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CarbOn 2 construction

An integrated approach of nature-based carbon storage and bio-based building materials.

COLOPHON

FROM CARBON TO CONSTRUCTION | SINKS TO RISE

An integrated approach of nature-based carbon storage and bio-based building materials.

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ABSTRACT

In an era marked by pressing environmental concerns and the urgent need for sustainable solutions, our project embarked on a transformative journey, envisioning a future where nature-based strategies not only combat climate change but also foster economic prosperity and social justice.

With CO2 emissions reaching alarming levels and posing grave threats to the environment, human health, and global stability, conventional approaches to combat climate change often fall short in addressing the intricate interplay between social, economic, and environmental factors. Our research sought to tackle this challenge towards a just transition to a low-carbon economy: "How can we design a circular economy of carbon storage focussing on nature-based solutions?"

Grounded in the principles of sustainability and equity, our approach initially focused on proposing nature-based solutions to reduce CO2 levels. However, recognizing the need for a holistic transformation, our methodology evolved to integrate bio-based economy concepts and community-centric design principles. This involved a rigorous examination of existing policies, spatial analyses, and stakeholder engagement to develop a comprehensive strategy.

The overarching goal was to present a visionary blueprint for transforming land use, emphasizing nature-based solutions as central to carbon mitigation efforts while fostering economic development and social resilience. This entailed the creation of green corridors, the establishment of productive communities, and the promotion of collaboration within the bio-based economy.

Through our research, we identified forests and wetlands as beneficial nature-based storage methods for the Netherlands, with significant potential to accelerate the transition to a low-carbon economy. Despite spatial conflicts and implementation challenges, investing in the bio-based economy, particularly in construction using bio-based materials, emerged as a promising avenue for economic growth. Our phased approach to implementation outlined pathways for achieving equitable CO2 reduction while maximizing environmental and social benefits.

Our work extends far beyond environmental conservation. By presenting a transformative vision that integrates nature-based solutions with socio-economic considerations, we offer a roadmap for policymakers, businesses, and communities to navigate the complexities of climate change mitigation. This matters because it signals a paradigm shift towards sustainable development, where the preservation of nature goes hand in hand with economic prosperity and social equity, ensuring a resilient and thriving future for generations to come.

Keywords: Nature Based Solutions; Climate Change Mitigation; Bio-based economy; Land-use change; Carbon Capture

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Introduction

Image: Man suffering from high weather
Source: https://storage.googleapis.com/afsprod/media/de0cf2716bf04bff82741a7284f9d00f/3000.jpeg

Image: Woman suffering from extreme temperatures
Source: https://news.miami.edu/_assets/images-stories/2022/07/europe-heatwave-hero-940x529.jpg

Image: flood occurred in the Netherlands (July 16, 2021)
Source: https://static.timesofisrael.com/www/uploads/2021/07/000_9F86YL-1-e1626528270866.jpg

Climate change is one of the most pressing challenges of our time, posing significant threats to the environment, human health, and global stability. At the heart of this issue lies the phenomenon of greenhouse gas emissions, particularly carbon dioxide (CO2), which plays a pivotal role in driving global warming and altering Earth's climate patterns. The surge in CO2 emissions, primarily attributed to human activities such as burning fossil fuels, deforestation, and industrial processes, has led to unprecedented levels of atmospheric CO2 concentration, triggering far-reaching consequences for our planet (European Union, z.d.).

Next to well-known natural consequences (e.g. extreme heat, flooding, droughts), social threats (concerns regarding health, employment) next to threats for businesses (with less yield on agricultural land, high pressure on the energy grid) are also indispensable.

Although the urgency is clear, there are many actions that have been taken in order to reduce CO2 emissions. On 11th of December the European Commision announced that it wants to be the first climate neutral continent by 2050. This would be done by transitioning our current way of living towards one where our greenhouse gas emissions are at least 55% less by 2030, compared to 1990 levels (European Commision, 2021). One of the EU methods to do so is through CCUS: Carbon Capture Utilization and Storage.

Figure : CCUS system
Source: https://blog.nwf.org/2021/07/carbon-capture-utilization-and-storage-is-an-important-climate-solution/

CCUS is a technology aimed at capturing carbon dioxide (CO2) emissions, re-using and storing them underground to prevent their release into the atmosphere (Rijksdienst voor Ondernemend Nederland, z.d.). While CCUS holds potential as a tool for mitigating climate change by reducing CO2 emissions, it also has several downsides and challenges.

One of the downsides of CCUS is its high cost. In 2020, governments and industries committed more than $ 4.5 billion to CCUS (IEA, 2021). The technology requires significant upfront investment for the construction and operation of capture, transportation, and storage infrastructure. The expense involved in retrofitting existing facilities with CCUS systems or building new facilities with CCUS capabilities can be prohibitive, particularly in industries with thin Prosperity margins.

Implementing CCUS often requires energy-intensive processes for capturing, compressing, and transporting CO2. This can result in increased energy consumption and associated costs, potentially offsetting some of the environmental benefits gained from CO2 capture and storage, with the great pressure on the energy-grid (Cremona, 2024) in mind.

But the primary issue with CCUS lies in its perpetuation of carbon emissions, as it effectively enables the ongoing release of carbon into the atmosphere. By not switching to cleaner energy and sustainable methods, CCUS keeps us hooked on fossil fuels, makes environmental problems worse, and takes attention away from other potentially better solutions.

Therefore, it is crucial to explore non-technical solutions and prioritize a nature-based approach that tackles the challenges of CO2 and provides possible solutions. Nature-based solutions often involve the restoration, conservation, or sustainable management of ecosystems such as forests, wetlands, and grasslands. These actions not only capture carbon but also provide multiple co-benefits, including habitat conservation, biodiversity preservation, water filtration, soil retention, and recreational opportunities (ICUN, z.d.). And by integrating nature-based solutions into a circular economy, it can foster synergies between economic development, environmental conservation, and social well-being, creating more resilient and sustainable systems for the future (European Commision, z.d.).

Therefore it is crucial to prioritize an integrated approach that frames challenges concerning nature-based solutions within the spatial, environmental and societal context.

Problem statement

Given the urgent need to mitigate the adverse effects of climate change, particularly stemming from greenhouse gas emissions like carbon dioxide (CO2), there exists a critical challenge in determining the most effective strategy for reducing emissions while considering social, economic, and environmental factors. Despite advancements in technologies such as Carbon Capture Utilization and Storage (CCUS), which offer potential solutions, there remain significant drawbacks including high costs, energy-intensive processes, and the perpetuation of reliance on fossil fuels.

Hence, there is a pressing need to explore and prioritize non-technical approaches, particularly nature-based solutions, which offer multiple co-benefits beyond carbon sequestration and integrate them within a circular economy as well as within the broader environmental, spatial and societal context to address the challenges posed by CO2 emissions effectively.

Research questions

Main research question:
"How can we design a circular economy of carbon storage focussing on nature-based solutions?"

To answer this question we constructed 4 subsidiary research questions:

1. "What nature based methods exist for carbon storage?"
2. "What are the challenges in applying nature based methods?"
3. "How can these nature based solutions be envisioned?"
4. "How can we implement these nature based solutions?"

Conceptual framework

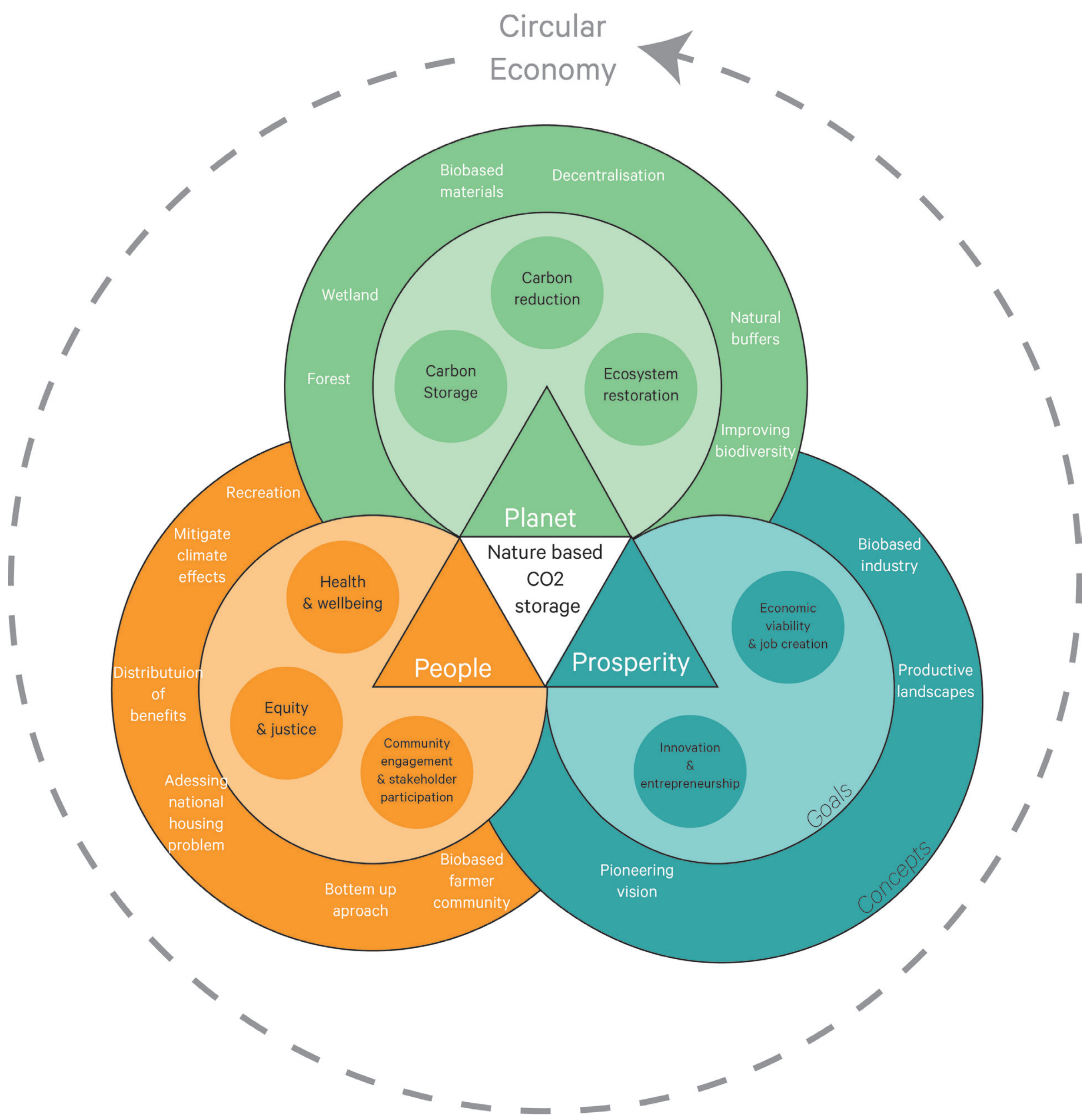


Figure: conceptual framework

Designing for a Circular Economy through Carbon Capture with Nature-Based Solutions

Our research project aims to address the urgent need for carbon capture solutions by exploring innovative approaches to designing results focused on capturing carbon dioxide from the atmosphere. Emphasizing nature-based solutions, we seek to integrate principles of sustainability, equity, and resilience into the framework of our carbon capture network to facilitate a just and efficient transition towards decarbonization.

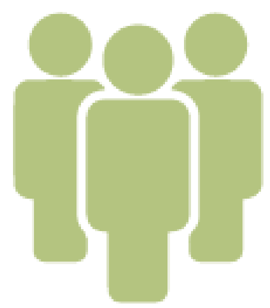
Designing a circular network for carbon capture prioritizes the integration of the three pillars of sustainability: "people, planet, prosperity". This goals accompany several concepts that are encouraged through this report, to ensure holistic sustainability and maximize societal, environmental, and economic benefits.

Theoretical framework

PLANET

We're focusing on the "planet" part of sustainability by looking into nature-based solutions. These solutions use natural ecosystems to store carbon dioxide. In doing so, we consider numerous documents, including a report from the Ministry of Infrastructure and Water Management addressing the importance of managing water and soil to protect the environment.

- **Carbon Capture and Ecosystem Restoration:** We plan to use nature-based solutions to capture carbon dioxide from the atmosphere and restore ecosystems, by increasing biodiversity. Thus, we can address multiple environmental problems with one approach, storing carbon and restoring ecosystems.



PEOPLE

Recognizing people as an integral part of nature, we are aware of the importance of laws such as the renewd "Omgevingswet", where every environmental change is subject to thorough discussion and consideration. By valuing and preserving our natural environment, we ensure that our actions are aligned with the broader goals of sustainability and ecological integrity.

- **Community Engagement and Stakeholder Participation**: Our project emphasizes the importance of engaging local communities and other stakeholders in projects that capture and store carbon. Community input and participation are essential in a bottom-up approach, which can improve the change of the project working in the long term.
- **Equity and Justice:** We prioritize equity and justice in the distribution of benefits and burdens associated with carbon capture initiatives, especially in communities that are more vulnerable. By including everyone in decision-making, we're working towards a more equal society.
- **Health and Well-being:** By reducing air pollution and mitigating climate change impacts, carbon capture and storage projects can contribute to improved public health. Combining the restoration of ecosystems by increasing biodiversity will have an even bigger impact on people's health.

PROSPERITY

Nature-based solutions for carbon capture and storage are not only crucial in climate change mitigation, they also result in new business opportunities and job creation. Both private parties and public parties, like the Dutch government, are willing to invest in the developing biobased industry, directing hundreds of millions of euros towards research and development initiatives. This can contribute to the creation of jobs and boost the economy, especially in rural areas. An example is the creation of the Top Consortium for Knowledge and Innovation in the Biobased Economy, where scientists and business owners work closely together on research projects.

- **Economic Viability and Job Creation**: Assessing the economic feasibility and cost-effectiveness of carbon capture projects is an essential part of the project. The costs and benefits of the projects will have to be well balanced to make the project economically viable and to attract investment. Our framework evaluates the carbon storage process and identifies opportunities for job creation and economic development, particularly in rural and disadvantaged areas
- **Innovation and Entrepreneurship**: Carbon capture and storage projects are initiating new ideas and businesses by the development of new technologies and markets, such as the biobased building material market.

Methodology

The project starts with preliminary research to create a foundation for the project. With this first step, we explore the background of the topic and identify the challenges that need to be addressed. A clear problem statement is then created to determine the exact scope and focus of the project.

After identifying the scope of the project, we create a theoretical framework and a conceptual framework to structure the approach and guide the work. These frameworks serve as our guidance during the project and help us stay focused on the goals.

After the first analysis, we conduct multiple spatial analyses. Using mapping and spatial analysis methods, we map out the area of the project in detail. This helps us to understand and analyze the relevant spatial components of the area.

Besides spatial analysis, we also conduct document research and archival research to collect additional information on the different subjects within the scope. This makes our knowledge of the different subjects better and gives us more in-depth insights.

After this analysis phase, we start developing the vision. We use scenario planning to explore and analyze different future scenarios. With these scenarios as a basis, together with the spatial data and research findings, we use multi-criteria decision analysis to create a well-structured vision.

The next step in the process is the stakeholder analysis. Through stakeholder mapping, we identify all relevant stakeholders and start analyzing the roles they play in the vision and their interests. This not only helps us understand their perspectives but also supports the strategy behind our vision.

To refine the strategy, we create a phasing timeline. This timeline provides insight into how the different strategic and spatial elements will evolve over time and how long it will actually take to see the full effect of the vision, and what will happen in the meantime.

Lastly, we conduct an evaluation for the whole project to assess whether the intended goals are achieved. This evaluation provides valuable insights that we can use to improve our approach in the future. As a team, we also reflect on the progress of the project, celebrating our successes and learning from challenges we encounter along the way.

Goals

The starting point for the project was storing CO2 through nature based solutions to tackle climate change and CO2 emissions and to preserve and enhance nature. This is in line with SDGs 15 and 17. The creation and conservation of nature is aligned with SDGs 3 and 6. The goal of this transition is a sustainable and resilient future in social and environmental terms, which is connected with the SDGs 11 and 17.

The creation of nature based-solutions, combined with potential sustainable practices, leads to the possibility of using this nature to store more carbon, produce bio-based materials and promote a circular economy, which is connected with SDG 9.

All of these goals cannot be achieved in a real, sustainable and equitable way without a bottom-up approach that empowers local communities. This is linked to SDGs 4, 8 and 12.

The whole vision is aligned and aims to achieve SDG 17, strengthen the means of implementation and reinvigorate the global partnership for sustainable development.

Image: Sustainable development goals
Source: https://sdgs.un.org/goals

Figure EGD edited by authors
Source : https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-

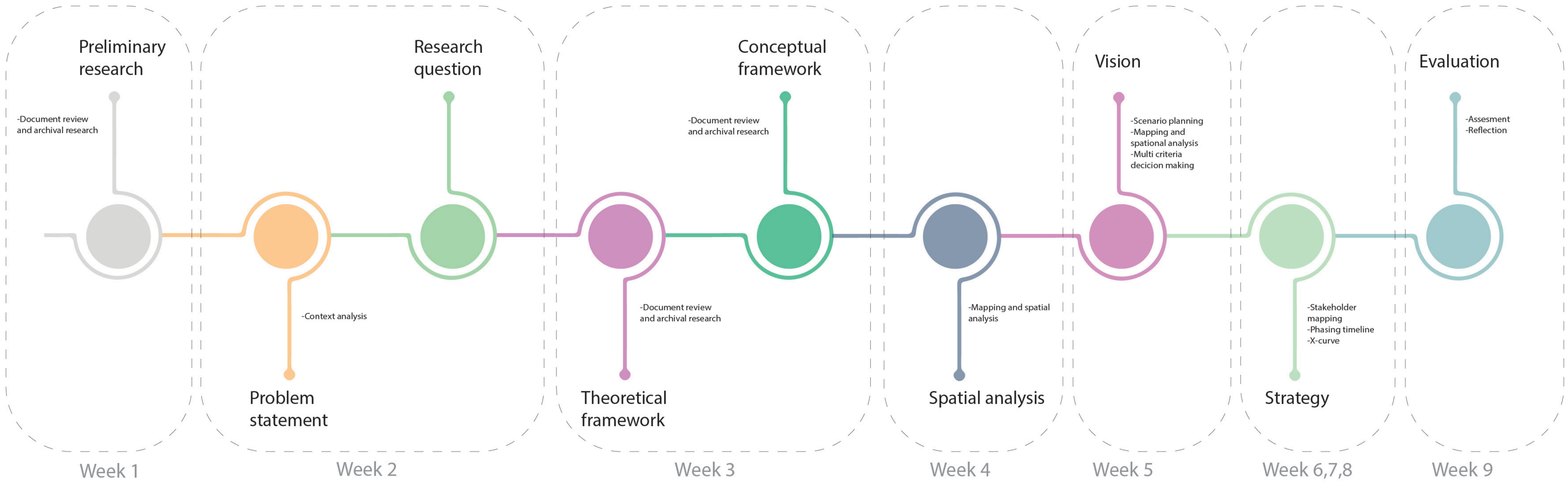
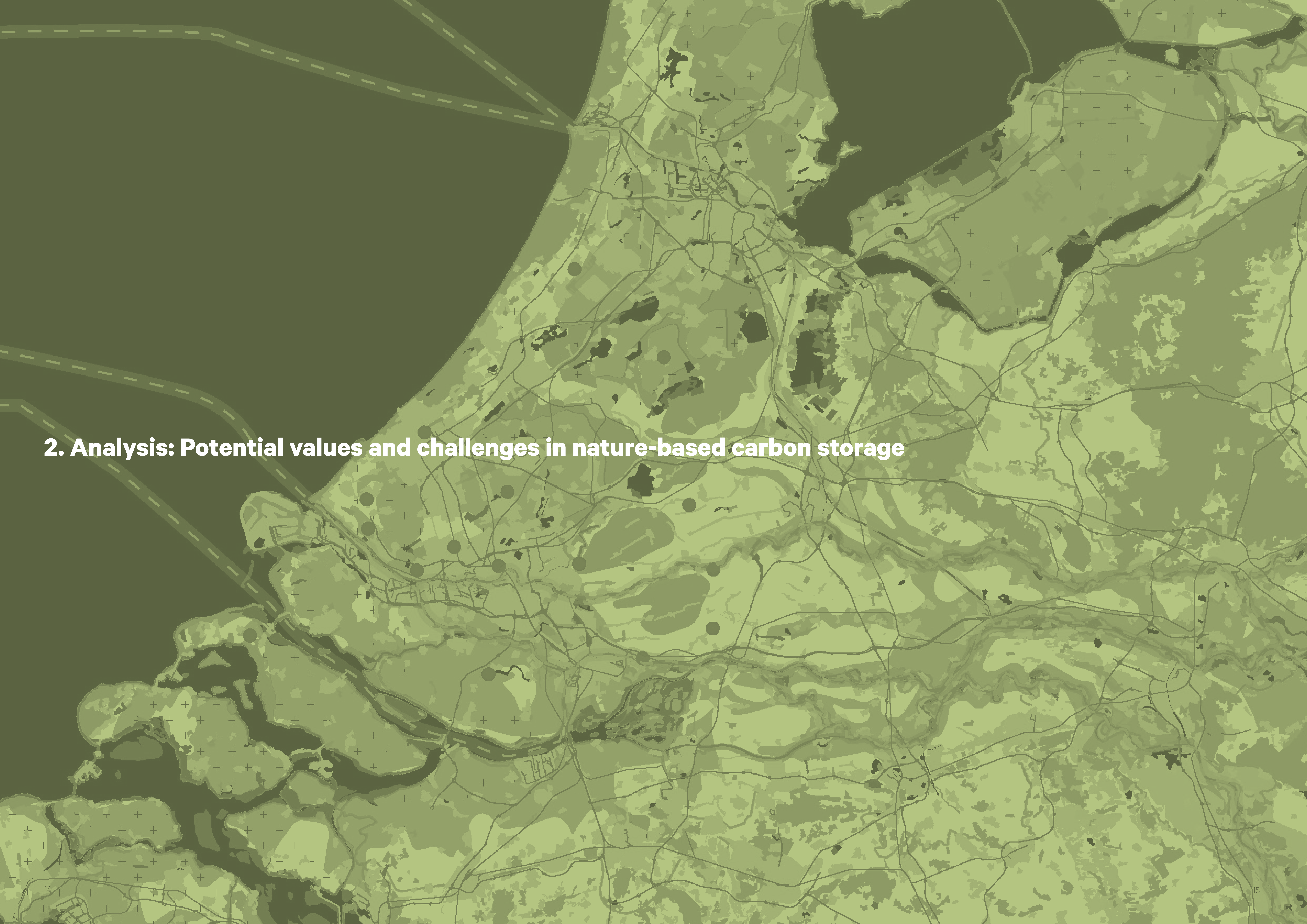


Figure :Methodology timeline



2. Analysis: Potential values and challenges in nature-based carbon storage

Introduction

As concerns about climate change continue to escalate, governments across Europe, as well as at national and provincial levels, are planning to reduce carbon emissions.

It is important to analyze exisitng plans and restrictions regarding carbon and the climate in order to create a realistic vision. This way, we can use exisint plans to enhance our own vision and maybe make use of subsidies that are given out for carbon reducing measures. In addition, not being aware of existing restrictions on diverent scales will result in an unrealistic vision.

In this chapter, existing policies and ambitions are analyzed on different scales, starting with the European scale. Then on the national scale, the plans to achieve the European goals are analyzed, together with individual ambitions of the country.

Finally, provincial plans are considered, with which national goals are to be achieved. In this case, only one province has set up a stategy on circular industry.

Existing policies

From European Green Deal to Provincial spatial strategy

Europe

On Eurpean scale the most important document regarding carbon is the Eurpean Green deal. This deal represents the European Commission's strategic vision aimed at fostering sustainability within the EU economy. It seeks to transform climate and environmental challenges into opportunities while ensuring an inclusive transition for all stakeholders (European Commission, 2019). With a target of achieving climate neutrality by 2050, the EU recognizes the need for comprehensive actions across all sectors of the economy. At the core of this is the European Climate Law which states that Europe must be climate neutral from 2050 and have emissions reduced to 40% by 2030. The Green Deal reviewed previous restrictions, including the ETS (emission trading system) In this, total emissions are limited and companies are required to have permits for their emissions. In addition, the European commission has proposed to revise the LULUCF (Land Use, Land Use Change and Forestry) scheme, where CO2 storage in biomass is to be increased, through more diversified land use (Figure ...) (European Comission, 2019).

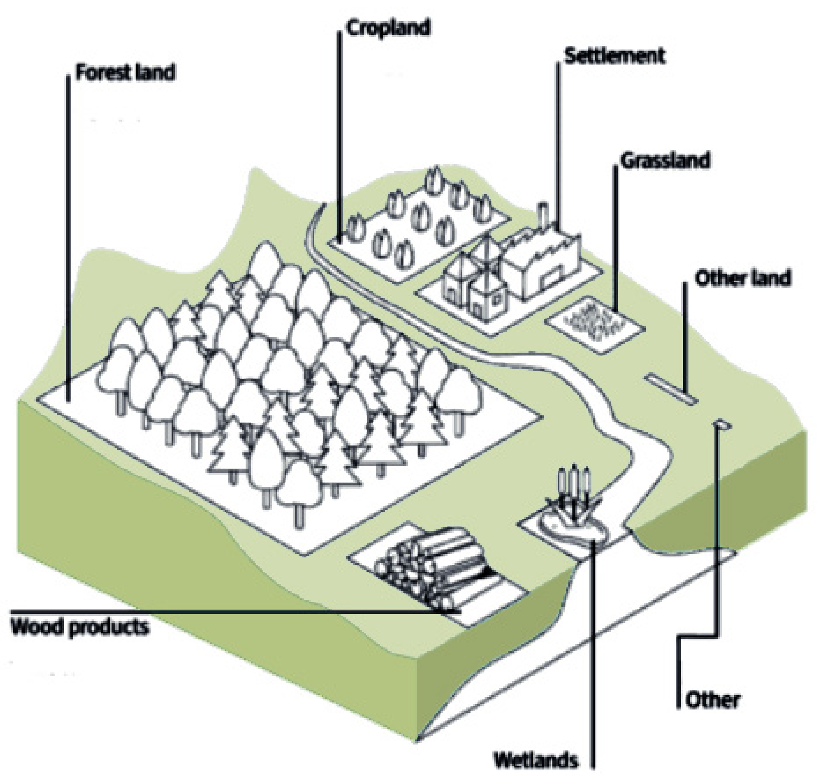


Figure ...: Diversifying of land-use according to the European Green Deal
Source: https://climate.ec.europa.eu/eu-action/land-use-sector_en

Fit for 55: In Fit for 55, existing measures to reduce emissions to 55% by 2030 have been enhanced. With regard to the LULUCF sector in particular, some interesting changes have taken place here. For example, the net removal of greenhouse gases from the atmosphere by 2030 must be another 15% lower (55%) than described in the Grean Deal and this sector must be climate neutral by 2035 (Hollmann, n.d.)

Netherlands

At the national level, several documents are available regarding CO2. These exist on the one hand to meet European climate objectives and on the other hand to meet nationally set targets and ambitions.

Environmental Management Act: Until January 1 of this year, this was the main law related to environmental management. Since Jan. 1, the new Environment Act has taken effect, in which parts of this Environmental Management Act have been passed). But the Environmental Management Act continues to regulate issues such as greenhouse emissions (including CO2). However, the Environment Act does broaden these issues, stating that since 2023, in addition to energy-saving measures, companies are also required to take CO2-reducing measures (Ministry of Infrastructure and Water Management, 2024).

Climate Plan 2021-2030: Every 5 years, the climate plan describes the plans for the next 10 years, with a view to achieving agreements laid down in the Climate Act, including the agreement that the Netherlands will have zero greenhouse gas emissions by 2050. Important specific CO2 related actions are firstly the national carbon tax for CO2 emissions for industry, which will save 14.3Mton emissions by 2030 (compared to the current trend), with which the Dutch government participates in the European ETS benchmark (Ministry of General Affairs, 2022). Second, subsidies will be available for CO2 saving measures for industries. Third, there are plans to reduce CO2 emissions and increase storage through smart land use, within the agriculture and land use sector. This includes raising water levels to limit CO2 emissions from peat, increasing natural areas and stopping deforestation (Ministry of General Affairs, 2022).

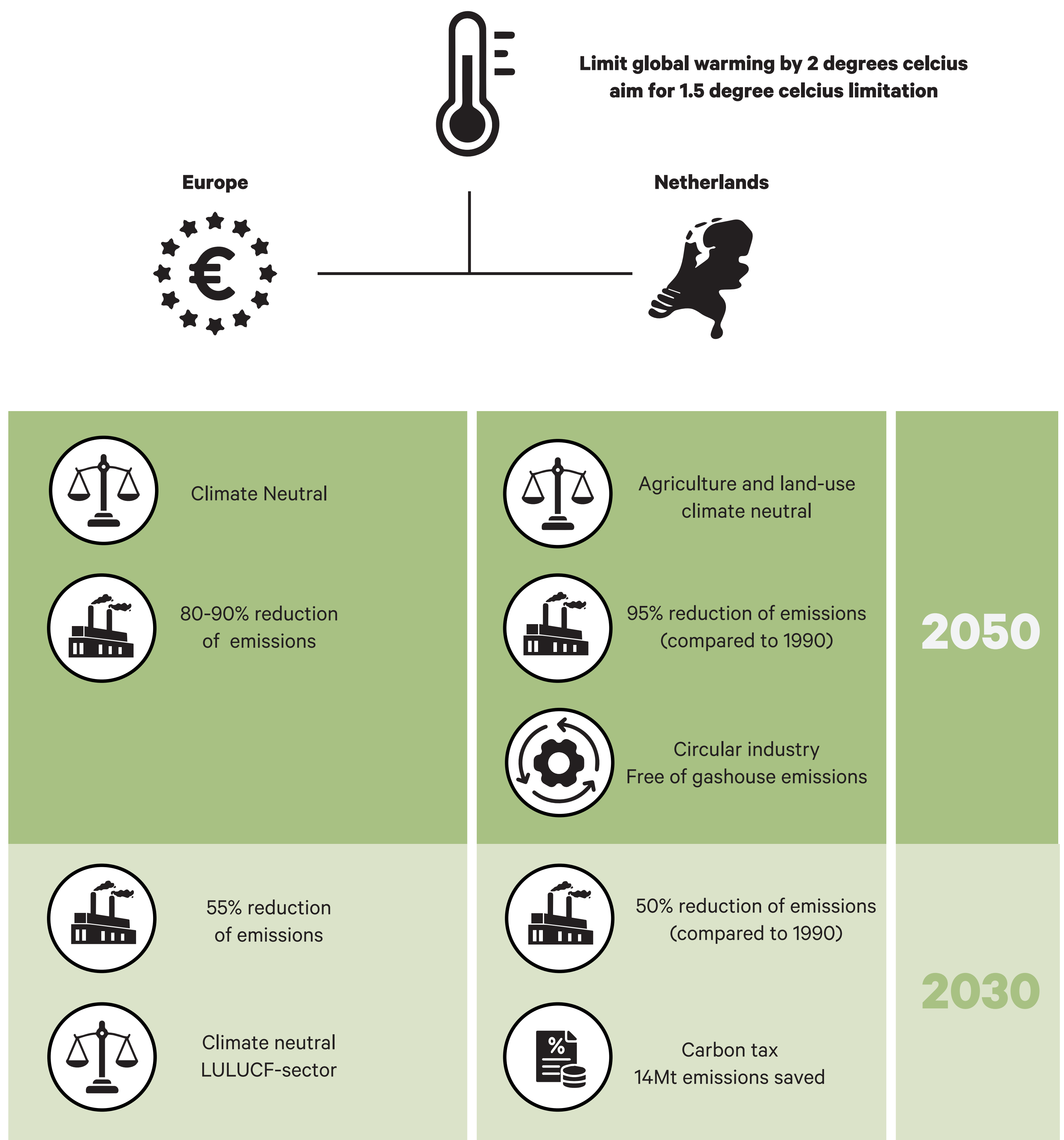
Climate Agreement: The Climate Agreement is a package of measures to halve greenhouse gas emissions in the Netherlands by 2030. It is a result of internationally made agreements and is a strategy on how the Netherlands will achieve those goals. Regarding CO2 that by 2050, industry is circular and emits no greenhouse gases, agriculture and land use is climate neutral and the mobility sector is emission free (Ministry of Economic Affairs and Climate, 2021).

Provinces

The sectors included in the climate agreement partially fall under the power of decentralized governments, thus the provinces have a crucial rol in lowering net carbon emissions. The province of South Holland is the first province developing a spatial strategy on this regard. The importance seems the biggest in this province, since about 30% of all material flows of the country pass through this land and The Dutch government wants to achieve a circular economy by 2050 and have halve the country's use of primary raw materials by 2030 (Province of South Holland, 2022).

At the core of this strategy are three principles: closing material loops, mimimizing negative impact and creating a biobased focus. The goal is to have a 100% circular South Holland by the year of 2050, the biggest challenge in the strategy being the lack of available space. To use the available space as efficiently as possible and promote spatial quality, they promote multifunctional land use, only separating hazardous functions such as processing and storing (due to noise and smells) from residential areas and nature.

While we would like to examine all potentially relevant areas, the size constraints of our project require a more focused frame. Thus, it is advisable to prioritize the utilization of existing policies and readily available data from the Netherlands. This approach ensures that our research can efficiently identify the most suitable nature-based solutions.



Nature-based storage methods

Properties

Nature-based carbon storage methods involve the investigation of two types: Forests and Wetlands. Together, these two types sequester approximately 3.6 megatons of CO_2 annually in biomass in the Netherlands, compensating for approximately 2% of the annual CO_2 production (Centraal Bureau voor de Statistiek, 2017). In Figure ..., the storage capacity of the two different methods is illustrated. Notably, wetlands exhibit a significantly higher capacity for CO_2 storage compared to forests, while current plans for carbon storage in nature primarily focus on forests.

When examining the current CO_2 storage in aboveground natural systems compared to underground natural systems (Figure ...), it is noteworthy that the latter contains a much higher concentration of stored carbon. It's important to specify that this pertains to the upper 30cm of the soil. Nevertheless, both wetlands and forests require distinct conditions and offer diverse added values.

Type	Av. Storage capacity (Ha/year)
Wetlands	12 Ton
Forests	59 Ton

Figure ..: Average carbon storage capacity of Wetlands and Forests

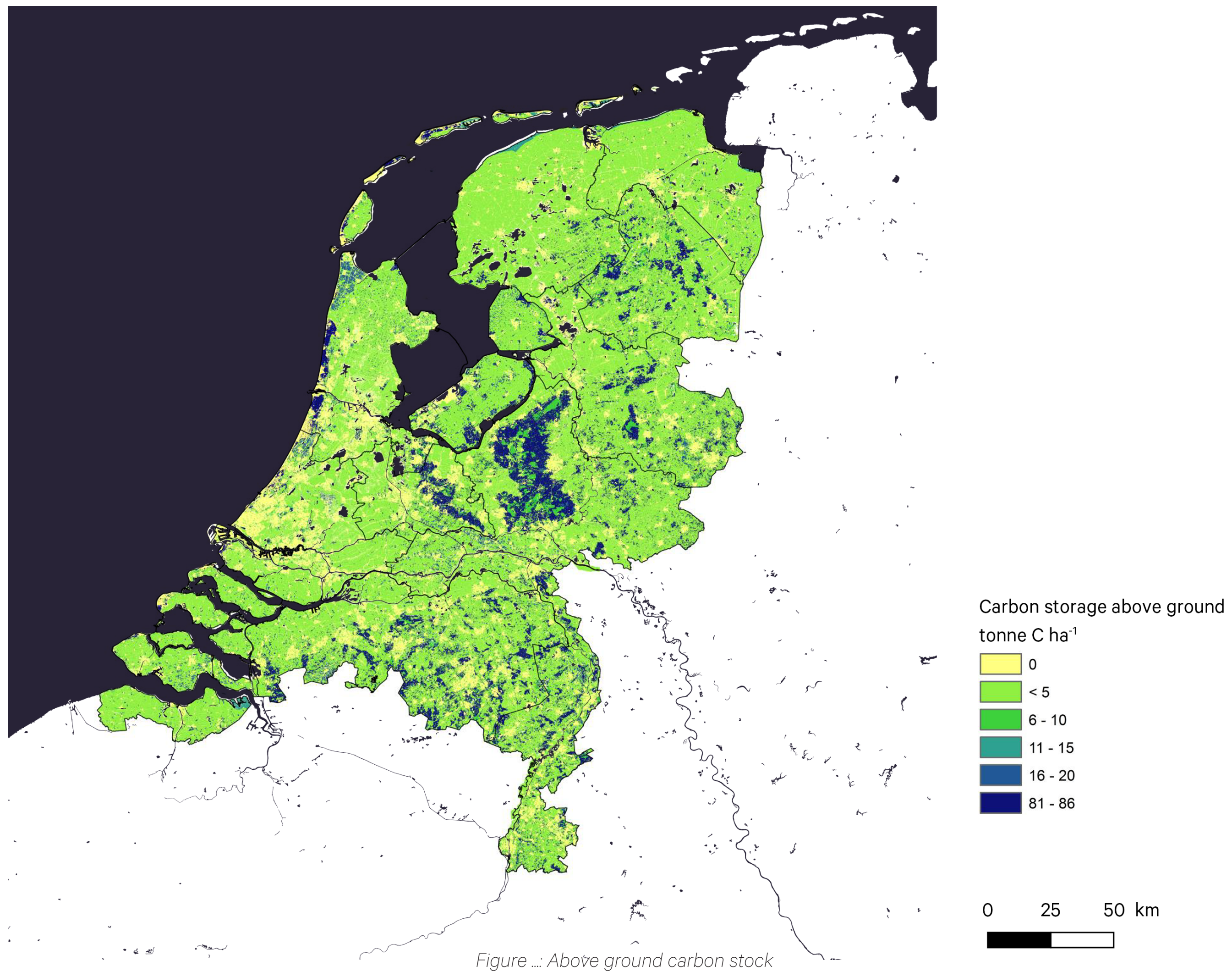


Figure ..: Above ground carbon stock
Dataset: Alterra

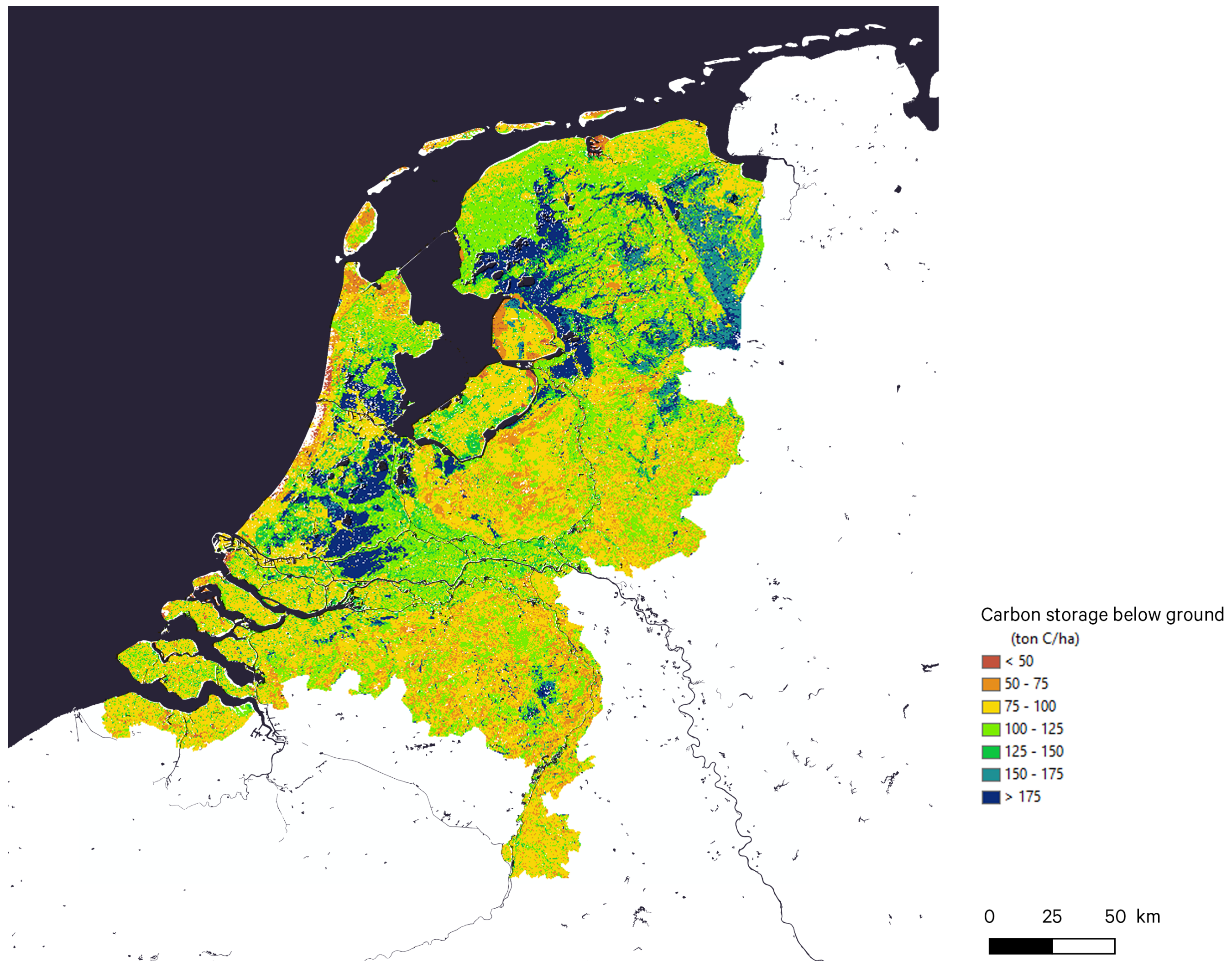


Figure ..: Below ground carbon stock
Dataset: Alterra

Figure ..: Forests in the Veluwe
Source: Naturescanner, n.d.

Forests

Through the process of photosynthesis, wherein nutrients are converted into sugars and carbohydrates under the influence of sunlight, CO_2 is stored in plants. It serves as an essential building block for plants, being stored in all parts of the plant. The more photosynthesis occurs, the more CO_2 is filtered from the atmosphere and stored in the plant (Gorte, 2009). As trees are substantial plants, they can store a considerable amount of CO_2. In general, a growing tree absorbs more CO_2 than an older tree, and a tree with a thick trunk absorbs more CO_2 than a tree with a thin trunk. On average, a standalone tree absorbs 10-40 kg of CO_2 per year from the atmosphere; thus, a tree that is 30 years old may have sequestered a ton of CO_2 (Staatsbosbeheer, n.d.). In a forest, individual trees are not standalone; the tree density is higher, but the amount of CO_2 extracted from the atmosphere per tree is lower. A forest is defined as land where the tree density is higher than 50 trees per hectare. This is a relatively low figure, considering the average number of trees per hectare in forests is 500 (Vereniging van Bos- en Natuurterreineigenaren, n.d.).

Netherlands possesses 370,000 hectares of forest. Over the past decade, the forested area has experienced a slight decrease, primarily due to the conversion of temporary forest parcels to agricultural use. Nevertheless, within the existing forests, there has been an increase in diversity, both in terms of tree ages and tree species. The proportion of deciduous trees is 55%, compared to 45% for coniferous trees (Compendium voor de leefomgeving, 2023).

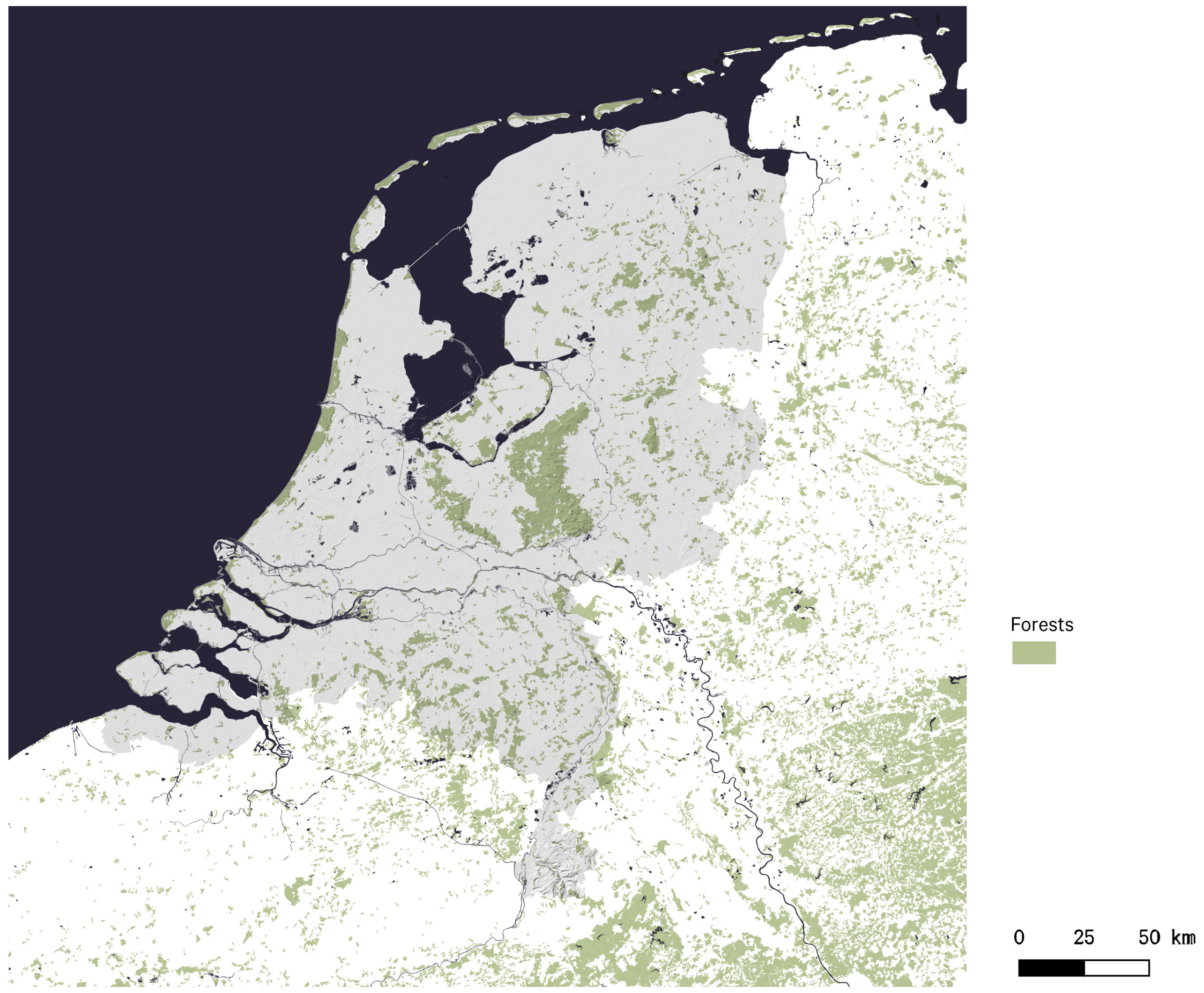


Figure ..: Map with forest coverage in the Netherlands
Dataset: SDGB

As discussed earlier, the CO2 storage capacity is dependent on various factors, including characteristics such as trunk thickness, size, and age. It is, therefore, evident that different tree types have different storage capacities. In Figure ..., the annual storage capacity per tree species is depicted in tons per hectare. However, a recent study indicates that a variety of different species leads to the highest CO2 storage (Mensah et al., 2016). This is attributed to the increased productivity of trees resulting from the interaction between different species. Additionally, the study reveals that the slope of forested lands can significantly influence CO2 storage capacity, with steeper slopes resulting in lower storage capacities. This finding holds promise for the relatively flat terrain of the Netherlands.

Forests, in addition to their ability to store CO2, encompass other crucial spatial values. They (naturally) make a significant contribution to increasing biodiversity in the Netherlands, aiding in the slowing down of rainwater runoff. This can be beneficial in the context of future extreme weather situations, where frequent occurrences of intense rainfall and extreme heat are expected. Forests also enhance soil health and purify the air. Besides serving recreational purposes, forests can play an economic role. For instance, they can be utilized as centers for wood production, thereby providing (construction) materials.

Tree species	**CO2-eq capture (ton/ha/year)**
Hardwood	
American Oak	8
Beech	11,8
Es	10,9
Common Maple	9
Poplar	5,4
Raw Birch	3,2
Trilpopulier	3,7
Pedunculate oak	7,5
Black alder	7,3
Softwood	
Corsican pine	6,3
Douglas	12
Norway spruce	8,1
Scots pine	4,3
Japanese larch	4,4
Austrian pine	4,5

Figure ...: Tree species and their carbon storage capacity
Source: Vereniging van Bos- en Natuurterreineigenaren, n.d.

Figure ...: Dutch peatlands (wetlands)
Source: University of Utrecht, n.d.

Wetlands

Wetlands possess a substantial carbon storage capacity, allowing them to significantly contribute to the reduction of atmospheric carbon concentrations (Junk et al., 2013). Approximately 20-30% of the total CO2 quantity in the soil is estimated to be stored in wetlands, despite covering only 5-8% of the Earth's surface (Mitsch et al., 2012). They exhibit a storage capacity ranging from 81,000 to 216,000 kg CO2/ha, with an average of 148500 Kg CO2/ha. The amount of CO2 wetlands can store depends on factors such as location, wetland type, and depth (Soto-Navarro et al., 2020).

Dutch peat areas are also classified as wetlands. Two-thirds of the Netherlands' land area was once covered by peatlands (over 4.2 million hectares), but only 267,000 hectares remain today (Staatsbosbeheer, n.d.). Centuries of peat extraction for turf (a fuel source) resulted in the removal of a significant portion of the peat layer. Due to population growth, much of the remaining peat landscapes now serve agricultural purposes, with dairy farming playing a prominent role. This agricultural function necessitates a water level of at least 60 centimeters below ground level (Grandiek et al., 2007), exposing the upper layer of peat to air and leading to peat oxidation. This process releases substantial amounts of CO2, with annual peat oxidation accounting for 3% of the total CO2 production in the Netherlands (Grandiek et al., 2007). The annual emissions average 4.2 Megatons, which is twice the amount of CO2 stored annually in all Dutch ecosystems combined (Staatsbosbeheer, n.d.).

The low groundwater level and subsequent decomposition of existing peat remnants contribute to land subsidence, and are responsible for 2-3% of the annual Dutch CO2 production (Staatsbosbeheer, n.d.). Presently, there is a negative carbon storage situation in Dutch wetlands, while there is big potential for CO2 storage. Addressing this issue requires precise groundwater level management and a strategy for the expansion of new peat areas.

Furthermore, wetlands exhibit several other spatially valuable characteristics. Firstly, they can act as sponges, absorbing and retaining water, which is advantageous in the context of climate change, where situations of extreme rainfall and drought are becoming more frequent. This makes wetlands particularly suitable as buffer zones around rivers, capable of storing excess water in the ground during flooding. Secondly, wetlands contribute to preserving and enhancing biodiversity by supporting a diverse range of plants, thus expanding habitats for animals and insects. Thirdly, wetlands can serve as water purification systems, as plants retain water, extracting nutrients and filtering out chemicals (Hammer & Bastian, 2020). Fourthly, wetlands can be utilized for food and/or material production, such as wet crops or insulation materials like reeds. Lastly, wetlands can have a recreational function, offering opportunities for activities such as cycling and hiking.

Approximately 20-30% of the total CO2 quantity in the soil is estimated to be stored in wetlands, despite covering only 5-8% of the Earth's surface (Mitsch et al., 2012).

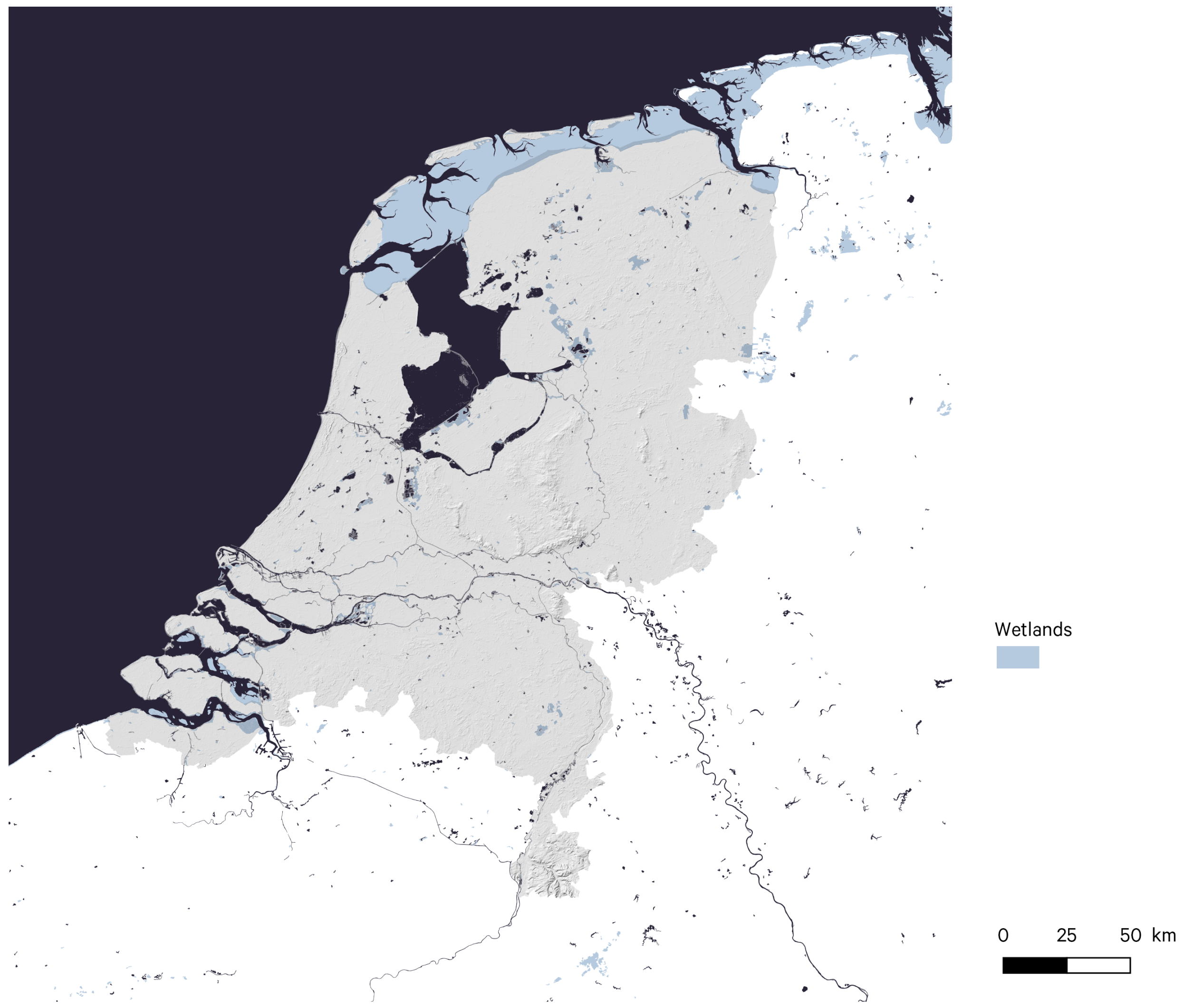


Figure ...: Map with wetland coverage in the Netherlands
Dataset: CLC 2018

Spatial Conflict

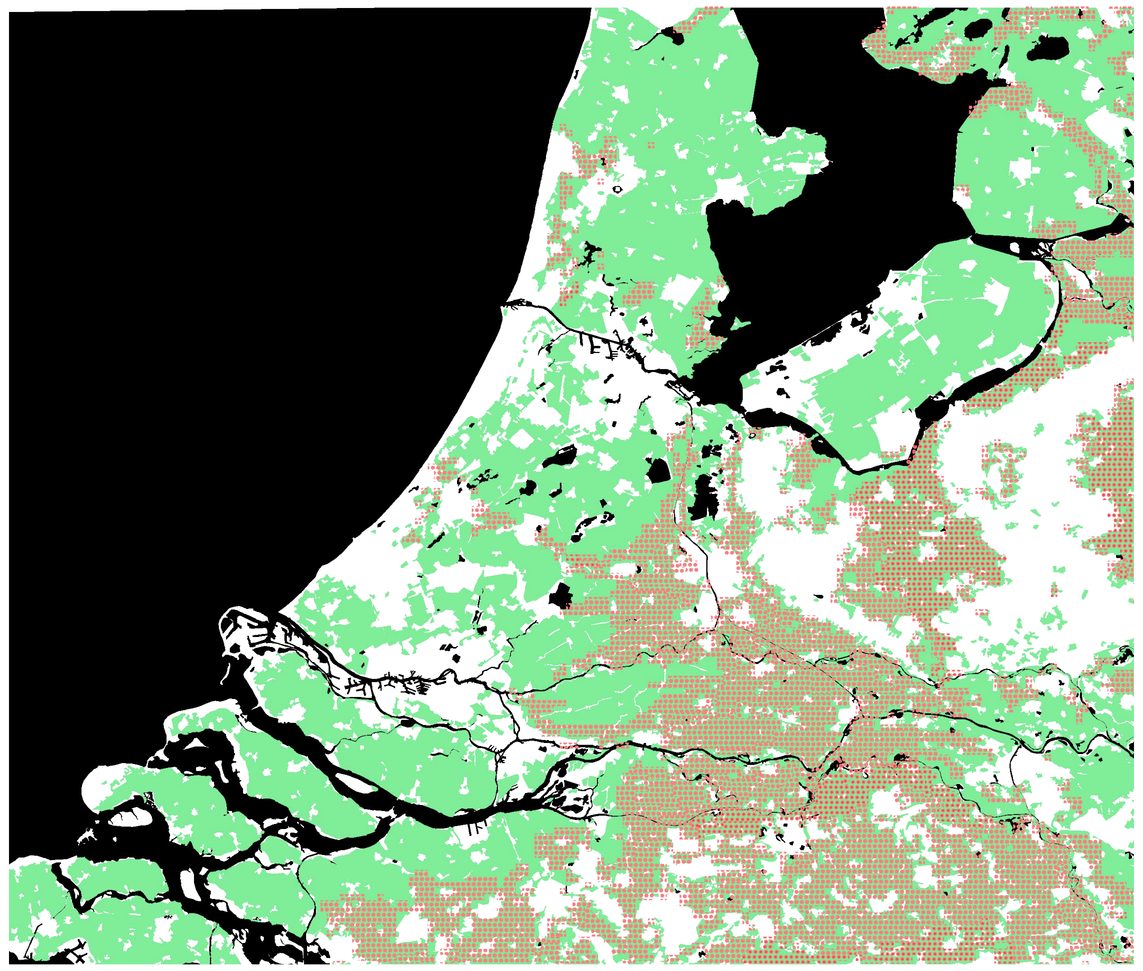
The challenge of changing land-use

When it comes to incorporating forests and wetlands into the Netherlands' regional landscape, one major challenge stands out: the scarcity of available space. The Netherlands faces constraints due to its built-up areas, covering 24% of the country, and designated Natura 2000 sites, which occupy 20%. This leaves a limited area under scrutiny, notably the agricultural land—a subject frequently making headlines.

If one is still uninformed about the farmer protests that have occurred over the past years, it is noteworthy to recognize their significance within the context of this report. Farmers are expressing their frustration with the government's efforts to address their nitrogen pollution, which includes a 30% reduction in the population of pigs, cattle, and chickens in the Netherlands.

The backlash aligns with the release of specific measures by Dutch authorities aimed at reducing levels of ammonia, nitrogen oxides, and nitrous oxide to safeguard over 150 nature reserves across the country. It is the agricultural sector that will bear the primary responsibility for achieving these emissions reductions.

A major concern within this sensitive topic revolves around what farmers perceive as unjust treatment. They feel they are being disproportionately penalized, particularly when large CO2 emitters such as Shell and Tata Steel seem to escape similar scrutiny.



Ammonia emmision areas
Agricultural land
Water bodies
0 10 20 km

Figure : Ammonia emmisions in agricultural land
Dataset: https://www.eea.europa.eu

"We've proposed all kinds of solutions but we are ignored. And finally, they come up with a plan for a reduction in livestock. No other sector has reduced nitrogen in the last 30 years [as much as] we have. This is why there's a lot of emotion and pain."
- Jeroen van Maanen, farmer (Boztas, 2024)

And farmers that want to change their current land-use, are indeed ignored and even worsent. A proposal to replace three cattle barns with houses has been rejected by local authorities, who instead approved the construction of a new barn for 100 additional cows. The couple behind the proposal have been in discussions with the municipality for four years, but feel unfairly treated as the reasoning behind the opposition remains unclear and are forced to upscale their livestock to be financially stable (Hanegraaf, 2023).

Thus, simply transforming from a productive farm-land ground towards non-productive forests and wetlands is not a straightforward decision. However, by investing in the biobased economy through making the carbon capture landscapes into productive land where we could extract biobased materials creates economic opportunities.

Figure : Farmers protests
Dataset: https://www.gelderlander.nl/arnhem-e-o/de-arnhemse-markt-vol-tractors-gestreste-kalveren-en-mest-zo-verliep-het-boerenprotest~afedb2ba/?referrer=https%3A%2F%2Fwww.google.com%2F

Figure : Protesting farmer block highway
Source: https://www.anp.nl/blog/48/boerenprotesten-ogen-fotografen

Spatial Justice

The addition of an economic factor

Assessing the economic feasibility of such projects and identifying revenue streams from carbon utilization can attract investment, stimulate job creation, and foster economic development. This is where the link is made with one of the largest polluting sectors of the whole world: the building and construction sector. Where annually it is responsible for 37% of all the CO2 emissions (Ritchie et al., 2024).

The Netherlands also has been grappling with a shortage of housing for several years, presenting significant challenges for both residents and policymakers. Various factors contribute to this shortage, including population growth, urbanization, and a lack of sufficient construction to meet demand.This shortage has also sparked debates on urban planning, land use policies, and the need for sustainable and innovative solutions to address the housing crisis and ensure adequate housing for all citizens (Ministerie van Algemene Zaken, 2023).

To reduce CO2 emissions in this sector, it is necessary to make the production of building materials more sustainable, for example by the production of biobased materials. With the production of biobased building materials, carbon can actually be stored within these materials and by making the process more local. Localizing production and use can reduce the carbon footprint associated with transportation and distribution. It promotes sustainability by encouraging the use of local resources and reducing reliance on imported goods.

The productive factor

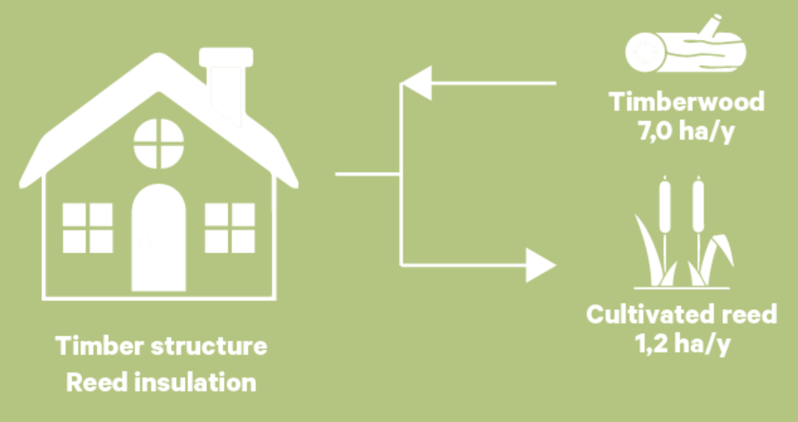
Local biobased building materials

Currently, the construction industry is dominated by materials such as concrete, steel and plastics that are manufactured from finite resources. Partly for this reason, they score high on environmental impact factors (Van Dam et al., 2019), meaning they generally have a large negative impact on climate change. The construction industry is the largest polluting sector in the world, the urgency to change this is crucial to prevent further global warming.

This will require the availability of renewable building materials that score low on environmental impact factors and can be sustainably produced. To reduce additional emissions from transportation as much as possible, locally produced materials are preferred.

The production of local biobased building materials can be combined with the ambition to store more CO_2 naturally: Materials can be produced in (new) forests and wetlands. In forests, production will be mainly focused on wood and in wetlands on reeds. But these two materials already offer many different applications.

1 Biobased house



The carbon impact of an biosourced wall (consisting of a wooden frame and reet insulation), with a lifespan of 50 years, is estimated at 4kg CO_2, compared to 49kg CO_2 for a conventional wall.

Figure ...:

Wood

Wood products can be used as a structural material, making it a sustainable alternative to materials such as steel, cement and concrete. In addition, it can be used for various home components, such as frames and doors. In addition, plywood can be used as a finish, as can fiberboard. By the way, the latter also have a high acoustic value. Wood glue can also be produced from wood, which can have a bonding function.

Figure : Wood used as biobased construction material
Source: Jansen Bouw, 2023

Reed

Reed has a relatively high insulating value, so you do not need a large thickness of material. This makes the material ideally suited as insulation or roofing material. But (non-bearing) interior walls can also be produced from it and even fiberboards, which can serve as a finish. In figure ... you can see how reet is used as insulation material in the wall of a house. Prefabricated panels are pinned to the existing structure.

Figure: Reed used as biobased isolation material
Source: Hiss reet, n.d.

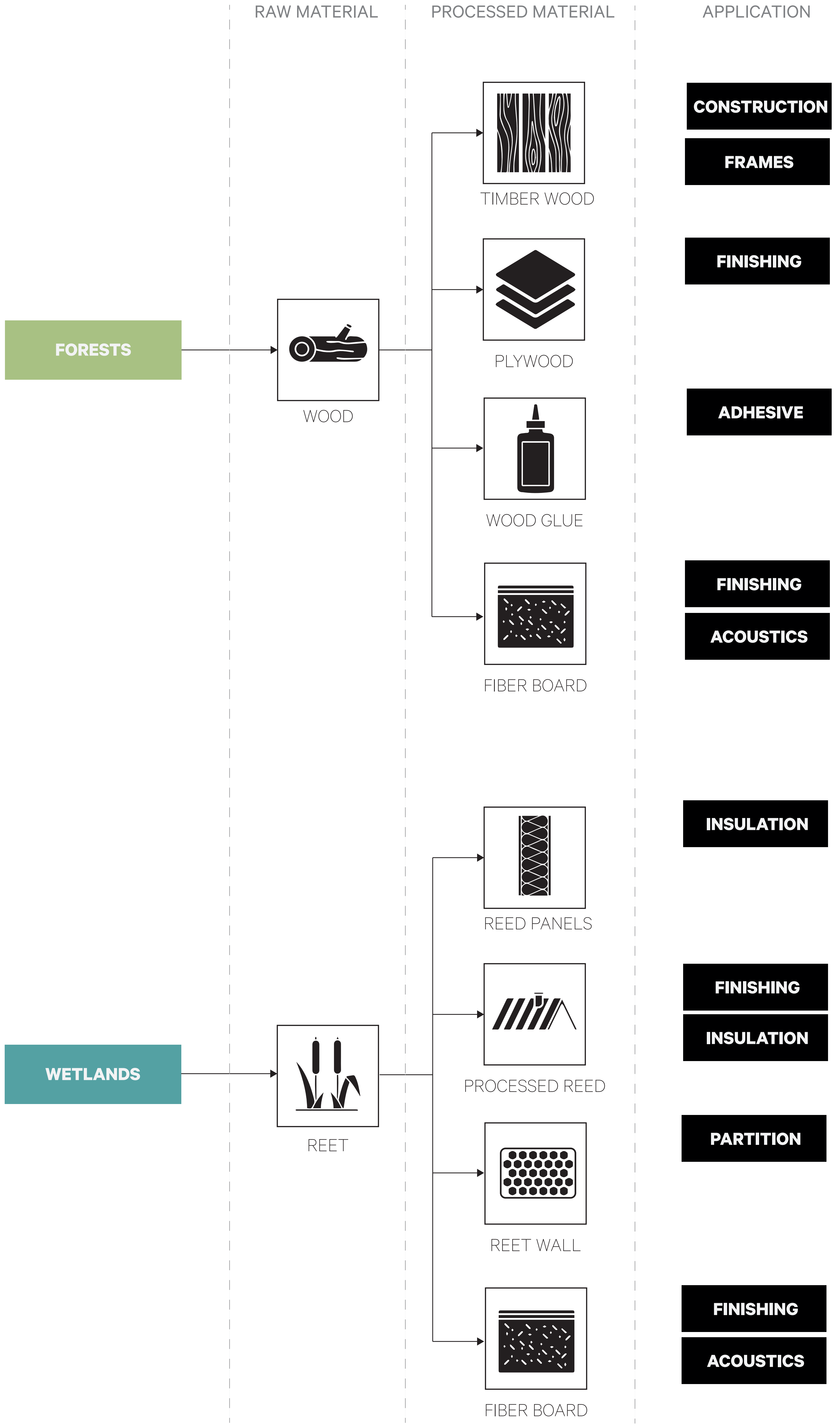


Figure Table of
Material applications for wood and reed

Who is involved?

The stakeholder analysis starts with the identification of all relevant stakeholders directly or indirectly affected by the project. 13 different stakeholders are identified.

The stakeholders were then evaluated on two dimensions: their power/influence and their interest in the project. This analysis provided insight into the extent to which each stakeholder is able to influence the project and to what extent they are motivated/interested to be involved in its outcome.

Based on this evaluation, the stakeholders were classified into a matrix with two axes,   power/influence on the one axis and interest on the other axes. This created different categories into which the stakeholders were placed, indicating how they should be dealt with within the project strategy.

In addition to assessing power and interest, stakeholders were also assessed on their specific interests in the proposed vision. These interests were grouped into three categories: economic, environmental/sustainability and social interests. By identifying these different interests, strategies can be developed to try to involve all stakeholders and reduce potential resistance and risks.

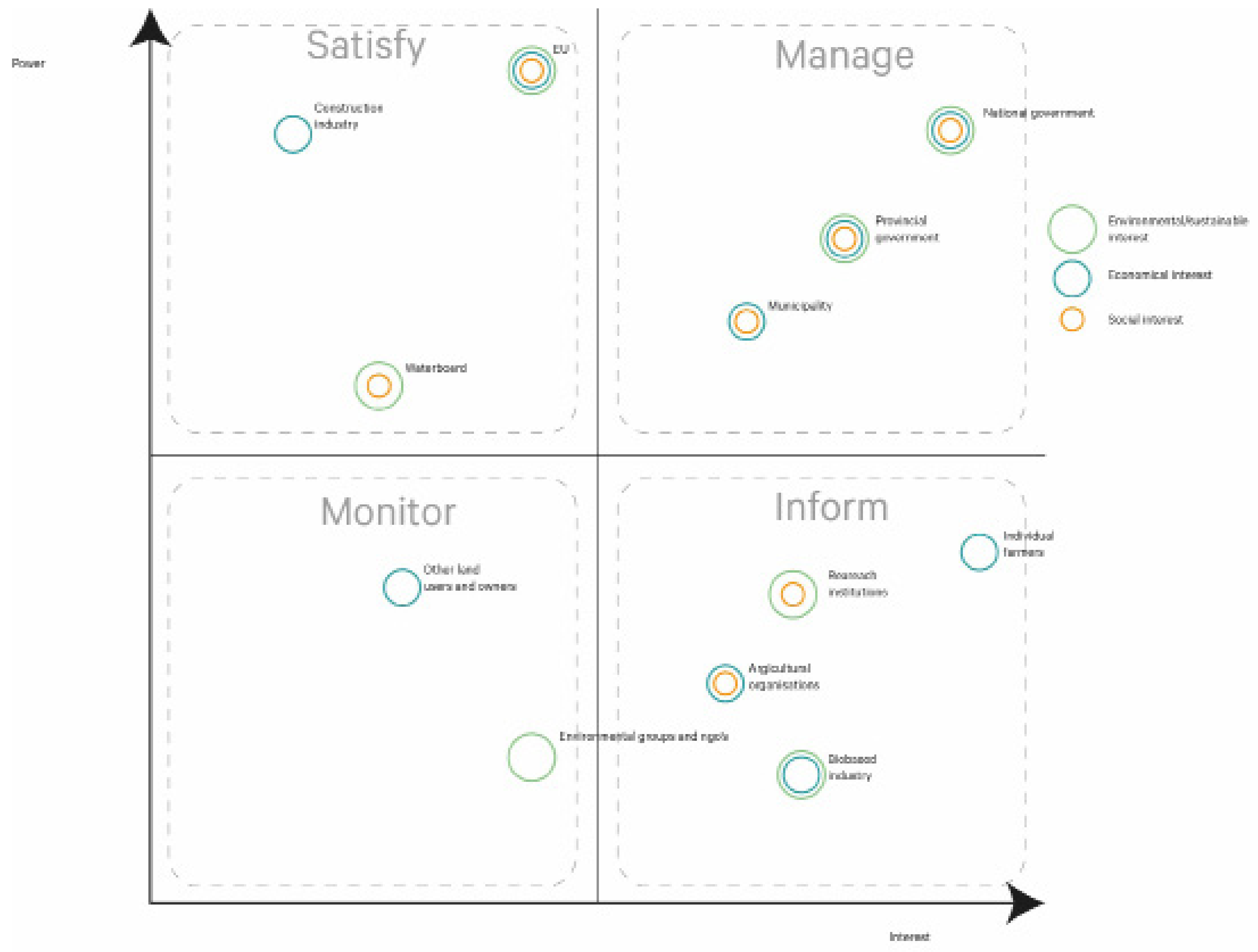


Figure : current stakeholders diagram by authors using the Power-interest matrix

European Union (EU):
Influence/Power: The EU has large power in policy-making, legislation, and funding related to things like conservation, environmental protection, and sustainable development within the states that are members.
Interests: The EU's interests are among other things: promoting sustainable development, improving biodiversity, reducing environmental pollution, and tackling climate change.

National Government:
Influence/Power: Decides legislation, locates funds, provides direction for plans.
Interests: Promoting national interests, trying to meet international commitments, helping the national economy, keeping political stability.

Provincial Government:
Influence/Power: Implements national policies, locates resources, makes regional regulations.
Interests: Regional development, economic growth, environmental sustainability, keeping political order.

Waterboard
·Influence/Power: Responsible for managing water quantity and quality, including tasks like water management, flood prevention, and purification.
·Interests: Focus on sustainable water management, minimizing pollution, keeping ecological balance, and creating a good water supply.

Local Government (Municipalities):
Influence/Power: In charge of local planning, gives permits, supports local initiatives.
Interests: Improving quality of life for inhabitants, protecting the local identity, creating social cohesion and stimulating economic growth.

Individual Farmers:
Influence/Power: Direct land use and management decisions.
Interests: Having good income, have a high productivity, stay on the line with environmental regulations, possible sustainable farming practices.

Other Landowners and Land Users:
Influence/Power: Land ownership
Interests: Maximizing profits, stay in line with regulations , good property rights, risk minimization.

Agricultural Organizations:
Influence/Power: Representing farmers' interests and creating collaboration between the farmers.
Interests: Protecting farmers' rights, supporting sustainable farming practices, access to resources and subsidies, creating a strong agricultural economy.

Construction Industry:
Influence/Power: Material selection for the building and construction methods.
Interests: Maximizing profits, efficiency, quality, staying in with regulations.

Biobased Material Industry (Wood and Reed):
Influence/Power: Production of biobased materials.
Interests: Promoting biobased materials, reduction of ecological impact in the construction sector.

Environmental Groups and NGOs:
Influence/Power: Lobbying for sustainability, raising awareness, influence on policy making.
Interests: Biodiversity and ecosystem improvement, sustainable development, community engagement, natural resource preservation.

Communities and Local Residents:
Influence/Power: Direct impact on environment and livelihoods.
Interests: Livelihood preservation, cultural heritage conservation, involvement in decision-making, quality of life improvement.

Research Institutions and the Academic World:
Influence/Power: Scientific support, project evaluation.
Interests: Researching sustainable practices, improving scientific knowledge, collaborating with stakeholders, publishing findings.

Suitability study

Once we understood the potential for turning land into carbon sinks, we overlaid different layers to create a map of suitability for this approach. A suitability map can enable us to support land use decisions enabling the efficient use of natural resources, while at the same time conserving those resources for the future (Wageningen University & Research, 2012).

We started with soil types and characteristics. Wetlands depend on the hydrological capacity of the soil. Soil texture, among other characteristics, directly affects hydraulic conductivity, water storage and water availability. Soil porosity determines the amount of water that can be stored in soils (Macreadie, 2021). Peatlands also play an important role due to soil characteristics and carbon release due to drainage (Craft, 2022). However, forests depend on loamy, moderately well drained and well-drained soils. (Bennett, 2010)

As shown in figure ... (CO2 emissions map), the CO2 concentration within southern region of the Netherlands is the highest due to many intensive industries. That is why we focus on that region of the Netherlands.

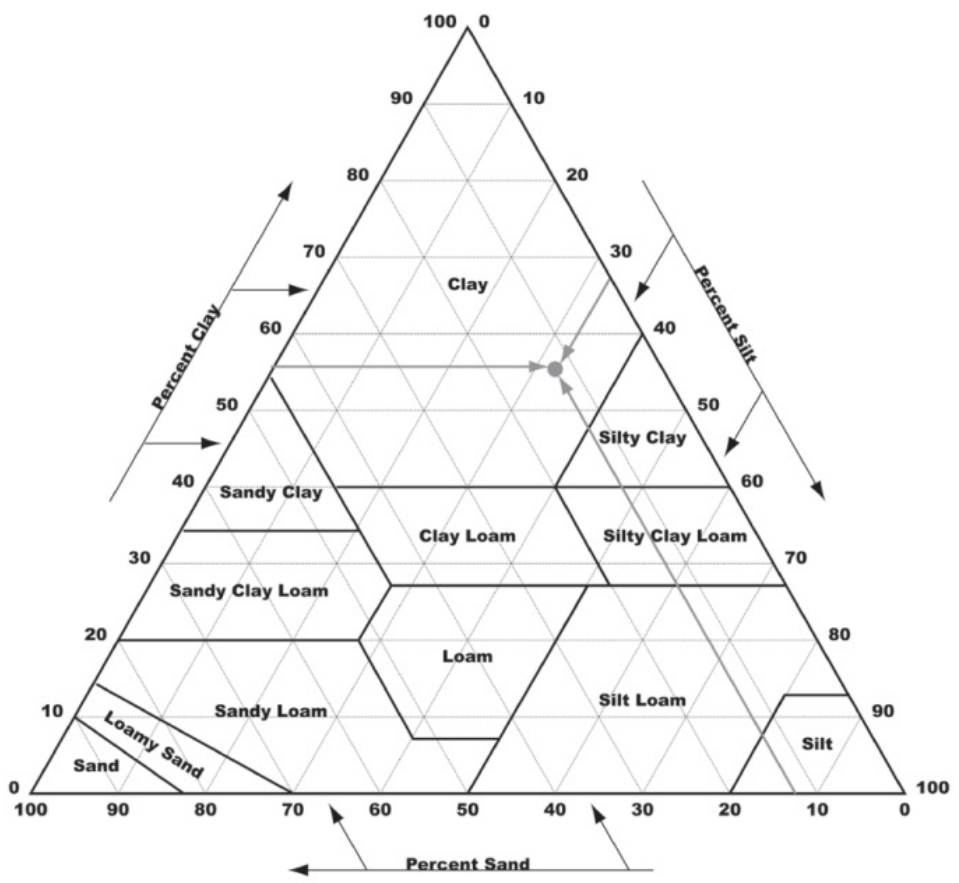


Figure ..: The soil textural triangle
Source: Macreadie, 2021

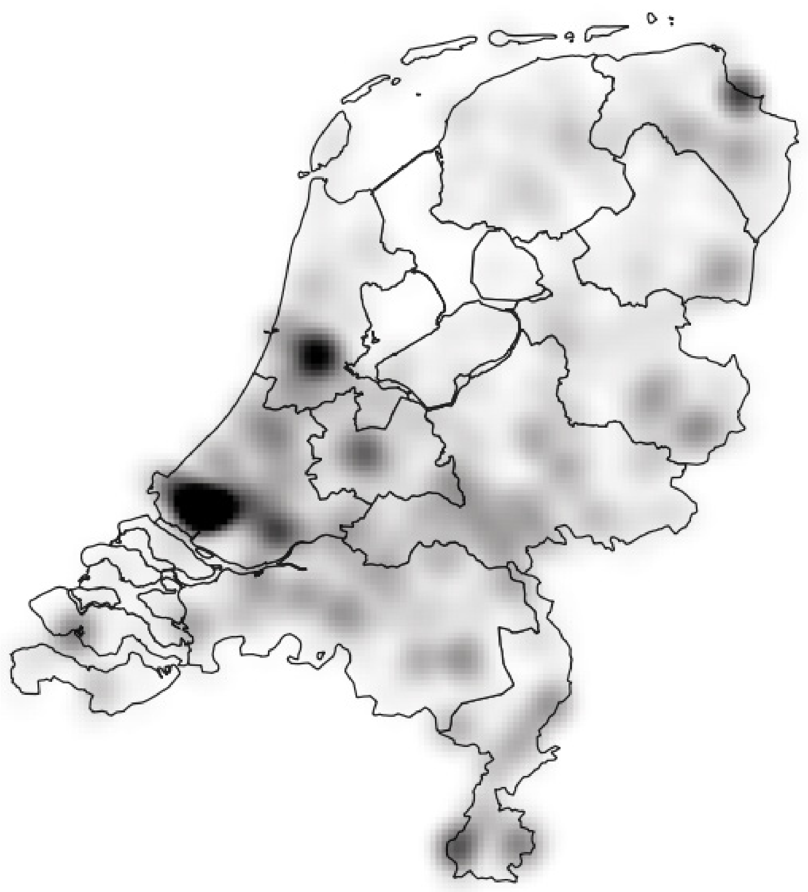
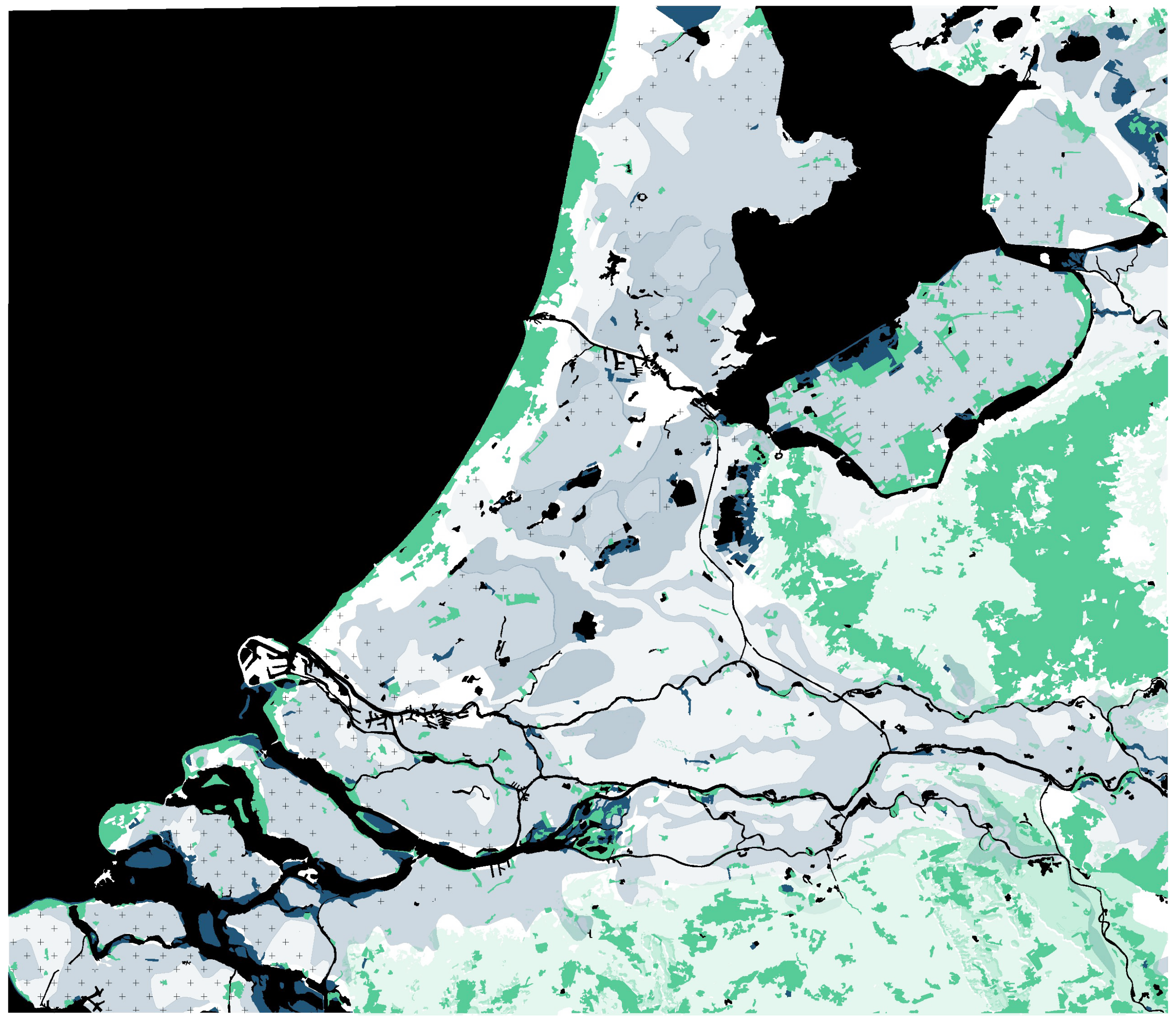


Figure ..: CO2 emissions map (by industry)
Dataset: EPRTR

1. Soil suitability



To this high suitability due to soil types, we overlaid current forests and wetlands areas.

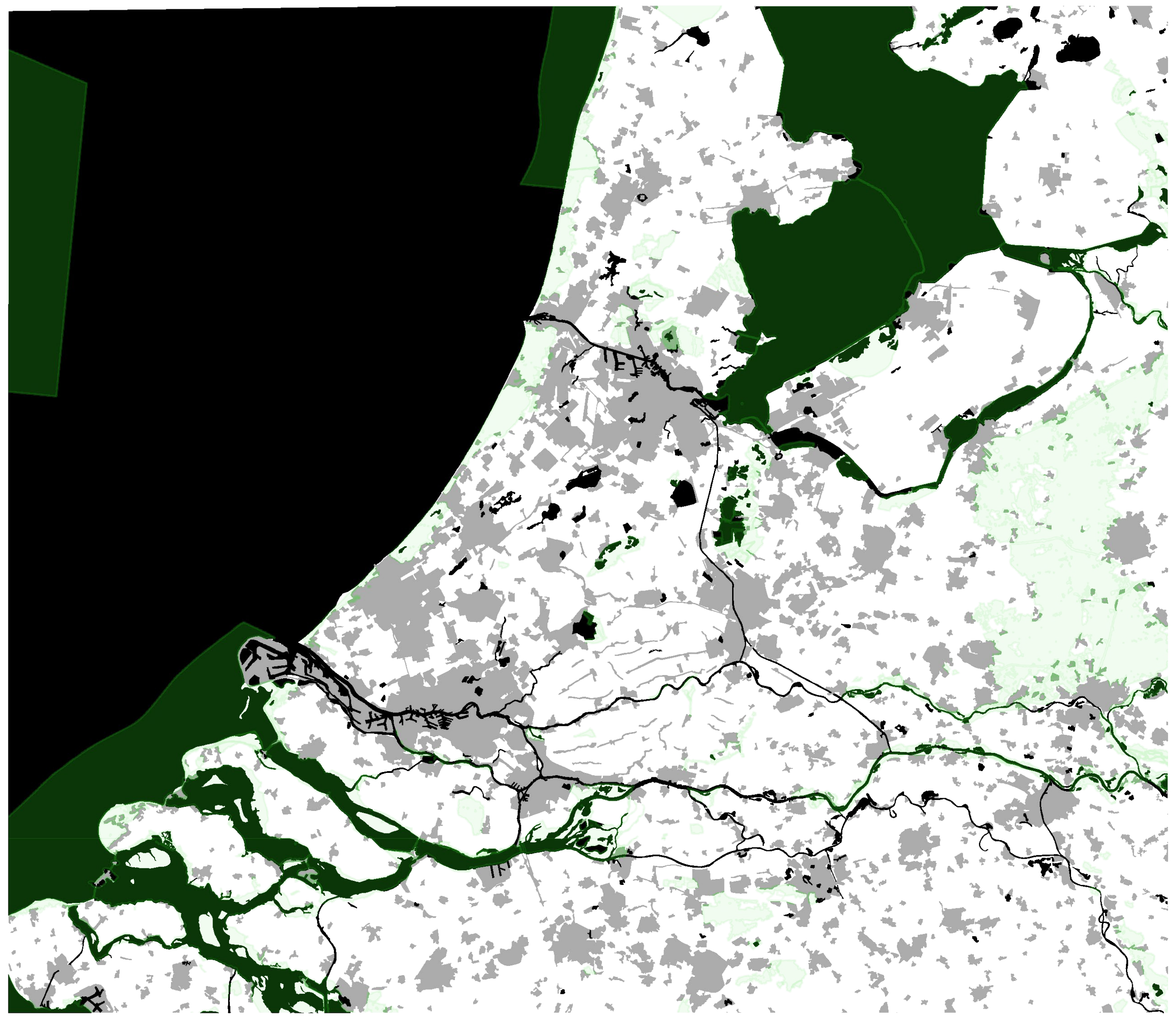
Figure ..: Soil suitability map
Dataset: SGDB - ISRIC - CLC2018

2. River flooding zone

As mentioned before, wetlands depend on the hydrological layer and where the soils are permanently or temporarily flooded. (William, 2013) To do this, we have overlaid the soil moisture and also the areas prone to flooding in 2050, mainly around river basins.

Figure ..: River flooding zone map
Dataset: ROR signiticant overstromingsrisico vlakken [overstromingsrisico – PDOK] and WAW_2015_020m_03035_d07

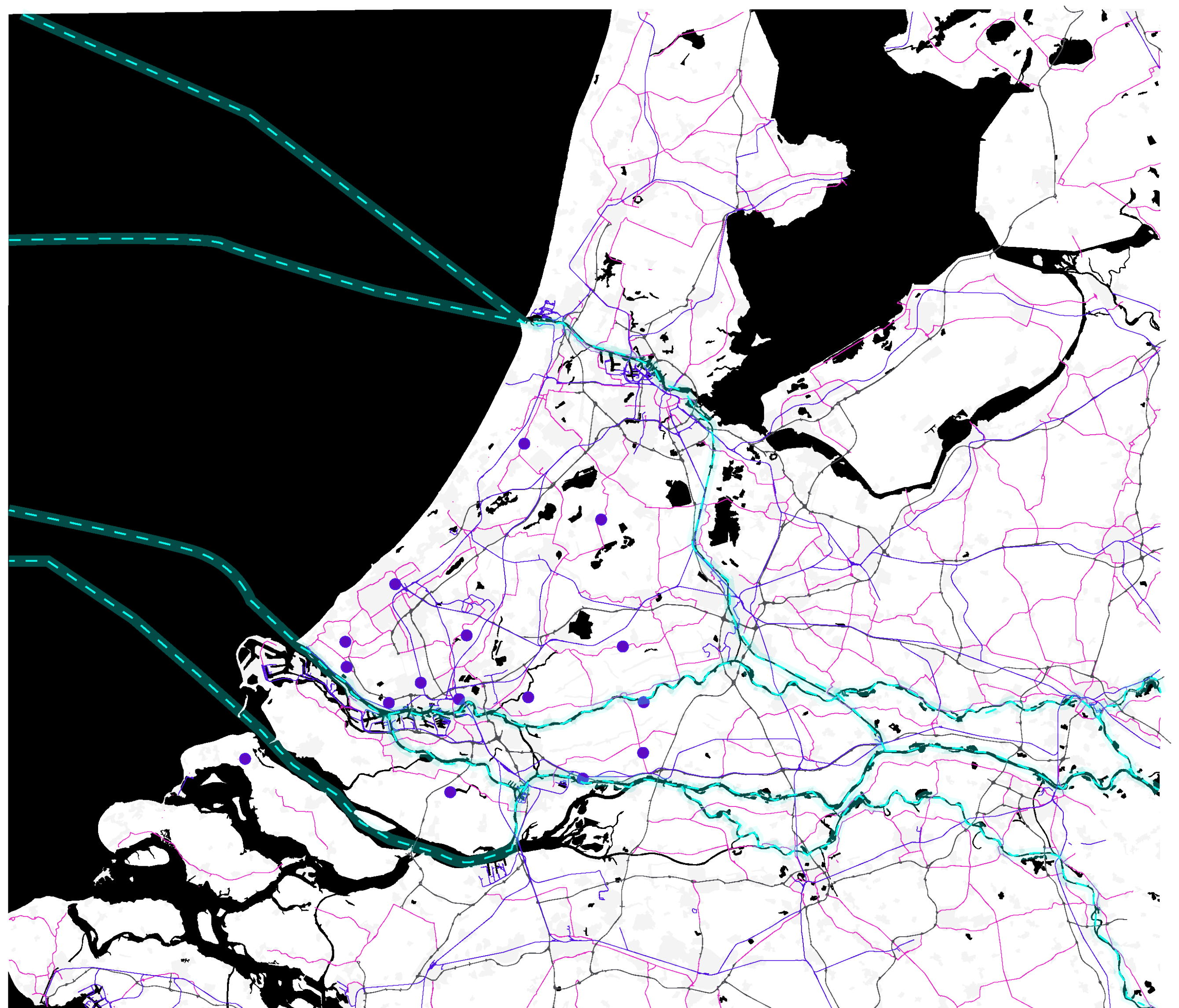
3. Natura2000 and Urban areas



Another factor to consider is the availability of the land (Uuemaa, 2018), considering that there are natural areas already that we want to preserve, and also urban areas that are fundamental for the functioning and development of the region. For this, we overlaid the land cover and land use, with the Natura2000 and the built areas.

Figure ..: Landuse
Dataset: PDOK - CLC

4. Networks



Relying on the current infrastructure network and promoting communication between the main production areas is essential for an effective production industry. To understand the current situation, we have superimposed the current processing areas of the bio-based construction industry and the main infrastructure lines.

Figure ..: Networks map
Dataset: PDOK - CLC

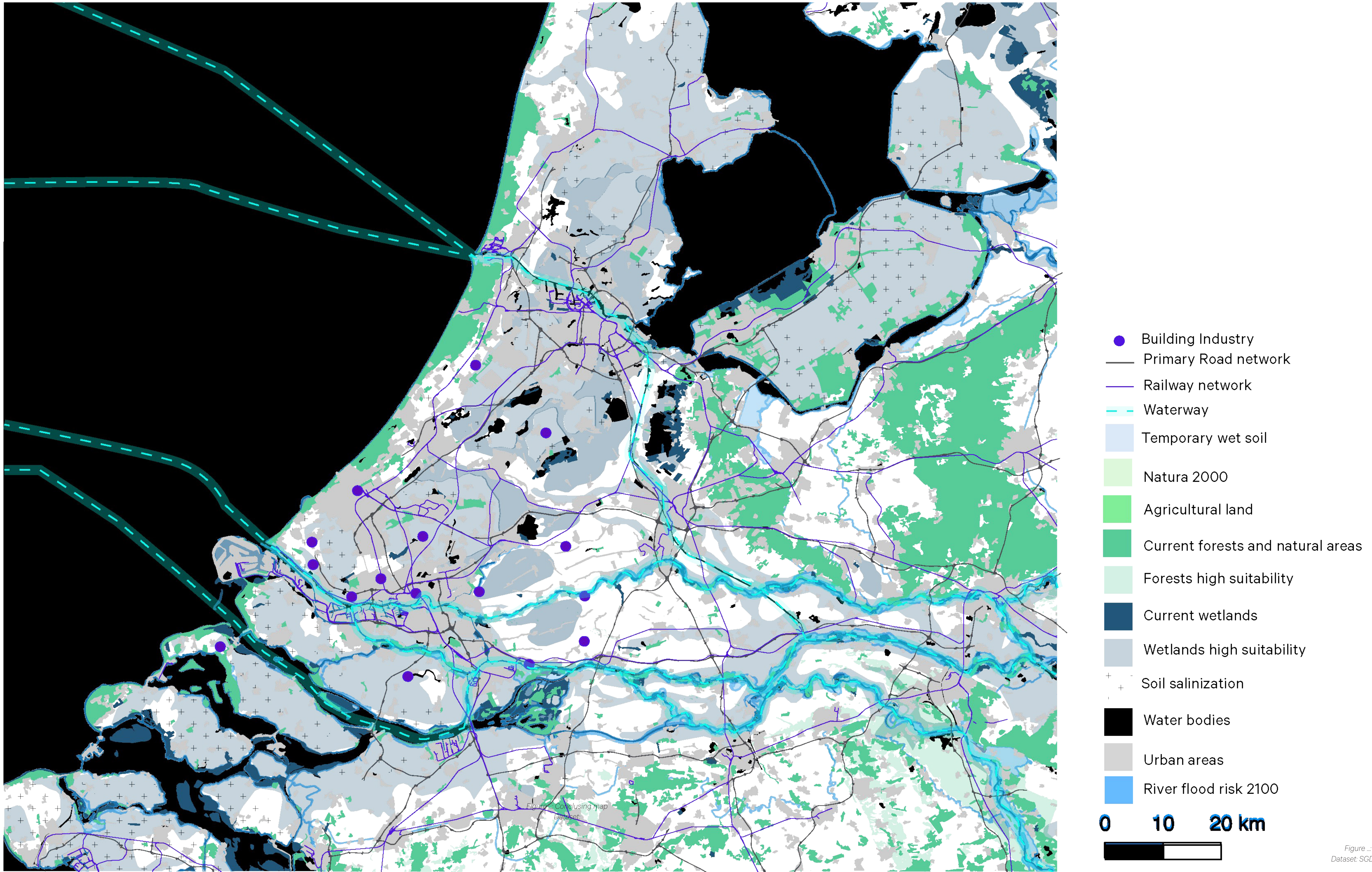


Figure ...: Conclusion map
Dataset: SGDB - ISRIC - CLC2018

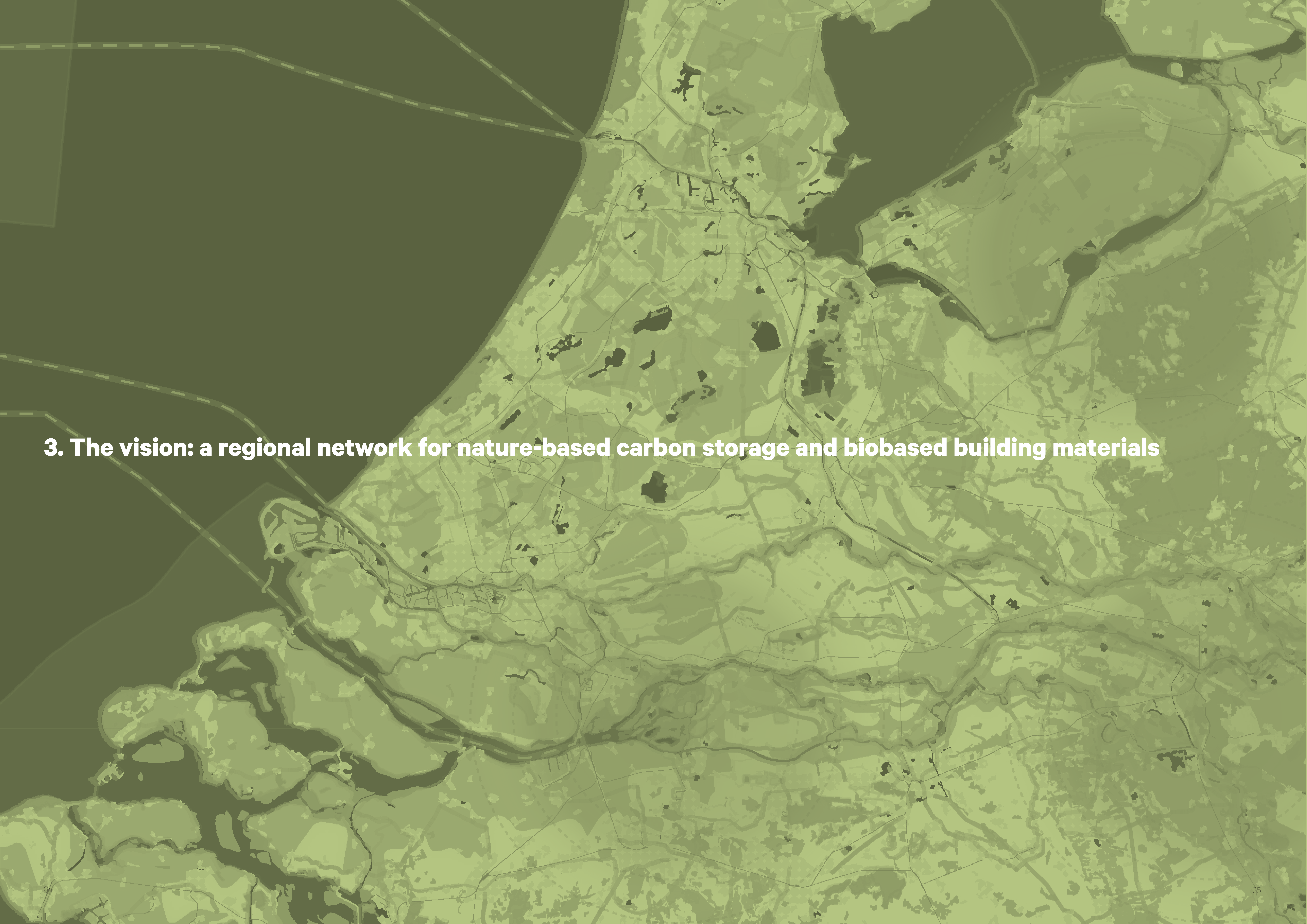
Conlcusion

The concluding suitability map is the result of the spatial analysis in which the different layers of the environment have been brought together. This map provides insights for the possible potential areas for the vision.

The areas on this map that score high suitability for both wetlands and forests, and are also close to urban areas and easily accessible by railways or waterways, are considered an interesting areas.

These areas could serve as interesting locations for development of the vision and implementation of the strategy.

3. The vision: a regional network for nature-based carbon storage and biobased building materials



Vision statement

In this vision for the Eurodelta we aim for a vision that changes the current strategy of CO_2 reduction. Away from traditional technological approaches that often involve large, spatially unattractive installations (CCUS) and with the chance of increased emissions from polluting industries because of a backlash effect. Our vision therefore introduces an alternative approach based on nature itself: Nature Based Solutions.

Central in our approach is absorbing CO_2 from the atmosphere by planting forests and creating new wetlands that serve as CO_2 storage. This means that we have to change the land use of agricultural land, the largest surface area in The Netherlands. This creates spatial conflicts because the value of the land decreases and farmers see their income shrink. However, to solve this, we integrate productive elements into these new landscapes.

The forests and wetlands are partly transformed into production areas, where the products from the natural sources such as wood from the forests and reeds from the wetlands are used as circular building materials. This approach transforms the CO_2-absorbing landscape into a productive landscape that is at the same time profitable.

Existing crop and cow farms will transform into the new bio-based building material farms (BBBM-farms) to cultivate and harvest the productive areas. Within the areas new community hubs will also be established, containing processing factories, educational facilities, markets, infrastructure networks hubs and attractive recreational trails.

In addition, the circular building materials contribute to a reduction of CO_2 emissions during the building construction phase. Our vision contributes to the effective reduction of CO_2 in the atmosphere on two fronts: by actively absorbing CO_2 from the atmosphere and at the same time reducing CO_2 emissions from agricultural and construction activities.

The renewed landscape also preserves and reinforces the current natural areas and stimulates recreation around the urban areas by creating natural buffers. By investing in these Nature Based Solutions we not only create a more sustainable Eurodelta, but also more resilient ecosystems, a thriving bio based construction industry and sustainable agricultural communities.

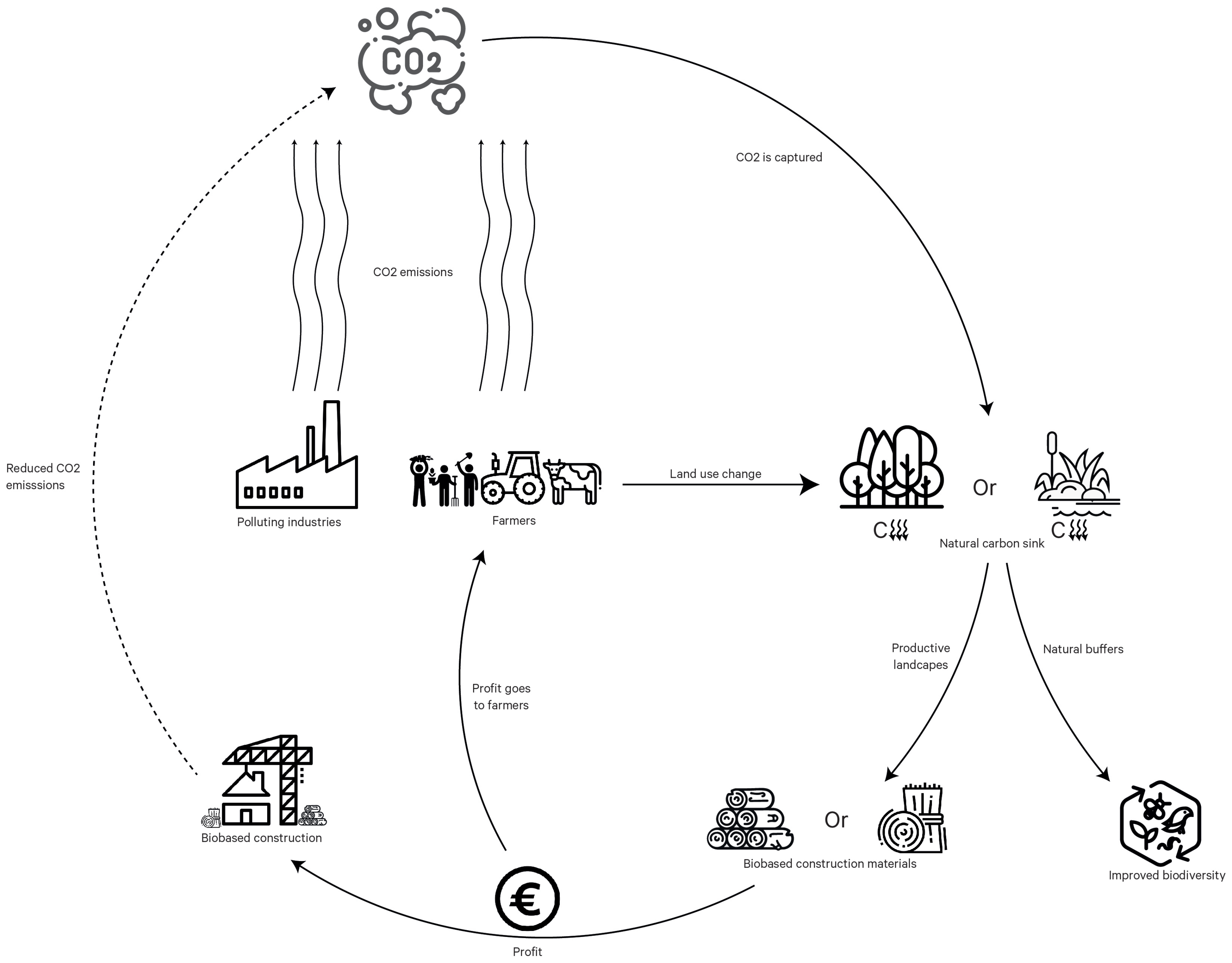


Figure: Vision feedback loop

Figure: Vision target

Transforming land-use to accomodate bio-based materials that capture CO2 doesn't only shape a future characterised by novel landscapes and construction enterprises, it also offers existing polluting agricultural land practises and industries the opportunity for spatial reconfiguration: All rooted in synergistic solutions benefitting people, planet and prosperity.

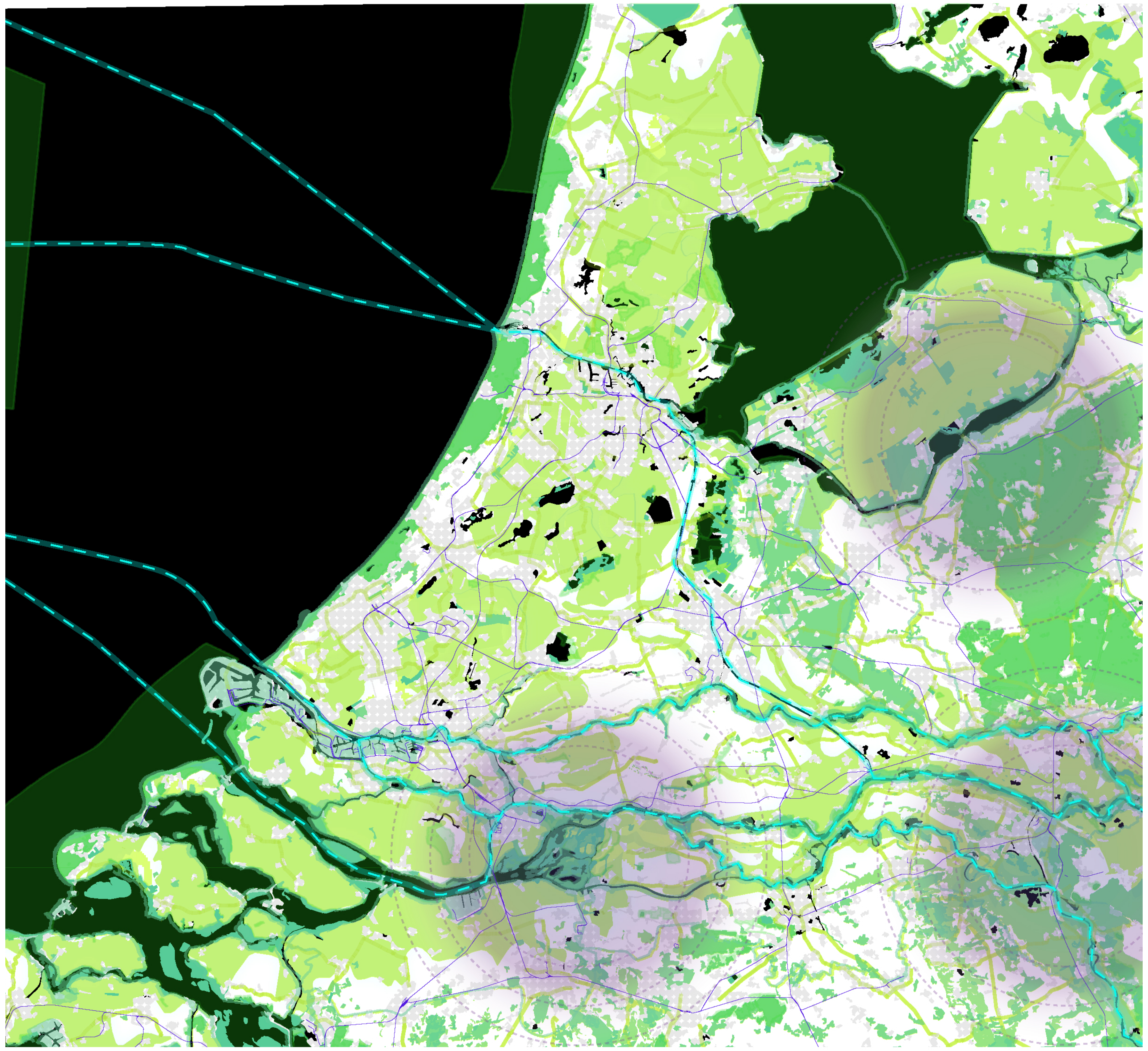


Figure ..: Vision map
Dataset: SGDB - ISRIC - CLC2018

Land-use typologies

A differentation in character

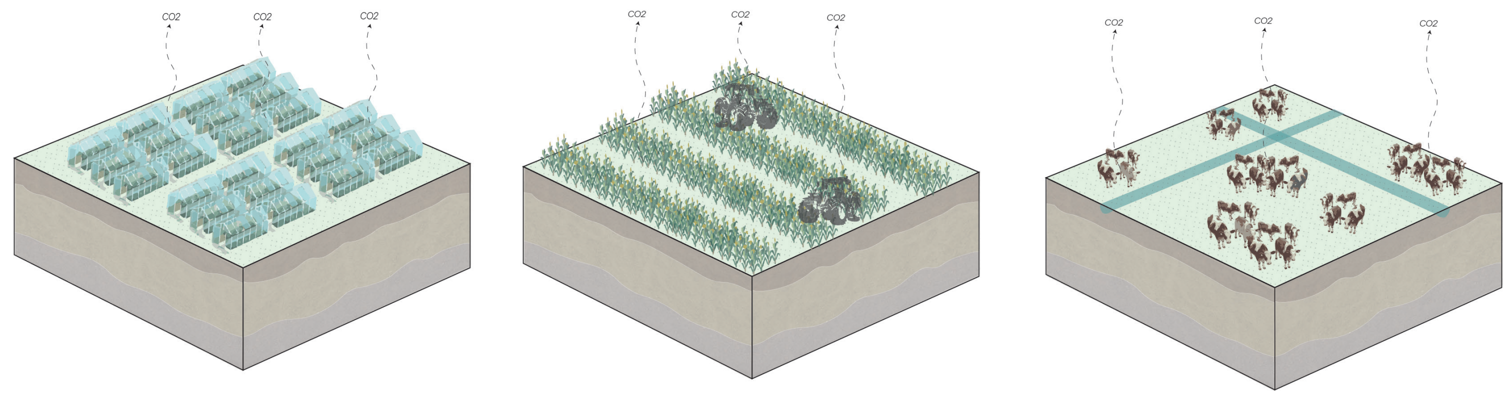


Figure ..: Existing land-use typologies

Framed in the Landscape approach (Denier, 2015) and based on the suitability map we defined on a national scale different preservation, production and buffer zones between them. It is important to clarify that this is a first step that involves mainly a physical approach and sets a rough base to define possible corridors, synergies and opportunity zones on a broader scale but a bottom-up approach will involve local stakeholders both for re-defining the landscape and zoning.

1. Nature

2. Production

3. Combination

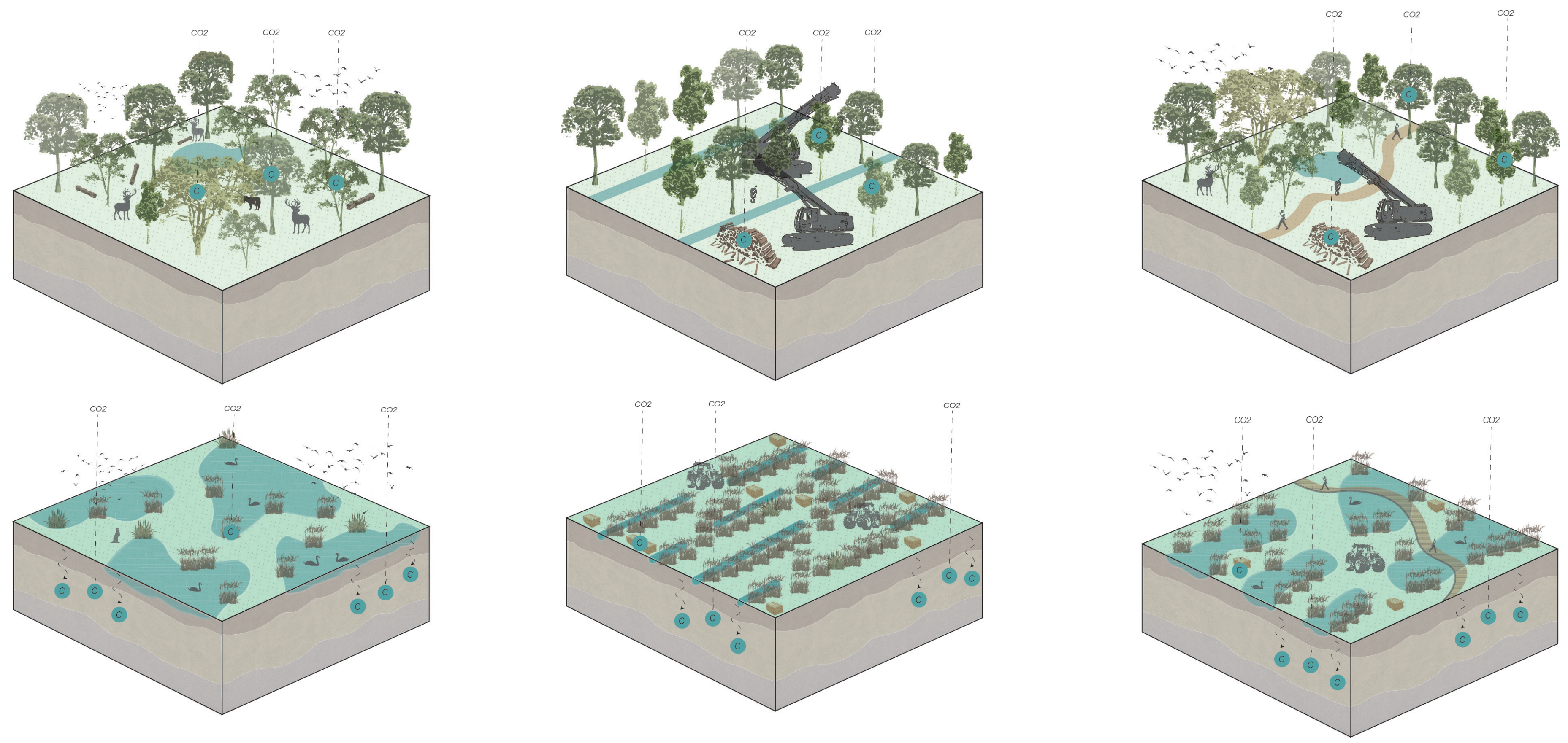


Figure ..: New land-use typologies

The monoculture of agricultural grasses is being replaced by a rich pallet of orchards, wet and dry forests and fields of diverse wetland crops. In addition, old landscape elements are restored or strengthened and new elements are introduced that enrich the current Natura 2000. This creates a landscape that is rich, varied and layered in planting. This diversity creates new habitats for flora and fauna that currently have no chance in the area.

The introduction of new trees and wetland crops, cultivation systems and landscape elements provide (clean) biobased building materials. An important starting point here is not to replace one monoculture with another, but rather to achieve a rich and varied landscape. The type of soil is the starting point for determining crops and cultivation systems. With wood production from orchards, tree lanes and wet and dry forest and fields of diverse wetland crops.

A production landscape for biobased building materials fits well with the urbanization and recreational tasks of the urban fringes. Because it creates a green and attractive landscape. The biobased crops and systems also make old landscape structures and lines visible again and make the fragmented urban periphery more of a whole. It builds on the landscape characteristics of the country estate landscape along the open landscape and the linear peat structure. Incidentally, productivity is not the only factor of interest in harvest plans, as crops must also be attractive year-round for recreation. For smart branding of the products, the goal is to have as short a market chain as possible for the building materials. A visible chain that includes, for example, harvesting along routes out of town. Production and processing in one place will hopefully stimulate recreationists and city dwellers to buy (even relatively expensive) products.

The organization

A systematic approach

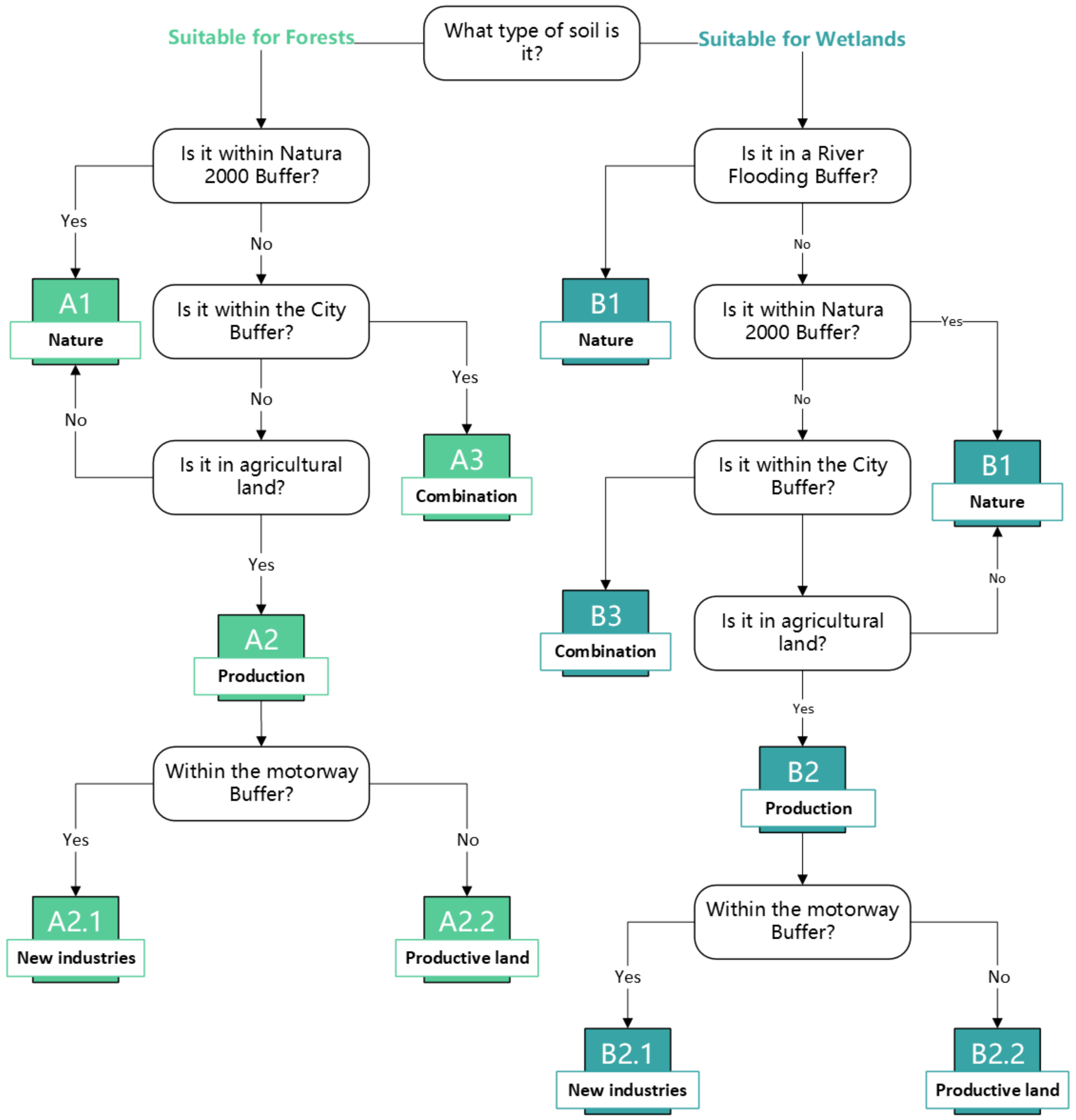


Figure ..: Flowchart for the possible organization of different typologies of wetlands and forests

Flowcharting the way to a possible future

As we have established, there are six types of land. We have wetlands and forests and in both of them a distinction can be made between nature-focused, production focused and a combination of them. These are merely the head categories, in reality the different types will be more comlex. The previously showed suitability study has showed some limiting and challenging factors in landuse-change, however, to create a global vision and decide on the types of land-use for the vision, it is necessary to add hierarchy in the limiting and challenging factors: We do this by creating a flowchart (figure ...).

It goes without saying that the limiting factors have a higher position than the challenging factors and therefore will appear as the first questions in the flowchart. Thus, the soil type is the first factor, deciding on either wetlands or forests. As biodiversity is an important value in our plan, we will try to preserve extsitng nature2000 area's and want to have the future possibility to expand these areas. That is why we are creating a buffer around the existing nature2000 areas where we will not plan any production, there will only be planned nature focussed wetlands and forests. In the case of wetlands however, the first question in the flowchart is about river buffers. Because buffer areas cannot have a consisted water level, it is hard to make it productive land. Therefore, it will be nature focused wetlands. The next factor within the flowchart is the city buffer. Within this buffer, there will be a combination of productive and nature focused wetlands/forests. This is because, on the one hand, this zone serves as a recreational are for city inhabitants, emphasizing the importance of nature and biodiversity. On the other hand, considering the densification challenge within cities in the coming decades, this is where the demand for building materials will be relatively high. The next factor in the flowchart considers the existing agricultural land, to justify the change of landuse, the new land will need to have an economic dimension and therefore will be productive land. The last factor in the flowchart is about the proximity to motorways, by creating a buffer around existing motorways the easily accessible areas are defined. These are suitable areas for new processing companies.

When this analysis is done for the total focus area, a rough programmatic vision appears, showing a patchwork of the different types of forests and wetlands (figure ...).

The map: Possible organization of typologies

In reality, the organisation of the different types of forests and wetlands will most likely turn out to be more complex. First of all because of existing plans, which will need to be taken into account. Second of all because the program will have to be more defined, the precise prgogramm will differ per location. For example, productive land can produce building materials, but can also produce fruits and vegetables, or perhaps even a combination of those. Third and last of all, making the new program fit the existing context can propose challenges.

What happens on the borders of the different programs? How are the different types of wetlands and forests connected to each other and to (new) building and processing companies? How can community engagement be encouraged? How will implementation be phased? Answering these questions requires a precisely formulated strategy.

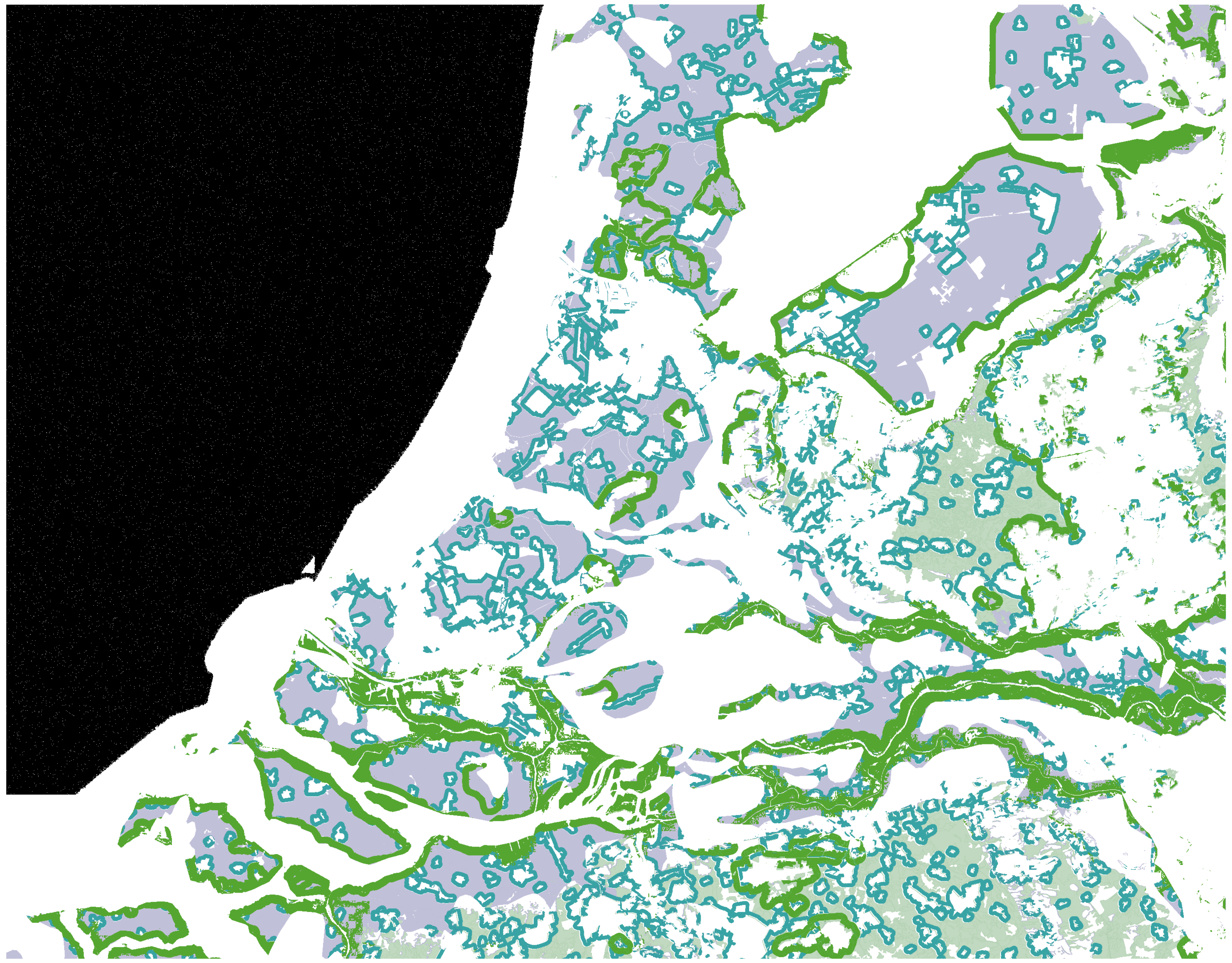


Figure ..: Spatial application of the flowchart based on the suitability map and spatial challenges

4. The strategy: Linking the possible to the probible

Introduction

How to create a just transition from agriculture to productive carbon sinks

It is not possible to think about a just, equitable and resilient future without thinking about solutions that are motivated by the grassroots (farmers and citizens). For this reason, we propose a multi-scalar approach involving all stakeholders, as coordinated action between groups of land users offers the potential to reconcile competing objectives at different scales (Scherr, 2015). Top-down decisions and policies should provide a structure that supports and strengthens farmers and farming communities to thrive.

Following a suitability study, which included soil types and socio-economic factors, areas of high suitability were identified. These areas should be demarcated and protected to store the maximum amount of carbon. There should also be links between them to connect fragmented areas and support biodiversity and combat biodiversity loss. This is something that needs to be promoted and protected through national and provincial policies.

On the other hand, in the framework of the landscape definition given in "The little sustainable landscape book" and the productive landscape definition given in "Continuous productive urban landscapes: urban agriculture as essential infrastructure", we propose a bottom-up approach with participatory decision making to define the landscape area and the zonas within it.

After defining landscapes and buffer zonas, productive communities are formed.

Definitions:

- A **landscape** is a socio-ecological system that consists of natural and/or human-modified ecosystems, and which is influenced by distinct ecological, historical, political, economic and cultural processes and activities. (Scherr,2015)
- **Productive landscapes** are open spaces - large or small, urban or rural - that are managed in such a way that they become ecologically and economically productive and provide social added value. (Adapted from André Viljoen, 2005)

Stakeholder future projections analysis

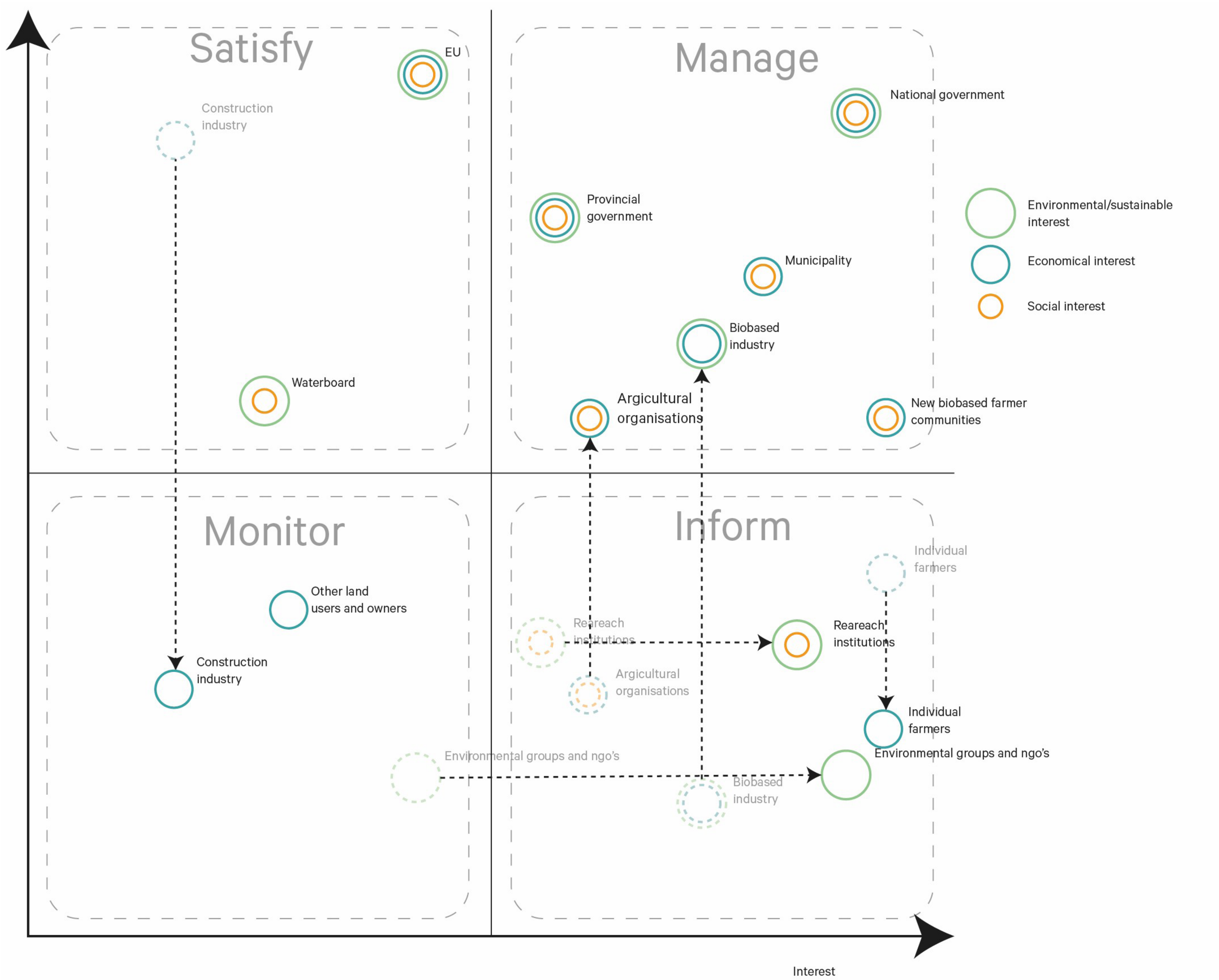


Figure ..: Future stakeholder analysis

Current and future mapping of involved actors

To know what kind of interventions are needed for making a just transition, we need to make sure what the possible shifts are and what problems would arrive from there. Based on the stakeholder analysis we conducted in the analysis chapter, a second stakeholder matrix was created to illustrate possible shifts in stakeholder positions after full implementation of the vision and strategy. This matrix examines changes in power dynamics and the level of interest among stakeholders as a result of the project. The matrix shows that some stakeholders will become more involved and/or more empowered as they experience the benefits of the project. On the other hand, stakeholders who initially had a lot of power are now losing power to the new emerging stakeholders.

Certain stakeholders will become more involved and/or exert more influence as they benefit from the project. In particular, the biobased industry and architectural organizations are emerging as stakeholders expected to gain significantly more power, reflecting their greater involvement and increased influence within the project framework. Additionally, a new stakeholder entity with moderate power and significant interest emerges, indicating a potentially impactful addition to the stakeholder landscape. Also, stakeholders who previously held significant power see a decline in their power as other (new) stakeholders become more important. In the new projection, the construction industry and individual farmers are expected to see a decline in their power, indicating their shifting roles within the project. You can also see that certain stakeholders are expected to show greater interest in the project. Research institutes, environmental organizations and non-governmental organizations (NGOs) are identified as stakeholders that are expected to show increased interest, because of their evolving interest in the project's outcomes and impact.

- **Agri Lobby**: As there are many shifts, conflicts between stakeholders are inevitable. The EU's policies have been primarily focused on agriculture throughout its existence. Agricultural subsidies accounted for over 40% of the EU's budget, around € 55,7 billion in 2021 (Homolová et al., 2022). Changing the agricultural subsidy market will be difficult because of the complexity of the current system and the diverse interests involved. Subsidies, based on the EU common agricultural policy, support both income and market formation, and include various rural development schemes. Subsidies are rooted in long traditions and interests (Schmider, 2023), such as cooperatives and larger farms, so change will be politically and practically challenging.
- **Construction Industry**: Minister De Jonge's recent decision to give-up implementing a strict CO_2 requirement for the construction industry despite concerns over the sector's significant emissions, shows how rigid the construction industry is for adopting sustainable practices. While there was initial support for the measure to limit CO_2 emissions from building materials, industry resistance and fears of overlapping regulations led to its abandonment. Advocates had pushed for promoting natural materials with lower carbon footprints, but ultimately, the government chose not to proceed with the requirement, citing concerns about disrupting current construction activities (Trouw, 2023).

One of the biggest factors for realizing the spatial components is dependent on the market of the biobased building materials. This market is an emerging market (TNO, z.d.). While for crops such as hemp and flax there are already more developed chains, this is less the case for newer crops such as cattail, reed and willow. For these crops, industrial processing is still in the experimental phase: the chain is still undeveloped. Furthermore, the cultivation of some crops for building materials is also still in an experimental phase. Because there is little large-scale production, there is uncertainty about sales opportunities and often a low price is offered for the crops (Nieuwbouw, 2024). As a result, the cultivation of crops in the Netherlands also remains absent. Thus, little knowledge is gained about best farm practices for crop cultivation because they are grown infrequently.

A sum that leads to relatively high costs and low yield prices, which currently makes it unattractive for farmers to switch to growing these crops. This can also, for example, prevent processing companies from establishing themselves in the Netherlands because they are not assured of a supply of raw materials. There is little cooperation in the chain. Farmers, processors and buyers do not know how to find each other. There are no streamlined chains or cooperatives for newer crops. Also, architects and contractors often have limited knowledge of the possibilities of bio-based building materials, so demand lags behind. This demand also falters due to limited awareness about the possibilities and benefits of biobased construction among end users, and due to the relatively high price of biobased building materials compared to regular building materials. Chain and market development is now lagging behind (Pálsdóttir, 2024).

With our nature-based interventions, we seek to dethrone the powerful corporations that currently hold the greatest influence over the current land-use practices and instead give power to nature and the bio-based economy.

Institutionalization interventions for bio-based economy

If we want to transition from an unjust towards a just CO2 reduction to take off, it will have to actively encourage several institutionalization interventions.

In order to achieve the proposed vision with its goals, we created a strategy that would help transitioning from an now unjust CO2 approach towards a just CO2 approach. Transitions represent pivotal shifts in the culture, structure, and practices of societal systems (DRIFT, 2024). The X-Curve, created by DRIFT, The Dutch Research Institute for Transitions, serves us as a visual aid designed to enhance comprehension of transition dynamics within the bio based materials as the nature based solution.

For our strategy, we zoom into the polder landscape of Alblasserwaard in South Holland. The various land-use typologies—forests (A), wetlands (B), nature reserves (1), and areas designated for production (2) or mixed uses (3)—create a rich tapestry of productive and natural landscapes. The first map provides a complete overview of this area. On this map, all elements of our strategy can be found, including the different productive areas or productive units, as well as key components within the supply chain for biobased materials, such as distribution centers and storage locations. Additionally, the biobased farmer community hub can also be seen on this map. This hub plays a central role within the community aspect of the strategy. Also the major roads serve as green corridors connecting the productive landscapes with natural areas to preserve and reinforce nature.

This strategy contributes to the emphasis on different public goods; nature conservation and biodiversity, recreation and landscape appreciation, knowledge sharing and community building, infrastructure for the biobased industry and of course the environmental benefits caused by the climate mitigating effects of CO2 capturing and reduction of CO2 emissions in the air.

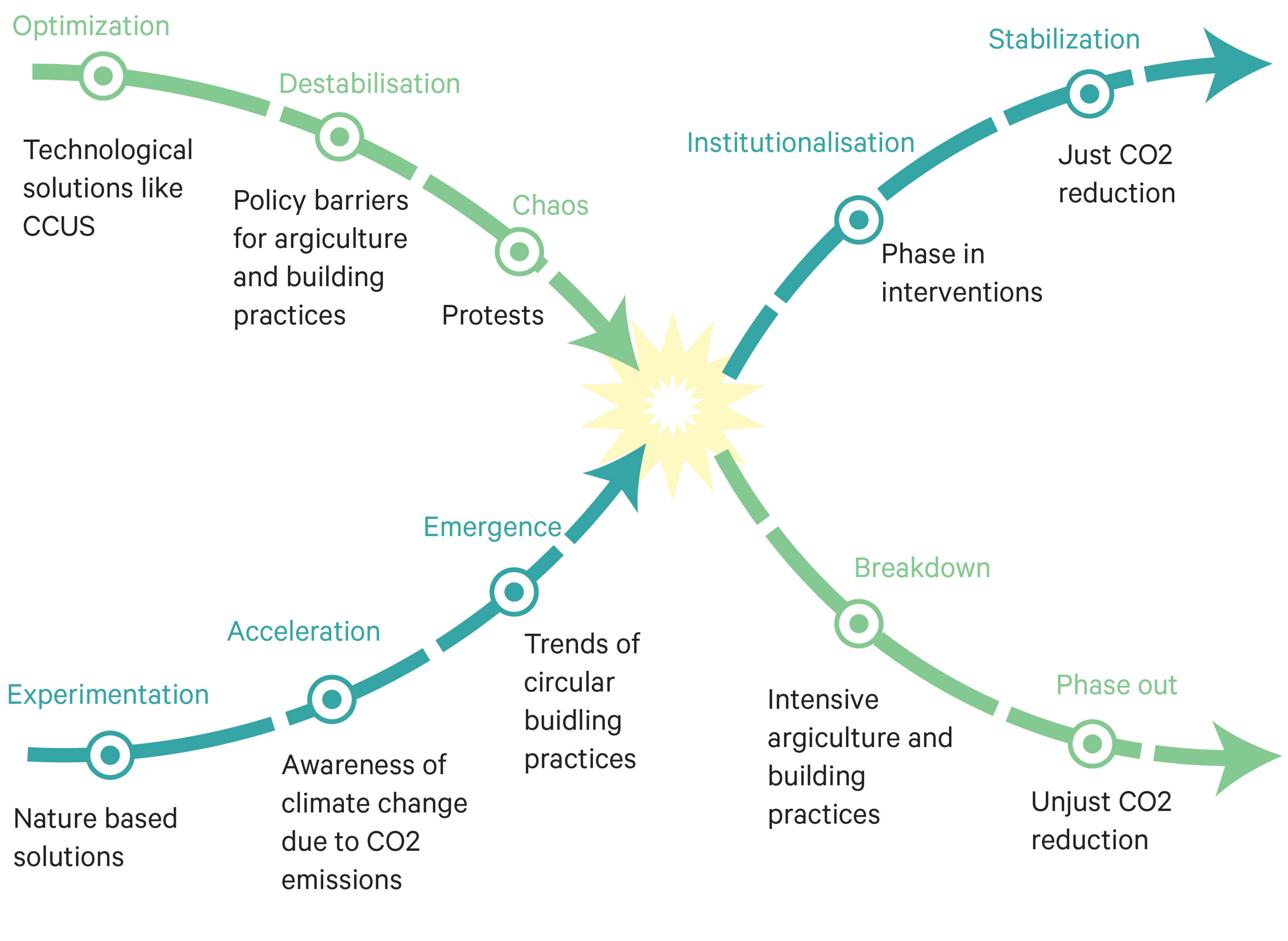


Figure ..: X-curve

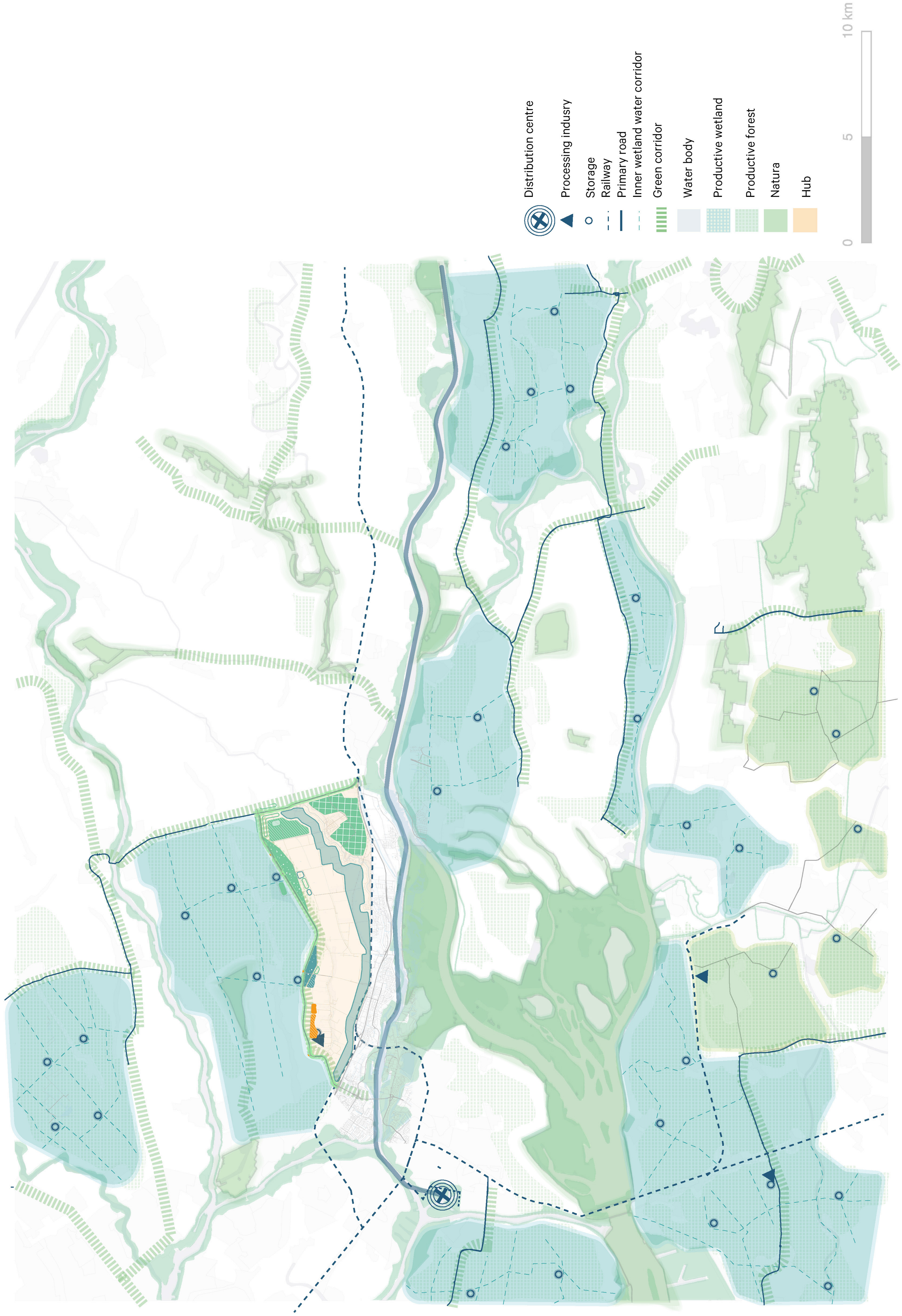


Figure ...: Piolt region interventions vision map

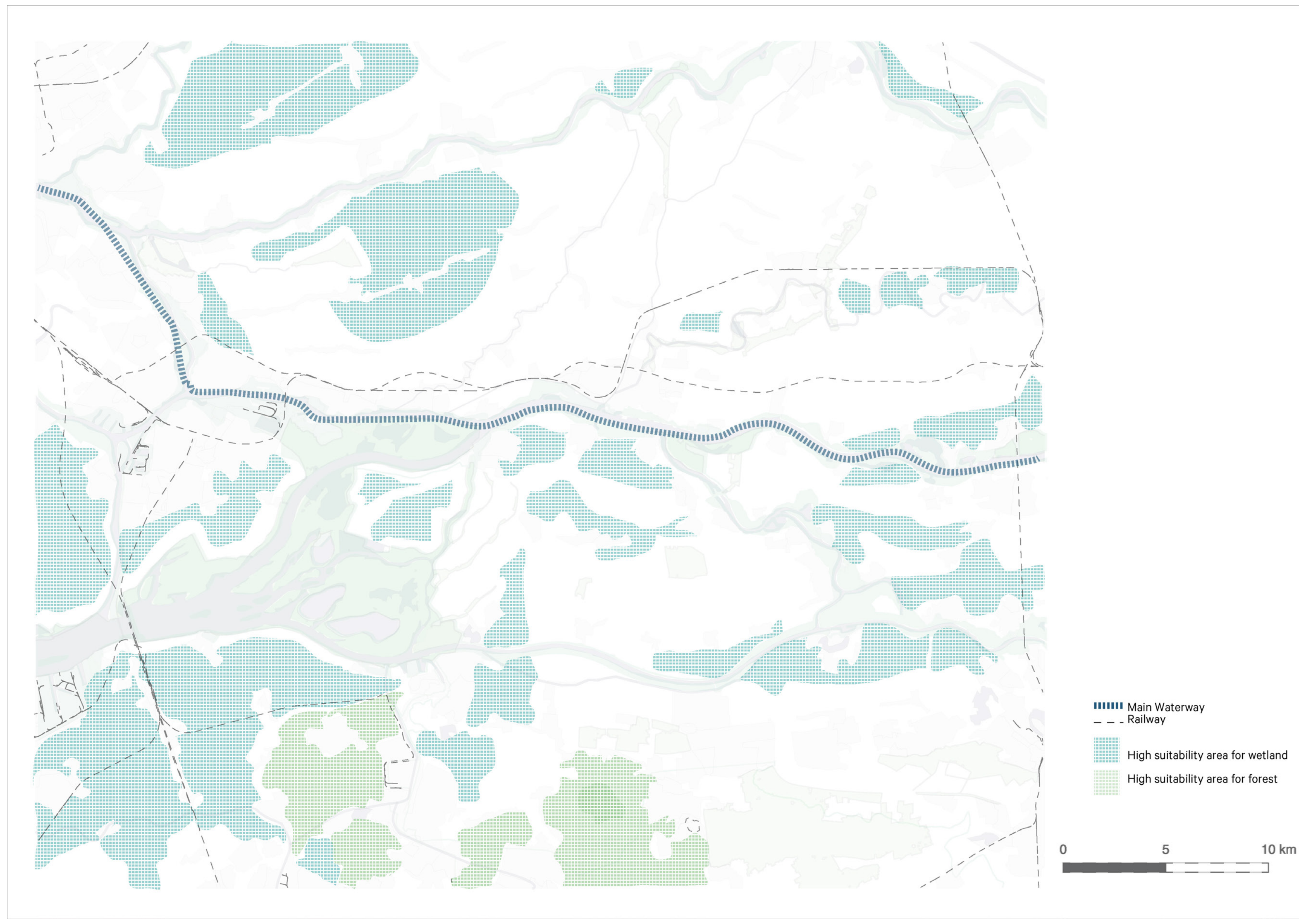


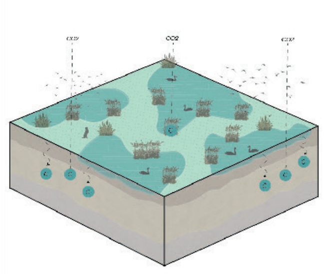
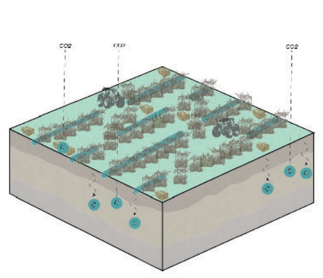
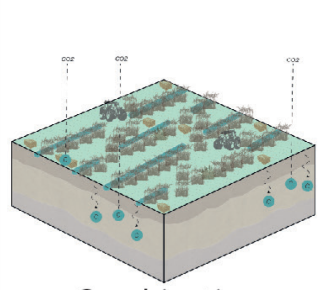
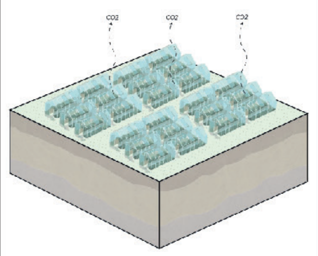
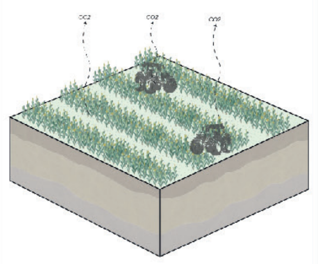
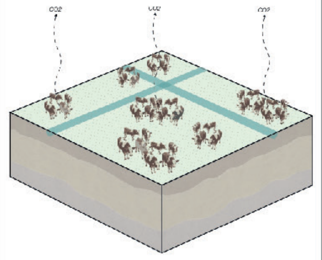
Figure ..: Suitability map within pilot region

Figure ..: Ecological context map within pilot region

1. High suitability areas and green corridors

Part of the vision is to establish new high suitability areas that can be productive, and with the existing Natura 2000 areas can store carbon. Connecting them with green corridors is also part of the vision: enhancing biodiversity and capturing CO2. On a smaller scale, these corridors play an important role in the transition to an ecosystem that delivers clean air, a healthier climate, and an aesthetic natural environment for humans.
Farms in these corridors must shift to nature-based techniques (e.g., afforestation, Silvo pastures, Crop-rotation - see point 2. Productive communities), allowing agriculture and nature to cohabit and progress toward a biobased economic system.

This first layer shows why we have chosen the location. All aspects of our vision are present. The highly suitable areas for both wetlands and forests that are also situated near urban areas. Also important waterway and railway connections and making it an interesting location for the pilot project of the strategy.
This second layer shows how the new productive landscapes are connected with each other and with natural areas through major roads that function as green corridors, enabling the natural connection between the different areas. The areas along the river have also been transformed into natural buffer zones that connect to the corridors. This natural connectivity contributes to the reinforcement and preservation of biodiversity and a resilient ecosystem in the area.

Wetlands	Nature 	Production 	Combination 
 Horticulture	Crop rotation	Wetland plants	Board walks and viewing platforms
 Crops	Submerged vegetation	Alley cropping	Intercropping
 Pastures	Floodplain grazing	Managed wetland grazing	Argicultural grazing

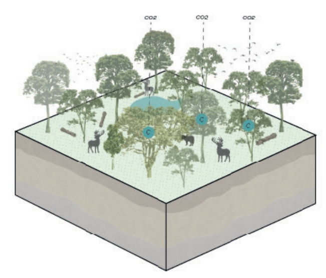
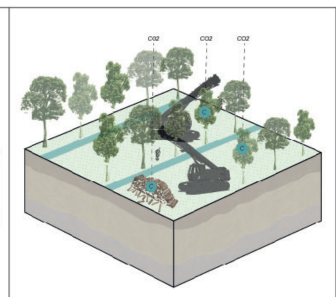
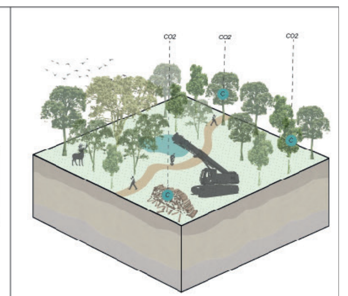
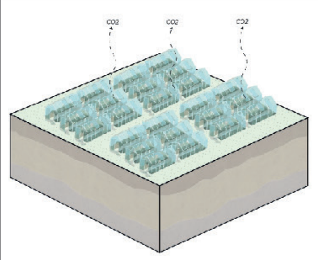
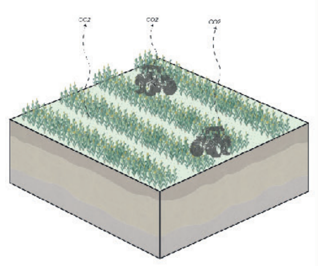
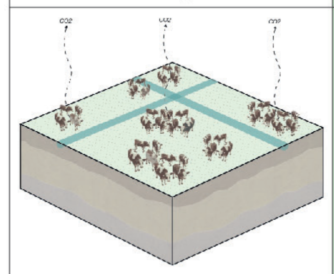
Forest	Nature 	Production 	Combination 
 Horticulture	Afforestation	Food forest	Forest parks
 Crops	Crop rotation	Alley cropping	Intercropping and relay Cropping
 Pastures	Non-timber forest product	Silvo pastures	Argicultural grazing

Figure ..: Land transition toolbox

2. Productive communities

As stated before, nature, productive and combination zones have to be created and that definition has to be made by farmers and citizens in workshops and collaboration.
The definition of this multi-functional landscape will create a shared understanding of the landscape and why the zones and the links between them are important. With the base of the CO2 storage high suitability places, the size of the buffers can be defined by farmers and citizens. This can be made possible by a "3 zones exercise" (Hester Koning, z.d.) to enhance the shared understanding of the landscape as an interconnected system by providing a clear definition of each zone and a shared vision and goals for the future landscape.

These productive communities are interconnected within the same landscape, driven by shared goals and mutual understanding. Collaboration fosters the development of a specialized toolbox, facilitating the exchange of knowledge through community workshops. These workshops encompass defining the landscape and its various zones, alongside the sharing of information and collaborative education. Moreover, they serve as platforms for collective decision-making regarding specific areas and components within the productive landscape. All while establishing time-based goals and managing expectations to ensure effective progress and outcomes.

In the figure on the left, you can see a part of the toolbox of how specific agricultural land could change through already well-established nature based techniques.

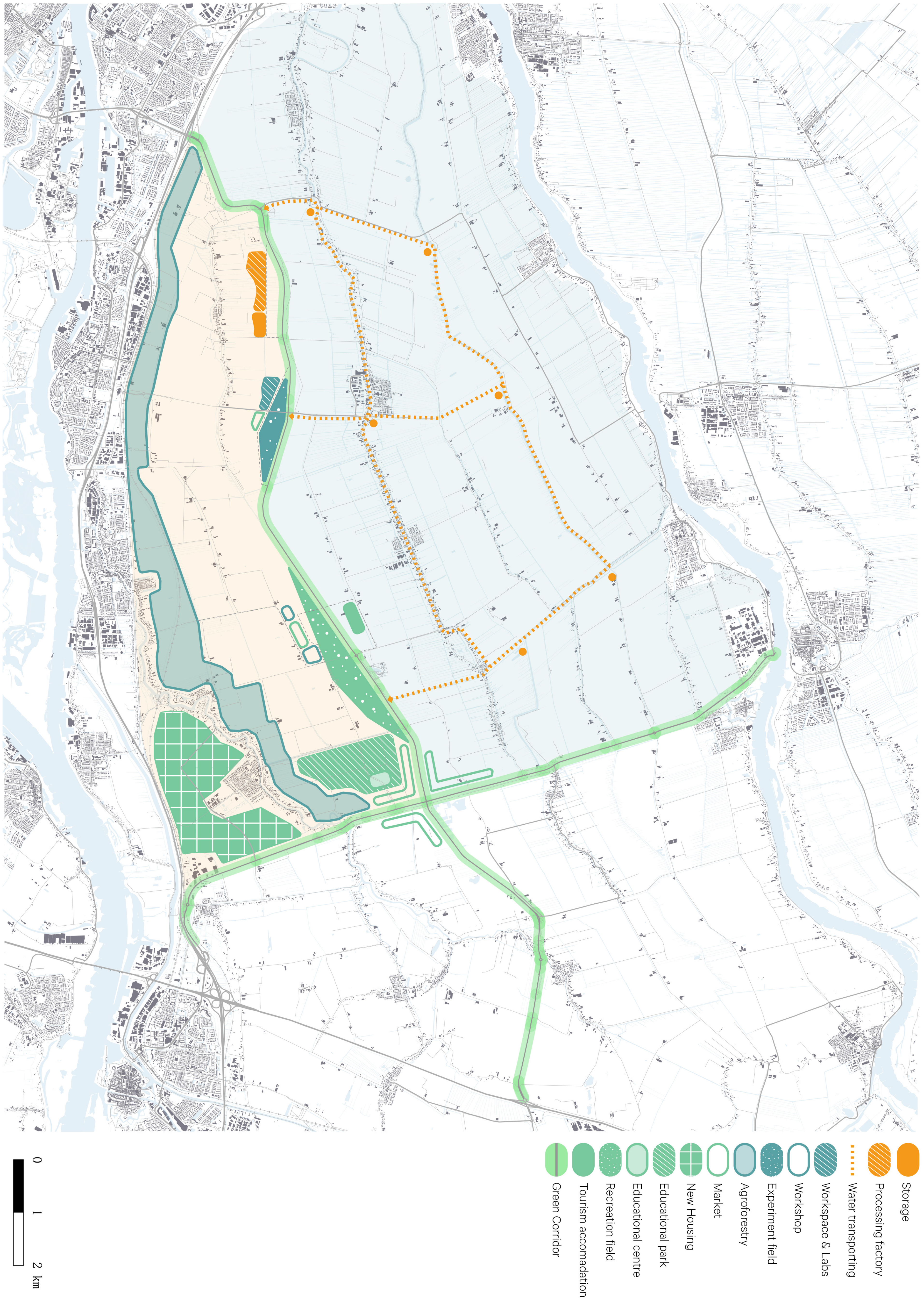


Figure ...: Hub design vision

3. Research, education and innovation

Even while the requisite information about the production, handling, and use of bio-based raw materials is already accessible, it has not yet reached the appropriate audiences to the fullest extent possible. This is partly due to the fact that the knowledge creation and distribution is still developing. This action line relates to a knowledge and learning endeavor that is being carried out by several organizations and groups.

For some crops with potential application in the biobased building industry, there is little to no large-scale, commercial production taking place. In particular, there is little experience with wet crops such as cattail and reed, or new crops such as elephant grass. Thus, there is also much that is not yet known about how to grow these crops most efficiently. For example, research is being done on how to maximize yields, but there is no unambiguous cultivation manual yet. Also in the area of costs, it is not clear where savings can be made, and how resources can be used most efficiently. For example, some crops lack machines that can efficiently harvest or plant. Investment in research into mechanization of cultivation can reduce cultivation costs and thus help make cultivation attractive to farmers.

With the help of a pilot we can research our solutions on a small-scale and to test it. It also offers an opportunity for farmers, construction workers, engineers and others to provide feedback and for adjustments to be made based on lessons learned. Ultimately helping to refine and improve the overall regional design strategy.
The last two images zoom in on the biobased materials hub. Here, you can see how the various spatial components of the strategy are spatially located within the hub and contribute to spatial quality and the community aspect of the strategy, as this hub is a place that connects all productive units in the biobased industry economically and socially.

Figure ...: Axonometric map of hub and spatial components

Figure _ Pilot region conclusion map

4. Facilitating biobased economy collaboration

Scaling up the market for biobased materials occurs by simultaneously stimulating supply and demand. If demand increases without increasing supply, scarcity occurs, prices rise, and materials must be imported. Before a farmer starts growing a crop for the biobased building industry, he wants to have a certain degree of certainty about off-take. The yield of some crops cannot be guaranteed now because there are often no markets to take it. In fact, factories are only built if there is certainty of an influx of materials, which is not the case at present. It stops farmers from moving to cultivate these crops. Making connections between farmers and processors and encouraging the creation of scale is therefore crucial.

By using renewable resources, biobased building materials provide better environmental performance than conventional materials such as rock wool or concrete. However, these benefits are not always factored into national standards that measure the environmental performance of certain materials, such as the 'MilieuPrestatie Gebouwen' (Environmental Performance of Buildings). In addition to the MPG, certification can also help map environmental performance of biobased building materials.

The fifth map provides an overview of the entire strategy once again, but now in a way that shows the landscape characteristics of the strategy and how the landscape might look after transformation.

Figure ..: Transforming photos of farmland to forests

From farm to forest

As mentioned above, although we focus on land use change in agricultural areas, there are many components involved in land transformation. In this section, we provide a 'what if' situation for land transformation into forests (this page) and wetlands (next page), including urban areas, buffer zones, nature reserves, networks and green corridors, floodplains and productive nature.

With the natural solution provided, we aim to create affordances for different uses and stakeholders, opportunities for resilient growth and a change in people's mindsets by linking natural infrastructure with economic levels and everyday life.

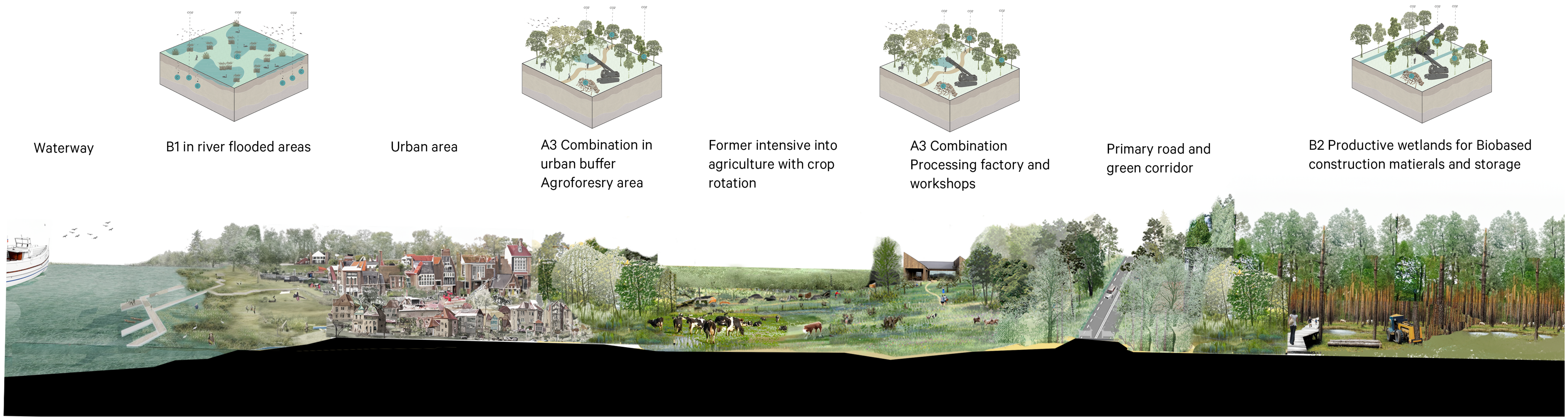


Figure ..: Section of implementing new forests typologies

Figure ..: Transforming photos of farmland to wetlands

From farm to wetland

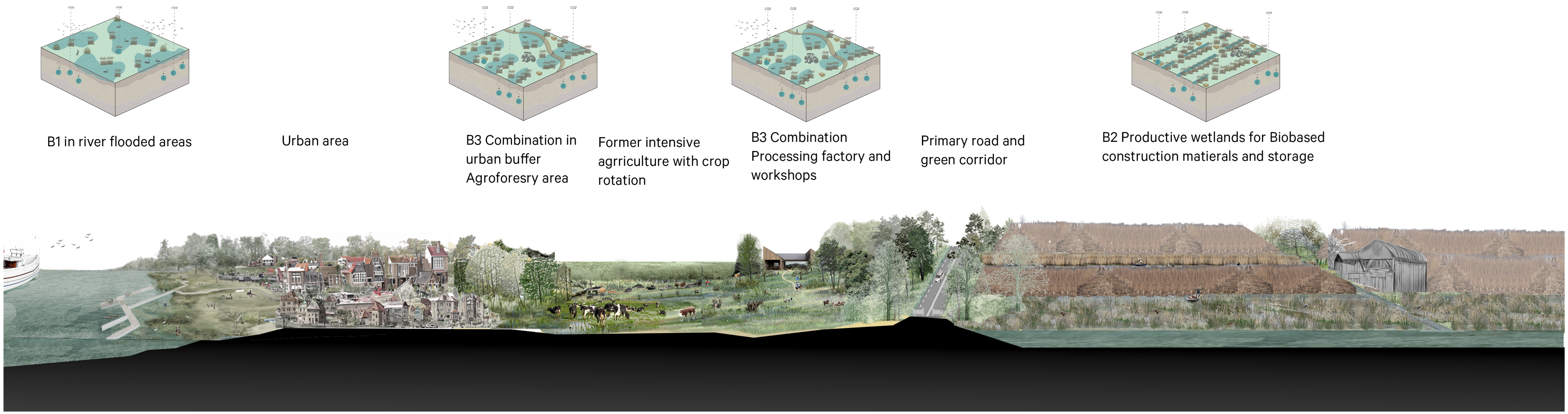


Figure ..: Section of implementing new wetlands typologies

Policies, subsidies and certification.

In order to assist create a just and sustainable transition, these policies aim to aid governments towards a top-down approach for a justifiable CO_2 reduction transition. The precise actions along which this shift must occur must be determined by EU governments. Local authorities—such as municipalities—should establish the green corridors and offer financial incentives to farmers who switch to more environmentally friendly methods.

1. Green corridors and high suitability places

High Suitability Area Designation Policy: Governments enact legislation to identify and designate specific areas as high suitability zones for conservation and carbon storage.

Green Corridor Development Policy: Governments develop policies to establish and maintain green corridors to connect high suitability areas.

Nature-Based Farming Subsidy Program: Governments offer financial support to farmers who transition to nature-based farming techniques.

2. Productive communities

Sustainable landscape Certification: Farms and communities meeting specific criteria related to biodiversity conservation, carbon sequestration, and community engagement would receive certification, providing them with recognition and potential marketing advantages.

Shared Resource Subsidy Program: Where farmers could get a subsidy for sharing resources such as harvesting machines and processing industries.

3. Research, education and innovation

Research and Development Grants: Government or industry-funded grants can be allocated to research institutions and universities to conduct further studies on the production, handling, and utilization of bio-based raw materials.

Biobased curriculum to be included in MBO/HBO/WO: The new curriculum enhances teachers' biobased materials expertise, with modular learning and local company resources, serving BOL/BBL educators and students, alongside technical universities.

4. Facilitating biobased economy collaboration

CO_2 credits certification: To accelerate the use of sustainable bio-based materials in construction, builders need assurance of product quality, sustainability and performance. Certification helps convince construction industry parties.

Market Incentives: By creating market incentives such as preferential procurement policies or subsidies for construction projects that incorporate biobased materials.

Supply chain

The supply chain starts at the productive areas of wetlands and forests, where CO_2 is captured from the atmosphere and stored as carbon in the landscape. These areas are maintained and harvested by BBBM(BioBased Building materials)-farms, which also have local storage places to temporarily store the harvest. From there, the materials are transported to a central storage location inside the hub, where the materials are collected before processing.

The hub is a central hub in the supply chain but also includes other elements outside of the supply chain itself that contribute to the community aspect of the strategy and the spatial quality. From the central warehouse, the material is transported to a nearby processing plant, which is located close to a railway line for efficient transportation. After processing the raw material, the processed material can be transported to a large distribution center in a strategic location where different transport methods come together, such as the port of Dordrecht.

In this distribution center, the processed biobased material from the wetlands and forests come together. The distribution center is centrally located between several productive areas that use this distribution center. From here, the material is widely transported via freight trains or freight ships, making international transportation economically feasible.

The material is then transported to the biobased construction companies that can produce products used in building construction. From here, the material is used by contractors for actual construction projects. Carbon remains stored in the building material throughout the life of the building. At the end of the building's lifespan, the material is recovered and, if possible, reused and/or recycled. When the material can no longer be recycled, it is burned to recover the energy in the material. The waste generated during the different steps of the supply chain are also recycled.

Although the productive landscapes capture CO_2, most steps in the supply chain also release CO_2 in the atmosphere. The strategy tries to minimize those emissions.

The use of biobased building materials and recycling of the materials minimizes CO_2 emissions during the production and construction of buildings. The decentralization of the supply chain also helps minimize CO_2 emissions caused by transport. By locating processing warehouses, facilities and distribution centers locally, transportation distances are minimized, resulting in reduced emissions caused by the transportation.

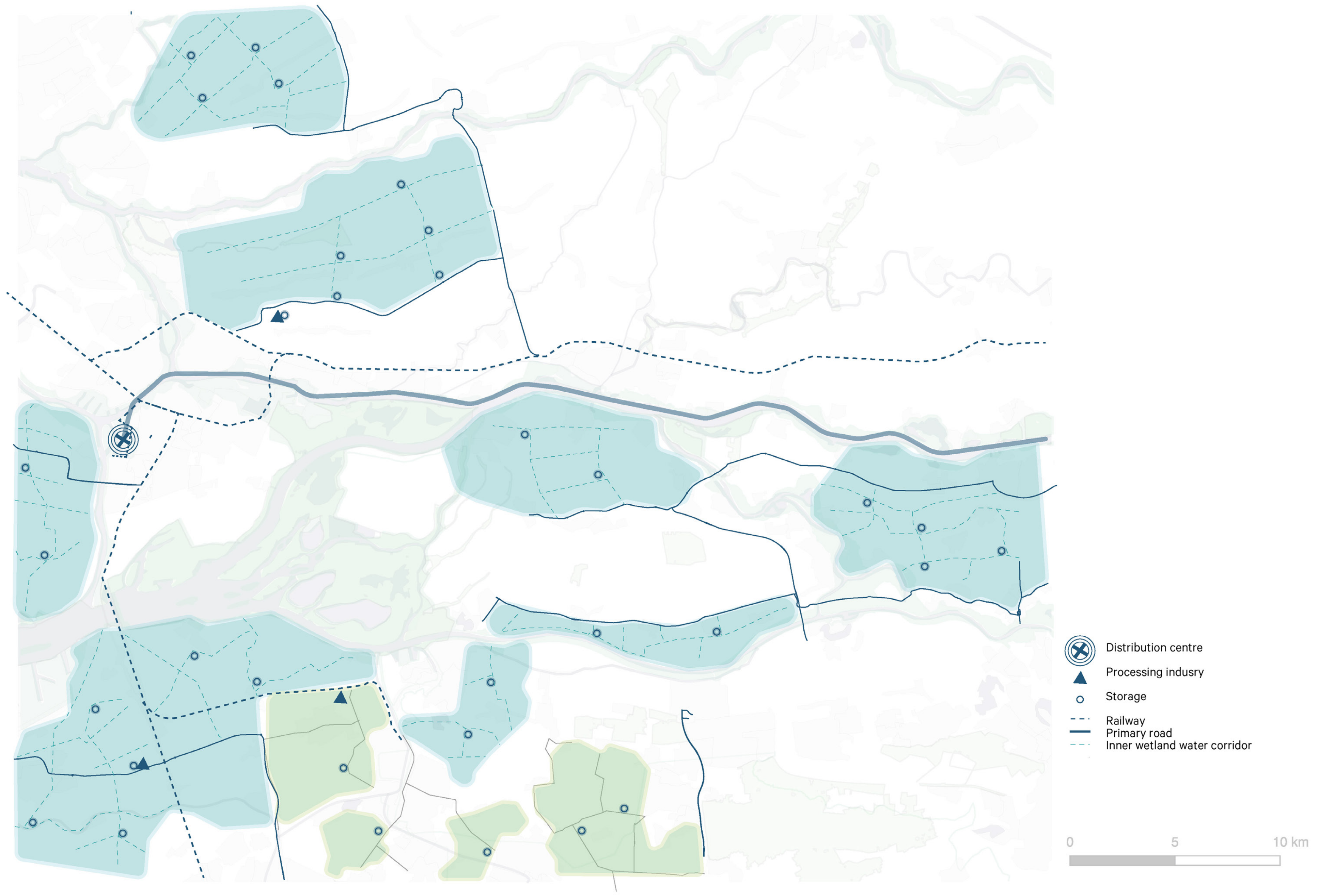


Figure ..: Major spatial components within pilot region

This layer illustrates the productive elements that are important for the supply chain within our strategy. You can see that for each productive area, there are several storage locations. The processing industries are used by multiple productive units. Therefore, close collaboration within the productive units and the biobased production industry is essential to achieve success together. Additionally, a central distribution center is located for a larger number of productive units, as shown on the map. This distribution center is located in a place where multiple different kinds of transportation come together, like in this case the port of Dordrecht.

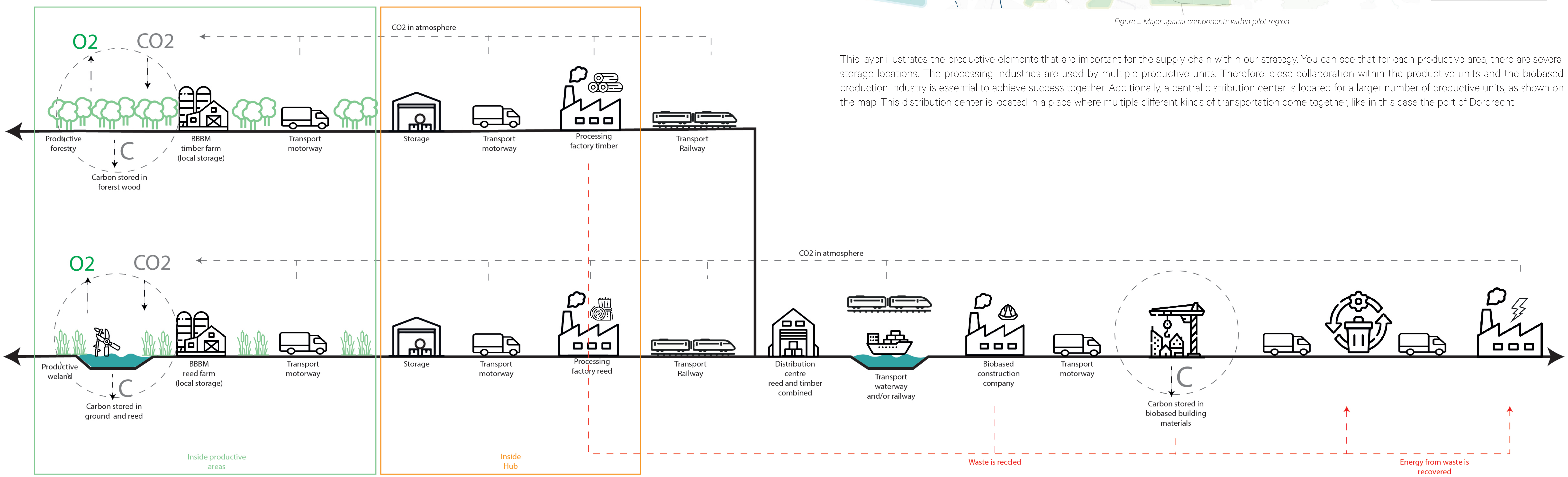
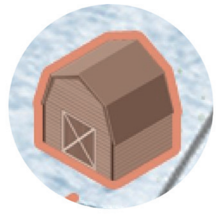


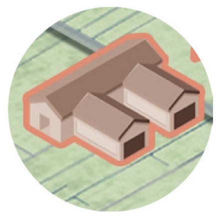
Figure ..: Systematic supply chain

Spatial components

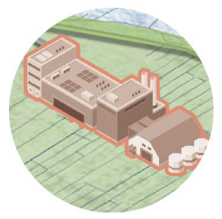
Within our strategy there are many different spatial components. The most important ones are the ones that are also essential within the biobased material supply chain. A short description of those spatial components can be seen below.



Bio Based Building Materials Farms BBBM-famrs
The Bio-Based Building Material (BBBM) farm is a traditional farm which is transformed into this new kind of farm. This farm cultivates and harvests the biobased materials. After harvest, the biobased materials are temporarily stored and prepared for further processing.



Storage
The storage facilities are strategically located within the productive landscape. Biobased material farmers can collectively store their materials here before they are transported to the processing factory in the hub. These storage facilities promote collaboration among individual farmers and contribute to the sense of community within the area.



Processing factory
The processing factory is located in the hub area and an important part of the supply chain. It's where the raw materials from the land come in and get turned into processed materials that can be sold, like CLT. This factory is an important part of the productive communities , facilitating collaboration in the biobased economy.

Distribution centre
The distribution center is located at a central place in the region where different kinds of transportation come together, such as the port of Dordrecht. All the processed materials are collected and stored. In the distribution center processed materials from forests and wetlands come together to be further transported on a larger scale (internationally) to construction companies.

Besides these essential components for the supply chain our strategy also proposes a number of spatial components which add to the overall spatial quality and the biobased community aspect of our strategy. These spatial components are strategically positioned in the combination areas in the buffers around the urban areas. These combination areas provide different kinds of opportunities. These opportunities are divided into different layers; productive, natural, tourism, education, public space, innovation and local production.

A list with all the spatial components related to these opportunities and a short description on each of these is provided in the appendix.

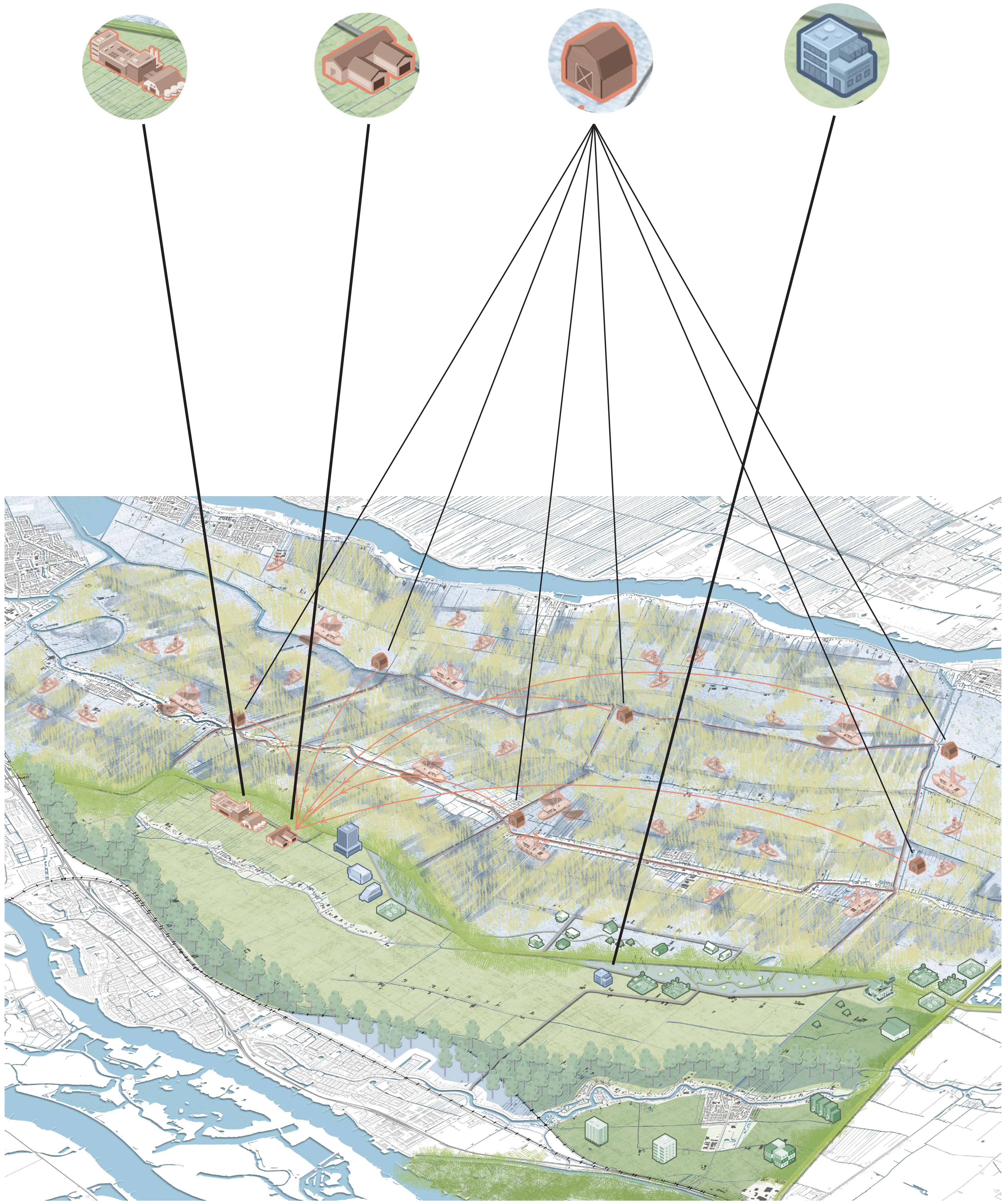
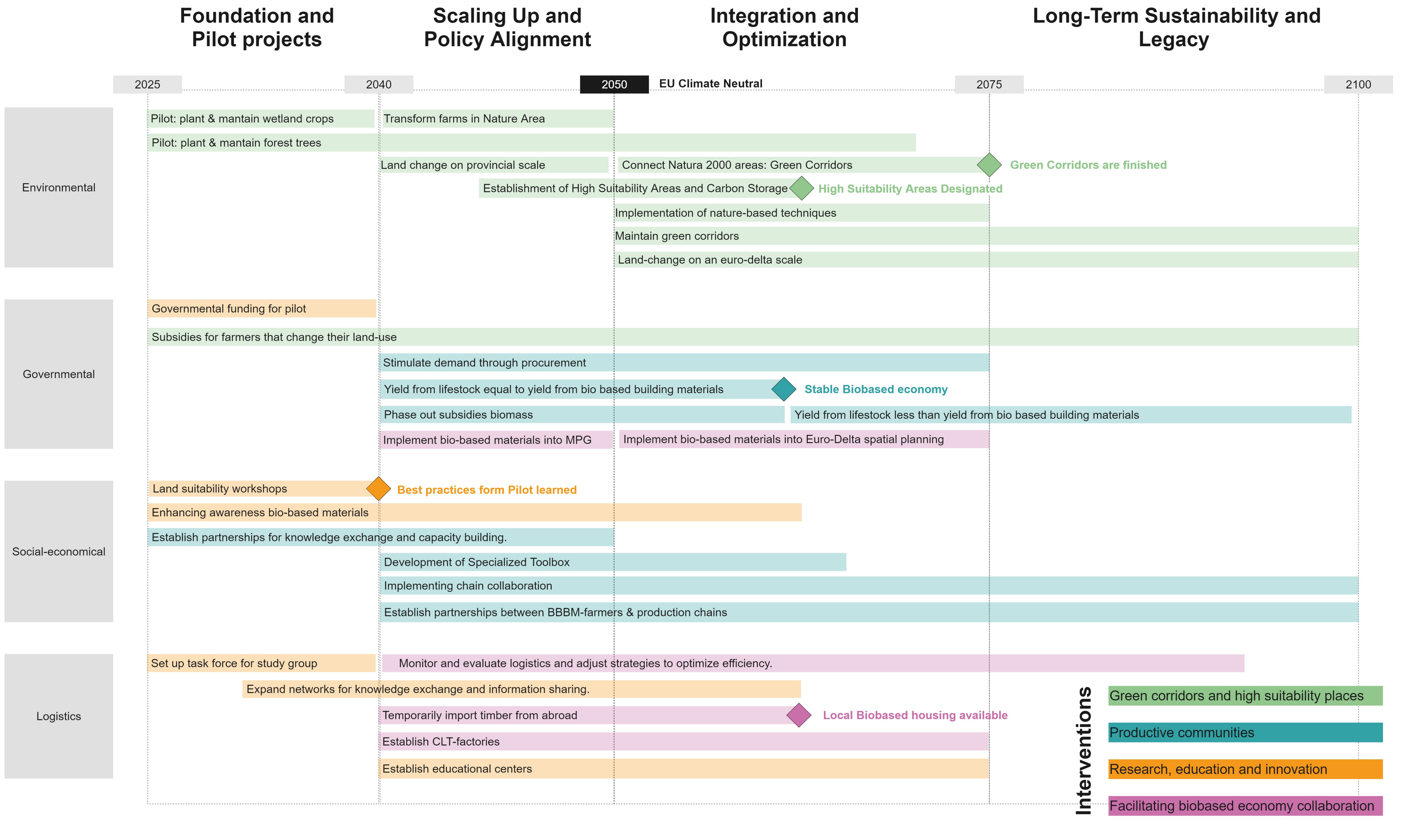


Figure ..: Spatial components within the hub

Phasing



Foundation and Pilot projects
Scaling Up and Policy Alignment
Integration and Optimization
Long-Term Sustainability and Legacy
2025
2040
2050
EU Climate Neutral
2075
2100
Environmental
Pilot: plant & mantain wetland crops
Transform farms in Nature Area
Pilot: plant & mantain forest trees
Land change on provincial scale
Connect Natura 2000 areas: Green Corridors
Green Corridors are finished
Establishment of High Suitability Areas and Carbon Storage
High Suitability Areas Designated
Implementation of nature-based techniques
Maintain green corridors
Land-change on an euro-delta scale
Governmental
Governmental funding for pilot
Subsidies for farmers that change their land-use
Stimulate demand through procurement
Yield from lifestock equal to yield from bio based building materials
Stable Biobased economy
Phase out subsidies biomass
Yield from lifestock less than yield from bio based building materials
Implement bio-based materials into MPG
Implement bio-based materials into Euro-Delta spatial planning
Social-economical
Land suitability workshops
Best practices form Pilot learned
Enhancing awareness bio-based materials
Establish partnerships for knowledge exchange and capacity building.
Development of Specialized Toolbox
Implementing chain collaboration
Establish partnerships between BBBM-farmers & production chains
Logistics
Set up task force for study group
Monitor and evaluate logistics and adjust strategies to optimize efficiency.
Expand networks for knowledge exchange and information sharing.
Temporarily import timber from abroad
Local Biobased housing available
Establish CLT-factories
Establish educational centers
Interventions
Green corridors and high suitability places
Productive communities
Research, education and innovation
Facilitating biobased economy collaboration

With the interventions and spatial components now clearly outlined, the next consideration is their implementation over the years leading up to 2100. Dividing the timeframes into four sections provides clarity regarding the scale and elements of the project. Additionally, this approach allows us to examine the environmental, governmental, and socio-economic aspects within the 3P framework, revealing their impact. The logistics section details the specific elements to be implemented to create the circular economy.

2025-2040: Foundation and Pilot Project

During the foundational phase spanning from 2025 to 2040, our ambitious vision for transforming land use unfolds through strategic planning and collaboration. We begin by establishing a task force or committee dedicated to overseeing implementation and cultivating partnerships with stakeholders to foster collaboration. Comprehensive research and development efforts identify suitable bio-based materials while initiating collaborative projects to develop innovative solutions.

The pilot project is launched to test approaches and gather data for scaling, alongside the establishment of regulatory frameworks and standards incentivizing bio-based materials. Simultaneously, pilot procurement policies (now as a form from government funding) prioritize bio-based materials, complemented by educational campaigns targeting the biobased building material-industry professionals. Networking opportunities abound as we organize industry events and conferences for knowledge sharing, also supported by government funding allocated to collaborative initiatives.

2050-2070: Integration and Optimization

From 2050 to 2070, the focus shifts to integrating sustainable land use practices and bio-based materials into mainstream construction and agricultural industries. Intensive construction and agricultural practices are broken down and a fair and just bio-based economy are institutionalized. This involves continuously monitoring and evaluating the environmental, social, and economic impacts of these initiatives, while fostering international cooperation to address global challenges related to climate change and sustainable development.

Efforts are made to support research and innovation to optimize e.g. harvesting methods for maximum efficiency. Regulatory incentives, tax credits, and subsidies are expanded and formalized to promote the use of bio-based materials in construction. Public procurement policies are implemented at national and regional levels to mandate the use of bio-based materials in public infrastructure projects. Industry collaborations are established to develop standardized testing methods and certification programs for bio-based construction materials. Furthermore, funding is allocated for research and innovation in bio-based materials technology, with a focus on scalability and commercialization.

2040-2050: Scaling Up and Policy Alignment

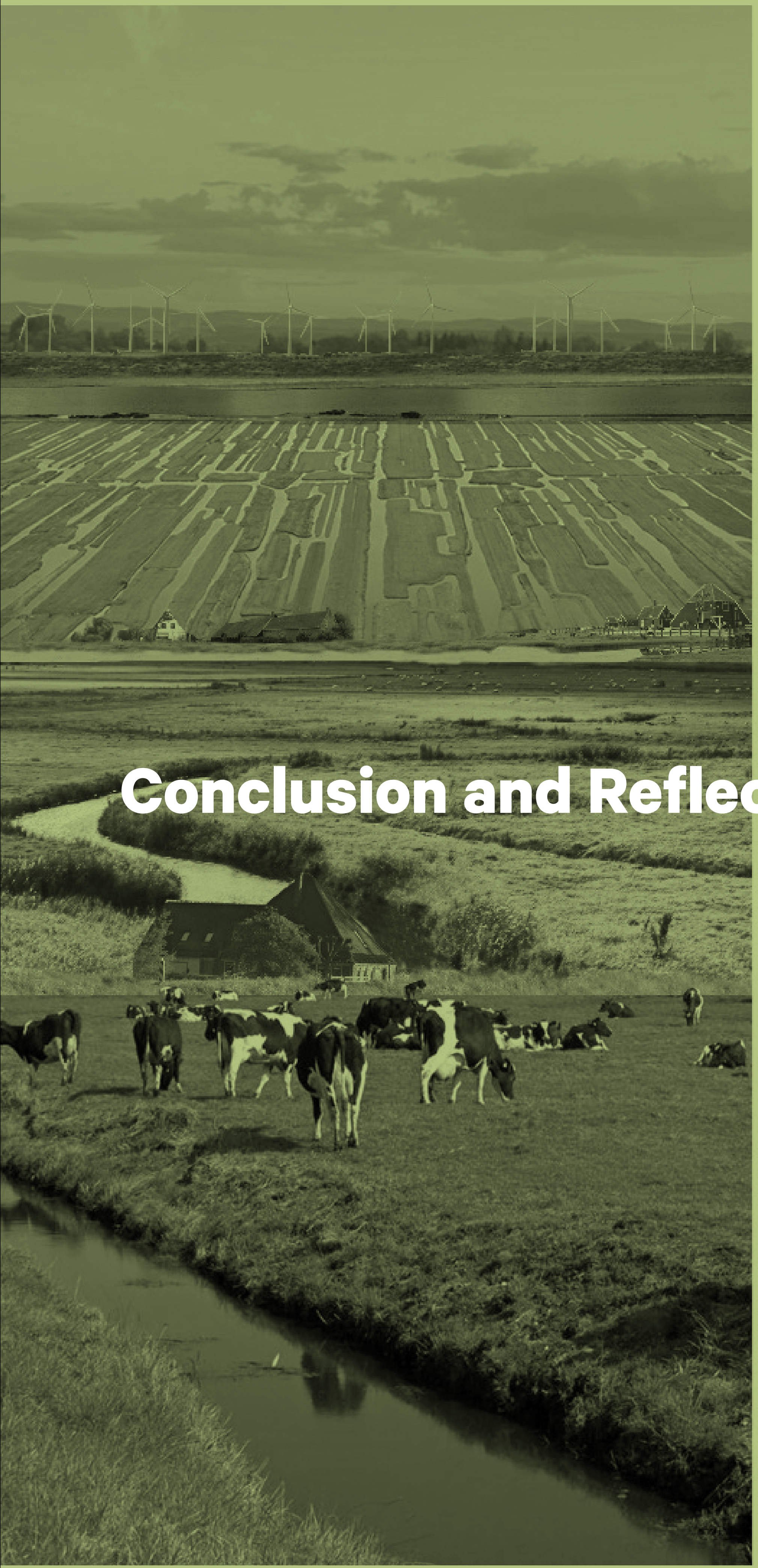
When the pilot project is successful, implementing policy reforms at provincial, national, and EU levels is the next step to incentivize sustainable land use, promote bio-based materials, and regulate carbon emissions. With the EU wanting to be climate neutral in 2050, having the insights from the pilot is helpful for establishing the new policies. Regulatory frameworks are established to encourage the use of bio-based materials in construction, and pilot procurement policies prioritize these materials in government-funded projects.
The placement of the green corridors between the Natura 2000 areas are established and farmers in those areas are bought out.

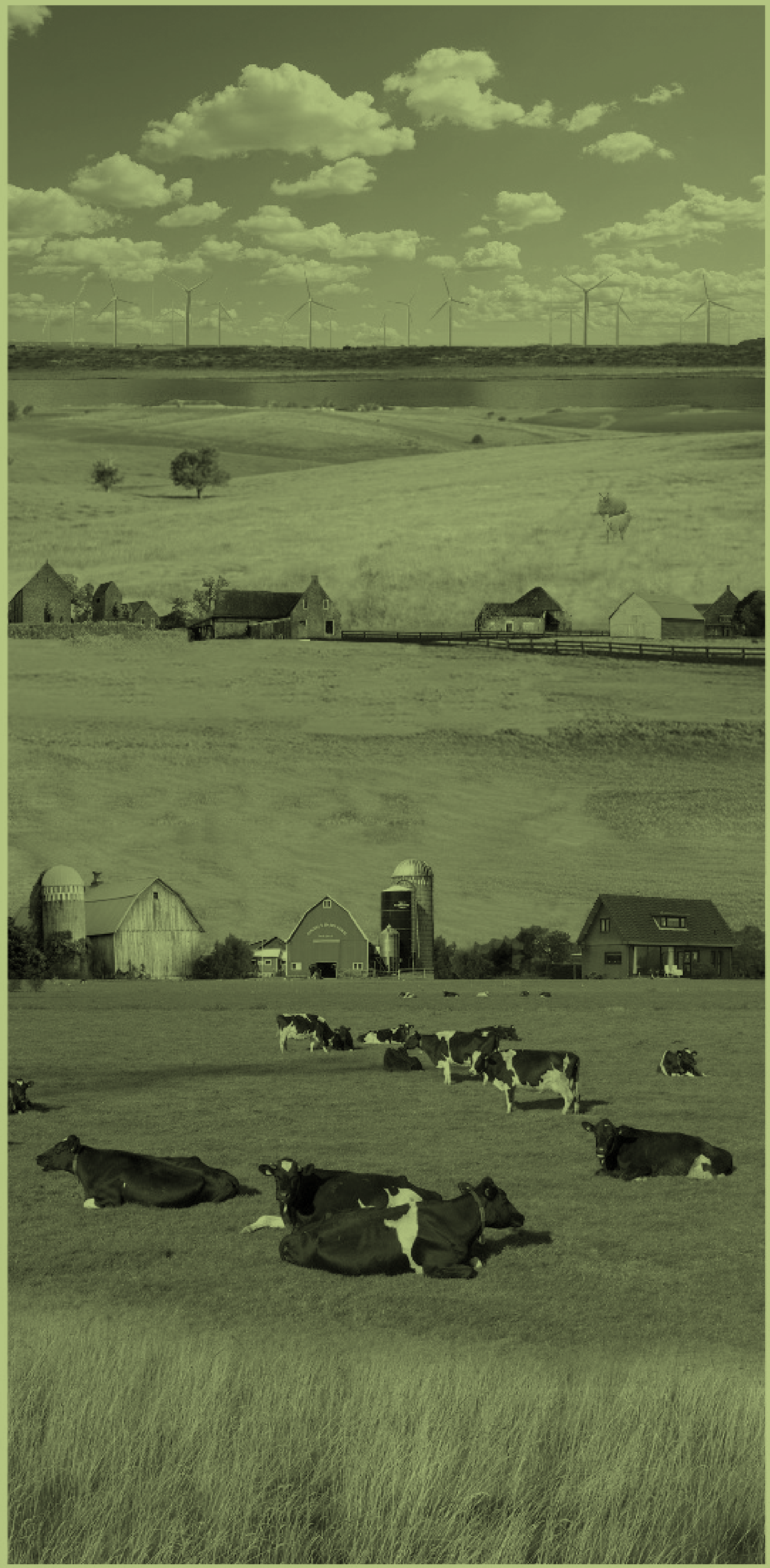
Additionally, efforts are made to increase awareness and support through educational campaigns targeting communities that are involved. Collaborative research projects between industry and research institutions aim to develop new bio-based materials suitable for construction applications, while targeted educational campaigns inform professionals about the benefits of bio-based materials.

2070-2100: Long-Term Sustainability and Legacy

During the period of 2070 to 2100, the emphasis lies on achieving widespread adoption of green corridors and sustainable land use practices and bio-based materials across all sectors of the economy. Integration of bio-based materials into mainstream construction practices is facilitated through revisions to national building codes and industry standards, while investment in workforce development programs enhances skills and capacity within the construction industry. International collaboration and knowledge sharing are fostered to accelerate the global adoption of bio-based construction materials and practices. As the 21st century nears its close, our legacy echoes through landscapes shaped by ingenuity and dedication—a testament to our commitment to people, the planet, and a sustainable tomorrow.

Conclusion and Reflections





Conclusion

Given the urgent need to mitigate climate change by reducing CO2 emissions and its negative impacts on the environment, human health and global stability, it is important to consider effective strategies that balance social, economic and environmental concerns.

While current approaches are mostly technological, our project initially aimed to propose nature-based solutions to reduce CO2 levels . However, the scope of the project has evolved into a grand vision. This vision is about more than reducing CO2 emissions; it is about a just transition. Central to this vision is the creation of green corridors designed to capture CO2 and the establishment of a bio-based economy. This economy would not only mitigate current polluting practices, but transform them into a system where CO2 is used as a resource for sustainable building materials. In addition, this transformation would transform former agricultural land into hubs of ecological restoration and innovation.

Through our research and examination of existing policies, it has become clear that the use of forests and wetlands are beneficial nature-based storage methods for the Netherlands. These methods would accelerate the transition to a low-carbon economy. It also identifies spatial conflicts and challenges associated with integrating forests and wetlands into regional landscapes, including limited available space and conflicts with agricultural land use. Despite the challenges, it highlights the economic opportunities of investing in the bio-based economy from carbon sinks to production-oriented approaches, particularly in the construction sector using bio-based materials.

By presenting a vision for transforming use of land by emphasizing nature based solutions as central to carbon mitigation efforts, the integration of bio-based materials and community-centric design principles offered a pathway to economic development and environmental resilience. Land-use typologies are based on preservation, production, and buffer zones. Nature-focused wetlands and forests will be created around existing Natura 2000 areas, while productive wetlands and forests will be established in other suitable areas.

After understanding that a resilient future will only be possible with the integration and cooperation of top down and bottom up decisions and with complexities arising from existing plans, multi-stakeholders involvement, programmatic variations, and contextual considerations, a strategy is required to address implementation challenges, to ensure community engagement, and facilitate phased implementation. This is done by setting up interventions that would help institutionalize a fair and just CO2 transition.
By creating green corridors and high suitability areas for land-use change, proposing productive communities, room for research, education and innovation as well as facilitating the collaboration within bio based economies, multiple future policies could be created. And, hand in hand with these policies, the spatial elements, where some of those would take part in the biobased supply chain, will be guided through four phases. With each phase stressing the environmental, social and economical relevance, resulting in a future with a just CO2 reduction, could be possible.

Figure ...: Displaying transforming photos

Group Reflection

Our whole project is about finding opportunities and linking problems to create new solutions. Co2 emissions as a starting point, but linking it with the injustice that farmers face because of the nitrogen crisis and spatial issues by changing land use in agricultural land, and also linking it with the transition into a biobased construction economy we could understand the complexity of the different layers that are present in the region. But because of the short duration of this project and the scale of this project, we could not cover everything and thus there is always room for improvement for subsequent research.

Scientific Relevance:
Our project initially focused on nature-based solutions to reduce CO2 levels, acknowledging the effectiveness of such approaches in carbon mitigation efforts. Through our research, we have identified forests and wetlands as beneficial nature-based storage methods, particularly suitable for the Netherlands. But within these ecosystems there are also distinctions between them that we have not covered, like mangrove forests or saltmarshes. By using nature based solutions, we align with scientific consensus on the importance of preserving and enhancing natural carbon sinks. Moreover, our emphasis on bio-based materials in the construction sector reflects a scientific understanding of the potential for innovative solutions to reduce carbon emissions. The precise reduction in CO2 emissions resulting from our proposed changes, which encompass not only the transition away from current polluting agricultural practices but also the integration of biobased materials in the building industry, has yet to be quantified. This exclusion stems from constraints in both time and experience.
The borders and buffers within the spatial relevance

Societal Relevance:
Central to our vision is the concept of a just transition, which emphasizes the importance of societal equity in climate action. By proposing the creation of green corridors and the establishment of a bio-based economy, we aim to not only mitigate current polluting practices but also transform them into sustainable alternatives, prioritizing societal well-being. By emphasizing nature-based solutions and the establishment of a bio-based economy, we are committed to generating tangible benefits that extend beyond individual interests to serve the broader community and society as a whole. These public goods include enhanced ecosystem services such as carbon sequestration, biodiversity conservation, and climate regulation, which are essential for the well-being of current and future generations.

Ethical Relevance:
Our project is guided by ethical considerations that prioritize environmental practices and social justice. By advocating for the transformation of land use through nature-based solutions, we seek to uphold ethical principles of sustainability and ecological integrity. Additionally, our emphasis on institutionalizing a fair and just CO2 transition reflects our commitment to ethical governance and accountability. Applying these solutions wouldn't be without consequences. Altering farm-land use would inevitably lead to a decrease in the amount of food harvested from those lands. How to deal with the less yield is another recommendation for future research.

In general, we fostered a highly positive group dynamic throughout our collaboration. Early in the quarter, we engaged in discussions to assess our individual strengths, weaknesses, and goals for this course. This process allowed us to develop a deep understanding of each other's professional backgrounds and aspirations. We successfully divided tasks based on each member's specific strengths, leading to a harmonious workflow. However, we encountered setbacks due to unforeseen illnesses among team members, which disrupted our progress for a longer period than we would have hoped for. Despite these challenges, we adapted our approach and supported affected members to ensure continuity in our work. The dynamics of our research and input fluctuated regularly, with varying levels of contribution from each member on a weekly or even daily basis.

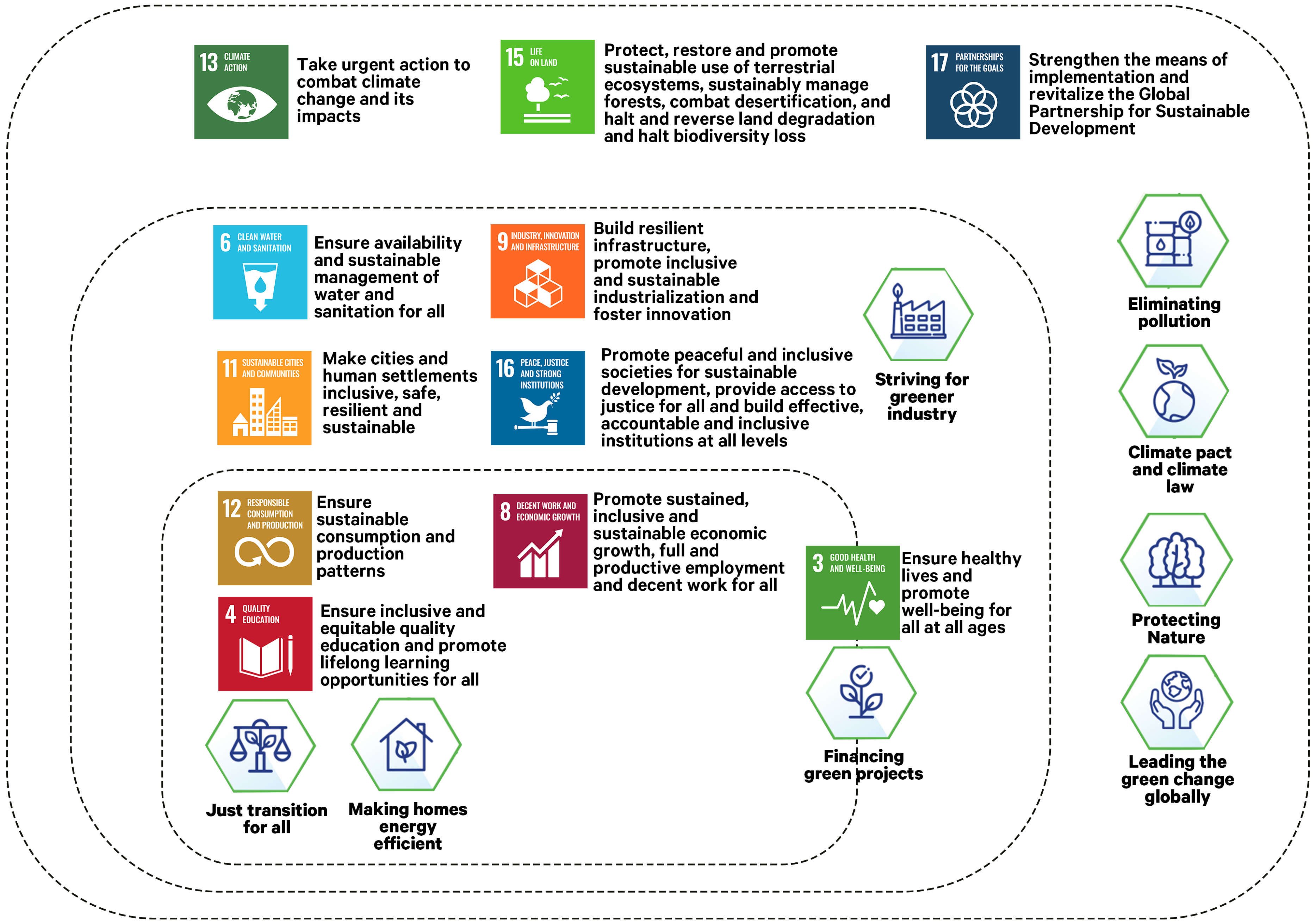


Figure .: Our goals for this project

Personal Reflections

Julika Van der Burg

Before starting this course, I could never have anticipated the depth and breadth of regional design. As a student from the MSc MADE track rather than Urbanism, I initially questioned my fit within both the project and an Architectural™ team. My limited understanding of urbanism and spatial design left me feeling insecure at the start.

These uncertainties manifested as challenges within our group dynamics. The initial hurdle of familiarizing ourselves with each other's workflows and communication styles was compounded by my own apprehensions. Wrestling with the combination of working on a large scale while shaping a visionary concept was entirely novel to me. Yet, despite the absence of clear leadership, our shared commitment to a nature-based approach galvanized our efforts.

However, when unforeseen setbacks, such as illness, overcoming several team members and where one had to almost drop out, our resolve was tested. Through concerted communication and prioritization, we united to complete the project cohesively by focussing on personal skills and how to implement them. My personal role in this project was to shape the project by providing the necessary drive to ensure that the team keeps moving and does not lose focus or momentum. While at the same time implementing elements of the report that where still concepts. Overall, I was out of my comfort zone, but learned a lot by doing so.

The enlightening Capita selecta lectures underscored the transformative potential of landscape-based regional design, encouraging me to think expansively and traverse disciplinary boundaries. Similarly, the thematic exercises from the SDS workshops introduced me to novel spatial elements, underscoring the value of multifaceted research approaches what I would not have learned elsewhere.

Equally impactful were the methodology classes, which broadened my perspective beyond design and physical sciences to encompass social sciences. Emphasizing the imperative of fostering just and equitable change, these classes underscored the importance of a robust conceptual framework as a guiding line amidst complexity. By embracing interdisciplinary approaches and thinking beyond conventional boundaries (within a certain fixed place), we empower ourselves to address the multifaceted challenges facing beyond our cities and regions. Moreover, our commitment to social justice and equity is found throughout our work. By centring concerns from farmers and prioritizing inclusive practices that are also good for the environment, we strived to create spaces that could be viewed as a common good.

Armed with newfound insights and confidence, I expect applying these learnings to future endeavours, steadfast in my newfound commitment to creating sustainable, inclusive, and resilient urban environments in my future career.

Angela Ferrero

Before starting the quarter, my biggest uncertainty was what it would be like to learn to understand and work with a regional scale, something I had not done before. Especially in a context of extreme uncertainty and climate change. In the beginning, when the topics were divided between Co2, Nitrogen, Circular Economy, decentralisation, it was hard to understand how such broad topics could be brought together into a strategy and how they could be used in a regional context.

In perspective, although the process was, as my processes generally are, chaotic and disorganised, the permanent use of multi-scalarity allowed me to understand and link different layers. Each of the scales allowed me to understand possibilities and limitations and relating them to the different spatial dimensions helped me to understand how to work with the territory and its complexities. And although in the beginning it was difficult to understand the scope of the research and the importance of each scale, and although it was difficult to stop thinking of the Netherlands as the largest scale to work with, understanding the Eurodelta region as a whole and looking for solutions without borders and at the same time understanding the limitations and possibilities that different governmental levels generate on global problems and solutions was a big shift in my approach to projects.
I come from a school where urban planning is taught and proposed in a top down manner, offering solutions from the professional and academic perspective. This always seemed to me to be a misguided way of designing, but I didn't understand how it could be done any differently. In a context of uncertainty where thinking about a resilient and sustainable future is essential, in the first quarters I was able to embrace design with nature and the possibility of thinking about a resilient territory but through the strategy in this quarter I was able to understand how from participation and grassroots and a link with government policies and decisions a resilient future can be planned also socio-economically and how good practices can link both.
Understanding the importance and scope of the vision and then the strategy as a way to carry it out with the different stakeholders, the phases and everything framed in a methodological research was an excellent combination and the different workshops and lectures were essential to understand and put everything together from different aspects.

Understanding the spatial dimensions of the systems that are linked in each subject was at first difficult to understand but very interesting and motivating for me.

We usually talk about carbon dioxide, nitrogen crisis, farmers strikes, but understanding it in a spatial and territorial way both with our project and with our fellow students was an eye opener for me and gave me a new way to see and understand complexities not only in academia but also in the news and everyday life situations. Although the outcome is far from the one I wanted, the learning process done in this quarter opened many new learning doors for me and made me want to start new research and projects with many more new tools and insights.

Jesse Hoogeveen

Throughout this project, I underwent a series of personal, social and urban design related developments. In the first phase of the project, where we focused on analytical work and spatial analyses using QGIS, I noticed that I wasn't as good with using QGIS as some of my teammates. This was a personal challenge for me as I couldn't always contribute as much as I wanted to in this aspect of the project. However, by closely collaborating with my teammates and seeing their expertise, I learned a great deal about doing such analyses in QGIS and their significance for regional design. Even though I was not able to fully contribute to the spatial analysis in QGIS, I still contributed by helping identify the necessary analyses and required data, as well as doing tasks like literature reviews and stakeholder analyses.

In the next phase of the project which was focussed on developing our vision, I felt more comfortable. Here, I could better utilize my design and creative skills to help create a relevant vision. Employing a systematic approach during the vision-shaping process enabled us to create a well-founded, data-driven vision. We also gained an important insight during this process: what we initially considered as creating a vision was actually the first starting point for our strategy. This sometimes caused confusion within the team, but after consulting with our coaches, we understood that we were already on the right track and needed to focus on concretizing our vision and continue on the strategy. We concluded that the creative process wasn't a linear process but rather an iterative process where you go back and forth in feedback loops to come to a good solution.

Unfortunately, we also faced setbacks when a team member, Emma, got injured and couldn't physically attend team meetings and discussions. This was a challenge because at first we didn't know how to deal with this situation, but we managed to involve her in the process by assigning remote tasks. It was important for us as a team to be flexible and find a solution that worked for everyone. Ultimately, we successfully completed the project by effectively dividing tasks and utilizing each team member's unique skills. Personally, I spent a lot of time creating diagrams, visuals, and writing text, which are my strengths due to my background in Industrial Design Engineering.

All in all, I learned a lot from this project, both technically and in terms of regional urban planning, as well as on a personal and social level. It helped me further develop my analytical and design skills and taught me to be flexible and communicate effectively in a team, even in challenging situations.

Haoyang Tang

Carbon dioxide emissions and storage have been an important urban topic for a long time, but we don't really know the exact solutions. So we started by analyzing spatial data, making GIS maps and reading a lot of materials. Throughout most of the project we were working on technical analyses and sorting out the project logic. From our initial understanding of CCUS as a carbon storage technology, we identified ways to utilise forests and wetlands for natural storage, and incorporated natural materials in the construction of the building to enrich the circularity and creative complexity of the project. We combine the design vision with how much carbon can be stored in specific nature or natural materials in a very rational and complex way that I've never used before. But that's part of the point of this project.

Regional research and design has never been my particular speciality. Obviously we all do, so we also started our design in a very technical direction and have been looking for a systematic approach. This approach came to light along with the biggest problem we encountered upfront, which was how we were defining different land uses and transformations over such a large region. I used the spatial data to generate maps of the different land uses, soil classes, and soil zones appropriate for forests and wetlands, respectively, and Jesse serendipitously suggested that we could define each of them in the form of "Yes" and "No" questions. This was a very useful idea, and a flow chart was created to define the different levels of hierarchy as well as the importance of the different elements.

This systematic flow chart allowed us to quickly define the different areas. Faced with a truly spatial design, and with the fact that our group was affected by external factors that caused a stagnation in progress, the design got stuck once again. Obviously, we were all confused, and along with the confusion came a great deal of stress. However, after many conversations with the tutor and a re-division of tasks within the group, Angela and I, who have a background in urban design, were mainly responsible for the spatial design and expression, while Jesse and Julika, who have a background in industrial design, focused more on the text and the organisation of the report, and Emma was responsible for the typography and data collection, so that the division of tasks made our goals clearer, and we were able to overcome the difficulties once again. In the last half of the month we were once again very productive and efficient and refined our phasing and stakeholder analysis for social content.

I would say it has been a difficult and struggling, challenging, exciting and academically intense learning journey. But together with my four wonderful teammates, we overcame a lot of problems, showed our own strengths and completed our project well!

Emma Wempe

When I started this project, my goals were primarily focused on the group process rather than the product itself. Often being the person in a group with the overview, I am accustomed to taking the lead. However, as this often causes me a lot of stress, I wanted to approach it differently this time. Unfortunately, initially, I didn't succeed well in this; I also experienced a lot of stress due to the lack of overview. But when I got a concussion, I was forced to take a step back and let go of control. I struggled with this because I felt guilty towards my groupmates for not being able to contribute as much in the final weeks of the project due to decreased health. However, my groupmates have been incredibly understanding and have thoughtfully considered ways for me to still participate in the project. We've had a challenging process as a group, but communication has always been excellent, which enabled us to deliver a final product.

Designing at the regional scale wasn't a scale I was familiar with for this project. I often felt overwhelmed by the vast amount of information available, such as all the parallel visions and ambitions. Ultimately, the challenge was to be aware of all this information while not losing focus on our own project. Additionally, there seems to be a correlation between the scale of a design project and its complexity. At the regional scale (compared to city scale and neighborhood scale), the strategy is much more complex and closely related to the design. This is mainly due to the large number of stakeholders involved in regional projects, as well as factors such as obtaining subsidies and relationships with other (parallel) plans. Careful consideration had to be given to stakeholder engagement and project phasing.

I found the topic incredibly interesting; of course, you hear a lot about climate change and greenhouse gas emissions in the news. But by giving a spatial dimension to a problem such as high CO2 emissions, the topic has gained much more depth. It forced me to make connections with other spatial, political, and societal issues, and I can say that I now follow current affairs related to this topic with much more interest.

Looking back on our approach, I can say we had a particularly scientific approach within this project. The approach has been very systematic from the beginning, with goal-oriented research, sharp analyses, and conclusions presented in the form of logical connections. The lectures from the parallel Methodology course have undoubtedly contributed to this, encouraging us to think deeply about the structure of the process and the approach to certain topics.

Overall, I look back on a rewarding group process and would like to express my gratitude to my groupmates for their understanding over the past few weeks.

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Appendix

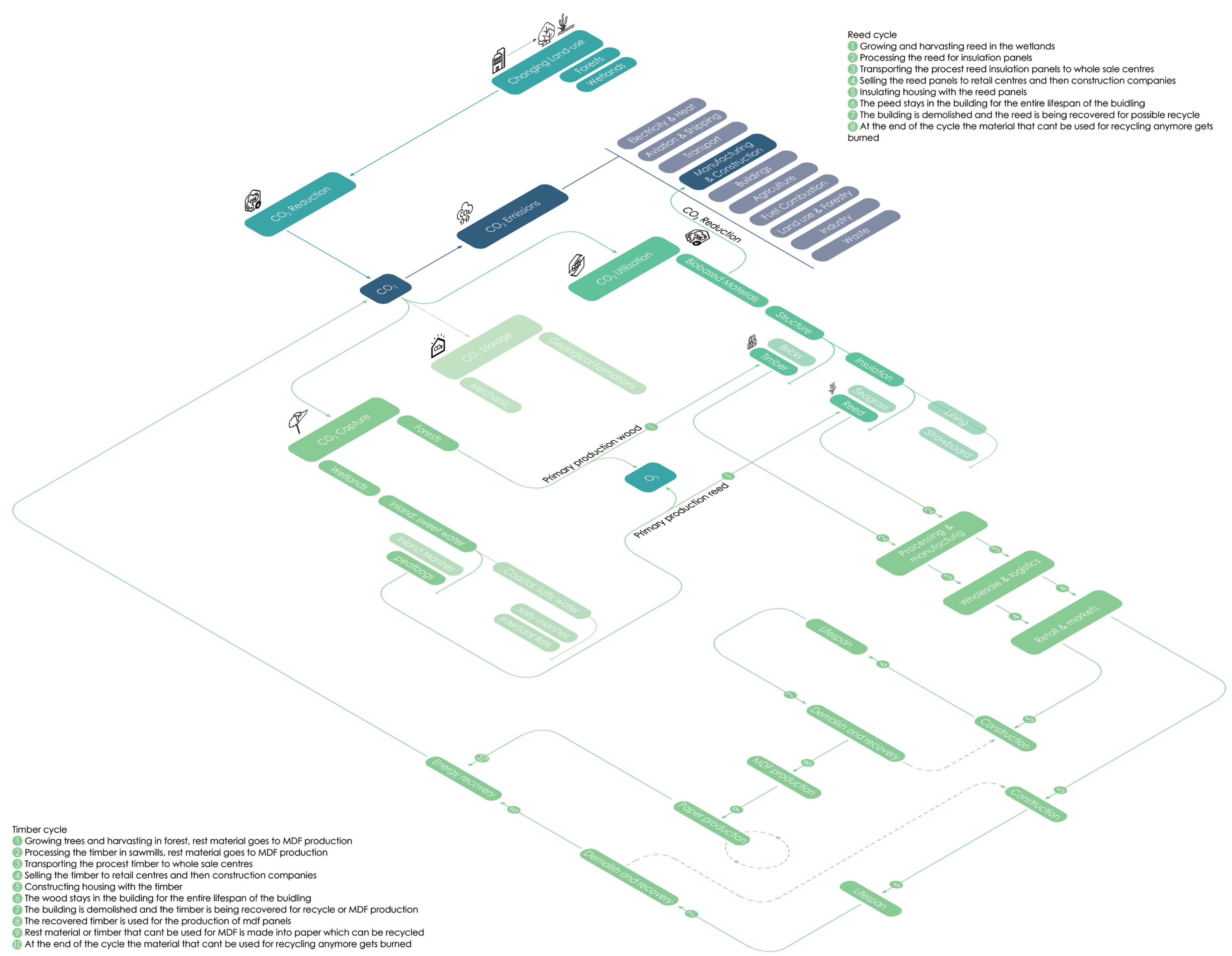

Image: Preliminery systematic flow

Image: Group dynamic metaphor
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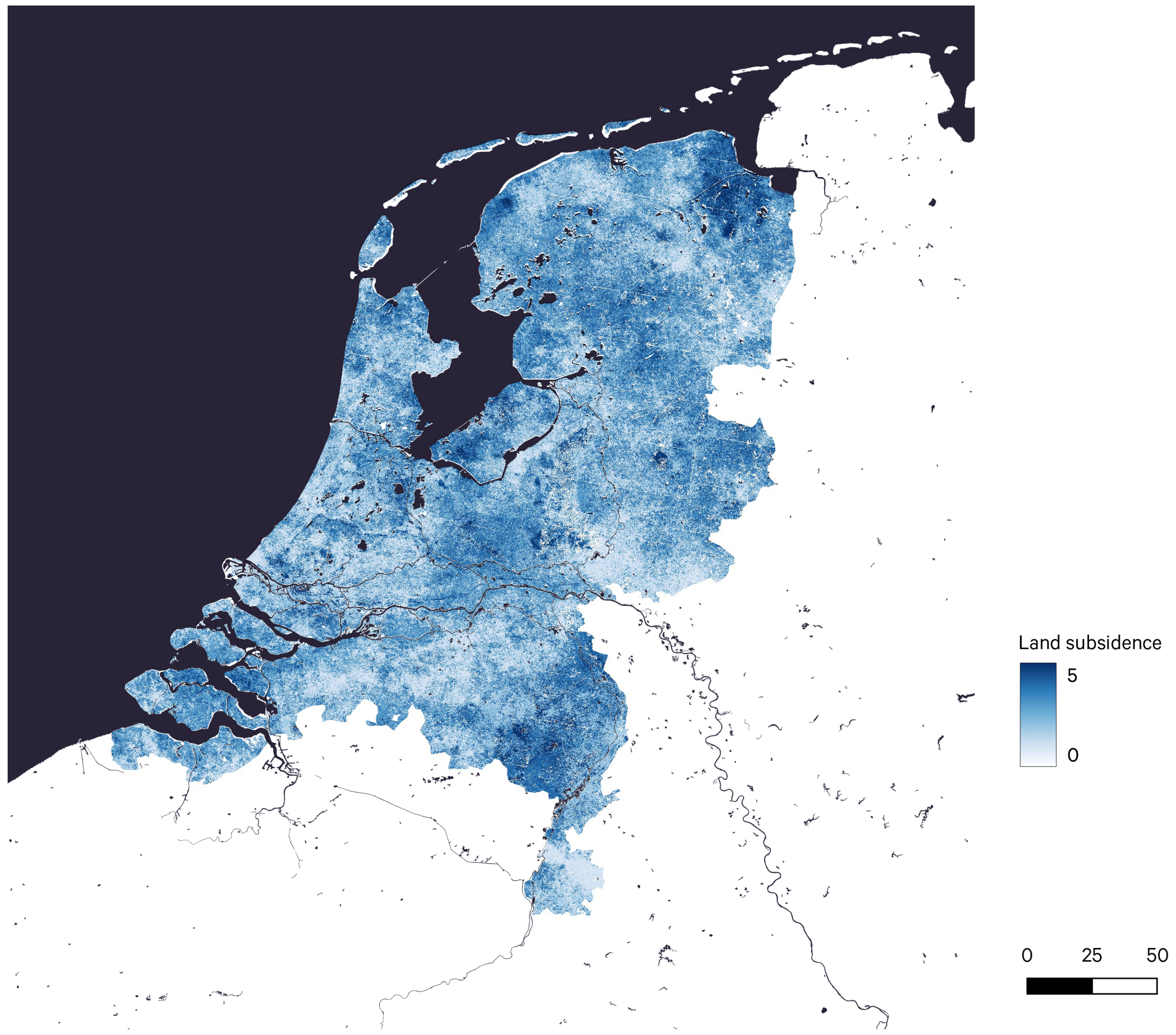


Image: Land subsidence
Dataset: SGDB - ISRIC - CLC2018

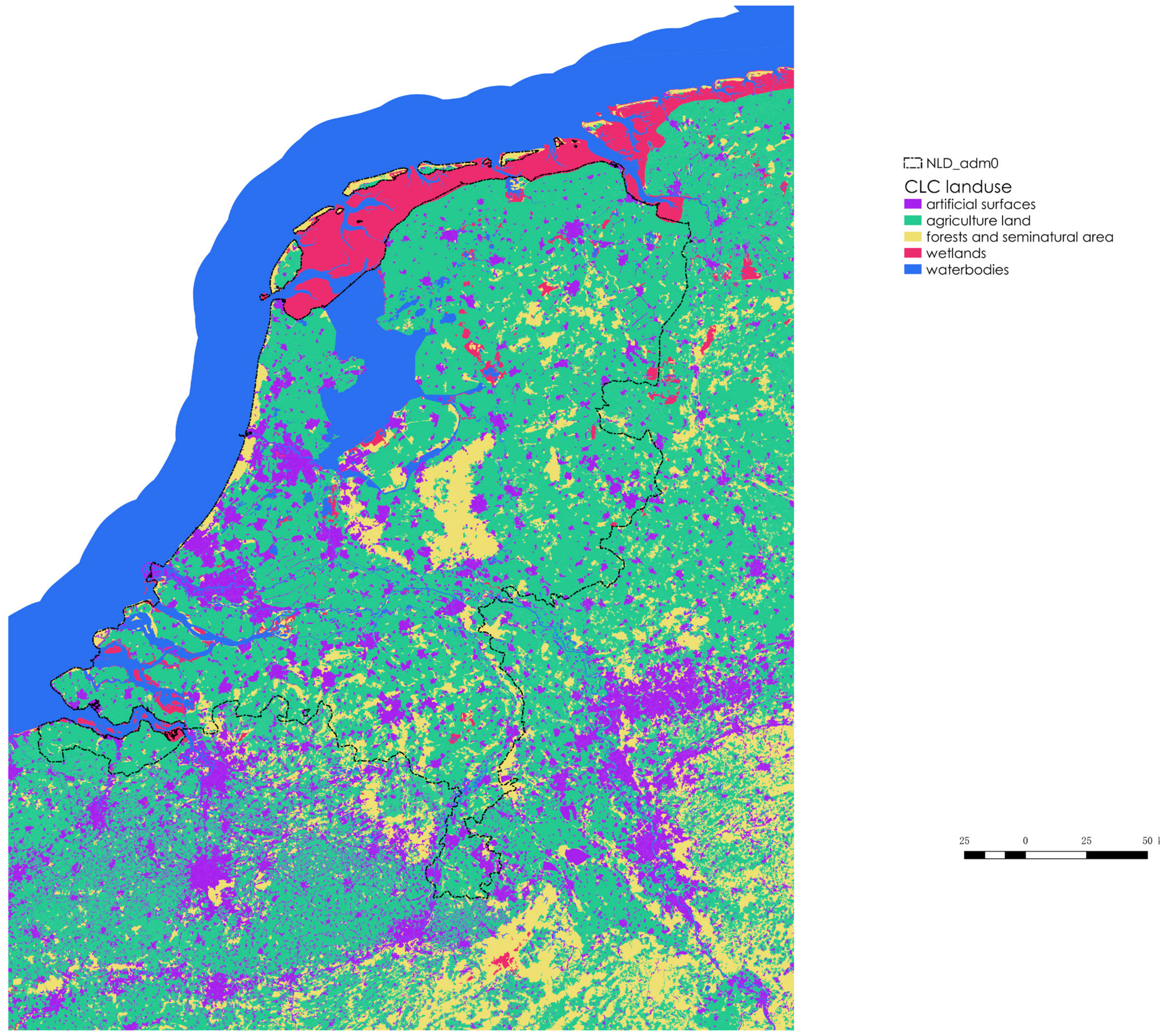


Image: Soil type analysis
Dataset: SGDB - ISRIC - CLC2018

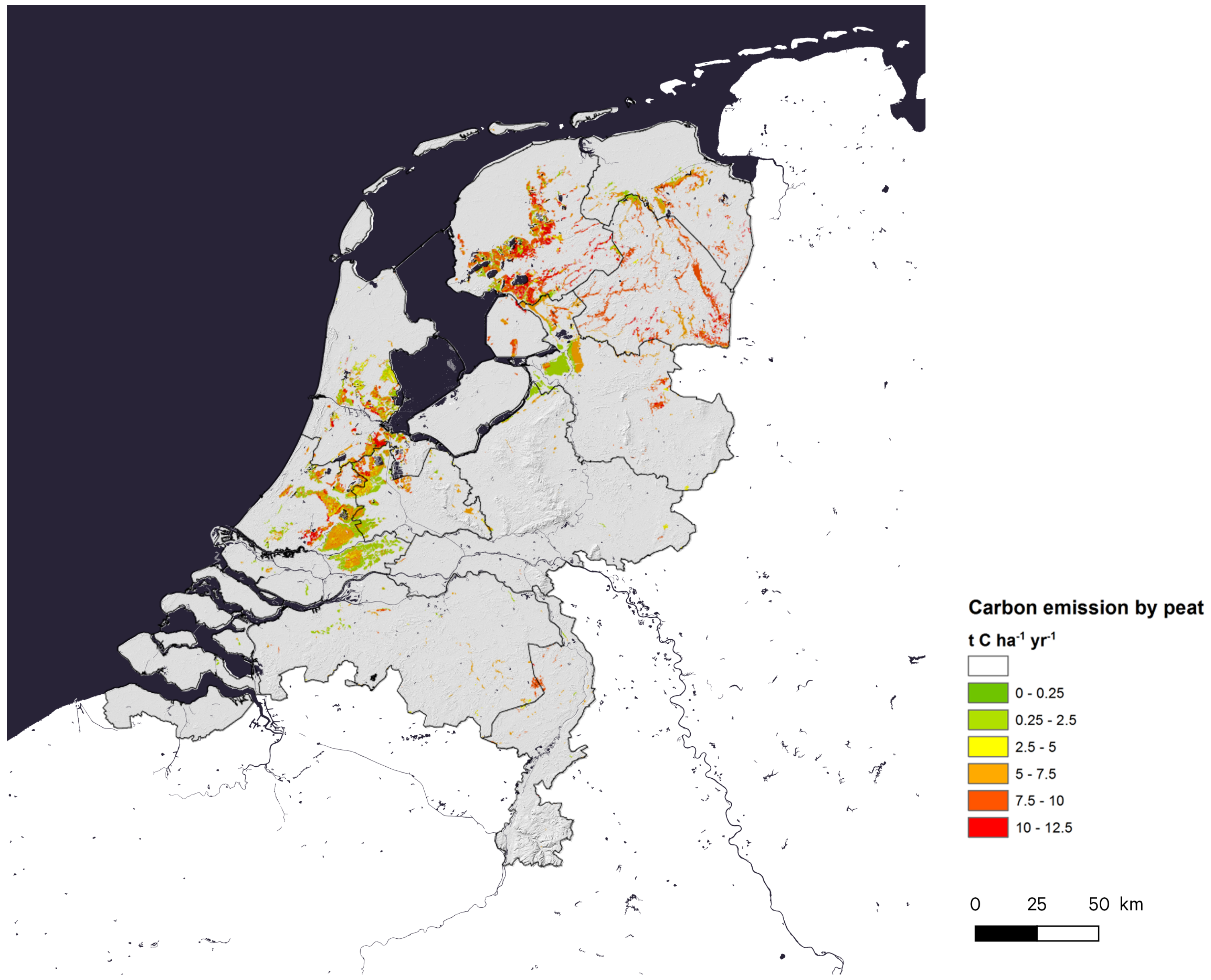


Image: Carbon emission by peatland
Dataset: SGDB - ISRIC - CLC2018

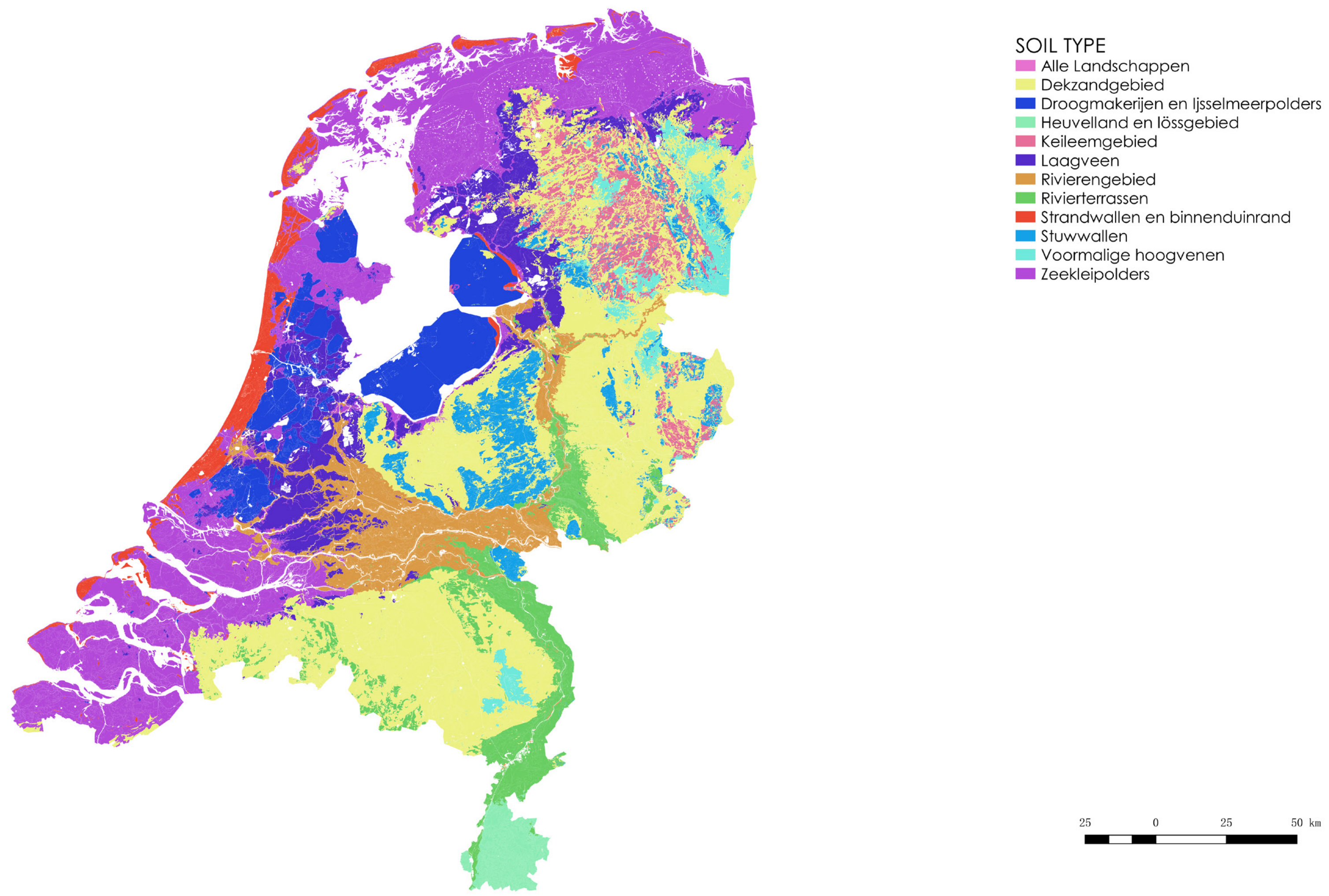


Image: Netherlands soil type analysis
Dataset: SGDB - ISRIC - CLC2018

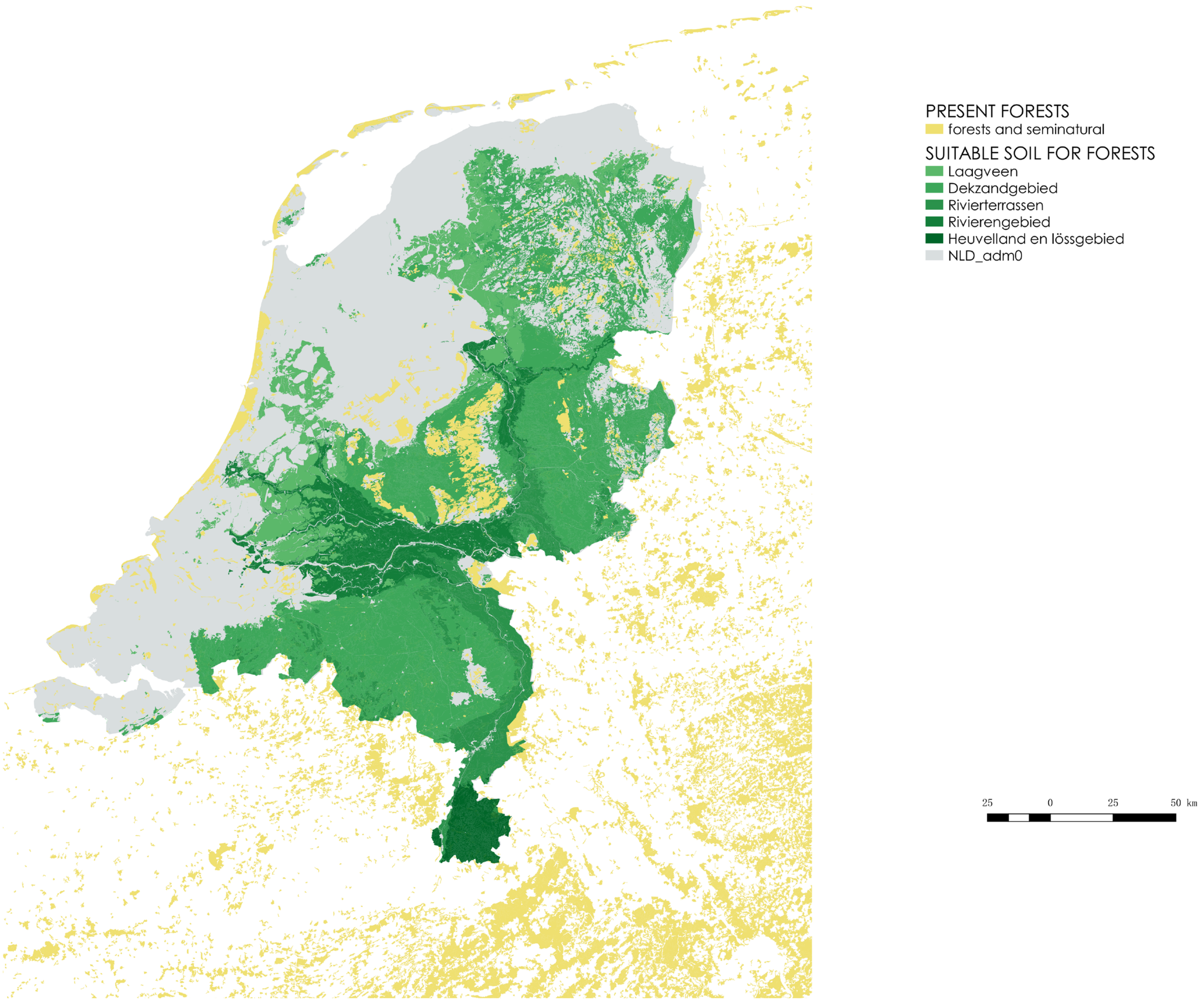


Image: Suitable soil for forests
Dataset: SGDB - ISRIC - CLC2018

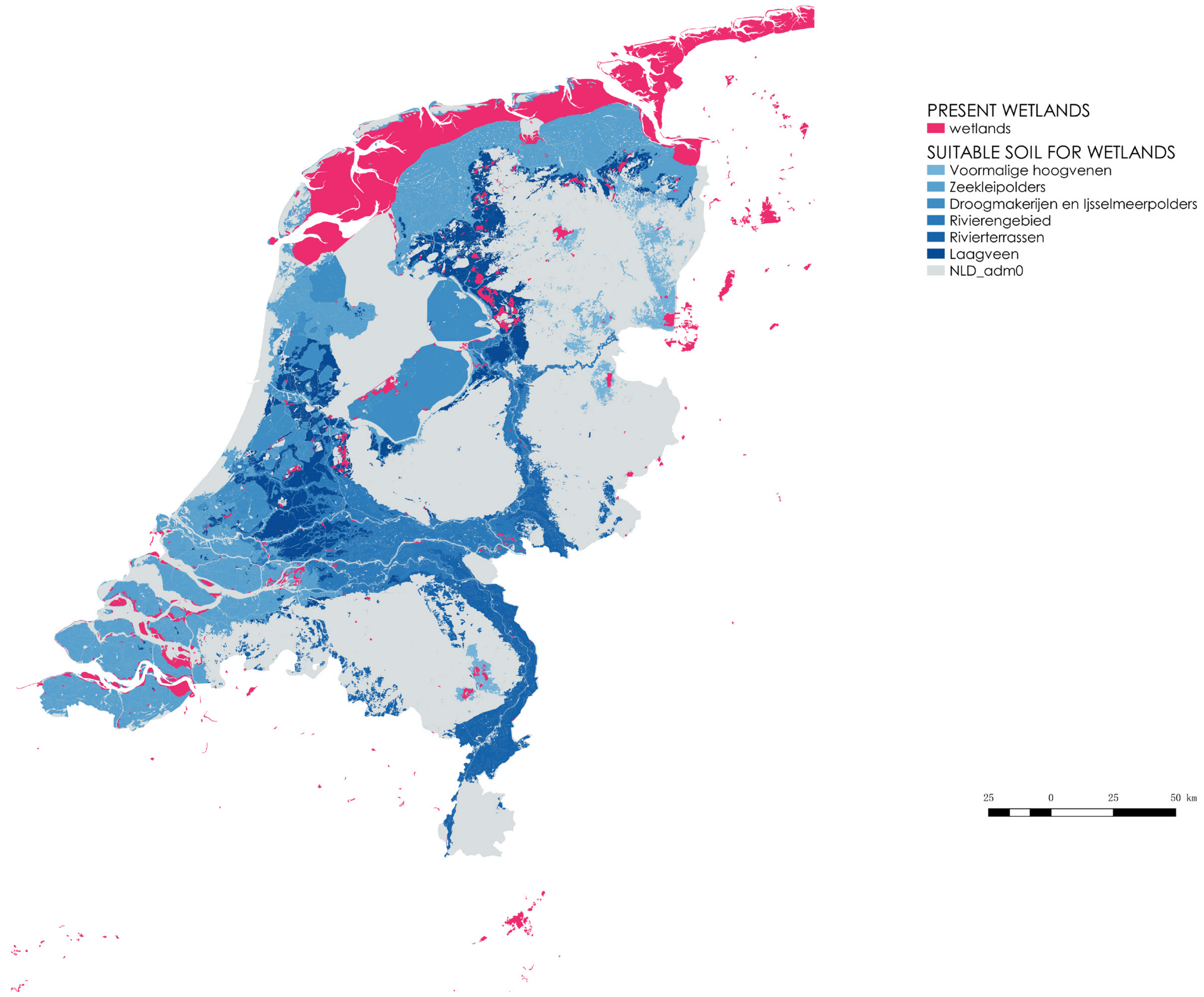


Image: Suitable soil for wetlands
Dataset: SGDB - ISRIC - CLC2018

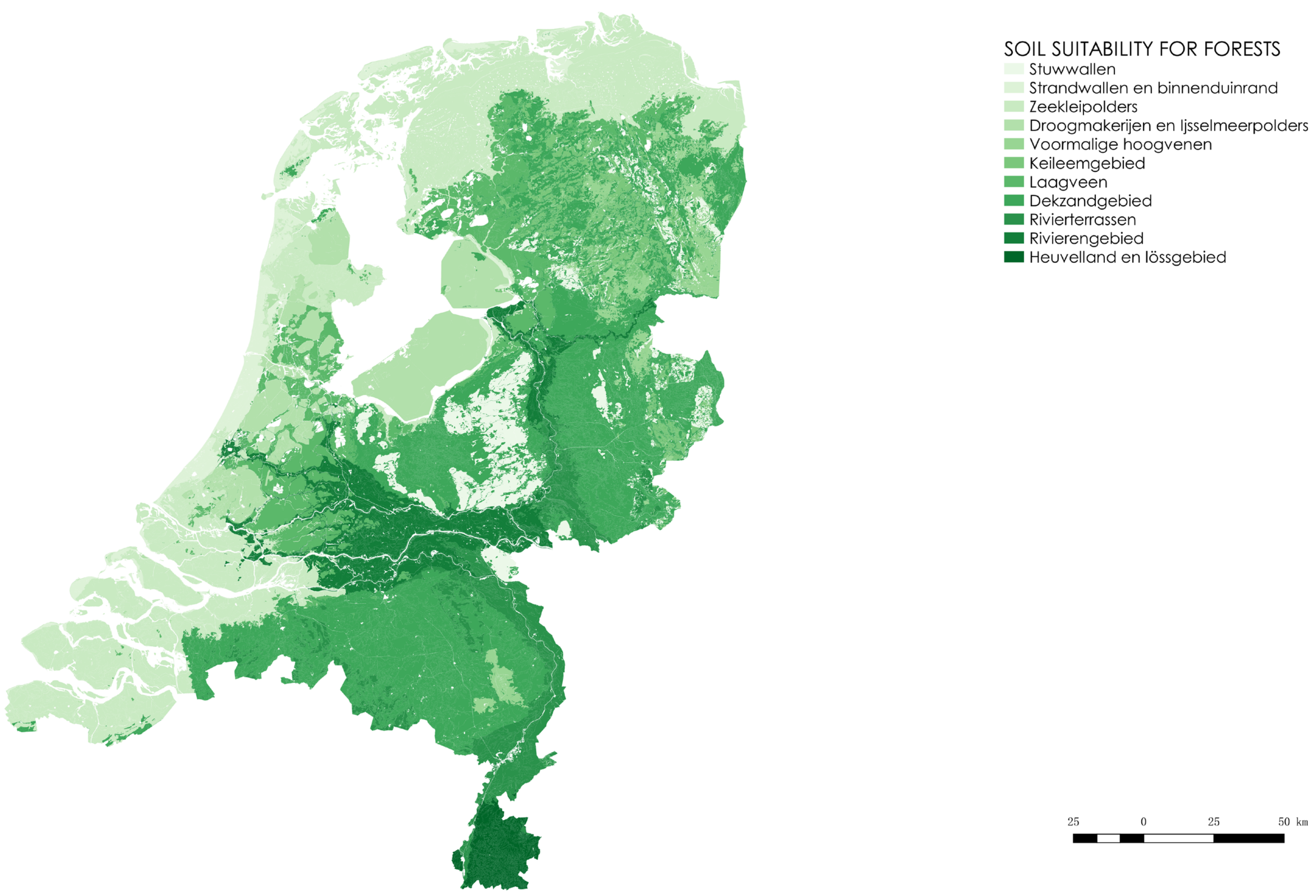


Image: Forests soil suitability map
Dataset: SGDB - ISRIC - CLC2018

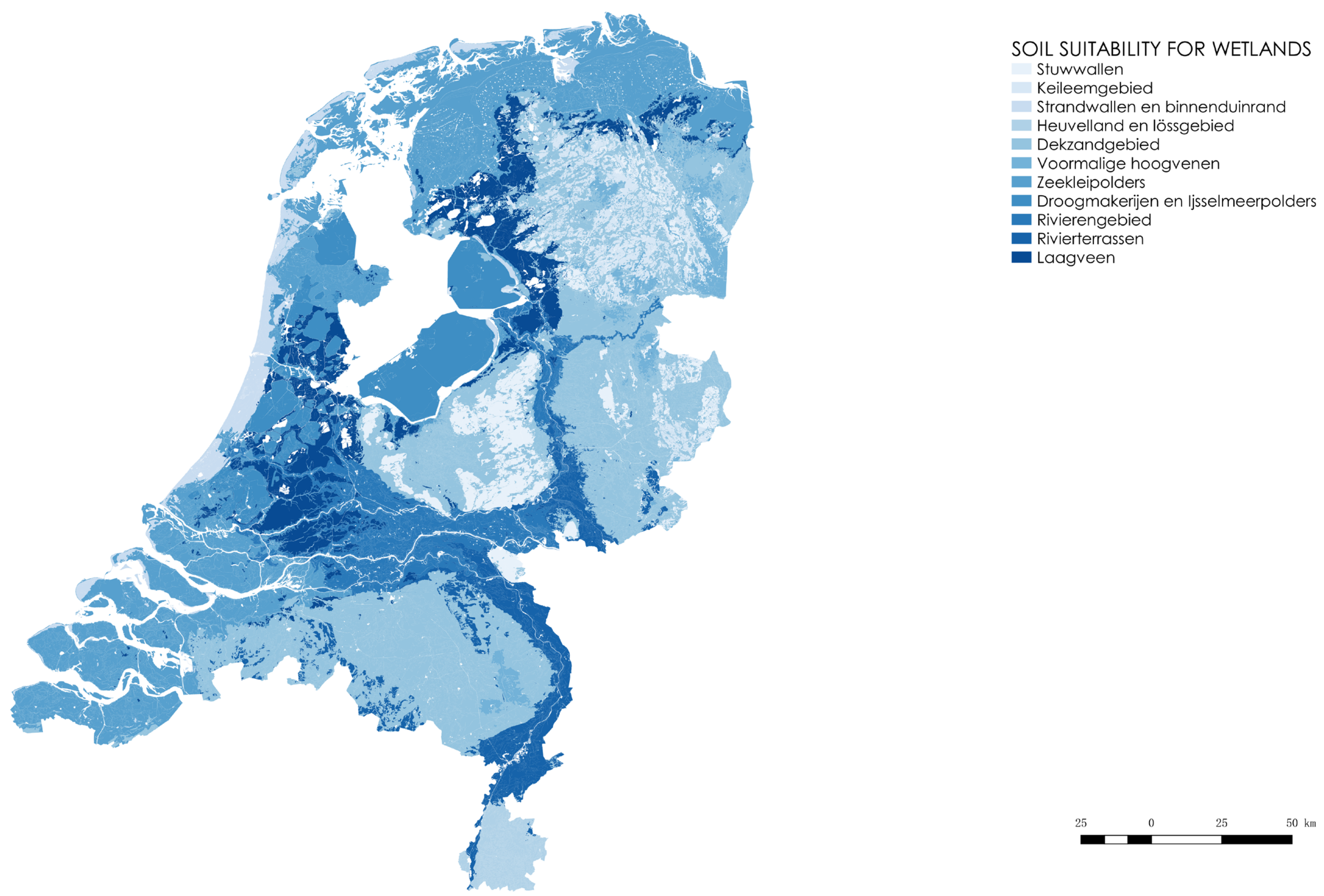
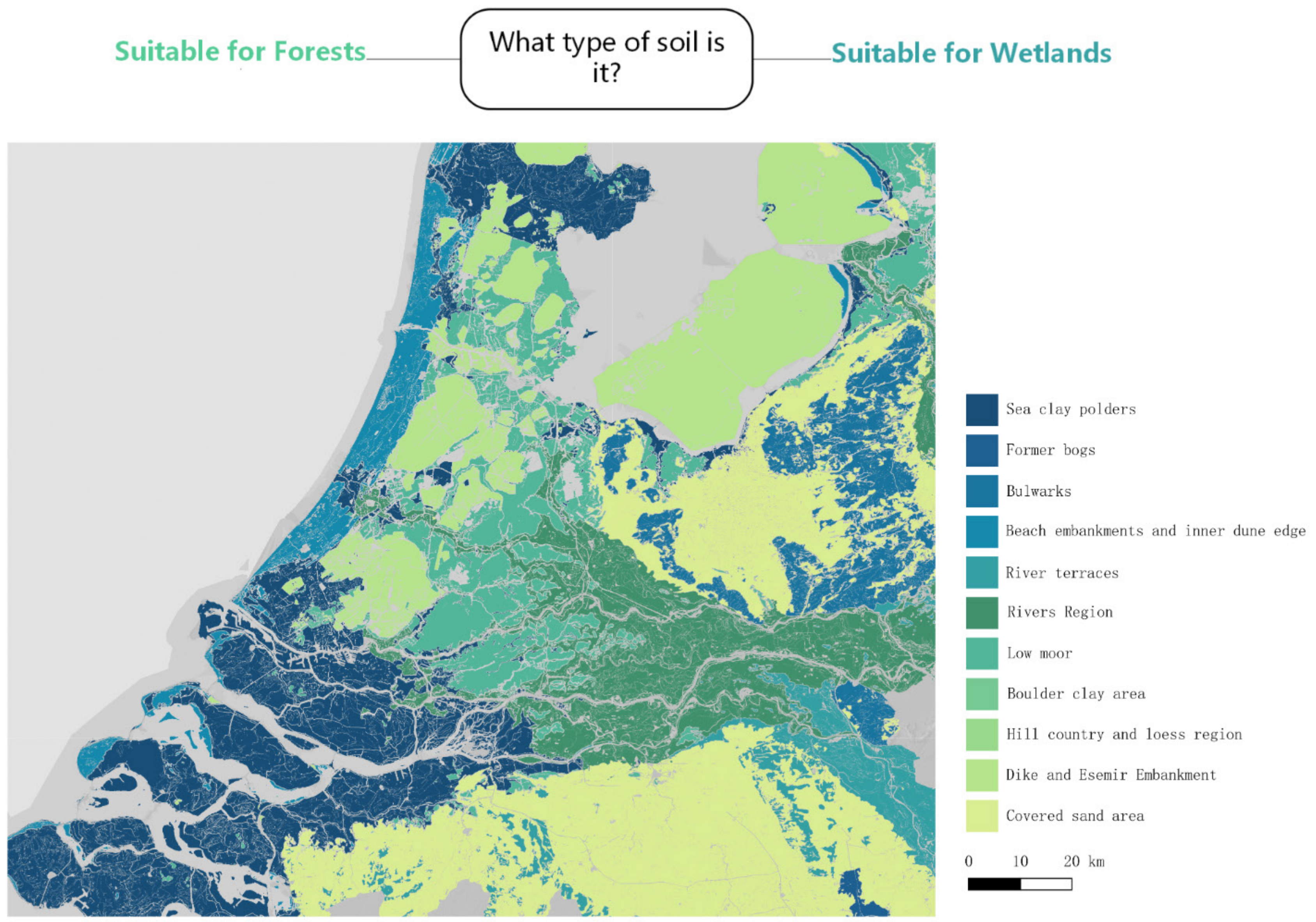


Image: Wetlands soil suitability map
Dataset: SGDB - ISRIC - CLC2018



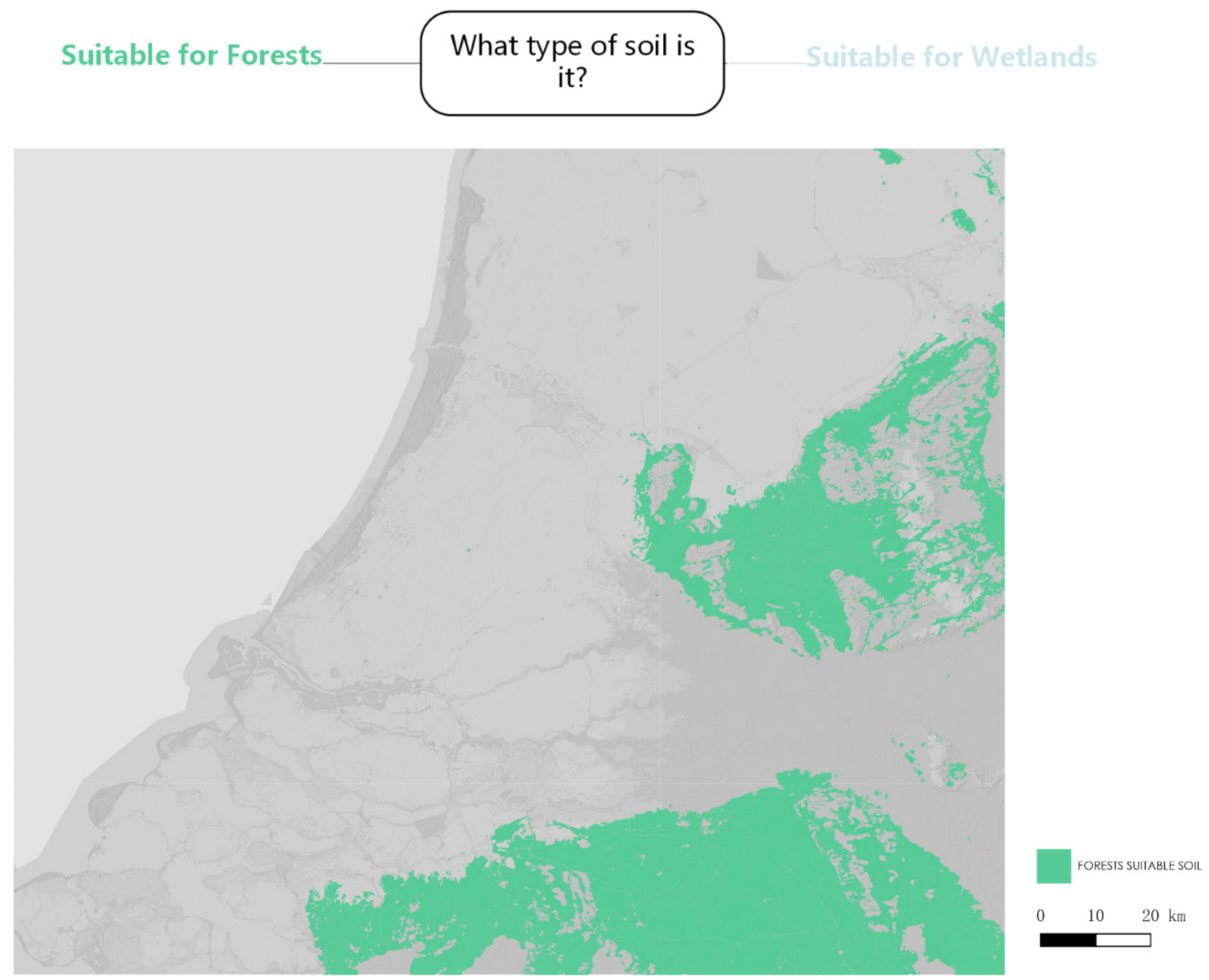
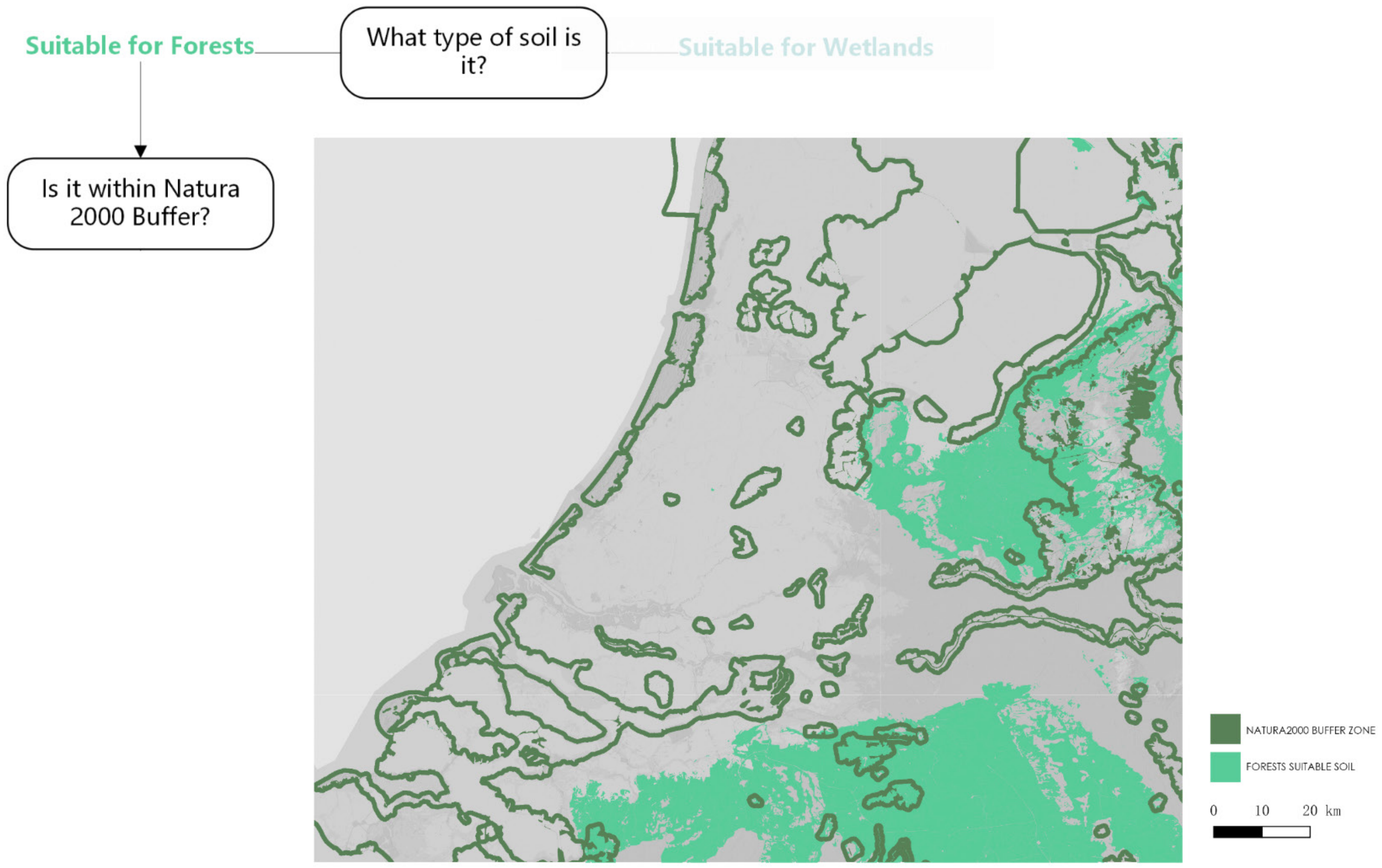


Image: Flowchart step map1
Dataset: SGDB - ISRIC - CLC2018



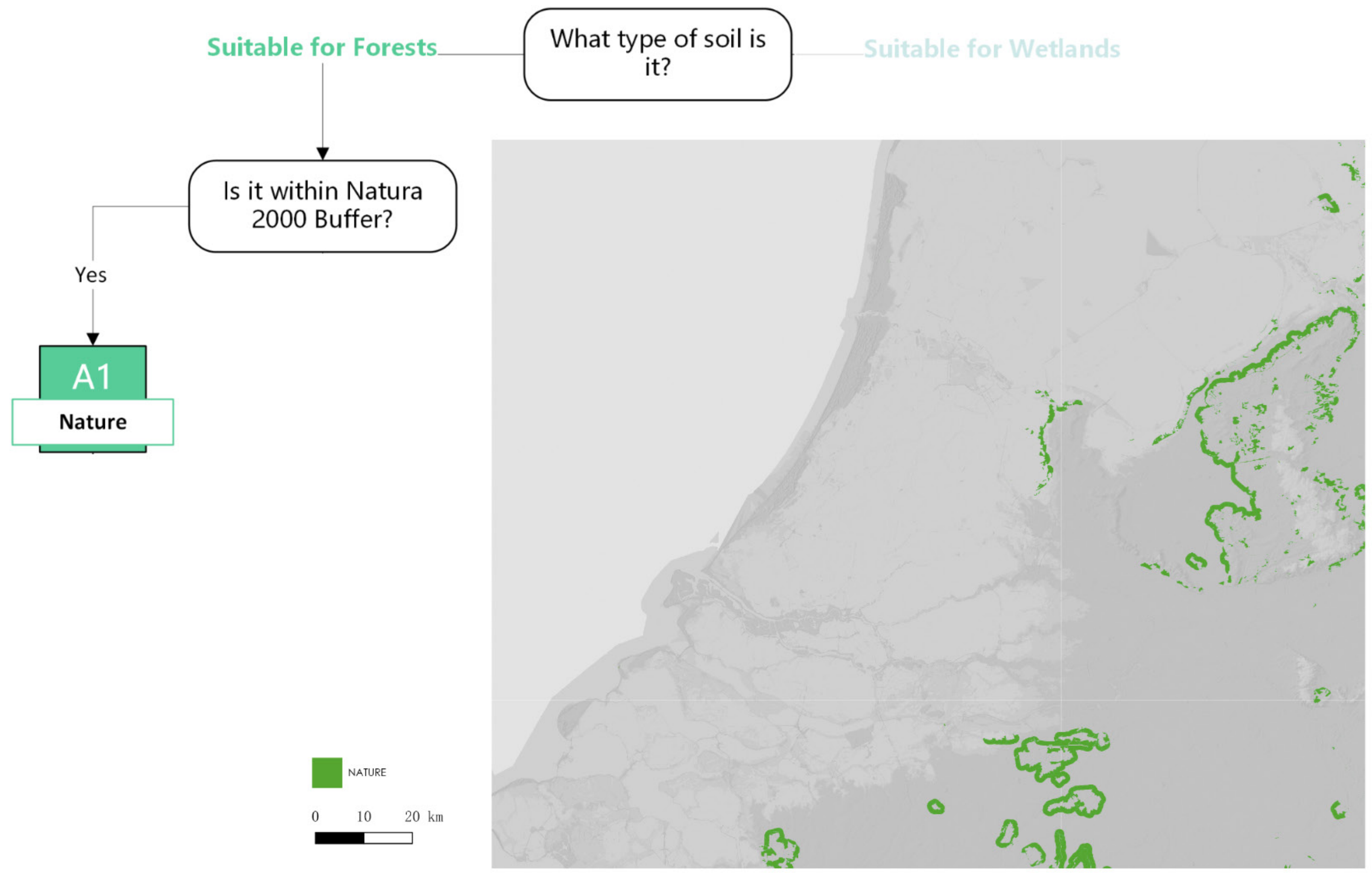
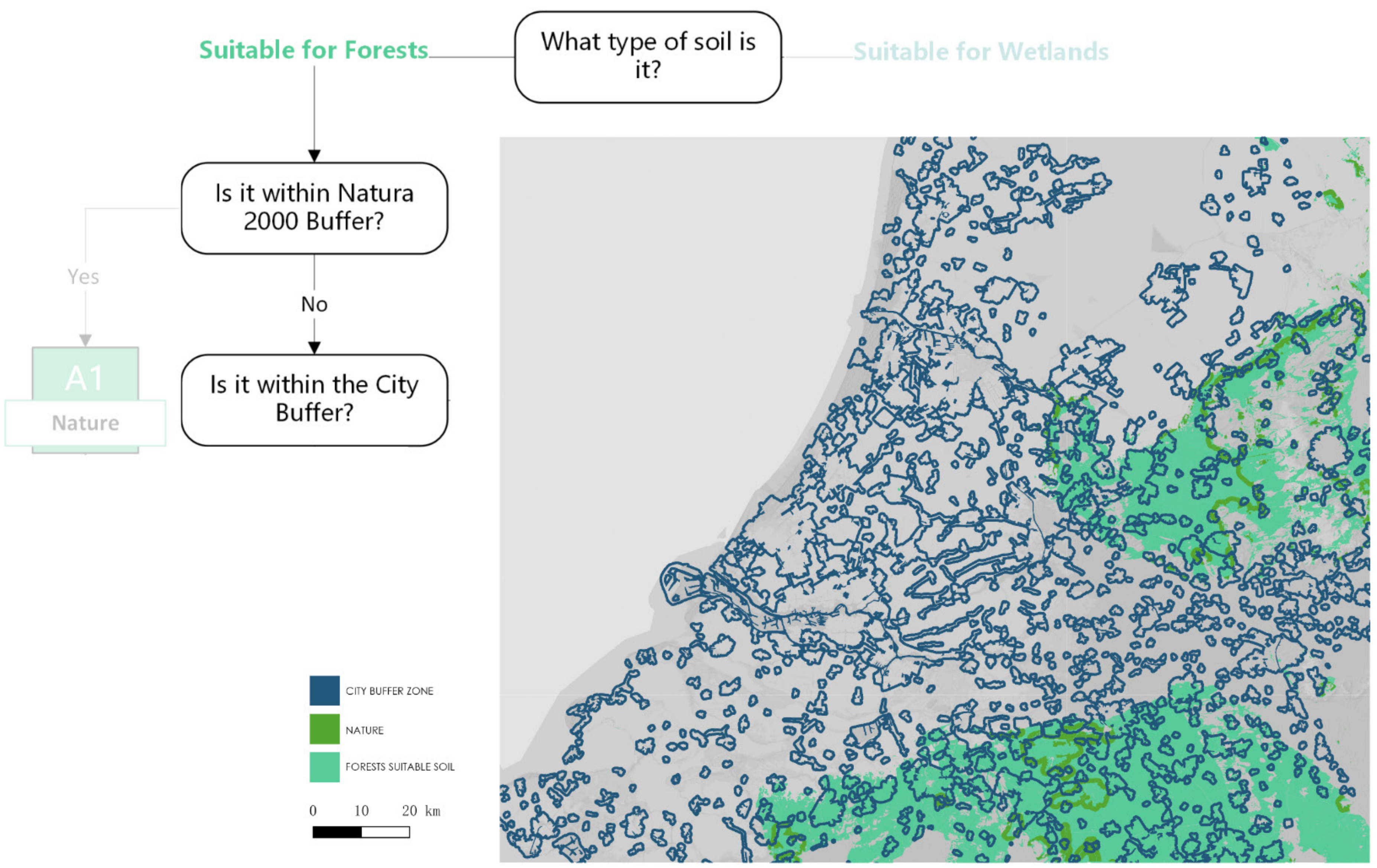


Image: Flowchart step map2
Dataset: SGDB - ISRIC - CLC2018



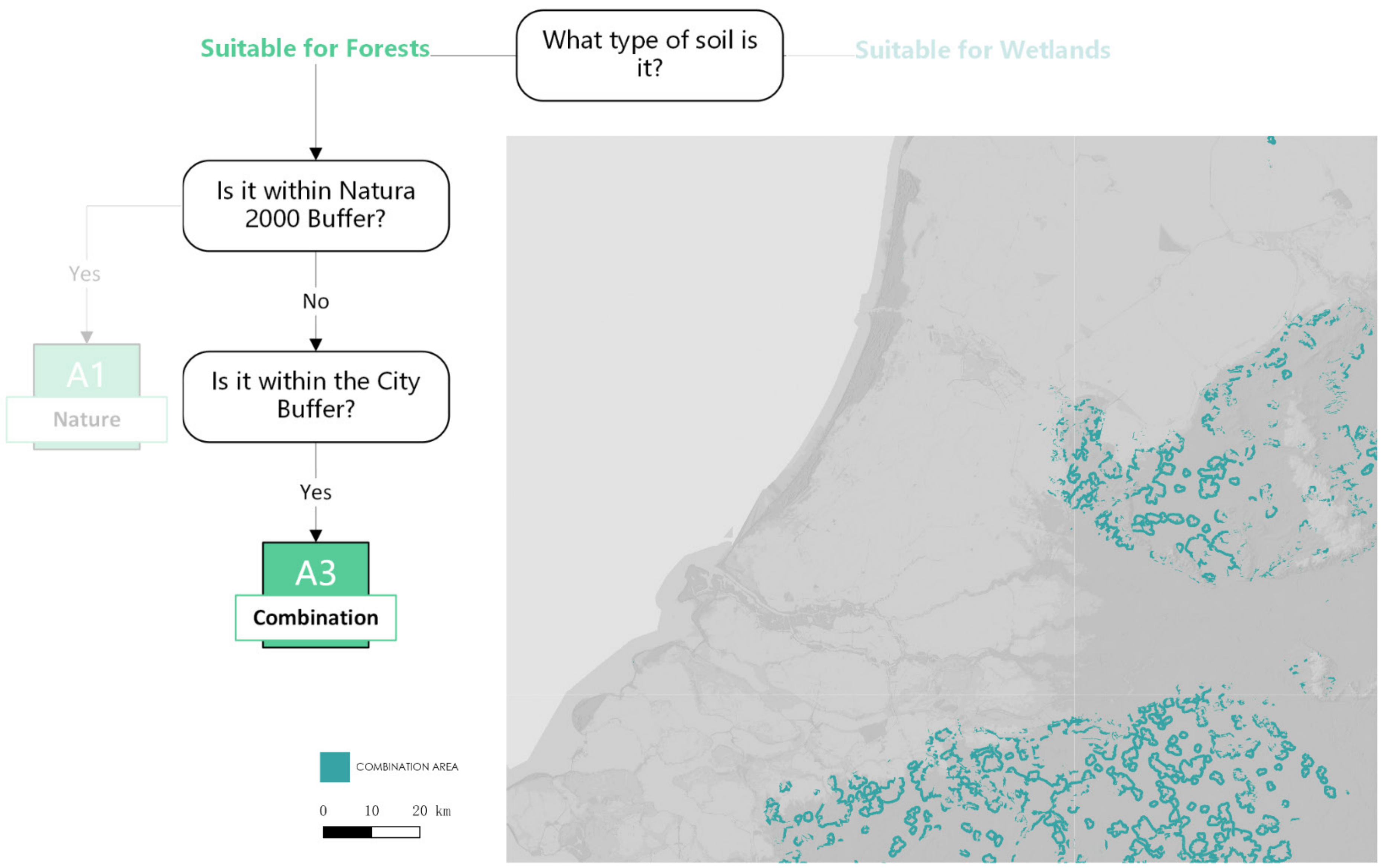
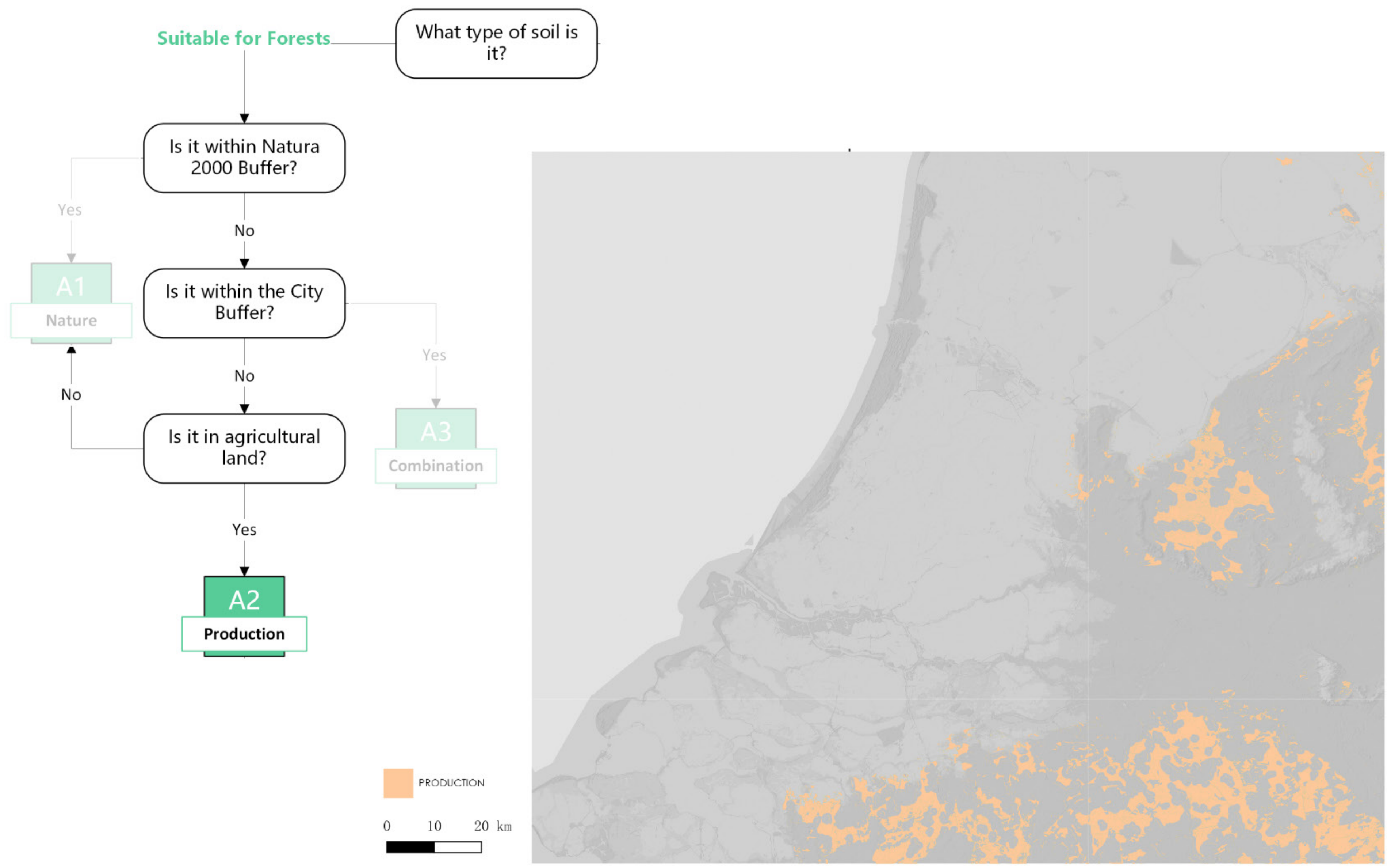


Image: Flowchart step map3
Dataset: SGDB - ISRIC - CLC2018



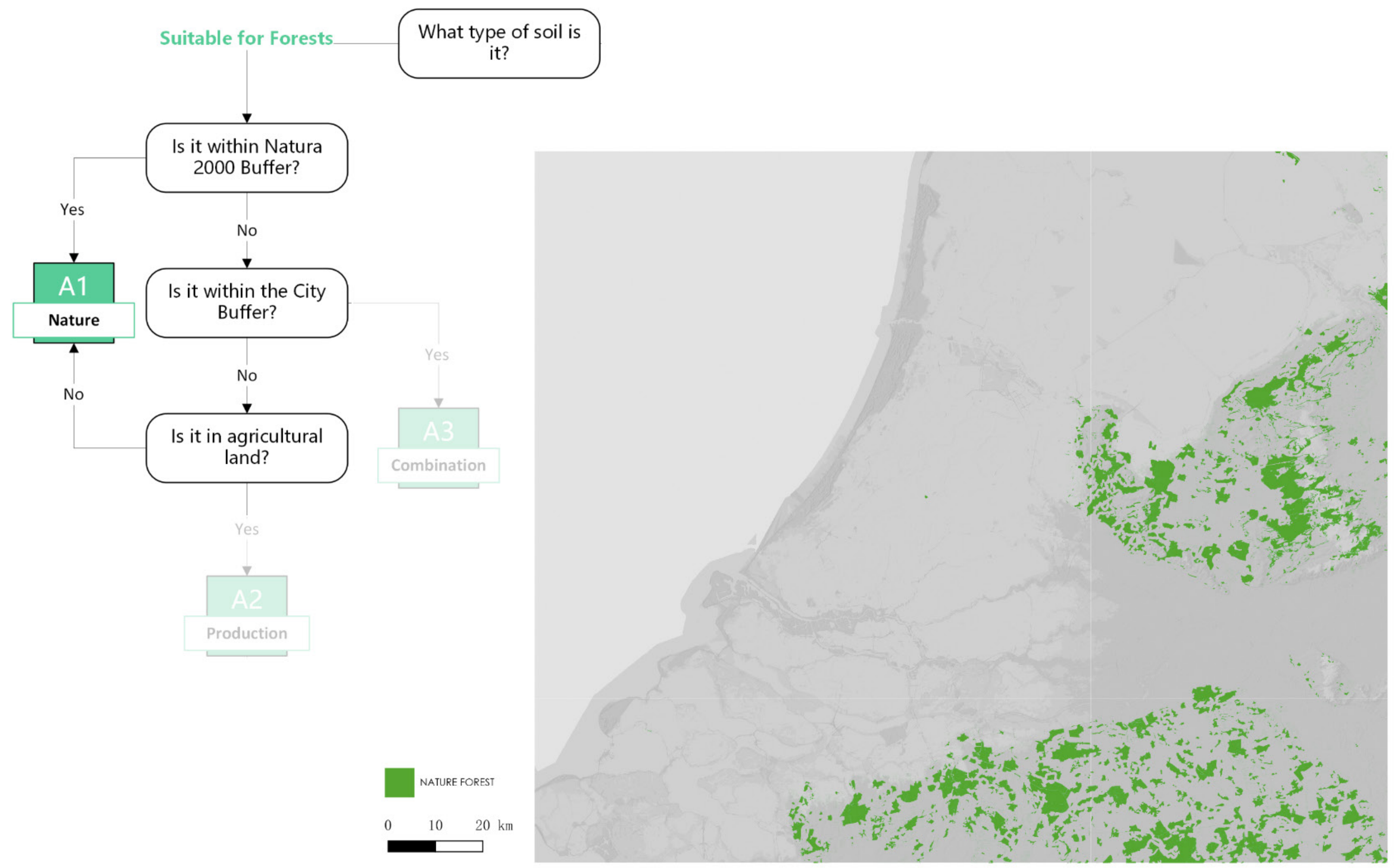
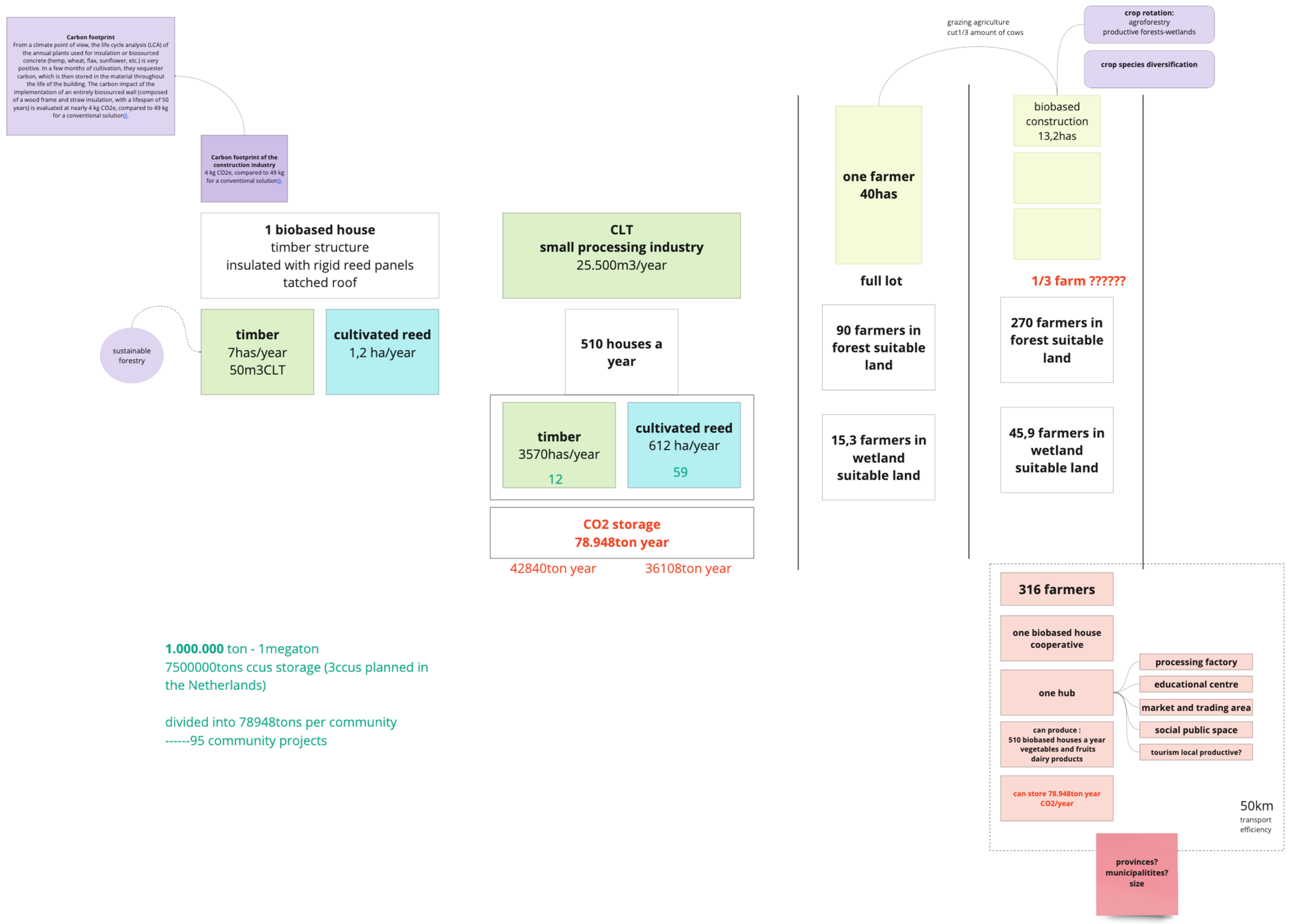


Image: Flowchart step map4
Dataset: SGDB - ISRIC - CLC2018

Rough calculation about carbon storage and biobased construction materials related with a House unit and the supply chain.



Data from:
Marco Vermulen - Build with wood https://marcovermeulen.eu/en/projects/building+with+wood/
Wetlands and Construction:An opportunity for Berlin-Brandenburg
https://builtbn.org/knowledge/documents/2023_material-cultures_wetlands-and-construction-report.pdf
Wageningen University
https://www.wur.nl/en/research-results/research-institutes/economic-research/show-wecr/dutch-dairy-farming-in-2030.htm

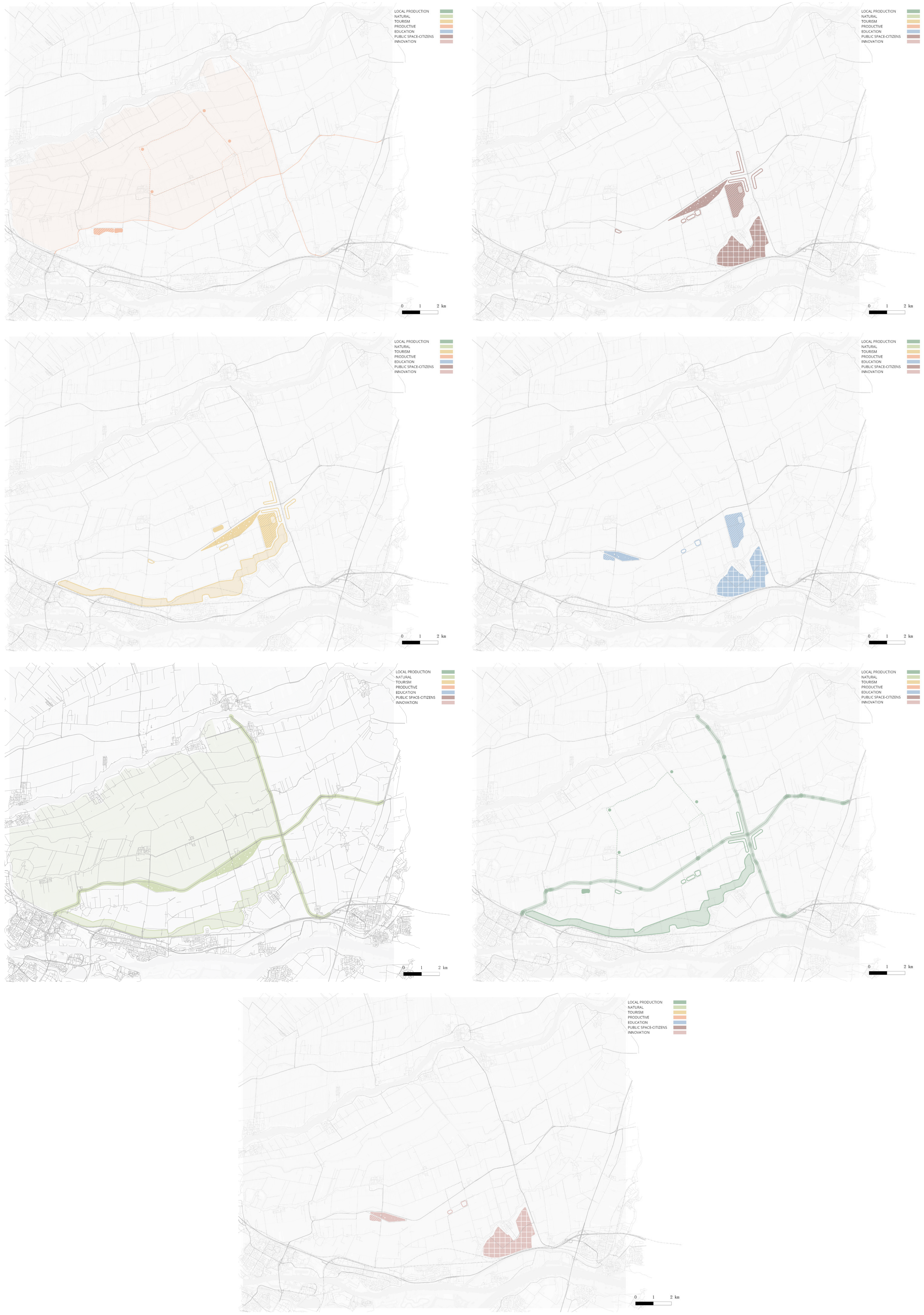


Image: Seven opportunities within pilot hub

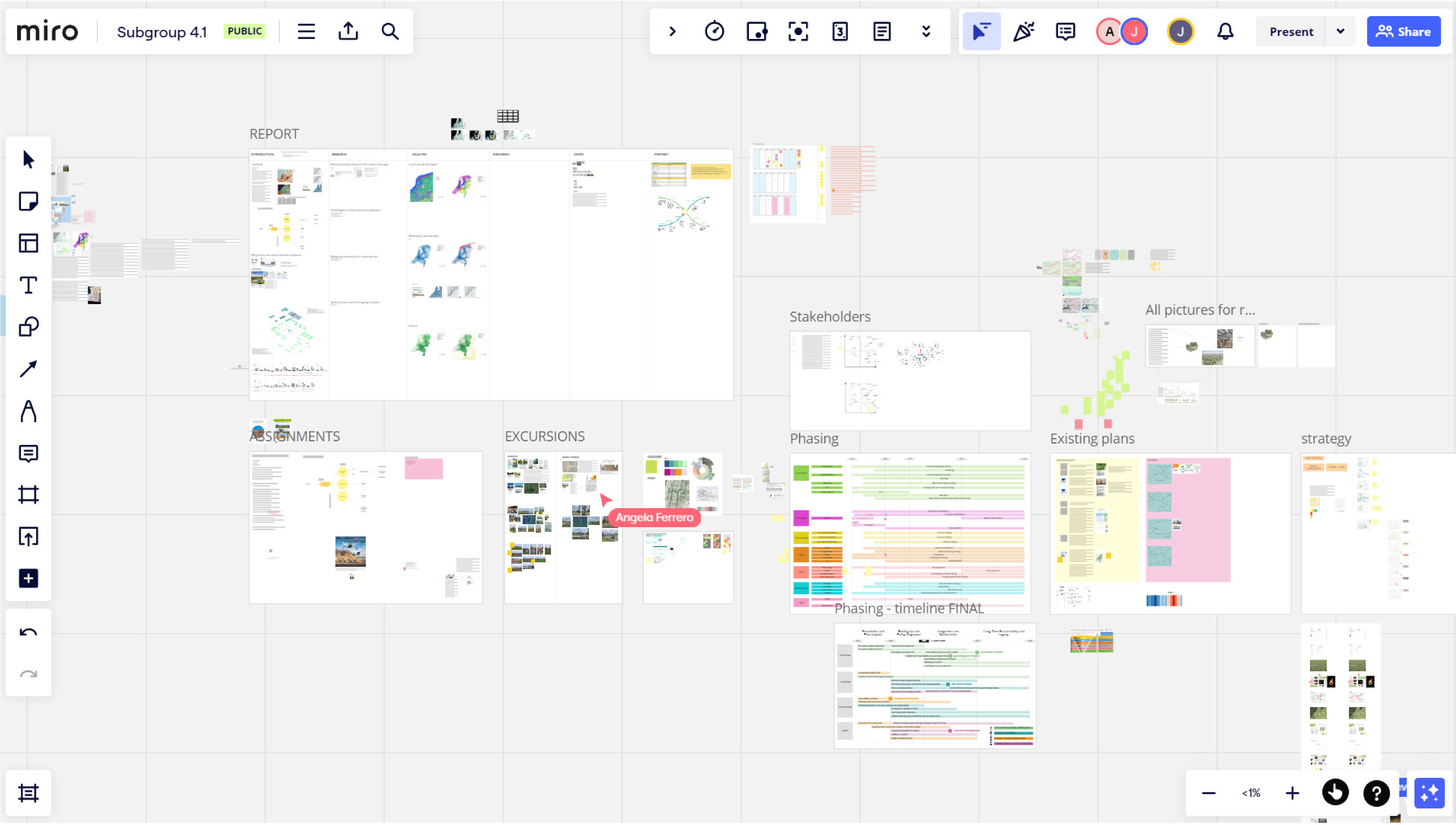


Image: Design process on MIRO