Aan tafel!

Redesigning North-West Europe's food system for zero-carbon food-print

colophone

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AR2U086 Research and Design Studio: Spatial Strategies for the Global Metropolis
AR2U088 Research and Design Methodology for Urbanim

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preface

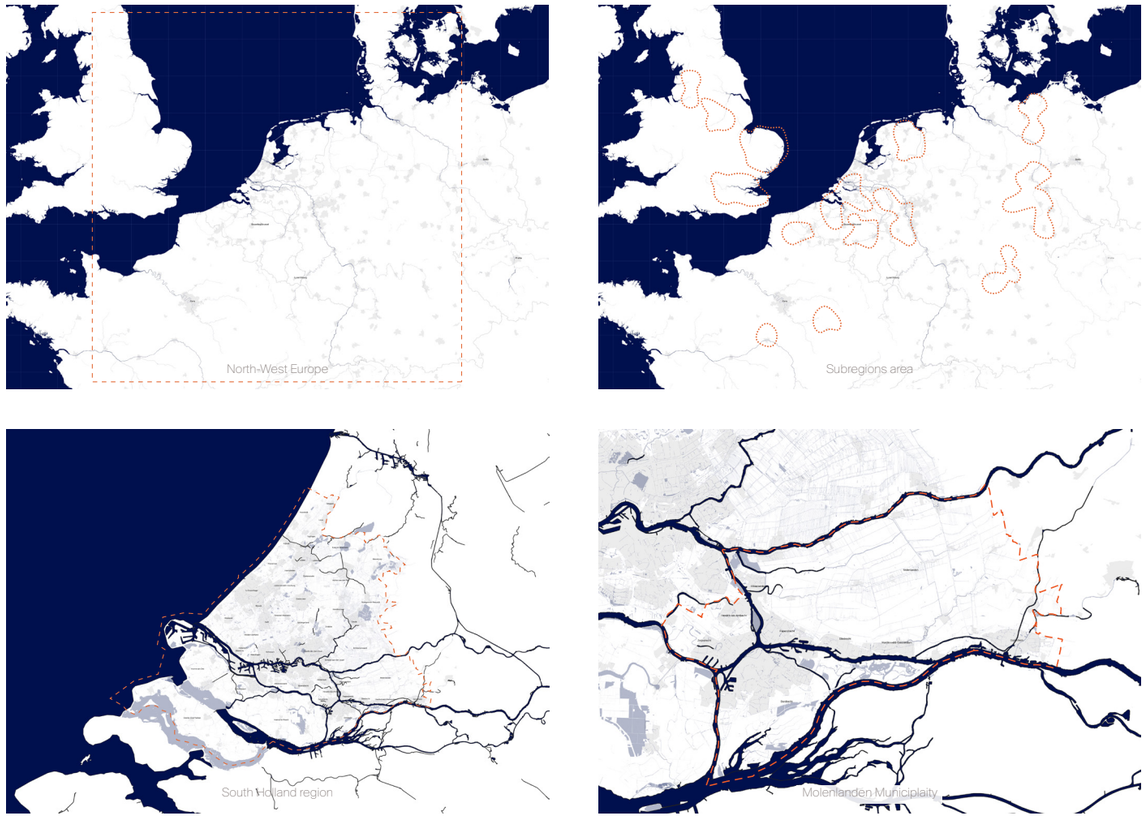

figure 1: scales of the project

This report is written as part of the design studio Spatial Strategies for the Global Metropolis of the TU Delft Urbanism track. The assignment is to make a regional design by moving through the scales. From analysis on the XL scale in North-West Europe, we move to a vision on the L scale in a European sub region, then to our strategy in South Holland on the M scale and finally to the S scale by creating a spatial intervention (figure 1).

The challenge is to make a sustainable transition that aims at "promoting the human well-being, meeting the basic needs of the poor and protecting the welfare of future generations (intra- and intergenerational justice), preserving environmental resources and global life-support systems (respecting limits), integrating economics and environment in decision-making, and encouraging popular participation in development processes" (Meadowcroft, 2000, in: Grin et al., 2010, p.2). As there are different approaches to sustainability we choose to focus on circularity in the context of reducing carbon emissions in the food production system.

In the introduction we address the big picture, the urgency, the aim of the project and the alignment with the Sustainable Development Goals first. In the second chapter we describe our methodology. In the third chapter we describe the current food production system in Europe including its produce, stakeholders and the related carbon emissions. In the fourth chapter we explain the concept of the open circular economy in relation to producing food. We then move on to our vision for North-West Europe. After that we show the strategy and implementation of our vision in South Holland. Finally, we conclude and reflect on our project in chapter seven.

abstract

North-western European countries play an important role in the global food system, by providing 80 percent of the whole European production. The current production system is focused on profit, has a yearly emission of 1250 megatons of CO_2 equivalent in North-western Europe and produces pollutants in the soil, water and air. This results in an imbalance between natural and human activities, which is destroying biodiversity, natural resources and is increasing food access inequality. Therefore, our goal is to reduce CO_2 emission to net-zero in 2050 and to reach food security for all people North-western citizens.

We aim to design a sustainable food production system that is based on three pillars: nature-based, community-based and production for need. We analysed the current system through fieldwork, data analyses and literature reviews.

The concept of the circular economy formed our basis for a vision of an open adaptive system for the food production system. It includes concepts of circularity from the production on the fields, towards the re-valuing and re-purposing of household and industrial by-products. For each of the production steps we have developed a toolbox of innovations, which are integrated following the local context. New ways of production are incorporated in the farming process; management techniques, which reduce CO_2, are implemented in the processing phase; new marketing strategies are applied in retail; in the consumption phase mindset is changed to accept alternative products and meal planning. In terms of disposal, waste is reduced by reusing it as an input for other processes. Lastly, carbon sequestration is improved by recovering and increasing natural areas, leading to an increase in biodiversity and soil health.

This toolbox is implemented as a strategy in the region of South Holland to illustrate the spatial, social and economic impacts of the new food production system. The circular concept ensures an approachable transition from linear to circular food production systems in North-West Europe. Therefore, it can be used to inform international cooperations, national and regional governments in making policies, and to provide an overview of the spatial implications of this transition on the national, regional and local scale. Overall it is a radical shift towards renewable energy sources, incorporating by-products as inputs and using and producing food products with a smaller CO_2 footprint.

Keywords: food production; net-zero; open circular economy; nature-based agriculture; community-based.

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In chapter one we introduce the reader to the scales of the report, North-West Europe and South Holland. Trading relationships between the northwestern countries are very much intertwined. On a field trip through parts of South Holland, we identified diverse and segregated areas, which inspired us in the later research.

the big picture

figure 2: agricultural import map in North-West Europe

figure 3: agricultural export map in North-West Europe

The focus area of North-West Europe consists of the Netherlands, Belgium, Germany, France, Luxembourg and the United Kingdom. Except for the United Kingdom all countries are part of the European Union. These countries play an important role in the global food production system (European Environmental Agency, 2014).

According to the World Wide Fund the European food production model is based on importing and processing low-value raw products and producing and exporting high-value products, such as wine and chocolate (Ruiz Mirazo, 2022). This can be seen in the import (figure 2) and export (figure 3) map and the overview of collected data (Appendix 14). France imports cacao beans and is the main exporter of wine; Germany mainly imports crude material and exports food preparations. The Netherlands is the biggest exporter in the agriculture and horticulture sector (Ministerie van Economische Zaken, Landbouw en Innovatie, 2022), however the biggest export comes from dairy and eggs with a total amount of 11.9 billion EUR annually.

Most of the main trading partners in North-West Europe are within the European Union. In terms of trade the Netherlands and Germany have a strong relationship: 24% of Dutch produce gets exported to Germany and 27% of German produce is exported to the Netherlands. Belgium and Luxembourg are relatively small players, but have a strong dependency on the neighbouring countries in terms of import and export. Outside the European Union the United Kingdom was one of the main trading partners in 2021 (Eurostat, 2022). This is related to the dependency of the United Kingdom on the import of fruits and vegetables from the Netherlands and meat from France (figure 2).

South Holland is located in the west of the Netherlands and houses over 3.7 million inhabitants in cities as well as rural areas. Around a quarter of the province consists of built areas (Centraal Bureau voor de Statistiek, 2019). All cities located in South Holland are part of the Randstad: a metropolitan area which stretches from Amsterdam in the North to Rotterdam in the South. Rotterdam holds a strong position on the international trade market due to the Rotterdam harbour, which is the biggest of Europe. The Hague is where the Dutch seat of government is located. The historical cities of Leiden and Delft both are home to a university. In between the cities a variety of production landscapes is located. On our site visit from the Maasvlakte (appendix 01-03), over the Biesbosch and back to Westland, we discovered a domesticated landscape with non-human scales separated by harsh borders.

urgency

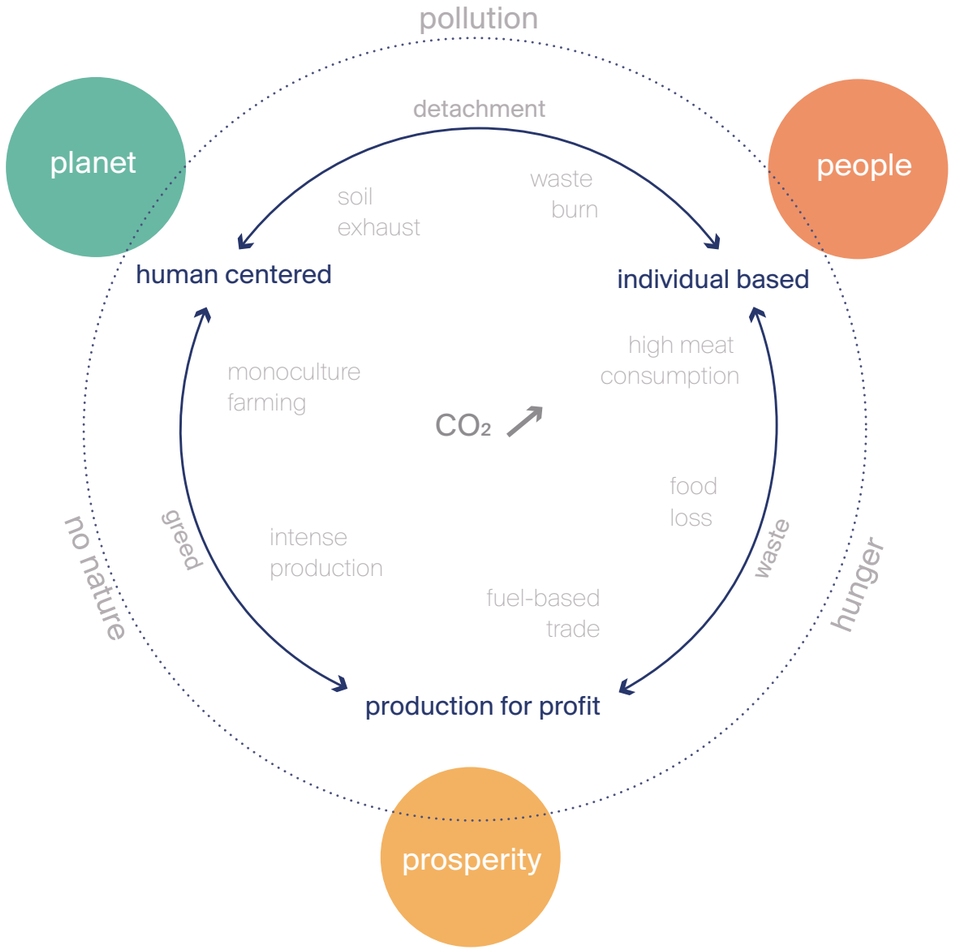


figure 4: diagram of the current food production system urgency in North West Europe

Agricultural productivity in North-West Europe has gone up by employing modern techniques such as monoculture, irrigation, use of machines and use of pesticides and fertilisers (European Environmental Agency, 2014). However this way of production is degrading our environment as stated by Steel (2020, p.5) in her book Sitopia:
"Food shapes our lives, yet since its influence is too big to see, most of us are unaware of the fact. We no longer value food in the industrialised world, paying as little as possible. [...] Many of our greatest challenges – climate change, mass extinction, deforestation, soil erosion, water depletion, declining fish stocks, pollution, antibiotic resistance, and diet-related disease – stem from our failure to value food."

The food production system uses up natural areas (Ruiz Mirazo, 2022) and uses mostly energy from fossil fuels, with renewable energy only having a small share (European Commission, 2015). In addition a third of the food is lost or wasted (Gustavsson et al., 2011). In this case food losses refer to food that was intended for consumption, but through poor functioning of the system decreases in quality and is consequently discarded (Cairn et al., 2021). The system is losing 14% during the production process and 17% after consumption (UN, no date a). The amount of food wasted per person in the EU is estimated to be 173 kg per year (Ruiz Mirazo, 2022). On the other hand soy and other types of feed are imported to feed livestock and over 50% of the current grain production is fed to animals (Ruiz Mirazo, 2022). Meanwhile almost 2 billion people are hungry or undernourished, while the same amount are obese or overweight (UN, no date a). Figure 4 illustrates this urgency in the food production.

aim of the project

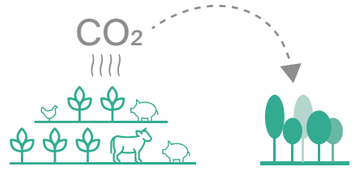


figure 5: protect environemtn and catch CO_2

figure 6: food security and equality

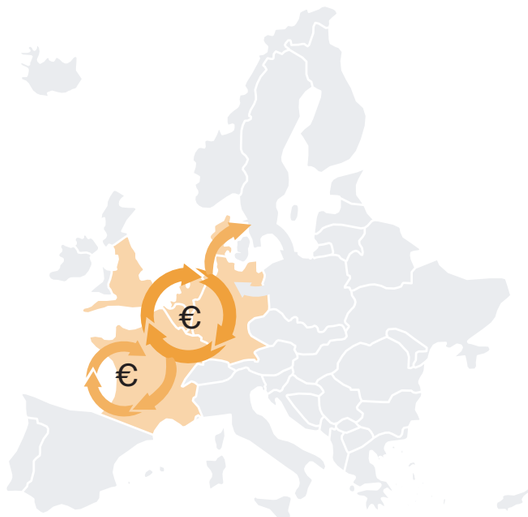


figure 7: economic feasibility

"We can use it [food] as a positive force, not only to address such threats [e.g. climate change] and reverse numerous ills, but to build fairer, or resilient societies and lead happier, healthier lives." (Steel, 2020, p. 5).

As stated in the urgency above the current food production system impacts the environment and human systems in many negative ways. In this project we therefore rethink the functioning of the food production system in North-West Europe.
We aim to:

- Ensure protection of the environment and its resources (figure 5)
- Provide food security and equality for all (figure 6)
- Create economic feasibility for every country (figure 7)

Our focus is on achieving net-zero carbon emissions in 2050. To achieve these goals we want to use the approach of the Circular Economy (Del Borghi et al., 2020), in which life cycle thinking changes the relationship with food in the production process and during consumption. In our project we aim to open up this circular economy to achieve adaptivity.

In relation to this we aim to support the existence and creation of several public goods. In the first and second place come food security and a clean environment for all living beings. In the third place knowledge on the food and the production system should be available to the public. This supports the creation of a community feeling in relation to food. Lastly, renewable energy has to become a public instead of only being available for the elite.

alignment with current policies

figure 8: sustainable developments goals (UN, 2016)

The Sustainable Development Goals (figure 8), created by the United Nations, are a call for action by developed and developing countries to achieve prosperity for all global citizens in 2030 (UN, no date b). It is important in our project to pay attention to several SDG's as they address urgent problems. However we do feel that most of the SDG's are focussed on improving developing countries, instead of changing the attitude of developed countries. Therefore changing the European mindset will be an addition to the below mentioned SDG's.

Our main aim is directly related to SDG no.12 'Responsible consumption and production'. The targets focus on sustainable programs and management of resources as well as reduction of waste and raising awareness. The protection of the environment and its resources relate to SDG no.15 'Life on Land' and SDG no.07. 'Affordable and Clean Energy'. 'Life on Land' focuses on making natural lands more resilient and regenerating forests and draining agricultural soils. 'Affordable and Clean Energy' is a supporting factor, because energy is needed to cultivate, process, pack and bring the food to European citizens' tables (Monforti et al., 2015). By increasing renewable sources or rethinking the use of waste we make a positive contribution to the increase of clean energy. Food security and equality for all is linked to SDG No.02 'Zero Hunger': the goal is to give the poor and vulnerable access to food, whilst increasing small-scale production and using resilient agricultural practices. Creating economic feasibility for every country is related to SDG no.08 'Decent work and economic growth' in which economic prosperity is related to diversification, innovation and effective use of resources.

policy alert

Dutch Circular Agriculture Vision in 2019

Dutch Government announced its vision for Circular Agriculture and set out the ambition of making the Netherlands a global leader in circular agriculture by 2030.

policy alert

Gemeenschappelijk landbouwbeleid (GLB) vanaf 2023

National Programme to give subsidies to sustainable and young farmers. The program takes place from 2023 to 2027 (RVO, 2023). It seems though that farmers with larger agricultural land receive more subsidies, which we do not support.

policy alert

Farm to Fork, 2019

Besides food security and safety, its main goals are operating within the planetary limits, promoting sustainable production and consumption and a healthy diet

policy alert

Hoofdlijnennotitie vitale landbouw Zuid-Holland, 2020

Basic guidelines for a vital agricultural sector in South Holland. (Provincie Zuid Holland, 2020)

The aim of 'Aan Tafel!' resonates with the European Green Deal and the Dutch National Circular Economy Programme.

The Green Deal is a collection of policy initiatives created in 2019 to guide the European Union towards climate neutrality in 2050 (European Council, 2022). Part of this is to reduce greenhouse gas emissions by 55% in 2030 and to tackle problems related to climate change, biodiversity and the current EU food system. The strategy for shifting the EU food system 'Farm to fork' aligns with our project aim.

The goal of the Dutch National Circular Economy Programme is to live within the planetary boundaries and to restore the balance between nature and human activities (Ministerie van Infrastructuur en Waterstaat, 2023). Crucial in its achievement is to implement circularity based on the concept of the R-ladder: narrowing the loop, slowing the loop and closing the loop (Ministerie van Infrastructuur en Waterstaat, 2023). The goals for 2030 are reducing resource usage, increasing secondary and renewable bio-resources, increasing product lifespan and increasing recycling. These ideas fit well with our aim and inform us on actions to take.

2 // methodology

methodology flowchart

research question

theoretical framework

conceptual framework

Chapter two explains the research questions that are answered surrounding the topics of the food production system, the net-zero carbon food-print and the open circular economy. It also offers the theoretical framework that was used in this project as well as the conceptual framework.

methodology flowchart

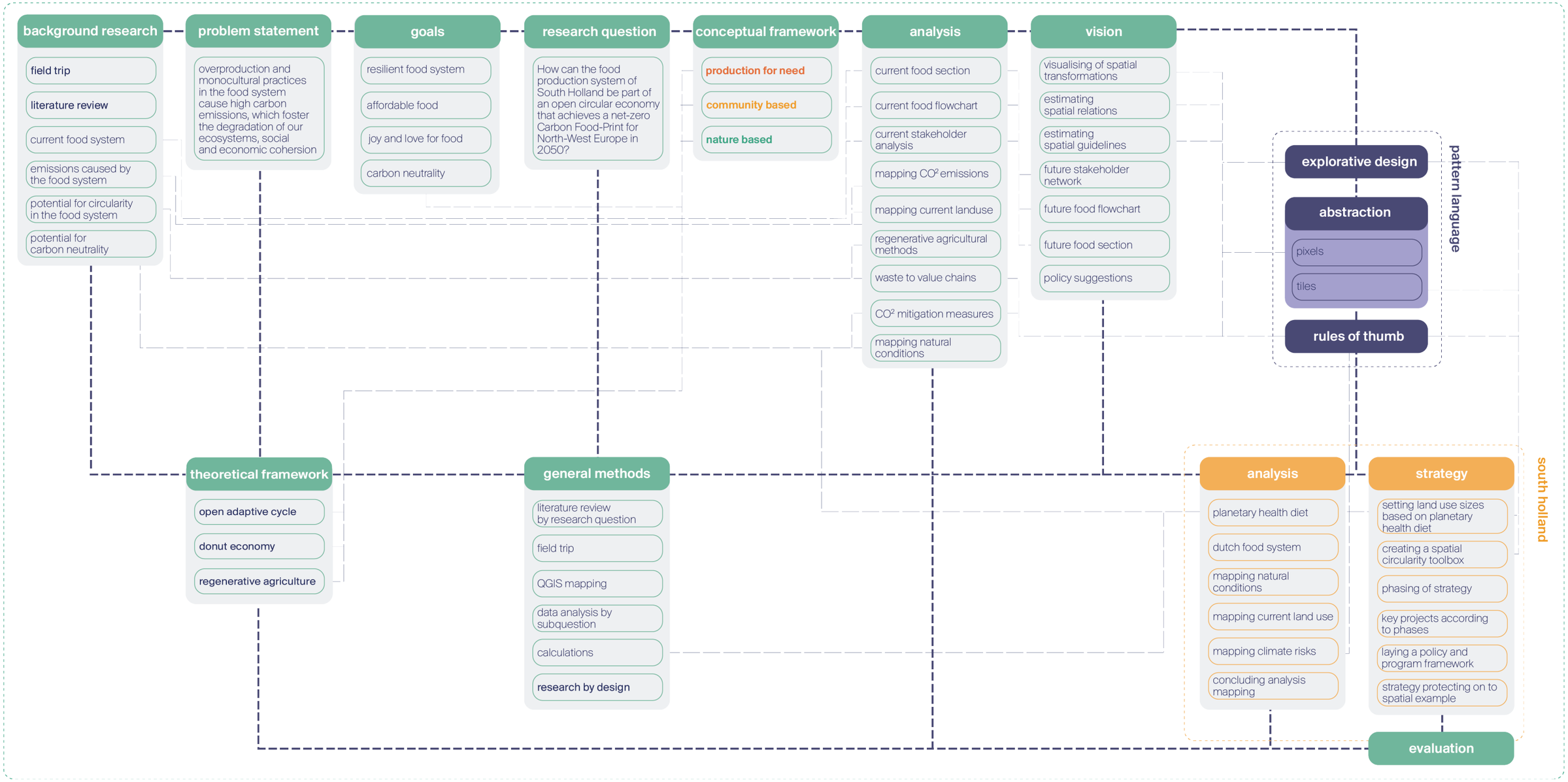


figure 9: methodology flowchart of the report

research question

“How can the **food production system** of South Holland be part of an o**pen circular economy** that achieves a **net-zero Carbon Food-Print** for North-West Europe in 2050?”

food production system

This system “includes all the materials, processes and infrastructures relating to agriculture, trade, retail, transport and consumption of food products” (Definition by European Environmental Agency, 2014, paragraph one). Agriculture in this case relates to the science or practice of farming, including cultivation of the soil for the growing of crops and the rearing of animals to provide food (Park, 2007). Therefore we restrict the scope of this research to livestock and agricultural farming in North-West Europe.

sub questions

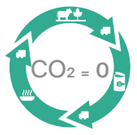
- Which processes are part of the food production system in North-West Europe and South Holland?
- What are the main livestock and agricultural foods produced in North-West Europe and South Holland?
- What is the opinion of current stakeholders in the food production process in North-West Europe on changing the food production system?

open circular economy

“Net zero means cutting greenhouse gas emissions to as close to zero as possible, with any remaining emissions re-absorbed from the atmosphere” (UN, no date a). In our definition we cover CO_2 equivalent emissions from all greenhouse gases: CO_2, F-gases, CH4 and N2O (Ritchie et al., 2020).

sub questions

- How does the concept of an open circular economy work in the context of the food production system?
- What innovations for food production in the open circular economy mitigate the carbon footprint?
- What are the economical-social-environmental challenges producing food in an open circular economy?



net-zero carbon food-print

The circular economy is a “model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible.” (European Parliament, 2023). The open aspect of circular economy will be explained in the theoretical framework.

sub questions

- Which areas in North-West Europe are most affected by greenhouse gas emissions released by the food production system?
- Which state-of-the-art measures are suitable for mitigating CO_2 equivalent emissions of the food production system?

theoretical framework

open circular economy

The Circular Economy is a different approach to economic production. It departs from a linear "take-make-consume-throw away"-model (European Parliament, 2023, paragraph 2) and arrives at a circular model. Its leading concepts are rethink, reduce, re-use, repair, recycle and recover (Kishna, 2019). Sustainability is achieved by minimising the production of waste and stimulating the principles of recovering, repurposing and reconnecting the paths of by-products into closed loops (De Boer et al., 2018; Ministerie van Infrastructuur en Waterstaat, 2023).

We approach the open circular economy by using the concept of the panarchy. The panarchy is a conceptual model that describes "the ways in which complex systems of people and nature are dynamically organised and structured across scales of space and time" (Allen et al., 2014). In the concept of the panarchy both small-scale and large-scale processes can influence the functioning of the system. As seen in figure 10 change can come from top-down (remembering) as well as from bottom-up (revolting) (Gunderson and Holling, 2002). The possibility for cycling on the small and large scale "emphasises cross-scale linkages whereby processes at one scale affect those at other scales to influence the overall dynamics of the system (Allen et al., 2014).

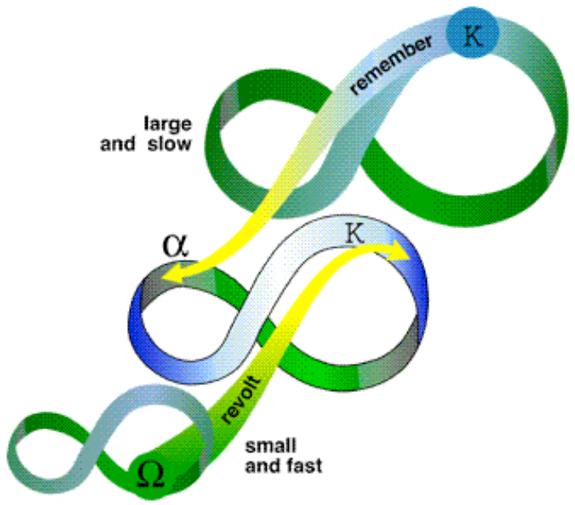


figure 10: concept of panarchy diagram (Gunderson and Holling, 2002)

doughnut economy

The Doughnut as visible in figure 11 "combines two concentric radar charts to depict the two boundaries—social and ecological— that together encompass human wellbeing" (Raworth, 2017, p.1) The concept by Raworth (2017) shows that by respecting these boundaries prosperity for humanity can be achieved whilst living within earth's limits. When the inner boundary falls short it indicates problems related to human well being, when the outer boundary is overshot it indicates problems with overusing earth's resources. The concept of the Doughnut Economy proposes to move away from an economic mindset of profit towards the mindset of prosperity, in which

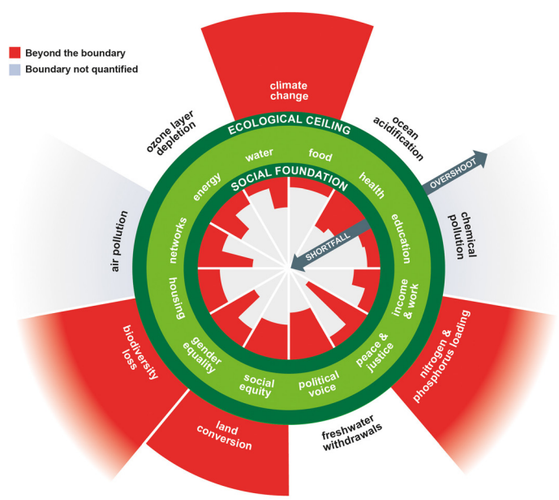


figure 11: doughnut economy diagram (Raworth, 2017)

cooperation is cooperative instead of competitive (DEAL, no date). This can be aligned with the idea of 'governing the commons' by Ostrom in which a common source should be managed in a collective way (1990).

agriculture nature-based solutions

"Agriculture Nature-Based Solutions (Ag-NBS) are an effective, long-term, cost efficient approach to tackling sustainable land and water resources management and climate change." (Food and Agriculture Organization of the United Nations, no date, sentence 1) Nature-Based Solutions stimulate natural processes that support agricultural produce (Iseman & Miralles-Wilhelm, 2021). This results in an economic benefit in addition to the societal and ecological benefit by increasing yields and reducing costs (figure 12). Lasting changes for landowners can be made with the support of new technology and funding (Iseman & Miralles-Wilhelm, 2021).

Part of the wide range of practices are regenerative agriculture, conservation agriculture and agroforestry. In these practices there are ranges of actions that farmers can take from tillage of crops, management of nutrients, grazing and animal management to incorporating trees and seaweed aquaculture (Iseman & Miralles-Wilhelm, 2021).

Globally policy makers have to work together with agricultural producers to create laws, regulations, subsidies for the implementation of sustainable and regenerative methods (Iseman and Miralles-Wilhelm, 2021).

figure 12: the benefits of nature-based solutions (IUCN and Geneva Environment Network, 2022)

conceptual framework

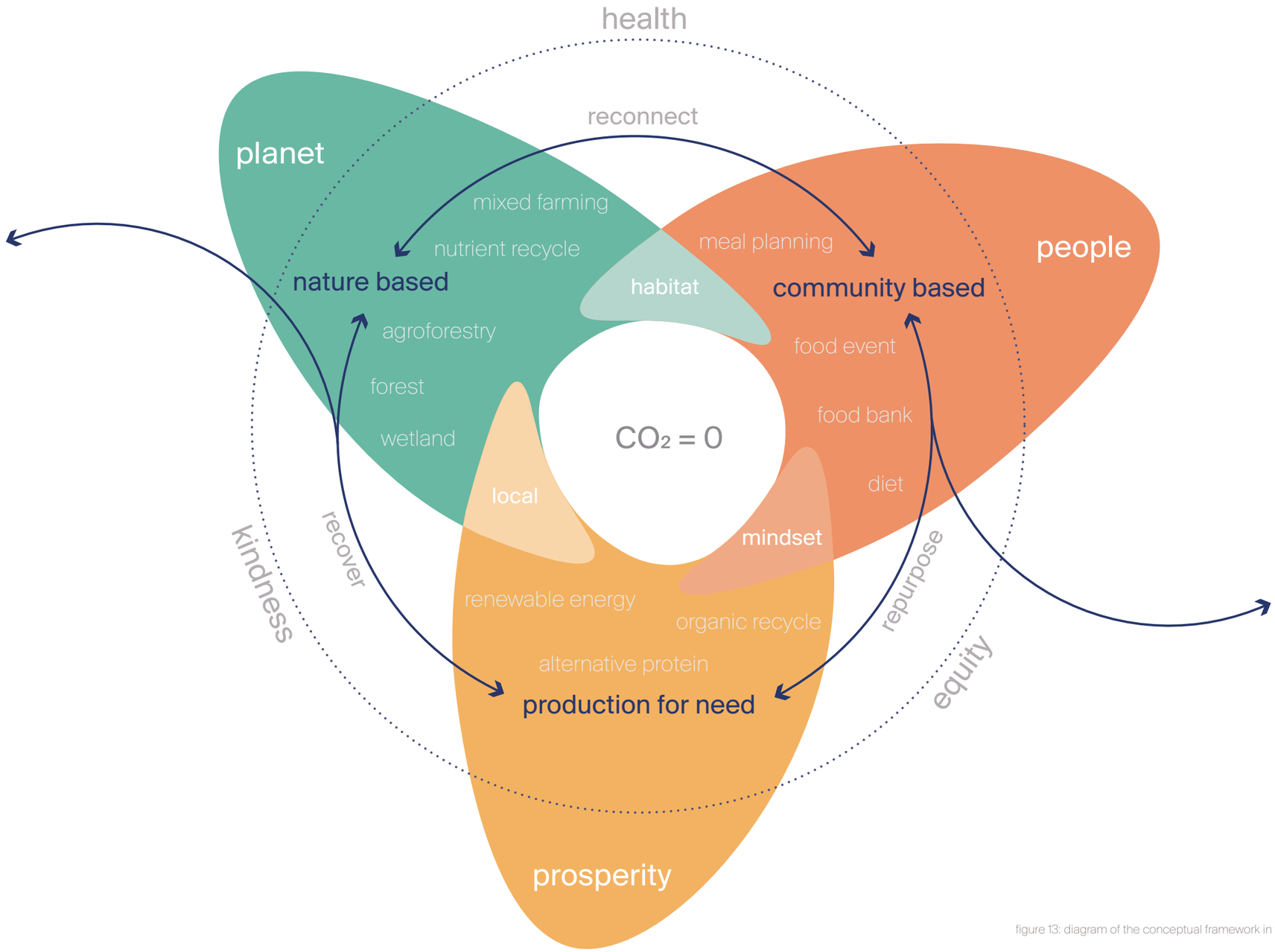


figure 13: diagram of the conceptual framework in the food production system of North West Europe

Our conceptual framework is based on the cycle of the Open Circular Economy and our three project pillars (figure 13). In the middle lies the goal of achieving net-zero carbon emissions.

The open cycle shows the idea of the open Circular Economy: processes relating to each other through the scales can create adaptivity. By receiving by-products from cycles on different scales the system can continue to operate if one falls away. Inside the green, orange and yellow area we show our project pillars and their relation to the 3Ps of sustainability.Production for Need, Community Based and Nature Based follow the logics of the Doughnut Economy and Governing The Commons. The pillars help us to change the relationships between people, prosperity and planet.

The arrows connecting the three pillars are inspired by the R-ladder of the Circular Economy and focus on rebalancing the system. The planet has to recover to achieve prosperity; The planet and the people have to reconnect; and people have to repurpose to reach prosperity. Inside the cycle methods are listed which make the execution of our pillars possible. In the overlapping areas the pillars meet and show in which part of the food production process their focus lies. Planet and people relate to the habitat of nature and communities; People and prosperity need a mindset that both supports production and communities; and planet and prosperity need to have a local focus. This whole system relies on the core values of health, kindness and equity.

3 // food production system

In chapter three we take the reader along the chain of food production. Insight into each step is accompanied by its implications in space. Additionally we analyse the relationship of the current stakeholders. Lastly we give an explanation on how the current production system influences greenhouse gas emissions.

functioning

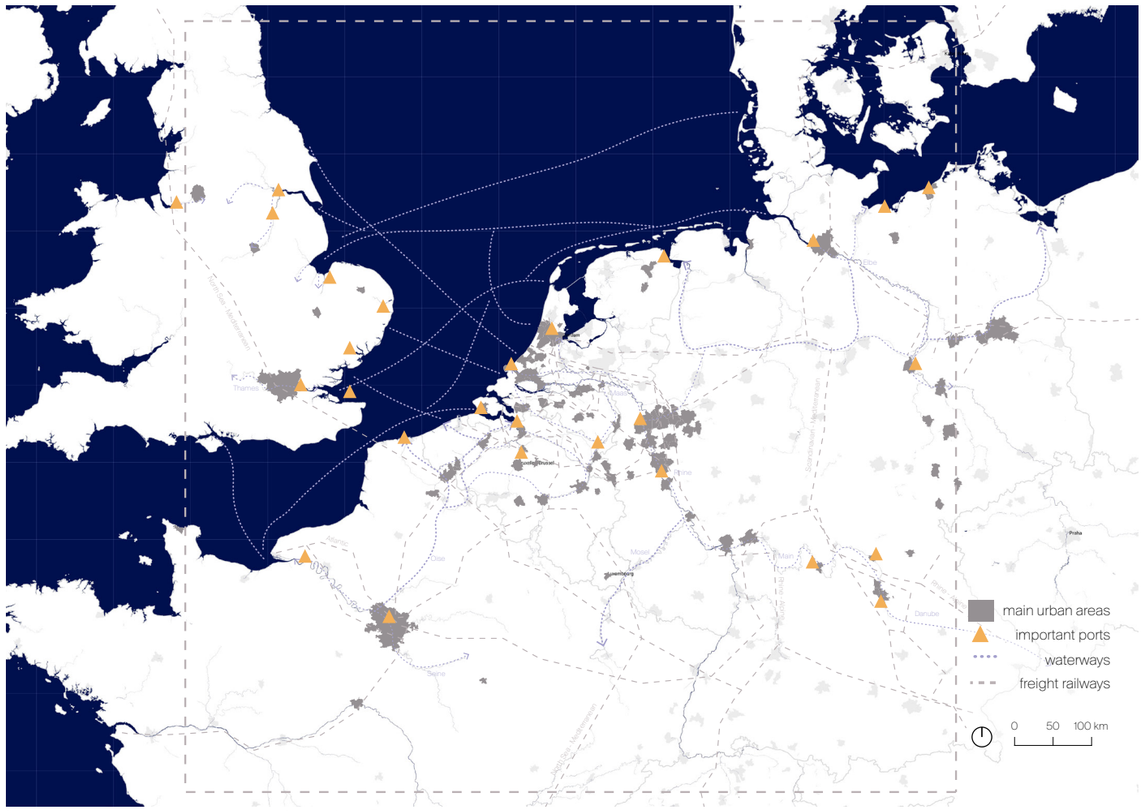


figure 14: transportation network map in North-West Europe

figure 15: transportation network map in South Holland

The food production system of North-West Europe is part of the current linear economic model of “take-make-consume-throw away”. The different parts of the food production system can be reduced to land-use, production, processing, retail and consumption (Van Genuchten, Mulder and Schaaf, 2017). We will address the separate parts of the food production system in the following section.

The linearity of the system is visible in the conceptual section (figure 20). The flowchart (figure 21) shows that the output of the previous step equals the input of the next step. The production of the individual supply chains results in: products, by-products and waste. The by-products and waste from spoilage and food loss are currently burned or brought to a landfill.

In both the section and the flowchart, the transport network makes the exchange of products possible.

In Europe several freight railways connect North-West Europe to Scandinavia, the Mediterranean and the UK (figure 14).
The rivers form major transportation corridors from the main ports of Rotterdam, Antwerp, Hamburg and Le Havre (RRG, 2011). Rotterdam as Europe’s biggest port lies in the heart of South Holland (figure 15). This makes the province well connected, although there is a clear difference between the urban and peri-urban areas with the latter having a disadvantage.

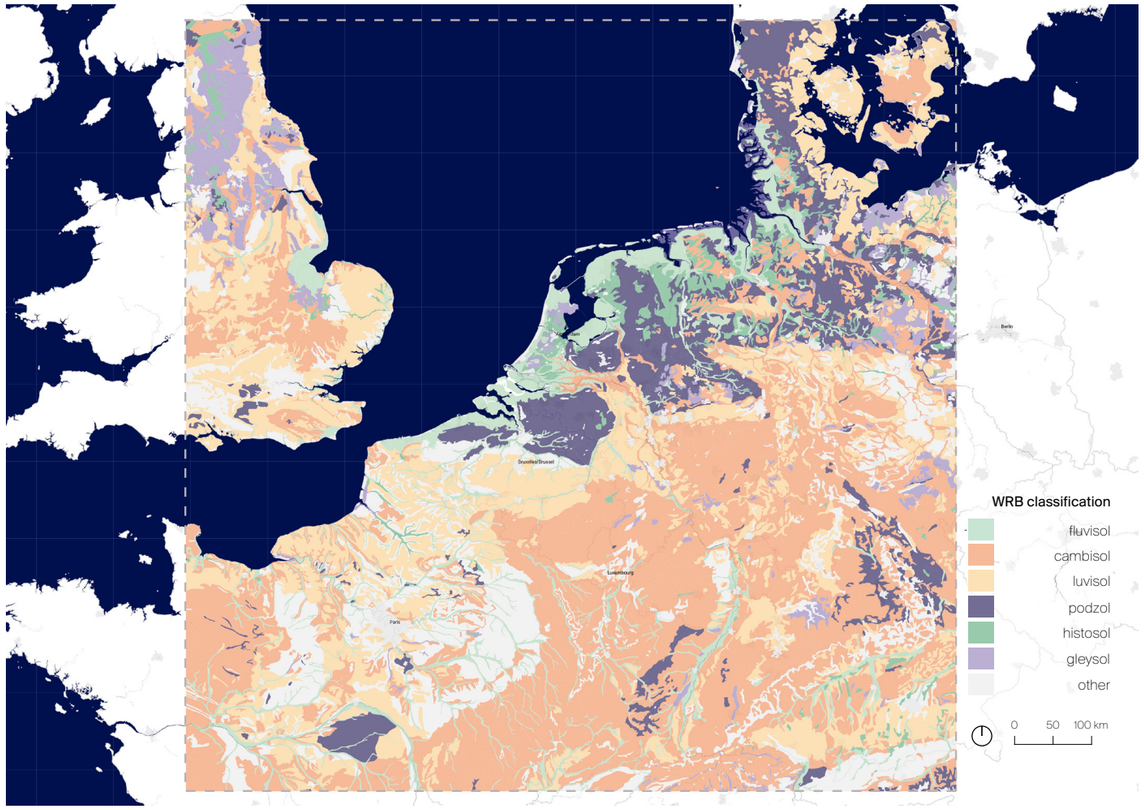


figure 16: soil conditions map in North-West Europe

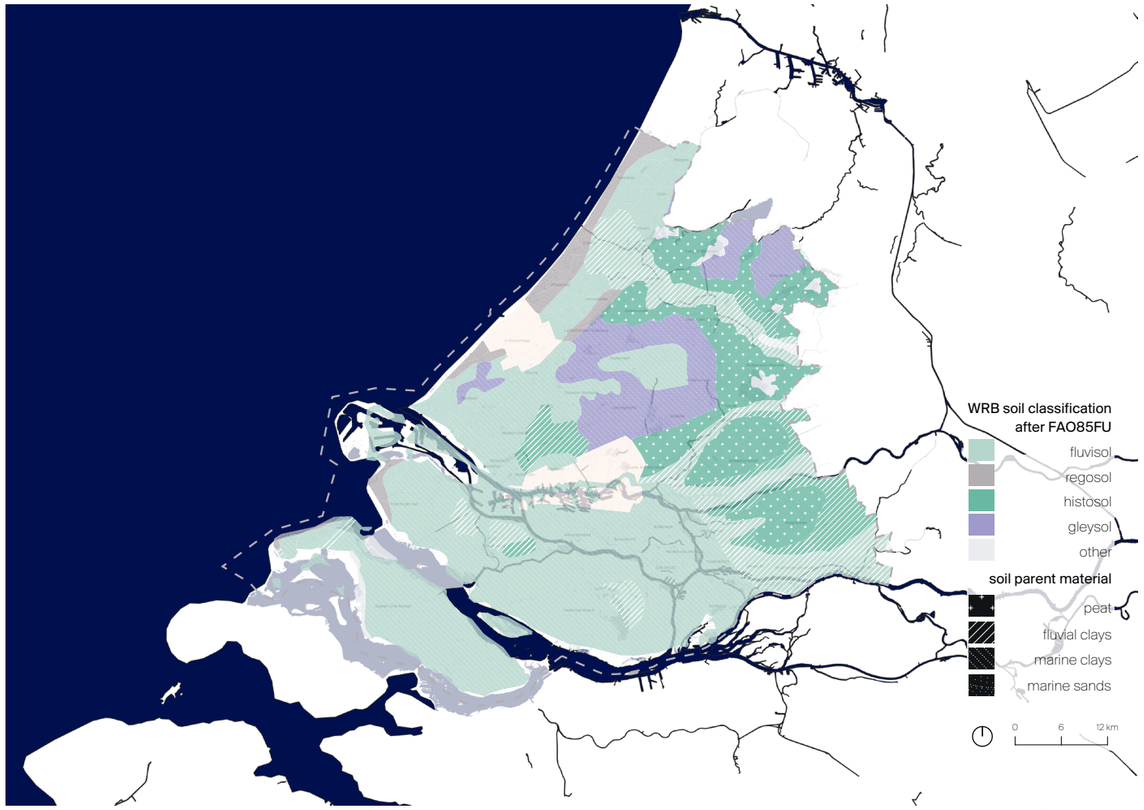


figure 17: soil conditions map in South Holland

Land-use refers to the cultivation of natural land (step 1 in figure 21) for either crop production or livestock (Ritchie, 2019). This is done through deforestation and drainage and the burning of organic soils (Food and Agriculture Organization of the United Nations, 2021). The quality of the soil influences the yields or the possibility to raise livestock. An excessive use of fertilisers and pesticides lead to its degradation over time (European Soil Bureau Network European Commission, 2005). The current nitrogen crisis in the Netherlands only further exemplifies the need to take better care of our grounds.

In North-West Europe some of the most fruitful soils are along the rivers and their estuaries. Their soils are dark and base-rich. The chalk and limestone plateaux of Southeastern England and the Paris Basin are heavily exploited for grain production. Looking at the WRB-Classification, we can identify six main types in North-West Europe (figure 16):

- Cambisols are agriculturally productive brown soils.
- Fluvisols lie along river deltas. Their fertility depends on the sedimentation process between floods.
- Gleysols need to be intensively managed in order to be of agricultural potential.
- Histosols are peaty soils.
- Luvisols vary a lot according to their parent materials.
- Podzols are well-drained

In South Holland we can identify the parent materials of the soils more closely (figure 17). Marine clays as well as fluvial clays are most present in Fluvisols, with a few in Gleysols. The dunes consist mainly of marine sands in Regosols, an undeveloped soil (European Soil Bureau Network European Commission, 2005).

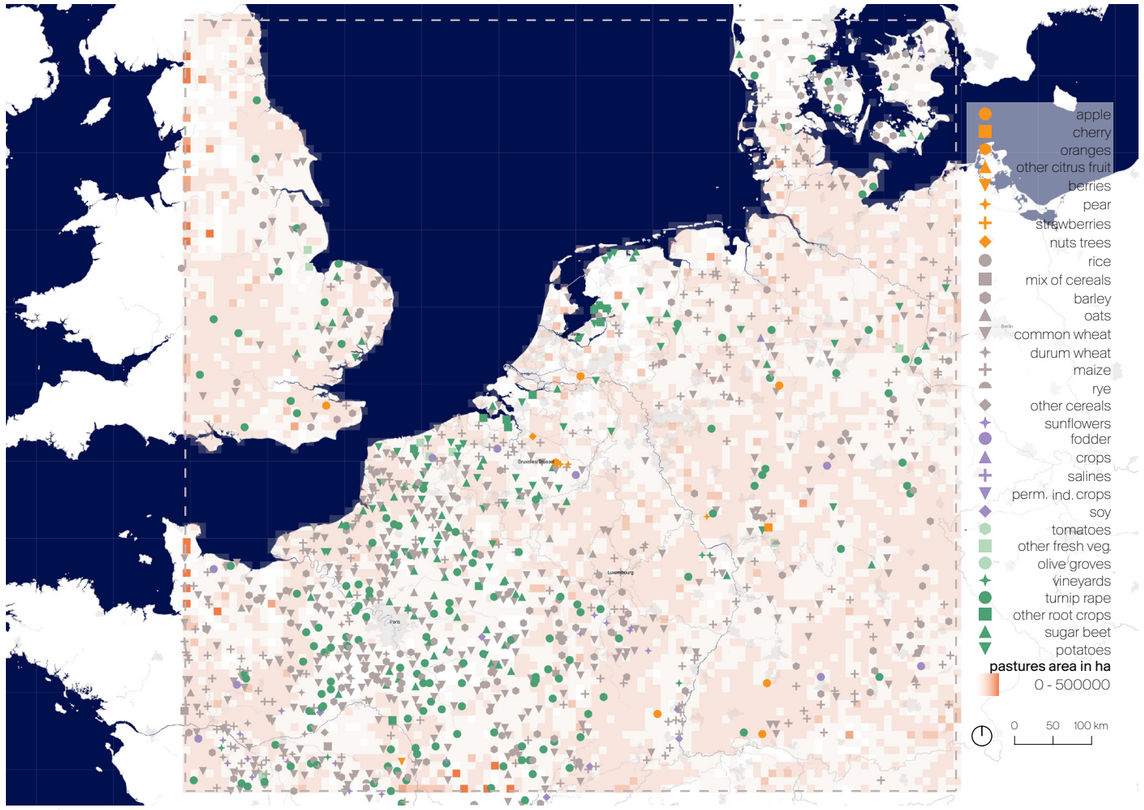


figure 18: agricultural distribution map in North-West Europe

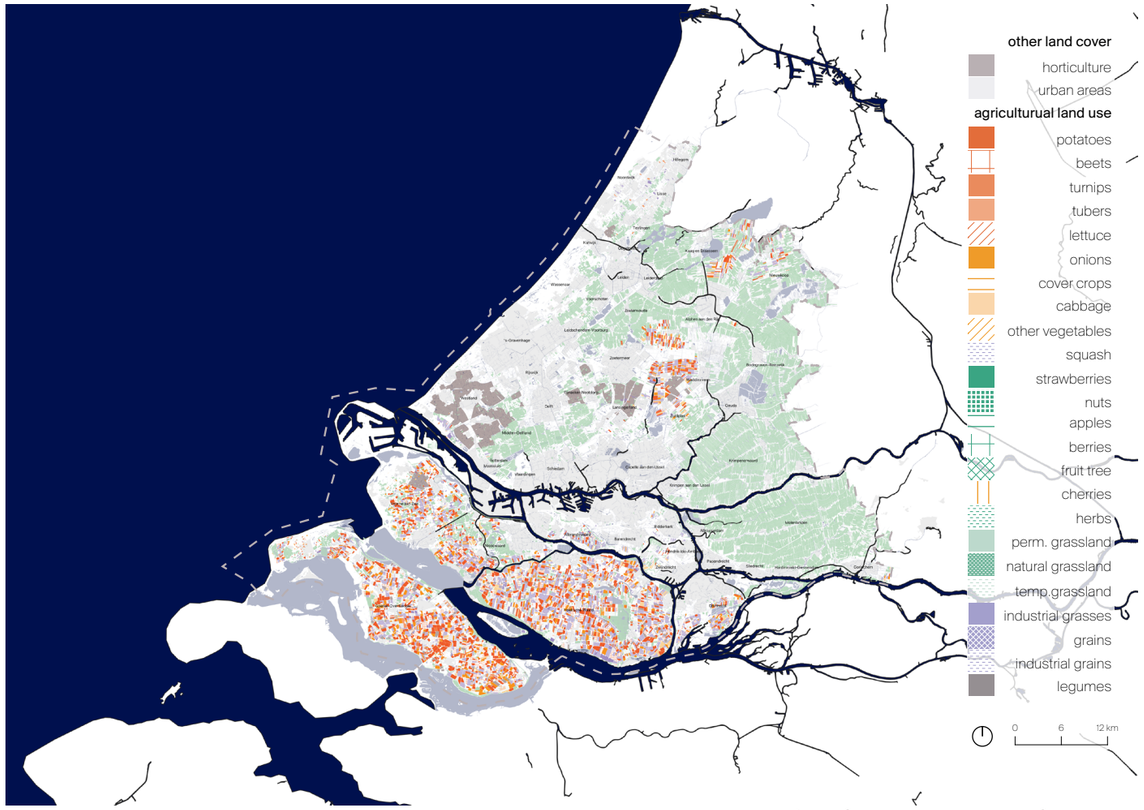


figure 19: agricultural distribution in South Holland

Production relates to the growing of crops and the rearing of animals (step 2 in figure 21). The production possibilities and the yield is influenced by both natural conditions, related to soil and water, and human conditions related to energy (Del Borghi et al., 2020).

Agricultural production in North-West Europe includes both livestock and crop farming (figure 18). A production of grains, mostly common wheat and barley, and tubers such as potatoes and sugar beets is present in all countries with differences in amount. There is a striking amount produced in France (Eurostat, 2022). Legumes and fruits only appear occasionally. Livestock farming is ever present ranging from the low northern coasts to the Alpine pastures. There is a difference of sizes of pastures visible: big farms are present in the north of Germany and Netherlands and throughout the UK. Average too small farms occur in the majority of Germany, Belgium and France.

There is a clear distinction in the production landscapes of South Holland (figure 19). Eastern South Holland is characterised by grasslands for cows and sheep. The middle of South Holland is home to its urban and horticulture centres. The greenhouses of Westland and Oostland produce a large amount of the province's tomatoes, lettuce and flowers and export worldwide (Reiley, 2022). In contrast the South Hollandic Islands are marked by wide fields of open field crop production. Similar to the average in North-West Europe its main crops include tubers and grains like potatoes, beets, wheat, barley as well as onions and flowers (PDOK, 2022).

processing, retail, consumption

During the processing phase (step 3 in figure 21) the produce is converted into a final product (Ritchie, 2019). This process requires both energy and resources and produces large amounts of by-products. The production of peels, trimmings, stems and shells can not be prevented, however they are inedible to humans. In addition 13.3% of food is lost during this phase according to the United Nations data published in the Sustainable Development Goals Report in 2022. This relates to losses from spoiled food (Ritchie, 2019) as well as losses from disapproving oddly-shaped or -coloured produce (Cairn et al., 2021). These 'ugly' products fail to meet requirements even though they are edible .

Retail (step 4 in figure 21) directly influences the way people perceive and consume food through marketing strategies (Cairn et. al., 2021). In this phase food gets sold in stores.

The mindset of people in the linear economic model results in both over consuming and wasting food. The food loss in retail and consumption adds up to 17% (UN, 2022). The flowchart (figure 21) shows the loss stems from plate waste and spoilage of food.

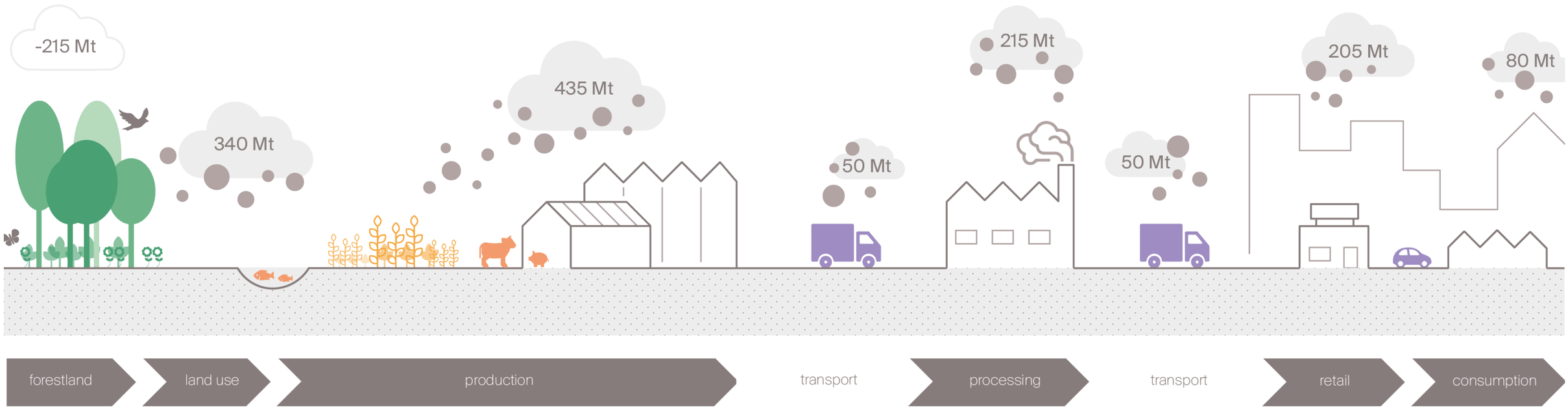


figure 20: section of flows in the current food production system

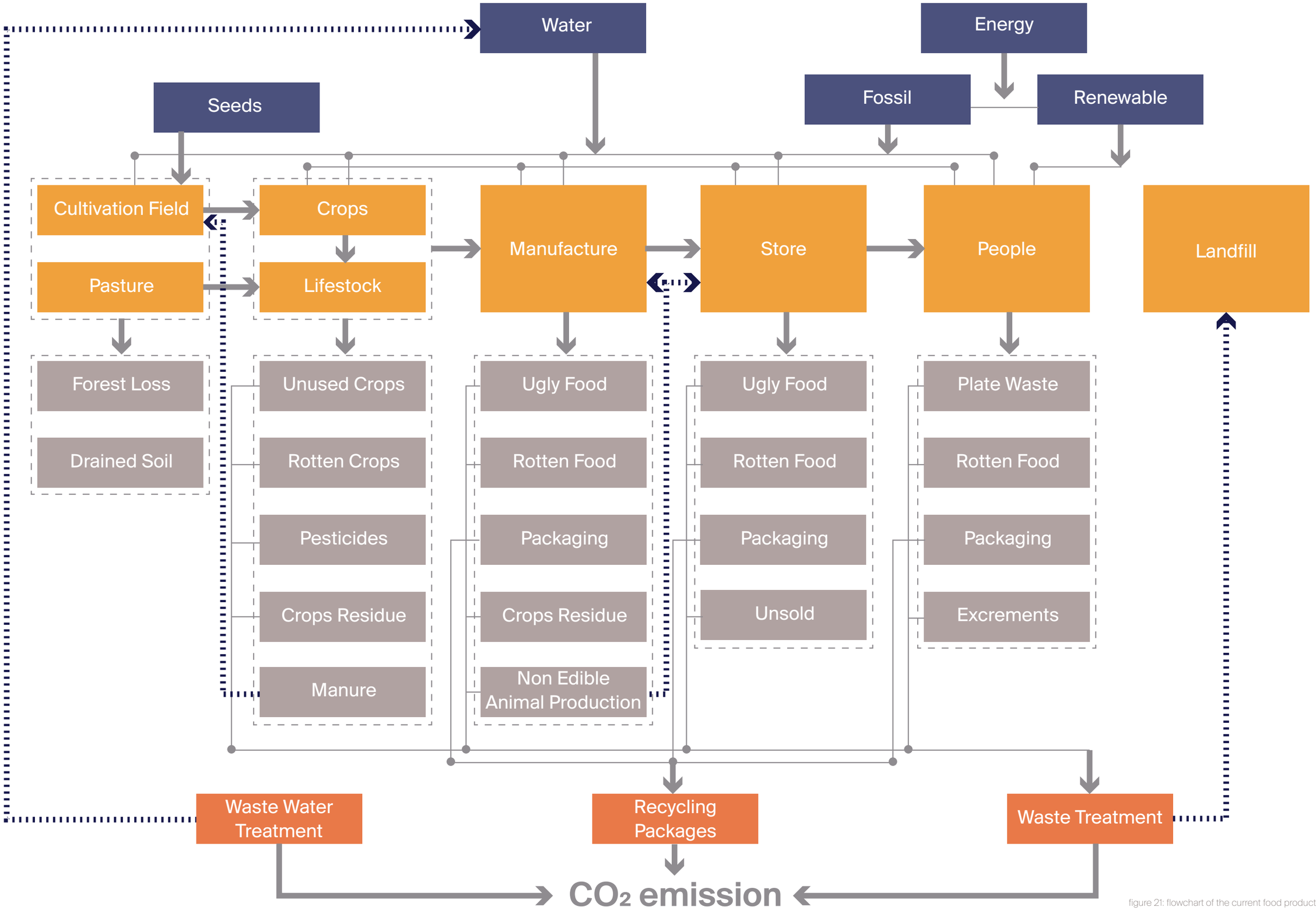


figure 21: flowchart of the current food production system

stakeholders

Different parties, the so-called stakeholders, are involved in the food production system. They are mostly people, companies or objects that can be categorised into the public, private or civil sector. Their sector determines their kind and amount of power (Rocco, 2021).

The stakeholders can be divided into five different groups, based on power and interest in relation to the main research objective (figure 22 and appendix 09). The people (consumers and farmers) who have the least amount of power and interest in changing the system (Fieldfisher, 2016). The service industry (energy companies and waste treatment companies) have a little more power as corporations, but still have little interest (Mesiranta et al., 2022). Next the biggest player, the food industry (wholesalers, food processors, farming companies, transport companies, and stores, supermarkets and restaurants) which has enormous power and also some interest in changing their industry (Fieldfisher, 2016). The government (EU and NL) has the most power and the most interest (Ministerie van Economische Zaken en Klimaat, 2016). Lastly, the silent stakeholders (nature, future stakeholders, and cattle, fish and poultry), a group with no power unless presented by another stakeholder.

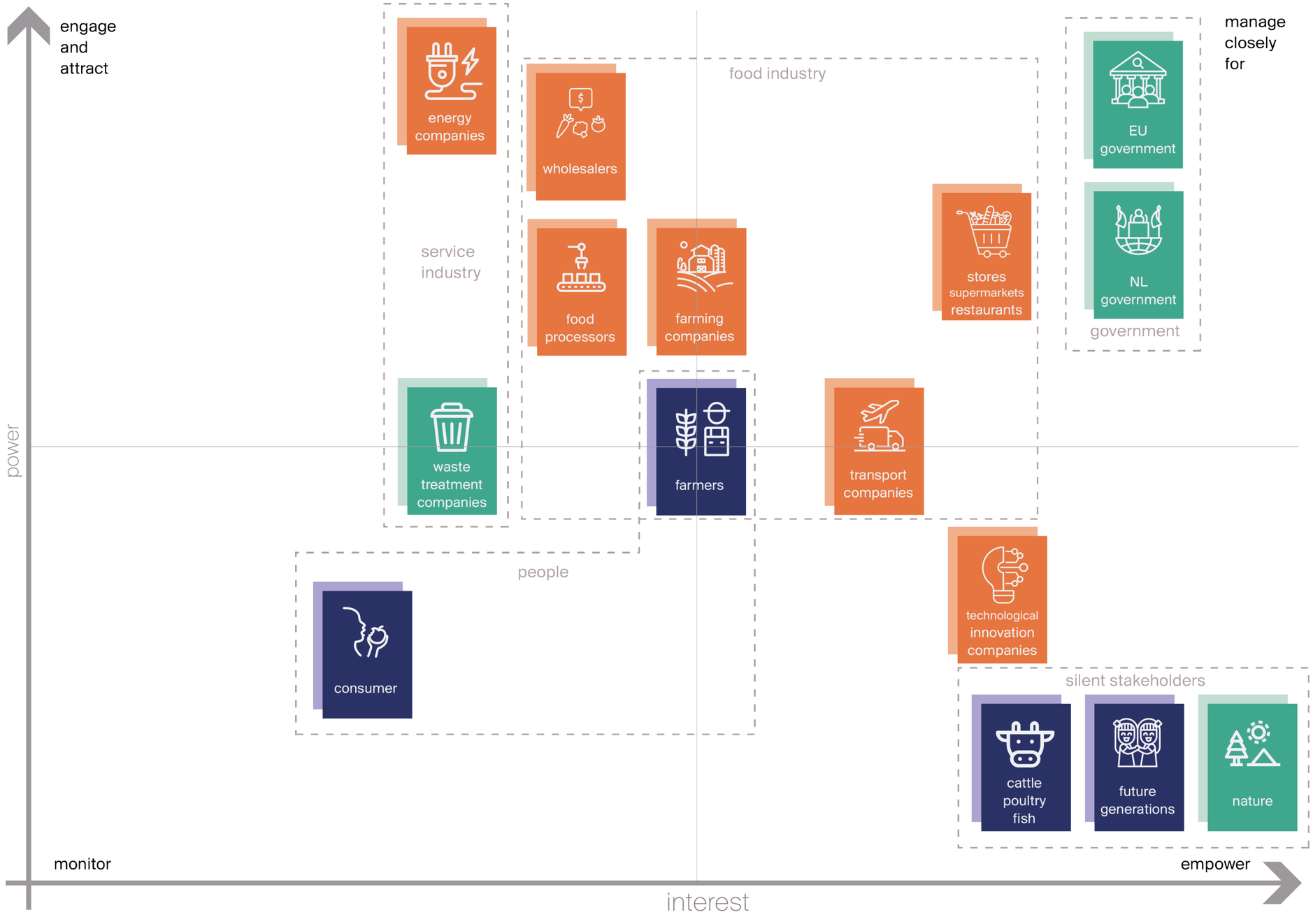


figure 22: power-interest matrix of stakeholder analysis in the current food production system

stakeholders relationship

In general the food industry and the silent stakeholders conflict the most. The food industry caters to the needs of the consumer, while also trying to make a profit. This results in an unsustainable capitalistic climate in which the resources that also belong to the silent stakeholder get exhausted. The stakeholder that can change the way the food production system works is the government. It regulates the playing field of the system.

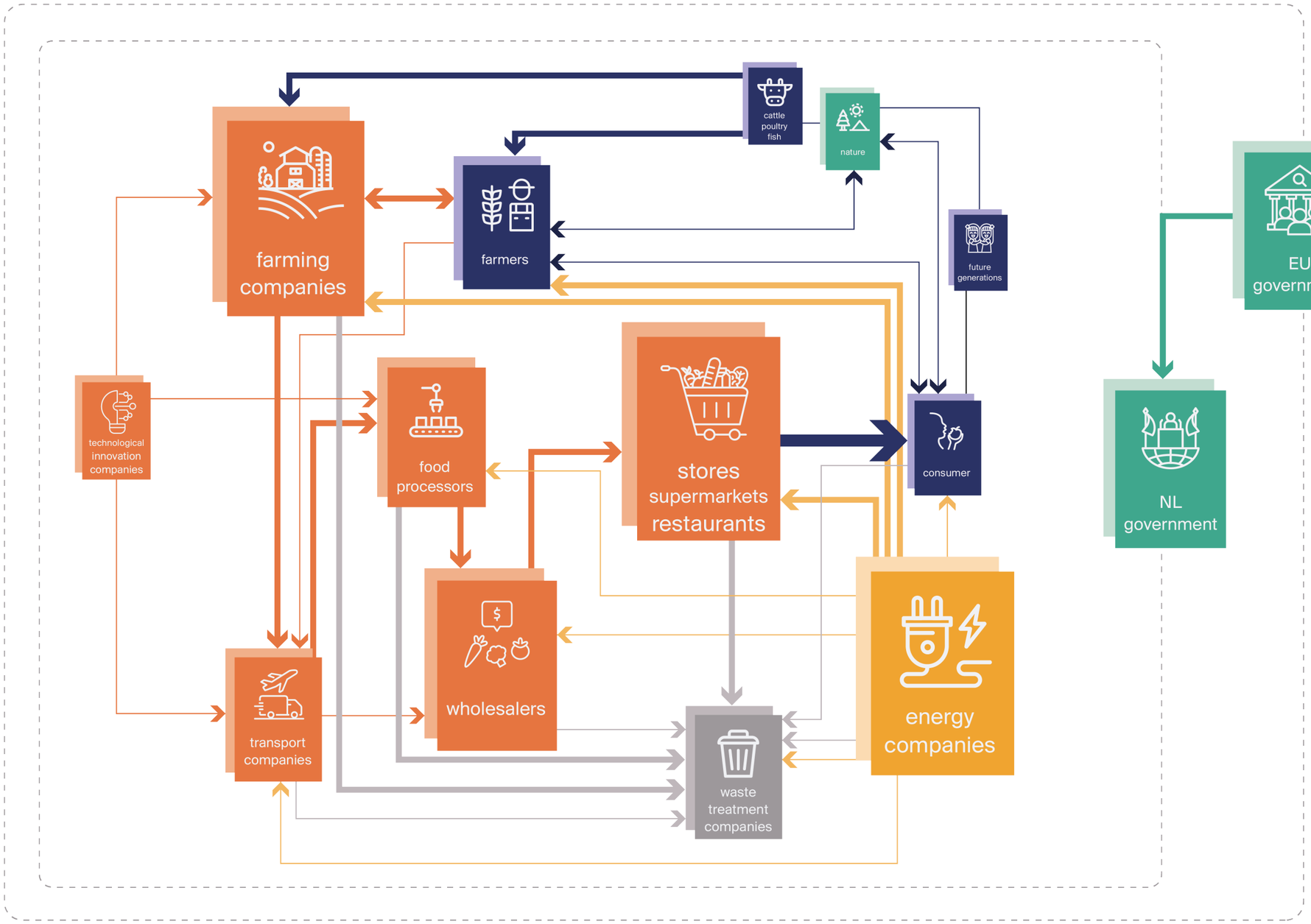


figure 23: stakeholders influence and relationships diagram in the current food production system

stakeholders statements

The Dutch government is paving the way to a more sustainable food production industry: ''In 2030 we want to be a circular nation, we are planning for a stable future, sustainable economy, also for the future generations'' (based on Ministerie van Infrastructuur en Waterstaat, 2022).

''We hold a big key in reducing greenhouse gases. In order to change we need more money and new strategies to do this. We as companies need to be held accountable'' (based on Hefty, 2020) is the statement of farming companies, governmental policy can give the extra guidance this stakeholder needs.

However, the current consumer mindset: ''I don't believe that my food choices influence sustainability. I think price, taste and individual health are more important than sustainability'' (Van Bussel et al., 2022) needs to be changed as well.

figure 24: stakeholder statements for the current food production system

carbon emissions

Globally the food sector contributes to one quarter of the overall greenhouse gas emissions (Ritchie, 2019). The emissions are related to the different steps in the system based on data gathered by FAO stat (2022, Appendix 14). Waste in figure 25 only relates to burning waste and landfill. Emissions due to food rot or loss are part of the emissions in the separate parts of the production system. The land-use changes for cultivation of the soil resulted in four billion tonnes of CO_2eq emitted in 2018 (Food and Agriculture Organization of the United Nations [FAO], 2021). In North-West Europe this accounts for 10% of the CO_2eq emissions (figure 26). Remaining forest land acts as a carbon sink with Europe sinking -215 mt CO_2eq year (figure 25). However the remaining forest land has declined by 50% in Europe in 2020 in comparison to 2015 (FAO stat, 2020a). Production is the biggest emitter along the food chain with 35% of total CO_2eq (figure 26). According to FAOstat (FAO stat, 2020b) two thirds of all emissions from agriculture stem from livestock due to manure processes and enteric fermentation. The emissions in the crop production mostly result from rice cultivation, fertilisation and draining organic soil (FAO stat, 2021; EEA, 2023). The supply chain accounts for 25% in total. This is related to the burning of fossil fuels for machinery in transport, packaging and processing, but also to food loss (Ritchie, 2019). Emissions in retail are related mostly to energy use due to refrigeration and lightning (Cairn et al., 2021).

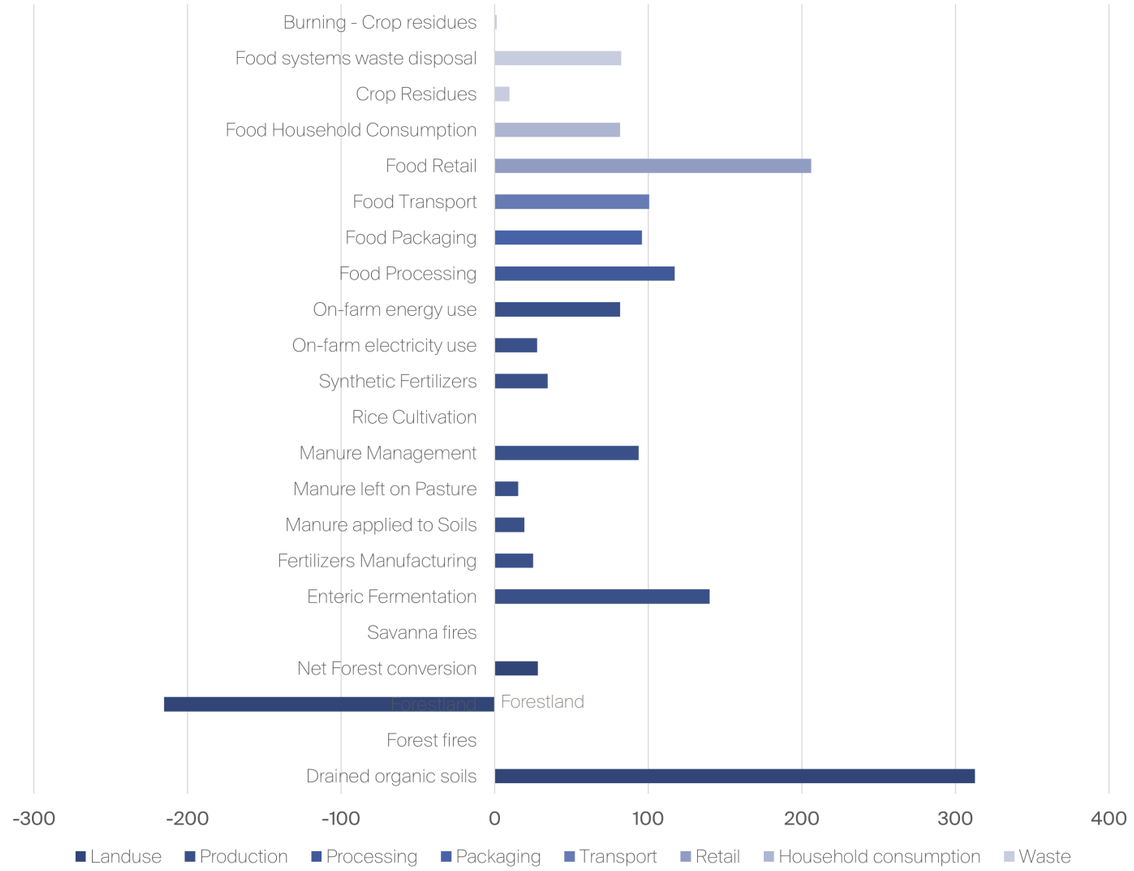


figure 25: CO_2 equivalent emissions released in the food production phases of North West Europe

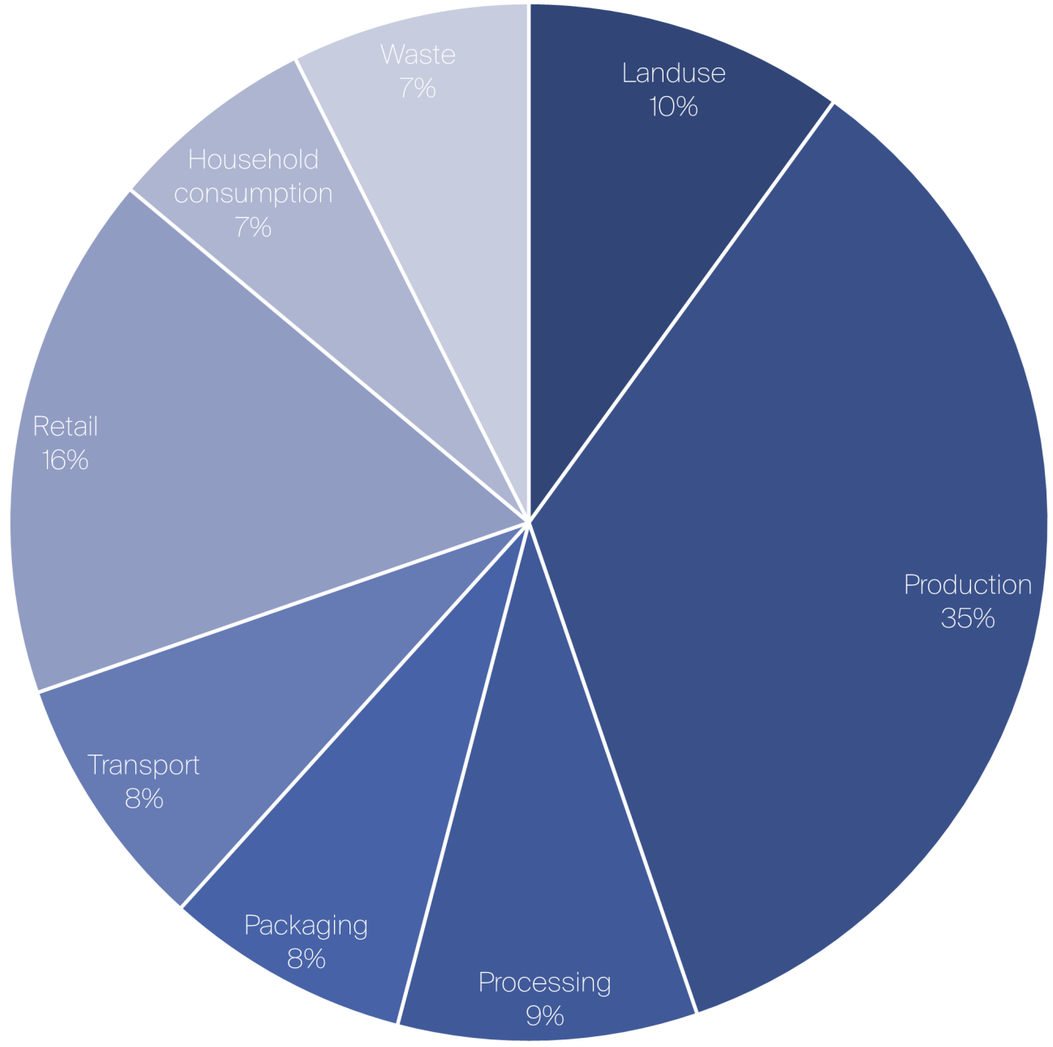


figure 26: percentages of CO_2 equivalent emissions released in the food production phases of North West Europe

GHG emissions analysis

In a next step, we identify areas of North-West Europe which are heavily affected by greenhouse gas emissions in relation to the food sector.

The livestock heatmap shows a major carbon exhaust all over the UK and partially in the Netherlands, Belgium and Germany (figure 28). The exhaust of farming and processing occurs similarly but with a higher overall concentration of farming activities. Moreover, we see a lack of emissions in a few areas with high concentration of pastures. This could be either due Nitrogen as main pollutant or a lack of reporting due to farm size and according to the amount of emission. The crop heatmap shows a main cluster of emissions in the north of France (figure 29). There is a clear distinction between the exhaust of growing versus the processing of crops with the latter exceeding by a huge amount. Which brings us to another factor which is not included in the E-PRTR dataset: the release of CO_2 during the opening of closed soils for agricultural purposes.

In general, common polluters include the farming of animals, such as poultry, swine and dairy cattle. A main polluter in the crop production chain is the processing of grains, potatoes, sugar beets and other starch products. In consequence, the problem of high carbon exhaust mainly lies in the farming of animals and the refinement of crops (figure 27).

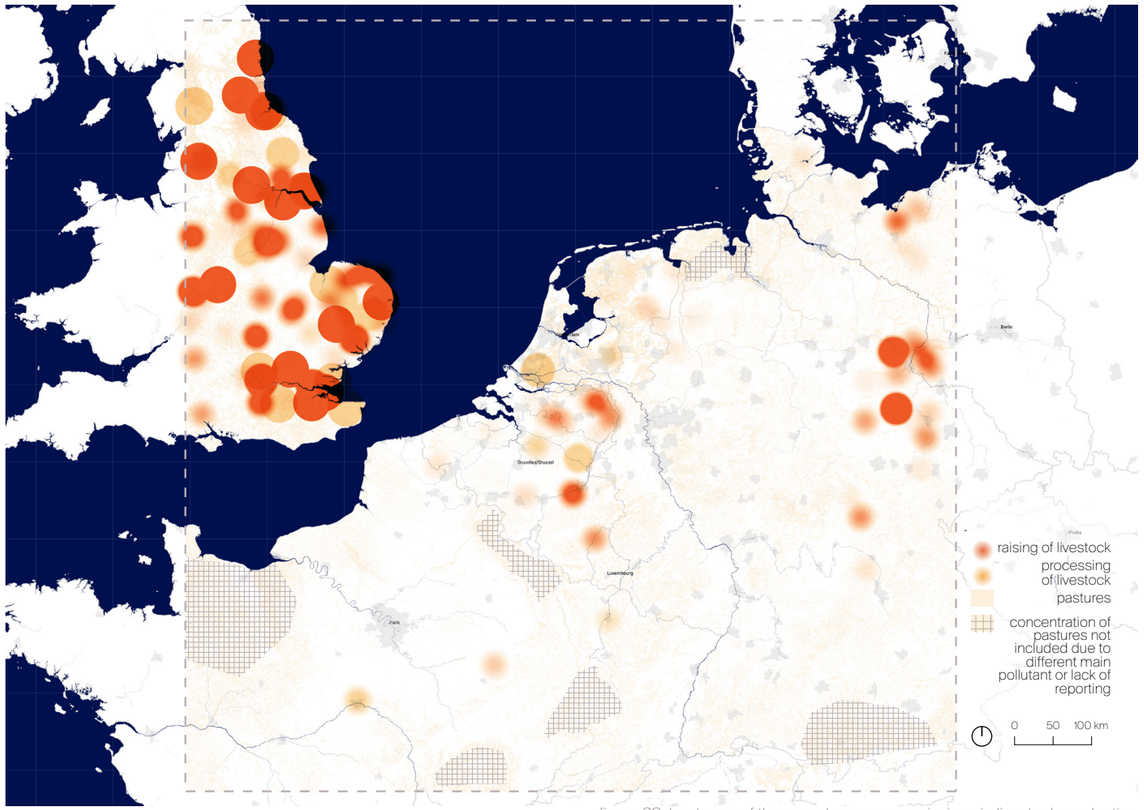


figure 28: heat map of the greenhouse gas emissions in livestock production

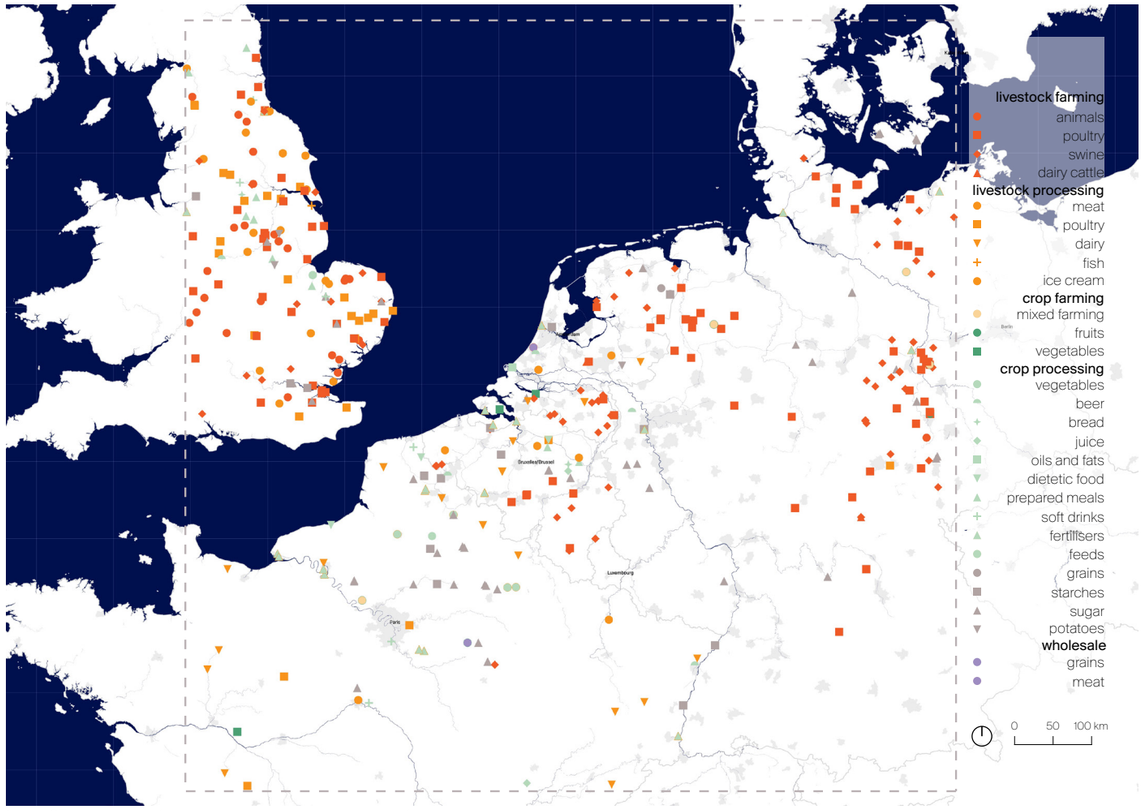


figure 27: point map of the greenhouse gas emissions in food production and processing

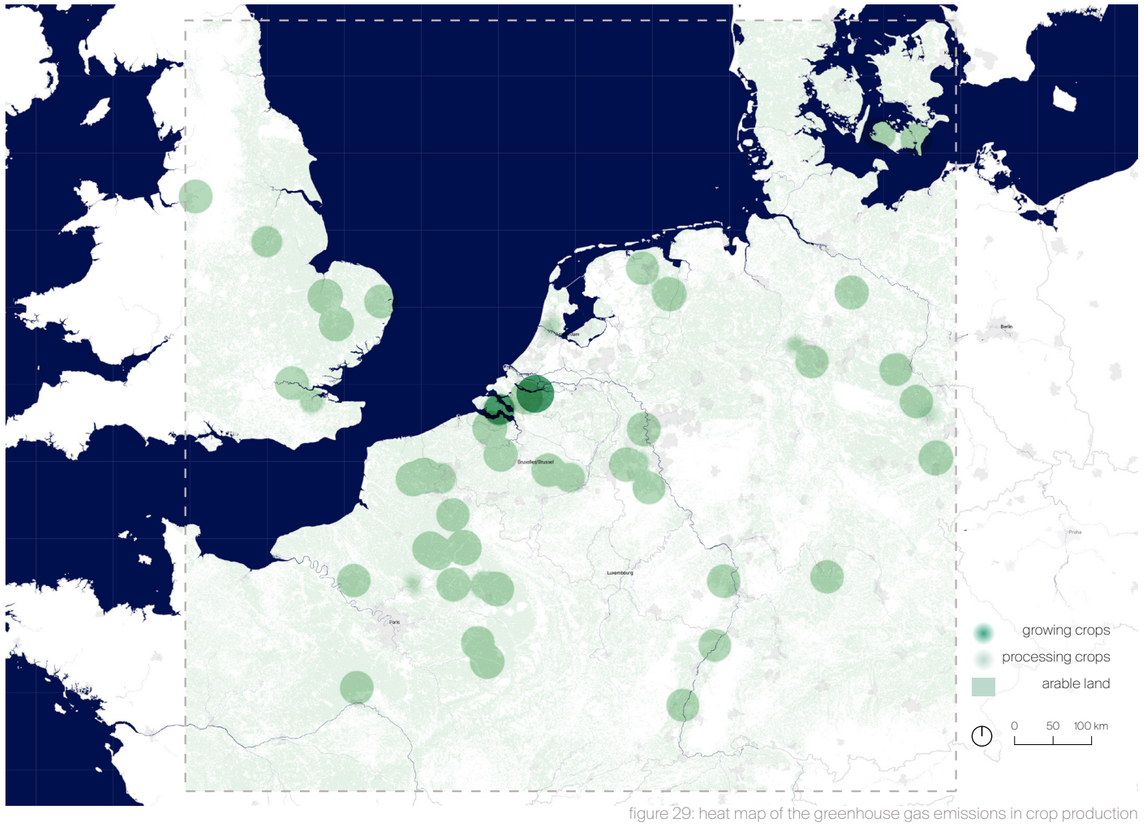


figure 29: heat map of the greenhouse gas emissions in crop production

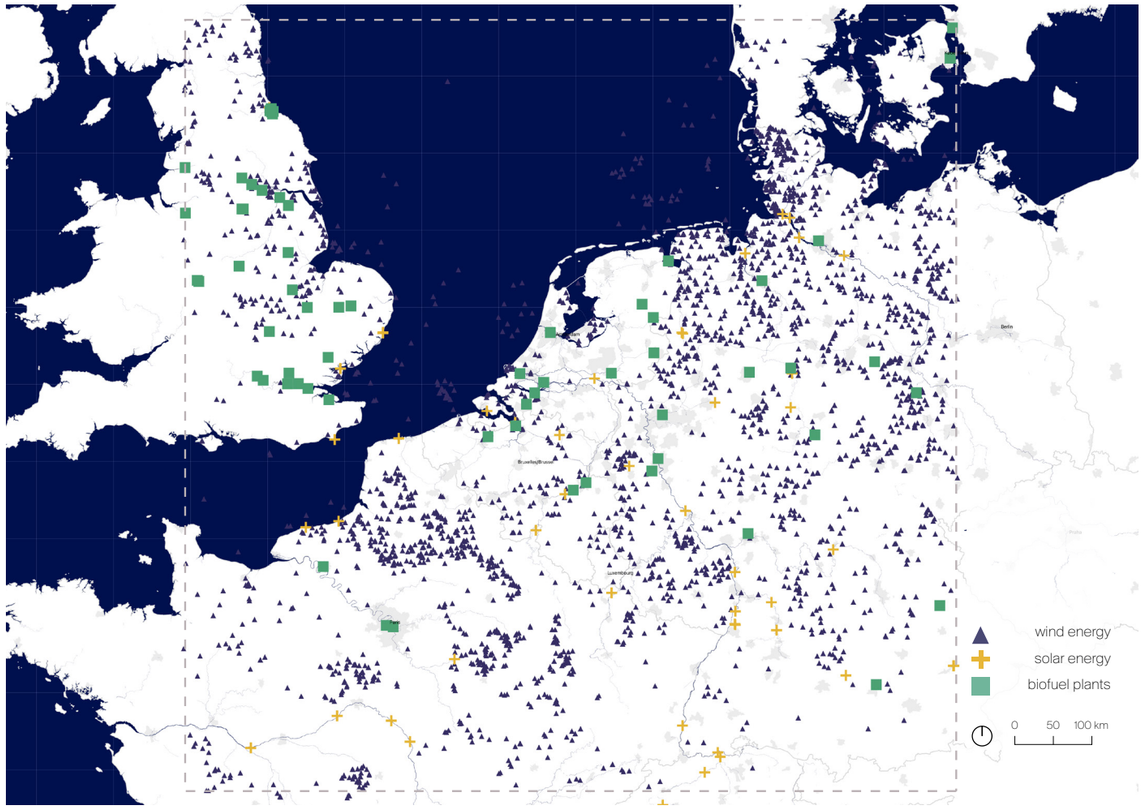


figure 30: renewable energy map in North-West Europe

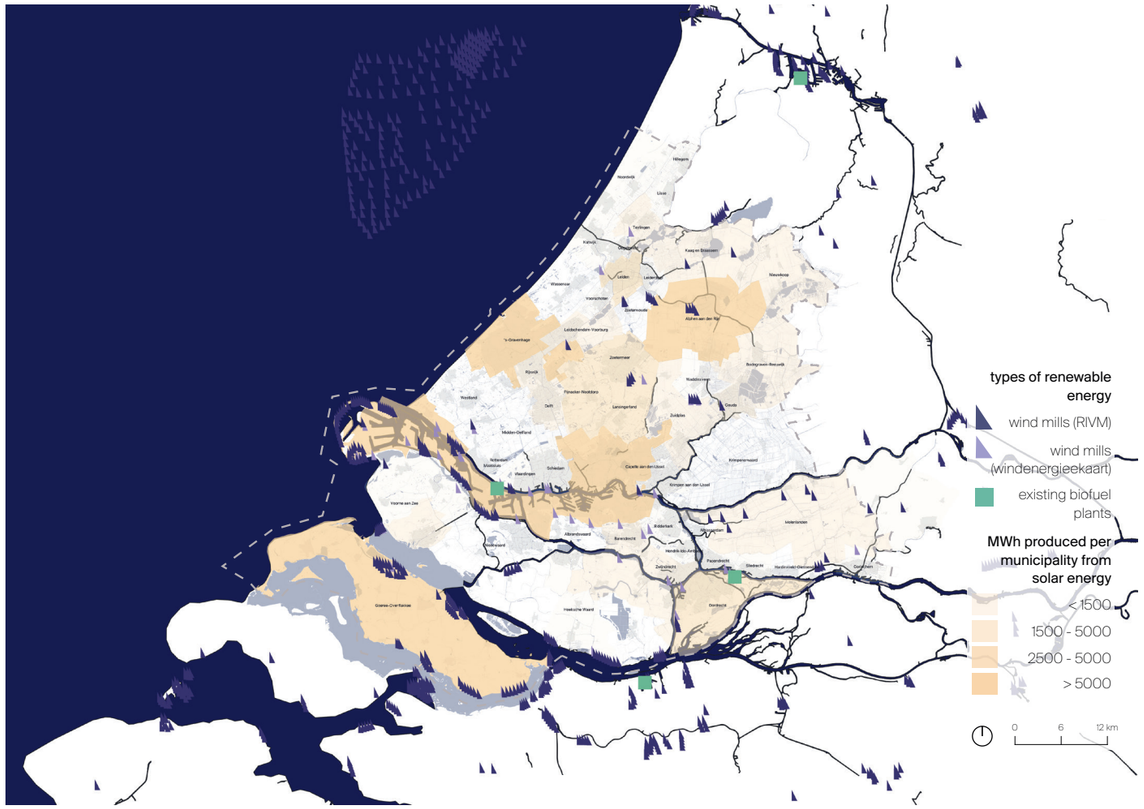


figure 31: renewable energy map in South Holland

Wind power is a huge contributor to Northwestern Europe's shift towards renewable energy (figure 30). In addition, biofuel plants and solar power fields are distributed all over the continent.

South Holland is part of the Regionale Energie Strategie (RES). This program aims to reduce 95% of carbon emissions by 2050 (RES, 2019). Seven subregions of South Holland present their proper potentials for wind and solar energy based on location conditions (Provincie Zuid-Holland, no date) (figure 31). An important spot for wind energy is the offshore wind farm of Hollandse Kust in the North Sea, where first turbines were implemented in 2022 and will continue to be implemented until 2026 (Ministerie van Algemene Zaken, 2017).

policy alert

Energieakkoord voor duurzame groei (2013)

Agreement of governments, citizens and companies for a sustainable future growth model in the Netherlands. It includes an overall reduction of energy consumption and the production through renewable energies (SER, 2013).

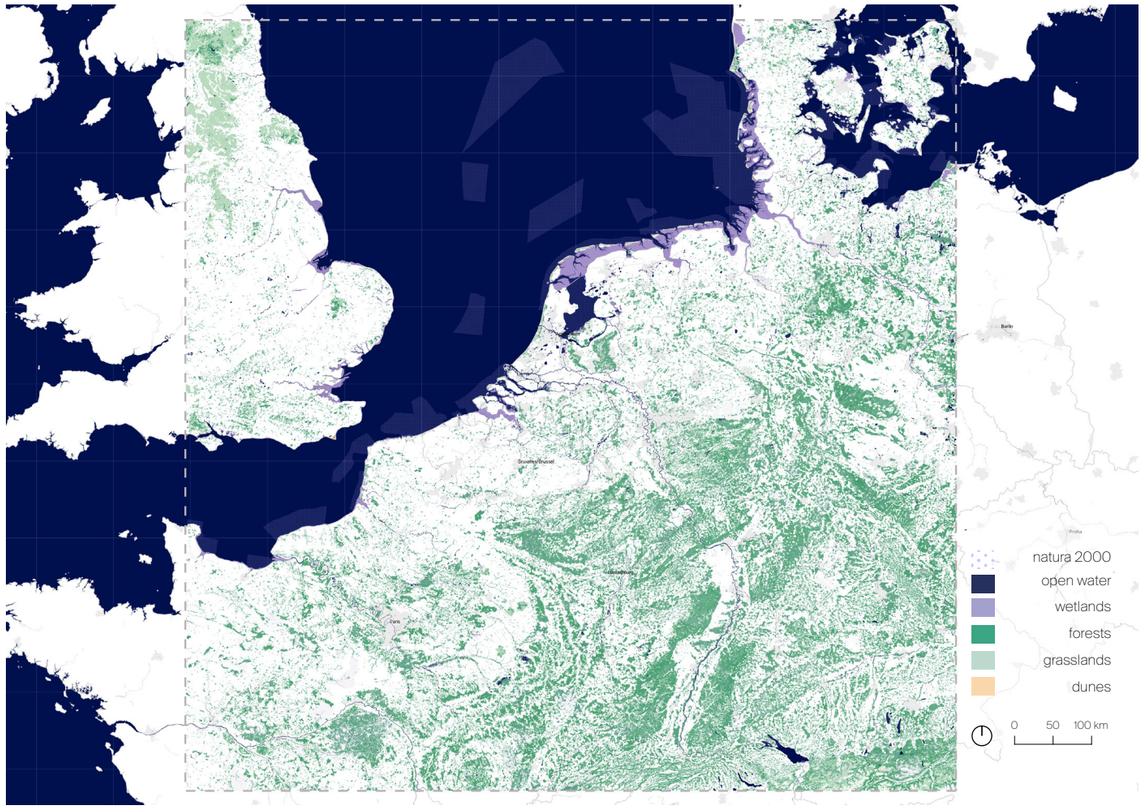


figure 32: potential areas to mitigate the greenhouse gas emissions in North-West Europe

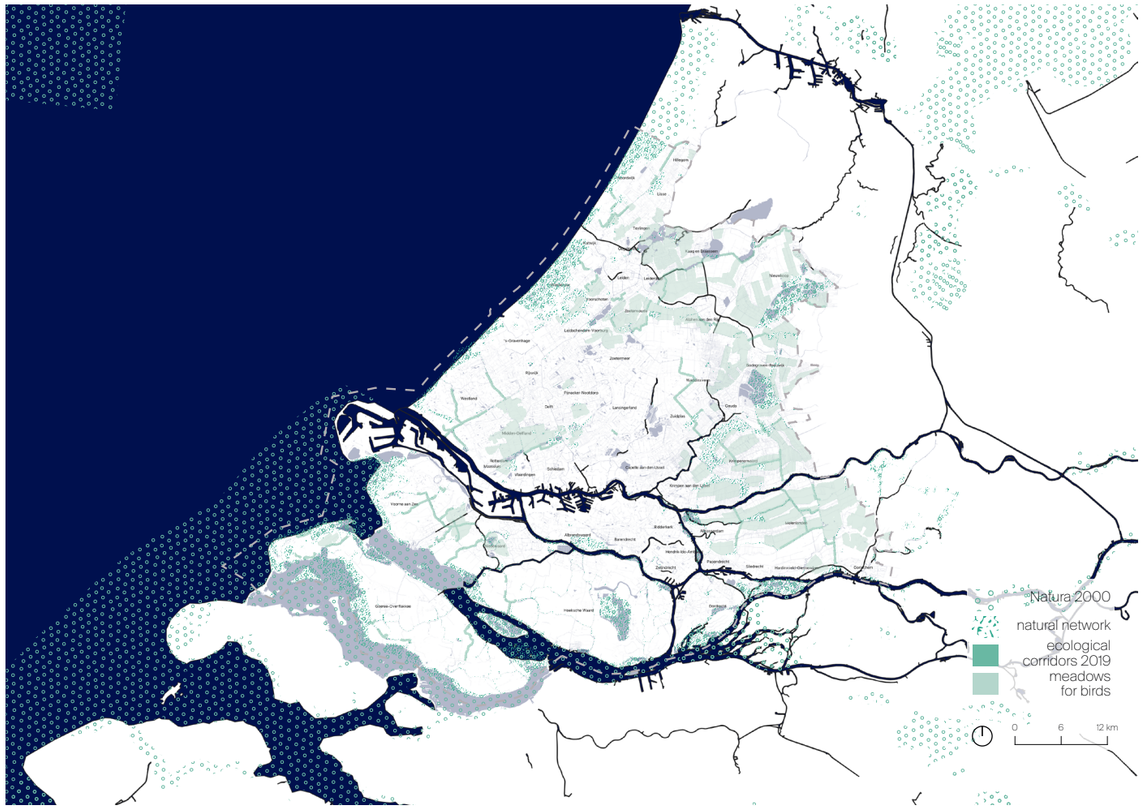


figure 33: potential areas to mitigate the greenhouse gas emissions in South Holland

In order to reduce greenhouse gas emissions we have to adapt as well as mitigate. Mitigation of greenhouse gases in the global food production system can be achieved in several ways. Costa et al. (2022) describe the major actions that we need to take over the upcoming decades. These relate to decreasing intensive production, increasing carbon sequestration, shifting to plant-based diets and using new technologies.

In 2030 the focus is on decreasing emissions. In the first place by reducing deforestation and other land conversions. In the second place by using new technologies to improve livestock and grain production processes. Lastly, cost-effective technologies and practices for sequestering carbon have to be set up: agroforestry, biochar for soils and improving crop and pasture management by tillage and rotational grazing.
By 2040 the focus should be on changing the system. Low-emissions agricultural practices have to be implemented, renewable energy has to be upscaled, electric transportation should be expanded and fertiliser production should be improved.
From 2040 to 2050 Costa et al. (2022, p. 6) propose to "develop and produce affordable new-horizon technologies for negative emissions''. According to them the focus should be on carbon capture using technologies and plants and improving energy efficiency.

Managing existing and restoring new natural areas (Cook-Patton et al., 2021) are part of our potential mitigation strategies. It is important to note that the coastal areas of North-West Europe offer opportunities to expand wetlands (figure 32). More wetlands will be needed in order to prevent floods. The majority of South Holland's Natura 2000 protected sites include the dunes and wetlands along the North Sea as well as the river deltas up to the Biesbosch (figure 33). The midlands of North-West Europe in contrast offer more opportunity to extend forests.

policy alert

EU Biodiversity Strategy for 2030

It aims at making the European Union more resilient by enlarging Natura 2000 protected areas. It also includes the Nature Restoration Law. Further guidelines will be set in 2023

conclusion

What are the main livestock and agricultural foods produced in North-West Europe and South Holland?

The main products consist of meat, such as poultry, pork and beef, dairy products and further processed food. Main crop products include common wheat, barley, potatoes and sugar beet. South Holland's open fields additionally produce onions, its greenhouses tomatoes.

Which areas in North-West Europe are most affected by greenhouse gas emissions released by the food production system?

A huge part of North-West Europe is affected by CO_2 emissions due to the food system. Main problem areas consist of the UK, northeastern France, Belgium, southern Netherlands, western and eastern Germany.

Which state-of-the-art measures are suitable for mitigating CO_2 equivalent emissions of the food production system?

The major mitigation measures relate to decreasing intensive production, increasing carbon sequestration and shifting to plant-based diets and using new technologies. Nature-Based Solutions in agricultural practices and alternative protein therefore offer great potential to reduce CO_2 emissions.

Which processes are part of the food production system in North-West Europe and South Holland?

The different steps include: changing of land use, production in farms, on fields and in greenhouses, processing in facilities, retail in stores and markets, in-house consumption and waste management between steps and in the end. Transport supports this system by providing the distribution.

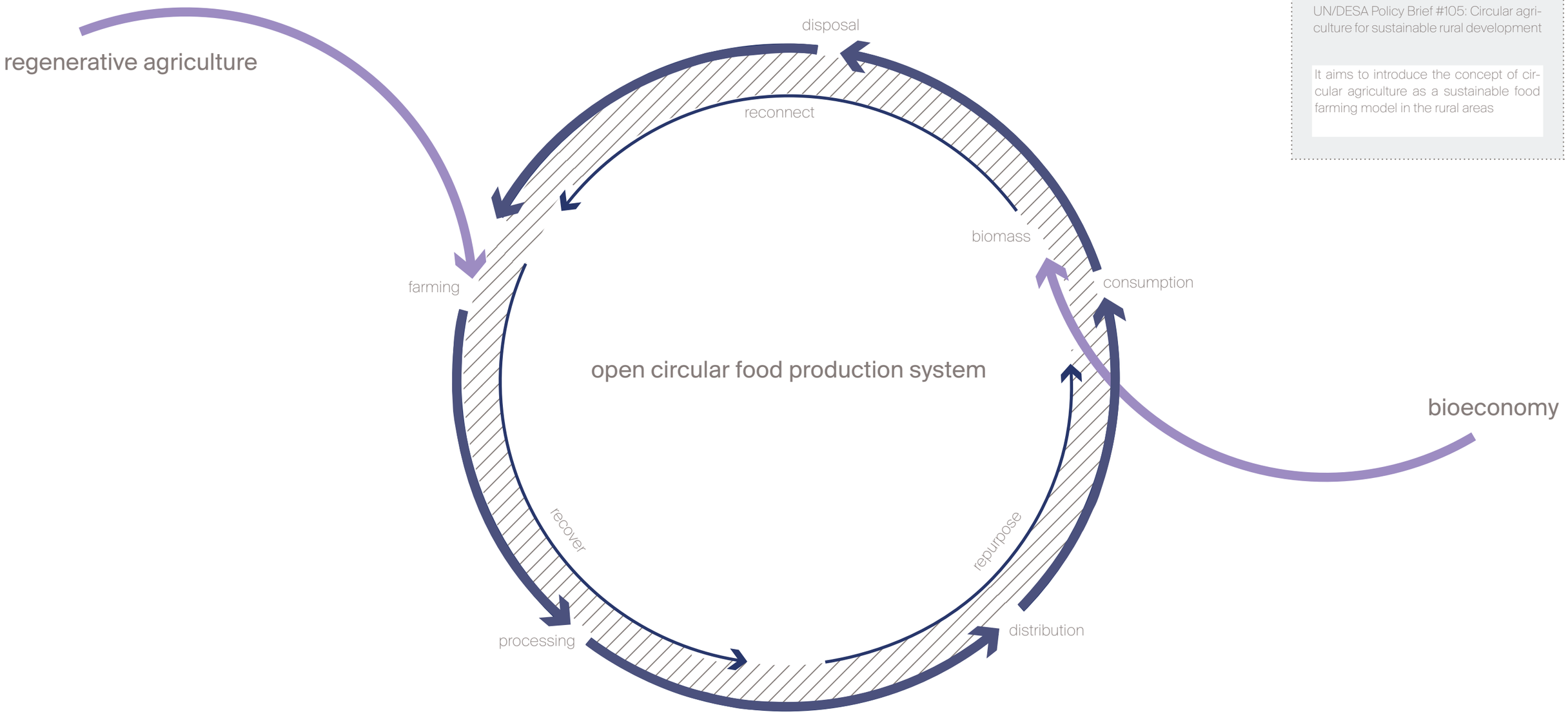
What is the opinion of current stakeholders in the food production process in North-West Europe on changing the food production system?

There is a lack of willingness from the stakeholders to change. The mindset of food for profit needs to be replaced by equal distribution of food. However the government is in line with the goal of a net-zero carbon footprint.

4 // open circular food production

Chapter four provides a thorough explanation on the concept of open circularity in the food production system. We present innovations in the food industry which enable transitions in all steps along the production chain. Furthermore the chapter states social and financial challenges in the implementation process. We conclude the gathered information in a toolbox for the vision in chapter five.

open circular system



policy alert

UN/DESA Policy Brief #105: Circular agriculture for sustainable rural development

It aims to introduce the concept of circular agriculture as a sustainable food farming model in the rural areas

figure 34: conceptual diagram of the open circular food production system

The concept of the Circular Economy has to be adapted in the context of food. According to Kishna et al. (2019) not all circularity strategies are applicable in relation to natural resources: For example a tomato is simply not repairable when it has been eaten. Therefore we focus on 1. optimally using resources and raw materials, 2. optimally using food and 3. optimally using by-products (Kishna et al., 2019). These ways of optimising the food production system are related to the Nature-Based solutions as stated in the Theoretical Framework. However not all Nature-Based Solutions are circular.

Regenerative agriculture contributes to the circular farming process by acting as an input for nature inclusive practices in food production. However, it does not include the process, distribution, consumption and waste treatment phases, which are very crucial steps in a circular food system (Cairns, S., Cyrus Patel, S., Jessop, A., Mullen, M., 2021). Bioeconomy is an input on using renewable sources, but it does not contribute to reconnect, recover and repurpose wastes (Cairns, S., Cyrus Patel, S., Jessop, A., Mullen, M., 2021).

So, the concept of circular food production is an open complex structure, where different inputs and outputs from other circles, such as regenrative agriculture and bioeconmy, need to come in and go out of the system.

innovations in production

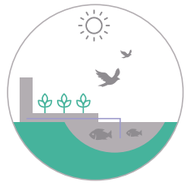
The open circular economy needs to be implemented in all phases of the food production system to reduce carbon emissions (UN, 2021). In the following section we will address the implementation of Nature-Based Solutions and mitigation actions that were proposed by Costa et al. (2022). In this section waste from all phases of the food production system is addressed collectively.

farming

In relation to production we introduce the concepts of regenerative agriculture, nature-based, farming, alternative protein and aquaponic farming

Mixed farming is aimed at removing monocultures and introducing seasonal crops and different livestock within the same agricultural land. It improves soil health and creates a wider variety of by-products (UN, 2021). By-products can also be given to farm animals (including fish in aquaponics and insects in insect farming). They can convert the by-products into food and manure. Animals will play a crucial role in achieving circularity. Poultry and farmed fish feed on by-products originating in food processing, such as bakery waste (Wageningen University & Research, no date).

In Agroforestry agricultural land is combined with trees. It increases biodiversity, soil health and reduces the use of chemicals or external fodder (UN, 2021).



Aquaponics integrates aquaculture with the production of crops. It creates a regenerative circular system between plants and fish and reduces the in- and outflows of by-products (Ellen MacArthur Foundation, 2019).

Alternative protein farming introduces insect and algae production as meat replacement. In comparison to traditional livestock the carbon footprint is lower and its nutrients are higher (Sustainable Inclusive Business Hub, 2021).
Insect farming can be used for 'nutrient upcycling' due to the fact that they can be raised on manure (Wageningen University & Research, no date). Insects can convert inputs of lower value into high value outputs in feed for all farm animals that otherwise would have been lost from the food chain. The frass resulting from insect farming could also be used as biofertilizer (FEFAC, 2020).

Algae have a capacity to absorb and convert 'waste streams' into biomass again, without the use of arable land. Waste such as manure, municipal and industrial waste could be used as substrate to produce algae for animal feed. (FEFAC, 2020).

figure 35: circularity toolbox of innovations in farming

processing

In relation to production we introduce the concepts of regenerative agriculture, nature-based, farming, alternative protein and aquaponic farming

The introduction of technology in the processing and manufacturing of food (e.g. artificial intelligence) ensures the quality and minimises food loss by identifying the contaminated ones. In addition it creases the efficiency and profits (Cairns et al., 2021).

Effective water management reduces excessive water use and reintroduces wastewater as a valuable source for food processing (UN, 2021).

The dependency of fossil fuels in the food industry can be reduced by using renewable sources. This decreases the carbon footprint (Cairns et al., 2021) and financial volatility based on fossil fuels (Segaar et al., 2023).

In relation to packaging of food the recycling of materials as well as extending product life spans are relevant. The amount of contamination can be reduced by maximising protection of bacterias and oxygen (Cairns et al., 2021).

Revaluing by-products increases the lifespan, for example by manufacturing new foods, other types of products and biofuels (Ellen MacArthur Foundation, 2019).

figure 36: circularity toolbox of innovations in processing

retail

Retail is a key phase in the food production system, because it has a direct impact on the way people perceive food and consumption.

Marketing "Ugly" is crucial in changing the mindset and consequently reducing loss of edible food (Iseman & Miralles-Wilhelm, 2021). In addition these products can be distributed to Food Banks to support low income households.

Standard labelling clarifies information on labels for people (Cairns et al., 2021). It can also be used as an information table of the CO_2 emission of a certain product in order to increase awareness on the environmental impact of its consumption.

The purchasing model of the supermarket, which is overpacked and focussed on overconsumption needs to be adapted into buying the necessities (Cairns et al., 2021).

figure 37: circularity toolbox of innovations in retail

consumption

In this phase we aim to increase awareness on food loss, sustainable food consumption and food security.

Meal planning can help people manage their consumption by keeping a healthy diet and reducing food waste (Cairns et al., 2021). It prevents over buying of groceries and stimulates seasonal consumption.

Diet change introduces food products with a smaller carbon footprint (Cairns et al., 2021). It changes the perception of 'healthy food'.

figure 38 circularity toolbox of innovations in consumption

waste

In waste we rethink the flows of waste and by-products by bringing them back into the system rather than collecting them in landfills.

Organic waste includes manure, non edible food and crops residues. It can be composted and used as an input for a healthy soil or as a fertiliser for crops (Westerman & Bicudo, 2005). To maximise the recycling of household waste, plant-based and animal contaminated food waste increases in recycling potential. Plant-based food waste can be immediately fed to farm animals. Pigs consume unavoidable food waste from cities, as they eat most food which are also consumed by humans. Animal contaminated food waste will first be heat treated to deactivate potential diseases before being fed to pigs, poultry, fish and insects. Animals will contribute to a circular food system by recycling biomass nutrients that are inedible for humans back into the food system (Wageningen University & Research, no date).

Nutrients can be recycled from waste, non edible food and agricultural by-products by composting and reuse in the production (Cairns et al., 2021). The current food production system ends in unavoidable food waste and human excreta. In the current situation human excreta is allowed to be wasted. In a circular system the nutrient outflows present in human excreta collected in cities will be recycled to fertilise soils or feed farm animals (Wageningen University & Research, no date).

Bio energy includes biofuel, biogas and biodiesel produced by the burning of by-products. It is a tool to recycle waste and create a relatively sustainable energy source which brings down production costs (Cairns et al., 2021).

Material recycling aims to return inorganic waste to the system. This can be done in the same or a different production process. In addition we can change product design to use less materials (Cairns et al., 2021).

figure 39: circularity toolbox of innovations in waste management

innovations in production

When comparing the different strategies from our toolbox to the three pillars of the conceptual framework, nature-based solutions in production score the best (figure 40). Mixed farming for instance promotes both natural conditions as well as the mindset change and diet shift. The by-products from mixed farming can be used for energy production, animal feed and compost sites.

In processes most tools are focussed on optimisation, however water management and renewable energy positively impact each other too.

Strategies in retail mostly have non-spatial consequences and focus on mindset change and process optimisation. The consumption strategies are mostly focused on the community through the diet shift and mindset change.
The waste treatment strategies mostly impact the pillar of nature-based and production for need. Organic waste and crops residue improve soil health and provide natural pesticides whilst improving production by efficient use of by-products. Bio energy and the recycling of material only addresses the production pillar.

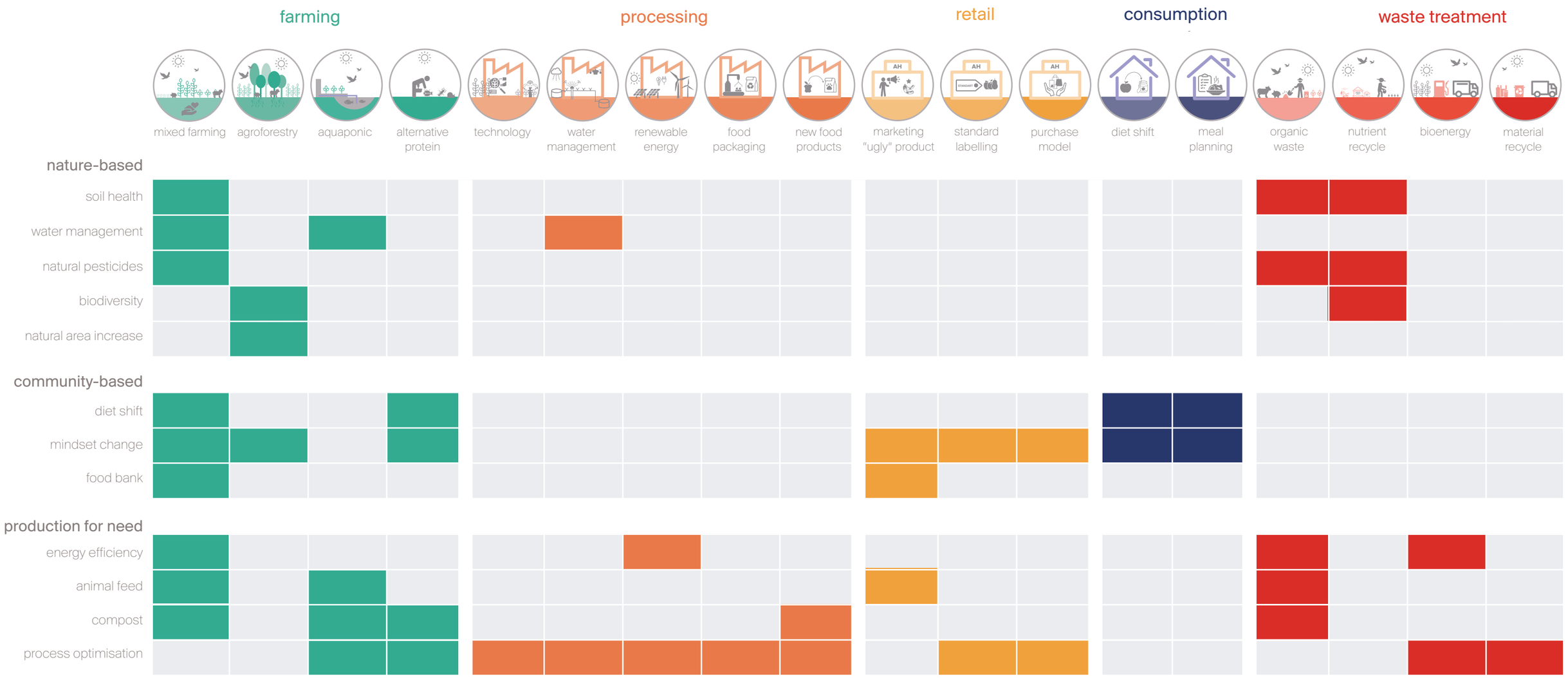


figure 40: positive impacts of circularity toolbox in natural, social and production for need pillars

social-economic acceptance

The switch to a circular food production system will result in social-economic challenges before the system is accepted.

It will be hardest to achieve the mindset change. Food culture patterns are difficult to adjust (Cairns et al., 2021). Especially the shift from eating meat to eating insects will be hard. In addition people are hesitant about buying repurposed goods, which they perceive as low quality and unhealthy (Cairns et al., 2021).
In addition the farmers would need to change their practice, because their businesses would need to include nature-based solutions, cater to the communities and produce for need. In the case of the Dutch dairy sector Vermunt et al. (2022) identified several blocking mechanisms for the transition towards nature inclusive farming. The lack of financial incentives and shared visions for the future limit farmers to change. In addition the action perspective is limited, because farmers are subject to unexpected reduction of land values and short-term rent agreements (Vermunt et al., 2022). Therefore building on knowledge to provide a collective vision for the future is of the essence.
The second challenge is making the open circular economy mainstream. Financial institutions hesitate to give funds to circular production projects, due to uncertainties on guaranteeing the financial outcome (Cairns et al., 2021). On the other hand, businesses that are already integrating nature-based solutions receive no financial compensation or motivation (Vermut et al., 2021).

Lastly, current EU regulations and policies have to be rethought to make the open circular economy possible. Challenges are related to unintentional gabs that limit closing of loops and use of regenerative techniques (Cairns et al., 2021). The main policy withholding the transformation to circularity is EU regulation No 999/2001. This forbids the usage of contaminated plant-based food and processed animal proteins for farm animals (European Parliament, 2001). In Asia 40% of food waste is pasteurised to eliminate viruses, after which it is used as animal feed (De Boer et al., 2020). These techniques should be implemented to achieve circularity.

policy alert

Regulation (EU) 2021/2115 of the European Parliament and of the Council of 2 December 2021 establishing rules on support for strategic plans to be drawn up by Member States under the Common Agricultural Policy (CAP Strategic Plans) and financed by the European Agricultural Guarantee Fund (EAGF) and by the European Agricultural Fund for Rural Development (EAFRD) and repealing Regulations (EU) No 1305/2013 and (EU) No 1307/2013

It aims to adapt sustainable strategies in the existing Common Agricultural Policy that would contribute in the role of agriculture in climate change challenges.

policy alert

Regulation (EC) No 999/2001 of the European Parliament and of the Council of 22 May 2001 laying down rules for the prevention, control and eradication of certain transmissible spongiform encephalopathies (OJ L 147, 31.5.2001, p. 1)

It aims to control the spread of certain transmissible spongiform encephalopathies, by preventing the usage of animal-based by-products or contaminated household waste as food for the farming animals.

conclusion

How does the concept of an open circular economy work in the context of the food production system?

In the Circular Economy for food optimally using resources and raw materials, optimally using food and optimally using by-products are the main goals. The open part is achieved by closing loops and efficiently using by-products. The open circular economy will be based on the three pillars. To sum up, the concept of open circular economy in food production will design a sustainable pattern of producing and consuming for a net zero carbon footprint future.

What innovations for food production in the open circular economy mitigate the carbon footprint?

The innovations in food production relate back to the optimal use of resources, food and by-products. We presented an overview of the different innovations in a circularity toolbox. The strategies in this toolbox relate to the different parts of the production system: production, processing, retail, consumption and waste. The production strategies are based on Natural-Based solution; the processing strategies are focussed at optimisation using new techniques; in retail the economic model is changed; in consumption the mindset is shifted; and finally in waste outputs are reused as input in another cycle.

What are the economical-social-environmental challenges producing food in an open circular economy?

The switch to a circular food production system will result in social-economic challenges. These are related to mindset due to changing food culture patterns and farmers needing to change their practice. The second challenge is making the open circular economy mainstream and creating financial support. Lastly, current EU regulations and policies have to be rethought to make the open circular economy possible

5 // vision
design for North-West Europe

vision statement

defined subregions

vision implementation

timeline and policies

In chapter five we envision a carbon neutral circular food system on the scale of North-West Europe. After the explanation on current opportunities and challenges on this international scale, we lay out the basic rules, which helped us construct the vision. Moreover we provide insight into the change of the stakeholder relations and end with the necessary steps for the implementation of our vision.

vision statement

figure 41: collage image of the future food production system in 2050

It’s time to slow down, sit down and enjoy our food. Aan tafel!

In 2050 the food system of North-West Europe will have reached a net-zero carbon emission in all steps of the food chain. The food production system is now nature based. It has respect for nature, produces no end waste and uses renewable energy. The system is based on a synergy between natural and technological management of resources. This results in a clean environment for all European citizens.

Equity is the main ingredient of the food system: it produces for need and not for profit. It guarantees food security for all, no matter the different economical, cultural and social backgrounds. Food is no longer a commodity but a common good. The promoted reuse of by-products all along the production chain and the revaluation of household waste ensures energy efficiency and food affordability.

Food production in 2050 is about collaboration and joy. Food is integrated in local community life. Production and consumption is a social and cultural event, where people share their love and knowledge of food. Food is not only shared within the local community, but is also part of a global community, where knowledge and resources are exchanged across borders. The anonymous corporate relationship between consumers, supermarkets, wholesalers and producers will be replaced by a relationship of trust between “groups of territorial collaborators” (Steel, 2020, p. 215).

defined subregions

As mentioned before, the food production scapes of North-West Europe play a substantial role in the European and the global food market. Trading relations are closely intertwined. We overproduce and over consume. This gluttony causes huge environmental consequences not only on our very own soils, waters and stomachs but advances global warming.

We overlay areas which are affected by a high carbon exhaust of steps along the livestock and crop production chain (figure 42). This leads us to fourteen problem areas and our subregion of North-West Europe. It is made of diverse patches in the UK, the Netherlands, Belgium, France and Germany. All patches have a common problem but different spatial correlations, opportunities and challenges.

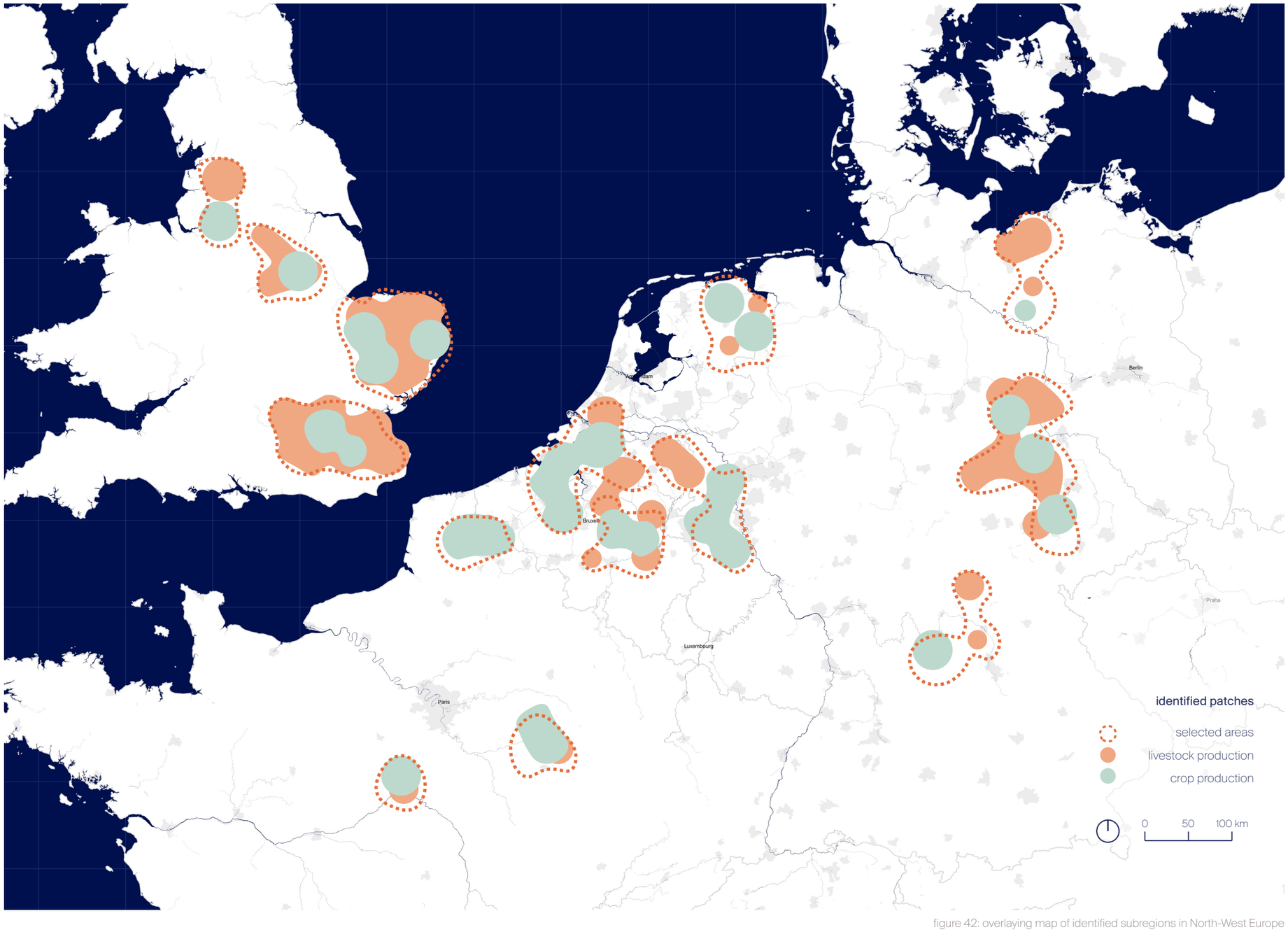


figure 42: overlaying map of identified subregions in North-West Europe

subregions evaluation

To understand these patches, we further categorised them in a matrix map (figure 43; more information in appendix: 10). We evaluated the patches according to their soil limitations to agricultural use. Patch 1a (Rotterdam-Antwerp) and patch 1d (Groningen) are affected by heavily drained soils in the Netherlands calling for a regenerative way of farming. Closeness to a wetland or forest as a carbon mitigator can be an advantage of a patch. Moreover we listed their main production field.

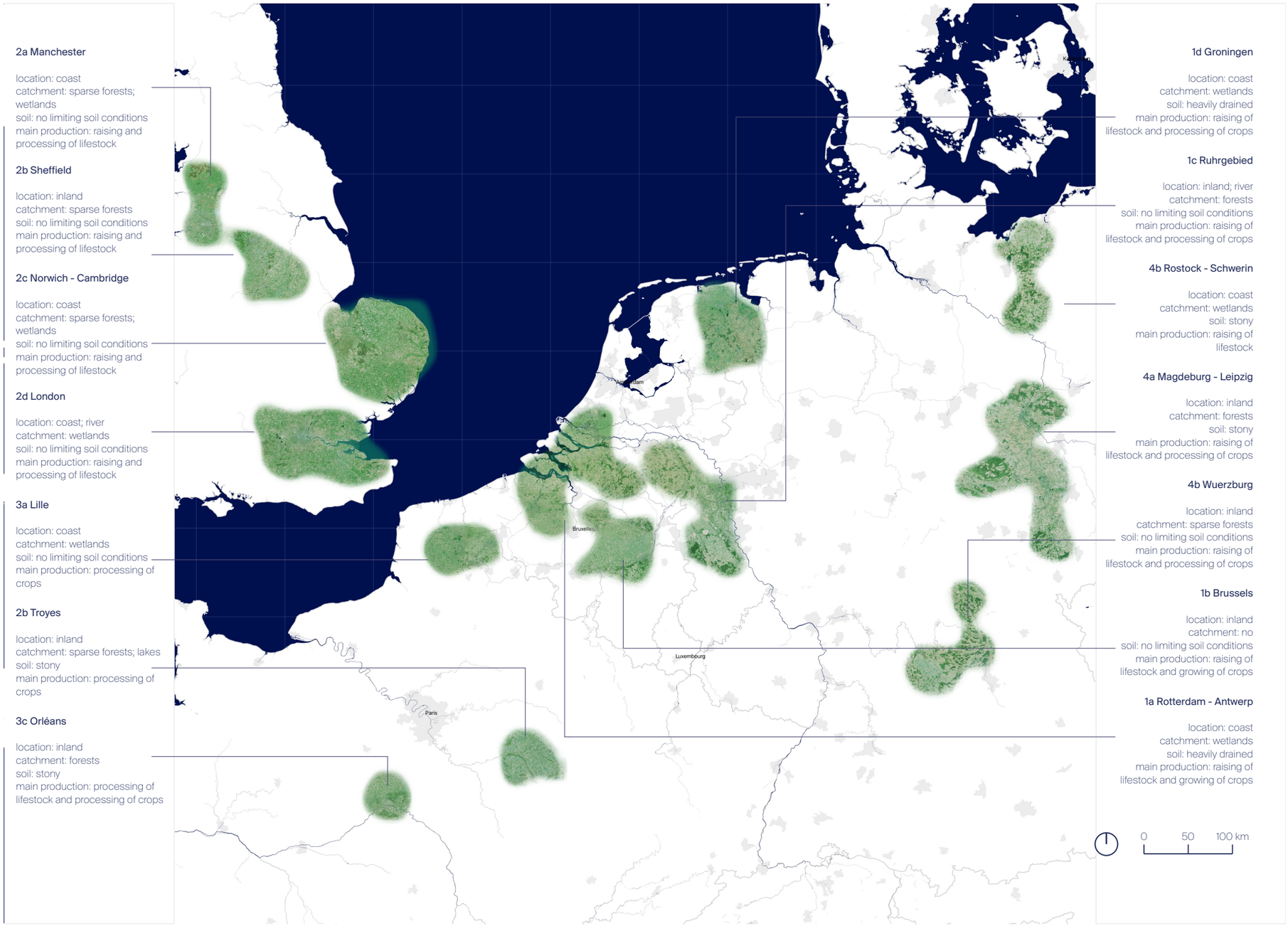


figure 43: evaluation of identified subregions in North-West Europe

typologies

As diverse as their conditions are, the spatial realities, range from the rural town over a network of cities to the Greater Metropolitan (figure 44). An identification of each patch as one of these basic typologies helped us to understand the basic flows within a patch but also a potential surplus or scarcity of a patch leading to potential exchanging goods with other patches.

The Greater Metropolitan (figure 45) consists of a metropole or major city with adjacent towns. The production of food takes place on the edges of this agglomeration. Flows are radial reaching along main transportation axes. The network of cities (figure 46) is made of equal sized cities and production landscapes in between. It is polycentric, making its product flows complex and very depending on the proper composition. Type C (figure 47), the rural town, consists of a town in the countryside surrounded by villages. Its flows are a toned down version of the monocentric metropole. The main town does not have the same overarching size and power of the metropole and its adjacent villages are consequently more independent, self-sustaining and create proper rural networks between each other. The production landscape exceeds the populated area in size.

figure 44: map of identified typologies for the subregion areas

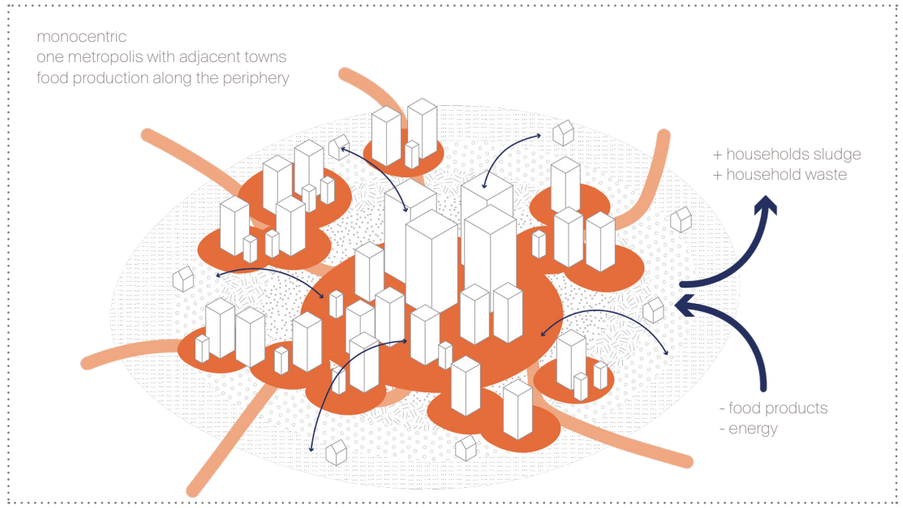


figure 45: typology A: greater metropolitan

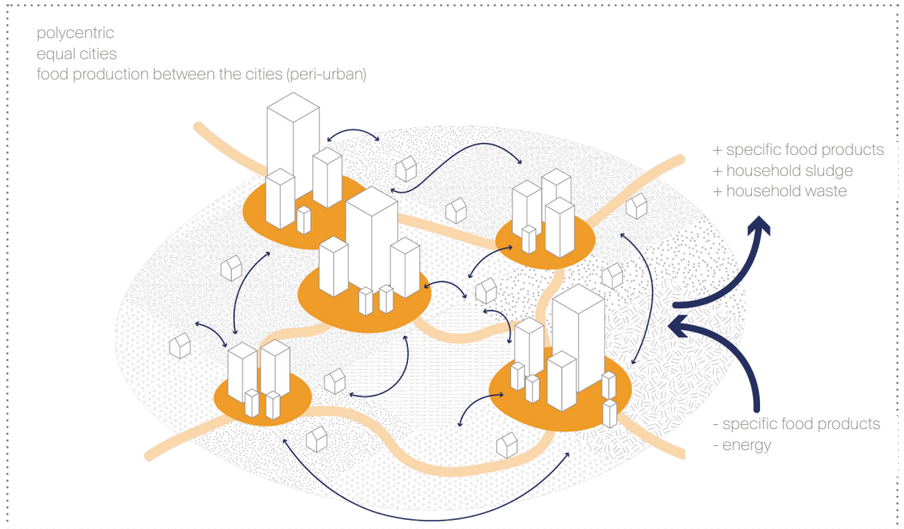


figure 46: typology b: network of cities

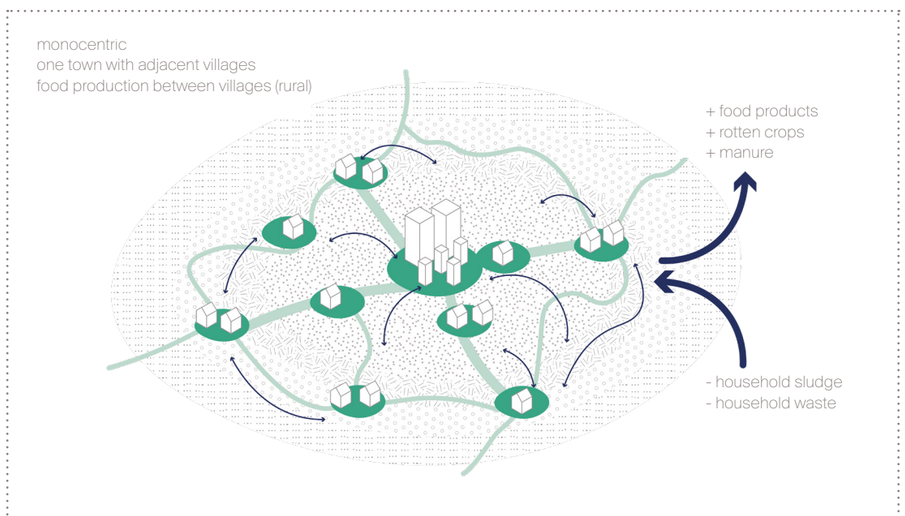


figure 47: typology C: rural town

conclusion

In order to grasp the spatial system of our patches we compiled all information in a conclusion map (figure 48). It becomes apparent that the carbon exhaust of the patches in the UK is mainly caused by meat production and processing, whereas in France high greenhouse gas emissions are due to the refinement of crops. In addition we can see that the patches in the Netherlands, Belgium and Germany are well connected, offering at least two possible connections by either train or boat. In contrast the two patches South of Paris rely heavily on their connection with the metropole. In this regard the agglomeration of the patches 1a (Rotterdam-Antwerp), 1b (Brussels), 1c (The Ruhr) is striking. It is a dense mix of urban areas and is at the same time characterised by a very productive but polluting peri-urban landscape.
In order to construct the vision we took the particular advantages, complications, opportunities and challenges of each patch into account.

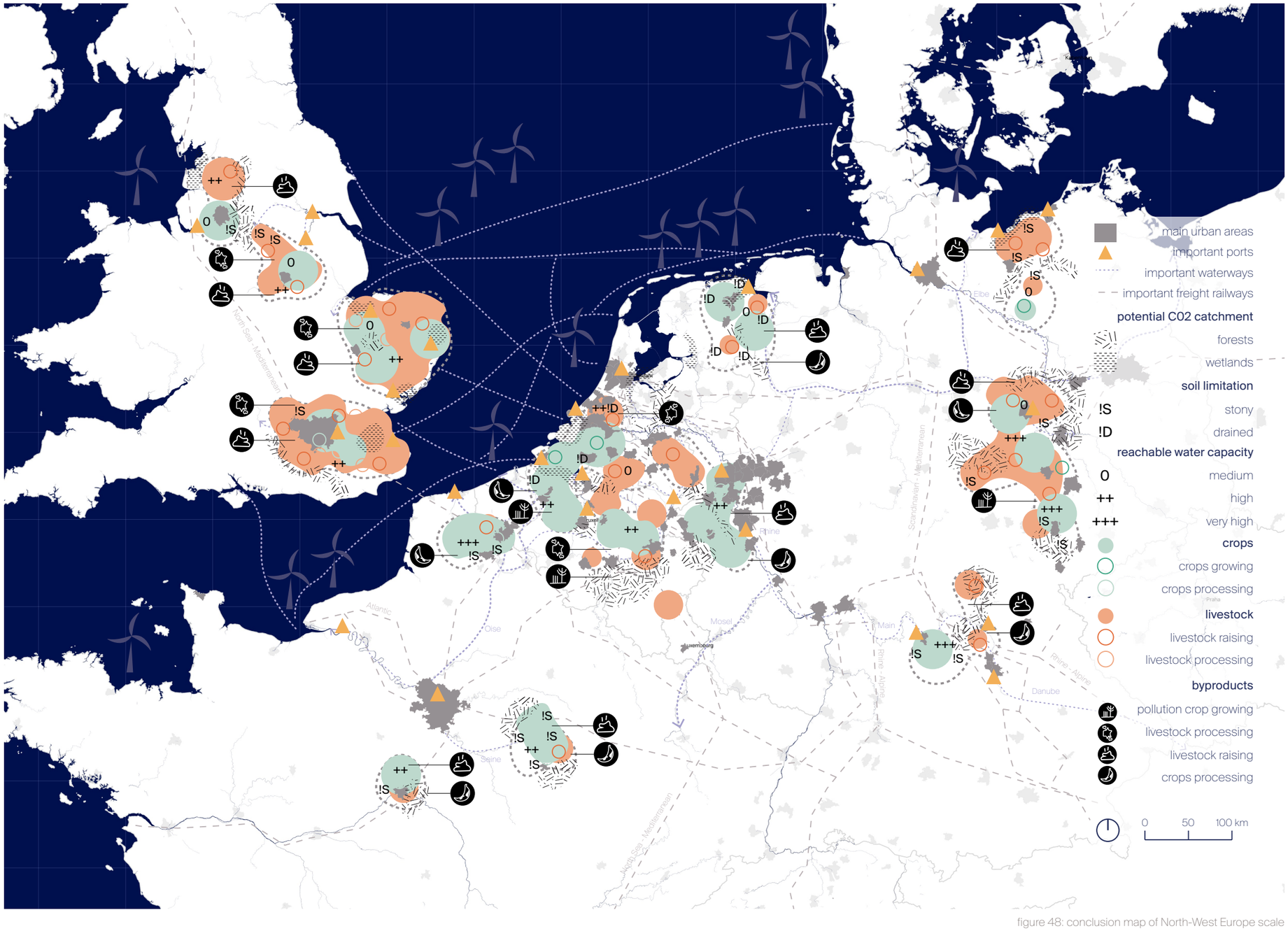


figure 48: conclusion map of North-West Europe scale

rules of thumb

The rules of thumb explain the placement of each tile in a specific location. The rules of thumb are based on knowledge gained in the previous analysis.

extended wetlands:

- As extension of existing wetland
- Goal: creating areas for CO_2 catchment and compensation

figure 49: extension of wetlands (National Oceanic and Atmospheric Administration, U.S. Environmental Protection Agency, no date)

extended forest:

- As extension of existing forest
- Goal: creating areas for CO_2 catchment and compensation

figure 50: extension of forest (Ecotree, 2022)

mixed farming:

- In areas where there are agricultural monocultures
- Goal: creating healthier soil and a more diverse harvest and reduction of livestock production

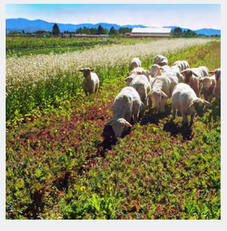
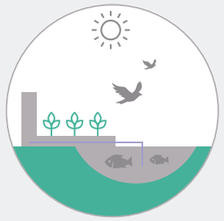


figure 51: mixed farming tool (RELX Sustainable Development Goals Resource Centre, 2017)

agroforestry:

- In areas next to natural forests and in transitional zones
- Goal: creating healthier soil, a more diverse harvest, creating a soft border between areas and reduction of livestock production

figure 52: agroforestry tool (Vi Agroforestry, no date)



aquaponics:

- In areas with coastal areas
- Goal: creating new ways of crop production without exhausting the soil and reduction of livestock production

figure 53: aquaponic tool (Nelson and Pade, Inc., no date)

alternative protein

- In areas where there was intense livestock farming
- Goal: introducing new kinds of protein in the food production system, reduction of livestock production

figure 54: alternative protein tool (Cyril Marcilhacy/Bloomberg via Getty, 2023)

technological innovations:

- In areas with high crop production, mixed farming and agroforestry, technological innovations are used to reduce crop loss
- Goal: increase productivity

figure 55: technological innovations tool (DJI-Agras, 2019)

renewable energy:

- In the sea where there is space and good conditions
- Goal: use the renewable energy in the production process

figure 56: renewable energy tool (Hohl, no date)

ugly collection:

- In areas close to crop processing and close to the city
- Goal: collection of 'uglies' and donation to communities who need it

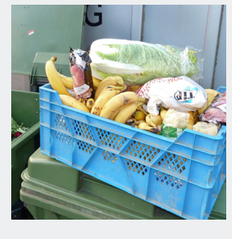


figure 57: ugly collection tool (Foester, 2013)

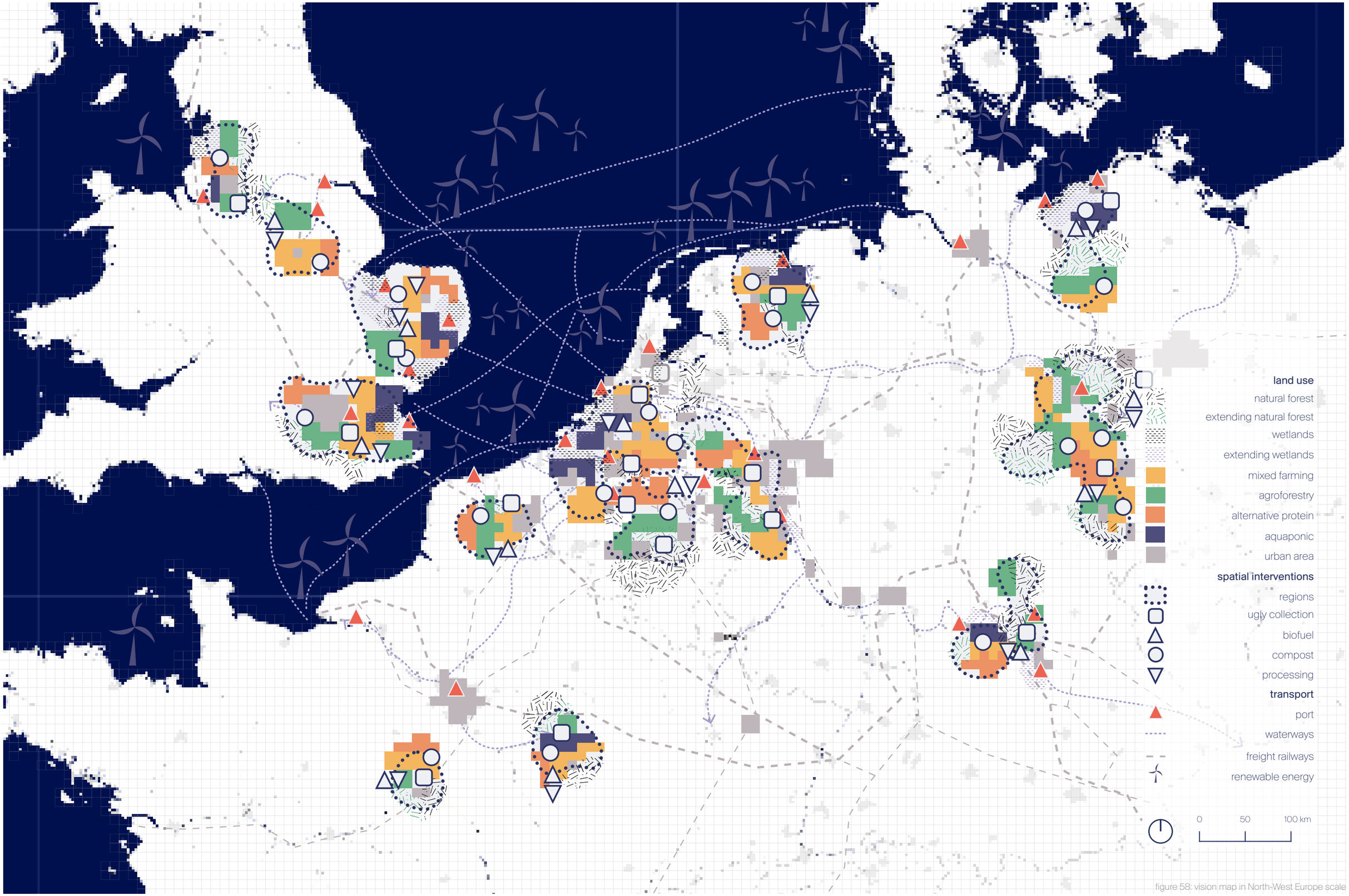


figure 58: vision map in North-West Europe scale

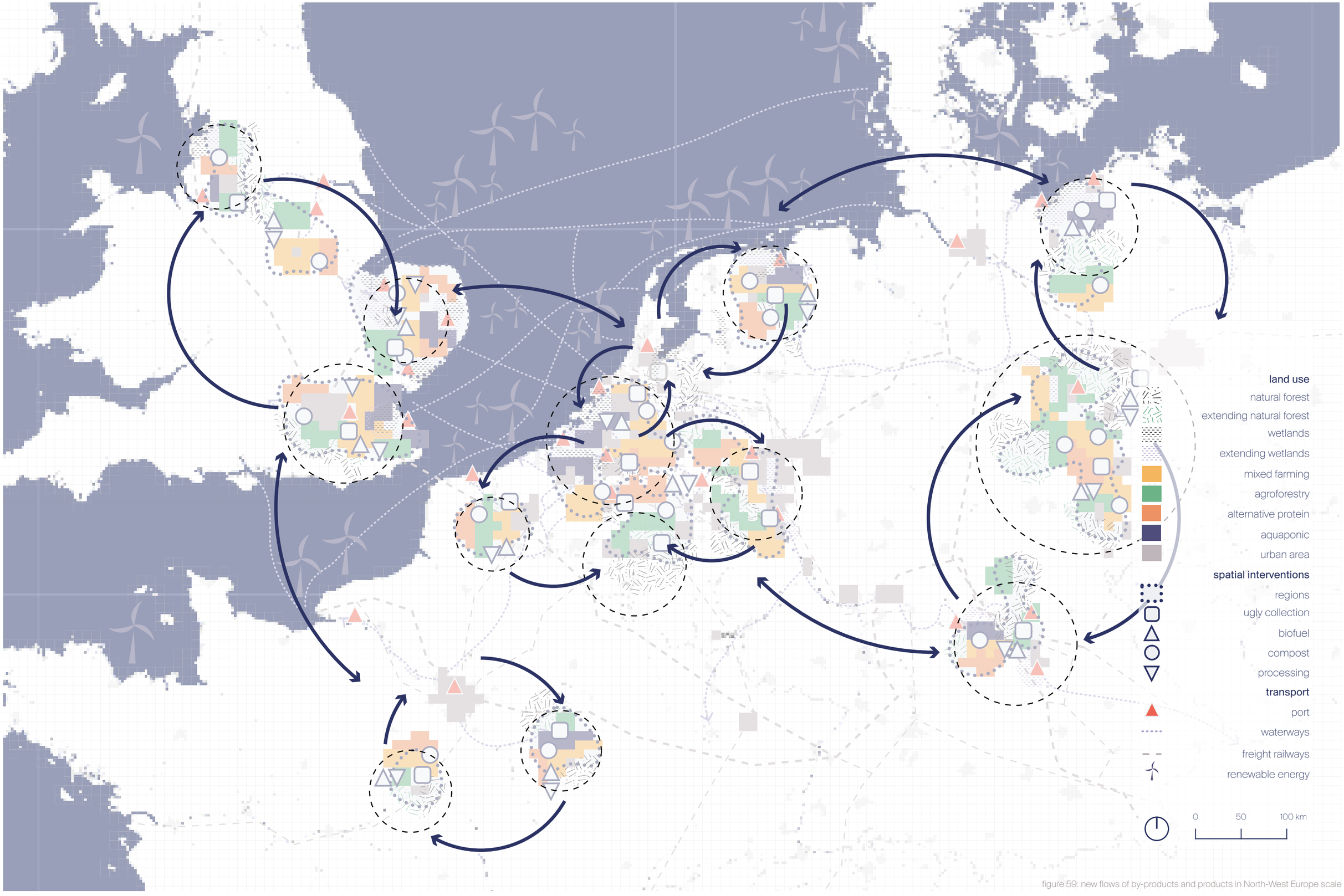


figure 59: new flows of by-products and products in North-West Europe scale

flows of by-products

In the new functioning of the food production system, shown in figure 60, the farming methods are more diverse and connected to the community. The processing uses renewable energy and different modes of transport are used for the distribution. Retail is aimed at healthy food in which the people are in close contact with production therefore having a relationship with what they consume. The outputs of the food production parts are inputs for other ones.

The flowchart of the new situation shows how by-products are not seen as waste, but as input (figure 61). Unused crops, crops residue and unsold food can be used for increasing the soil quality as well as animal feed. Ugly food is not thrown away, but given to the people. Rotten food, plate waste, manure and excrements are used to make renewable energy. Through slowing, narrowing and closing these loops the need for fossil fuels, waste treatment and landfill is reduced.

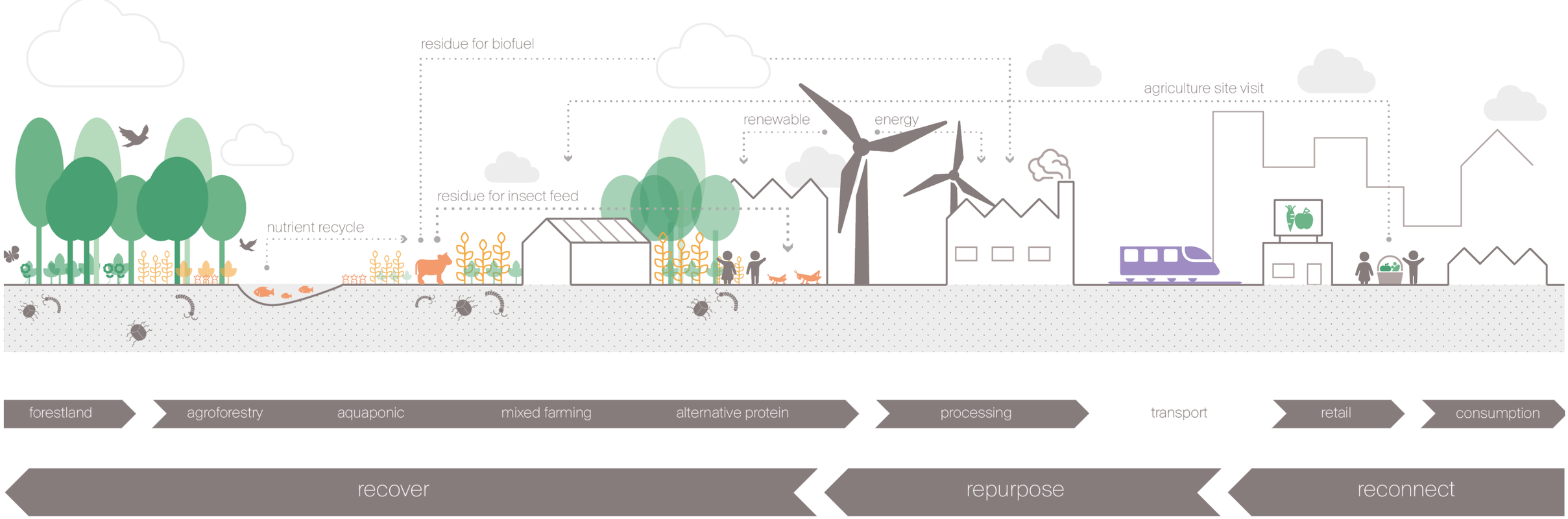
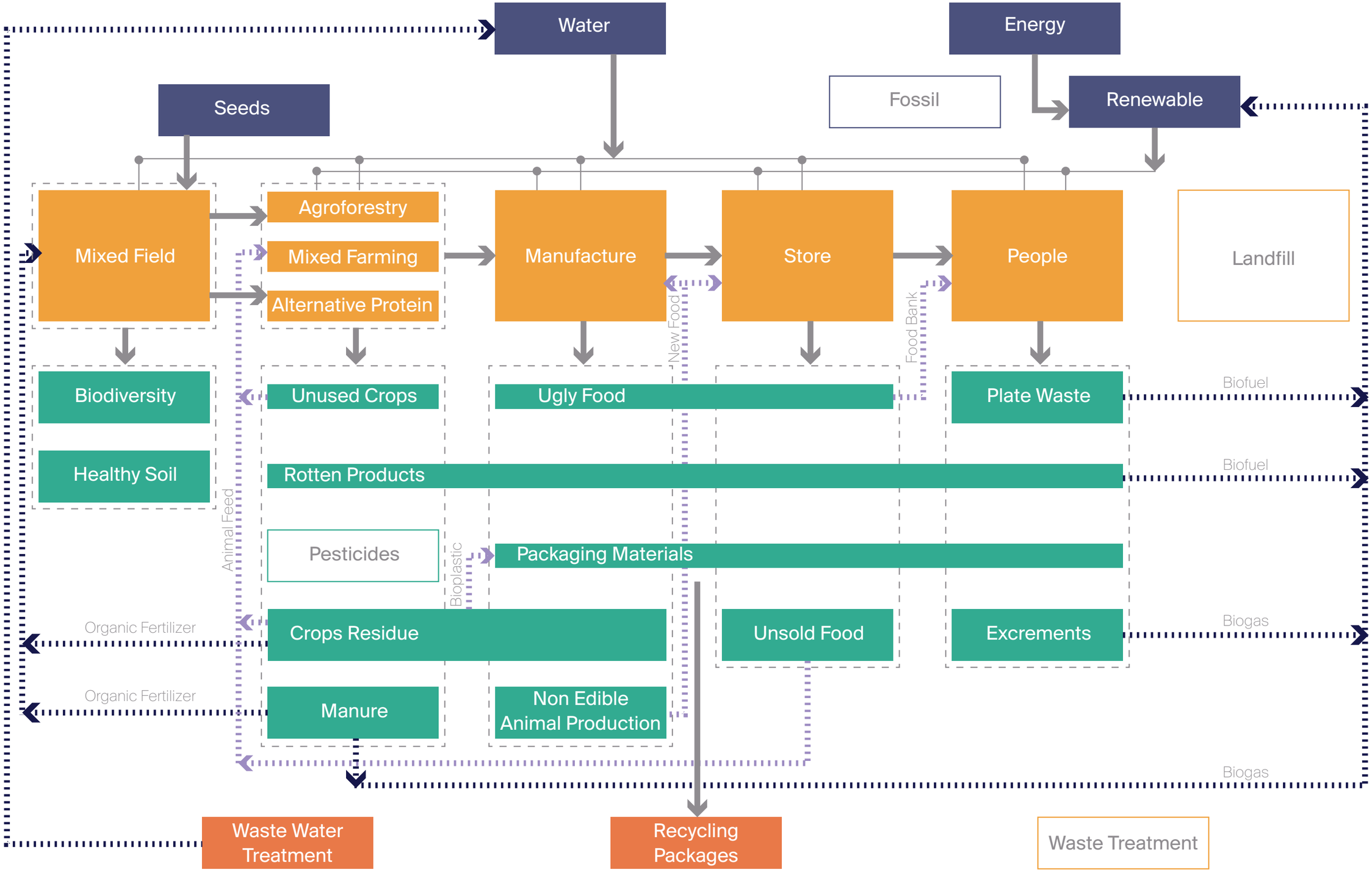


figure 60: section of flows in the open circular food production system



$CO_2 = 0$

figure 61: flowchart of the open circular food production system

A new power interest arrangement of stakeholders has been made to achieve a net-zero carbon food-print (figure 62). In this arrangement, the government, the most powerful stakeholder, stands up for the silent stakeholders by creating regulation and policy. The discourse culture it creates should be supportive and mediative in order to achieve the end goal.

Energy companies, farmers and farming companies' interest in the goal is increased to the maximum. The food production system will only be net-zero if the service industry and the food industry are made to follow fitting regulations and are given the right tools for the transformation. The tools can be given by technical innovation companies. These companies will have more power in order to enforce innovations concerning the food production system.

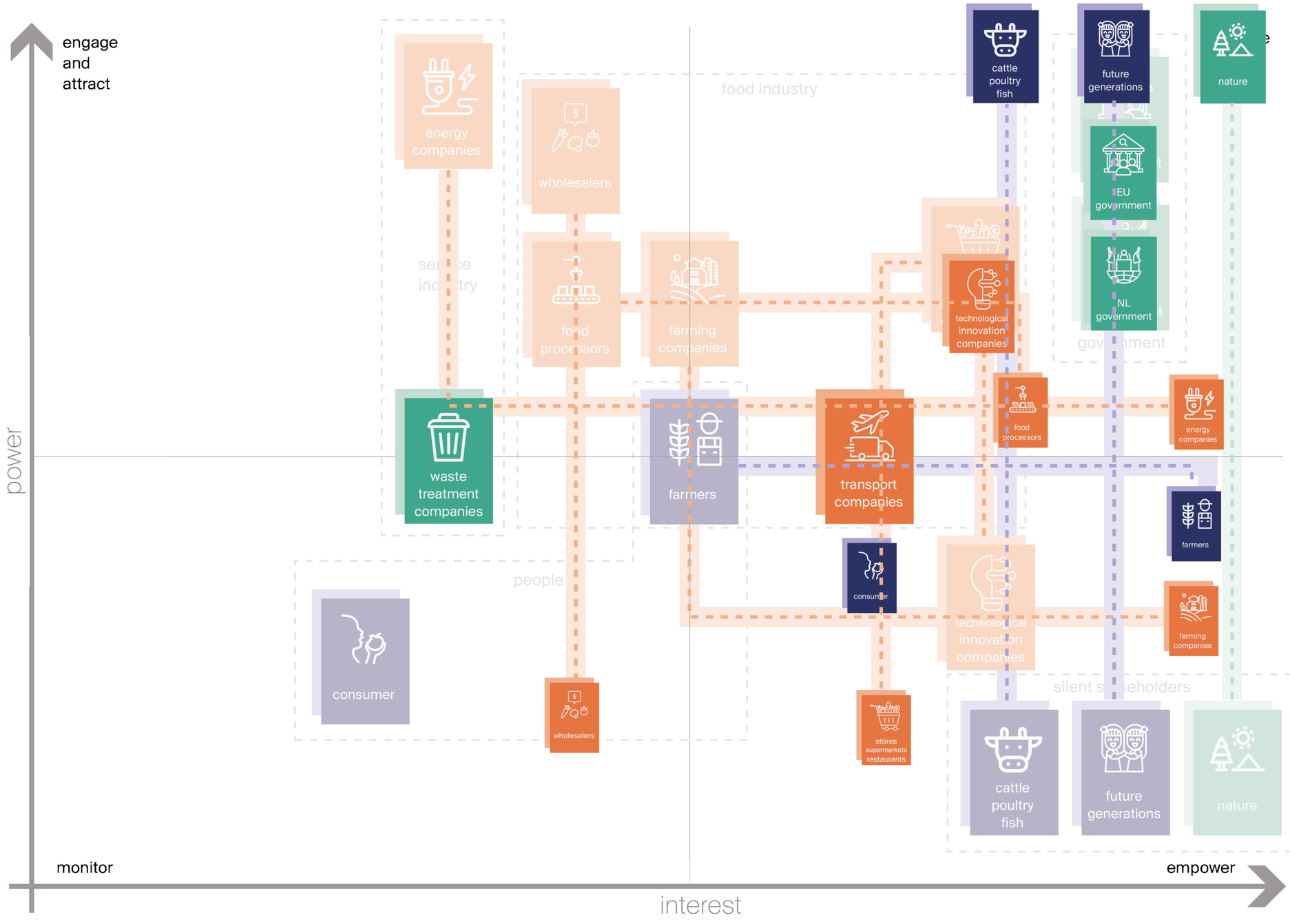


figure 62: power-interest matrix of stakeholder analysis in the future food production system

timeline and policies

The vision timeline is built following the concept of X-curve tool (Silvestri et al., 2024). It visualises the complex transition of the food production system in North-West Europe, by building up the new policies for a nature-based, community-based food system and production for need. At the same time, it shows the breakdown path of the current system. (figure 63)

The timeline goes through three main phases: experimenting and learning, rewarding the frontrunners, and upscaling. In the middle of the 'rewarding the frontrunners' phase, the current system will meet with the new build-up flows (M1, M2, M3). It is a main point in time for negotiations with different stakeholders and open a debate. After this crucial dialogue phase, the policies will lead toward the 'upscaling' phase.

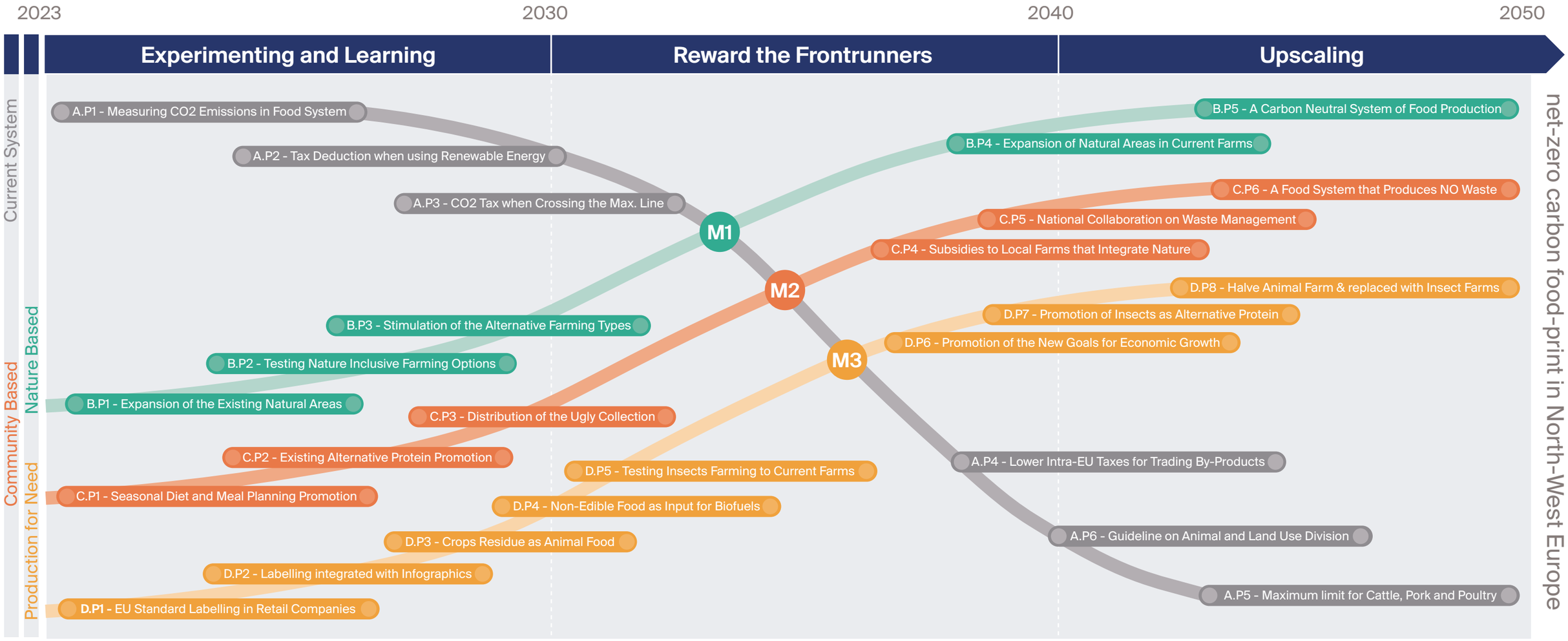


figure 63: vision timeline and policies framework for a net-zero carbon food-print vision

policies recommendation

transition of the current system

A.P1
Measuring CO_2 Emissions in Food System

An institution focussed on measuring CO_2 emissions in the food production process is created. They provide a striving number of maximum CO_2 emissions.

A.P2
Tax Deduction when using Renewable Energy

Production and processing companies that use renewable energy sources get tax deduction.

A.P3
CO_2 Tax when Crossing the Max. Line

Production and processing companies pay a CO_2 tax when the maximum CO_2 emission line is crossed.

A.P4
Lower Intra-EU Taxes for Trading By-Produs

Lower intra-EU taxes for import and export of by-product flows.

A.P5
Guideline on Animal and Land Use Division

EU defines guidelines explaining the ratio between animal and land use division on a farming land, following the Planetary Health Diet.

A.P6
Maximum limit for Cattle, Pork and Poultry

The EU prohibits bio-industries that do not follow the guidelines for a healthy animal

nature-based policies

B.P1
Expansion of the Existing Natural Areas

EU funds for North West Europe countries to expand natural areas by replanting forests and creating more space for wetlands.

B.P2
Testing Nature Inclusive Farming Options

In 2025 testing grounds for mixed farming, agroforestry, algae farming and aquaponics using renewable energy sources are appointed.

B.P3
Stimulation of the Alternative Farming Types

Mixed, agroforestry, aquaponics receive stimulation subsidies. Additional subsidies are awarded to companies that share in- and output.

B.P4
Testing Nature Inclusive Farming Options

In 2025 testing grounds for mixed farming, agroforestry, algae farming and aquaponics using renewable energy sources are appointed.

B.P5
Expansion of Natural Areas in Current Farms

European countries buy out old monoculture farming grounds for replanting forests and creating more space for wetlands.

B.P6
A Carbon Neutral System of Food Production

The carbon capture of the extended natural areas equals the CO_2 emission of the food production system.

community-based policies

C.P1
Seasonal Diet and Meal Planning Promotion

Diet Awareness; European promotion campaigns on seasonal crops, meal planning and alternative protein.

C.P2
Exiting Alternative Protein Promotion

European promotion on the use of existing products (e.g. soy) and ALGAE as an alternative protein and the reduction of meat consumption.

C.P3
Distribution of the Ugly Collection

The food production companies in North Western Europe are obligated to collect all their ugly products and distribute (sell) them to the Food Banks or farmers.

C.P4
Subsidies to Local Farms that Integrate Nature

60% of waste produced by companies in the food production chain has to be redistributed as an input to another sector.

C.P5
National Collaboration on Waste Management.

80% of waste produced by companies in the food production chain has to be redistributed as an input to another sector.

C.P6
A Food System that Produces NO Waste

100% the waste produced in the food production system has to be reused as an input for a certain Process

production for need policies

D.P1
EU Standard Labelling in Retail Companies

European retail companies are obligated to incorporate EU standard labels.

D.P2
Labelling integrated with Infographics

EU labels have an infographic with: CO_2 impact, season of consumption, nutritional value, origin country.

D.P3
Crops Residue as Animal Food

Crops production companies in North Western Europe are obligated to collect their crop residues and distribute (sell) to animal farmers.

D.P4
Non-Edible Food as Input for Biofuels

Non edible food residue from different parts of the production process in North Western Europe is gathered and distributed to biofuel plants

D.P5
Testing Insect Farming to Current Farms

Testing grounds for insects are appointed. These are current farms willing to cooperate in the research process.

D.P6
Promotion of the New Goals for Economic Growth

EU changes the system of calculating the economic growth, by shifting from the concept of gross income as a value of measurement, into the quality value.

D.P7
Promotion of Insects as Alternative Protein

European promotion on the use of insects as alternative protein and sharing funds to the farmers who will reduce meat production.

D.P8
Halve Animal Farm & replaced with Insect Farms

North West European countries have to replace 50% of the animal farming with Insect Farming.

6 // strategy
design for South Holland

South Holand in focus

operative strategy

adaptive timeline and policies

strategy intervention

Chapter six shows the implementation of our strategy on the scale of South Holland. We implement the agricultural land use required for the planetary health diet on the existing pastures and crop yards in the phases of slowing, narrowing and opening. This land shift is accompanied by the construction of facilities necessary for the revaluation of waste, which is explained further in the case study on the municipality of Molenlanden.

South Holland in focus

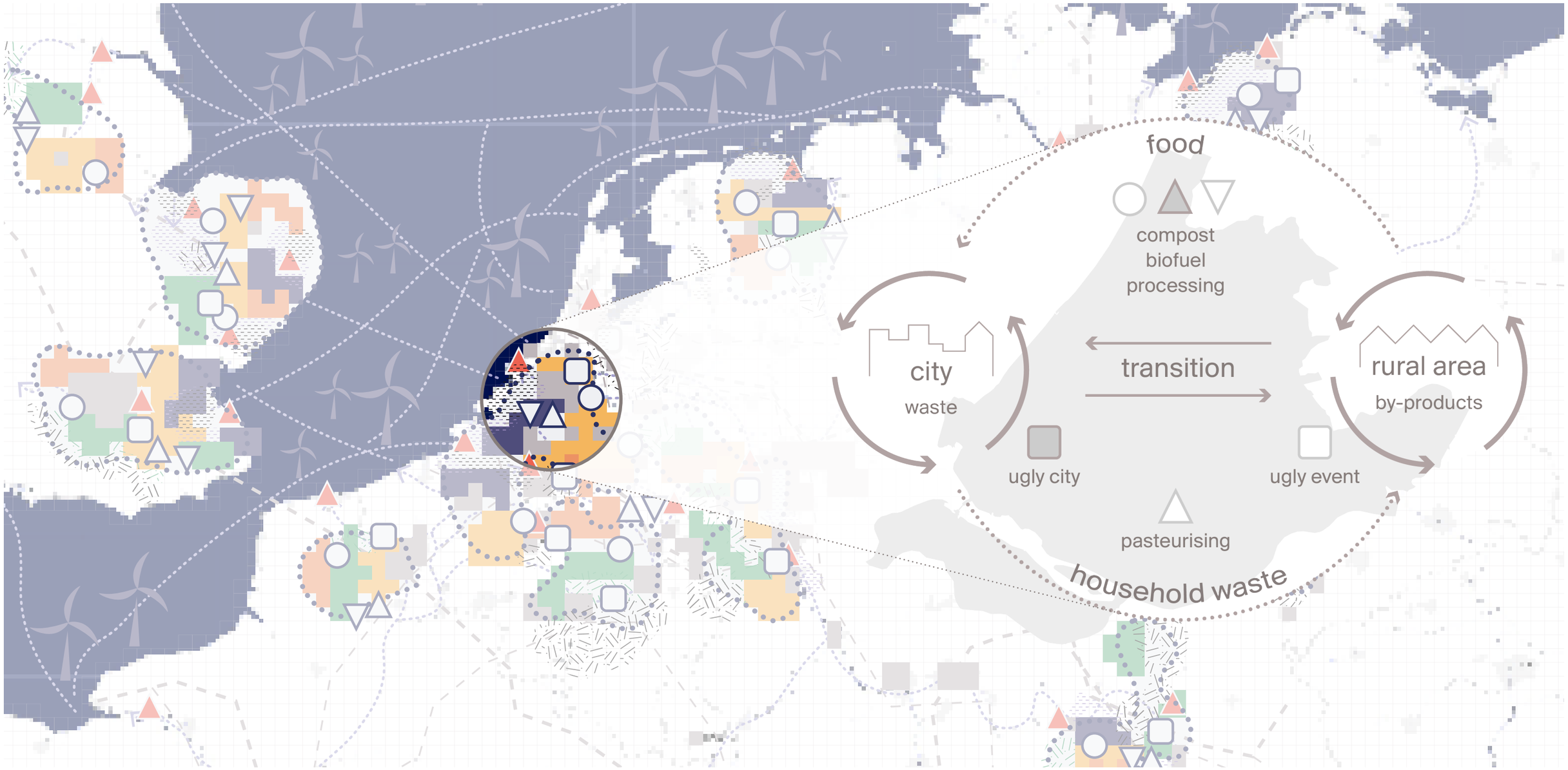


figure 64: conceptual diagram of the spatial strategy intervention in South Holland region

Patch 1a (Rotterdam-Antwerp) (figure 64) is an integral part of the problem and addresses our research question and big scale vision. With its high level of connectivity it offers a strategic position and a perfect testing ground for a circular zero-carbon strategy.
We saw that there is a major trade between all the European countries and many common problems, but particular conditions, policies and local challenges which are difficult to analyse and solve properly on a big scale. In consequence, for the implementation of our strategy we limit ourselves to the province of South Holland, a part of patch 1a (Rotterdam-Antwerp). It is a testing ground for the implementation of our vision.

In 2050 South Holland will not look the same as today. Climate change definitely will have brought stronger natural disasters (figure 65). In order to prepare the province for its future we have identified risk-prone and relatively safe areas. Relatively safe areas are marked by floods in certain points and deficits in the fresh surface water. Risk-prone areas are in danger of catching fires in dry periods. On the other hand some risk-prone areas will be affected by floods which occur once every 100 years or if the boezem system breaks. While further defining our strategy we take these risks into account, offering South Holland a resilient food system.

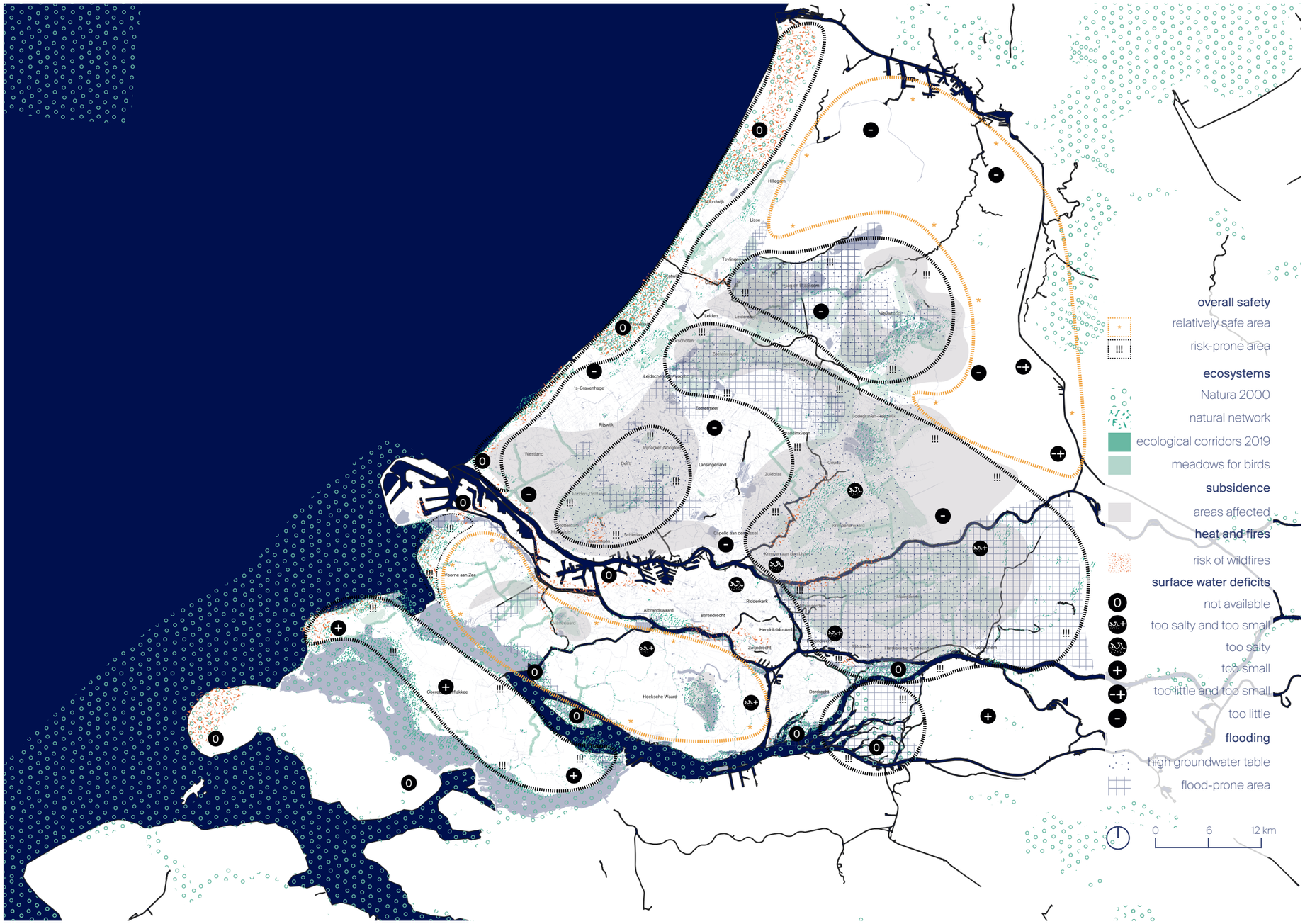


figure 65: conclusion map of climate impact in South Holland region in 2050

conclusion

We can identify clear differences in the land use according to the predominant soil material. Large-scale production of crops mainly occurs on marine clays and silts. Pastures occur on fluvial clays as well as larger areas of peat throughout. The middle part of Haaglanden and Rijnmond is largely covered by urban agglomerations and the cover of greenhouses in Westland and Oostland. The spatial distinctions can also be seen in the primary waste products each area produces

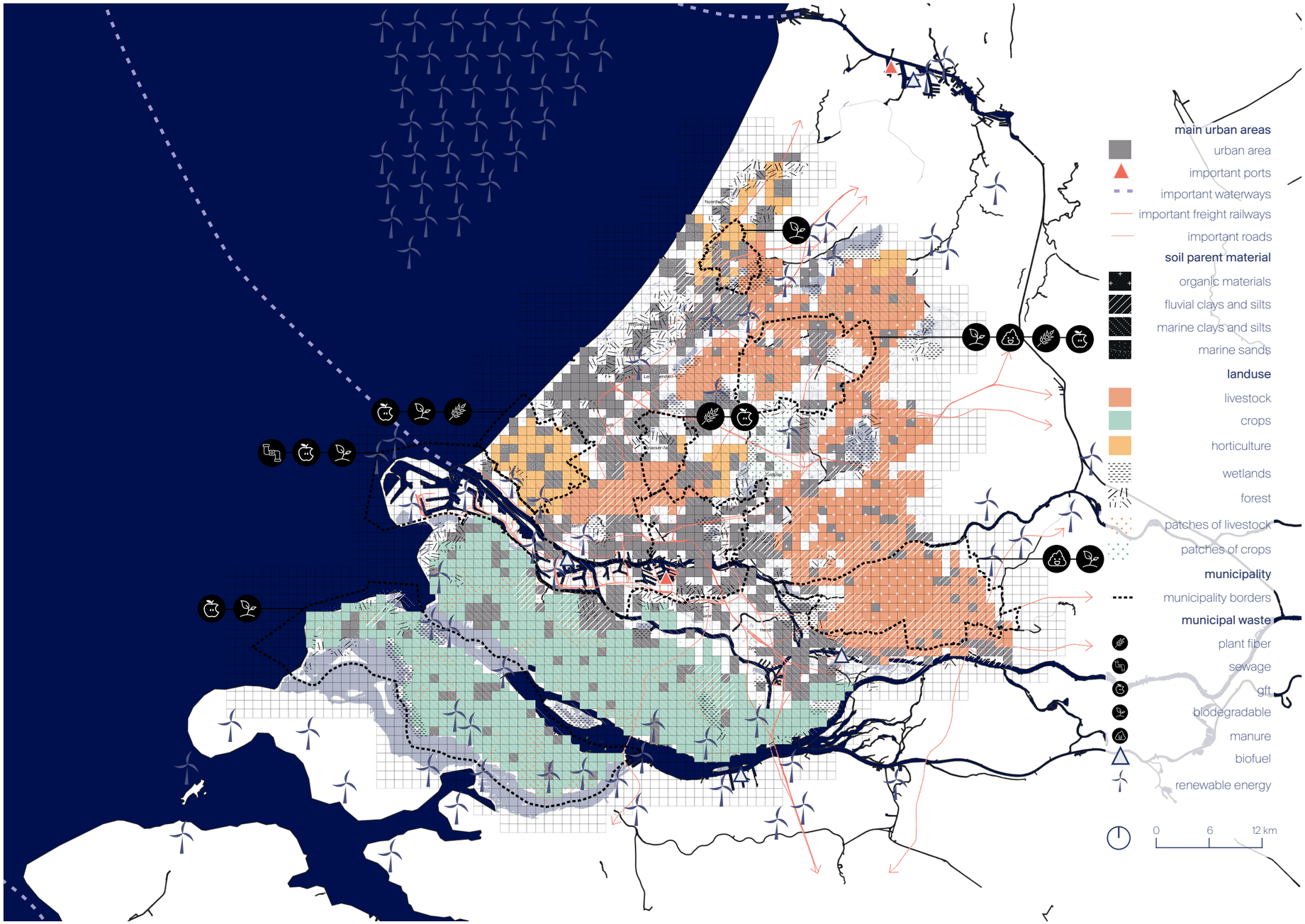


figure 66: conclusion map of analysis in South Holland region

operative strategy

The typologies identified in North-West Europe can be projected onto South Holland. Comparably to the bigger scale, these typologies give us an indication of potential in- and outflows and connectivity between the types.

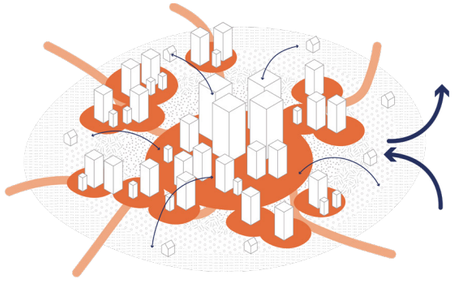


figure 67: typology A: greater metropolitan

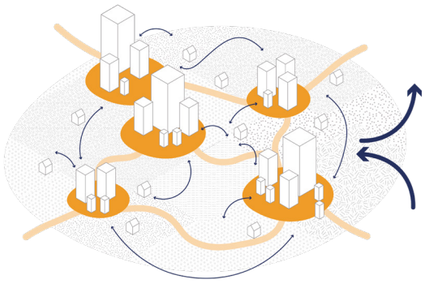


figure 68: typology b: network of cities

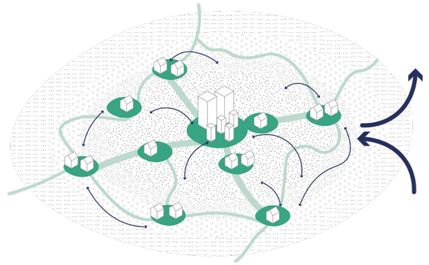


figure 69: typology C: rural town

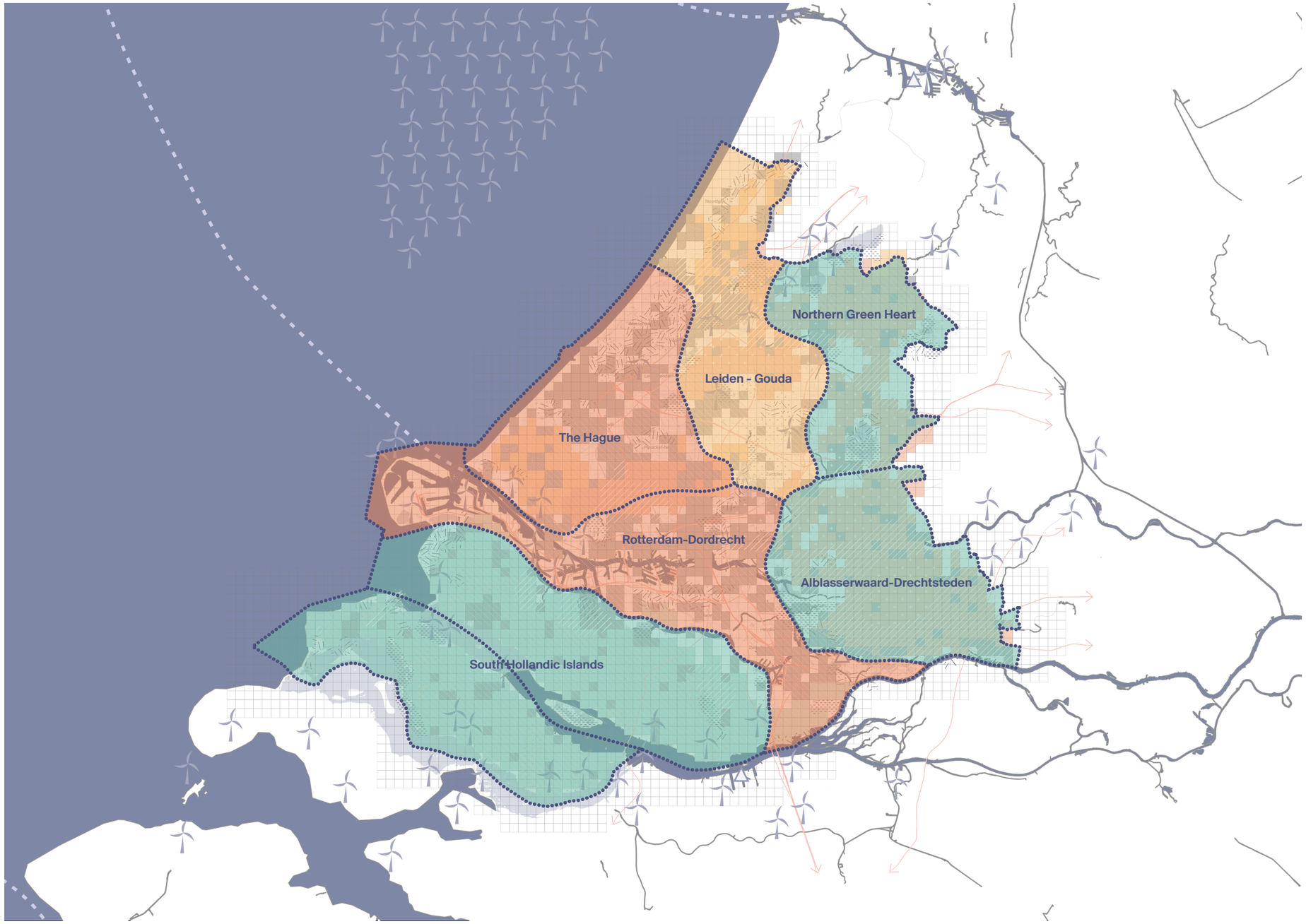


figure 70: conclusion map of typologies identification in South Holland region

planetary health diet

The reduction of CO_2 in the food production system of North-West Europe is based on the concept of circularity as well as a healthy diet. The EAT-Lancet Commission on Healthy Diets From Sustainable Food Systems has provided a target for a diet that stays within the planetary borders of food (Willett et al., 2019).

Selm et al. (2022) have tested the EAT-Lancet planetary health diet in relation to circularity within the food production system. Circularity in this case was achieved by reducing the idea of feed-food and giving LCB (low-opportunity-cost biomass), such as by-products which can not be consumed by humans, to animals instead. They made the assumption that 35% of food waste is fed to animals and the use of renewable energy sources instead of fossil fuels.

After comparing four scenarios, a circular wholegrain fixed diet performs the best in reducing greenhouse gases. However this mostly plant-based diet misses intakes of calcium, B12, zinc and omega-3 acids. Moreover, less cattle and pigs are needed. But a certain number of these animals is necessary to revalue waste and regenerate soils.
Therefore we adapted the current Dutch diet (figure 71) to the diet intake of scenario (2) (figure 72) to include insects for human and animal consumption. Insects have lower GHG emissions and are a source of protein, calcium and zinc (Bret, 2018). In addition they can consume low and high LCB (Gangwere, 2006), which means they can be used for upcycling LCB to the same extent as cattle and pigs. Lastly insects can be used for feeding poultry which increases white poultry meat production, especially in times when humans are not ready for insect consumption.

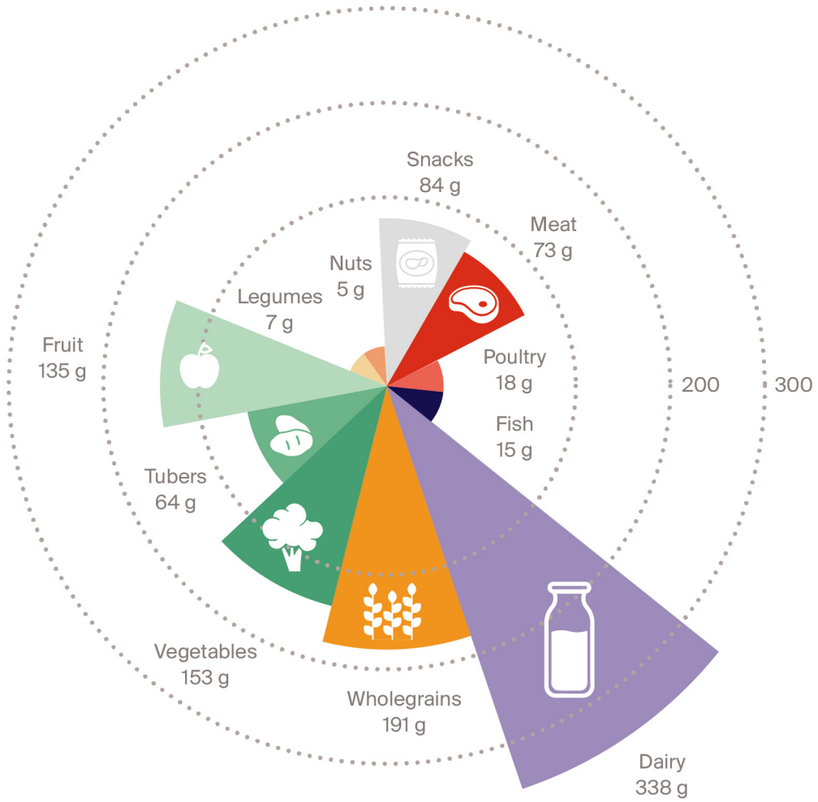


figure 71: diagram of the current Dutch diet

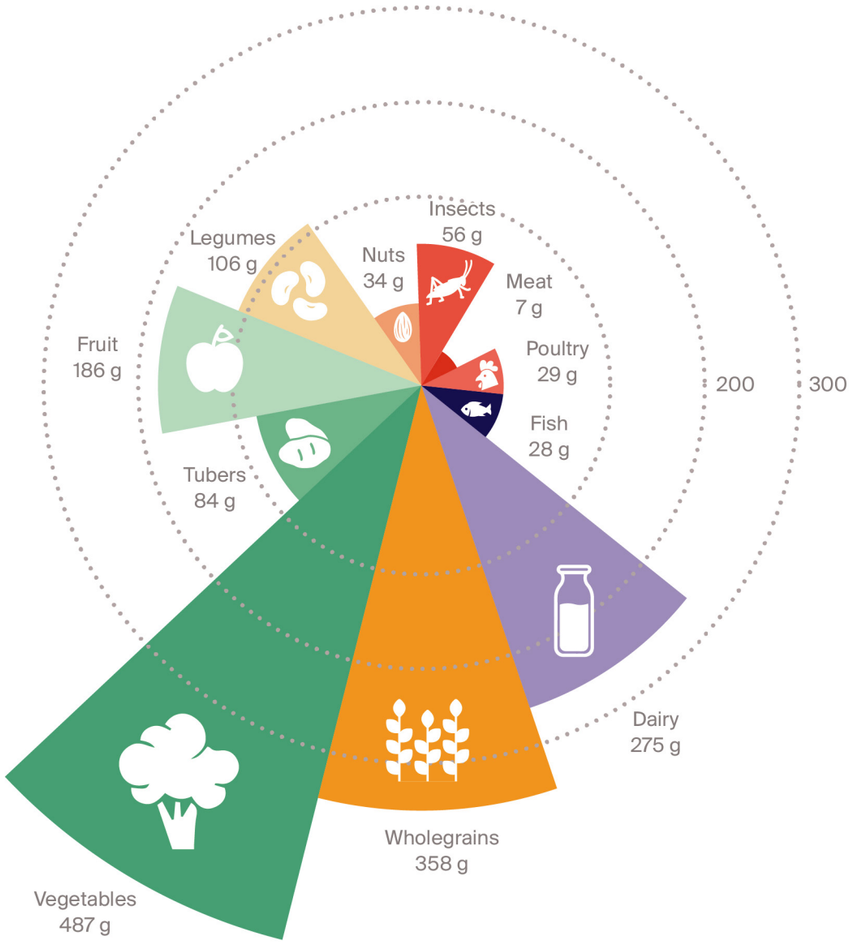


figure 72: diagram of the new scenario of the planetary health diet in South Holland region

calculations

By using the reference intakes of the planetary health diet of scenario (2) from Selm et al. (2022) we have calculated the agricultural area needed to make the province of South Holland self sustainable (appendix 16).

In step 1 (figure 73) we calculated the diet change by comparing the planetary health diet of scenario (2) with the current intake of Dutch inhabitants. This ratio was combined with the current livestock numbers and agricultural production areas of the Netherlands to indicate a future change in livestock numbers and agricultural production areas.

In step 2 (figure 74) we used the export and import numbers of the Netherlands to calculate a surplus or a shortage in trade to correct the livestock numbers and agricultural production areas. In between step 2 and 3 the animal numbers were converted to farm and pasture areas by using the square metre indicated for biological farming. In step 3 (figure 75) we calculated the amount of pastures and agricultural areas needed for the inhabitants of South Holland.
For the final step, step 3, we made a division of the different types of food in relation to the different farming methods (Figure 76). This division allowed us to gauge how many tiles of 1x1 km we would need to achieve self sustainability within South Holland.
The result showed us that South Holland has some limitations to produce all the required food products. In the first place the production of durum wheat, which are the grains needed for the whole grain diet, do not fit. The production area needs to be tripled and in addition to that the climate conditions limit the production to common wheat. In the second place the amount of fruits South Holland cultivates is sufficient, however due to climate conditions there is little possibility for a wide variety. These limitations both result in a need for trade with the neighbouring regions.

In conclusion the division of surface areas in South Holland should consist of:

- 30% mixed farming
- 22% agroforestry
- 8% aquaponic
- 3% alternative protein
- 10% wetland & forest
- The remaining 25% is the current built surface area of South Holland (Centraal Bureau voor de Statistiek, 2019) with 3% as a margin of error.

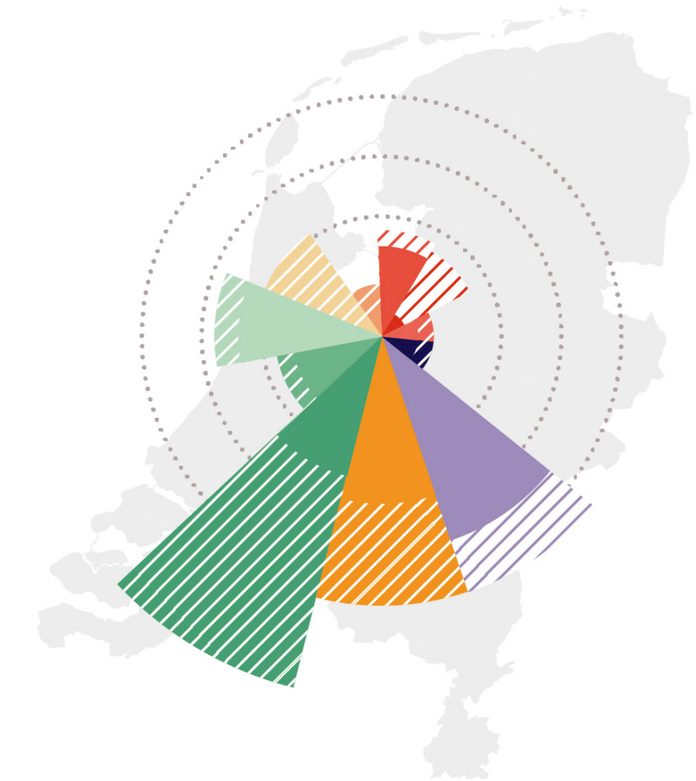
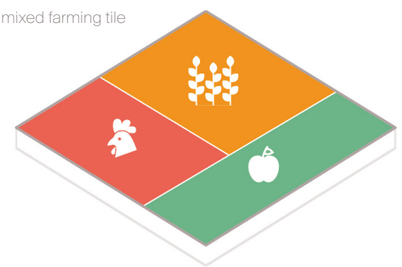


figure 73: diagram of the diet change in South Holland region

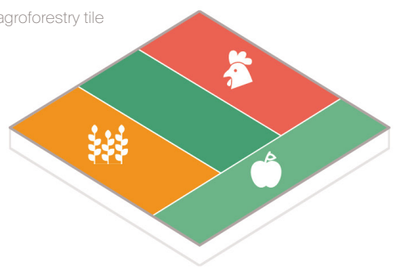
figure 74: diagram of export and import data in South Holland region

figure 75: diagram of agricultural areas needed for the inhabitants in South Holland region

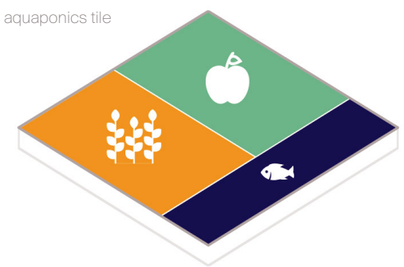
mixed farming tile



agroforestry tile



aquaponics tile



insect farming tile

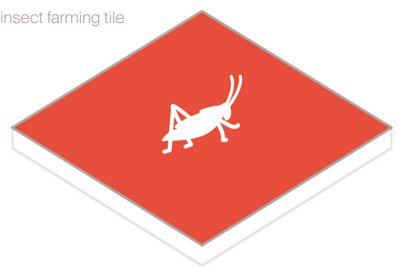


figure 76: diagram of diiferent farming methods ratio in a 1x1 km tile of South Holland region

by-product flows

Research from Wageningen University & Research shows that the current food production system produces a lot of by-products that are now labelled as waste. However, these flows of by-products could be recycled, reused, or brought back into the system by a circular approach (no date). The waste streams of one supply chain can be the raw materials for another. Achieving this kind of circular agriculture system will require smart integration between plant-based and animal-based supply chains (Wageningen University & Research, no date).

All the different elements in the new food production system will create flows that can be used as input in other elements in the system in order to achieve circularity. This is shown in diagram (figure 77), the inner layer describes the element in the food production system. The flows are put in the following categories: rest flow, waste circularity, agricultural by-product and food production. The flow enters the receiving element on the left side, where the name of the product is noted in the outer ring.

The first category is rest flow. CO_2 released in food processing and in the production of biofuel will be compensated by the creation of wetlands and forest, where CO_2 catchment will take place is. Another rest flow is the manure animals excrete, this manure will be used in agroforestry, greenhouses, mixed farming, and algae farming as fertiliser if needed.

Waste circularity is about how urban waste flows can be brought back into the agricultural part of the food production system. The unsold food flow from the city and the food processing is brought back into the system by being used as animal feed. Spoiled, damaged and rotten food, human excrement and household waste will go to the compost and be transformed as fertiliser in agroforestry, greenhouses, mixed farming, and algae farming. End waste from all processes will be burned to either be used as biofuel or as another form of energy.

Plant by-product will be used as animal feed. In return the by-product that is created when animals get processed will also be used as animal feed. The same goes for insect and fish by-products.

All food created will be brought to the city, the city receives food from different outlets. First directly from food processing. Food processing will have sorted out food that is not 'perfect' and will donate these pieces to the ugly city and to ugly events. Through the ugly city and ugly events these pieces of food will also reach the consumer in the city.

figure 77: non-ribbon chord diagram of the by-prducts flows

figure 78: non-ribbon chord diagram of waste reuse

figure 79: non-ribbon chord diagram of the restflow

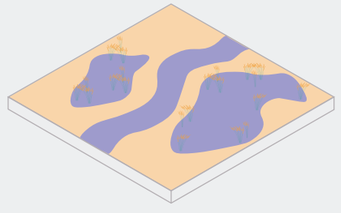
figure 80: non-ribbon chord diagram of food products

figure 81: non-ribbon chord diagram of the agricultural by-products

rules of thumb

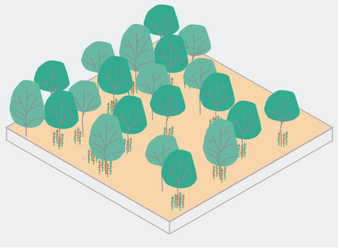
The rules of thumb explain the placement of each tile in a specific location. The rules of thumb are based on knowledge gained in the previous analysis like fruitful soil types for crop productions, the impacts of climate change and innovations from the vision toolbox.

natural areas



extended wetlands:

- location: in areas of subsidence, in flood-prone areas with a high groundwater table
- goal: combat flooding and fires
- goal: as water storage in areas endangered by wildfires



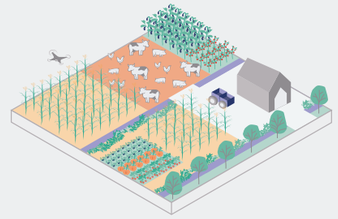
extended forest:

- location: in areas of drought risk and low groundwater table (for example along the dunes) and as extension of existing forest
- soil type: on clay and sandy soils
- goal: combat drought in soils

We see an expansion of natural areas as crucial. Forests and wetlands as well as other forms of water storage can act as a resilient backbone for future dangers and balance the ecosystem. The expansion of natural areas in each phase follows the logic of the open cycle: Ranging from an extension of existing nature over a point expansion and integration into the farmland towards flourishing and connected ecosystems as part of the production landscape.

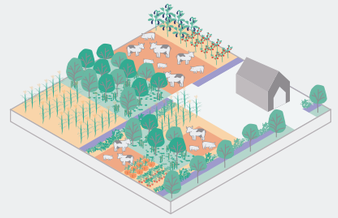
figure 82: strategic means of extending natural areas

food production farming



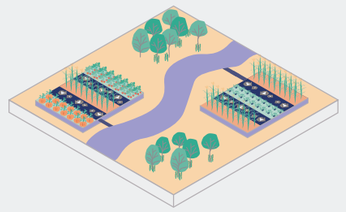
mixed farming:

- location: in areas that are made safe by the resilience measures of extending forest and wetlands
- soil type: on marine and fluvial clay soils
- needs: compost and processing
- goal: regenerate soil, increase yield due to natural symbiosis



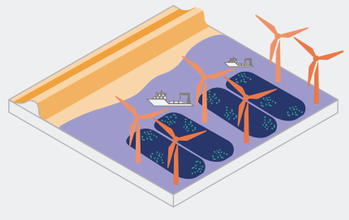
agroforestry:

- location: next to natural forests
- soil type: on clay and sandy soils
- needs: compost and processing
- goal: regenerate soil, establish a closed carbon cycle



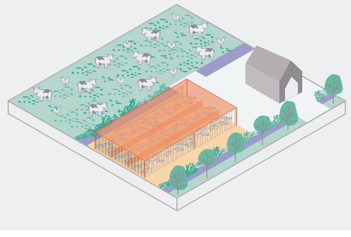
aquaponics:

- location: along the riverside as replacement of open field crop farming, in flood prone and areas of low groundwater table
- soil type: on clay soils. on peat soils
- needs: compost and processing
- goal: filter water, increase yield due to natural symbiosis



alternative protein - algae farming:

- location: in between off-shore wind farms
- ineeds: processing and pasteurising
- goal: provide a carbon-neutral protein source



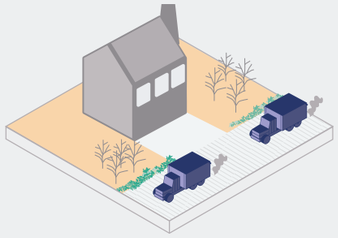
alternative protein - insect farming:

- location: along the river side and elevated on peat soils and replacing existing animal farming
- ineeds: processing and pasteurising
- goal: provide a carbon-neutral protein source

We see a change in the means of food production as crucial. Mixed farming, agroforestry and aquaponics are forms of agricultural production with an intrinsic particular cycle between the farming of livestock, crops and nature. The replacement of monocultural means of production in each phase follows the logic of the open cycle: Ranging from testing the grounds in particular locations over a point expansion and integration into the ecosystem towards network farming

figure 83: strategic means of farming phase in food production system

clusters of facilities

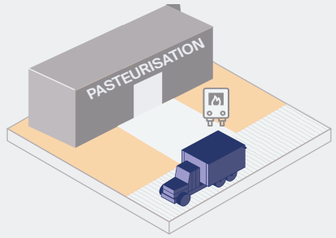


processing:

- location: on the intersection of farmland and an urban area
- cluster: integrated with a compost and a pasteuriser
- needs: ugly city or ugly event
- goal: close connection to production and demand sites

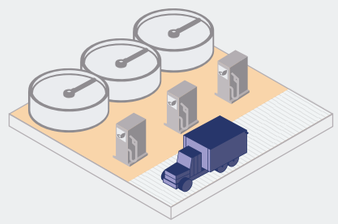
compost:

- location: between a processing facility and farmland and additional ones in between farmlands
- cluster: integrated with a processing and a pasteurising facility
- needs: biofuel plant
- goal: provide organic fertiliser for farmers



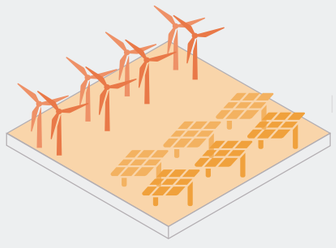
pasteuriser:

- location: next to processing and insect farming
- cluster: integrated with a processing and a pasteurising facility
- needs: urban area
- goal: reuse of household waste, limit additional animal feed production



biofuel:

- location: between a cluster of composting, processing and pasteurising and an urban area
- goal: generate energy with unusable waste



renewable energy:

- location: in close realm to the production landscape
- processing and pasteurising facilities (cladded with solar panels) should be self-sufficient or supported by the renewable energy sources
- goal: exclude fossil energy sources

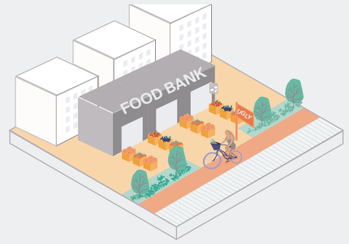
The intrinsic cycles of the new forms of farming are supported by clusters of circular facilities. These facilities exist to handle flows of surpluses and scarcities which exceed the capabilities of the farmland. The placement of the circular facilities in each phase follows the logic of the open cycle: Ranging from a few testing clusters in location of testing grounds over a point expansion especially of composting facilities and additional biofuel plants towards a network of multi-scale clusters.

figure 84: strategic means of cluster of facilities in food production system

ugly collection

ugly events:

- location: in the rural area, at least one for each municipality, on an intersection diverse types of farmland
- needs: processing
- goal: sharing of knowledge and joy for food, culture in the countryside



ugly city:

- location: in the urban area, at least one for each municipality or every city district
- goal: sharing of knowledge and joy for food, nature in the city

In addition to the circular facilities we locate several ugly facilities (figure xx), where professionals connect with consumers. The Ugly Event is a rural institution which collects left-over ugly products from the farm and processing. The Ugly City is its urban sibling, collecting left-overs from retail and processing. Their placement follows the logic of the open cycle: Ranging from a few testing events over a point expansion in relation to the farms, towards a network of regular events.

figure 85: strategic means of ugly collection in food production system

phase 1 - slowing

We begin by slowing down the current system (figure 86). An extension of nature in risk-prone areas is crucial as it is important to prepare them for the future impacts. Small experimental farmers in endangered areas or areas of special expertise are asked to experiment with new forms of agricultural production. Placing the testing sites in a close realm to each other but in different situations, accelerates cooperation from the beginning. Key projects in this phase include first collection points such as compost, a processing and a pasteurising facility.

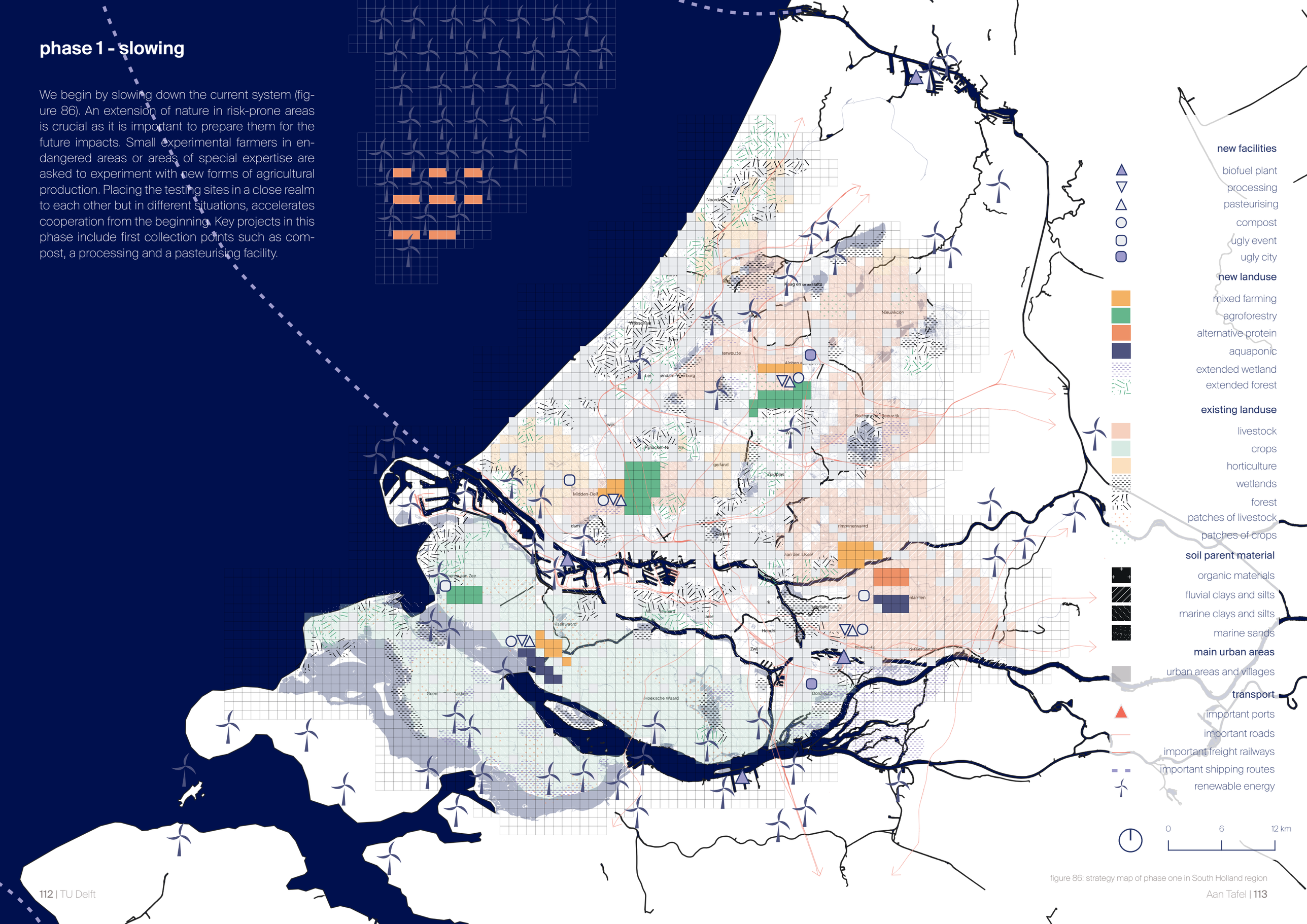


figure 86: strategy map of phase one in South Holland region

phase 1 - slowing

The first flows are defined by a close local exchange of the farmland but an overarching exchange of manure as fertiliser and crop residue as feed between facilities (figure 87).

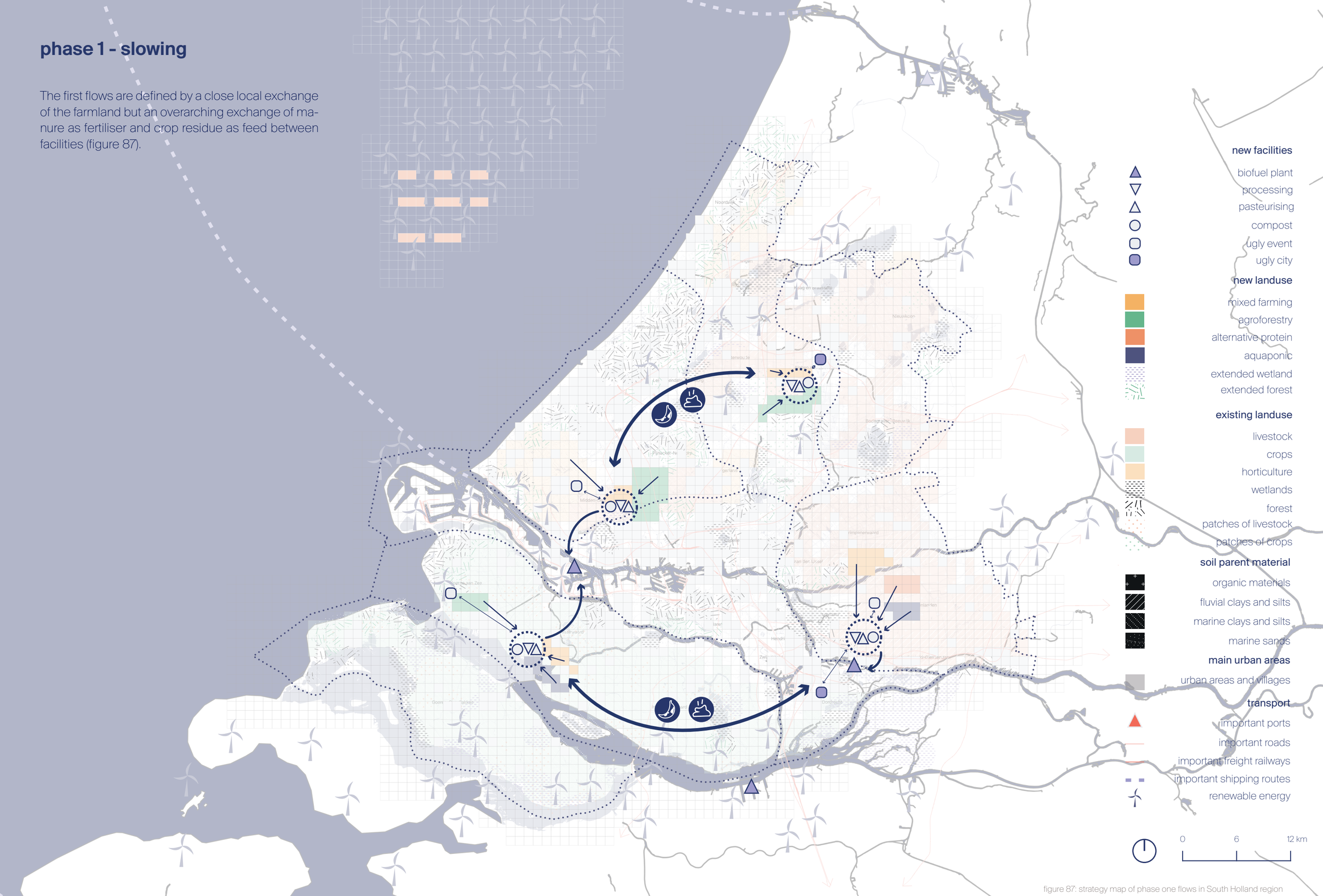


figure 87: strategy map of phase one flows in South Holland region

phase 2 - narrowing

We continue by narrowing old habits and future possibilities (figure 88). More farmers will have learned from the experimenters and can implement innovations independently. This scattered appearance leaves opportunities to integrate natural areas on a smaller scale within the farmland. All composting sites will be built to give enough room to share by-products.

phase two: narrowing

new facilities
- biofuel plant
- processing
- pasteurising
- compost
- ugly event
- ugly city

new landuse
- mixed farming
- agroforestry
- alternative protein
- aquaponic
- extended wetland
- extended forest

existing landuse
- livestock
- crops
- horticulture
- wetlands
- forest
- patches of livestock
- patches of crops

soil parent material
- organic materials
- fluvial clays and silts
- marine clays and silts
- marine sands

main urban areas
- urban areas and villages

transport
- important ports
- important roads
- important freight railways
- important shipping routes
- renewable energy

0 6 12 km

figure 88: strategy map of phase two in the South Holland region

phase 2 - narrowing

The flows (figure 89) concentrate around the clusters of compost, processing and pasteurising. These clusters connect to other compost sites and the ugly event series. The overarching flows become

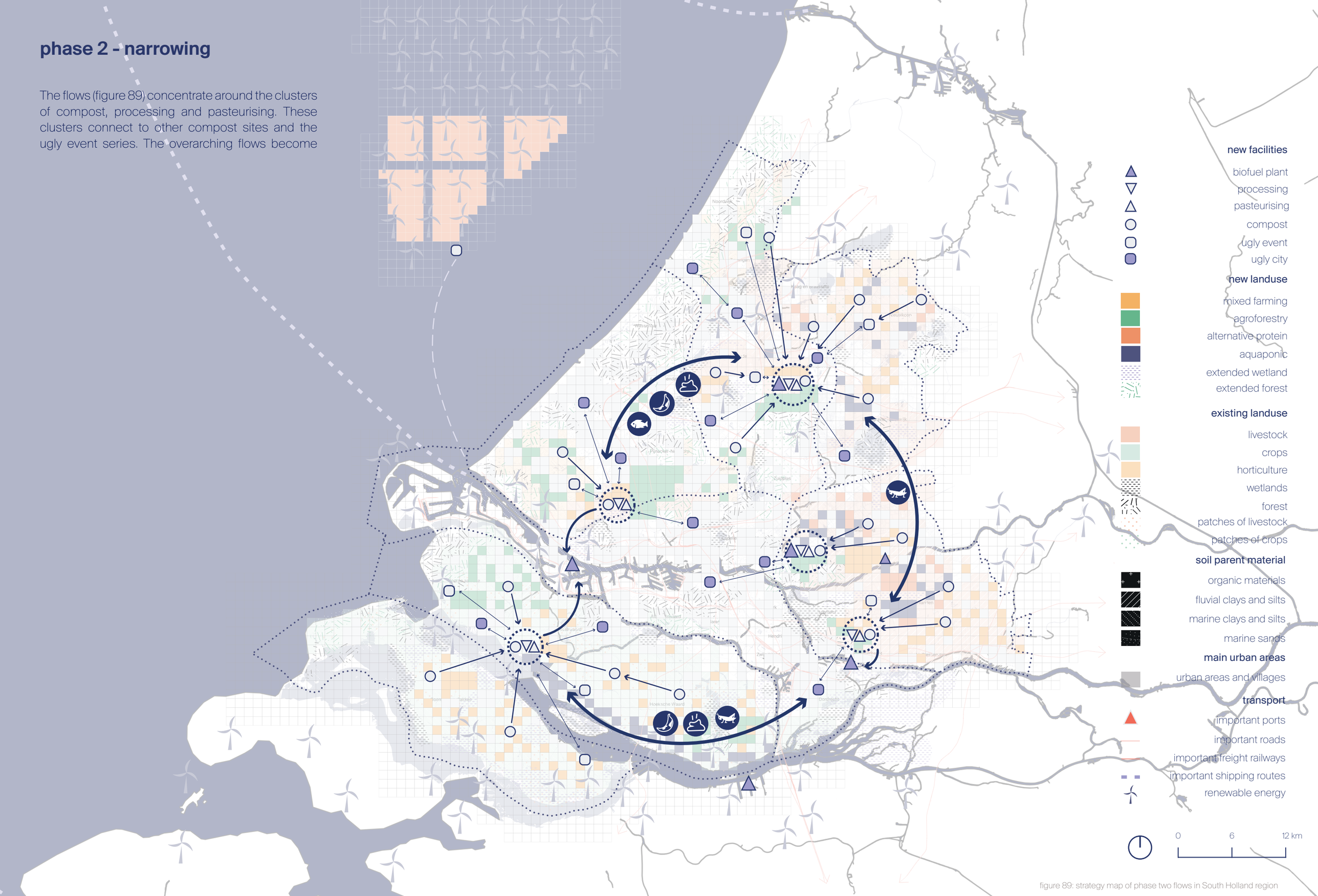


figure 89: strategy map of phase two flows in South Holland region

phase 3 - opening

We end by opening the loops, our minds and our stomachs towards new networks and an uncertain future (figure 90). The sprawl of innovative farming will have merged into an agglomeration. Nature is fully integrated in the production landscape. All facilities are constructed.

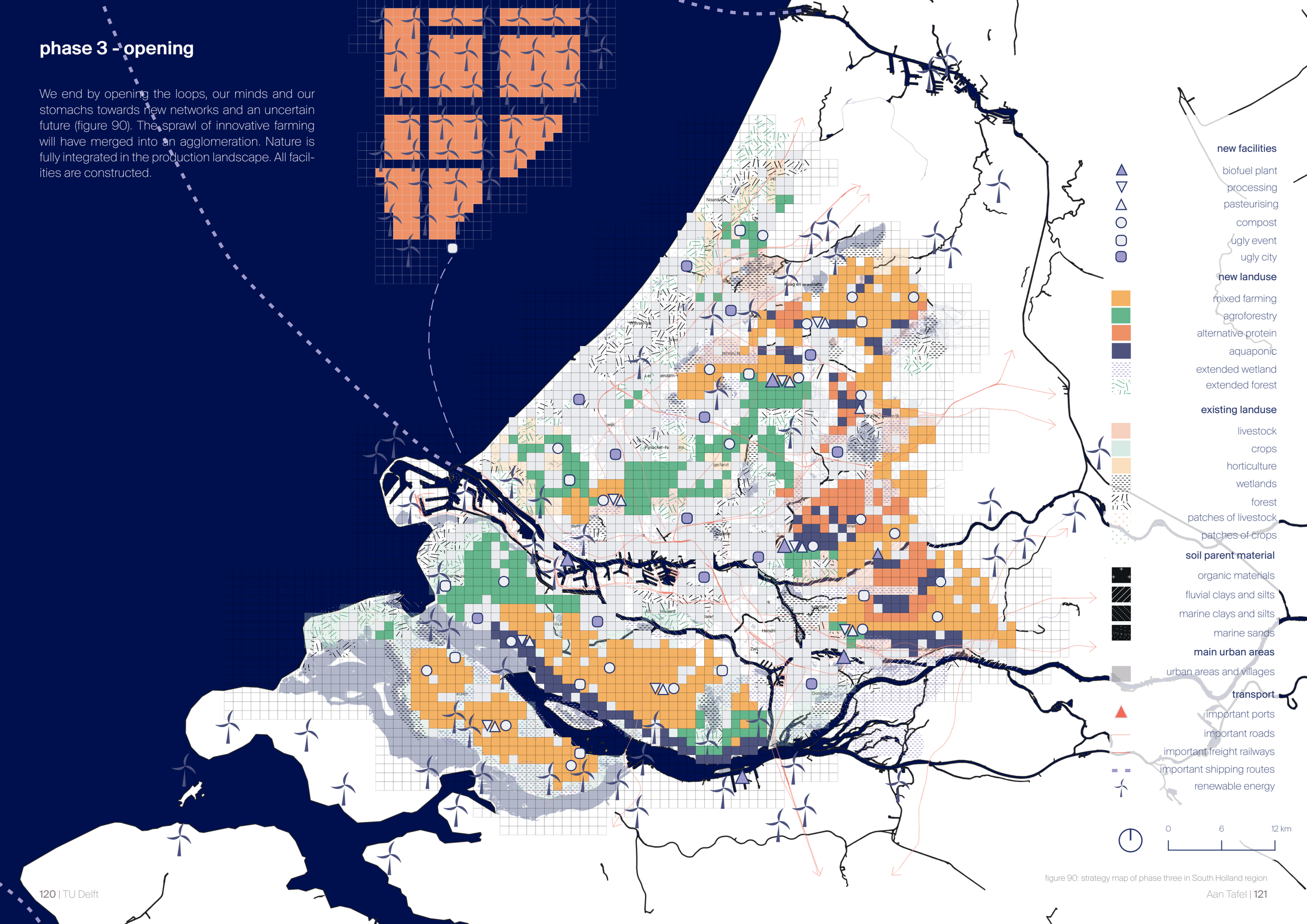


figure 90: strategy map of phase three in South Holland region

phase 3 - opening

The flows in this phase (figure 91) become more complex. A majority are handled locally. Longer flows include the transportation of sludge to the biofuel plant and the trading of specific products. A main outflow of South Holland into its patch 1a (Rotterdam-Antwerp) or to other patches include insects, fish and specific fruits. A main inflow consists of wholegrains and other fruits.

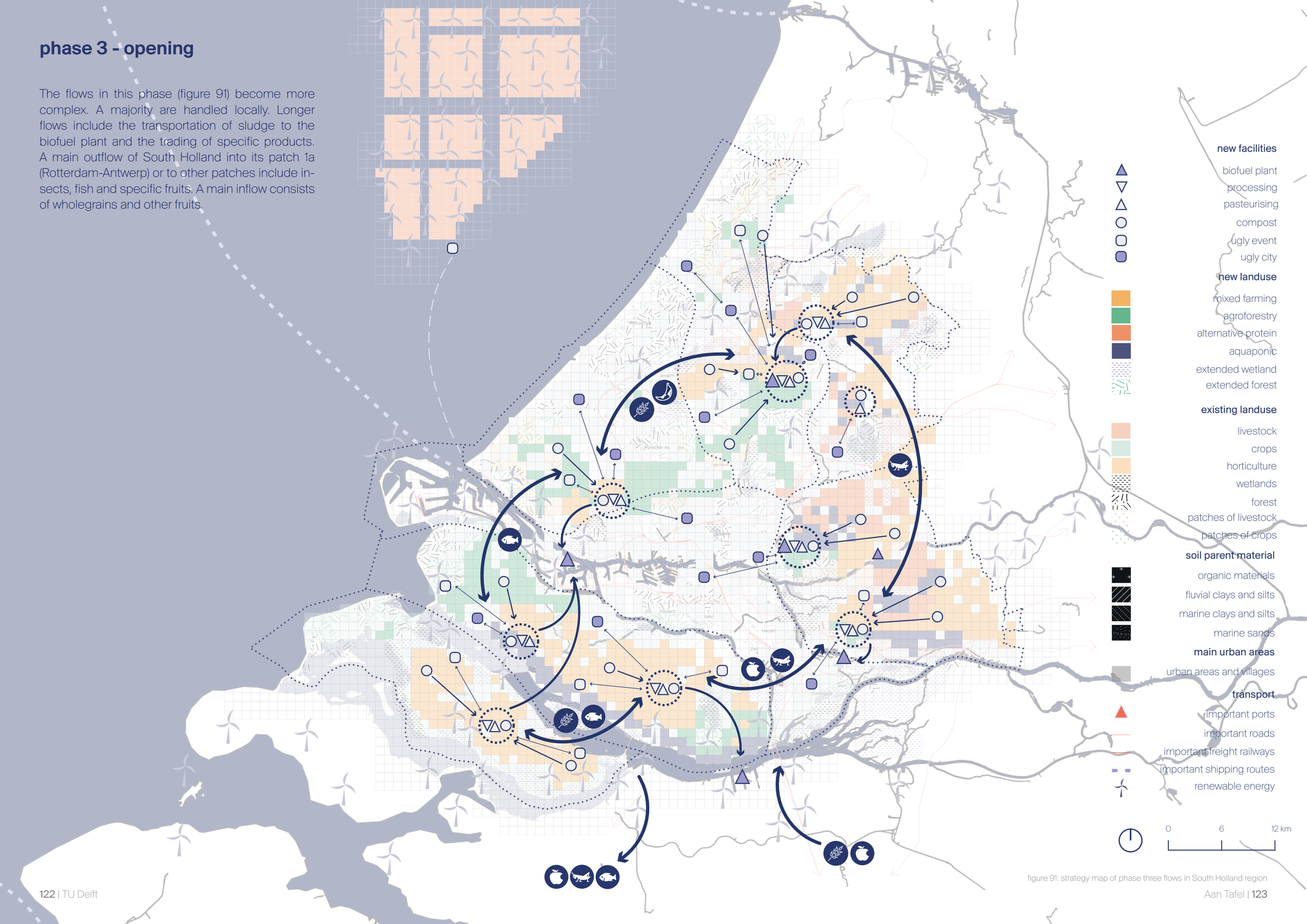


figure 91: strategy map of phase three flows in South Holland region

adaptive timeline and policies

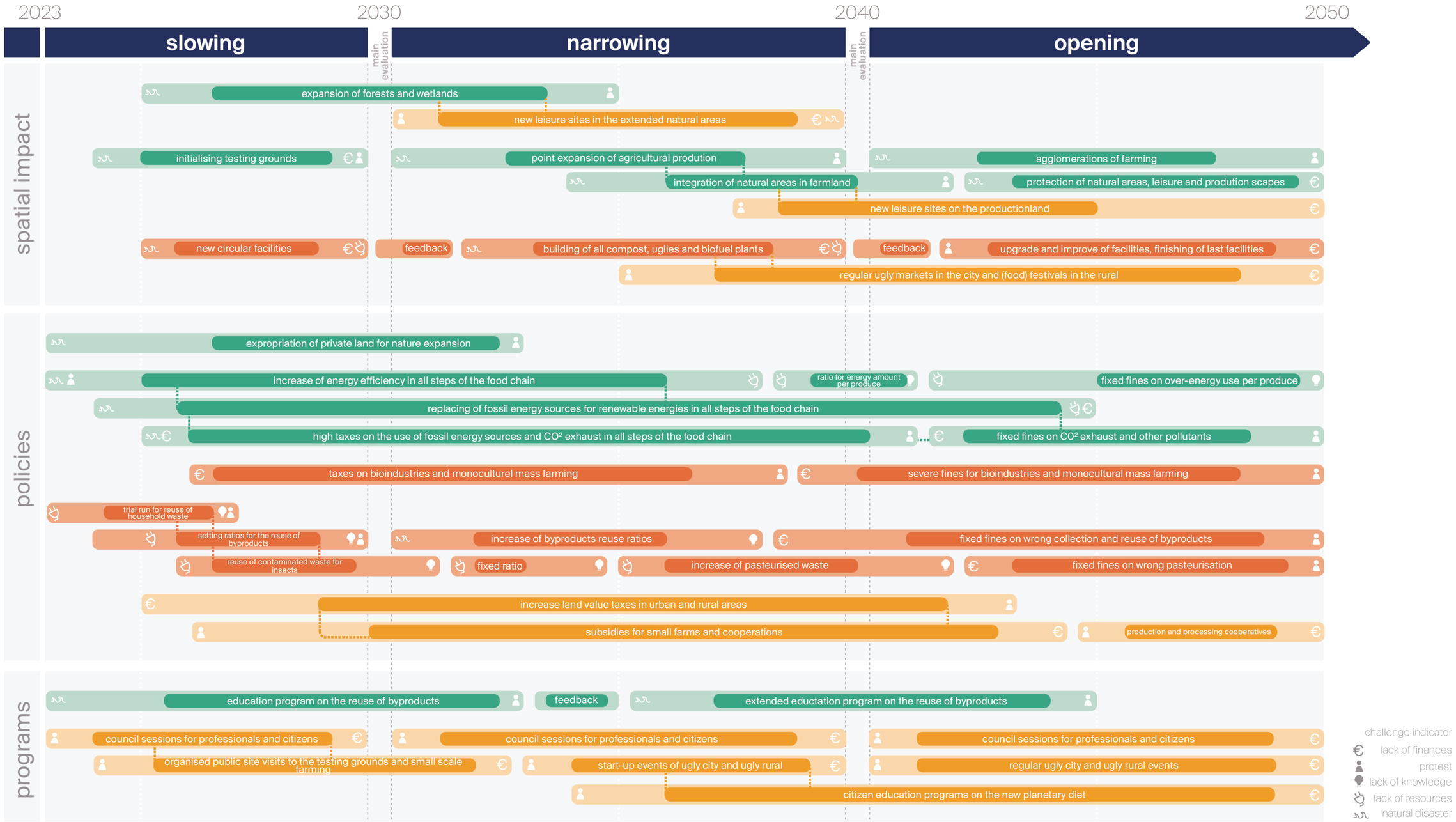


figure 92: adaptive timeline and policies framework for the strategy implementation

The timeline (figure 92) is divided into spatial impacts, suggestions for policies and programs. Each step has a specific time of implementation and a time frame when it should be implemented. Challenge indicators suggest possible conflicts, delays or accelerations. A majority of the nature-based steps face farmers' protests as they undermine their current source of income. The immediate risk of a natural disaster in contrast promotes the expansion of natural areas as it threatens harvests, livelihood and property. Additionally education programs for farmers provide new income opportunities.

strategy intervention

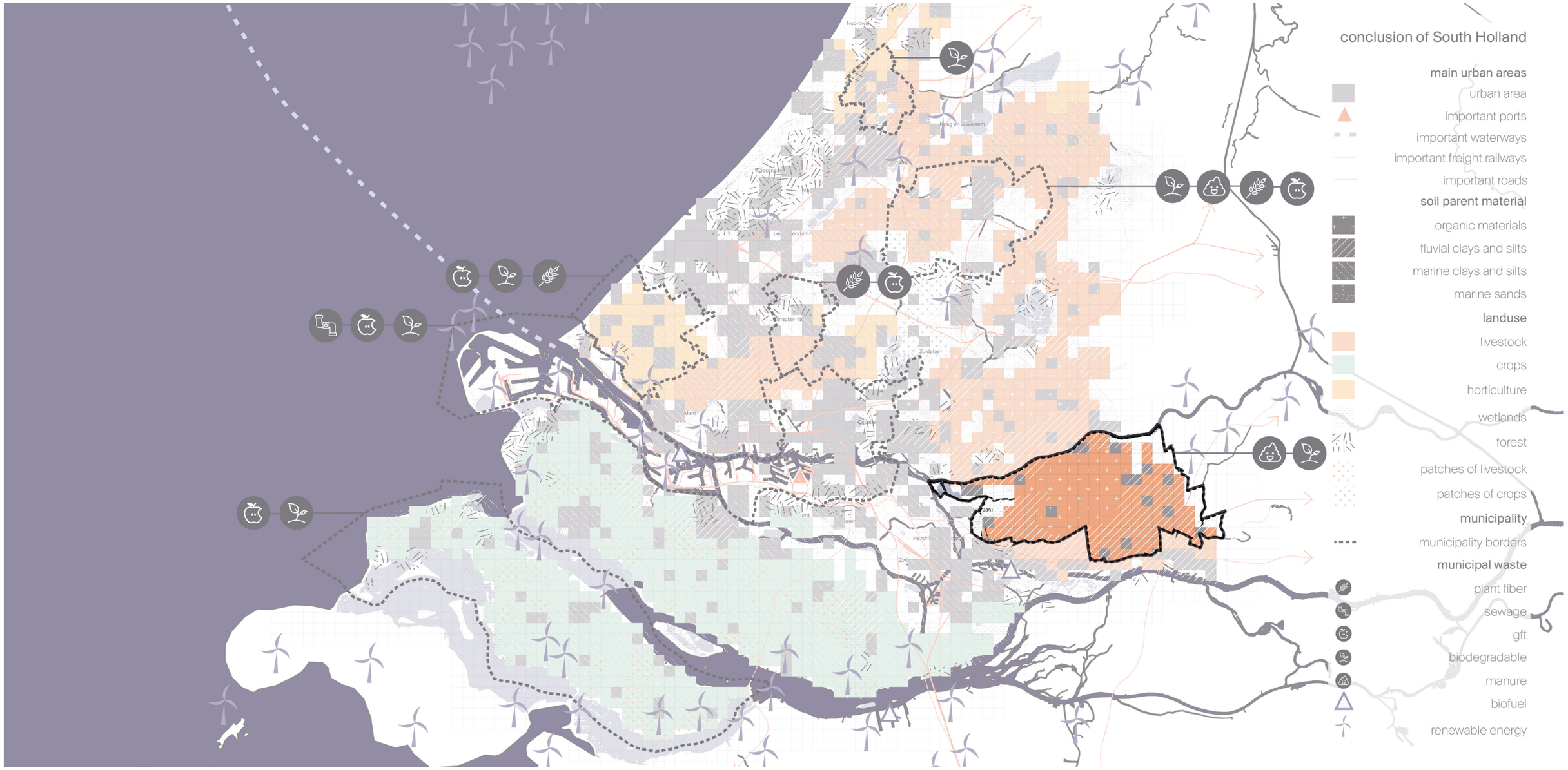


figure 93: conclusion map of the municipality of Molenlanden

Molenlanden's mainly covered by livestock farming, small towns and villages, making it a Type C area. Its soils are peat in its centre and fluvial clays surrounding. A few wetlands are located alongside the river. The inner structure of Molenlanden is connected through N-roads and an A-road on the east side which connects to the highway structure. Molenlanden produces a surplus of manure and biodegradable waste.

The livestock farming has made place for mixed farming, agroforestry and aquaponics. The wetlands in the municipal area are getting extended to contribute to CO_2 catchment. Insect farming on stilts is added on flooded peat soils to prevent flooding.

To comply with the protein needs of the consumer insect farming also has been added to Molenlanden. The by-products created in the processing of food will be send to compost sites spread evenly across the municipality, for local use. Closer to an urban area, a cluster of pasteurising and composting waste takes place, close to the processing of food. This way all the new facilities can exchange products with each other.

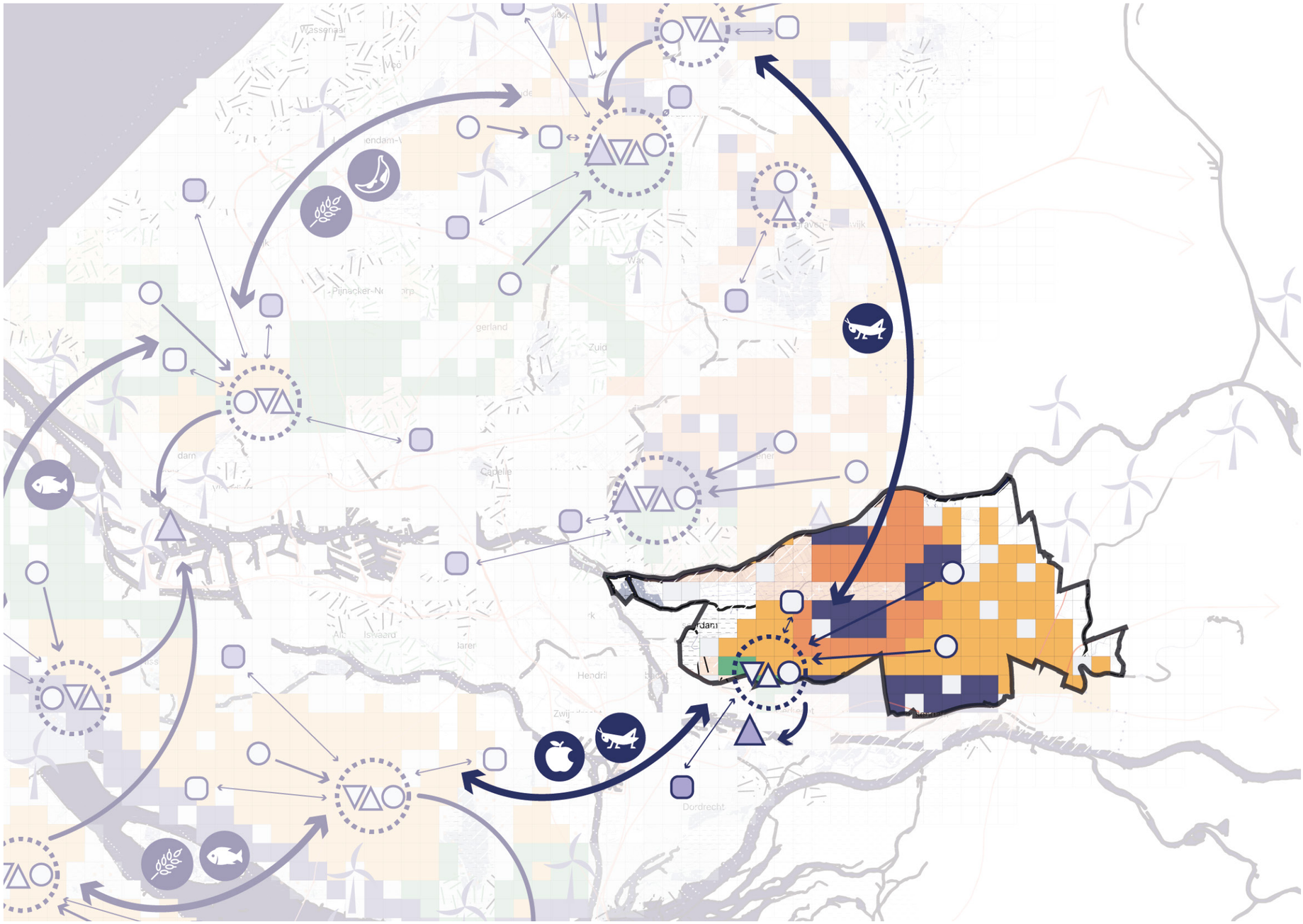


figure 94: zoom-in map of the Molenlanden municipality strategy

spatial interventions

The livestock farming has made place for mixed farming, agroforestry and aquaponics. The wetlands in the municipal area are getting extended to contribute to CO_2 catchment. Insect farming on stilts is added on flooded peat soils to prevent flooding.

We arrange a cluster of processing, pasteurising and compost in-between the city and farming interventions (figure 95). This intervention concept aims to shorten the distance of the by-products flows and to connect all the steps together.

Flows of the by-products in the food production system of Molenlanden municipality are illustrated in figure 96. They are recovered, repurposed and reconnected within the phases of the food system, by implementing the concept of circularity in a small scale.

figure 95: spatial interventions in the food production system in Molenlanden

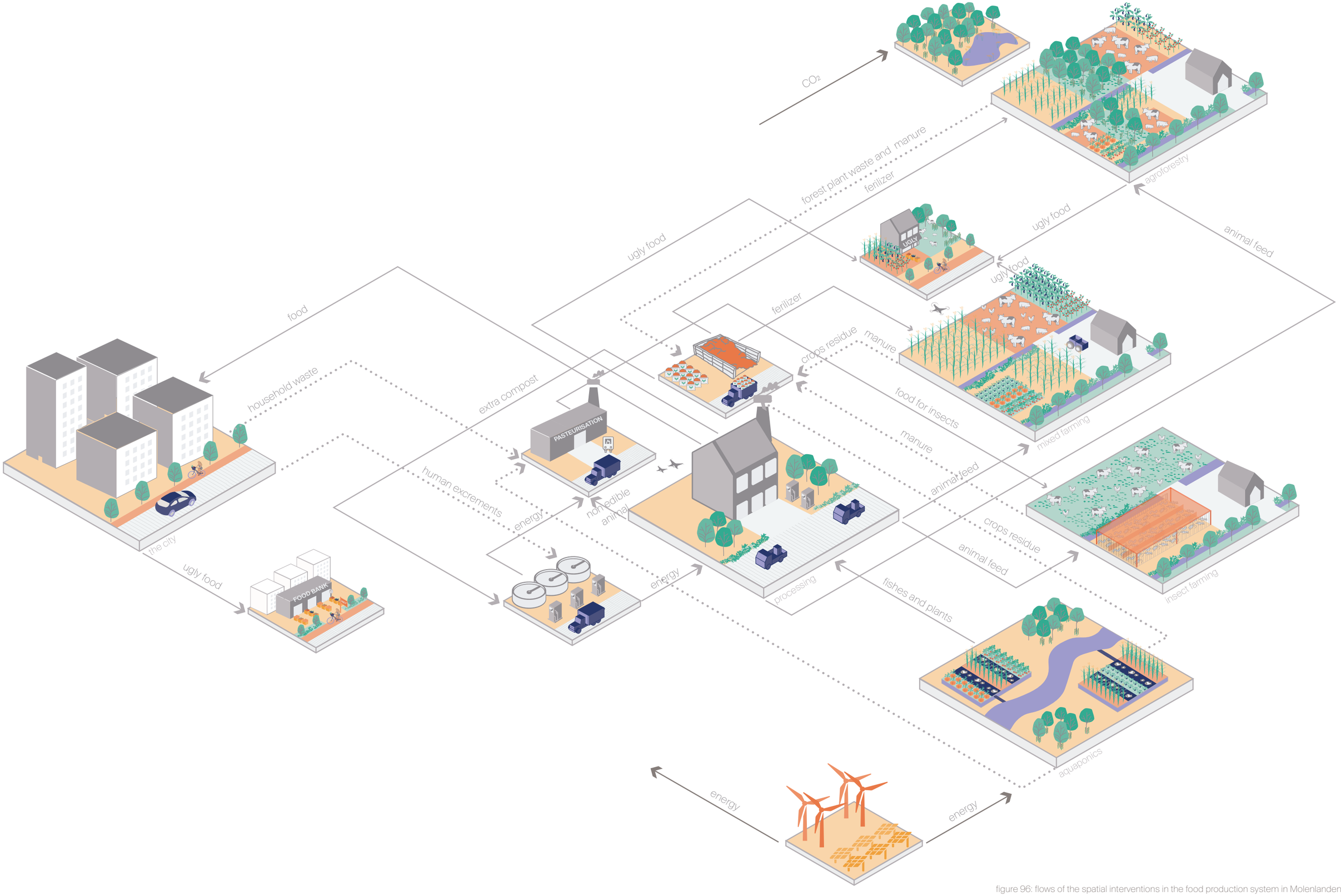


figure 96: flows of the spatial interventions in the food production system in Molenlanden

figure 97: collage of the spatial interventions in the food production system in Molenlanden

7 // conclusion

This project aimed to answer the following research question: ''How can the food production system of South Holland be part of an open circular economy that achieves a net-zero Carbon Food-Print for North-West Europe in 2050?''

The Northwestern European food production system has to radically change its means of farming, processing, consuming and revaluing by-products in the chain. In this economy production is not for profit, but for a need. Food is no more a commodity but a common. South Holland can be a part of this open circular carbonneutral economy by adapting its production landscapes. However, it can not act on its own. In our research we concluded that the province can not produce enough to be self-sufficient. Thus, an European approach to an open circular carbonneutral economy is necessary in which European governments support with policy changes, laws and subsidies.

The challenges related to this change are related to changing the mindset, financing the transition and rethinking (EU) legislation. Monocultural farming has to be replaced, overproduction stopped and accumulation of private land has to be reduced. This will lead to a change in the main income sources of farmers and farming companies. This results in an ethical dilemma for farmers who were pressured to overproduce for a long time and will now have to restructure their livelihoods. Inhabitants of North-West Europe have to renounce individualism in which gluttony and luxury prevails. These ideas align in many ways with the European governments' except for their strive for growth which clashes with our ideas on production for need.

An addition would be to research the willingness of people to transition, as well as how to equip nature with subjective rights by changing jurisdiction. At the moment nature is left as a passive stakeholder in scenario policies that are based on management and regulation.

We identified a knowledge gap in guidelines on soil and crop types as well as yield and climate conditions. This is a consequence of the difficulty of understanding agriculture fields as a whole, since they are influenced by many uncertain conditions. This knowledge gap makes it difficult for specialists (e.g. urbanists) to support farmers in their transition and negotiate between different sectors. This is of the utmost importance as the implementation of our project relies on bottom-up changes from farmers.

Our project thus addresses flaws and issues of our democracy in the neoliberal age. The profit of some glosses over the needs of many. We hope that our vision for the food system can inspire an alternative future where the fulfilment of our collective needs lets us forget about individual profit. Food, if nothing else, is meant to be shared. Our project provides society with food for thought.

8 // references

image directory

bibliography

image directory

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Front cover: Authors work

Preface:

Figure 1: Authors work in combination with basemaps and the following source

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Figure 88: Authors work

Figure 89: Authors work

Figure 90: Authors work

Figure 91: Authors work

Figure 92: Authors work

Figure 93: Authors work

Figure 94: Authors work

Figure 95: Authors work

Figure 96: Authors work

Figure 97:

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9 // appendix

individual reflections

impressions from the field trip

social media content

in-depth stakeholder analysis

subregion matrix and supporting maps

FAOstat data

calculations

food label

individual reflection

individual reflection Rexhina Basha

In the individual reflection I would like to talk about the role of a vision in the planning and design proposal of my group project and how it has influenced our strategy.
I perceive vision as a tool to frame out the big picture of a possible future scenario. It is based on values that we want to achieve, evidence of the current and upcoming challenges that we have to face, goals of different voices that should be heard and on spatial strategies that need to be implemented in a long-term perspective (Rocco, 2023). The vision in my group project emphasises the values of the future we want to address in 2050 for the food production system of North-West Europe, based on the three sustainability pillars: people, planet, prosperity. It integrates spatial and non-spatial interventions by creating a toolbox that will translate the vision statement in space.
But how to design a vision for a metropolitan region in a world that is dealing with the climate, economic and social crisis at once? That was the first question that came up in my mind during this project. I would answer that question now by saying that you should consider different cross-sectoral actions and jump in scales, if you want to design a vision for a metropolitan region. It is a complex structure of analysing, decision-making, critically thinking and co-designing with different contexts, scales, issues, opportunities and challenges. I see now the metropolitan regions as the new and most efficient potential areas of dealing with the future scenarios and paradigms. Designing a vision for a metropolitan region for me during the group project was like a mechanism that could move the growth system of land scarcity and competition for land, into slowing down, setting boundaries and managing the flows within the system itself (Cardoso, 2023).
How to achieve the vision and develop strategies to reach our aim of a net-zero carbon footprint for the food production system in North-West Europe? The planning tools introduced in the lecture of Fred Hobma were very helpful in structuring the vision and developing strategies (2023). Shaping, stimulating, capacity building and regulating are the instruments that helped in defining strategies and achieving the vision (Hobma, 2023). I think that these tools make the vision more tangible and leads to a better understanding of the strategies we needed to implement. The role of vision has framed not only the future scenario of North-West Europe, but it also gives directions to develop the strategies in the scale of South Holland.
To conclude, I think that the role of vision in planning is quite crucial in aligning a big picture of the future scenario and identifying the steps we have to go through to reach that future. It influenced the development of my group project strategies, by structuring what needs to be done during a specific time and the tools that need to be used. So, vision and strategies go hand by hand, aiming to make tangible and translate in space the desirable future that we are aiming for.

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individual reflection Darcey Bil

In this section I reflect on our design project using the question "In which way is the governance aspect embedded in the planning and design proposal of your group project and what are the reasons for this embedding?"
In our project we aim to rethink the current linear food production system to a circular one. This is a proposal for a radical transition in economy and society. Achieving circularity means moving to a reuse economy, then a circular economy and finally ending at a regenerative economy (Wandl, 2023).
We were proposing to make a transition in a complex system. As stated by Wandl (2023), this requires rethinking systematic relations. Problems we identified at that moment related to changing mindset, creating financial support and changing laws and policies.
At this point the problem of coordinating the change of this complex system became relevant. In relation to that Rocco and Dabrowski (2023) gave the example of Elinor Ostrom. Her work addressed management of common resources. Essential in these management techniques were "polycentric governance, symmetric communication and subsidiarity" (Rocco and Dabrowski, 2023, p. 61). This allowed for a variety of voices to be heard. This way of governing change and resources was a way to make a collective transition towards the open circular economy.
Shaping the attention of stakeholders (Rocco and Dabrowski, 2023) by creating a vision and a strategy helped us tackle problems of different stakeholders collectively. Consumers, farmers and the government each had their own storyline and their own role to play. Therefore the most important part was making sure that the vision was based on the idea of community.
We implemented policies that financially stimulated 'grassroots' and educated different stakeholders. This stimulated the individual transition of farmers and consumers. This relates to the idea of Rooij (2023) that adjusting rather than steering is important in times of transition. "Large transitions go together with a shift in power [...] with small and deep support" (Rooij, 2023, slide 44). Regeneration and traditional management of common resources is reflected in our implementation of Nature-Based Solutions in farming. These ways of farming traditionally used by-products in an effective way, consequently they fit well within the idea of an open circular economy.
In the end I feel that Jan Rotmans said it well: "Embrace the chaos!" (Rooij, 2023, slide 44). We had to stimulate chaos to a certain extent to give room to new ways and allow the transition to happen. Governance supports the creation of space from both top-down and bottom-up initiatives in which a variety of voices have to be heard.

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individual reflection

individual reflection Serah Bremer

In this reflection I will address the relationship between research and design in this project. I will do this by discussing the timeline of the project and the different phases of research and design that went along with that.
The first goal of our project was to find a topic our research objective was going to be targeted towards. We had to find a problem to design a solution for. Our group was categorised on CO2 and circular economy. In order to find a topic we first did research on problems surrounding these topics.
To think about this, the scope of our research to find a research objective, was heavily influenced by our personal background and interest. We researched within topics we found interesting and fitting towards the theme. I think it is interesting how other cumulations of people have ended up doing different research and have created different designs. Research was done in order to pick a research objective in order to make a design.
After finding a research objective we phrased sub questions to be answered. These sub questions were mostly meant to find information that could help us to make informed decisions when making the design.
However, I always felt like specific research frameworks or approaches that were familiar helped by gathering information on complex challenges. This is also what Rooij talked about in his lecture on methods of regional planning and design.
The research and the design both went through different scales that we were working on for the project. Research defined the frames and the scales for the design. Most of the research was depicted in maps, text or graphics. The design led to new ideas to be researched, this research provided a backbone to create rules from in order to create the design.
In my opinion most of the research was done in order to back up the design, this was the way I think the relation between research and design was like. But in the lecture of Thöle (2023) he talked about doing research on what claim your design has on the land. I feel like this also happened in our project, by zooming into our smallest scale, where the claim on land becomes more feasible.
I think in this quarter I have learned the following things about the relationship between research and design. I learned that it is important to do research on the impact of your design alongside values, ethical issues and how it impacts society. This way research is used as a backbone and a control tool on your design. I learned about different existing research approaches you can use in order to make a step by step analysis.

Thöle, H. (2023) An Introduction to Zuid-Holland [pdf]. Available at: https://brightspace.tudelft.nl/d2l/le/content/503072/viewContent/3099037/View.

Rooij, R. (2023) Methods of regional planning and design; Approaches to tackling complex challenges [pdf]. Available at: https://brightspace.tudelft.nl/d2l/le/content/503072/viewContent/3115957/View.

individual reflection Johanna Zehntner

In this reflection I will explain how and why the aspect of governance is embedded in the planning and design proposal of our group project. The project aims for a radical transition in the food production system. Because of huge challenges in the implementation, a holistic approach to governance is necessary on local and transnational levels because transition to a renewable and bio-based economy likewise causes geopolitical conflicts (Wandl, 2023). In many cases the design and planning practice still relies on private investment and rentability of a project on the free market. Especially with the neoliberal turn in the 1980s of many governments to open the financial market globally (Rocco, 2023a), there is a need to reorientate urban planning towards a practice of consensus making. It should be a service to society (Beech, 2023). Collective decision- and vision-making can be a solution to bypass a capital profit-oriented market. A common goal guides all involved parties in the making of a vision (Rocco, 2023b). Strategy development in spatial planning incorporates vision-making as a core aspect. During the establishment of a legal, financial, and temporal framework, strategies should include citizen and stakeholder engagement. The tradition of Dutch spatial planning is built on a collaborative effort to overcome major challenges by coordination and negotiation between diverse sectors and people (Balz, 2023).
The project aims to follow the tradition of Dutch planning and includes farmers, other professionals, decision-makers, and citizens in all steps of the implementation. The construction of key projects, especially the Ugly Events and Ugly City, represent a spatial manifestation of diverse participation and knowledge-sharing. In this project we see it as our duty is to create spaces where people are invited to govern themselves and reintroduce the core value of food and land as our common good.
It is built on the concept of polycentric governance of the commons by Elinor Ostrom (Rocco, 2023b). While the stakeholder's opinion is actively involved in the development and adaptation of the strategy, they are vice versa asked to conform to the rules of the open circularity. This means on the one hand, rightfully sorting their by-products and contributing to a net-zero future on individual grounds. The common goal based on the three pillars of community-based, nature-based and production of need, must ensure the prosperity of all. If this prosperity is not fulfilled an adaptation of the strategy on common agreement must be executed. Our project creates a new social and legal contract based on food. The governance of the food system is based on the logic of the open cycle. In- and outputs of governing and knowledge exceed local structures and meet in our vision on a European level.

Balz, V. (2023) Strategy Making [pdf]. Available at: https://brightspace.tudelft.nl/d2l/le/content/503072/viewContent/3124390/View (Accessed: April, 12 2023).

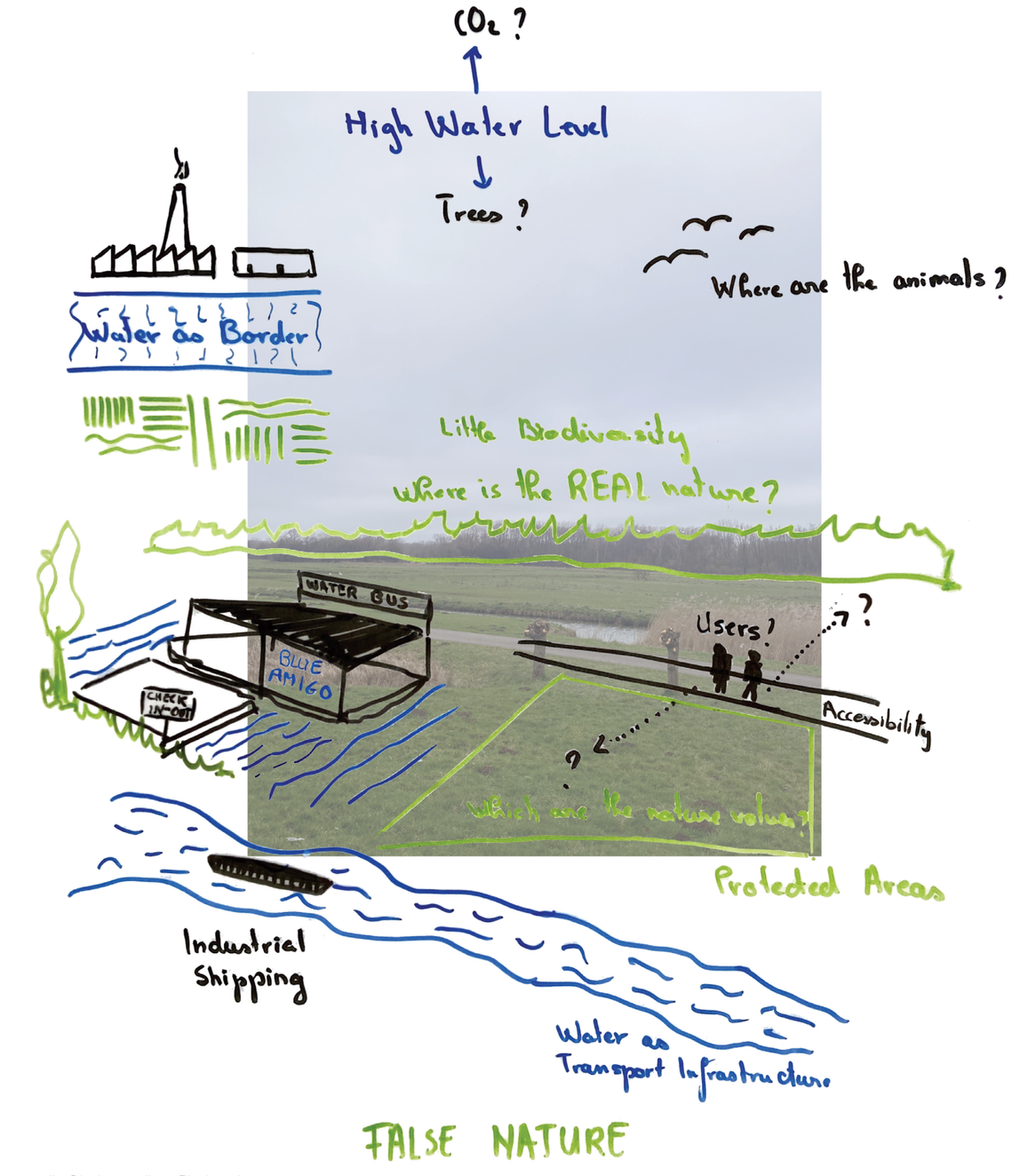
Beech, N. (2023) Legislating Architecture, English Version. Available at: https://archplus.net/en/Legislating-Architecture-EN/ (Accessed: April, 12 2023).

Rocco, R. (2023a) It's a deal. How humans started to regenerate the planet [pdf]. Available at: https://brightspace.tudelft.nl/d2l/le/content/503074/viewContent/2969772/View (Accessed: April, 12 2023).

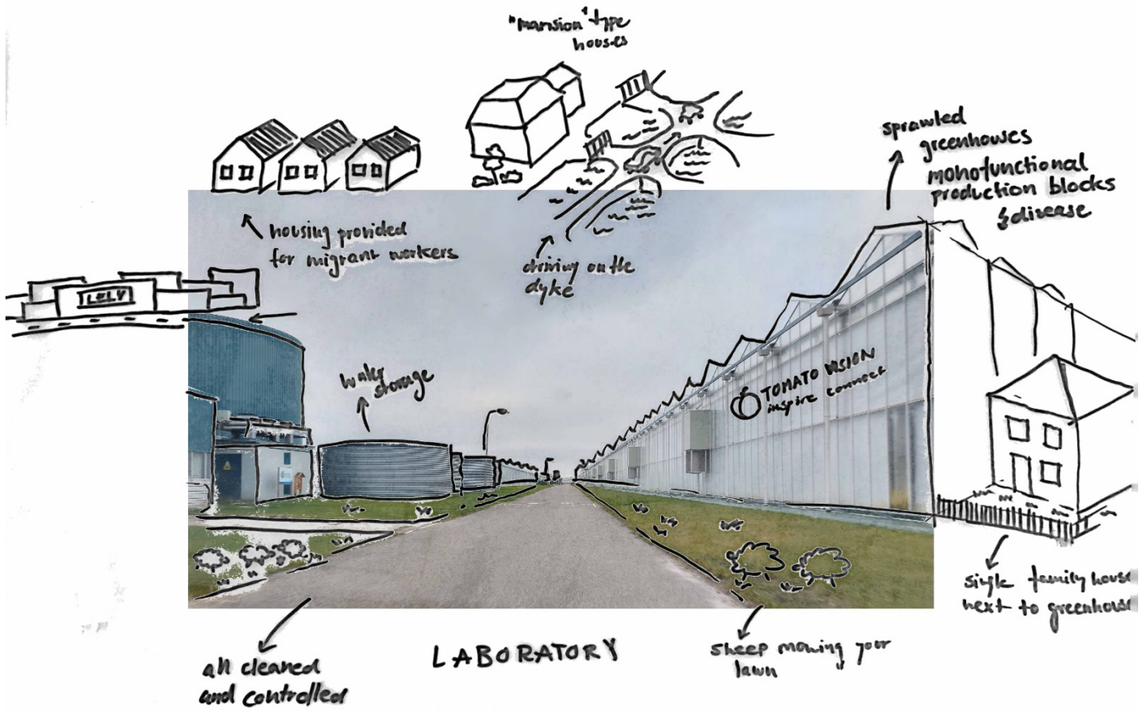
Rocco, R. (2023b) I have a dream. The role of visioning in planning and design [pdf]. Available at: https://brightspace.tudelft.nl/d2l/le/content/503074/viewContent/2969772/View (Accessed: April, 12 2023).

Wandl, A. (2023) Circular Economy Challenge [pdf]. Available at: https://brightspace.tudelft.nl/d2l/le/content/503072/viewContent/3100864/View (Accessed: April, 12 2023).

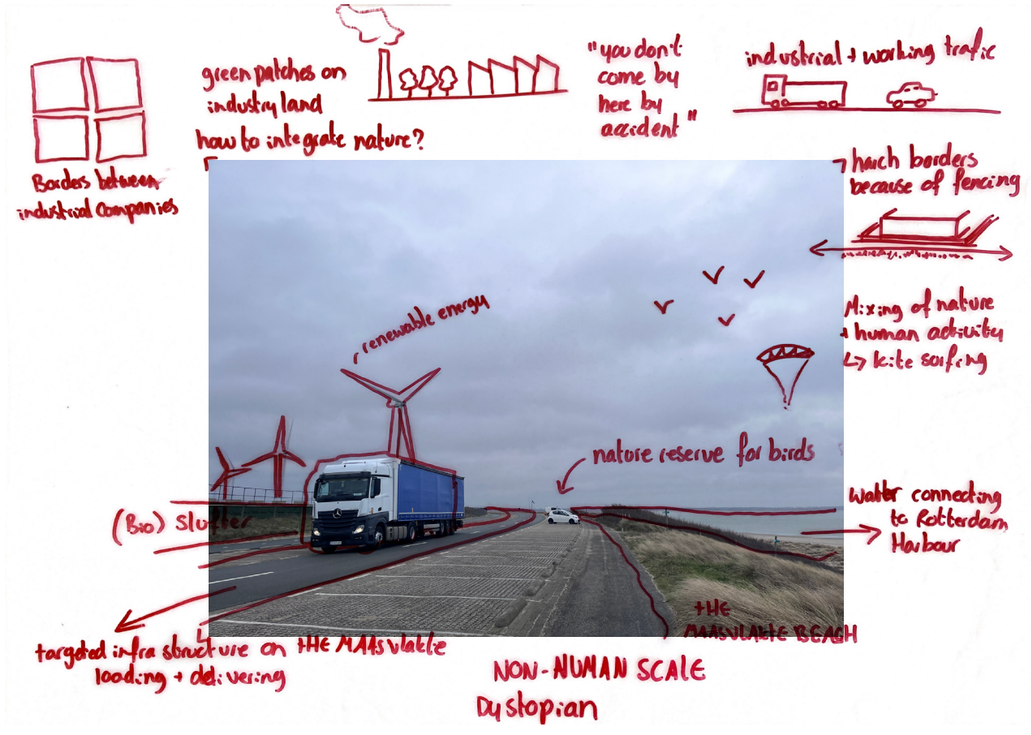
impressions from the field trip



appendix 01: photo collage Biesbosch



appendix 02: photo collage Westland



appendix 03: photo collage Maasvlakte

social media content

Planet Earth
@realMotherEarth

I can't stand back & watch this happen to the GREAT production system of South Holland. This is such a HUGE problem. A total lack of leadership. Only by being part of the open circular economy of North-West Europe you will get the JOB DONE RIGHT..... and have a ''NET-ZERO CARBON FOOD-print.''

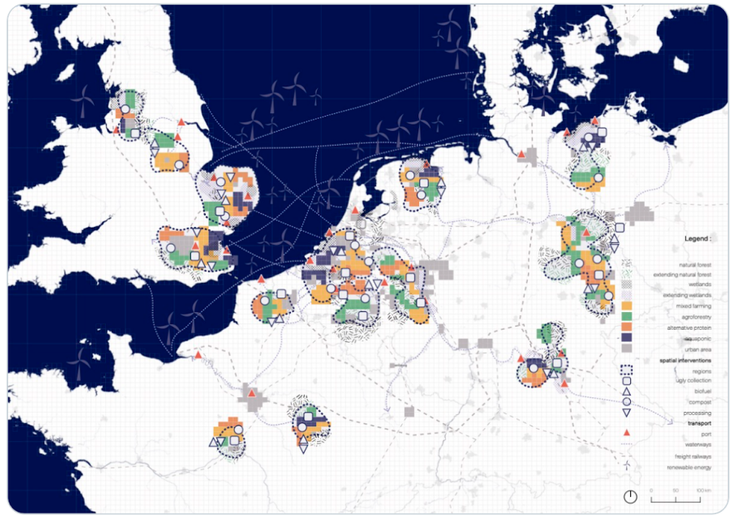
4:09 PM · Mar 13, 2023

141 Retweets **33** Quote Tweets **11K** Likes

appendix 04: tweet earth

Aan Tafel!
@DelftSpiceGirls

@realMotherEarth 's tweet really shook us th day... we need to take her concerns seriously! Sooo we made a project out of it: In 2050 the food production system of North-West Europe will be carbon-neutral and South Holland a strategic part of it! Here is how!



1:56 PM · Mar 20, 2023

83 Retweets **3** Quote Tweets **2.2K** Likes

appendix 05: tweet Delft Spice Girls

Aan Tafel • Following
The Netherlands

Liked by **Marcin** and **1,560 others**

Aan Tafel What is so great about the future of the #FoodProduction system in the #NorthWestEurope? It respects #Nature, brings back #Joy in the community and #Equity is the key ingredient during the process of #ProductionForNeed. Let's go all together towards a #ClimateNeutral continent in 2050 and enjoy our #Food. Aan Tafel ... more

View all 20 comments

5 MINS

appendix 07: instagram post

Aan Tafel!
Today at 6 1am ·

Friends, come aan Tafel! 26% of global Carbon-Emissions are caused by our food! This is also a problem, where we live! It's time to rethink our food production system. The EU claims to be carbon-neutral by 2050 to ensure the future of our children and grand-children. A huge step towards sustainability. But how to do that? We have to slow down and sit together: Our vision for the food system of North-West Europe is based on nature, the community and it produces for need!

We should bring back joy, equity and respect for nature in the relation to our food!

Like Comment Share

Roberto and 7865 others

Max Musterman Great work! so inspiring!
20
undefined · undefined · 5 mins

Write a comment...

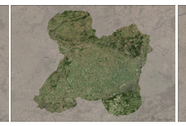
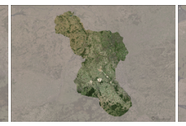
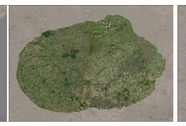
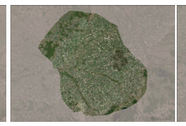
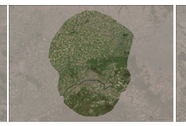
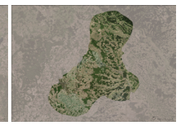
appendix 08: facebook post

in-depth stakeholder analysis

stakeholder	numers (NL) (ZH) (EU)	Explanation stakeholder (Add how they are important to achieve the goal)	Public Private Civil	Power	Interest	Opinion/take on	source
Consumers	NL: 17,5 mln. ZH: 3,7 mln. EU:	Humans who consume the food at the end of the food production system.	Civil	Have a say in what food gets produced.	Access to affordable and healthy food, consumers can have different wishes surrounding food.	‘‘I don’t believe that my food choices influence sustainability. I think price, taste and individual health are more important than sustainability.	Van Bussel, L.M. et al. (2022) “Consumers’ perceptions on food-related sustainability: A systematic review,” Journal of Cleaner Production, 341, p. 130904. Available at: https://doi.org/10.1016/j.jclepro.2022.130904.
Nature	NL: 41.850 km²	The physical world, including plants, animals, the landscape and other features and products of the earth. Is a silent stakeholder.	Public	Has no power, unless another stakeholder speaks up.	Not having its resources exploited and environment polluted.	‘‘Please do something!’’ ‘‘Human activity surrounding the food system is damaging for me, the food system has an excessive ecological footprint that I can't sustain.”	Nova School of Business & Economics (2022) “Foodprint” – The Environmental Impact of Human Diet — Nova SBE Role to Play. Available at: https://roletoplay.novasbe.pt/content/foodprint-the-environmental-impact-of-human-diet (Accessed: April 10, 2023).
Future generations		Cohorts of hypothetical people not yet born and other stakeholders not yet involved. Is a silent stakeholder.	Civil	Has no power, unless another stakeholder speaks up.	An unexhausted planet and also access to affordable and healthy food	‘‘We have the most at stake and the most to gain from a change we’re not part of.”	
Cattle, poultry & fish		Animals at the beginning of the food production system	Civil	Has no power, unless another stakeholder (animal activists) speaks up.	Good living conditions	‘‘Animals have an important part to play in developing circular systems in order to reduce emission.	Veolia Group (2021) How Animals Are Working Hard Toward a Circular Economy. Available at: https://blog.veolianorthamerica.com/animals-working-toward-circular-economy (Accessed: April 10, 2023).
Farmers	NL: 65.000	Professionals who produce products at the beginning of the food production system	Civil	Has the power on how they produce food.	Making profit off of products in the food production system	‘‘We hold a big key in reducing greenhouse gases. In order to change we need more stimulation, money and new strategies to do this.”	Hefty, B.B. (2020) Farm Fresh: A Farmer’s View on Carbon Footprint. Available at: https://vitalbypoet.com/stories/a-farmers-view-on-carbon-footprint
Farming companies		Companies who produce products at the beginning of the food production system.	Private	Has the power on how and what food they produce.	Making profit off of products in the food production system	‘‘We hold a big key in reducing greenhouse gases. In order to change we need more money and new strategies to do this. We as companies need to be held accountable’’	Hefty, B.B. (2020) Farm Fresh: A Farmer’s View on Carbon Footprint. Available at: https://vitalbypoet.com/stories/a-farmers-view-on-carbon-footprint
Food processors	NL: 6500	Companies who acquire food from producers in order to process the food, package it and sell it.	Private	Has the power on how food gets processed and packaged.	Making profit off of adding value to food products	‘‘Food processing is responsible for great amounts of waste per year. We need solutions in order to leave a smaller environmental impact. Reusable and more eco-griendly materials will find their way into the supply chain.”	Gonçalves, M.L.M.B.B., Maximo, G.J. Circular Economy in the Food Chain: Production, Processing and Waste Management. Circ.Econ.Sust. (2022). https://doi.org/10.1007/s43615-022-00243-0
Wholesalers	NL: 5	Companies who sell sell-ready food to customer service.	Private	Has the power on what food gets sold.	Making profit off of selling food products.	‘‘Circular economy in wholesale can mean new possibilities in logistics. Logistics can become bi-directional.”	Baumbach, W. (2020) “How Circular Economy Concepts will change Wholesale Distribution,” Linkedin. Available at: https://www.linkedin.com/pulse/how-circular-economy-concepts-change-wholesale-werner-baumbach (Accessed: April 10, 2023).
Transport companies / distributors	NL: 1550	Companies who distribute food to different chains in the food production system. The transport and logistics sector contributes around 24% of global CO2 emissions.	Private	Has the power on how food gets transported.	Making profit off of distributing food from chain to chain.	‘‘Transportation is a big part of the circular economy and part of the reduction of the carbon footprint, in order to do this transportation needs to be reformed.”	Vandycke, N., Singh Sehmi, G., Rolz Sandoval, I., Lee, Y. (2023) Defining the role of transport in the circular economy. Available at: https://blogs.worldbank.org/transport/defining-role-transport-circular-economy (Accessed: April 10, 2023).
Energy companies	NL: nearly 60 https://www.energievergelijk.nl/onderwerpen/welke-energieleveranciers-zijn-er	Companies who produce energy and provide to all chains in the food production system.	Private	Has the power to decide how energy gets produced.	Making profit off of selling energy to chains in the food production system.	‘‘The energy transition is gathering pace. And at its core is a move away from burning fossil fuels to a system which uses a much broader range of raw materials to fulfill our energy needs. We need to install massive amounts of renewable energy over the coming decades.”	Owen-Burge (2022) 3 ways the circular economy is vital for the energy transition - Climate Champions. Available at: https://climatechampions.unfccc.int/3-ways-the-circular-economy-is-vital-for-the-energy-transition/ (Accessed: April 10, 2023).
Stores Supermarkets Restaurants	Supermarket NL: 4850	Companies who shelf or prepare food for customers to buy.	Private	Has the power on where they get food from and what food they sell.	Making profit off of selling food to consumers	‘‘We are dealing with the effects of climate change on our businesses. We, too need to reduce our emissions, or else we have to do it under someone else’s terms.”	Putnam (2021) Is Climate Change the Food Retail Industry’s Biggest Opportunity? Available at: https://ratioinstitute.org/is-climate-change-food-retails-achilles-heel-or-its-biggest-opportunity/ (Accessed: April 10, 2023).
Waste treatment companies	NL: 4135 https://bolddata.nl/nl/bedrijven/nederland/afvalbedrijven/	Companies who process waste produced in the food production system. As waste treatment companies are pivotal for a shift towards the circular economy,	Public	Has the power to decide how waste gets treated.	Getting rid of waste in order to create a cleaner environment.	‘‘A Circular Economy is not conceivable without a sound waste management system. We need regulation, financing, enforcement and innovation in order to be successful.”	Acciona (no date) Circular Economy and Waste Management | ACCIONA | Business as unusual. Available at: https://www.acciona.com/solutions/cities/activity-areas/circular-economy/ (Accessed: April 10, 2023).
Technological innovation companies		Companies who produce technological innovations for the food production sector.	Private	Has the power to improve the food system.	Creating technological innovations in order to create a better food production system and make profit off of it.	‘‘The world is facing a crisis, the good news is that technology already provides tangible solutions to some of these challenges.”	Itelligence Nordic (2021) Technology in Horticulture for Reliable and Optimized Food Production. Available at: https://nttdata-solutions.com/no/blog/technology-in-horticulture-for-reliable-and-optimized-food-production/ (Accessed: April 10, 2023).
NL government		Government who control policies and regulations on a national level.	Public	Can regulate, police and control the different stakeholders in the food production system.	Governing on a country scale, reaching the sustainability goals	‘‘In 2030 we want to be a circular nation, we are planning for a stable future, sustainable economy, also for the future generations.”	Ministerie van Infrastructuur en Waterstaat (2022) Circular Dutch economy by 2050. Available at: https://www.government.nl/topics/circular-economy/circular-dutch-economy-by-2050.
EU government		Government who control policies and regulations on a bigger scale.	Public	Can regulate, police and control European countries and their food production system.	Governing on a bigger scale, achieving a better Europe for all its citizens.	‘‘The EU needs to accelerate the transition towards a regenerative growth model that gives back to the planet more than it takes, advance towards keeping its resource consumption within planetary boundaries, and therefore strive to reduce its consumption footprint and double its circular material use rate in the coming decade.”	European Commission (2020) Circular Economy Action Plan, ec.europa.eu. European Commission. Available at: https://ec.europa.eu/environment/circular-economy/pdf/new_circular_economy_action_plan.pdf (Accessed: April 10, 2023).

appendix 09: stakeholder analysis table

subregion maps and matrix

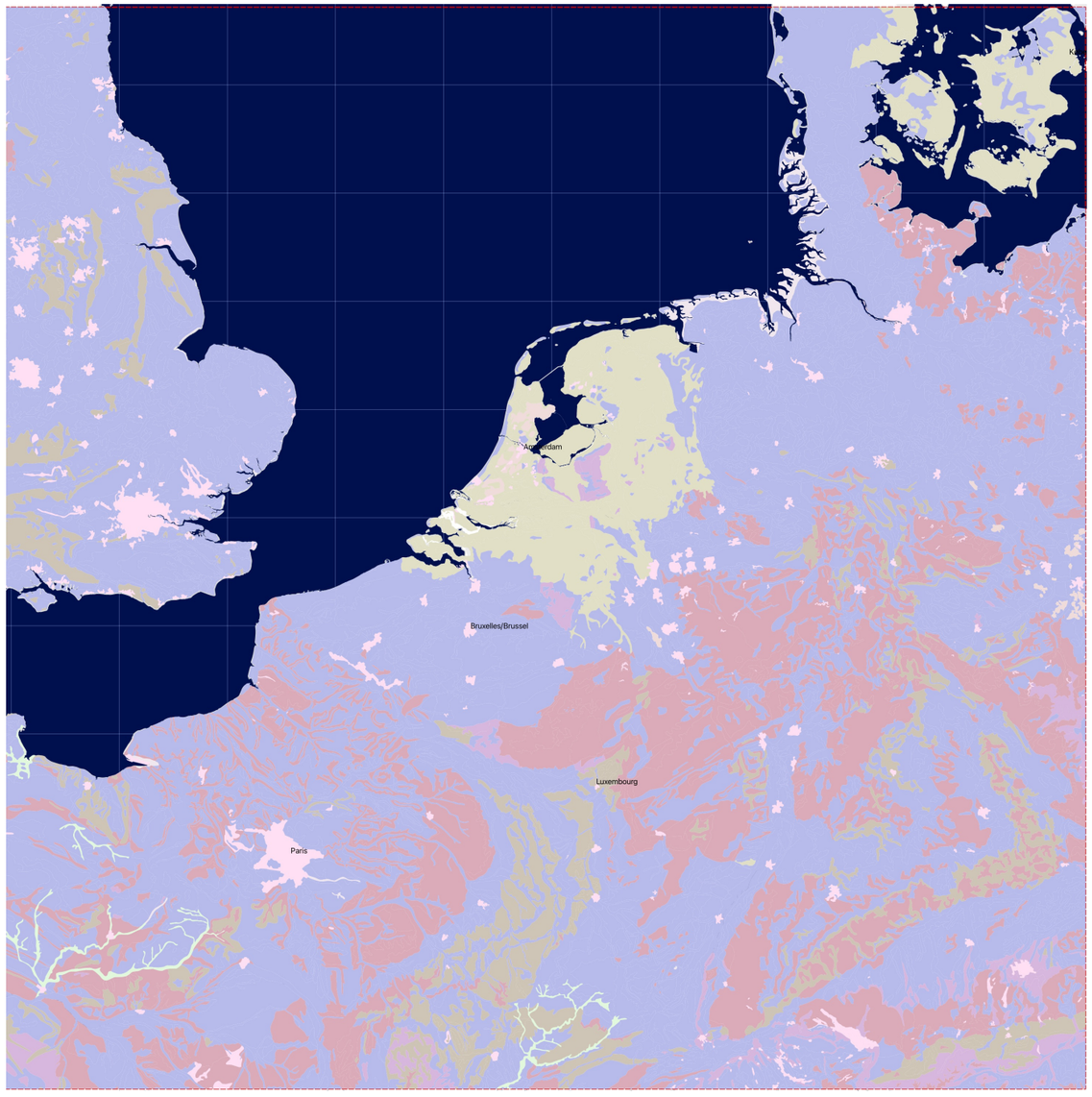
Cluster	1a	1b	1c	1d	2a	2b	2c	2d	3a	3b	3c	4a	4b	4c
Satellite Image														
Name	Rotterdam - Antwerp	Brussels	The Ruhr	Groningen	Manchester	Sheffield	Norwich - Cambridge	London	Lille	Troyes	Orléans	Magdeburg - Leipzig	Rostock - Schwerin	Wuerzburg
Forest	- small, spread out	- surrounding	- surrounding	- surrounding	+	-	-	-	+ spread out	+	+	+	+	+
Wetland	+ along coast, river	-	-	+ along coast, river	-	-	+ along coast	+ along coast, river	+ along coast	-	-	-	-	-
Soil Limitation	drained medium carbon content	0 medium/high carbon content	0 high carbon content	drained medium carbon content	0 medium/high carbon content	0 very high carbon content	0 very high carbon content	0 mixed carbon content	0 very high carbon content	stony, medium carbon content	stony, hard rock medium carbon content	stony mixed carbon content	stony mixed carbon content	stony high carbon content
Water Capacity	0 medium/high	+ high/very high	+ very high	0 medium	+ high	0 medium	0 medium/high	+ high	+ very high	+ high/very high	0 medium/high	0 medium/very high	0 medium/high	+ very high
Open Water	+ river, sea	+ river	+ river	+ river, lakes, sea	+ sea	+ river	+ sea	+ sea, river	+ sea, river	+ lakes	+ rivers	+ rivers, lakes	+ sea	-
Main Production	crop growing; livestock processing	crop growing; livestock processing	crop processing	crop processing; livestock farming	livestock processing	livestock farming, processing	livestock farming, processing	livestock farming, processing	crop processing	crop processing; livestock farming	crop processing; livestock farming	crop processing; livestock farming	livestock farming	crop processing; livestock farming
By-products	rotten crop; meat parts	rotten crop; meat parts	food scraps; uglies	scraps, uglies; manure	meat parts	manure, meat parts	manure, meat parts	manure, meat parts	crop scraps	crop scraps; manure	crop scraps; manure	crop scraps; manure	manure	crop scraps; manure
Type	B	C	B	C	A	B	C	A	C	C	C	B	B	C

advantage +
disadvantage -
neutral 0

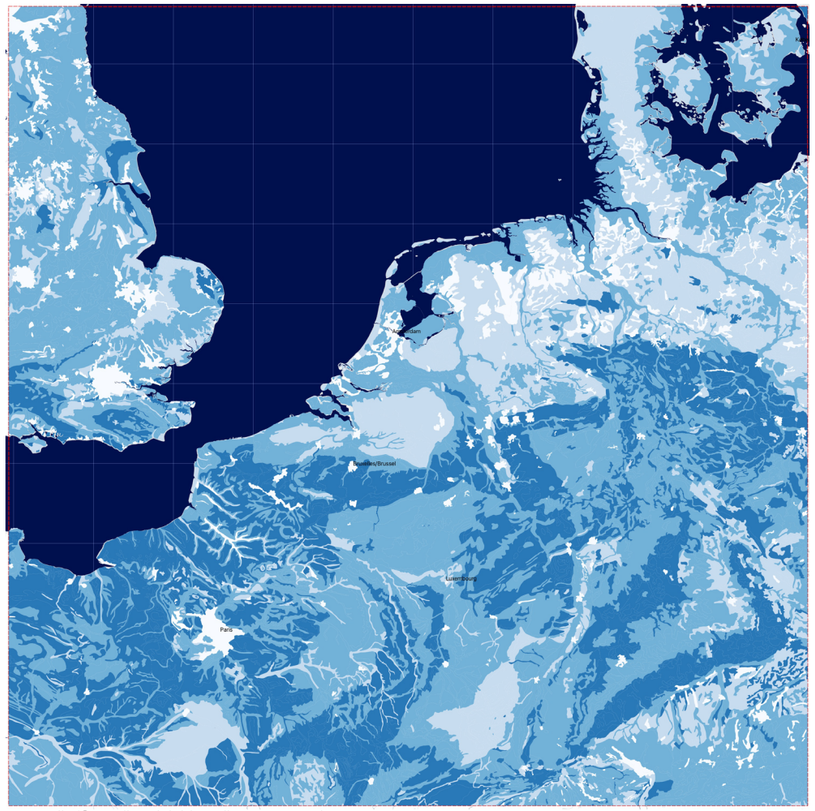
appendix 10: subregion matrix

subregion matrix and maps

limitation to agricultural use



appendix 11: soil limitations to agricultural use

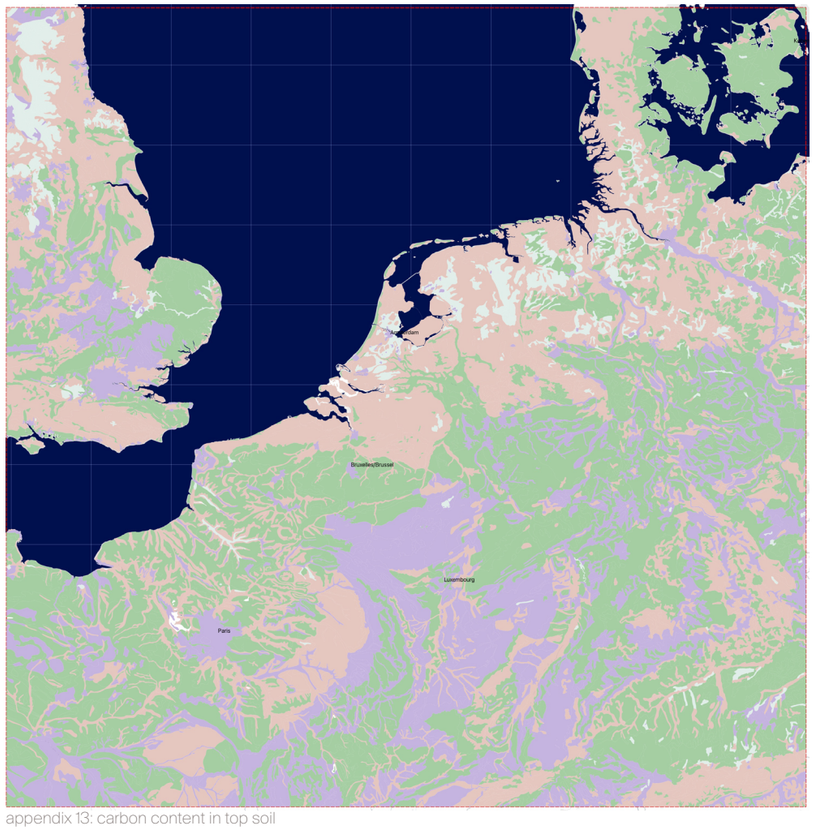


appendix 12: easily avialable soil water capacity

easily available water capacity in the top soil

#
Medium
High
Very High

0
100
200 km



appendix 13: carbon content in top soil

carbon content in the top soil

Low
Medium
High
Very High

0
100
200 km

FAOstat Data

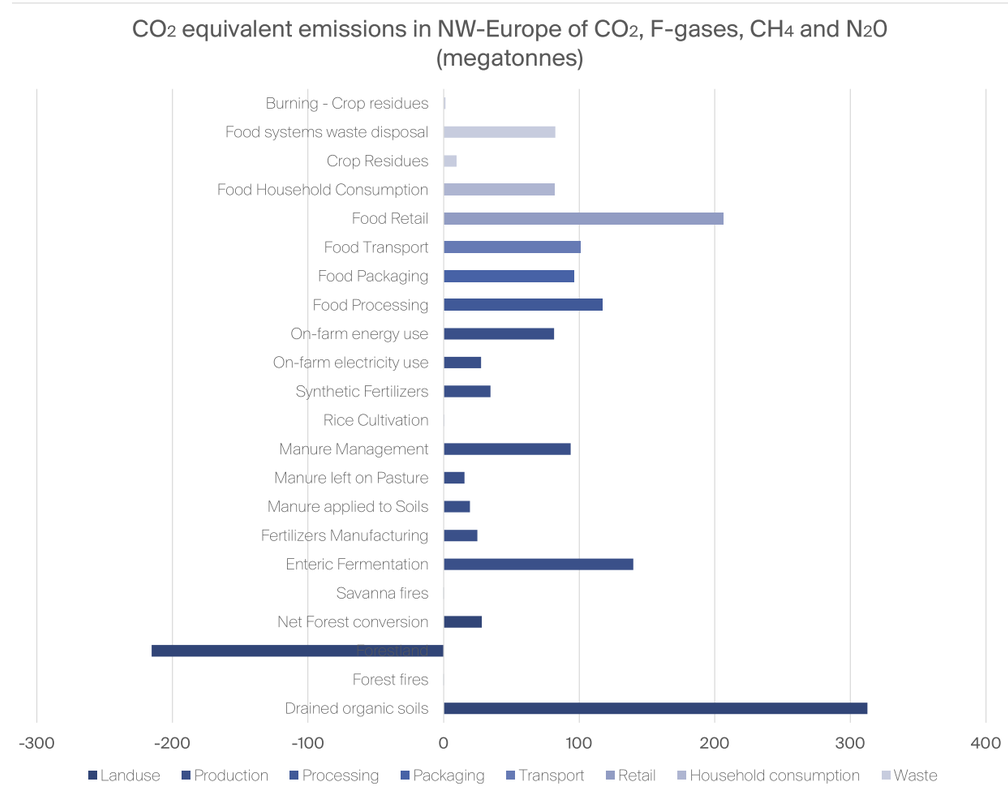
on greenhouse gas emissions in North-West Europe

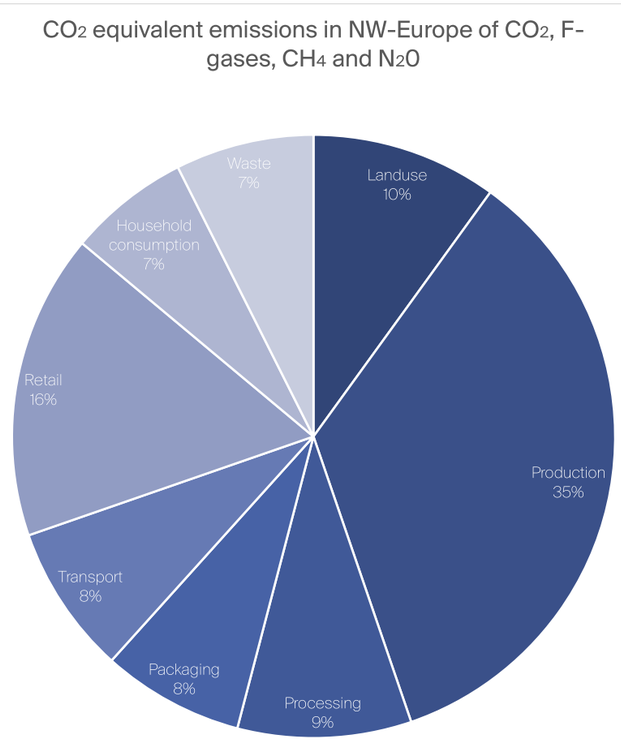
"Emissions (CO2eq) (AR5); Emissions (CO2eq) from CH4 (AR5); Emissions (CO2eq) from F-gases (AR5); Emissions (CO2eq) from N2O (AR5)" (2022) *Emissions Totals* . FAO. Available at: https://www.fao.org/faostat/en/#data/Gt.

Part of food production process	Item	Value
Land use	Burning - C	1384.275
	Drained or	312618.2
	Forest fire:	24.4653
	Forestland	-215331
	Net Forest	28167.6
	Savanna fi	8.868
Production	Enteric Fer	139832.7
	Fertilizers I	24906.83
	Manure ap	19417.78
	Manure le	15407.52
	Manure M	93729.52
	Rice Cultiv	208.9987
	Synthetic F	34529.58
	On-farm el	27687.44
	On-farm e	81570.1
Processing	Food Proc	117203.4
Packaging	Food Pack	95767.92
Transport	Food Trans	100717.6
Retail	Food Retai	206049
Household consumption	Food Hous	81710.78
Waste	Crop Resid	9549.915
	Food syste	82415.19

Part of food production process		Landuse	Production	Processing	Packaging	Transport	Retail	Household consumption	Waste
Land use	Drained organic soils	312.6182	0	0	0	0	0	0	0
	Forest fires	0.024465	0	0	0	0	0	0	0
	Forestland	-215.331	0	0	0	0	0	0	0
	Net Forest conversion	28.1676	0	0	0	0	0	0	0
	Savanna fires	0.008868	0	0	0	0	0	0	0
Production	Enteric Fermentation	0	139.8327481	0	0	0	0	0	0
	Fertilizers Manufacturing	0	24.9068286	0	0	0	0	0	0
	Manure applied to Soils	0	19.4177767	0	0	0	0	0	0
	Manure left on Pasture	0	15.4075207	0	0	0	0	0	0
	Manure Management	0	93.7295193	0	0	0	0	0	0
	Rice Cultivation	0	0.2089987	0	0	0	0	0	0
	Synthetic Fertilizers	0	34.5295759	0	0	0	0	0	0
	On-farm electricity use	0	27.6874444	0	0	0	0	0	0
	On-farm energy use	0	81.5701005	0	0	0	0	0	0
Processing	Food Processing	0	0	117.2034428	0	0	0	0	0
Packaging	Food Packaging	0	0	0	95.7679231	0	0	0	0
Transport	Food Transport	0	0	0	0	100.7176033	0	0	0
Retail	Food Retail	0	0	0	0	0	206.0490313	0	0
Household consumption	Food Household Consumption	0	0	0	0	0	0	81.7107758	0
Waste	Crop Residues	0	0	0	0	0	0	0	9.5499152
	Food systems waste disposal	0	0	0	0	0	0	0	82.4151867
	Burning - Crop residues	0	0	0	0	0	0	0	1.3842747
	Total	125.4883	437.2905129	117.2034428	95.7679231	100.7176033	206.0490313	81.7107758	93.3493766

	Landuse	Production	Processing	Packaging	Transport	Retail	Household consumption	Waste
Total megatonnes CO2 eq	125.4883	437.2905129	117.2034428	95.7679231	100.7176033	206.0490313	81.7107758	93.3493766
cultivation	340.8191							
sink	-215.331							





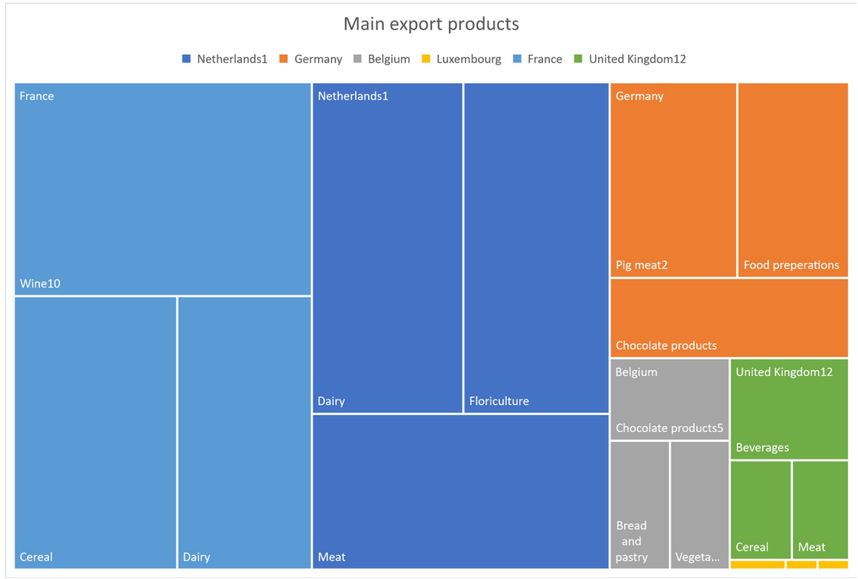
appendix 14: calculations on carbon emissions

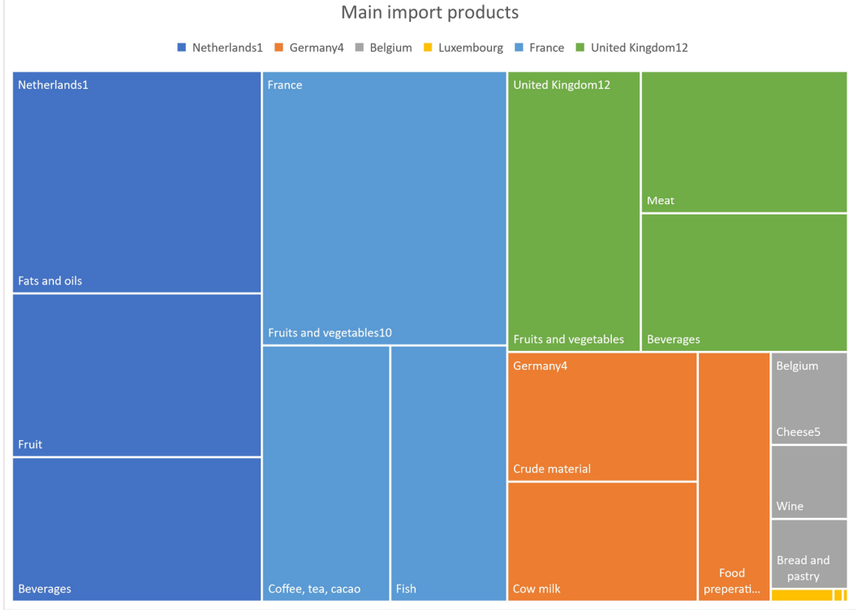
calculations

on food trade in North-West Europe

	Export			
	Main products	**Amount in billion EUR**	**Trading partners**	**%**
Netherlands[1]	Dairy	11.90	Germany	24.20%
	Floriculture	11.50	Belgium	11.86%
	Meat	11.00	France	8.50%
Germany	Pig meat[2]	5.94	Netherlands[3]	27.00%
	Food preperations	5.19	France	11.00%
	Chocolate products	4.53	Italy	10.00%
Belgium	Chocolate products[5]	2.37	France[6]	19.36%
	Bread and pastry	1.83	Netherlands	18.69%
	Vegetables	1.82	Germany	14.28%
Luxembourg	Dairy[8]	0.13	Germany[9]	26.03%
	Meat	0.07	France	16.27%
	Forage plants	0.07	Belgium	12.44%
France	Wine[10]	15.16	United States[11]	11.92%
	Cereal	10.58	United Kingdom	11.29%
	Dairy	8.71	Germany	10.06%
United Kingdom[12]	Beverages	2.90	Ireland	15.18%
	Cereal	1.46	France	11.34%
	Meat	1.34	United States	9.77%

	Import			
	Main products	**Amount in billion EUR**	**Trading partners**	**%**
Netherlands[1]	Fats and oils	10.25	Germany	17.74%
	Fruit	7.56	Belgium	12.67%
	Beverages	6.62	France	6.56%
Germany[4]	Crude material	4.57	Netherlands	24.64%
	Cow milk	4.19	Italy	8.53%
	Food preperations	3.35	Poland	7.79%
Belgium	Cheese[5]	1.33	Netherlands[7]	28.91%
	Wine	1.05	France	17.62%
	Bread and pastry	0.99	Germany	10.73%
Luxembourg	Food preperations[8]	0.147	Belgium[9]	24.27%
	Maintenance	0.022	Germany	24.06%
	Energy	0.012	France	10.74%
France	Fruits and vegetables[10]	12.4	Belgium[11]	17.50%
	Coffee, tea, cacao	6.05	Germany	15.49%
	Fish	5.52	Netherlands	13.17%
United Kingdom[12]	Fruits and vegetables	6.92	Netherlands	10.04%
	Meat	5.43	France	9.01%
	Beverages	5.29	Ireland	8.49%





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calculations

on the land shift change in South Holland

Facts and figures

Inhabitants NL	17590672	Centraal Bureau voor de Statistiek (2022) *Regionale kerncijfers Nederland* . Available at: https://www.cbs.nl/nl-nl/cijfers/detail/70072ned.
Inhabitants SH	3711176	
% NL inhabitants in SH	21%	
Surface area SH (km2)	3.403	
Built surface area SH (km2)	796	Centraal Bureau voor de Statistiek (2019) “Bijna een kwart Zuid-Holland nu bebouwd,” Centraal Bureau Voor De Statistiek, 12 March. Available at: https://www.cbs.nl/nl-nl/nieuws/2019/11/bijna-een-kwart-zuid-holland-nu-bebouwd#:~:text=De%20regievoering%20over%20de%20ruimtelijke,of%20de%20aanleg%20van%20bedri
Natural surface area SH (km2)	47	Zuid-Hollands Landscap (no date) *Gebieden* . Available at: https://www.zuidhollandslandschap.nl/over-ons/gebieden-lijst/page/3#:~:text=Het%20Zuid%2DHollands%20Landschap%20onderhoudt,en%20van%20duin%20tot%20bos. (Accessed: April 12, 2023).

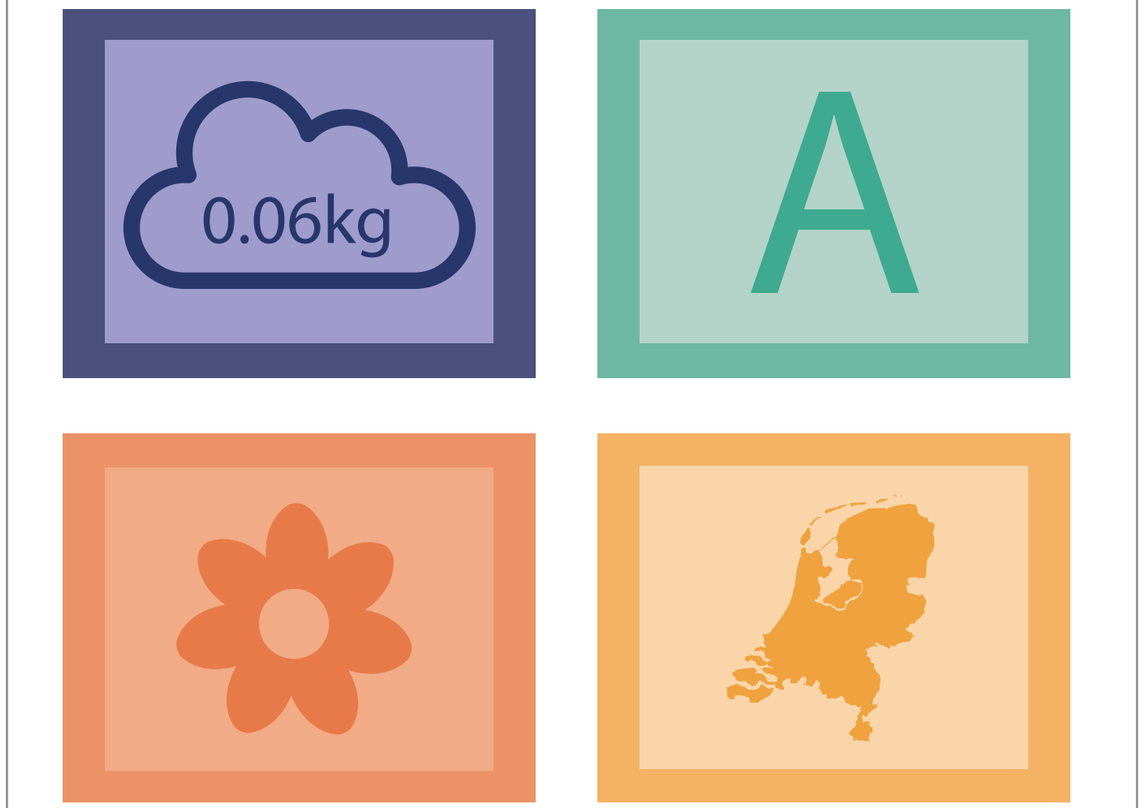
	Dutch diet	EAT-lancet	Diet change	Current yield NL		NL Trade surplus/defficit			Yield NL with trade correction		Future yield NL (Diet change correction and biological production)				
Type of food	**(g/day/capita)**	**(g/day/capita)**	**(%)**	**Livestock (amount)**	**Agricultural Area (m2)**	**Export (mld.€)**	**Import (mld.€)**	**Revenu (%)**	**Livestock (amount)**	**Agricultural Area (m2)**	**Livestock (amount)**	**Farm area requirements (m2/animal)**	**Farm area (m2)**	**Agricultural Area (m2)**	**Land change (%)**
Insects/algae	0.0001	56	100.00%												
(red) meat	73	7	9.59%	**15,758,062**		11.00	5.52	33%			**1,009,804**		3,523,715	496,021,934	6.41%
Beef				3,834,171					2,562,303		245,700	8.50	2,088,453	493,489,054	
Pigs				11,278,858					7,537,445		722,769	1.90	1,373,261	2,421,275	
Goats				645,033					431,063		41,335	1.50	62,002	111,604	
Poultry	18	29	161.11%	**97,532,795**		11.00	5.52	33%	65,179,301		**105,011,096**	0.09	9,546,463	219,568,656	107.67%
Fish	15	28	186.67%	No data available		4.10	3.10	14%	No data available		No data available				
Dairy	338	275	81.36%	**1,570,673**		11.90	5.95	33%	1,047,115		**851,943**	10.00	8,519,429	1,712,405,327	54.24%
Grains (wheat)	191	358	187.43%		**1,882,383,000**	0.60	4.38	-76%		3,311,179,735				**6,206,295,001**	329.70%
Vegetables	153	487	318.30%		**940,954,404**	7.80	2.96	45%		517,699,821				**1,647,841,913**	175.12%
Agriculture are					619,148,400										
Horticulture open soil are					264,253,400										
Horitculture under glass m2					57,484,336										
Mushrooms m2					68,268										
Tubers	64	84	131.25%	No data available							No data available				
Fruits m2	135	186	137.78%		**1,226,436**	7.00	7.56	-4%		1,273,607				**1,754,747**	143.08%
Legumes	7	106	1514.29%	No data available							No data available				
Nuts	5	34	680.00%												
Snacks	84	0	0.00%												
Source	Voedingsmiddelen (no date). Available at: https://www.wateetnederland.nl/resultaten/voedingsmiddelen.	Selm et al. (2022)	Calculated C/B	Centraal Bureau voor de Statistiek (2023) Landbouw; gewassen, dieren en grondgebruik naar gemeente. Available at: https://www.cbs.nl/nl-nl/cijfers/detail/80781ned.		Jukema, G., Ramaekers, P. and Berkhout, P. (2023) “De Nederlandse agrarische sector in internationaal verband : Editie 2023,” *Wageningen Economic Research Rapport* , 2023(004). Available at: https://doi.org/10.18174/58	Calculated ((export-import))/ total	Calculated F*(1-J)	Calculated G*(1-J)	Calculated D*K	*De dieren op een rij - Beter Leven keurmerk* (2020). Available at: https://beterleven.dierenbescherming.nl/over-de-dieren/alle-dieren/.	Calculated N*O	Calculated (N*weidegang)+P	Calculated Animals N/F Agriculture Q/G

Type of food	**Tiles NL (1km2)**	**Tiles SH (1km2)**	
Insects/algae		100.00	Equal to meat
(red) meat	496	104.65	
Beef			
Pigs			
Goats			
Poultry	220	46.32	
Fish		46	Equal to poultry
Dairy	1,712	361.27	
Grains (wheat)	6,206	1,309.37	
Vegetables	1,648	347.65	
Agriculture are			
Horticulture open soil are			
Horitculture under glass m2			
Mushrooms m2			
Tubers		50	Legumes and tubers together equal to meat
Fruits m2	2	0.37	
Legumes		50	Legumes and tubers together equal to meat
Nuts			
Snacks			

	Insects/algae	**Animals**	**Fish**	**Crops**	**Grain**	**Built area**	**Nature**	**Sum total**	
Amount of tiles	100	512	46	448	700	796	547	3,150	Surface area South Holland (%)
Mixed farming		312		248	400			960	**30%**
Agroforestry		200		100	200		200	700	**22%**
Aquaponic			46	100	100			246	**8%**
Alternative protein	100							100	**3%**
Natural area							300	300	**10%**
Deficit					609				

food label

example for standardised labeling of an apple from the Netherlands



appendix 17: food label for an apple

The standardised label explains the amount of CO_2 eq. required for its production, its nutrient score, the product family and the country of origin.