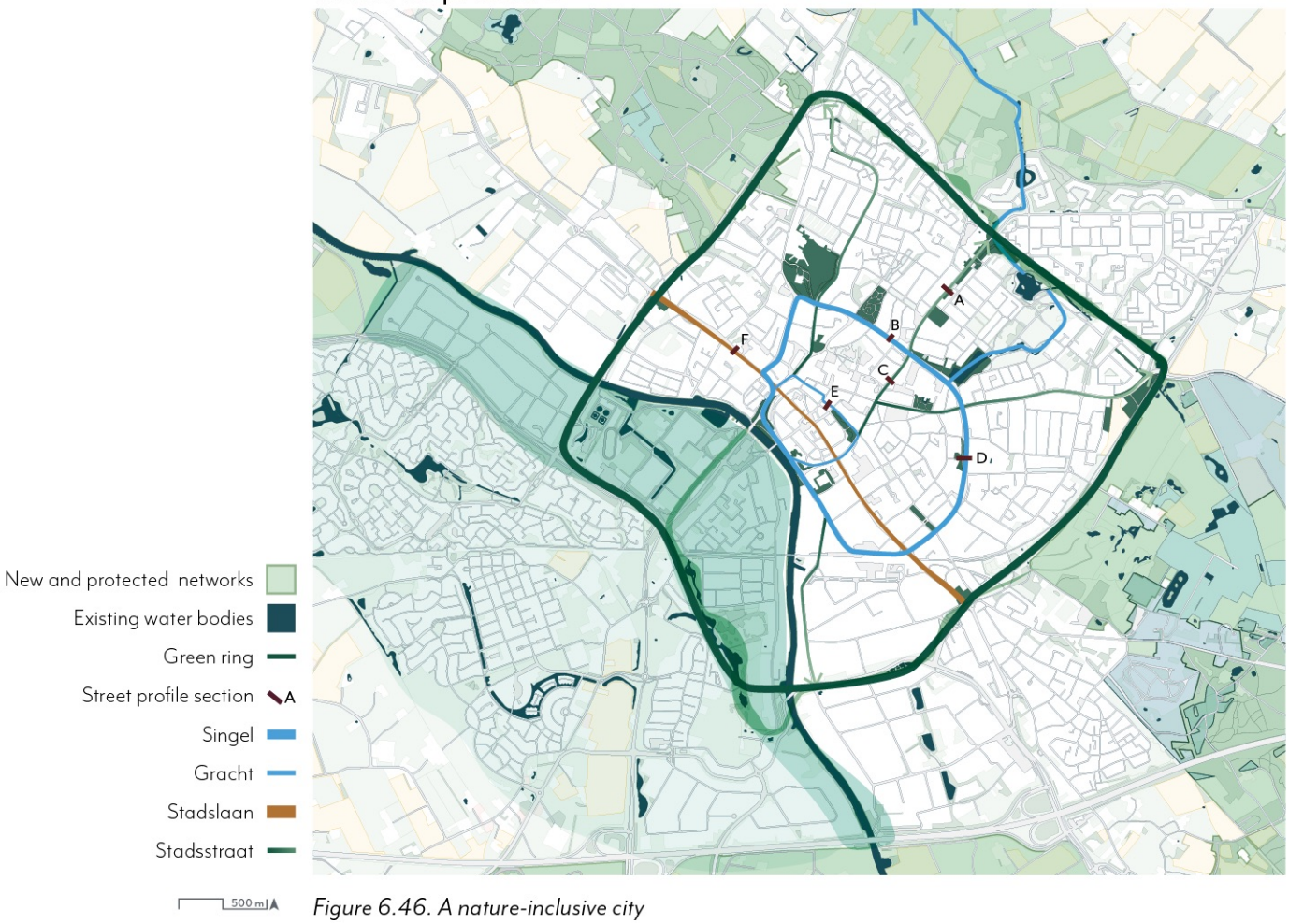


Figure 6.46. A nature-inclusive city

Diverse densification

Densification should be guided by the (new), desired urban qualities and character of each neighbourhood and should preferably be focused around the main streets and service centres. The different urban characters increase diversity within the city, which ensures that there is a range of qualities to be found and that there is a place for everyone. The smaller service centres improve autonomy of the neighbourhood, improve social cohesion, decrease the dependency on the city centre and on car usage and allow for dwellings to become smaller, as people then also can find space for daily activities outside of their home.

Vision map: character, density and centrality

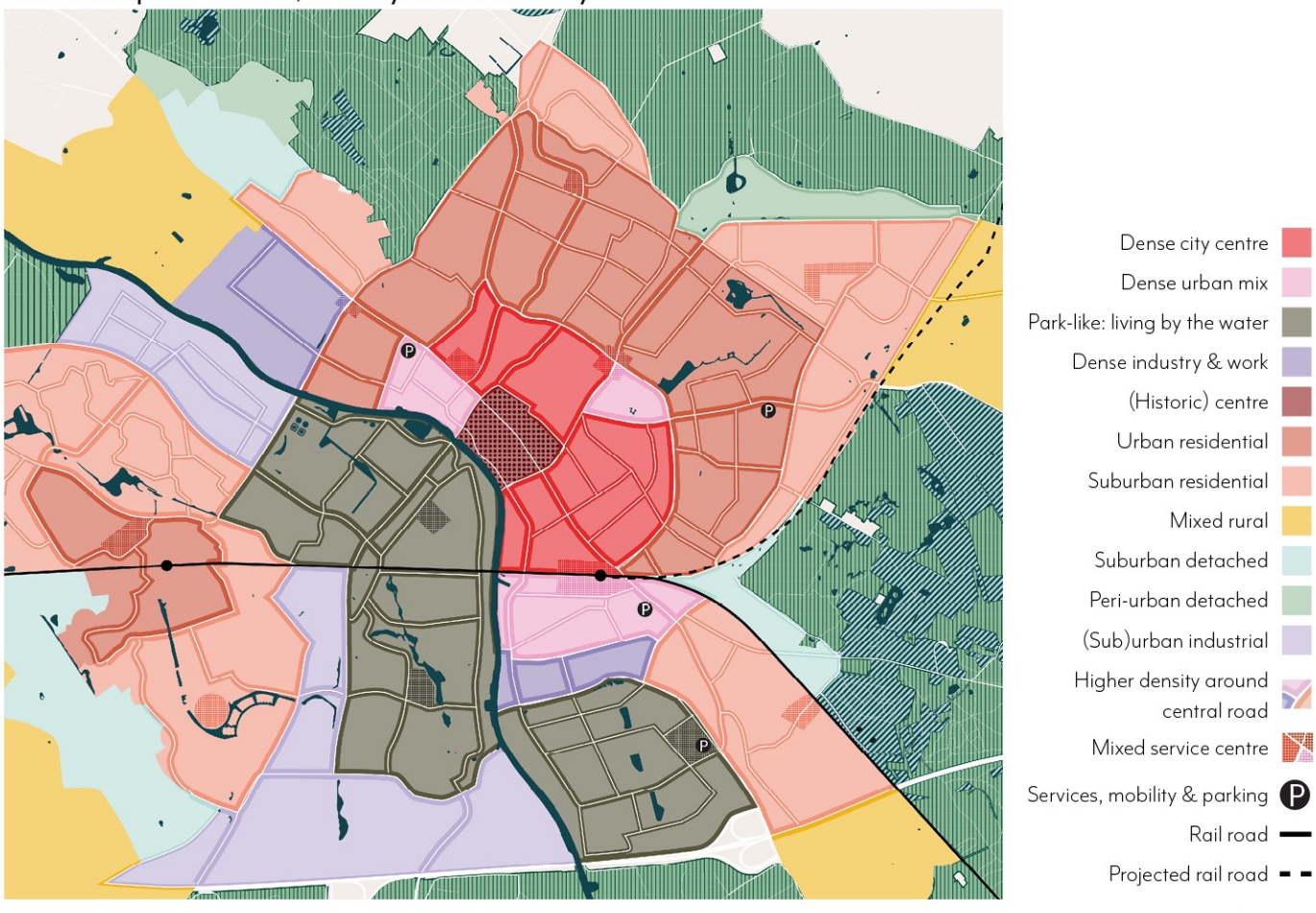
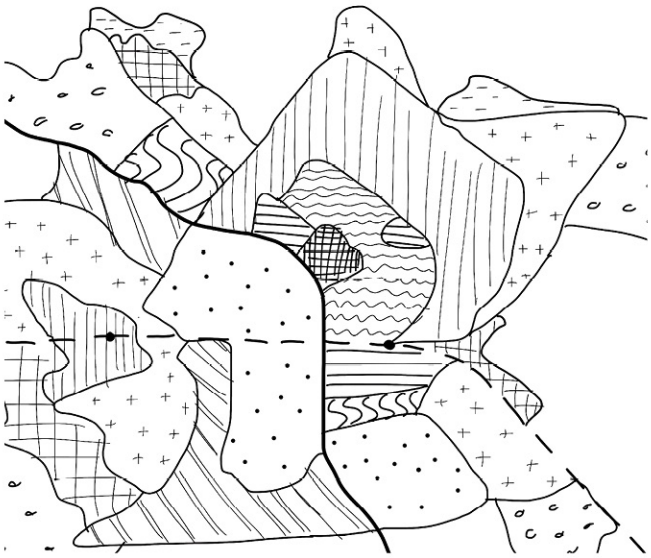


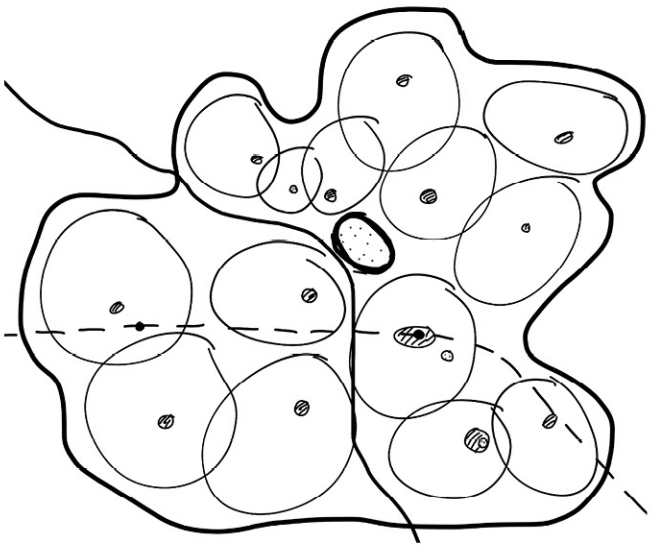
Figure 6.47. Diverse densification

Hierarchical network

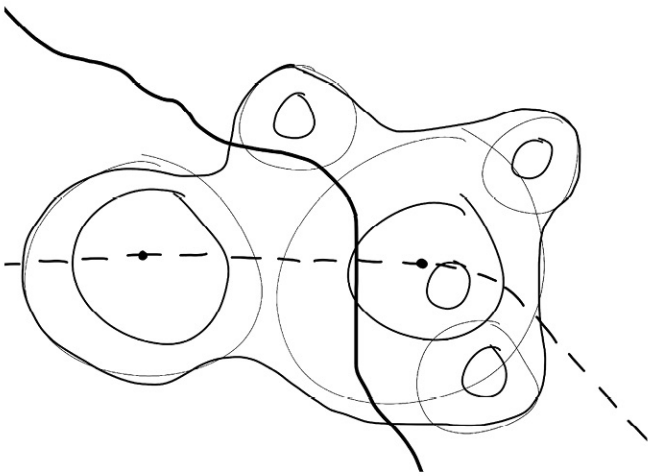
Diversity of characters



Centres and neighbourhoods



Pedestrian-priority zones



Designing the new street profiles

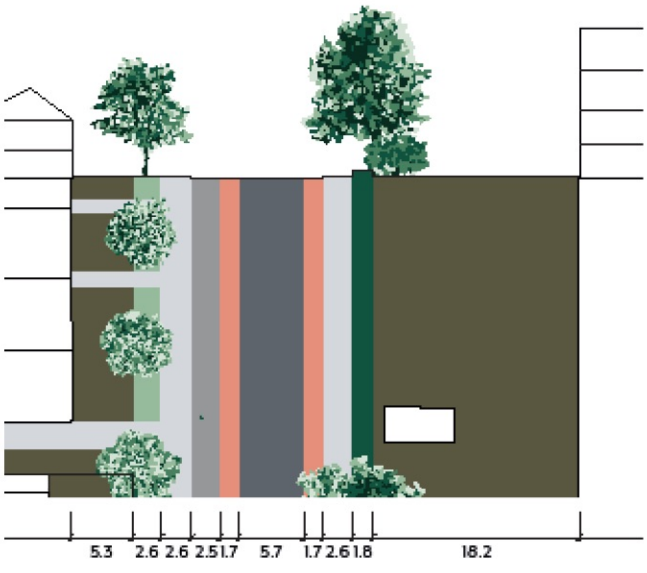
Section A: stadsstraat

Reference: Pulteney Road, Bath, UK

- multi-modal street
- preserve existing trees
- the building line can differ, but the street is framed by a clear edge between public and private
- new trees in between the pavement and street, so they are in the public sphere as well and not only in the gardens. This ensures the presence of green along the length of the street, tying it together

Existing situation

New profile



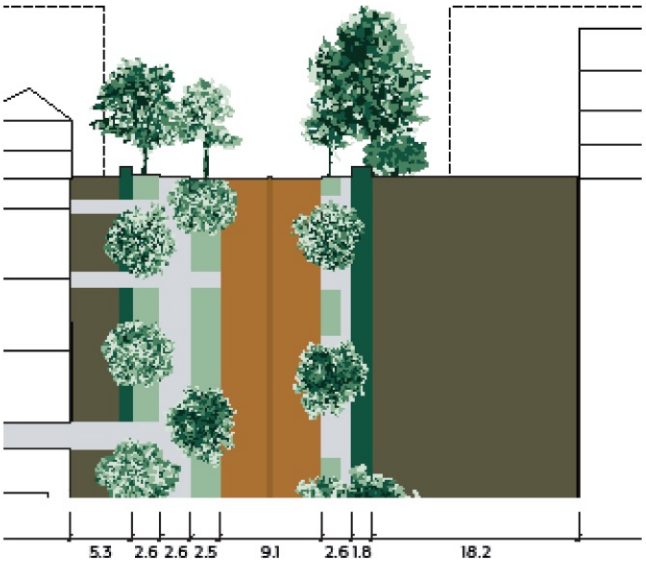


Figure 6.48. Street view photos: Google Maps, n.d.

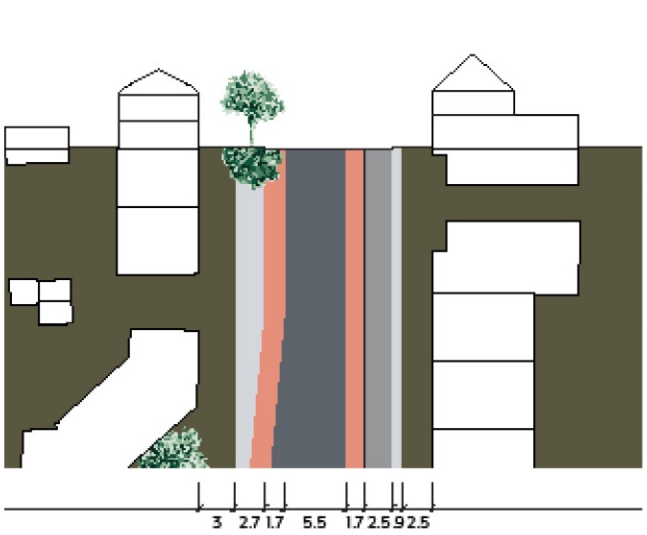
Section B: woonstraat

Reference: Van de Sande Bakhuyzenstraat, Hilversum

- multi-modal street
- trees replace most of the parking spots
- traffic is slowed down
- extra green space, less sealed space in the public realm

Existing situation

New profile



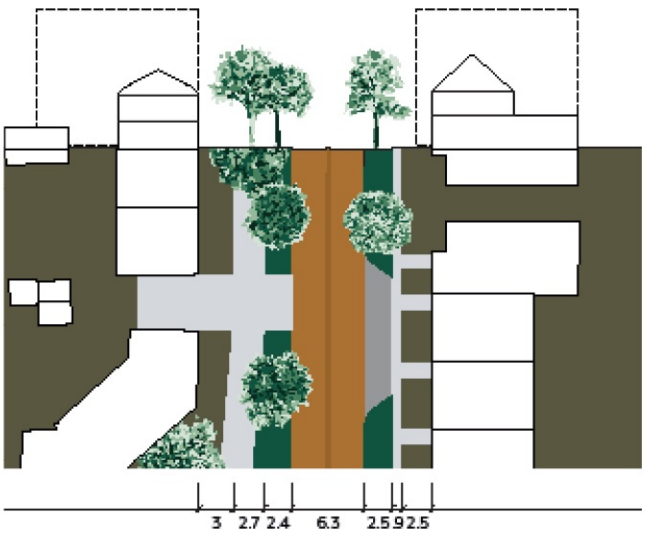


Figure 6.49. Street view photos: Google Maps, n.d.

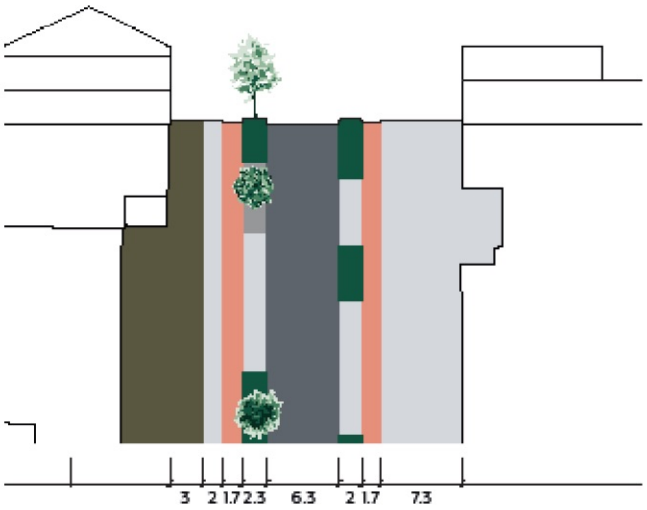
Section C: stadsstraat

Reference: Wycker Brugstraat, Maastricht

- multi-modal street
- preserve existing trees
- most buildings should have an active plinth and should be higher
- more room for green and trees to grow
- the pavement is wide enough to host terraces or other public functions

Existing situation

New profile



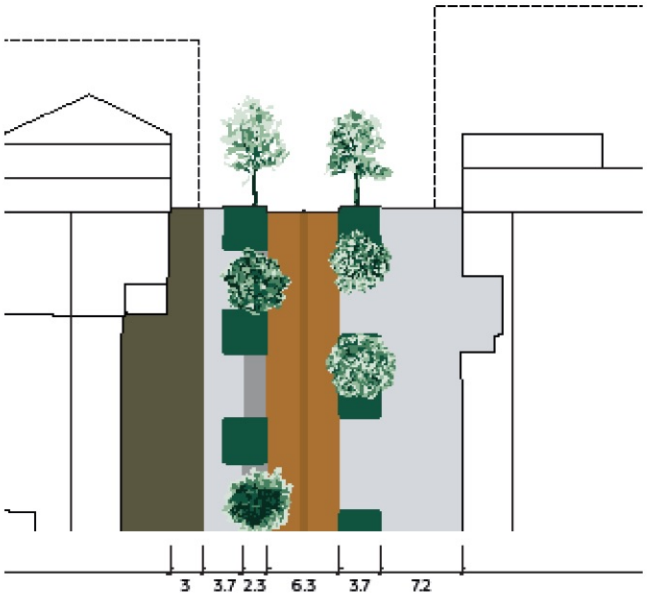


Figure 6.50. Street view photos: Google Maps, n.d.

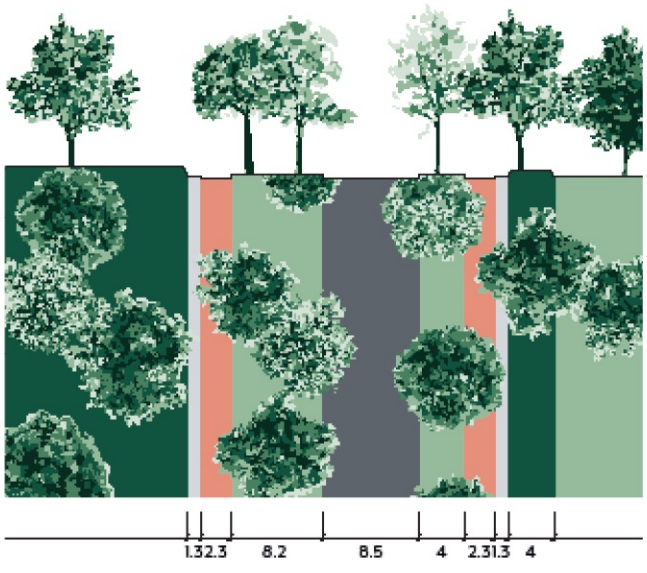
Section D: singel

Reference: Baansingel, Alkmaar

- the water is brought back, making use of the wide street in which car traffic will be restricted/reduced
- preserving existing trees
- a park in between the trees along the water on one side
- buildings closer to the street for social control and for 'framing' the street

Existing situation

New profile



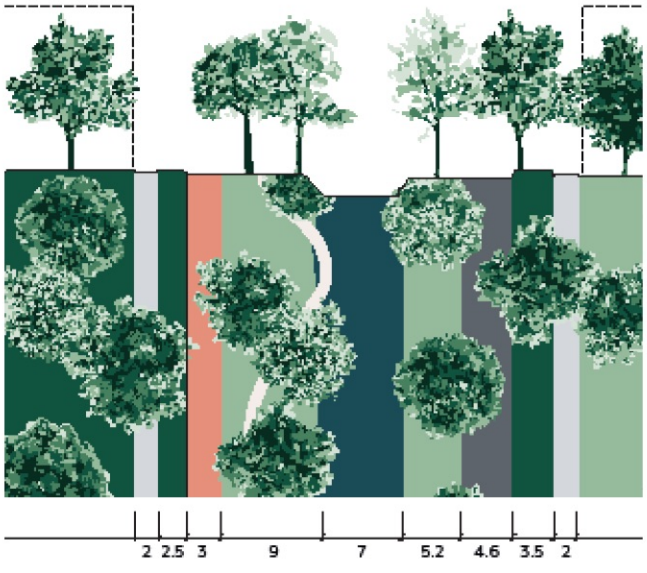


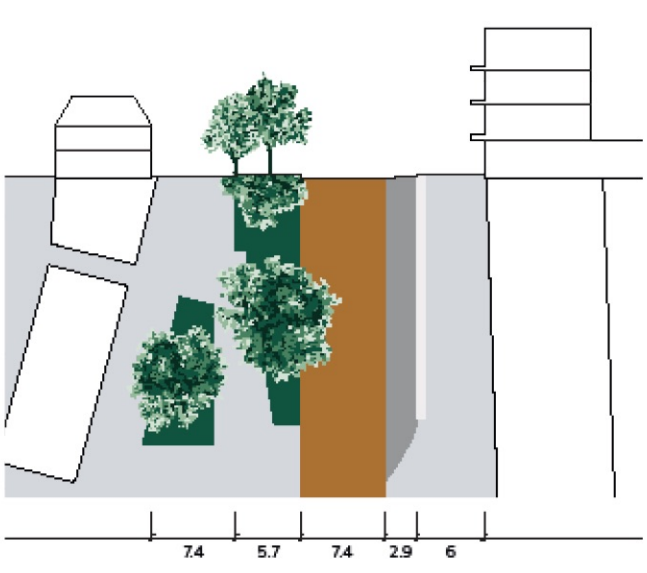
Figure 6.51. Street view photos: Google Maps, n.d.

Section E: gracht

- the old canal is reintroduced and interwoven with the existing green structure
- the street for traffic is reduced to one lane and one direction
- more space for the pedestrian

Existing situation

New profile



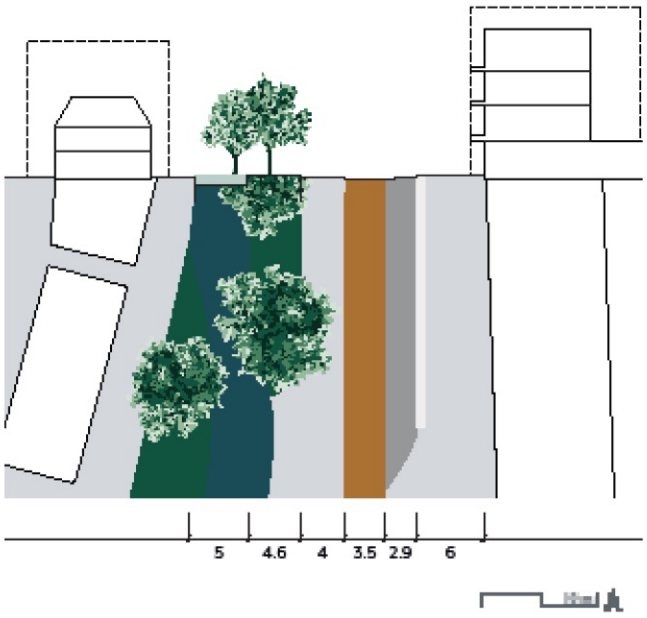


Figure 6.52. Street view photo: Google Maps, n.d.

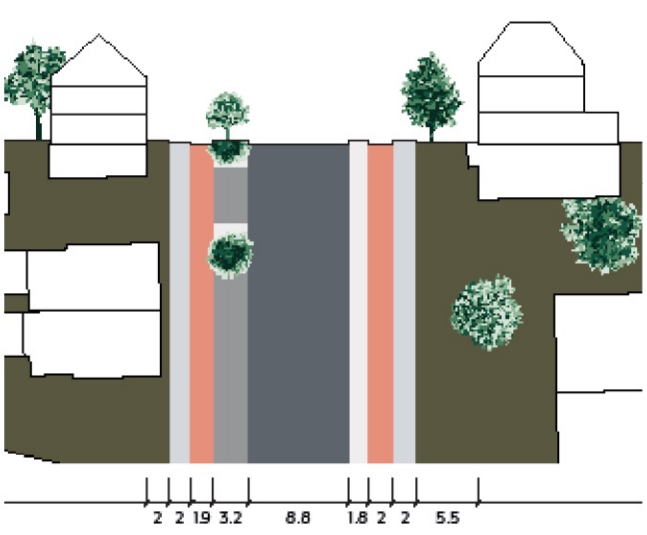
Section F: stadslaan

Reference: Sint Lambertuslaan, Maastricht

- multi-modal street
- more room for green strips on either side
- lane character with monumental trees, more historical character is brought back

Existing situation

New profile



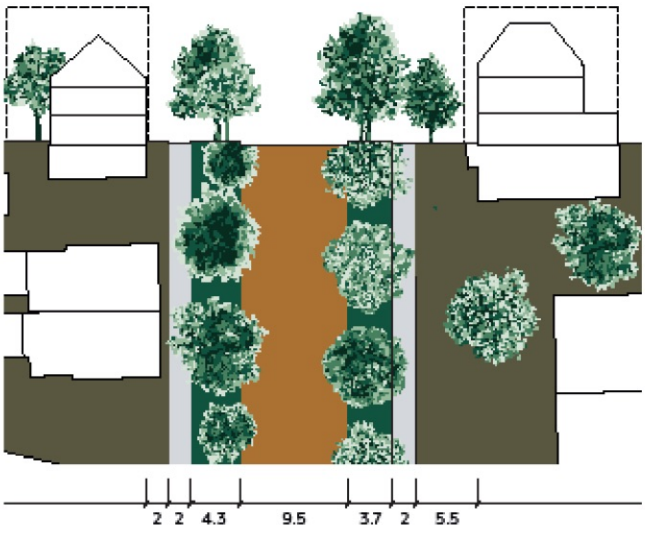


Figure 6.53. Historical image: Beeldbank, n.d. Street view photos: Google Maps, n.d.

Test case: design of a neighbourhood

To see how the analysis of the meaning of and the methods for densification and design interventions of the network can come together in physical terms, the project takes a closer look at a specific location. A 500 by 500 m site is taken in which the new 'stadsstraten' and 'singel' come together around the development of new types of urban environments: the dense city centre and the dense urban mix. The urban residential character is to be expanded beyond the outer border of the 'singel'.

Figure 6.54. Elements with certain potential for densification

The area is already relatively mixed and provides many services for the surrounding environment. On the other hand, there is still a lot of (paved) open space and most of the buildings are very low. In order for the neighbourhood to develop into a dense and mixed environment, many changes have to be made.

Existing situation

GSI	0.23	FP	57.600 m^2
FSI	0.56	FS	140.600 m^2

Figure 6.55. Data from Kadaster, 2020; tudelft3d, n.d.

Phase 1

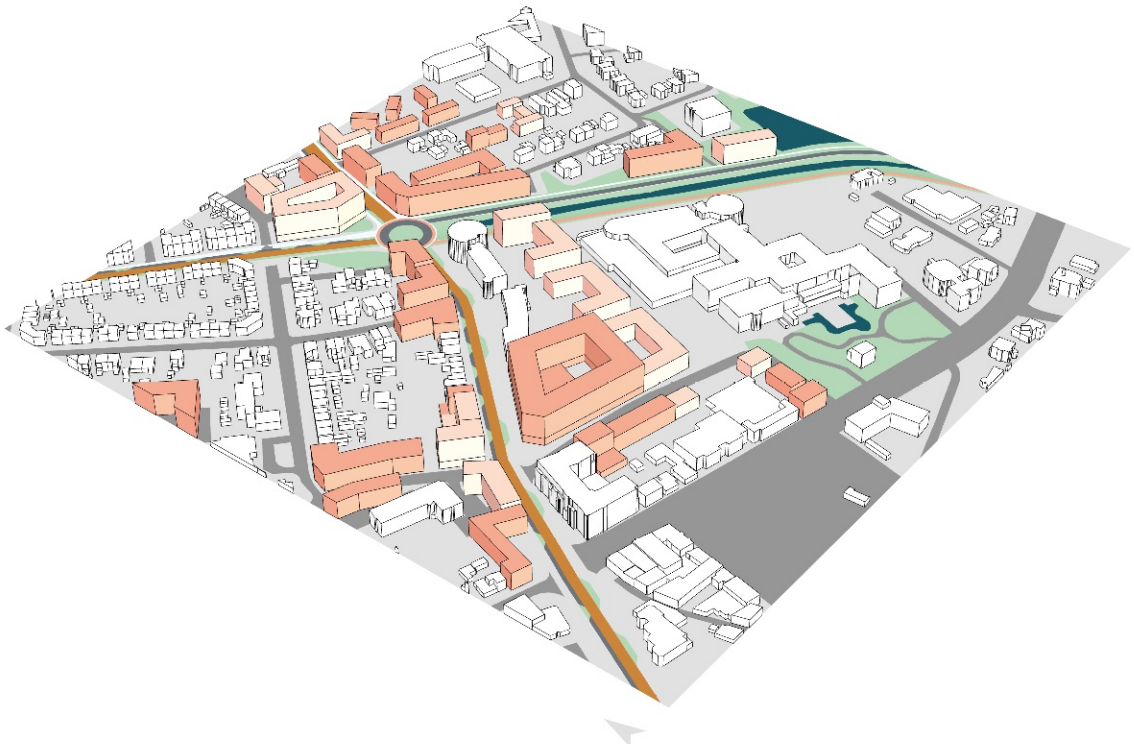
The start of the development is focused on unlocking the potential wherever already possible without too many drastic interventions in the buildings. Two small shops are demolished to make space along the new main roads for more housing while still providing space for services and all the other developments are about infill of unused space. This way, there is more financial profit from the development that can be used to put into the transformations of the streets. As stated before, it is important that the public space is redeveloped before the area becomes very dense if we want to negate the negative consequences of densification. The idea behind many of the buildings is that they can exist on themselves as well, but if the site gets developed further, there are also structures that new projects can easily link to.

Existing situation		Phase 1			
GSI	0.23	GSI	0.26	FP	+ 15 %
FSI	0.56	FSI	0.72	FS	+ 27%

Phase 2

Phase 2 is about continuing what happened in phase 1: further activating the main roads, filling in drosscapes and changing those buildings that are either very low, small, or of low quality. The larger park is exempt from construction to safeguard the presence of qualitative, quiet spots in the area. On the northern part of the area, different building types also arise, that are smaller buildings but are not single-family housing: the small strips resemble a new kind of configuration that refers back to that of a 'buurtschap': dwellings grouped together without a clear central point or square. By creating more open and communal space between the buildings, even people living in an apartment can enjoy the feeling and style of dwelling much appreciated in the guelder culture: outdoor living.

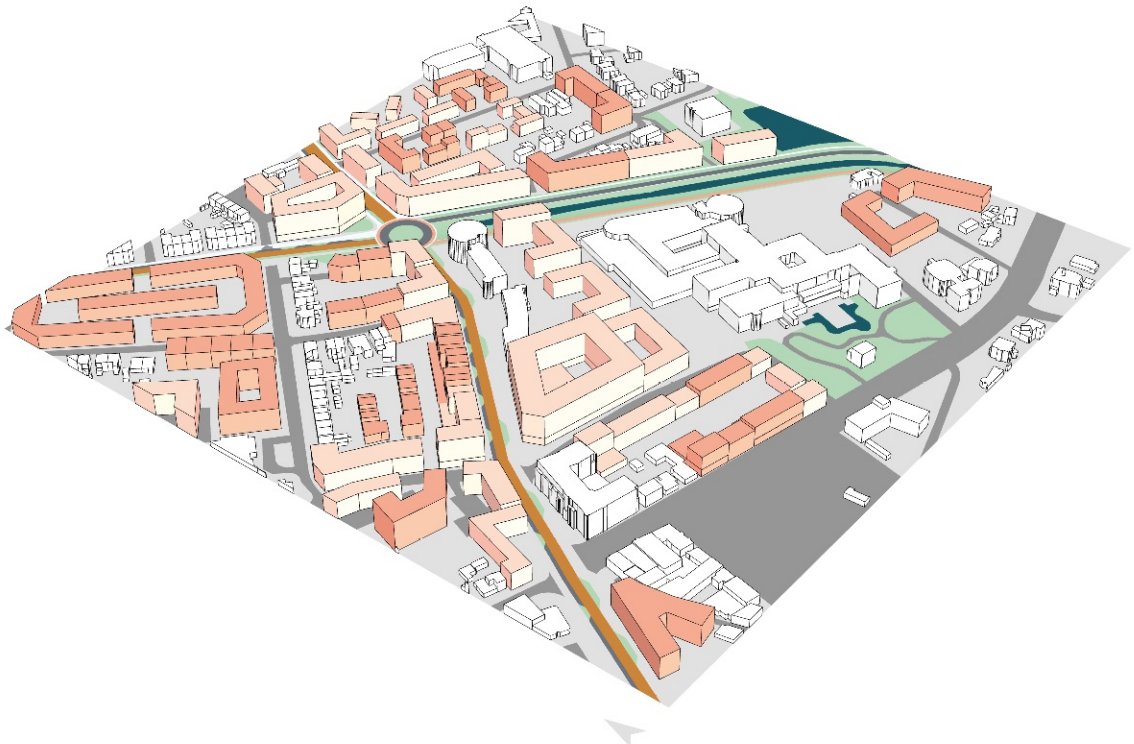
Existing situation		Phase 2			
GSI	0.23	GSI	0.3	FP	+ 28 %
FSI	0.56	FSI	0.93	FS	+ 65%



Phase 3

In phase 3, the development is focused more on densification while keeping the building and parcel structure intact. Some new developments with buildings of larger dimensions still take place, but the largest change happens in the alteration and extension of existing buildings. By this time in the future, the pressure on space will likely start to become higher and higher, which gives owners more incentive to extend their home or sell it to a developer, who can then extend it as part of a larger project. Technological advancements, research into new ways of building (sustainably) and governmental funds can make it easier for this phase to become successful.

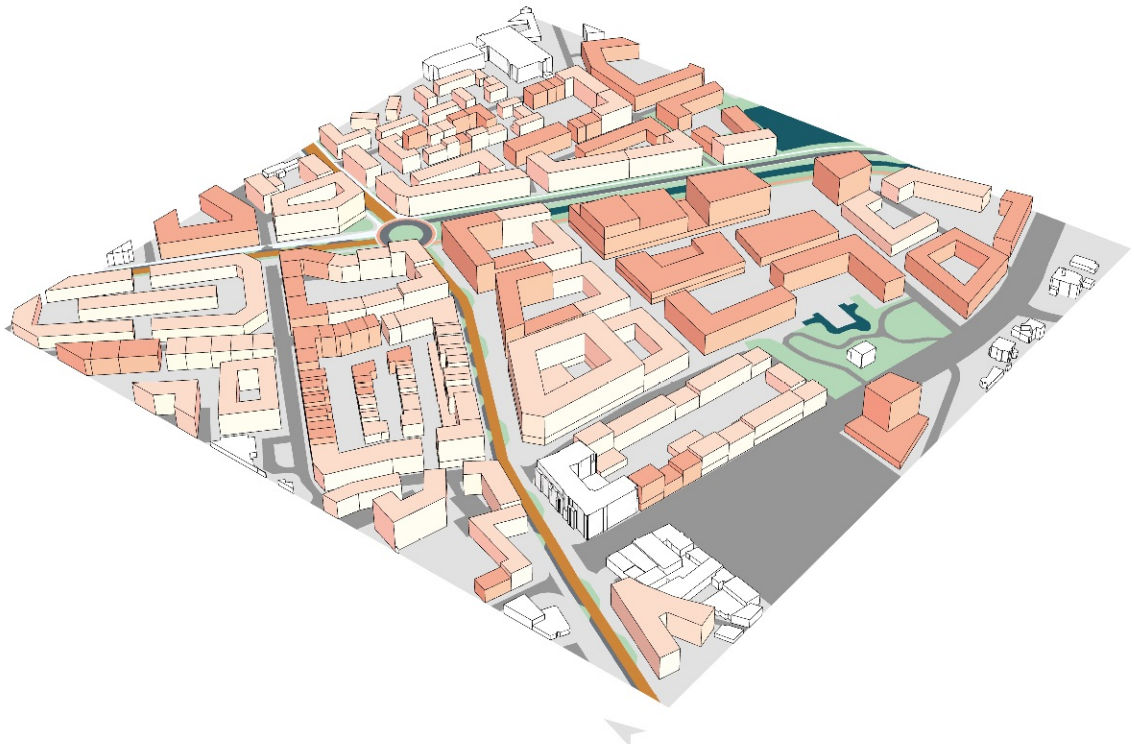
Existing situation		Phase 3			
GSI	0.23	GSI	0.33	FP	+ 44 %
FSI	0.56	FSI	1.15	FS	+ 105%



Phase 4

Eventually, also the larger existing buildings will become outdated or will need an update to become energy-efficient. Almost all of the original buildings have been replaced, extended or adapted. There is still a variety of building types to be found, but the focus is more on multi-family housing and apartment buildings with shared or public open space. Some blocks are deliberately closed off to have a semi-private, communal garden, whereas in others the open space is part of the public realm. Because the buildings are still relatively low and most have a flat roof, they can be relatively easily adapted were it possible in the future, or the roofs can be given an extra use.

Existing situation		Phase 4			
GSI	0.23	GSI	0.4	FP	+ 72 %
FSI	0.56	FSI	1.44	FS	+ 165%



Design explorations: public space

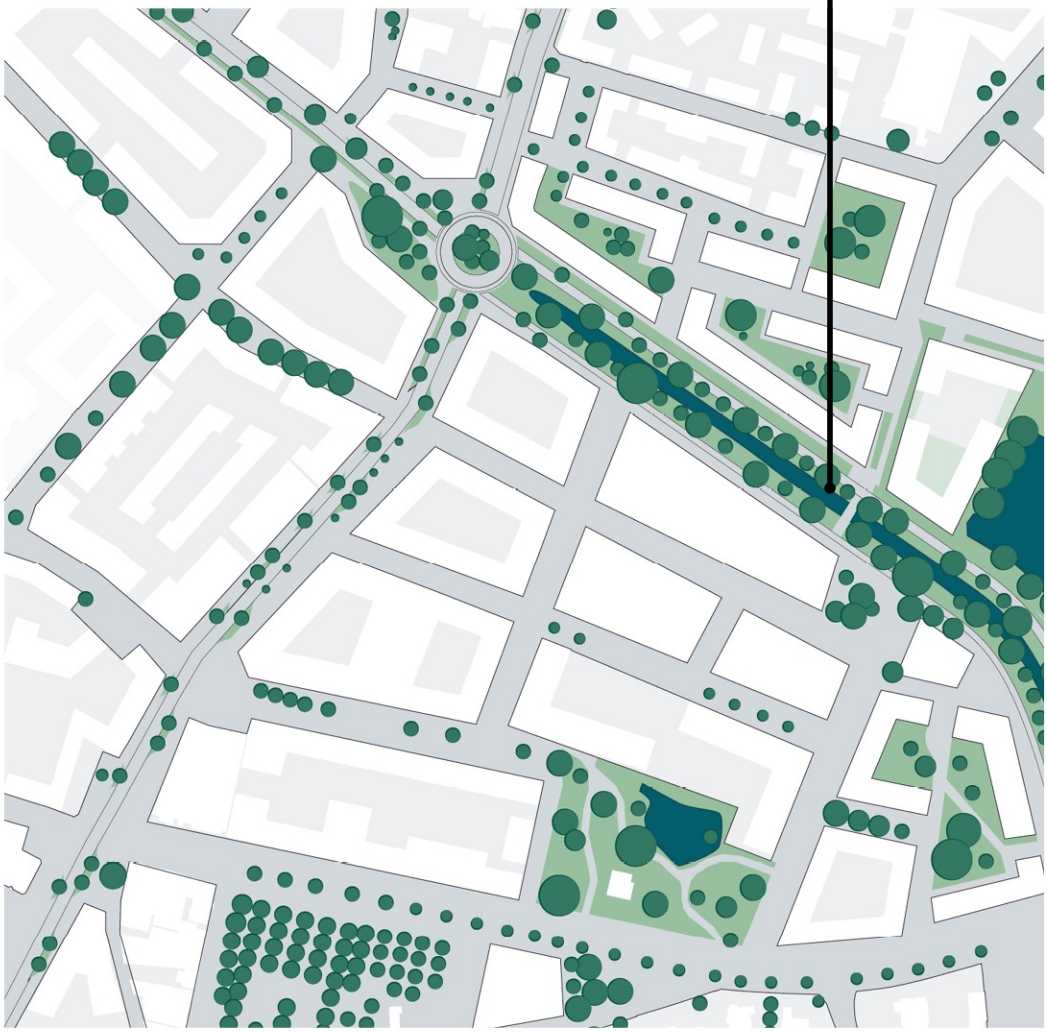


Figure 6.56. Existing situation (top) and new design for the public space (bottom). Data from ©Boomregister.nl., 2023

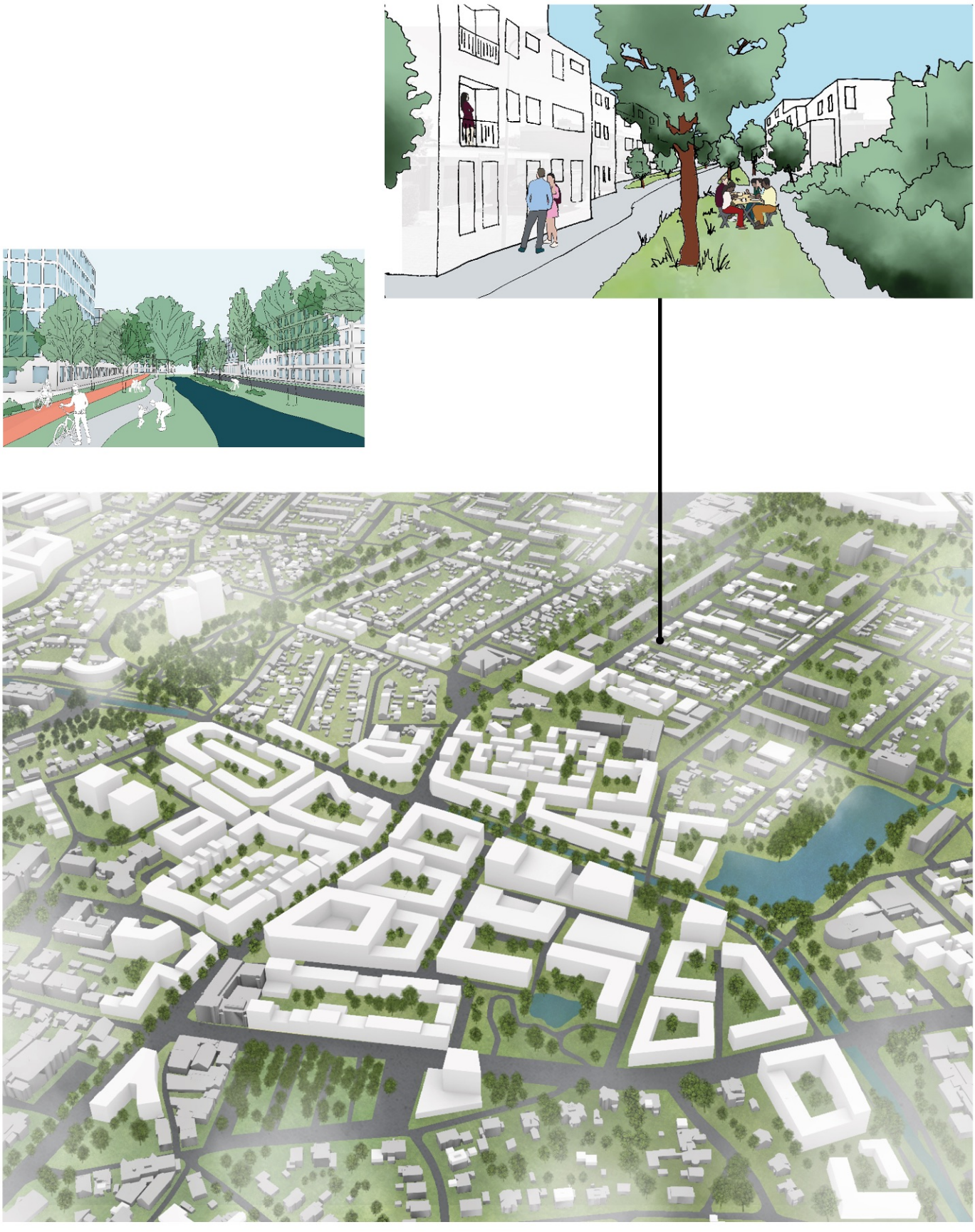


Figure 6.57. Existing situation (top) new design proposal (bottom). Data from ©Boomregister.nl., 2023

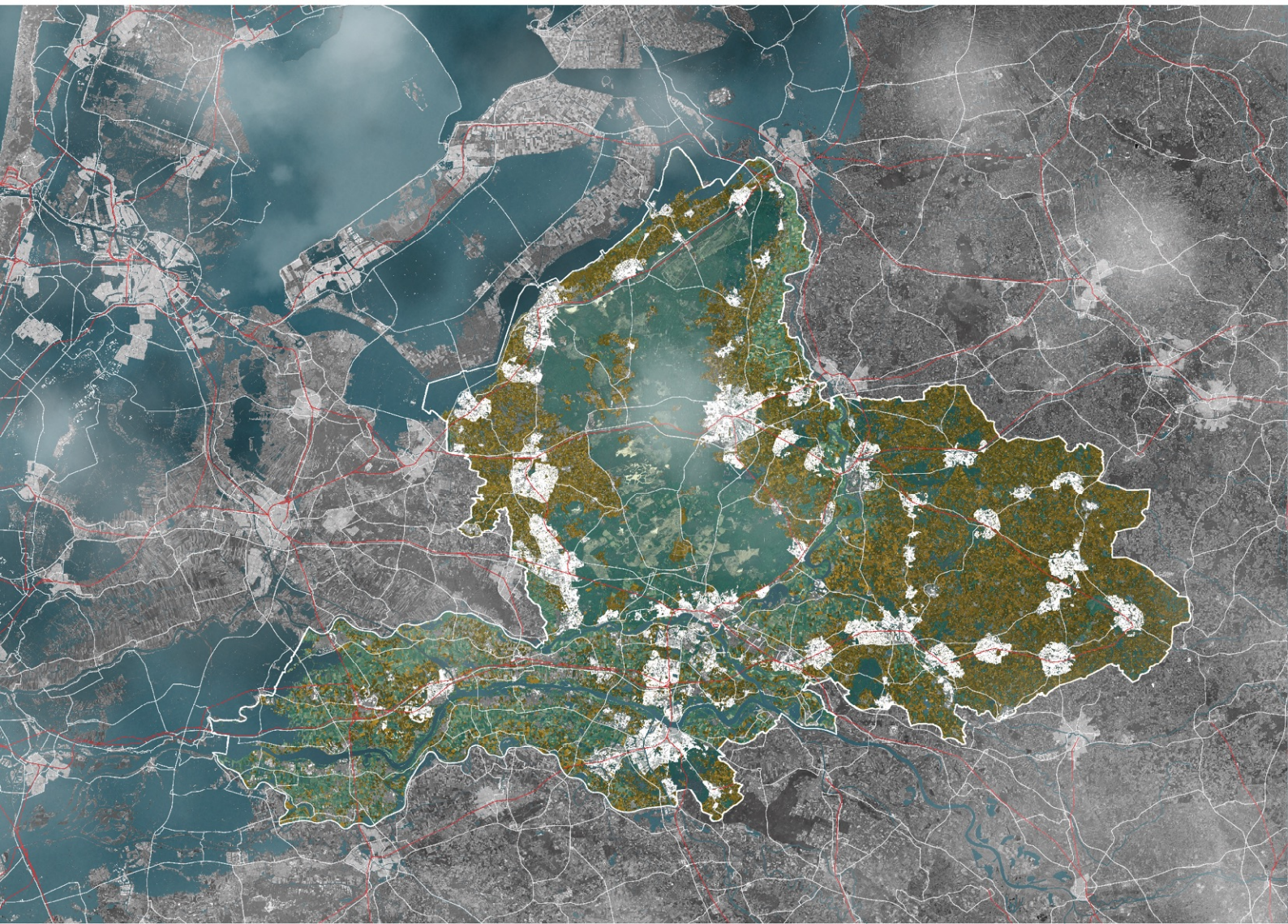
Figure 6.58. Existing situation (top) and new design proposal (bottom). Data from ©Boomregister.nl., 2023

Location 1

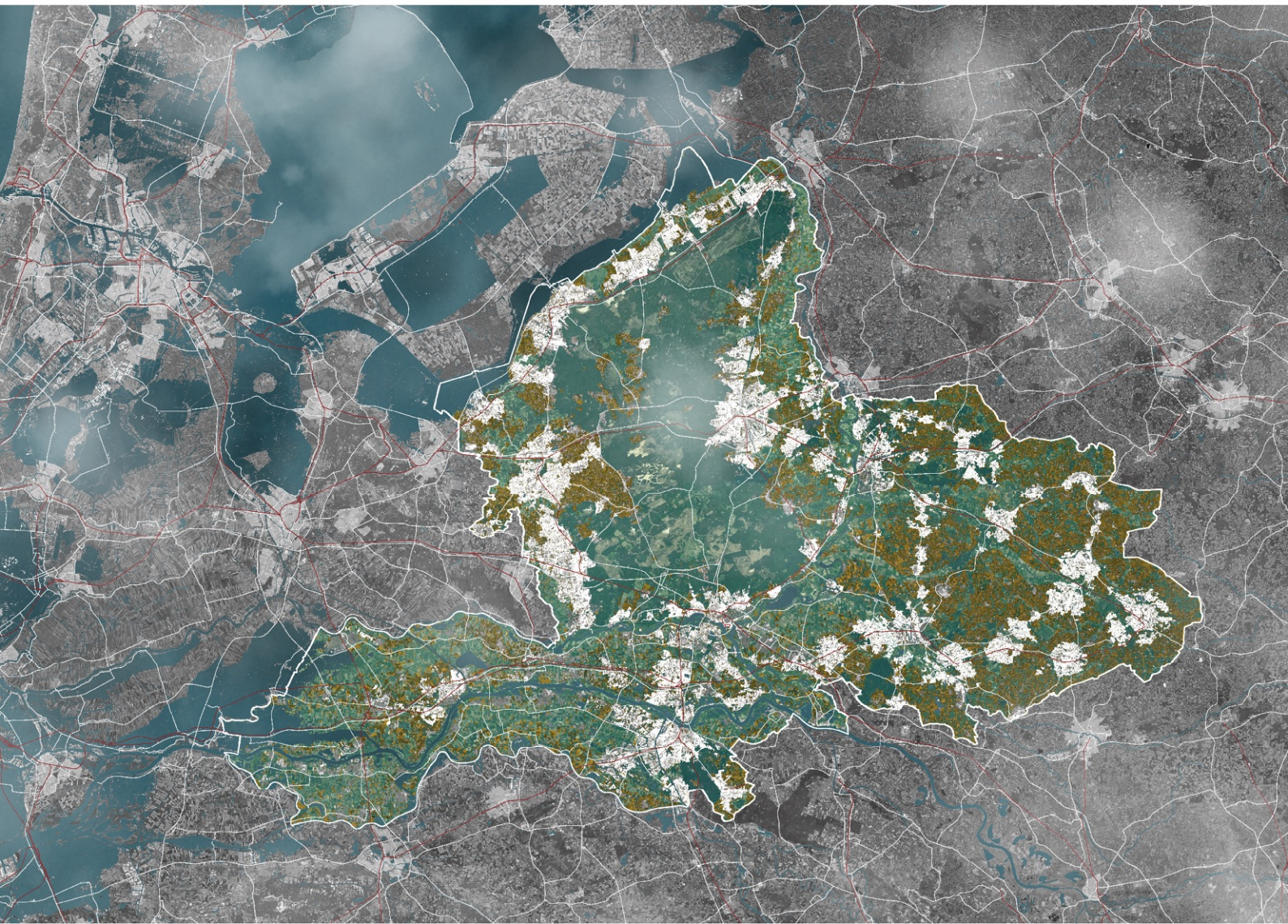
Location 2

6.6 THE PROJECTED FUTURE

Power to the people

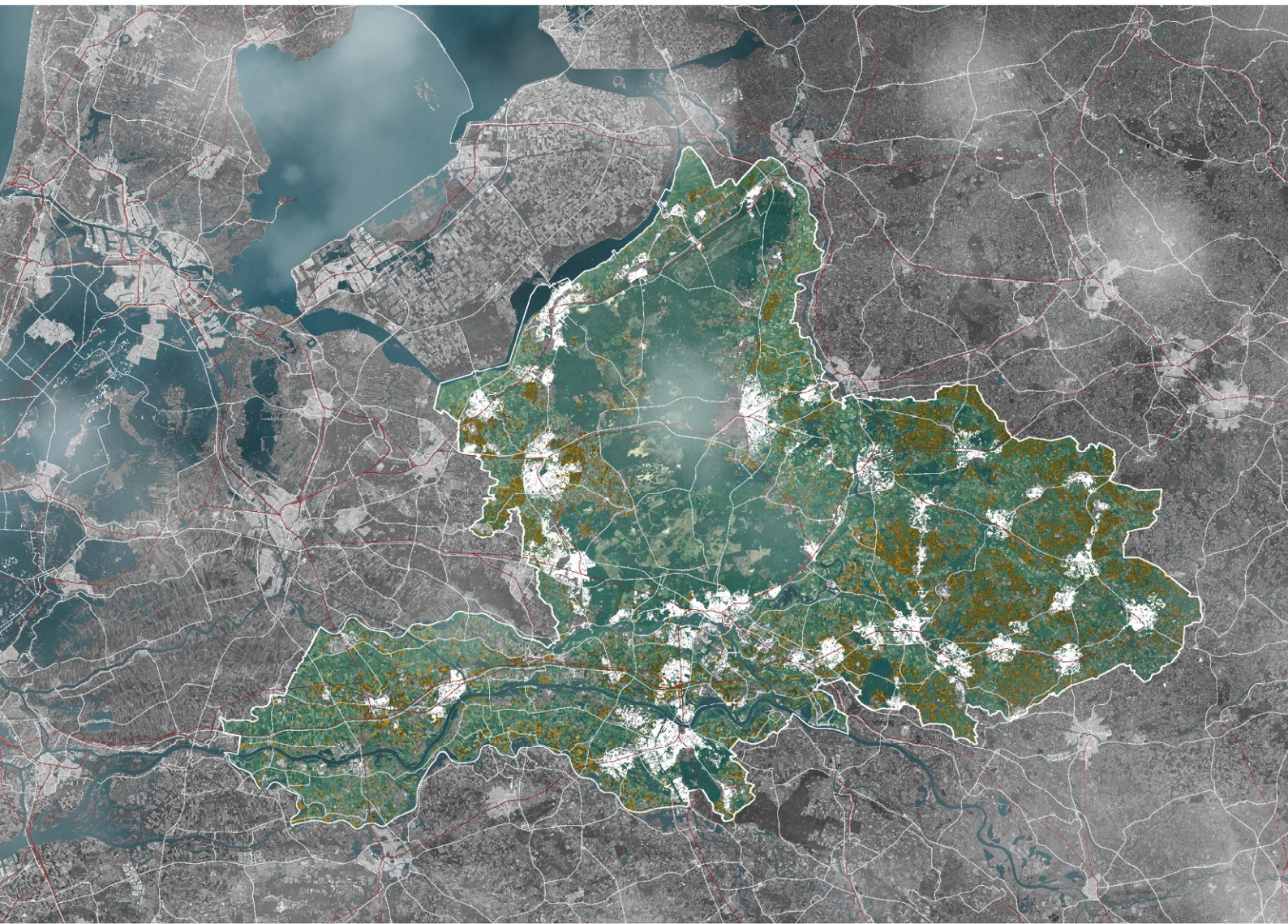


Business as usual

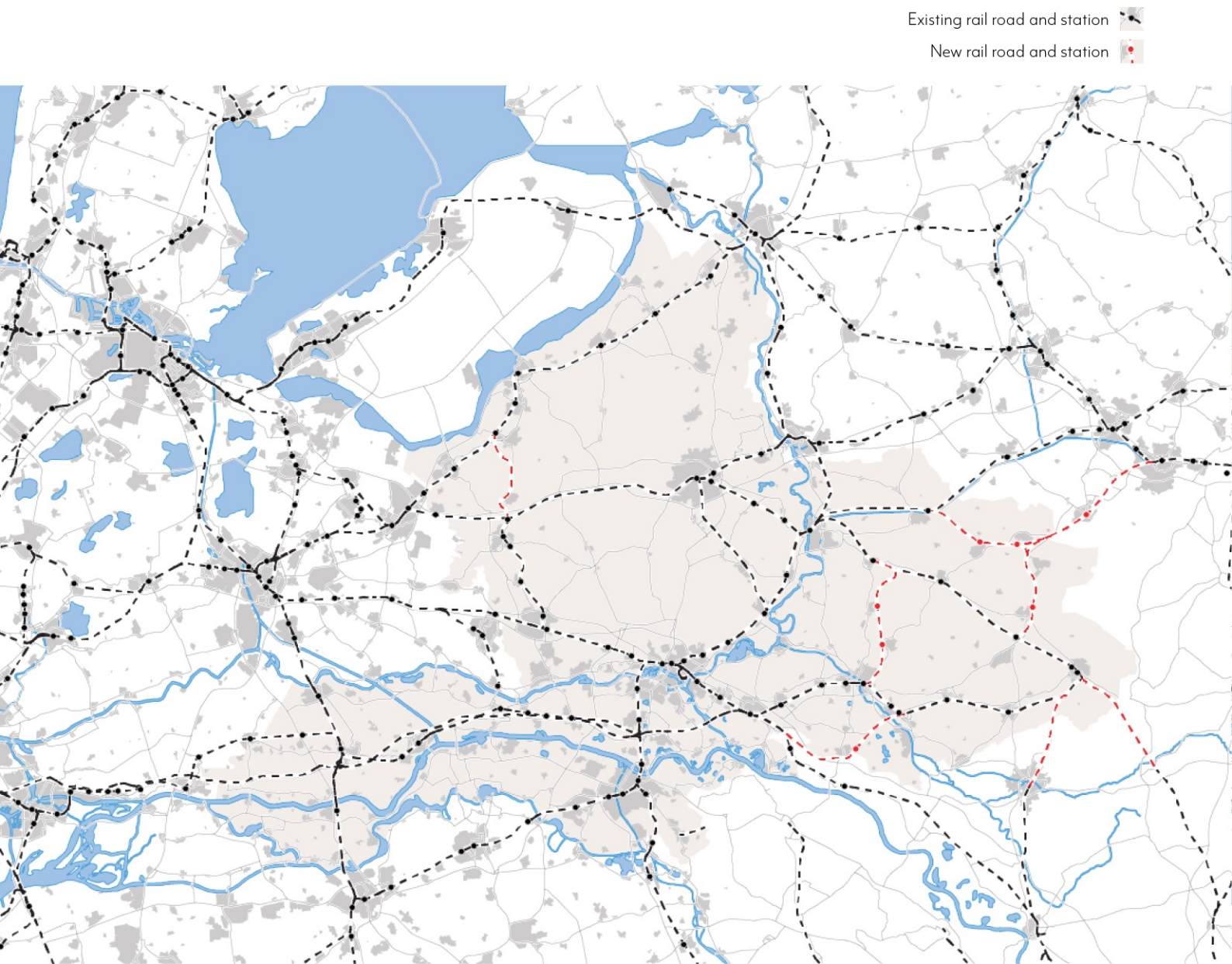


Nature first

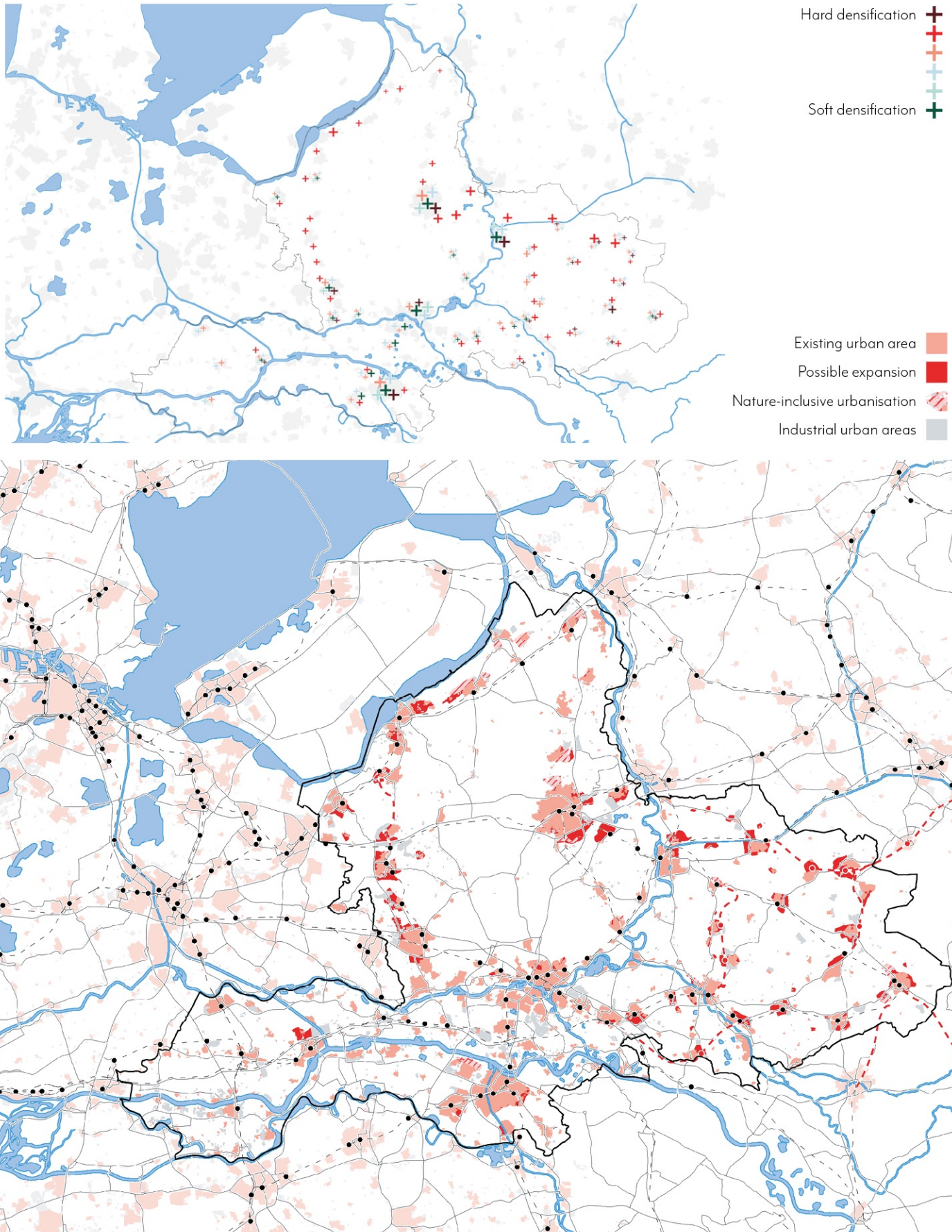
Living in harmony

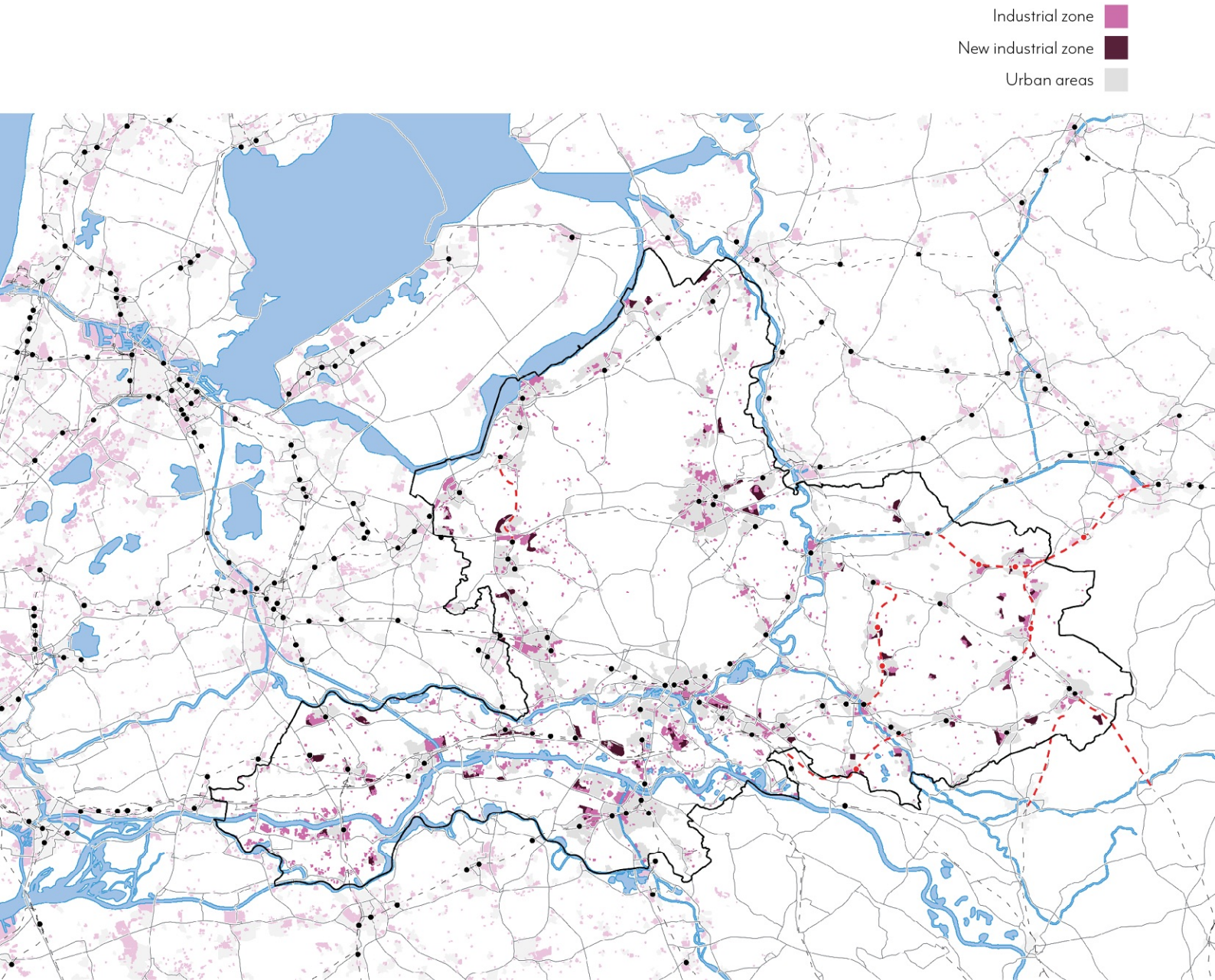


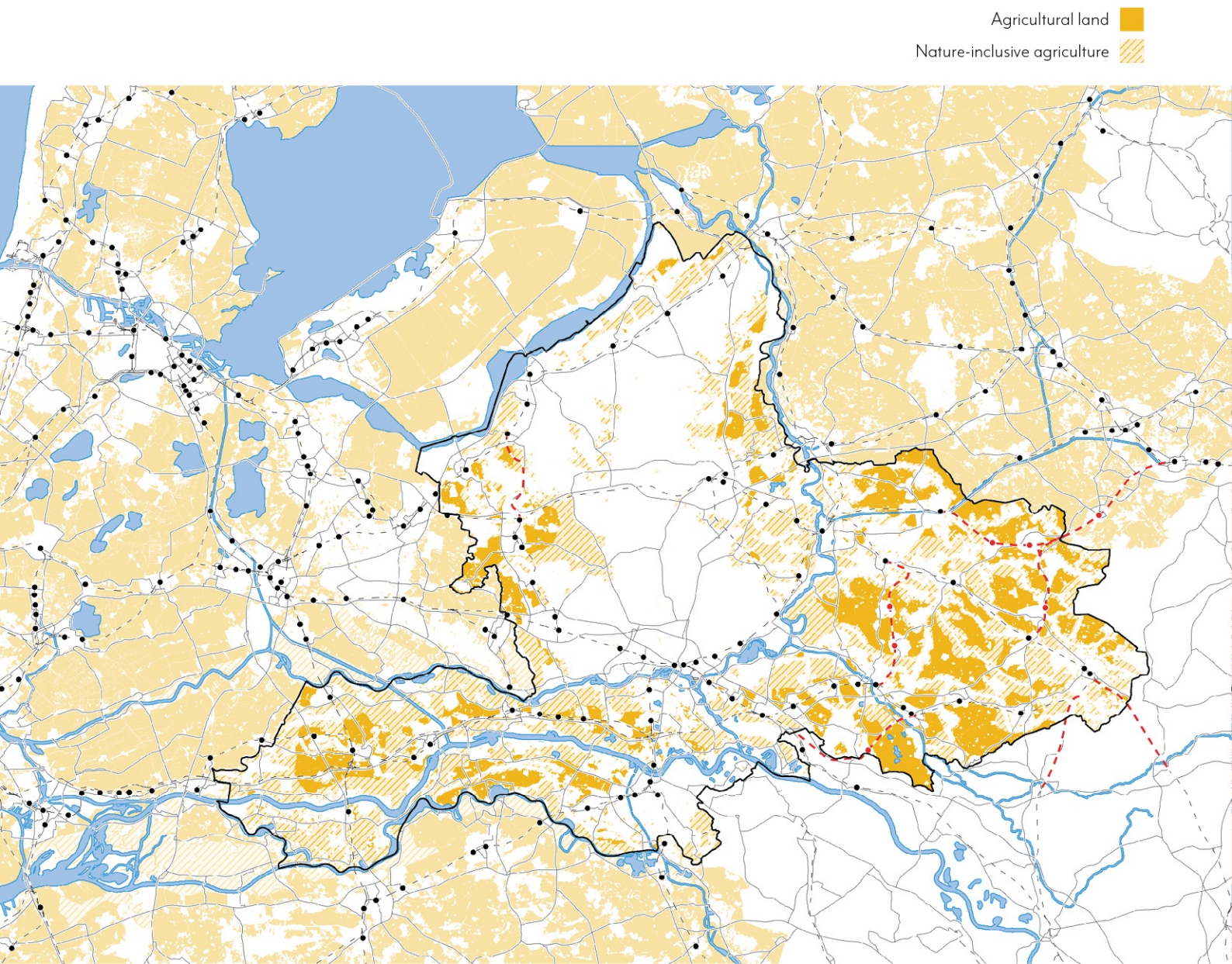
6.7 THE ENVISIONED FUTURE

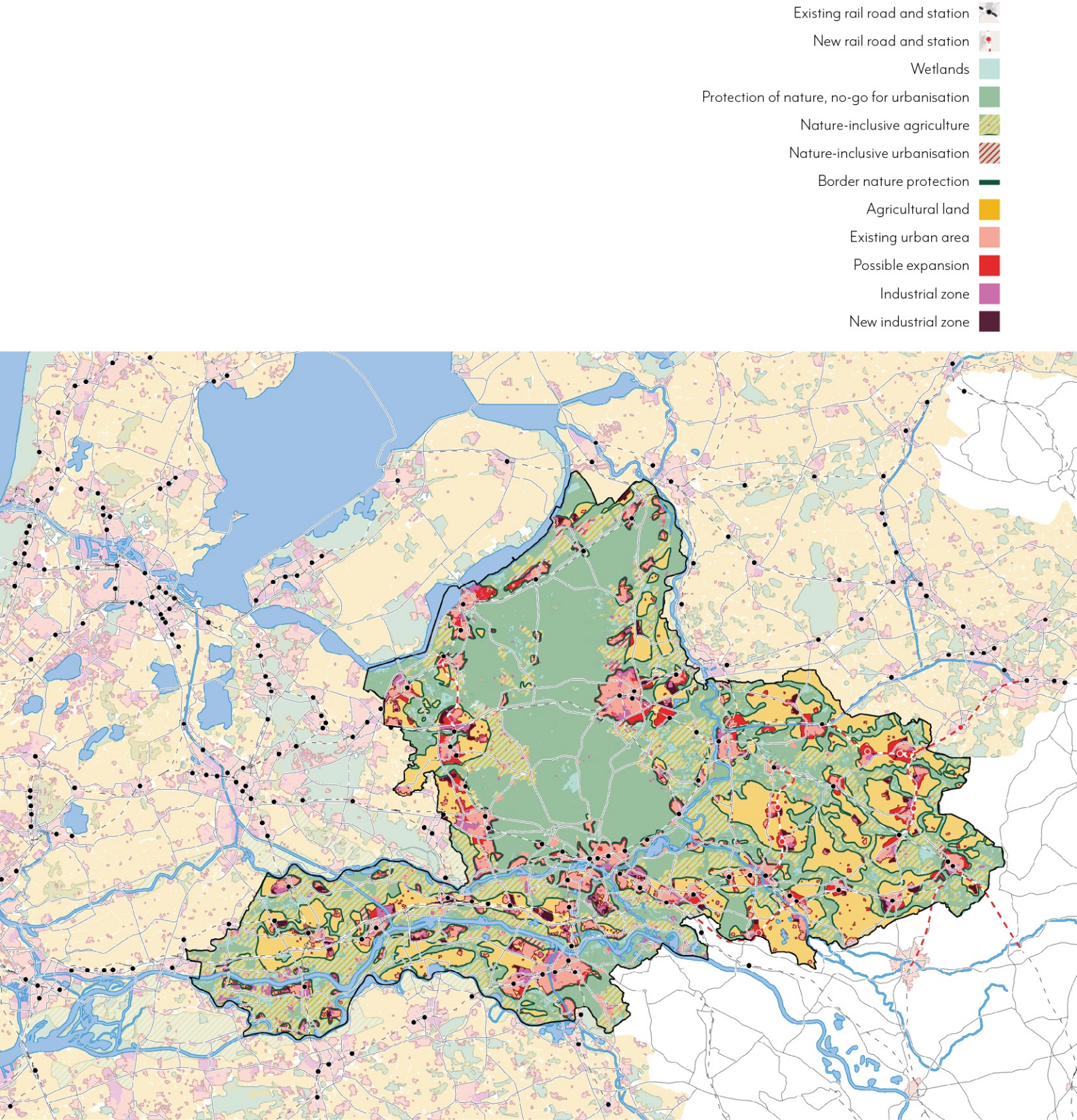



Existing green structure
Expanding green
Connecting green
Wetlands
Protection of nature, no-go for urbanisation
Multifunctional, nature inclusive activity
Border nature protection


Hard densification
Soft densification
Existing urban area
Possible expansion
Nature-inclusive urbanisation
Industrial urban areas


Industrial zone
New industrial zone
Urban areas


Agricultural land
Nature-inclusive agriculture

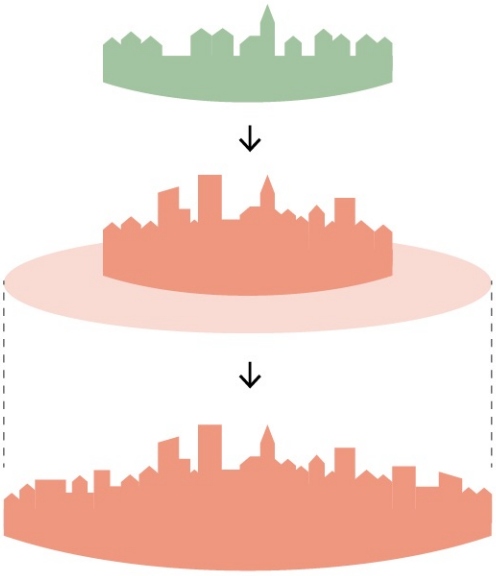

Existing rail road and station
New rail road and station
Wetlands
Protection of nature, no-go for urbanisation
Nature-inclusive agriculture
Nature-inclusive urbanisation
Border nature protection
Agricultural land
Existing urban area
Possible expansion
Industrial zone
New industrial zone

6.8 GUIDELINES FOR RESILIENT DENSIFICATION

From the analysis and design tests on the different scale levels, different problems, opportunities, and solutions come to surface. As the project is meant as an exploration of what could happen, rather than a ready-made masterplan or design, the project concludes in a set of guidelines that can be applied within densification developments to ensure an increase of resilience. While these concepts stem from the analysis of different urban environments within Gelderland, some are more generic, and could be applied in any environment with many low-density, peri-urban areas. Others are more specific, and about safeguarding or improving the qualities of living in Gelderland. They are all complementary and partly overlapping and should therefore be seen as things that work together in a holistic manner, rather than pick-and-choose solutions. The guidelines are also not complete and should always be combined with the more generic principles that make for a sound and sustainable design. They can be seen as the start of a framework for design and planning methods towards a more resilient future for Gelderland.

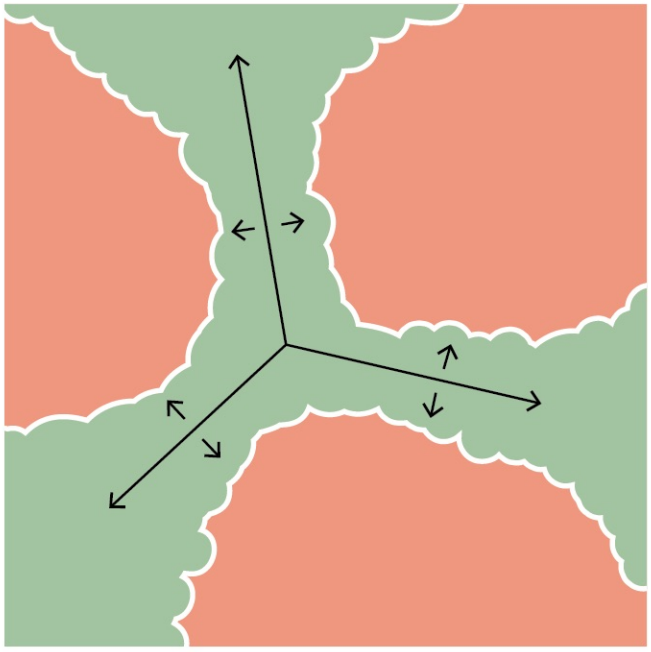
LIVING IN A VILLAGE

Gelderland always has been a place where most people live in (small) villages, but this character and way of life got lost in post-war residential areas due to a lack of centrality, mono-functionality, and the prioritisation of the car. Through densification, the qualities of living in a smaller settlement can be brought back within neighbourhoods, by ensuring they function more as autonomous entities within the town or city, with each their own character, centrality and social system.



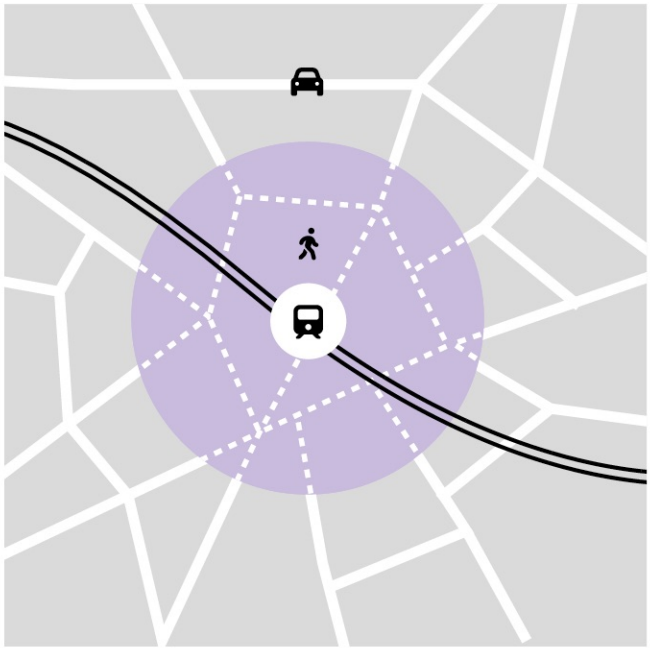
DENSIFICATION > EXPANSION

Before settlements can answer to the pressure on space by expanding, their density needs to increase and obtain similar densities and characteristics as that of settlements of a higher level of urbanity. Moving up the ladder of urbanity should always come with a diversification of urban environments and building types: the more a settlement grows, the more diverse it should become.



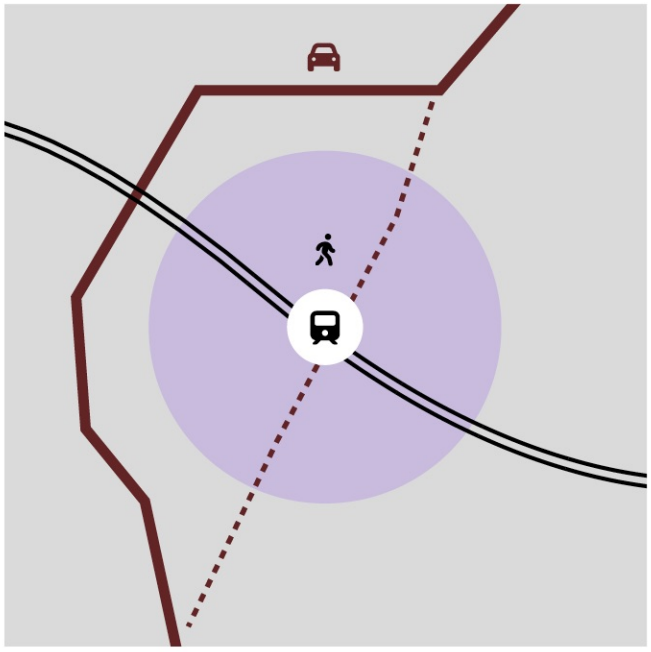
DO NOT MERGE

When different settlements are separated by stretches of open land or natural zones, they should not 'grow together'. It should be made sure there is a remaining area of land that is always kept free of developments. This ensures the possibility for ecological corridors to remain or form and also preserves the open views over the typical landscape of Gelderland, which is one of its great qualities.



WALKABLE REGION

(Wide) main roads that lie within the walkable perimeter of a high-quality transport stop (HOV) should be transformed to be more green, active and pedestrian-friendly. This way, the network can be used to mitigate the risks that come with densification before the city becomes too dense. As this area is already accessible from the whole region by train and then by foot, excessive usage of the car within this perimeter is unnecessary. For people trying to reach the city (or the station) from a location without public transport, mobility hubs on the border of the city and measures such as one-way or destination traffic can be a solution.

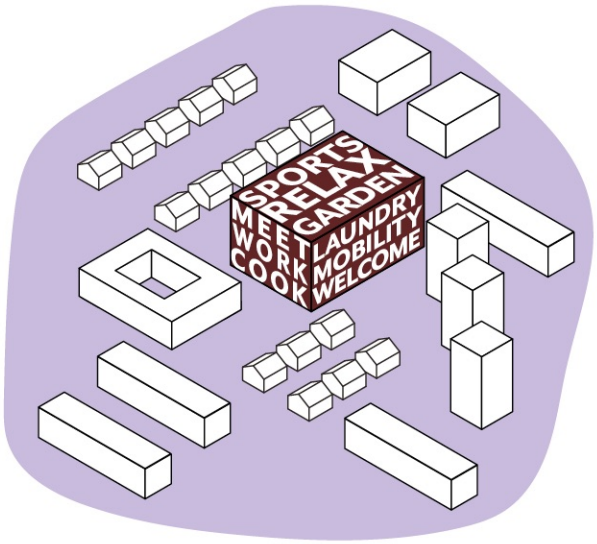


NO WAY THROUGH

Ensure that vehicular through traffic does not have to use roads that cross the dense city centres. This does not only slow down the traffic on those roads, but also takes up valuable space and has many negative implications for the people living in the city.

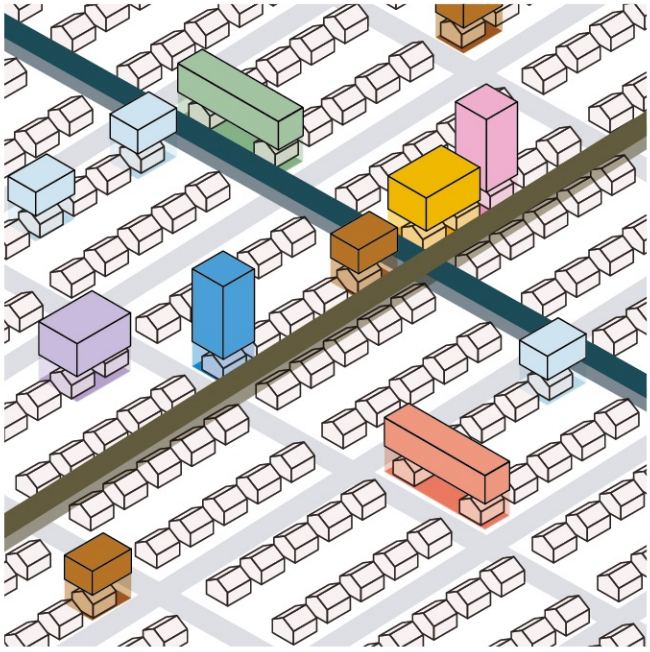
HIERARCHY IN THE MAZE

Many residential areas are currently built as mazes of small, residential streets. Main roads are either lacking, meandering around the small mazes or function only as an infrastructural connector, without any buildings being directly connected to it. By bringing hierarchy into the network, simplifying it, increasing connectivity to the main roads, and populating these so that they become high streets within the neighbourhood, connectivity, diversity, and redundancy can be improved.



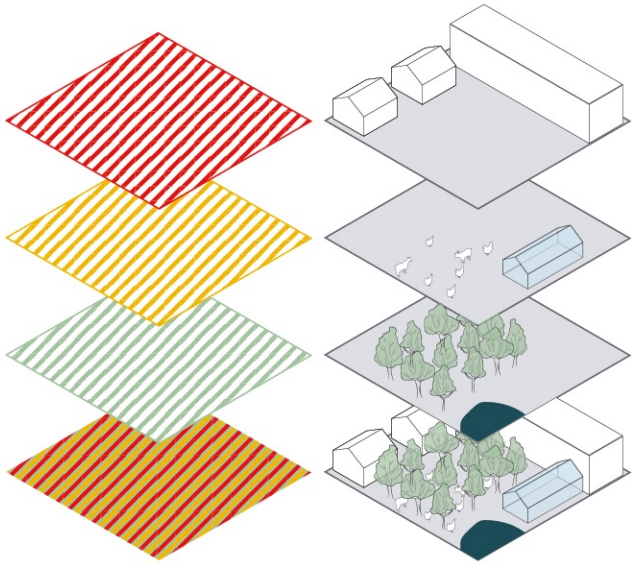
SERVE THE NEIGHBOURHOOD

Invest in places in every neighbourhood where people can find space they may lack in their home once the dwellings become smaller. These neighbourhood centres could host communal spaces to work, exercise, relax, cook, invite people, and come together, garden & grow foods, play, do laundry, etc... Investing in these types of functions does not only help in raising more support for densification developments, but also enhances social resilience.



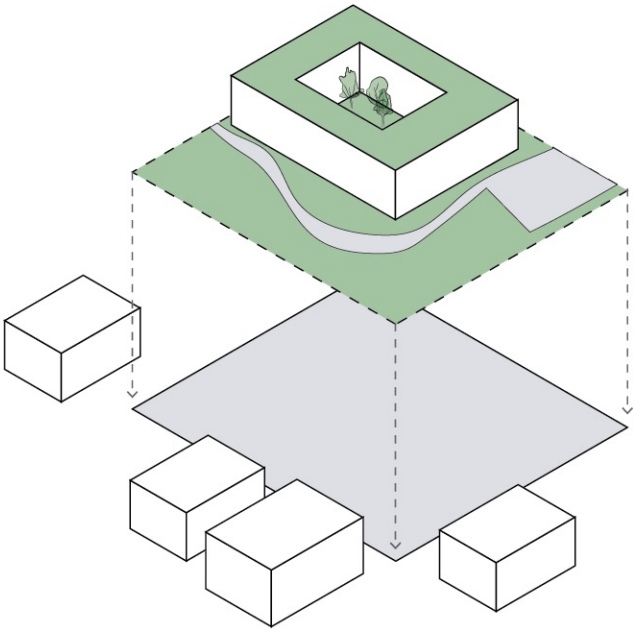
MIX UP THE 'MUSH'

Many environments miss identity as a result of the 'mass production' of houses and residential environments, the homogeneity results in the absence of a place-specific character. Densification should be used to diversify the homogenous 'mush'. To ensure the place becomes more of a result of its specific time and place, soft densification should be included to give people the opportunity to change their living environment and leave their mark on it.



A STACK OF USES

A lot of space is lost, and therefore opportunities missed, due to the mono-functional appointment and use of space. By realising that many uses can often work well together or even reinforce each other if combined properly, a lot can be won. Urban or agricultural activity do not have to exclude nature, small industries can be combined with offices or housing, places for sports can be integrated into the city, etc. Examples of projects that deal with multi-functionality such as agroforestry, urban farming or even building on the water should be used as a driving force behind new developments.

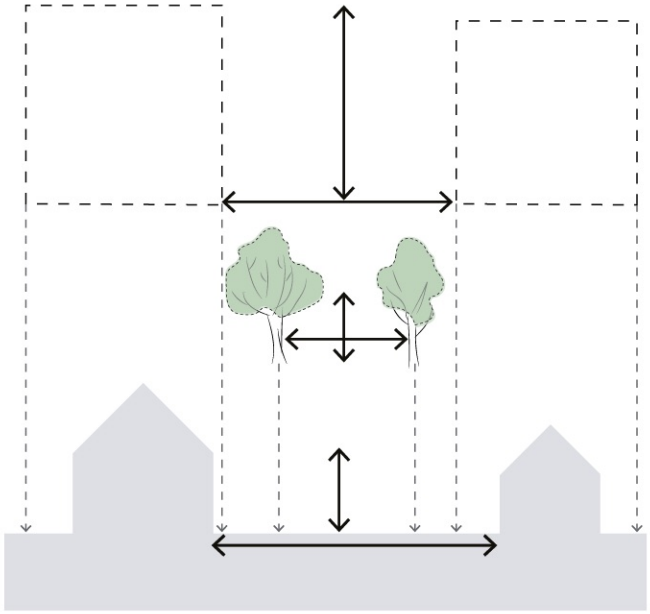


DENSIFY = GREENIFY

By transforming central, paved drosscapes (first), densification can actually make the amount of infiltratable surfaces lower. It is therefore helpful to not only use GSI as a criterion for assessing whether a design improves the existing conditions and climate resilience but take the materialisation of what is now and what would be into account.

WHERE TO MEET?

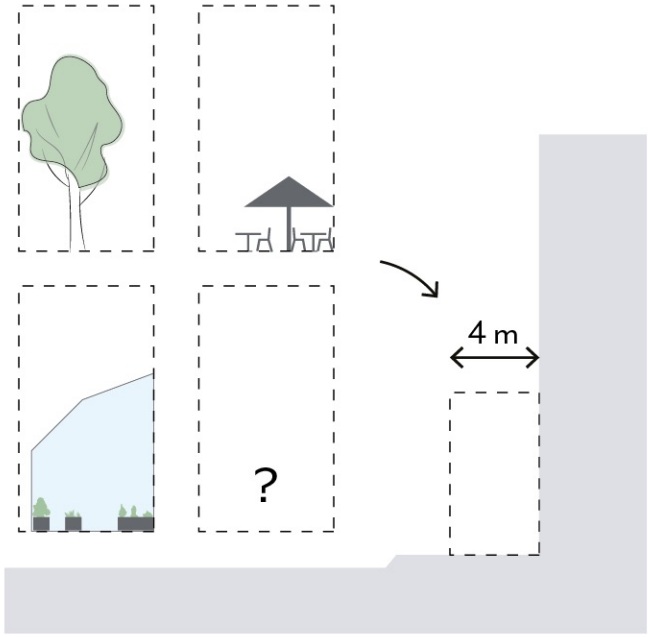
Most neighbourhoods in Gelderland lack a specific designated public space where they naturally meet their neighbours or have a place for public urban life. The public space in these areas mostly consists of roads that are reserved for the car, parking spots, pavements (that oftentimes suddenly end), a playground to make up for the fact that it is not safe to play in the street, separated bicycle paths, and fragmented patches of grass. This, in combination with a lack of centrality, results in people rarely using the public space and thus, in a lack of urban character and social cohesion. By reducing the space for the car, bringing hierarchy in the network, introducing more shared open space, and creating central squares or public spaces, these qualities can be improved.



BALANCED DIMENSIONS

While designing with densities, defining the desirable street profile early in the process can point the development into a certain direction. It can be used to determine both the potential as well as the limits to a development.

As a guidance, the higher densities of a neighbourhood should be centred along or around the most central places in the network. This way, the height to width ratio is adjusted to the type of street, there is more chance of survival for amenities in the main streets and there is a more distinct difference between busier and more quiet streets. This also means people can escape from or search for the bustle as they please.

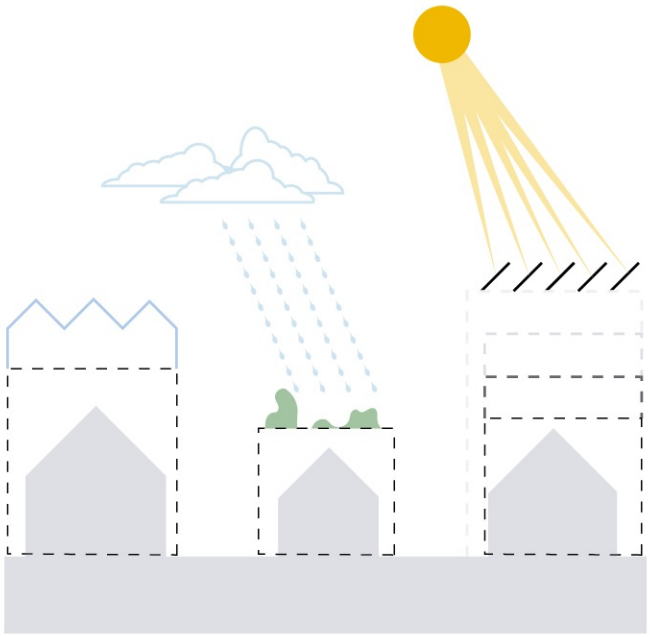


FLEXIBLE TRANSITION

By ensuring a 4-meter-wide setback from the street to building facade, a flexible transition zone can be made. This means there is more space for:

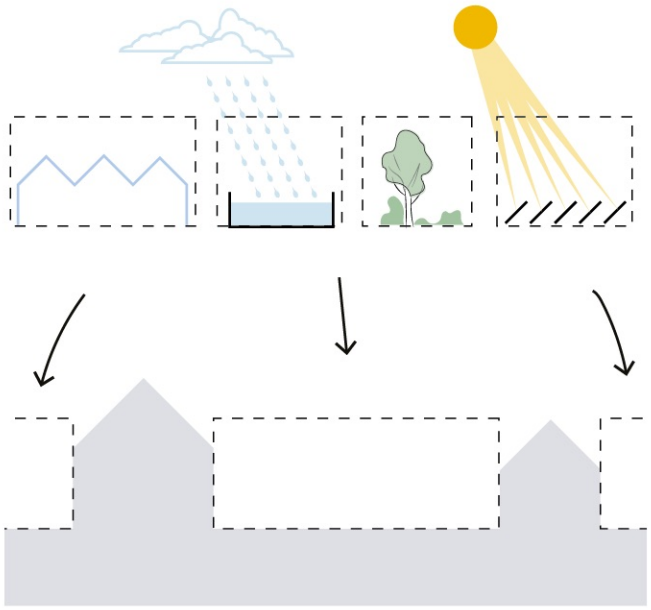
1. greenery or gardens
2. shopfronts
3. terraces
4. mobility
5. innovative, yet unknown solutions

The trick is finding a healthy balance between efficient use of space and the implementation of flexible, open structures, which improve adaptive capacities. The scales of flexibility and resilience on one side and answering to the pressure on space should never tip to one side.



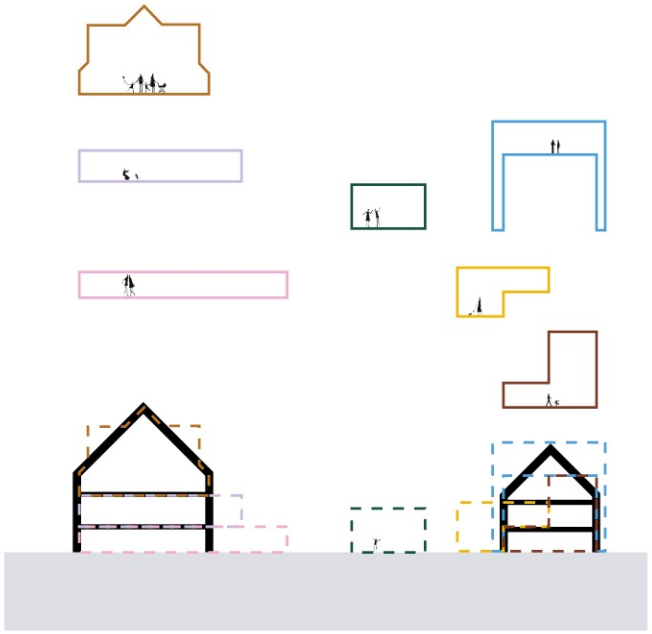
FLAT = ADAPTIVE

With the construction of new buildings, both an efficient use of space as well as flexibility should steer the design. One measure that enhances both, is the use of flat roofs. While this may seem like a trivial characteristic, the fact that most buildings in Gelderland have a slanted roof makes urban environments less resilient on every scale level. Flat roofs, if constructed appropriately, can host a multitude of functions and can therefore serve as a enormous extension of the usable space. If not employed for human activity, it can be utilized for energy production, as a green roof, growing foods, to enhance biodiversity, to slow down stormwater runoff, and so on. And when, in the end, more floor space is needed, vertical expansion is much more feasible as to when the roof has a slope.



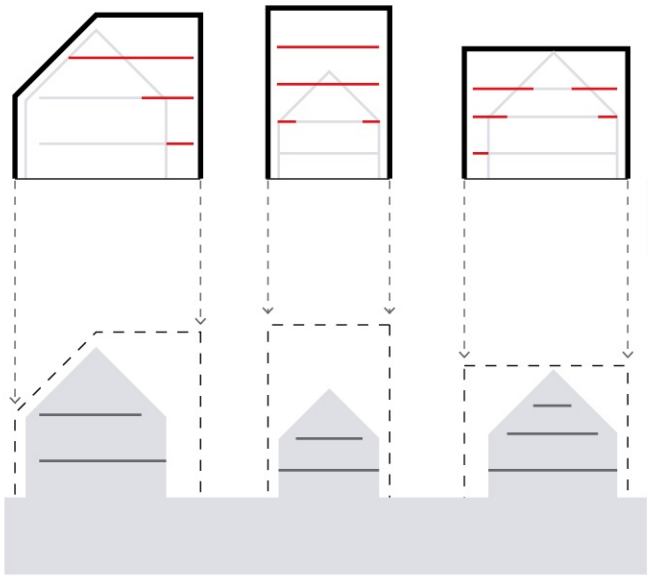
POTENTIAL OF THE GARDEN

Encouraging people to use their private open space or gardens can mean a tremendous unlocking of potential. Many gardens are currently just a paved surface, but if they were used for growing foods, water storage, energy production or maybe even extra dwellings in the forms of tiny houses, this would substantially lower the pressure on space for the province as a whole. Even nudging people to remove tiles from their garden and make it more green and nature inclusive will have a positive effect on the pressure on space and will improve the climate mitigation and adaptation performance of a city.



CREATIVE DWELLING

The homogeneity of the current building stock and the average amount of dwelling space per person imply that the solutions to the pressure on space are not only found in the construction of new buildings. By encouraging people to live on less amount of space, to split or share their home, in combination with the extension of the building, the region can answer to the pressure on space with resilience in mind. The strategy embraces resilience for a few reasons: these changes are often relatively slow, small scale and incremental, which means they are not too much of a disruption to the system. It also improves the overall diversity of the building stock on all scale levels as it can happen virtually anywhere, and it gives people the freedom and means to use their resources and knowledge in the way they see best fit, after all: inhabitants are also experts of their own living environments. Encouraging small scale developments and projects can provide opportunities for stronger bonds and communities to form, improving social resilience.



WRAP & EXPAND

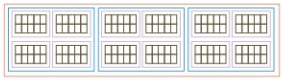
As the problems with the current building stock are not only a lack in numbers, but also a lack in quality, densification is an opportunity to kill two birds with one stone. When extending buildings for an additional amount of floor space, it is only logical to also improve the thermal layer of a building, especially when the construction also needs reinforcement before it can be extended. This way of building and renovating is quite new and unexplored territory but could prove to be an effective method in solving problems in the sector. While more research is necessary for the possible ways of implementing this method, it should be investigated as a serious option.

Qualities of resilience & design measures

scale and abstraction level

DIVERSITY	CONNECTIVITY	REDUNDANCY
		
the introduction of new types of transport urban growth guided by place-specific qualities and cities' roles in the larger system soft densification: increasing the diversity of building ages, layout and qualities	improving and extending the network on the regional scale planning urban growth around existing public transport nodes and services	expanding the range of transport options working with polycentric models on multiple scale levels: ensuring areas are never fully dependent on one centre diminishing urban sprawl and ensuring the existence of (natural) open spaces in the landscape through the compact city model
new and more diverse urban characters more hierarchy in the street network and different types of streets mixing of functions: a higher diversity of (economic) activities at the neighbourhood level	densification focused around public transport higher densities along main and/or central roads and services introduction of mobility hubs, increasing centrality in monofunctional areas connecting fragmented green and blue structures simplifying the network in residential areas	new service centres: introduction of more (centralised) services at the neighbourhood level more space for green and blue within the city mobility hubs: the possibility to reach a destination through different modes of transport
new dwelling types 'creative dwelling' and the alteration of existing dwellings: unique types more even distribution of dwelling types: less single family homes (row houses and villas), more apartment buildings encouraging different uses of gardens and roofs	from private gardens around single-family dwellings to public or shared open space between buildings: increasing permeability of the block	flexible transition zones allow for a higher redundancy of whatever is necessary increasing self-sufficiency: using spaces within the city (public space, gardens, roofs) for (small) agricultural and industrial activities, energy production, water storage

MODULARITY



through the multiscalar approach modularity can be enhanced: ensuring that each aggregate functions both autonomously as well as within the larger context, ensuring that the whole is always greater than the sum of its parts

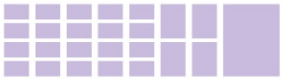
mixing industrial zones: disaggregating large plots and buildings into smaller ones

increasing local autonomy through adding of services and mixing of functions: the neighbourhood as a structurally and functionally autonomous module

flexible transition zones: a new element of modularity between the public and private realm

extending, adapting and splitting existing dwellings

EFFICIENCY



ensuring a balanced distribution of settlement sizes: few large cities, some towns, many villages and hamlets

mixing industrial zones: diminishing the relative amount of large plots and buildings

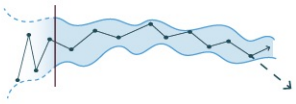
more hierarchy in the street network

the combination of services and mobility on different scale levels: a small one for each neighbourhood, one or two larger ones per city, a few larger cities per region, etc.

building more smaller dwellings / apartments: diminishing the relative amount of large, detached dwellings

service centres within residential areas as the few larger buildings within the neighbourhood

SPECIFIC RESILIENCE



climate change: planning urban growth based on risks such as height levels, flooding, drought, subsidence, etc.

car dependency: planning urban growth from the starting point of the 15-minute city model

scarcity of space: diminishing sprawl

climate change: more space for green and blue within cities, more production of renewable energy

car dependency: neighbourhood centres and mobility hubs

scarcity of space: combination of soft densification through alteration of buildings and hard densification in places with few environmental or urban qualities

social resilience: soft densification, bottom-up developments and services close to home

climate change: increasing the amount of permeable surfaces, improving the (thermal) performance of facades, encouraging urban farming and small scale energy production

scale and abstraction level

07 FINAL REMARKS

7.1 DISCUSSION

The project combines resilience and densification in a strategy and design which focuses on the alteration of urban form in pursuit of, in theory, very clear goals, namely being prepared for uncertain developments and enforced uncertainties. While both concepts are effective in preparing for the future, they address different challenges and might be seen as opposing in certain aspects. In some ways, they are indeed contradictory, which is why it is important that a good balance is always sought between the both. It is equally important to consider quantitative and qualitative assessments in relation to each other to avoid oversimplifying complex questions and providing solutions that only address one aspect of the problem while neglecting others.

Resilience, as a holistic concept, encompasses factors such as durability, sustainability, adaptivity, inclusivity, and adequacy of urban environments. Given the current crises we face, resilience presents a suitable approach for responding to these challenges comprehensively. However, the concept of resilience is characterized by various definitions and interpretations, and there is a lack of practical examples demonstrating how it can be effectively applied. To establish resilience as a widely adopted concept within the field, further testing and integration with other prevailing concepts is necessary. It is essential to reach a consensus on its meaning and desirable applications to avoid misinterpretation and misuse. Until such consensus is reached, it is advisable to incorporate the aforementioned concepts of durability, sustainability, adaptability, and inclusivity alongside resilience.

From the design testing and calculations on possible densification strategies, it becomes evident that, if the scenarios that the project assumes turn out to be of a correct order of magnitude, the environment will have to change drastically. In all of the scenarios, there hypothetically is enough room in Gelderland for expansion of urban environments beyond the existing borders into areas that do not face any high risk. Besides the fact that many other uses would have to make way for this (agriculture, industry, nature), developing in such manner will most likely only cause more problems that increase the pressure on space. As densification patterns have a high impact both on climate change as well as resilience to climate change, choosing to develop through hard densification only can be seen as a vicious cycle. In order to avoid endless urbanisation through hard densification, soft densification can relieve some of the pressure, but this will also mean a relatively drastic change of existing urban areas.
Gelderland currently has some environments of a higher density, but these comprise only a very small part of the built environment. Type D counts 7% of the blocks and 1.2% of the block area, Type E only 1,2 and 0,14% respectively. In the calculations, an FSI of 3 is more commonly represented, which already indicates that many settlements will be introduced to types of densities yet unknown to them. The design tests show, however, that densification and thus

a change in character does not have to be a bad thing, but that it can actually create new qualities that are currently lacking in Gelderland. The project also shows that regardless of the lack of space and needed densification, the analysed urban environments will have to change in order to become resilient. Though modularity is relatively well-embedded into the fabric, the other lack of other qualities of resilience along with certain path dependencies make the system vulnerable. Though the project started from the pressure on space as an instigator of change, it becomes clear that a better suited approach is to analyse and acknowledge the ways in which the area is not resilient, and explore how densification could contribute to amend those.

Reviewing the practices of urbanism thus far, it becomes evident that a new approach is needed. While the theoretical and practical developments in the field, especially since the 20th century, have been valuable, it is clear that the planning and design methods employed in the past have also contributed to the problems underlying the crises we are faced with today. Rather than disregarding previous research and practices, there is a need to learn from them and develop a new relationship with them. This project aims to contribute to the emergence of this "new kind of urbanism": developments that acknowledge the larger scales of space and time as guidance for what will happen in the future, are focused on enhancing qualities and not just responding to the lack of space, aim at reconciling the boundaries between humans and nature, and use the power of design for imagining how things could change for the better in a holistic manner.

Analysing planning practices in the 20th century in the Netherlands, one observation or critique that arises is the perception of society and space as entirely customisable. This idea of a 'maakbare samenleving' waned over time, and it could look as if this project suggests that it should be reintroduced, but this is not the aim. Instead, it recognizes the presence of uncertainties that can radically shape the future. However, uncertainty should not impede innovation or the desire to improve current and future circumstances. On the contrary, uncertainty has the potential to stimulate imagination. Urbanism should strive for a balance between idealism and realism, seeking simple yet smart, complementary, and nuanced solutions.

The project is not intended to be viewed as a strict set of rules or a final design or strategy, but rather as an exploration into what this "new way" of urban design and planning could entail. The project holds its greatest value as a generator of knowledge, fostering a deeper understanding of the subject matter, rather than providing ready-made solutions.

7.2 CONCLUSION

In conclusion, this research has explored the interconnectedness of resilience, morphology, and densification and how this interrelationship can be utilised in design. As for any other complex system, it is crucial for urban environments to be able to respond to change, shocks, and disasters. The concept of resilience, through the explanation of panarchy, includes all the possible ways of doing so: by transforming, persisting, or adapting to change, across multiple scales of space and time. Densification, through the alteration of urban form, can propel urban systems to evolve into enhanced states, contributing to their resilience. Important to consider when discussing and designing with morphology is the layer model: the idea that different physical and systemic layers influence each other. If the aim is to create a truly resilient urban system, it is therefore important to understand that while densification directly alters only part of the layers within the layer model, it has consequences for the whole system. Helpful in the application of resilience within the field of urbanism and through the method of densification is the distinction between general resilience and specific resilience. General resilience encompasses qualities such as diversity, connectivity, redundancy, modularity, and efficiency, which are vital for creating durable and adaptive urban environments. Specific resilience focuses on identifying vulnerabilities within the system and developing strategies to address them. By combining both general and specific resilience, densification can become a holistic approach for improving urban environments.

To answer to the pressure on space, different scenarios have been considered. These scenarios account for the impact of climate change, population growth, and population distribution, as well as the socio-economic conditions of economic growth or de-growth. By understanding the relationship between space and societal conditions, we can envision new ways of living together and distribute space accordingly.
Examining the historical, governmental, and spatial context of the project in Gelderland, the project acknowledges the region's rich and diverse history of settlement formation. While urbanism practices have primarily focused on the Randstad, Gelderland has also undergone extensive urbanisation. By analysing the region's landscape features, urban characteristics, and network functioning, we gain a comprehensive understanding of its urban system.

The meaning of densification varies depending on the contextual conditions. By assessing the presence of services, accessibility to public transport, and existing density types, different strategies for densification can be categorized. Areas that have a sufficient amount of services, but are not dense yet, are marked as having potential, with a possibility to be further improved through densification. Areas that are of medium density but score very low on the proximity to services are marked as being vulnerable. These are locations in which densification could be used as a method to increase resilience. Before being able to define what the meaning of densification would be in each of these areas, however, the risks and restrictions also need to be considered. With the use of the scenarios, the project takes matters such as flood risk, bearing capacity, sea level rise and the protection of natural environments and ecosystems into account, to define which areas are suitable for densification under certain circumstances.

Both the characteristics of general as well as specific resilience are employed to define possible strategies and transformations on the provincial, regional and urban scale.
Connectivity can be improved through the extension of public transport networks and by reimagining the network in such a way that roads are employed for those uses for which they are most suitable: close to public transport, pedestrians and cyclists should be given priority, whereas people traveling by motorised vehicles should be able to travel from A to B without having to drive through congested city centres. Also, the compact city as a model for urban transformation instead of the horizontal city inherently means better interconnectivity: because the elements are situated closer together, the overall integration is increased.
High efficiency can be reached through encouraging small-scale, incremental change and by ensuring that densification does not only happen in small settlements, as it is important to preserve a good balance between the uniqueness, size, and quantity of all elements in the system. Efficiency and modularity often go hand in hand and are normally quite automatically incorporated in an urban design or environment. It is, however, important to state that these are the elements that dictate why an environment consisting of different, undividable megastructures is not resilient, which is also why the project encourages small scale and modular transformations, alongside larger ones.
Redundancy can be reached through having a better alignment between supply and demand on the housing market and by creating more (public) services within neighbourhoods, as this makes neighbourhoods less dependent on the whole settlement in which they are situated.
Increasing diversity of urban environments on all scales is very central within the project and in most of the design principles. The project proposes a diversification in levels of urbanity and urban characters, types of neighbourhoods and functions, the network, types of dwellings and the building stock as a whole and encourages bottom-up development, which more often produces innovative and diverse results.

The specific vulnerabilities and risks that the strategies and transformations respond to, are the dependency on the car, mobility poverty, (the consequences of) climate change, biodiversity loss and weather extremes and scarcity of resources.

The methods that should be employed to answer to the pressure on space cannot be summarised in a rectilinear solution and requires a multifaceted approach, as the magnitude of the pressure and the variables involved are unpredictable. What is clear from the project, however, is that the solution will not lie in the construction of high rises on drosscapes in the city or in small-scale alterations of existing buildings alone. The project therefore proposes diverse and phased developments of different methods, sizes, proportions, and throughout different timeframes. If we disregard the need for extra dwelling space, however, densification strategies will have the most positive results when the starting point is increasing resilience, and then reviewing how densification can be used as a means of diminishing vulnerabilities. Clearly, in order for either one of the two problems of space scarcity and lack of resilience to be solved, urban environments in Gelderland will have to transform to include types of characters, buildings and public spaces that are currently rarely found there.

In summary, this research has highlighted the interplay between resilience, morphology, and densification, providing insights into the complexity of urban systems and the importance of considering diverse factors and contexts. By combining the principles of resilience with the strategies and transformations discussed, urban environments can become better equipped to face (yet uncertain) challenges and create sustainable, adaptive, and inclusive spaces.

7.3 REFLECTION

The most obvious relationship between the topic of my graduation project and my studio of choice is that morphology plays a prominent role in both my research as well as in the design of the Urban Fabrics studio. The link between physical environments and socio-economic and ecological processes is explored in depth in the search for solutions for increasing resilience. The connection with the master track, Urbanism, is most evident in the project's focus on various scales, ranging from the province of Gelderland as a region to specific test cases on neighbourhood level. The multiscalar approach, coupled with the emphasis on urban form, underscores the necessity of being enrolled in the Urbanism track for the successful execution of this graduation project. It is important to note, however, that the goals set out in this project can not be reached without use of the knowledge that can be acquired through other the other tracks within the AUBS master program, as the topics studied in those tracks also have a profound impact on the resilience of complex urban systems.

Reflecting on the process, I found it to be both exciting and challenging. On one hand, the freedom to choose my research topic provided a sense of enjoyment and intrinsic motivation. However, it also brought about a certain pressure to select the "perfect" subject that would meet all the criteria. In retrospect, I now understand that the pursuit of a perfect topic is unrealistic, and it would have been beneficial to consider different goals and aspirations at the outset. Questions such as identifying my own knowledge gaps, determining what I wanted to learn or which skills I would want to acquire, and defining my personal measure of success within the project would have helped alleviate my result-oriented mindset. By setting clearer objectives from the beginning, I would have been able to approach the process as a learning journey rather than being consumed by decision paralysis. My perfectionism occasionally hindered progress and caused unnecessary delays. Recognizing this personal struggle, which often however also fuels my determination to push myself to obtain better results, I gradually shifted my focus towards the knowledge gained throughout the process, rather than fixating solely on the outcomes. While the final result may not have aligned with my initial expectations, the non-linear, challenging nature of the project underscored the valuable lessons learned. I am grateful for the extensive knowledge, examples, and ideas shared by my mentors, Birgit and Alex, as their guidance greatly shaped both the process and outcomes of the project, surpassing my initial (academic) expectations.

Selecting the Design of the Urban Fabrics studio allowed me to embark on the project from a design perspective. However, I initially struggled to not get lost in the research component after the completion of the essential and intensive courses. It took me a considerable amount of time to fully grasp the concept of resilience and its potential role in urban design, both in a general sense and within the context of my graduation project. After P2, however, it became clear to me that even though this topic is not much covered in urbanism, it is core to the principles I want to take with me when working as an urbanist. The remainder of the process revolved around exploring how resilience theory and concepts could be practically applied while designing on different scale levels. I am very thankful that Birgit and Alex encouraged me to push myself to dive deeper into the research and for their guidance in securing me that I had enough time to do so.

Following the research phase, I embarked on an analysis of the site based on multiple themes. This phase also took longer than anticipated, potentially due to the scale of the location. Selecting the areas of focus proved challenging, as analysing the entire region in-depth was unfeasible. Determining which factors defined a place as typical or special proved to be a difficult task. Eventually, I developed methods to aid in selecting the most representative, special, and important locations within the province, which provided partial answers to my research question. Although the project commenced with a research-oriented approach, conducting small-scale design tests aided in formulating a vision for the larger scale.

Throughout the project, I acquired a substantial amount of knowledge about topics within the field, particularly content-wise. I extensively read about various topics: firstly, working with densities through the book Space Matrix and about analysis of networks through Space Syntax. Subsequently, my focus shifted to resilience and panarchy and their potential applications in urbanism. I learned more about different city models, urban sprawl, territories-in-between, and the concepts of the compact city versus the horizontal city. Additionally, I deepened my understanding of the field of Urbanism as a whole, its historical development, and the transformative impact urbanists have had on shaping Europe and particularly the Netherlands. Besides theoretical research, my skill set has been expanded as the project allowed me to work with large sets of data. Through the use of different software, such as QGIS, GeoDa, R, excel, Rhino and Grasshopper, I was able to filter, categorise, transform, and visualise data in ways that I have never done before. It has made me more aware of the limitations, difficulties, and potential of working with data.

The essential and intensive courses taught me about new methods and approaches that have had a large impact on my research project, such as scenario-making, the mapping of drosscapes, identifying all (important) elements through an atom list and different ways of testing and designing through small and fast sketches. What was particularly helpful was to learn how to switch between tasks and methods relatively quickly. Often, the only way to move on from a situation in which you feel 'stuck' is just by doing something else, first.

The choice of working on a site outside a major city or the Randstad proved to be a refreshing and rewarding experience. Personally, it held significance as part of my heritage is rooted in Gelderland. The opportunity to select my own site allowed me to reminisce on old memories and feel a stronger connection to that part of my family.

Throughout the graduation process, I thoroughly enjoyed learning more about my field of study. Engaging in conversations with my mentors, participating in the essential and intensive courses, and attending the inspiring lectures offered within the Design of the Urban Fabrics studio were particularly enlightening experiences. However, I must admit that the structure of the process itself did not always foster an environment that was helpful for my personal growth and fulfilment. While the autonomy to select my own subject and methods is also a luxury, there were instances where I felt isolated and lonely, lacking inspiration, and where I was highly unmotivated. The absence of substantial collaborative opportunities with peers, beyond mere discussions concerning simplified versions of our respective projects, highlighted the significance of working collectively towards a shared objective. Not only does collaboration enable us to achieve more collectively, but it also fulfils my inherent need for shared endeavours. The solitary nature of working on a self-assigned task often prompted me to question the purpose and intended audience of my efforts. Particularly during periods when personal circumstances impeded my productivity, maintaining motivation to complete the project proved challenging. Nevertheless, this introspective journey has provided invaluable insights into my own preferences, the type of work that resonates with me, and the work environments in which I could thrive.

In conclusion, my thesis in urbanism has been an enriching and challenging endeavour. The fusion of research and design within the Urban Fabrics studio has enabled me to explore the crucial role of morphology and delve into the complex relationship between physical environments, socio-economic and ecological processes. Reflecting on the process, I have come to appreciate the importance of setting clear objectives, embracing the learning journey, and acknowledging the iterative nature of the project. The guidance and expertise provided by my mentors have been very valuable in giving me confidence in my own capabilities, helping me to grow as a designer and researcher and also as a source of inspiration. Whenever I was unsure of which path to take or which topics to investigate further, they provided me with references, examples and interesting theories and concepts, without telling me exactly what to do or how to do it. Furthermore, the project has broadened my knowledge base in urbanism, fostering a deeper understanding of various topics and sparking a newfound appreciation for Gelderland. Ultimately, I feel this thesis serves as a foundation from which to start my work as an urbanist, linking theory and design, incorporating the principles of resilience and acknowledging the importance of multi-scalar approaches to create sustainable and thriving urban environments.

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8.2 REFERENCE LIST

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09 APPENDICES

9.1 FIELD WORK

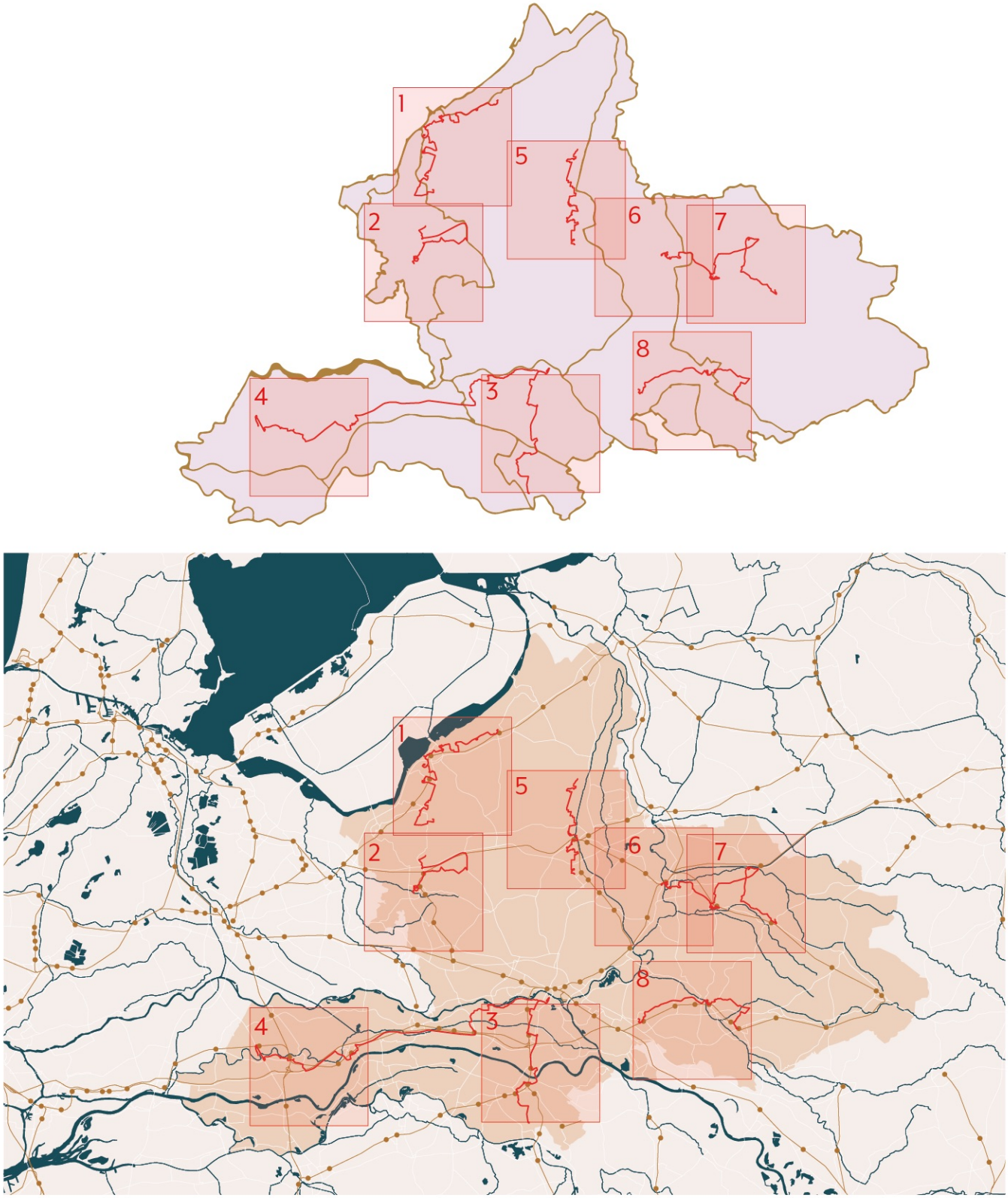


Figure X: Explored routes during the field trip

Location 1


Biddinghuizen
Nunspeet
Hulshorst
Hierden
Zeewolde
Harderwijk
Vierh
Elspeet
Ermelo
Putten
Uddel
Garderen
0 1 2 km

























Location 2

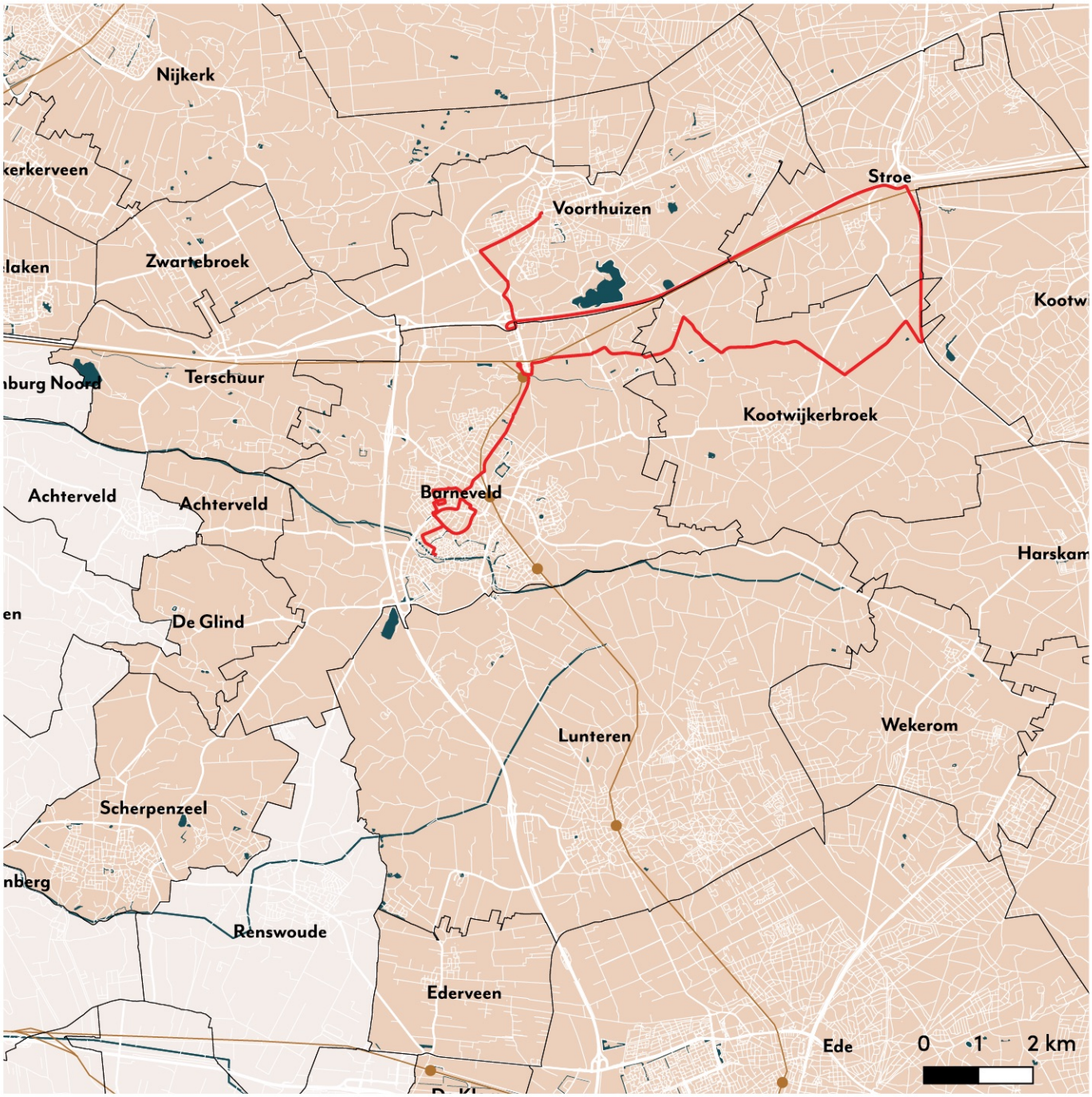


Figure X: Explored routes during the field trip

Location 3

Figure X: Explored routes during the field trip

Location 4

Figure X: Explored routes during the field trip

Location 5

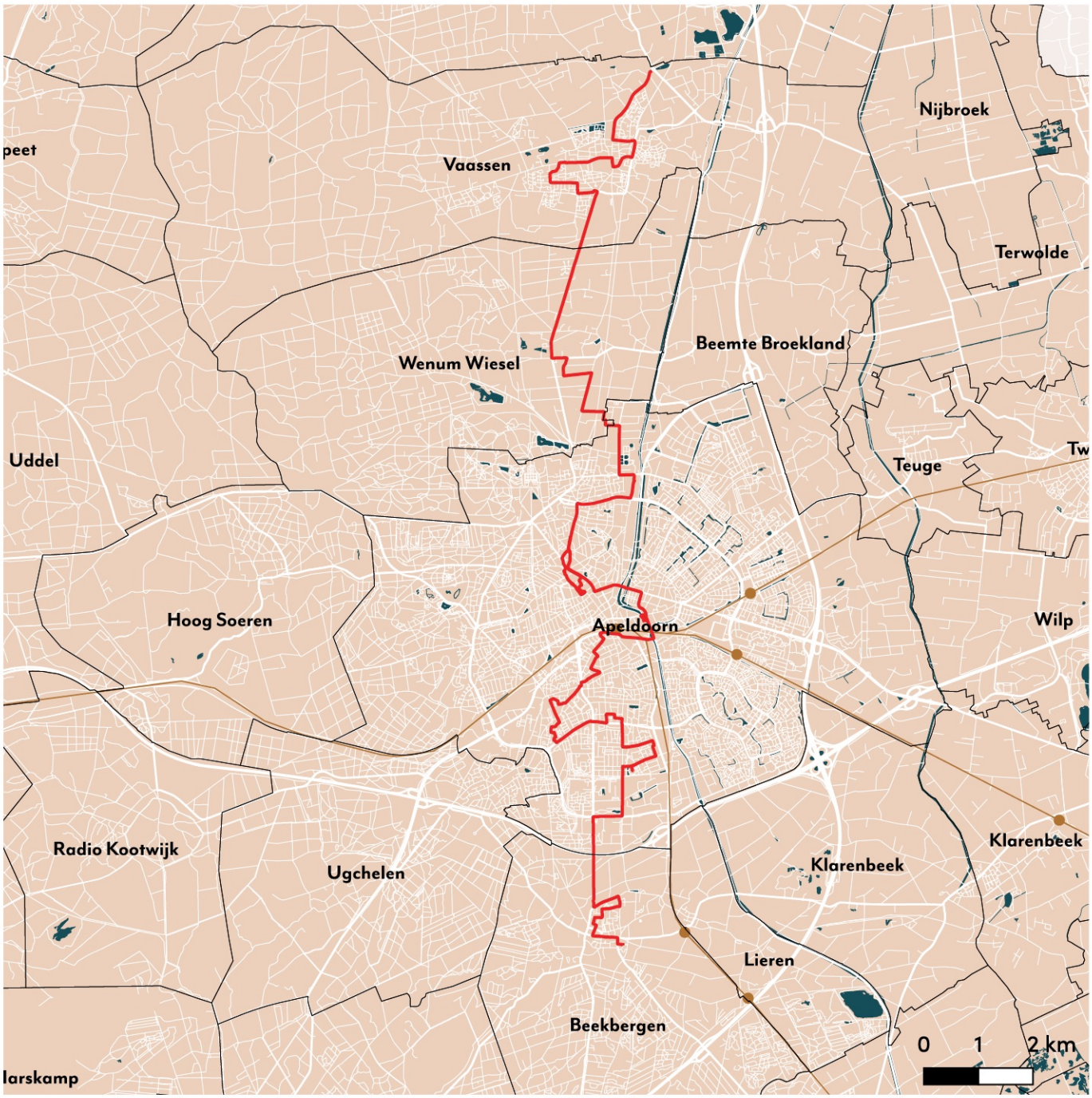


Figure X: Explored routes during the field trip




























Location 6

Figure X: Explored routes during the field trip

Location 7

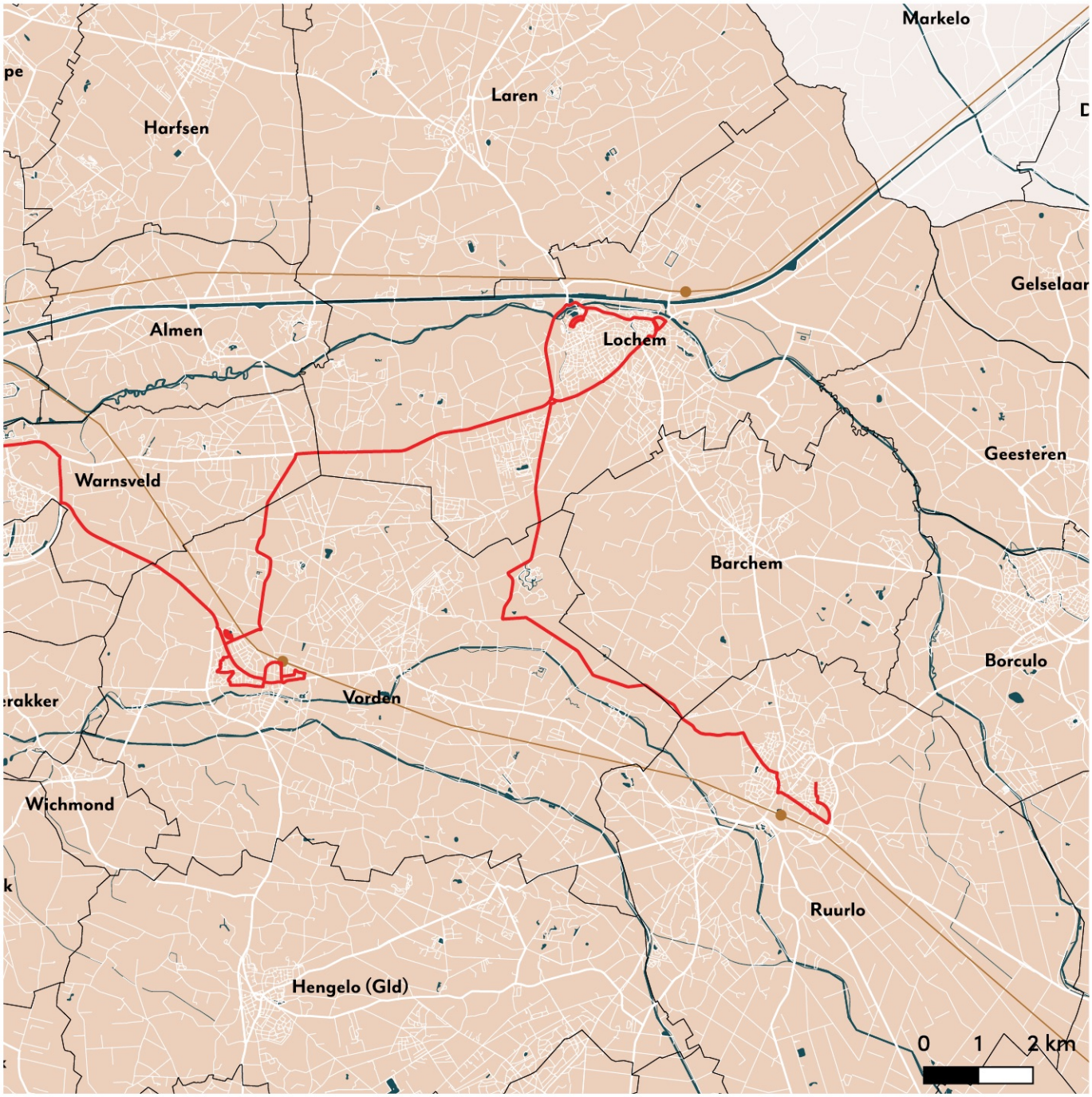


Figure X: Explored routes during the field trip

Location 8

Figure X: Explored routes during the field trip









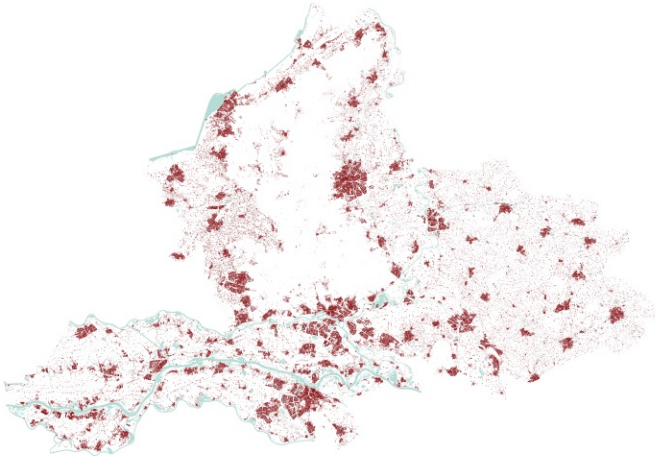




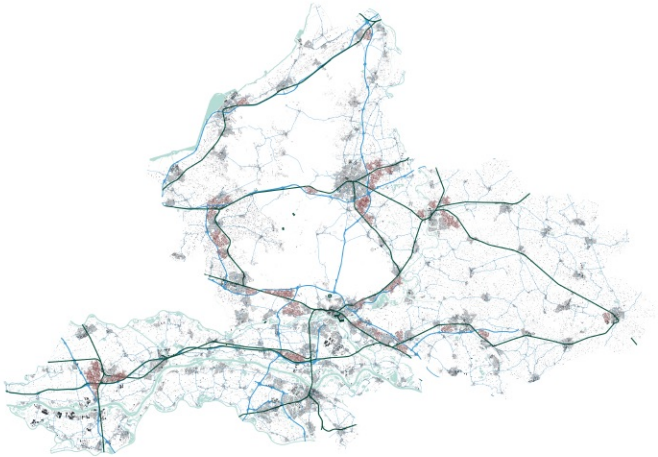
9.2 EARLY DESIGN EXPLORATIONS

Densification patterns: macro scale

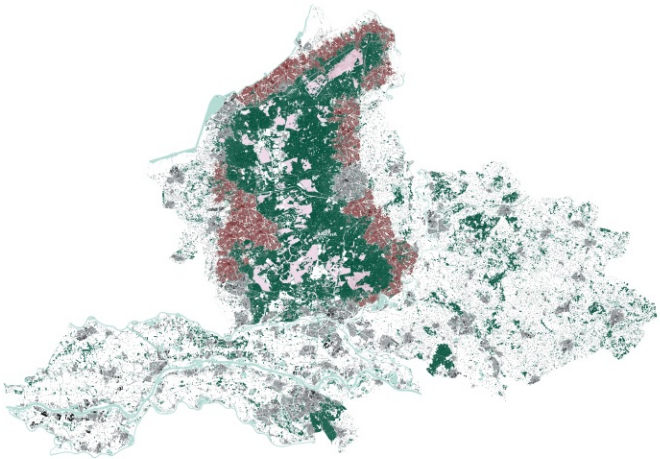
Densification of current cities



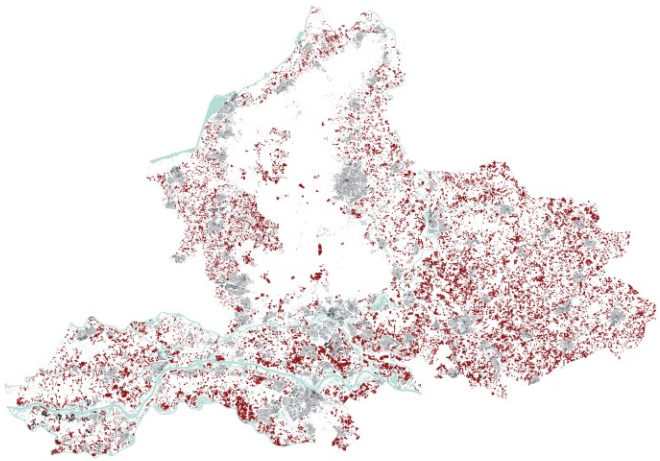
Densification around network



Densification around Hoge Veluwe

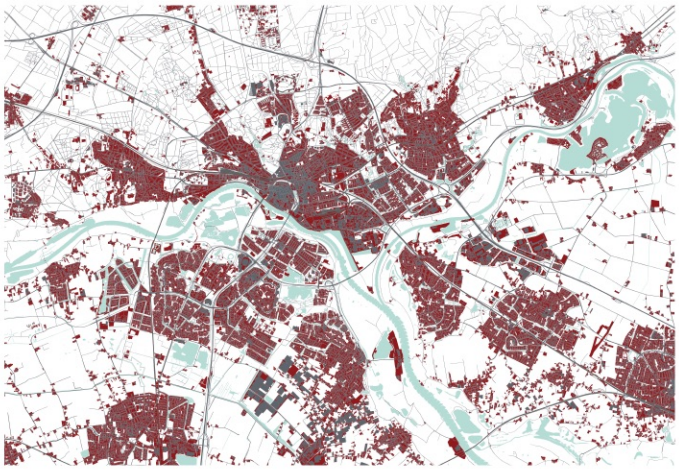


Densification of farmland

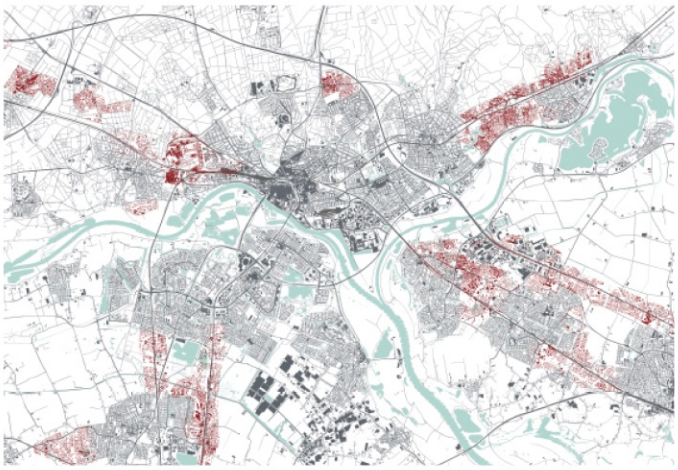


Densification patterns: meso scale

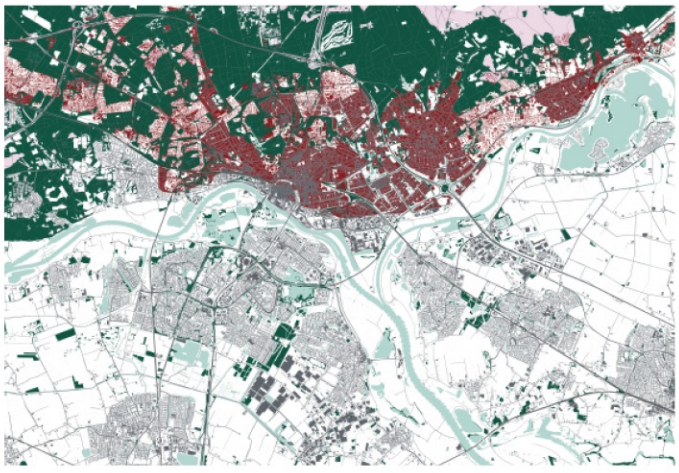
Densification of current cities



Densification around network

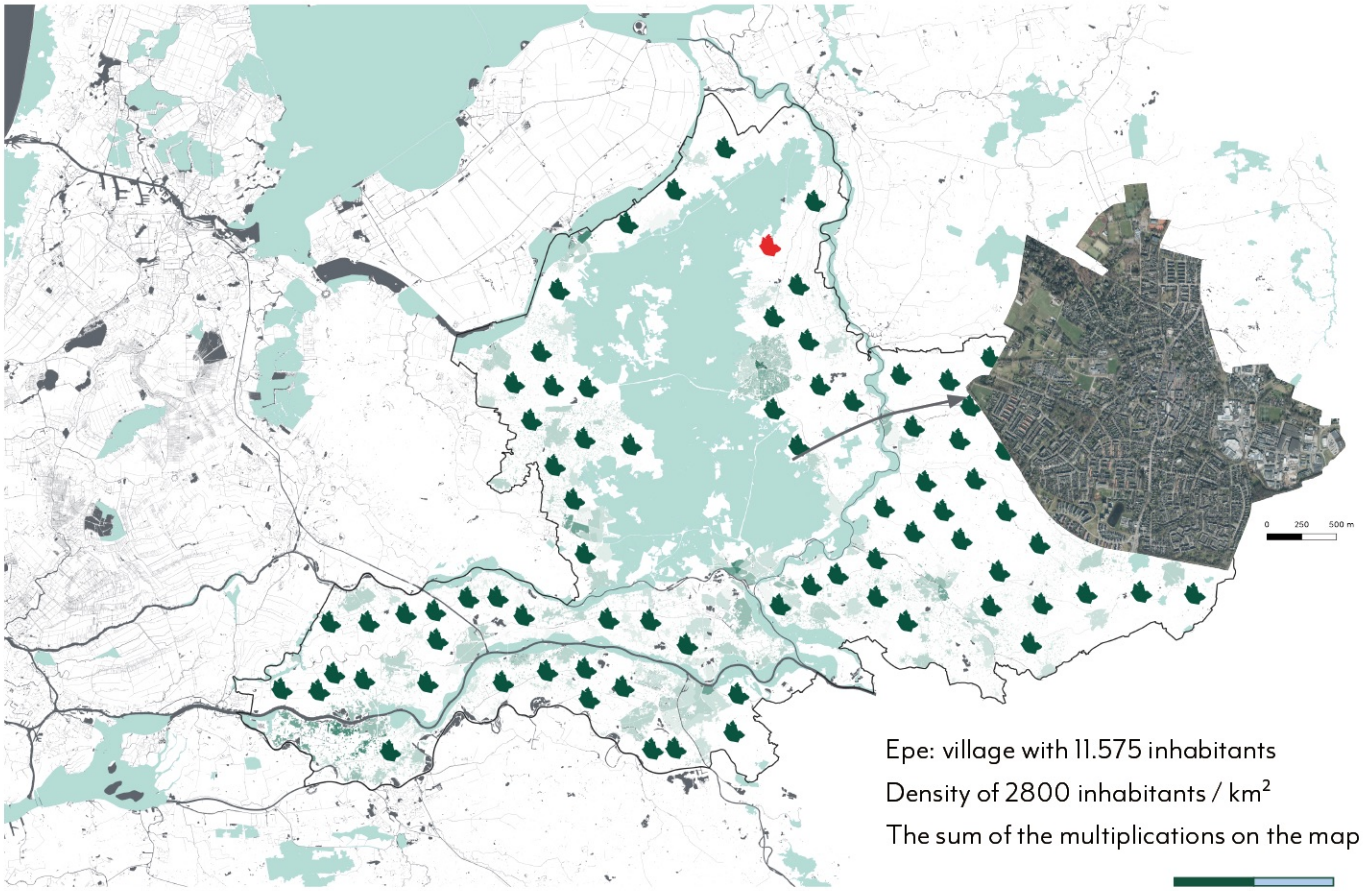


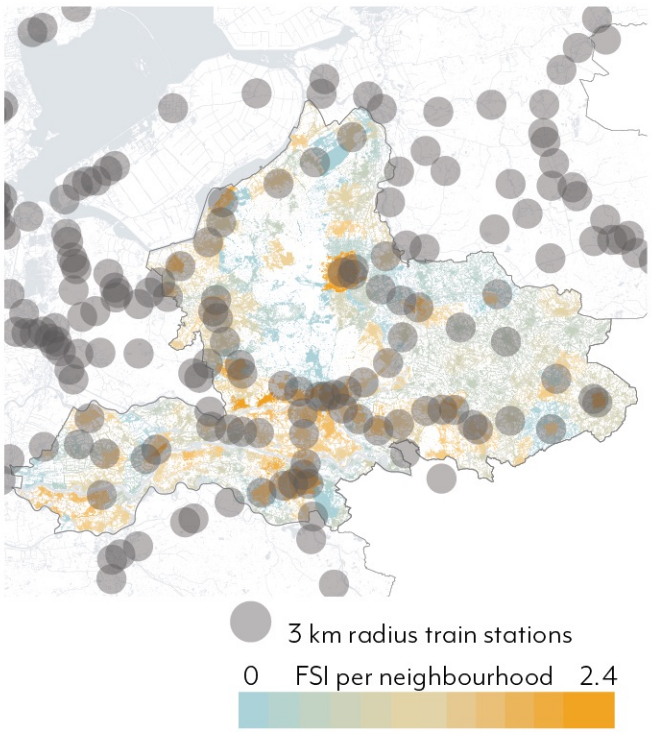
Densification around Hoge Veluwe

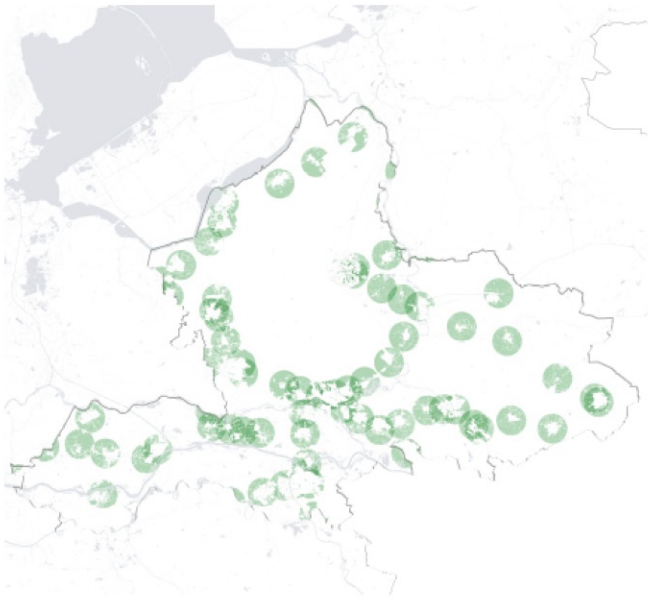


Densification of farmland

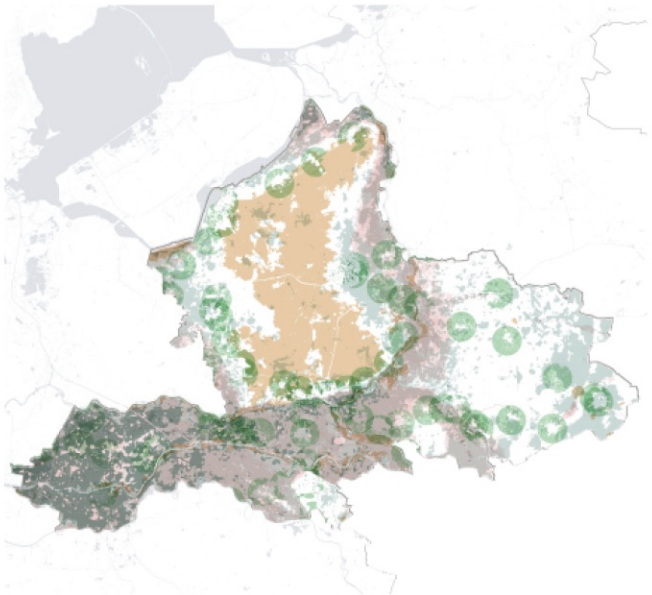

25.7 MILLION PEOPLE
1 MILLION PEOPLE
*Calculated with a density of 5000 people / km²

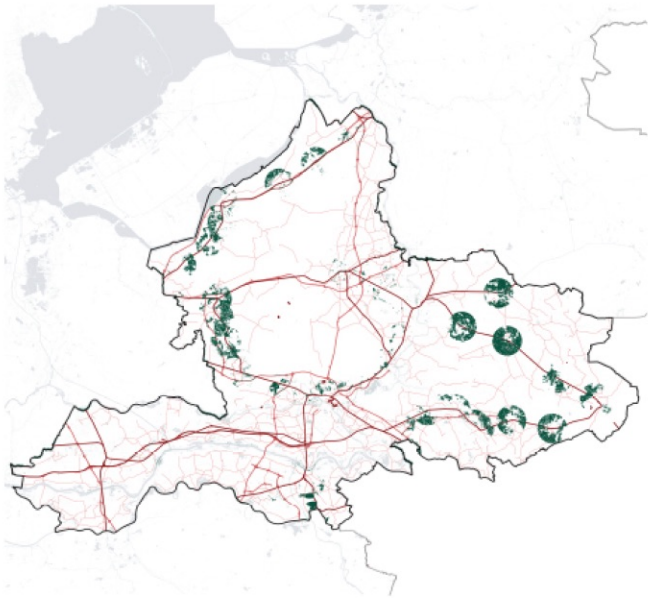

0 250 500 m
Epe: village with 11.575 inhabitants
Density of 2800 inhabitants / km²
The sum of the multiplications on the map





Unbuilt area in 3 km radius from a train station
Lower bearing capacity
Natura2000 area
Higher flood risk





9.3 SCENARIO COLLAGES

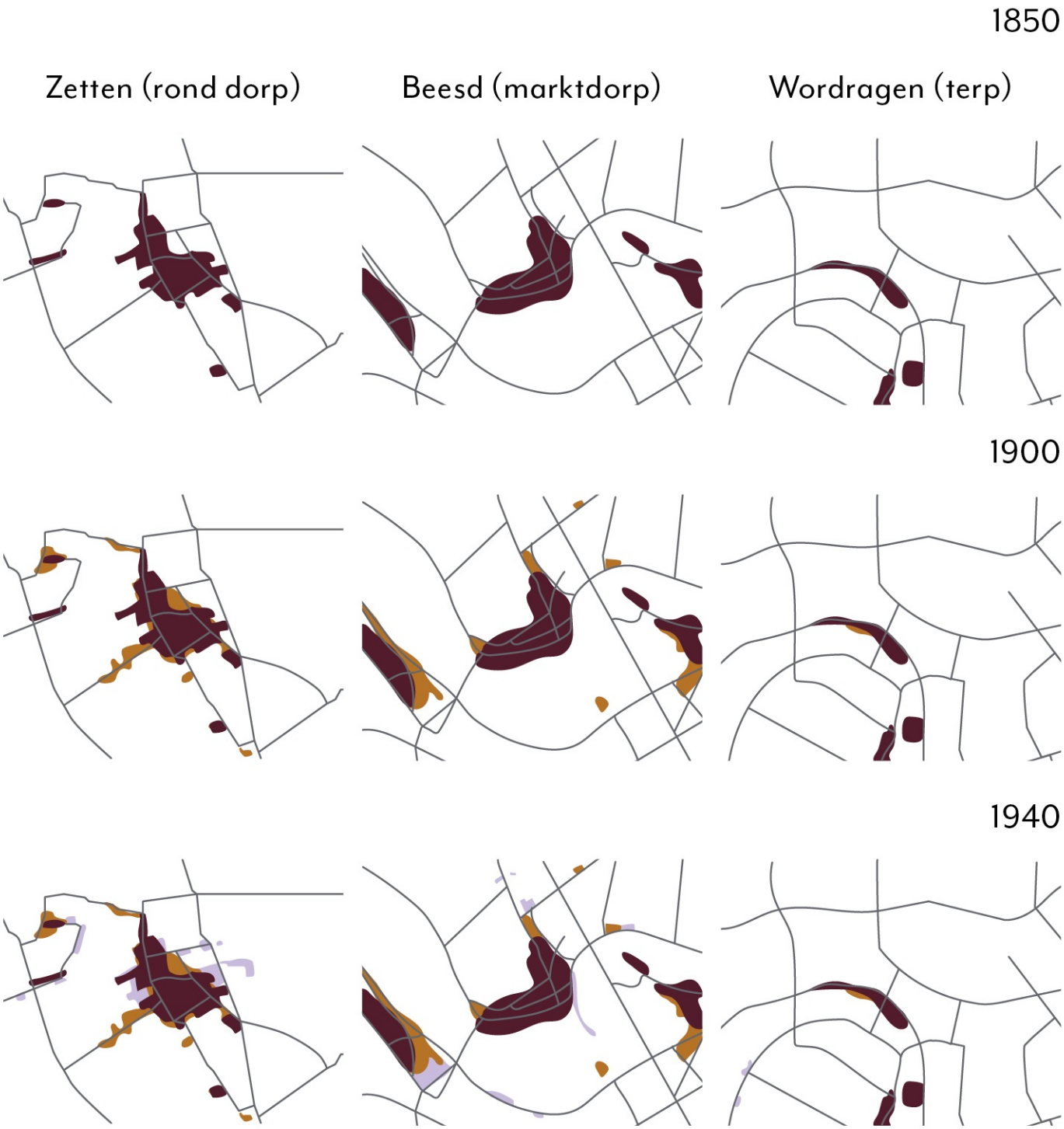
Power to the people

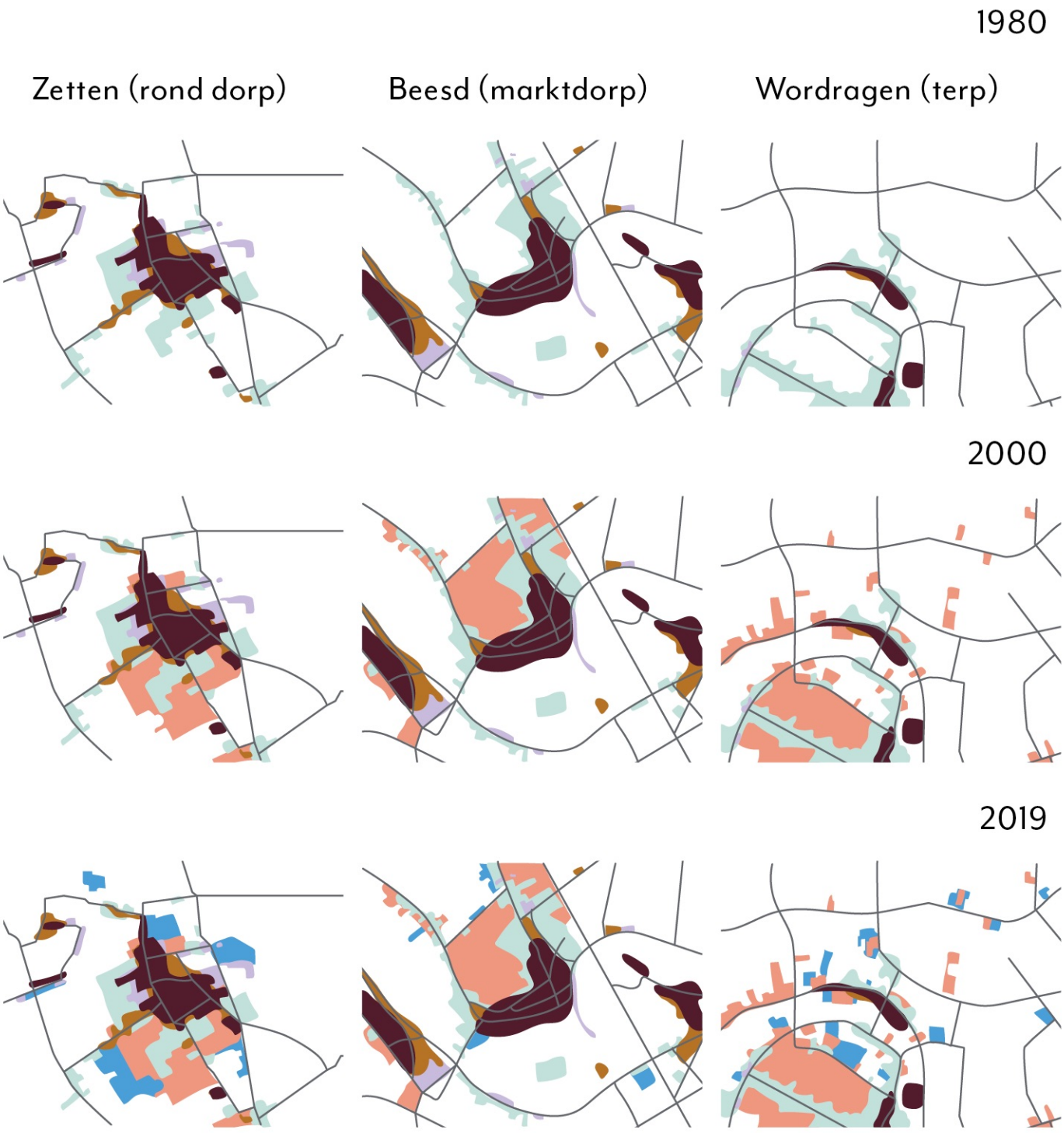
Nature first

Business as usual

Living in harmony

9.4 LOCAL HISTORICAL ANALYSIS




1980
Zetten (rond dorp)
Beesd (marktdorp)
Wordragen (terp)
2000
2019

9.5 CALCULATIONS Ddensification STRATEGIES

Scenario	Power to the people		
Extra people	3000000	Inhabitants (2020)	2141915
Footprint added buildings	**95**	Existing footprint	128
Extra space needed	**285000000**	New average footprint	**108,7**

				OPTION A most likely to happen		
		Densification structure	m2 (footprint)	% of space	added FSI	floor space
A		Sealed surfaces	7209878	70	3	15,141
B		Low quality green	159981464	20	2,5	79,991
C		Industrial areas	31198298	11	1	3,432
F		Drosscapes for expansion	460459401	24	1,5	165,765
						0
G		Large, low and flat	5115375	40	2	4,092
H		Mixed megastructures	3634266	20	2	1,454
I		Post-war	8922609	40	1,5	5,354
J		Sheds	2167090	15	2	0,65
K		Row houses	11482177	30	2	6,889
L		(Semi-)detached	7916977	15	2	2,375
M		All else with opportunities	1497356	20	0,5	0,15
		Total square km	**699,6**			285,3

Floor space per person	New buildings 2020	
Dwellings	45	71,4
Other uses	50	56,6

OPTION B no expansion in drosscapes			OPTION C only expansion in drosscapes			OPTION D balanced densification		
%	+ FSI	floor space	%	+ FSI	floor space	%	+ FSI	floor space
90	3	19,467	0	0	0	75	4	21,63
45	2,5	179,979	0	0	0	30	3	143,983
14	1	4,368	0	0	0	9	1	2,808
0	0	0	42	1,5	290,089	12	1,5	82,883
		0			0			0
100	2	10,231	0	0	0	60	2	6,138
100	2	7,269	0	0	0	30	1	1,09
100	2	17,845	0	0	0	75	1,5	10,038
100	2	4,334	0	0	0	30	1,2	0,78
100	2	22,964	0	0	0	75	1,5	12,917
100	2	15,834	0	0	0	40	0,8	2,533
100	2	2,995	0	0	0	60	0,5	0,449
		285,3			290,1			285,2

Scenario	Business as usual		
Extra people	3500000	Inhabitants (2020)	2141915
Footprint added buildings	**105**	Existing footprint	128
Extra space needed	**367500000**	New average footprint	**113,7**

				OPTION A most likely to happen		
		Densification structure	m2 (footprint)	% of space	added FSI	floor space
A		Sealed surfaces	7285335	70	3,5	17,849
B		Low quality green	141071681	25	2,5	88,17
C		Industrial areas	31634015	26	1	8,225
F		Drosscapes for expansion	380475288	52	1,2	237,417
						0
G		Large, low and flat	5091562	30	2	3,055
H		Mixed megastructures	3589436	25	2	1,795
I		Post-war	8879146	40	2	7,103
J		Sheds	2158155	5	1	0,108
K		Row houses	11431478	20	1	2,286
L		(Semi-)detached	7855576	10	2	1,571
M		All else with opportunities	1475555	15	0,8	0,177
		Total square km	**600,9**			367,8

Floor space per person	New buildings	2020
Dwellings	55	71,4
Other uses	50	56,6

OPTION B no expansion in drosscapes			OPTION C only expansion in drosscapes			OPTION D balanced densification		
%	+ FSI	floor space	%	+ FSI	floor space	%	+ FSI	floor space
95	3,5	24,224	0	0	0	75	4	21,856
70	2,5	246,875	0	0	0	30	3	126,965
49	1	15,501	0	0	0	8	1	2,531
0	0	0	65	1,5	370,963	32	1,5	182,628
		0			0			0
100	2	10,183	0	0	0	60	2	6,11
100	2	7,179	0	0	0	30	1	1,077
100	2	17,758	0	2	0	75	1,5	9,989
100	2	4,316	0	0	0	30	1,2	0,777
100	2	22,863	0	0	0	75	1,5	12,86
100	2	15,711	0	0	0	40	0,8	2,514
100	2	2,951	0	0	0	60	0,5	0,443
		367,6			371			367,8

Scenario	Nature first		
Extra people	1000000	Inhabitants (2020)	2141915
Footprint added buildings	**80**	Existing footprint	128
Extra space needed	**80000000**	New average footprint	**112,7**

				OPTION A most likely to happen		
		Densification structure	m2 (footprint)	% of space	added FSI	floor space
A		Sealed surfaces	2564274	80	3,5	7,18
B		Low quality green	69166655	7	2	9,683
C		Industrial areas	14741862	15	1	2,211
F		Drosscapes for expansion	186072285	14	2	52,1
						0
G		Large, low and flat	2229967	20	1	0,446
H		Mixed megastructures	1452646	20	1	0,291
I		Post-war	4138866	80	1	3,311
J		Sheds	875090	40	1,5	0,525
K		Row houses	4933948	40	1,2	2,368
L		(Semi-)detached	3507108	50	1	1,754
M		All else with opportunities	597442	30	1	0,179
		Total square km	**290,3**			80

Floor space per person	New buildings 2020	
Dwellings	40	71,4
Other uses	40	56,6

OPTION B no expansion in drosscapes			OPTION C only expansion in drosscapes			OPTION D balanced densification		
%	+ FSI	floor space	%	+ FSI	floor space	%	+ FSI	floor space
90	3,8	8,77	0	0	0	75	4	7,693
22	2	30,433	0	0	0	24	3	49,8
37	1	5,454	0	0	0	52	1	7,666
0	0	0	29	1,5	80,941	0	1,5	0
		0			0			0
100	2	4,46	0	0	0	60	2	2,676
100	2	2,905	0	0	0	30	1	0,436
100	2	8,278	0	0	0	75	1,5	4,656
100	2	1,75	0	0	0	30	1,2	0,315
100	2	9,868	0	0	0	75	1,5	5,551
100	2	7,014	0	0	0	40	0,8	1,122
100	2	1,195	0	0	0	60	0,5	0,179
		80,1			80,9			80,1

Scenario	Living in harmony		
Extra people	1500000	Inhabitants (2020)	2141915
Footprint added buildings	**90**	Existing footprint	128
Extra space needed	**135000000**	New average footprint	**112,3**

				OPTION A most likely to happen		
		Densification structure	m2 (footprint)	% of space	added FSI	floor space
A		Sealed surfaces	6455051	80	4	20,656
B		Low quality green	131513975	18	2,5	59,181
C		Industrial areas	27145291	30	1	8,144
F		Drosscapes for expansion	358117212	5	1,5	26,859
						0
G		Large, low and flat	4230969	60	2	5,077
H		Mixed megastructures	3013706	30	1,5	1,356
I		Post-war	7607755	50	2	7,608
J		Sheds	1689993	10	2	0,338
K		Row houses	9374243	25	2	4,687
L		(Semi-)detached	6351985	15	1	0,953
M		All else with opportunities	1270239	20	1	0,254
		Total square km	**556,8**			135,1

Floor space per person	New buildings 2020	
Dwellings	45	71,4
Other uses	45	56,6

OPTION B no expansion in drosscapes			OPTION C only expansion in drosscapes			OPTION D balanced densification		
%	+ FSI	floor space	%	+ FSI	floor space	%	+ FSI	floor space
70	4	18,074	0	0	0	75	4	19,365
16	2	42,084	0	0	0	19	3	74,963
29	1	7,872	0	0	0	47	1	12,758
0	0	0	26	1,5	139,666	0	1,5	0
		0			0			0
100	2	8,462	0	0	0	60	2	5,077
100	2	6,027	0	0	0	30	1	0,904
100	2	15,216	0	0	0	75	1,5	8,559
100	2	3,38	0	0	0	30	1,2	0,608
100	2	18,748	0	0	0	75	1,5	10,546
100	2	12,704	0	0	0	40	0,8	2,033
100	2	2,54	0	0	0	60	0,5	0,381
		135,1			139,7			135,2