CO2MORROW

THE ROLE OF CO_2 IN THE AGRIFOOD SECTOR IN THE TRANSITION TO A CIRULAR ECONOMY IN THE PROVINCE OF SOUTH HOLLAND

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BY THE ORGANIC GUYS

COLOPHON

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The role of CO_2 in the agrifood sector in the transition to a circular economy in the province of South Holland

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PREFACE

This report proposes a regional planning and design vision to the Province of South Holland (PZH) for the year of 2050, and present a suit of strategies to achieve this vision, based on relevant research, analysis and design. It has been made during the first year of the MSc in architecture and the built environment at the Delft Technical University, as part of the master of Urbanism program. It was created during a 10 weeks course titled:"Research and Design Studio: Spatial Strategies for the Global Metropolis". The studio dealt with the issues of circular economy, agrifood sector transition and spatial justice in the PZH, and addressed these topics from the field of regional design.

This report was created by the group called "the Organic Guys", through intensive collaboration. By"intensive collaboration", it means loud arguments, repeated back-and-forths, and of course, with some solid work on narrowing the topic, adjusting research methods, building logical frameworks, producing and organizing the materials. These efforts in the intensive teamwork are proved to be very valuable and helpful, without this tricky and struggling process, the report cannot be formed and competed.

We would like to thank our tutors, Dr. Lei Qu, Dr. Verena Balz and Dr. Cecilia Furlan, who have given us a lot of valuable and inspiring advice and guidance, especially in those moments when we were stuck and struggling.

We also want to give our special thanks to ZOOM, an online meeting platform, for helping us stay connected and productive in a remote work environment in this COVID-19 situation. Just like what has been shown on their website, "In this together; Keeping you connected wherever you are". Also, the function of abrubt automatically shut-down of online meetings due to 40 minutes time limit is really helpful, for reminding us to take a break. Both in the situations when we are too dedicated in the discussion and loud arguments.

ABSTRACT

The province of South Holland is a key player in the global food economy. However, its agrifood sector is currently generating unwanted outputs. CO_2 emissions are the largest and most problematic output flow of this sector, causing negative externalities such as climate change and sea-level rise. Actors producing the CO_2 are interlocked into a system and do not have the resources to escape this. This report uses the concept of the circular economy to design out this polluting output flow, while also taking the financial position of the actors into account. The transition to a circular agrifood economy for CO_2 has to happen spatially. The available space in the province of South Holland is already under pressure to solve other major challenges, such as land degradation, climate adaptation, decreasing biodiversity and a poor urban landscape relationship. Solving all these challenges separately is inefficient and impossible.

This report explores the possible synergies between mitigating those challenges and the transition towards a CO_2 circular (i.e. CO_2 neutral) agrifood economy, while also taking spatial justice into account. A future is envisioned of an interconnected metropolitan landscape where CO_2 is stored in the form of biomass and where knowledge about a biobased economy is gained and exported to the world. A cross-subsidy CO_2 exchange policy based on creating synergies with other challenges is proposed as a catalyst policy for this transition. Furthermore, specific spatial interventions in the form of setting up knowledge parks are also contributing to the transition. The agrifood sector will become much more robust and sustainable by trading CO_2 together. The production of biomass mitigates other spatial challenges too, and vulnerable farmers get an additional source of income. With the proposed strategies, the province of South Holland is ready for a sustainable and cooperating tomorrow.

Keywords: CO2; circular economy; biobased economy; agrifood; spatial justice

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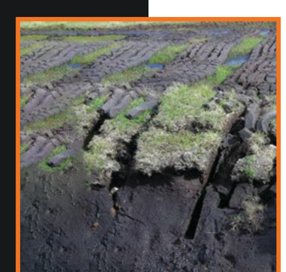
01 INTRODUCTION



1.1 INTRODUCTION

In the last 200 years, the world's population has undergone unprecedented growth. In this relatively short time span, the number of people on earth went from just 1 billion people in 1800 to over 7.7 billion people today (Roster *et al.*, 2019). As a result, increasingly more resources are required to fulfil the needs and desires of all these people. Many resources are depleted at a rate faster than the natural system is able to replenish them. Forests, such as the Amazon Rainforest, are cut down to make space for cattle feed, and oil and gas reserves are exhausted to meet the ever-growing energy demand (Roemers *et al.*, 2018; Bentley & Roger, 2002).

With a lot of these resources nearing the point of complete depletion, the realization has come that this unlimited growth on a planet with limited resources is unsustainable in the long term. The concept of the circular economy poses a direct solution to this problem. It has been defined as:

"A circular economy is based on the principles of designing out waste and pollution, keeping products and materials in use, and regenerating natural systems." (Ellen MacArthur Foundation, 2017)

Circularity can be applied to all kinds of economies. In this report, we will focus on the agrifood economy. This economy involves all business concerned with the agricultural production of food and plants.

The Dutch province of South Holland is a key player in this global agrifood economy. Besides its small size, just 2.700 km^2, the province is the largest exporter of fresh vegetables in the world. Due to a very land-efficient production process, large amounts of food are produced yearly in this province. In 2018 the food output included over 1 million tons of vegetables, almost 1.5million tons

of animal products such as milk and meat, and over 1 ton of potatoes, beets and grains (Roemers *et al.*, 2018). These products are exported all over the world, providing food security in many countries, see figure 1.1. All these goods together provided a yearly income of 1.1 billion euros in the province alone, creating a lot of economic prosperity in South Holland (Knoema, 2018).
However, like many other economies, the agrifood sector is largely dependent on non-renewable resources. The reason for this issue is that a lot of the inputs in agrifood sector of the Province of South Holland are non-renewable, and plenty of the outputs are treated as waste, posing negative externalities to the environment. This linear model is causing threats and putting pressure on the existing powerful agrifood economy. In a long-term perspective, the threats and pressure will undermine the strong position of the Province of South Holland in the global economy. In order to change the situation, a transition towards an agrifood sector with circular production model is needed.

This project focuses mainly on how to make a transition from the existing linear production model towards a circular agrifood sector in the Province of South Holland. Because we are at the beginning of this transition, we focus on the circularity of the largest unwanted output flow. This is, by far, CO_2 emissions, as can be seen in figure 1.2. The detailed flow analysis is included in the appendix. As explained before, the circular economy aims to design out waste and pollution. CO_2 emissions can be considered a very polluting output flow, as it has been proven that CO_2 causes global warming (Anderson *et al.*, 2016). Global warming is related to many negative effects, but for the province of South Holland, situated mostly under the sea level, sea-level rise is one of the most challenging (Meehl *et al.*, 2005). Hence, in this report, we present a strategy related to the circularity of these CO_2 emissions.

The transition to a circular economy will have large spatial implications, putting pressure on the little available space in the province. It is therefore important to take also other spatial challenges into account during the transition, to be able to use the available space efficiently. The challenges we take into account in this report include land degradation, climate adaptation, decreasing biodiversity and poor relationship between city and landscape. Each of these challenges will be elaborated in the research chapter.

Additionally, social and spatial justice will also be considered. To be able to include social and spatial justice, we take into account three main actors of the agrifood industry: greenhouse farmers, peat farmers and clay farmers, see figure 1.3. The next chapter, general research, will explain more about the social and financial position of these actors.

Figure 1.1 | Global export products *(Authors own, 2020)*

LARGEST OUTPUTS OF THE AGRIFOOD SECTOR IN SOUTH HOLLAND

By weight (in tonnes)

- **CO2 emissions:** 4.997.390
- **Animal products:** 1.459.140
- **Crops from open soil:** 1.145.190
- **Organic waste:** 1.028.870
- **Crops from greenhouses:** 820.030

*manure is not included as most of this amount is reused within the system as fertilizer

Figure 1.2 | Largest outputs of the agrifood sector *(Roemers et al., 2018)*

Figure 1.3 | Main actors *(Authors own, 2020)*

1.2 PROBLEM STATEMENT + RESEARCH QUESTIONS

Based on the context of the agrifood sector, problems from three aspects including circular economy, spatial design, and social justice have been generally analysed. The results of the problem analysis are concluded as follow and finally lead to the goals, which forming and shaping the direction of the research.

The current way of production in the agrifood sector is unsustainable and not feasible for the long term. The existing production in this sector is highly dependent on non-renewable resources and the output is mainly treated as waste, rather than resources to be put in production due to the linear model. Continuing this way of production will put the agrifood sector of the Province of South Holland under pressure and undermine its position in the global economy.

In order to change the situation, a transition towards an agrifood sector with acircular production model is needed. Among the waste material flows in the agrifood sector, *CO_2 emission* is the biggest one. Hence, this regional design project will focus on this largest waste flow and examine how with spatial strategies a transition towards a circular, CO_2 neutral agrifood sector can be carried out. The goal of the transition is full CO_2 circularity in 2050, which results in a CO_2 neutral agrifood sector.

However, spatial scarcity is a problem, because the available space in the Province of South Holland is already under pressure to solve other major challenges, including *climate adaptation, land degradation, decreasing biodiversity and strengthening the relationship between urban areas and landscape.* Tackling all these challenges separately is inefficient and impossible because all of these challenges as well as transition towards CO_2 circularity, highly related to spatial redistribution of the regional resources. Therefore, the strategy should be spatially synergetic in order to mitigate other challenges while making the transition.

Finally, when it comes to the redistribution of regional resources, spatial justice becomes an important issue. When spatial changes in agrifood production happen in a regional level, three groups of farmers will become the main actors, including greenhouses farmers, peat farmers and crop farmers, whose production will be directly affected. Because there are value differences in different sectors of production, spatial injustice might happen if the differences are not properly considered in strategy development. Therefore, guarantee of spatial justice in the transition is essential.

Based on these problem conclusions and goals three research questions are formulated.

Problem Conclusions:

1. **CO_2 emission is the largest issue in this unsustainable agrifood sector**
2. **Land scarcity make it hard to solve other challenges separately**
3. **Spatial injustice could happen due to the value differences in the production between actors**

Goals:

1. **Spatial transition to a CO_2 circular system (becoming CO_2 neutral in 2050)**
2. **Synergetic system to mitigate other challenges in the transition**
3. **Guarantee spatial justice in the transition**

Research questions:

1. **How to make spatial transition towards the circularity of CO_2?**
2. **How to mitigate other challenges in a synergetic way?**
3. **How to guarantee spatial justice in and after the transition?**

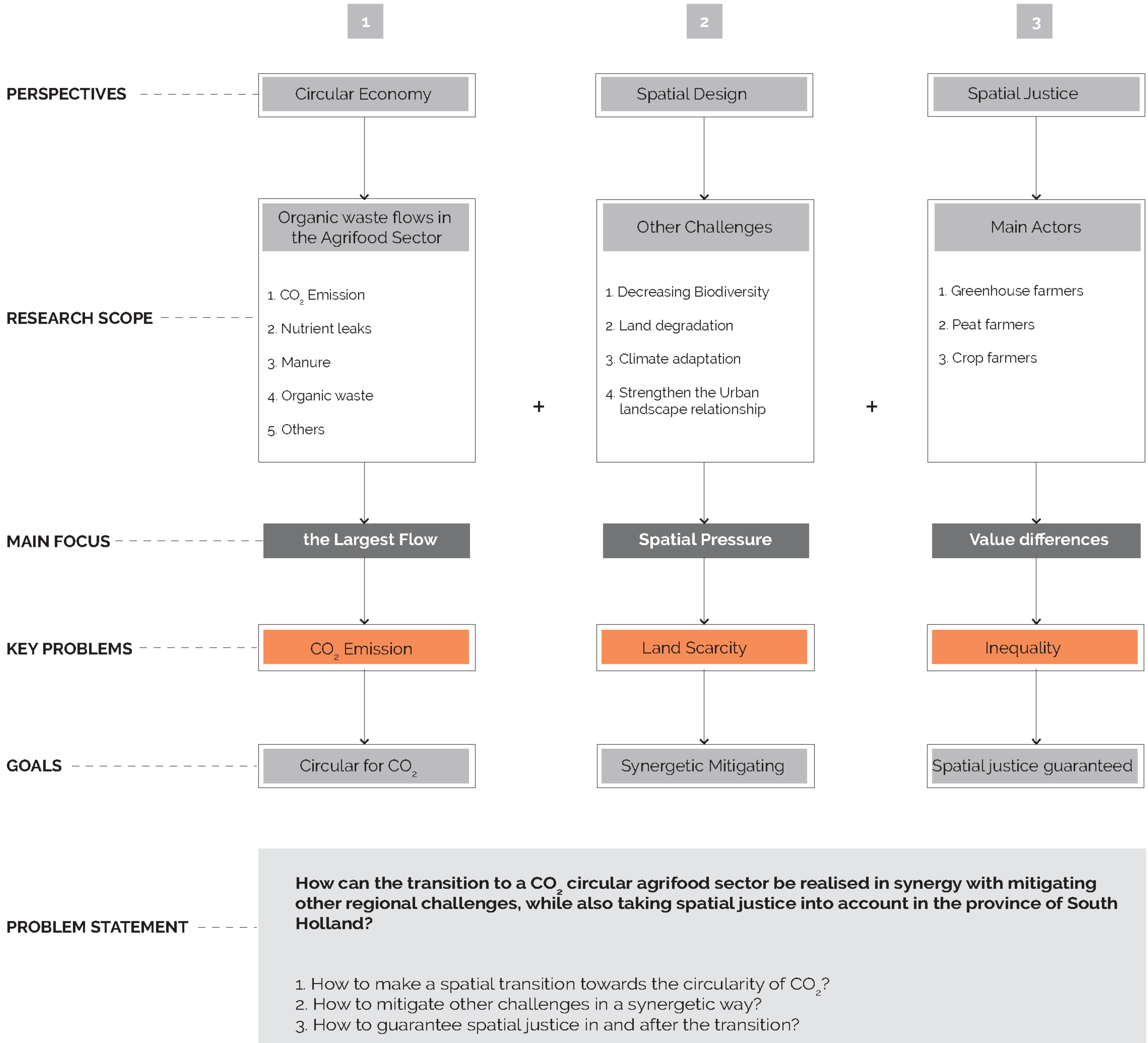


Figure 1.4 | Scheme problem statement *(Authors own, 2020)*

I.3 METHODOLOGY

Figure 1.4 illustrates the methodology used to answer the given research questions and the structure of the report. In chapter two, applied research, consists of deeper research on the topics briefly mentioned in the introduction and the problems statement. The conclusions of this chapter are building up to the next chapter: the vision. In the vision chapter, a spatial vision for the agrifood sector for 2050 is presented. Then, strategies are worked out in the fourth chapter, including a strategy system, a strategy map and a phasing plan. Finally, a conclusion is given, followed by a reflection, references and the appendix.

The methods used in the process are the combination of designing methods and research methods, including site visit, photo documentation, data collection and processing, comparison of data, production process analysis, mapping, potential analysis, spatial simulation design, and case study. An overview of these methods is discussed in chapter 2.1.

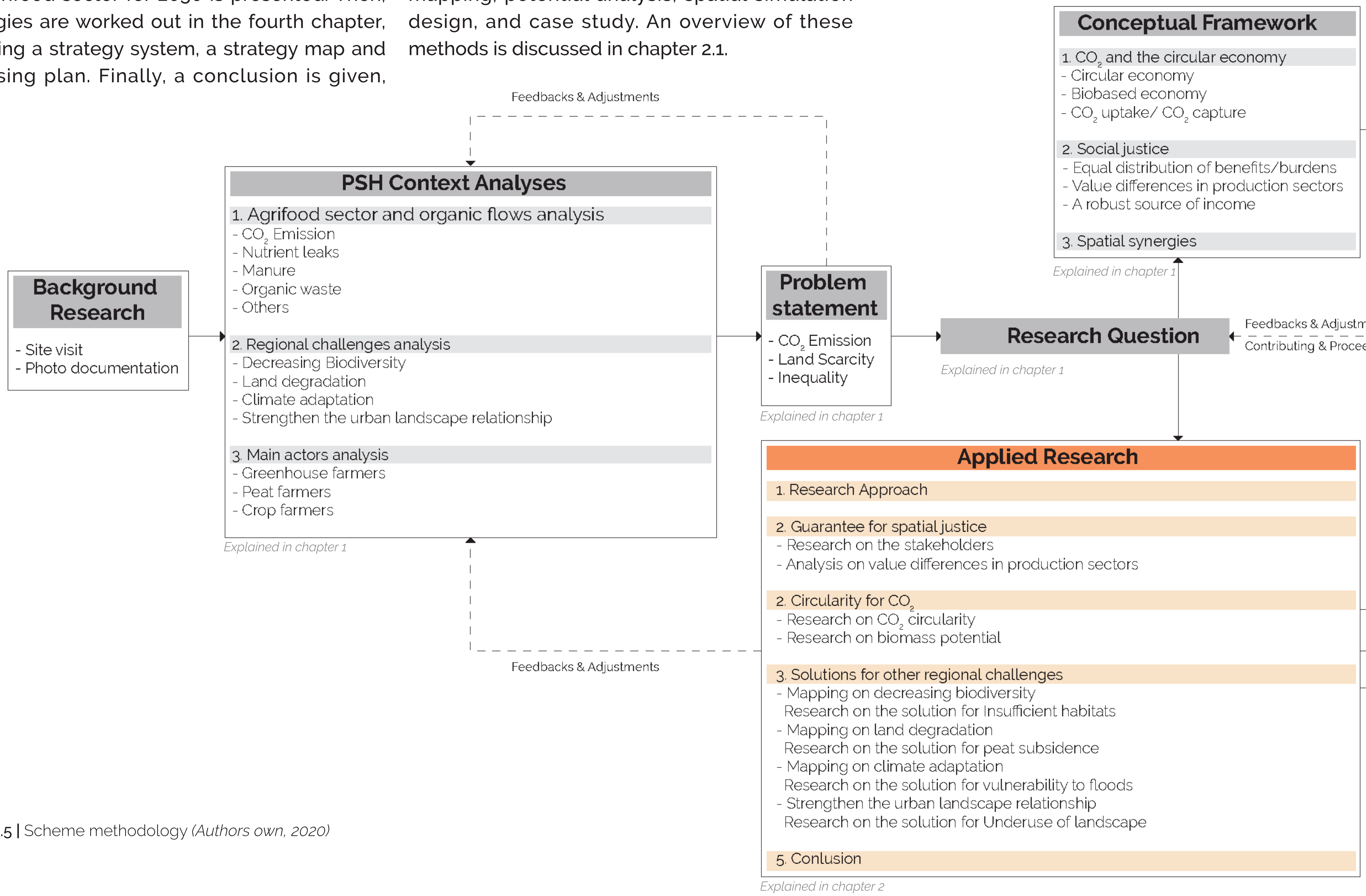
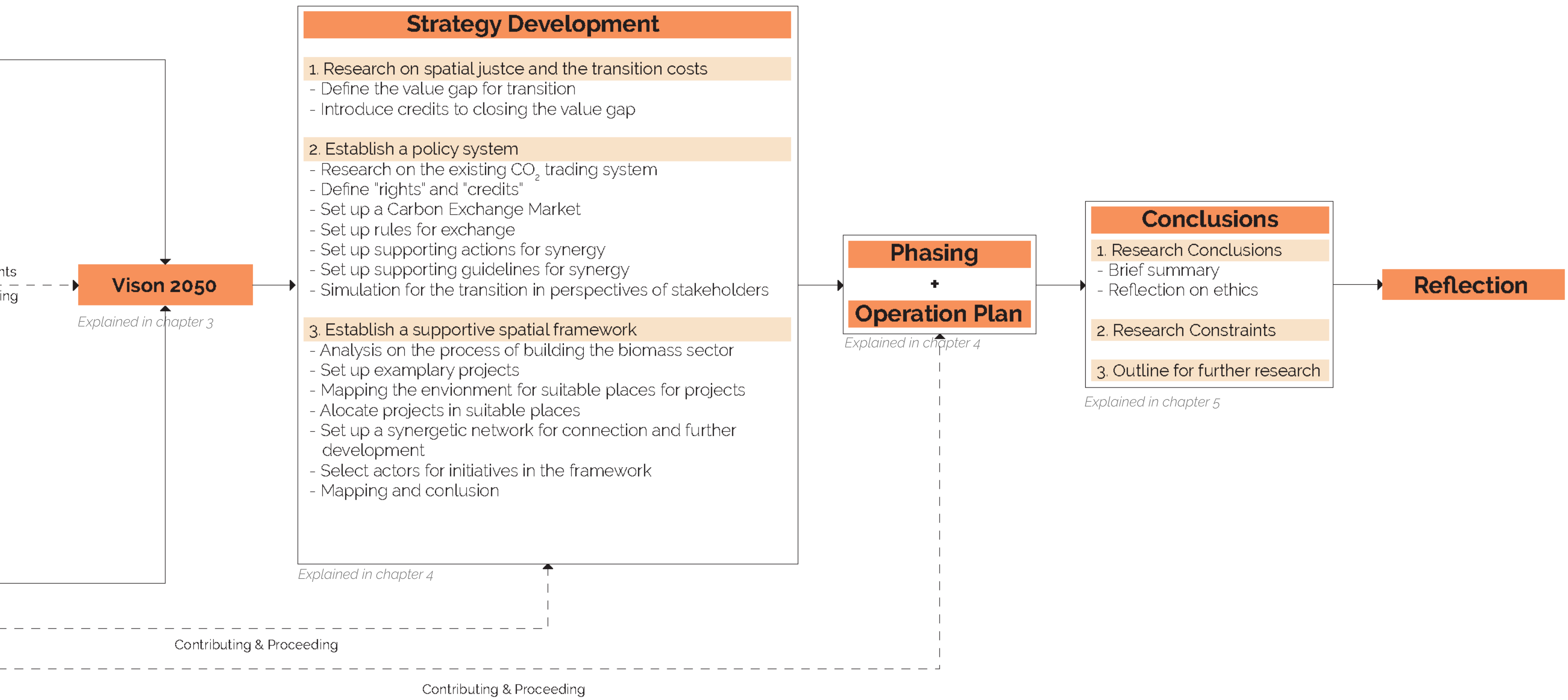


Figure 1.5 | Scheme methodology *(Authors own, 2020)*



nts
ing
Vison 2050
Explained in chapter 3
Strategy Development
1. Research on spatial justce and the transition costs
- Define the value gap for transition
- Introduce credits to closing the value gap
2. Establish a policy system
- Research on the existing CO_2 trading system
- Define "rights" and "credits"
- Set up a Carbon Exchange Market
- Set up rules for exchange
- Set up supporting actions for synergy
- Set up supporting guidelines for synergy
- Simulation for the transition in perspectives of stakeholders
3. Establish a supportive spatial framework
- Analysis on the process of building the biomass sector
- Set up examplary projects
- Mapping the envionment for suitable places for projects
- Alocate projects in suitable places
- Set up a synergetic network for connection and further development
- Select actors for initiatives in the framework
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Conclusions
1. Research Conclusions
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Explained in chapter 5
Reflection
Contributing & Proceeding
Contributing & Proceeding

1.4 CONCEPTUAL FRAMEWORK

The main focus of this report consists of three challenges at the basis of our regional design for the Province of South Holland (PSH): linear CO_2 emission system (pollution), the need to create synergies with other spatial challenges in the region and spatial justice. In this chapter, we elaborate on the following concepts: CO_2 circularity transition as part of the transition towards circular economy in the agrifood sector, the guarantee of spatial justice during the transition sector and creating synergies to mitigate other regional challenges including decreasing biodiversity, land degradation, climate adaptation and strengthening urban landscape relationship within this transition.

CO_2 and the circular economy

Circular economy:

A circular economy is an economic system of closed loops in which raw materials, components and products lose their value as little as possible, renewable energy sources are used and systems thinking is at the core (Ellen MacArthur Foundation, 2017). This report focuses on the circular agrifood economy. This economy has already some circular elements in it, like the reuse of manure on the land. However, in the agrifood sector, the majority of the material flows are widely open rather than closed. The relevant processes such as animal farming, greenhouses farming and heating, crops farming and so on, are dependent on non-renewable fossil fuels and imported resources like artificial fertilizer and cattle feed (Roemers *et al.*, 2018). These resources are used and waste is generated afterwards including CO_2 emission, nutrient leaks, excessive manure and organic waste from plants and crops (Roemers *et al.*, 2018). Within these waste flows the largest one ic the emission of CO_2, which known to contribute to climate change (Anderson *et al.*, 2016). One of the goals of the circular economy is to design without waste and pollution (Ellen MacArthur Foundation, 2017). Hence, our strategy is focussed on solving the problem of CO_2 emission in the agrifood sector and launching a transition towards a CO_2 circular agrifood economy. In order to achieve this, strategies including policies and spatial interventions will be carried out.

Biobased economy:

Biobased materials, such as wood and algae, are by definition renewable. Furthermore, biobased materials can replace non-degradable plastics that are harmful to the environment (Álvarez-Chávez, *et al.*, 2012). Hence, the transition to a biobased economy does offer a lot of benefits.

CO_2 uptake/ CO_2 capture:

Two important concepts are linked in the strategy: CO_2 neutrality and the transition towards a biobased economy. Biobased materials consist of biomass. During the process of growing biomass, CO_2 is taken up and stored (in the form of carbon) in the material itself. This is known as carbon sequestration (Rytter, 2012, p. 91) As a result biobased materials can be considered as a carbon sink for as long as they are in use.

Spatial justice

Spatial justice involves “the fair and equitable distribution in space of socially valued resources and opportunities to use them” (Soja, 2016). Spatial injustice could happen when there is lack of focus on issues relevant to spatial distribution or redistribution of resources and opportunities. Mitigating spatial injustice as a result of spatial conditions and developments is an important element of the proposed regional design. By acknowledging differences in wealth as a result of spatial distribution, an attempt can be made to solve these inequalities. The following related concepts are elaborated more to deepen the practical understanding of spatial justice in the context of the report.

Equal distribution of benefits/burdens:

An important condition of the regional design is that the various benefits and burdens of spatial transitions are equally distributed over the different actors. While developed policies may demand a different level of change of different actors, the costs of such transitions need to be divided equally over all the participants of the food sector.

Value differences in production sectors:

Different activities in the production sector of biomass creating a different level of value (Lange *et al.*, 2012). It needs to be acknowledged that a shift from a ‘valuable’ to a ‘lesser valuable’ product will affect the economic stability of the producers and therefore will mostly not happen without financial compensation.

A robust source of income:

In the agrifood sector actors often have a single source of income, related to the soil. This makes the land use less flexible for change, because the owners have no different source of income. Strategies must ensure opportunities for multiple sources of income within the potential of the local plots. Offering such alternative incomes will help the entrepreneurs in the food sector with the function transition of their land and strengthen their economic position.

Spatial synergies

Spatial synergy is composed of characteristics of physical-spatial organization of the city which support the actions and behaviour of people (Frick, 2007). This report not only focuses on how to make the transition to a circular economy regarding CO_2 neutrality while taking spacial justice into account, but it also tries to tackle multiple challenges using the same location and resources. The major regional challenges in the Province of South Holland are decreasing biodiversity, land degradation, climate adaptation and strengthening urban landscape relationship. In a regional scale, solving all these challenges separately is inefficient and impossible, because there is always spatial scarcity faced when implementing various spatial strategies. Most of them will also share the same spatial resources. By using spatial synergy, firstly solutions for multiple challenges will be carried out due to relevant research and analyses. Then, links between the foundation of the solutions such as shared resources, tools and spaces will be researched and worked out. Finally. Based on this, the possibility of combining those solutions will be discussed and synergetic strategies, that can be multitasking, will be carried out.

Conclusion

In summary, to achieve the goal of CO_2 circularity within the agrifood sector, several concepts are implemented in the process of defining problems, analysis, and working out the vision and strategies. This report not only focuses on how to make the transition to a circular economy regarding CO_2 neutrality, but it also tries to tackle multiple challenges using the same location and resources while taking spacial justice into account.

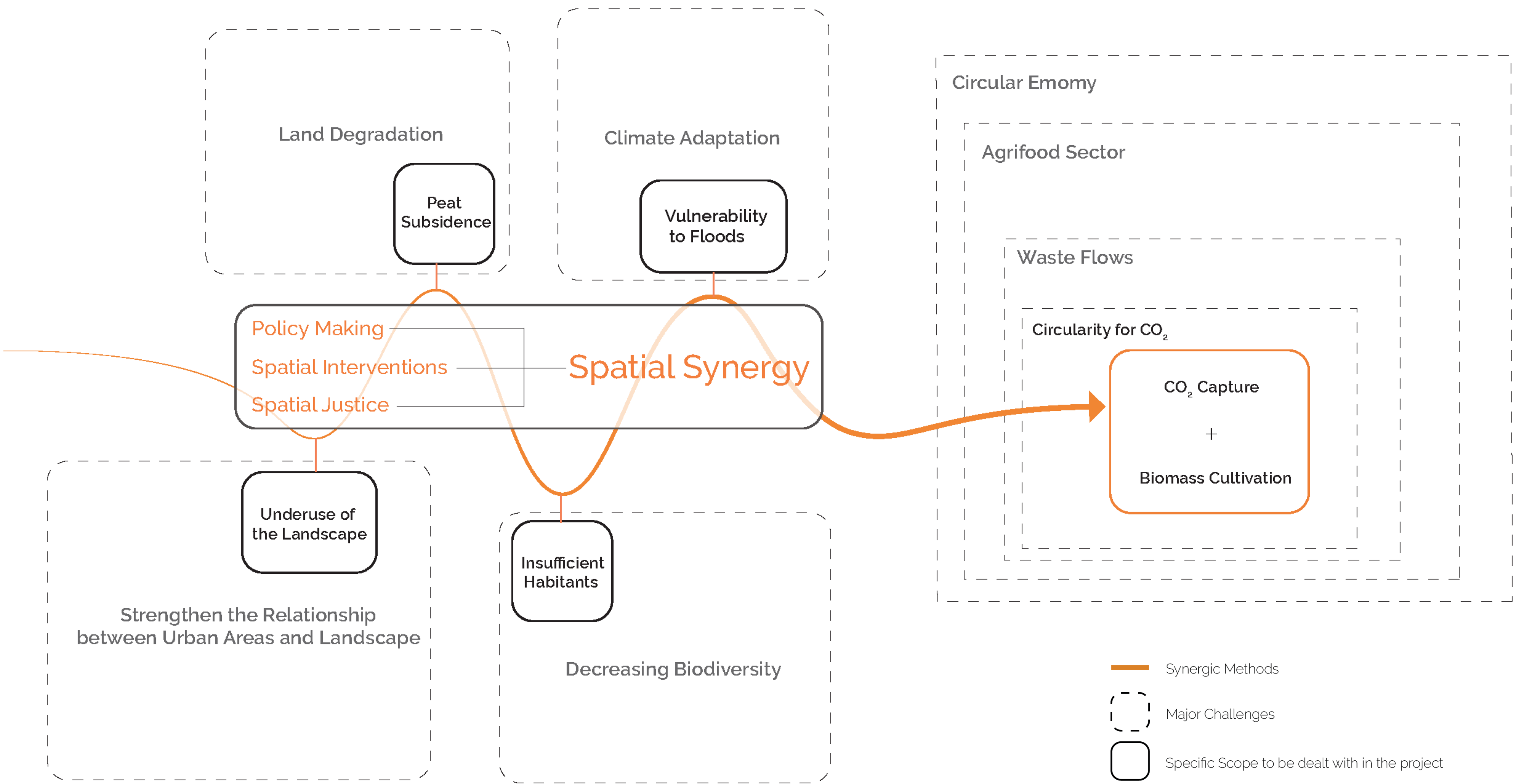


Figure 1.5 | Conceptual framework *(Authors own, 2020)*

02

APPLIED RESEARCH ON AGRIFOOD CIRCULARITY

2.1 RESEARCH APPROACH

In this chapter, the research about the three aspects will be applied based on the research question, as it shown in the figure 2.1. The research approaches here used are selected according to the specific data collected and the sub-research questions, which are as follows:

1. **How to make a spatial transition towards the circularity of CO_2?**
2. **How to mitigate other challenges in a synergetic way?**
3. **How to guarantee spatial justice in and after the transition?**

The first part of research will focus on the main actors in the agrifood sector of the Province of South Holland, including greenhouses farmers, peat farmers, and crop farmers. However, during the analysis, spatial justice issue is the main focus based on all of these. The research started from data collection and processing, to production process analysis, and mapping relevant data on a spatial level. Finally, by comparison of selected data, conclusions have been worked out.

The second part will focus on CO_2 circularity in the agrifood sector, including CO_2 emission sources, CO_2 production process and possible solutions for control CO_2 emission. The research started from data collection and processing, to emission process analysis, and biomass potential analysis. Finally, after analysis about biomass potential, conclusions have been worked out.

The third part will focus on other spatial challenges in the regional level, including four aspects: decreasing biodiversity, land degradation, climate adaptation, and urban landscape relationship. This part is not solely focused on how to solve problems in these four issues, but on how to mitigate the problems in a synergetic way with the transition towards the circularity of CO_2. The research started from data collection and processing, to key problems analysis, and mapping issues spatially. Finally, with evidence and science based solutions, conclusions have been worked out.

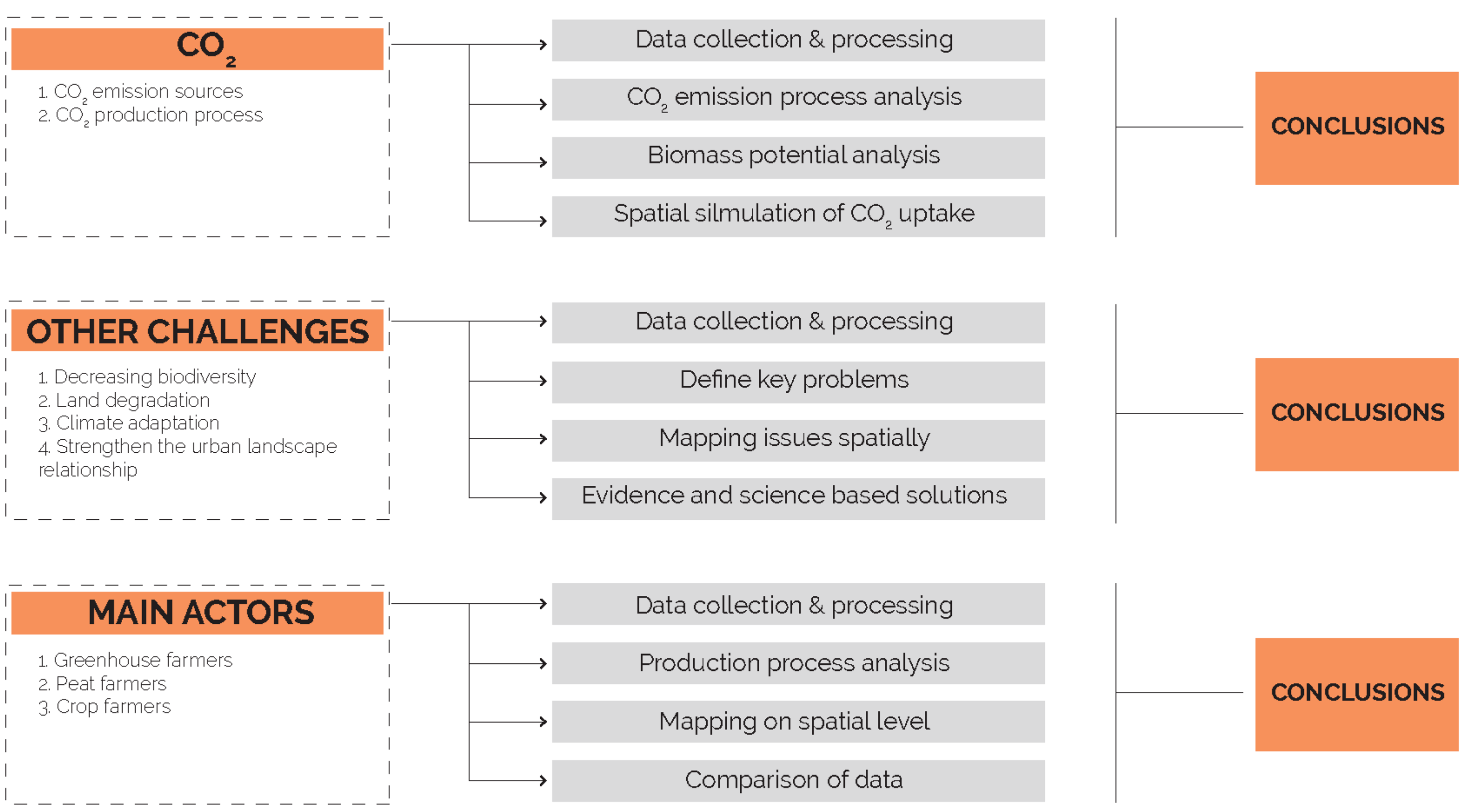
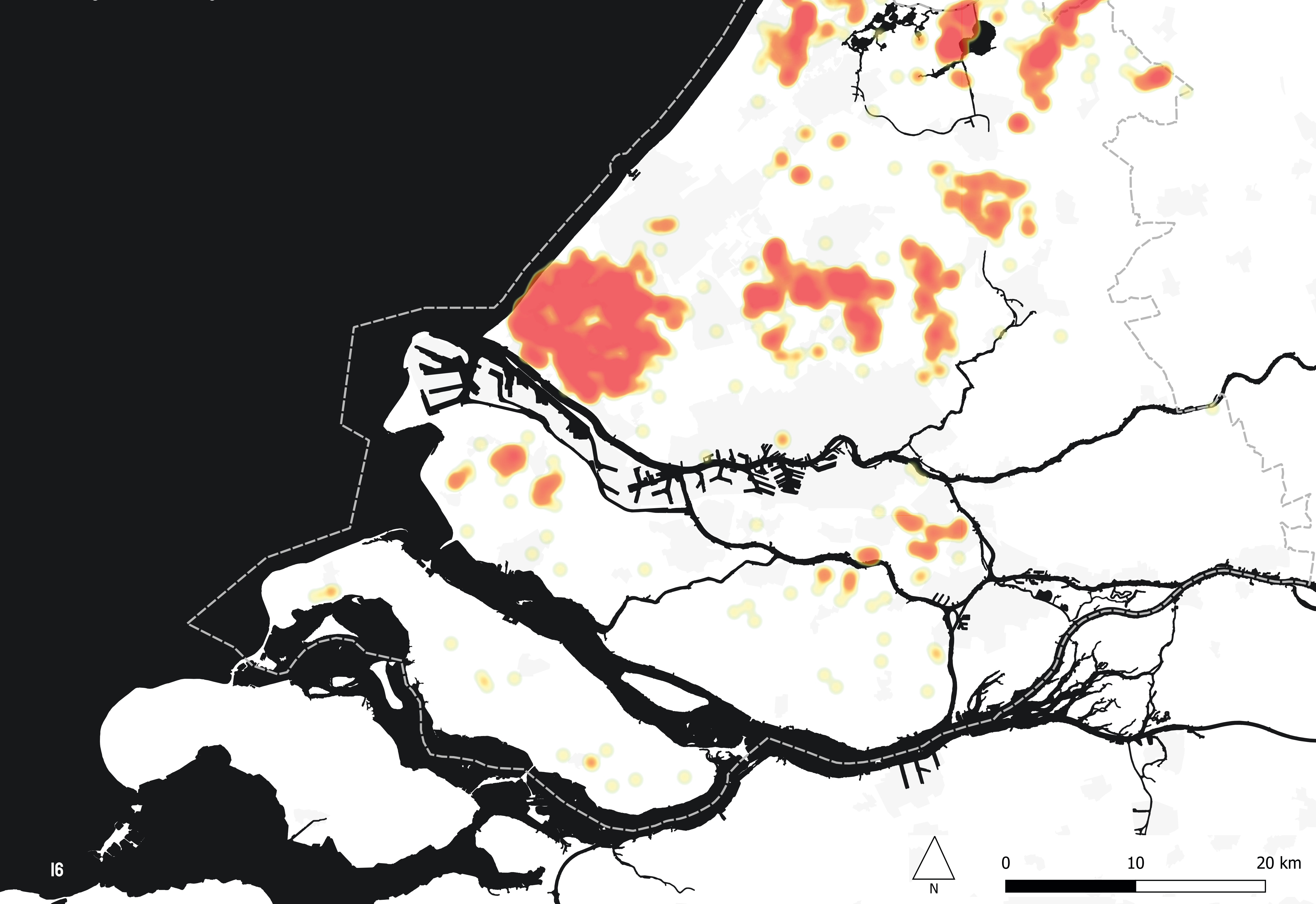


Figure 2.1 | Scheme research approch *(Authors own, 2020)*

Figure 2.2 | Process greenhouses *(Authors own, 2020)*



2.2 MAIN ACTORS

The greenhouse farmer

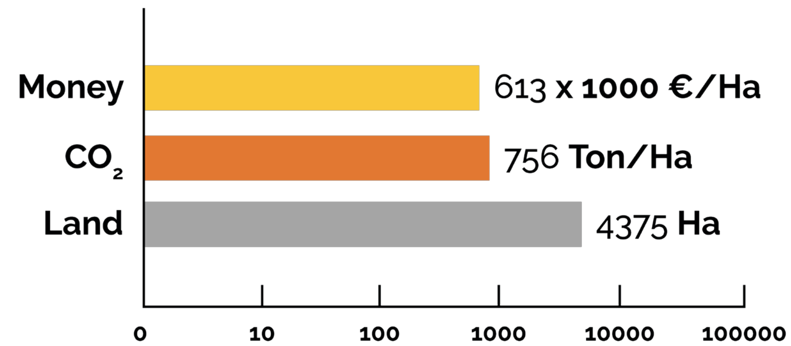


Figure 2.3 | Barchart actor *(Data from CBS, 2018)*

Three main stakeholder groups are important to distinguish within the agrifood sector. These stakeholders are farmers on peat soil, farmers on clay soil and greenhouse farmers. The next paragraphs explain the position of these stakeholders in the province of South Holland and their relation to CO_2 emissions.

Greenhouse farmers

The first group of actors consists of greenhouse farmers. Typical products that are grown in greenhouses include fresh vegetables, such as tomatoes and cucumbers, but also potted plants and flowers for the house plant market. The controlled environment of the greenhouse allows for an extremely efficient production process.

Most greenhouses are heated using gas, resulting in 3.6 million tons of CO_2 emissions every year (Roemers et. al., 2018), or 756 tons per hectare. Greenhouse farmers are located in clusters, so-called Greenports. This can be seen in figure 2.4 and 2.5. Agglomeration of these actors makes it possible to share facilities, such as an auction hall. The largest Greenport is the Westland. Together, the Greenports are the largest exporter of fresh vegetables in the world (Greenport Holland, 2020). This is especially impressive given the little land this group owns: just 4.375 ha. This also results in a very high yield of over €600.000 per hectare, see figure 2.3 (CBS, 2018).

<< Figure 2.4 | Heatmap greenhouses *(Data from LISA, 2020)*

Figure 2.5 | Photo greenhouses *(Shutterstock, n.d.)* >>

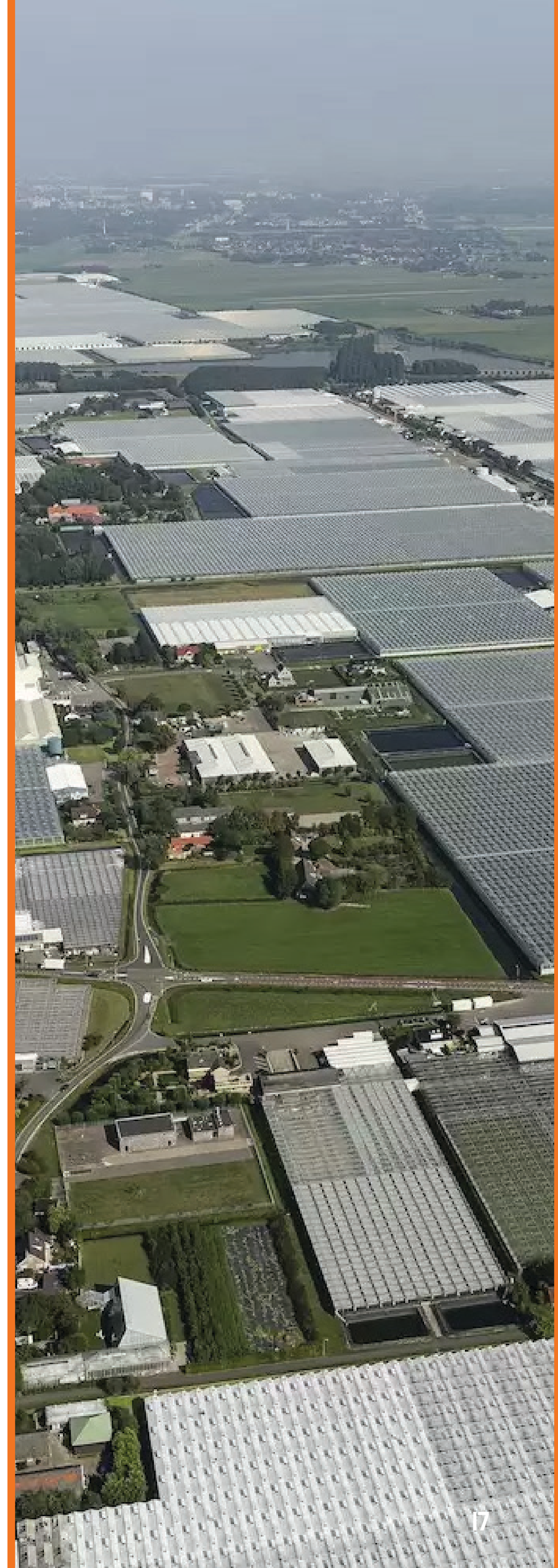
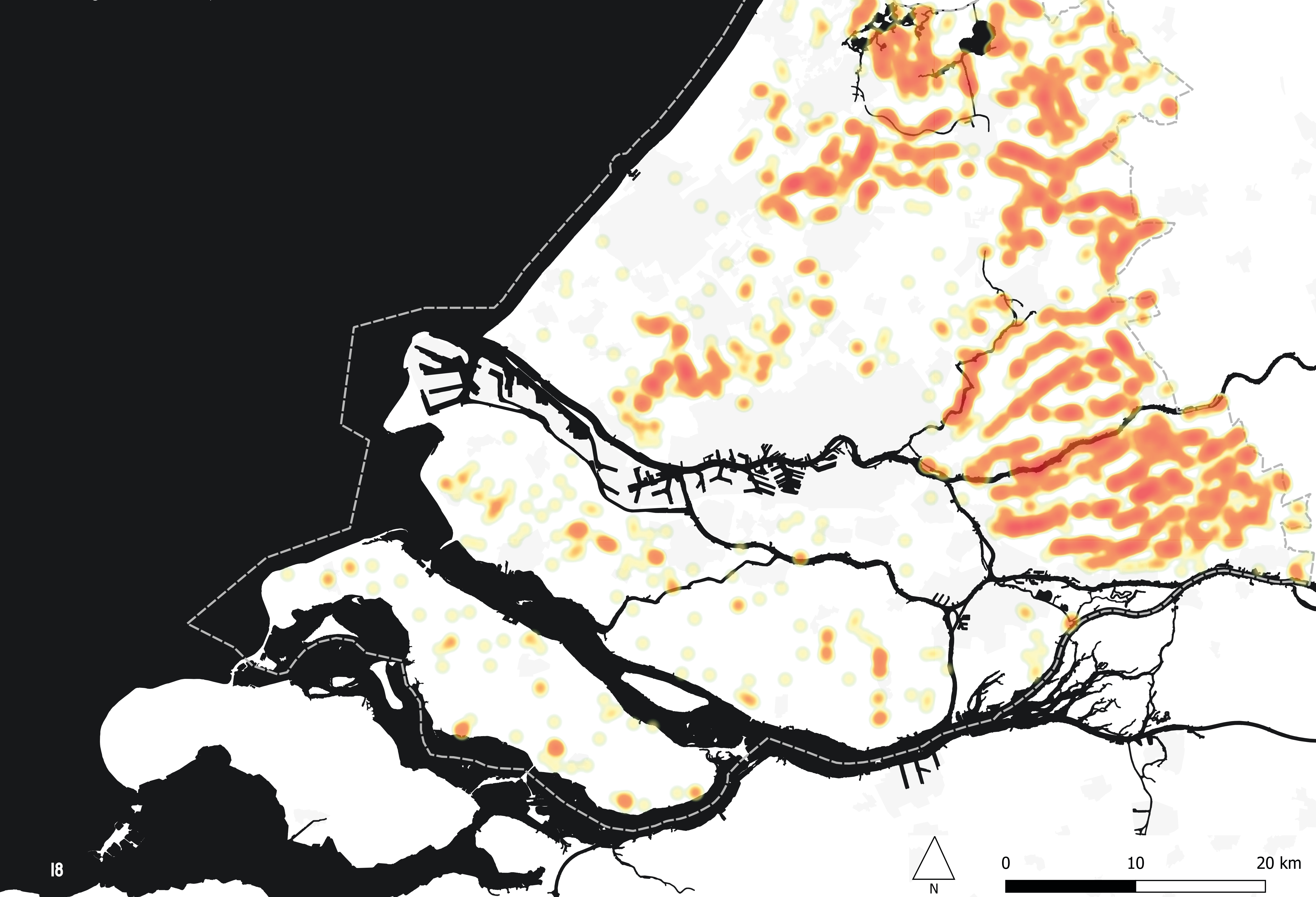


Figure 2.6 | Process peatland *(Authors own, 2020)*



2.2 MAIN ACTORS

The peat farmer

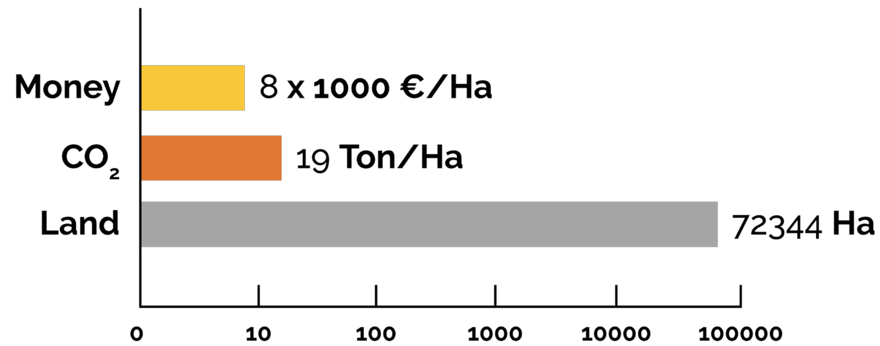


Figure 2.7 | Barchart actor *(Data from CBS, 2018)*

Peat farmers

The second group of stakeholders is formed by peat farmers. This group consists of farmers that have a cattle farm (typically cows) on peat soil. Peat soil is not suitable for conventional crop cultivation, hence growing grass for cows is the most feasible option in these areas. The map in figure 2.9 shows the location of these farms, almost all in the eastern part of the province, also known as 'the green hart'. In total, peat farmers are the actor group with the most land: 72.344 ha (CBS, 2018).

Farmers on peat soils have to lower the water table in order to increase the stability of the soil. This causes the peat to oxidate, a chemical process that results in CO_2 emissions. This is shown in figure 2.8. For the province of South Holland, this farming method causes 1.4 million tons of CO_2 emissions per year (Roemers et. al., 2018). This is 19 tons per hectare peatland. Intensive water management in the landscape has also influenced the visual appearance of the peatland as it is known today, characterized by long parallel ditches (figure 2.10).

Farming on peat soil is an increasingly difficult practice. Subsidence of the soil causes maintenance costs to rise (Pieterse *et al.*, 2015). Furthermore, the revenue of the produced products such as milk are decreasing in price. Altogether, the average yield per hectare of this actor group is among the lowest, about €8.000 per year (CBS, 2018). All these numbers are represented in the graph in figure 2.7.

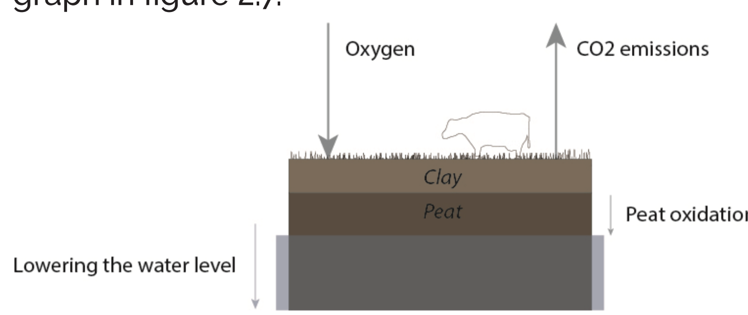


Figure 2.8 | Process of peat oxidation *(Authors own, 2020)*

<< Figure 2.9 | Heatmap cattle farming *(Data from LISA, 2020)*

Figure 2.10 | Photo polder *(Shutterstock, n.d.)* >>

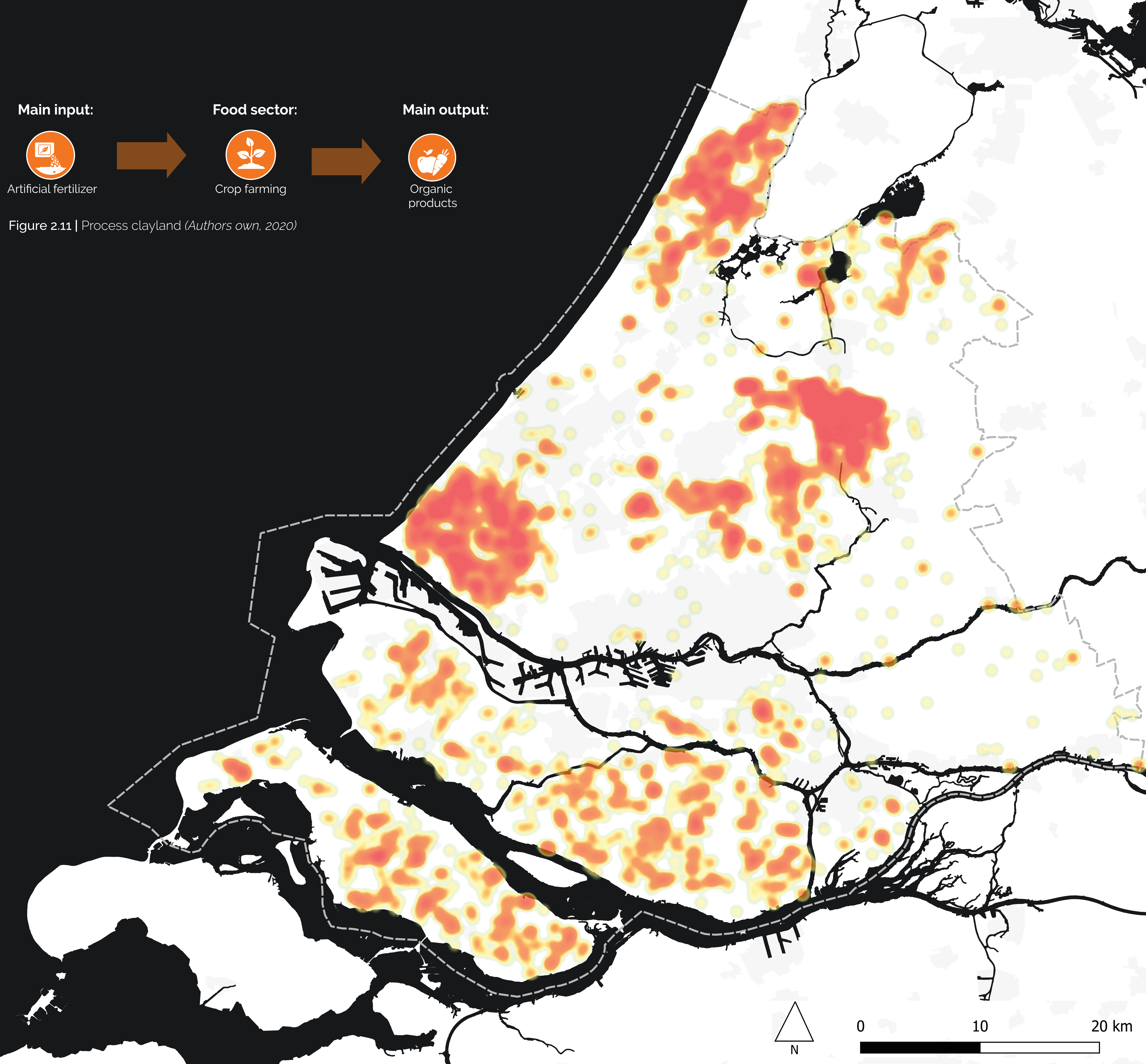


Figure 2.11 | Process clayland *(Authors own, 2020)*

2.2 MAIN ACTORS

The crop farmer

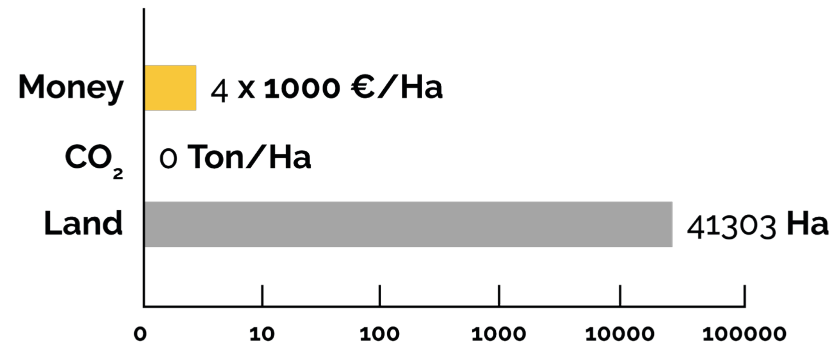


Figure 2.12 | Barchart actor *(Data from CBS, 2018)*

Crop farmers

Unlike the other two actors, crop farmers do not produce a significant amount of CO_2 themselves. However, this group is important to include as these farmers own a lot of land in the province. A total of 41.303 ha is used to cultivate crops in the open air, see figure 2.12. The most cultivated crops are potatoes, sugar beets and vegetables. Only soil with a significant amount of clay are suitable for this. These types of soils are located in the south of the province and along the main rivers, as can be seen in figure 2.13. The economic yield of this group is the lowest of all actors, with about €4.000 per hectare, see figure 2.12.

Spatial justice

It can be concluded that there are large differences between the different actors. The greenhouse farmers emit the most CO_2 per hectare, followed by the peat farmers. However, due to their very efficient production process, greenhouse farmers have also the highest economic yield per hectare. The yield per hectare is more than 150 times higher when compared to the crop farmers. At the same time, a distinction can be made based on the amount of land owned by all the actors in one group. Peat farmers own collectively 16 times more land then the greenhouse farmers. More detailed statistics are available in the appendix.

It is important to take these differences into account during the process of strategy making, to ensure spatial and social justice for all actors.

<< Figure 2.13 | Heatmap crop farming *(Data from LISA, 2020)*

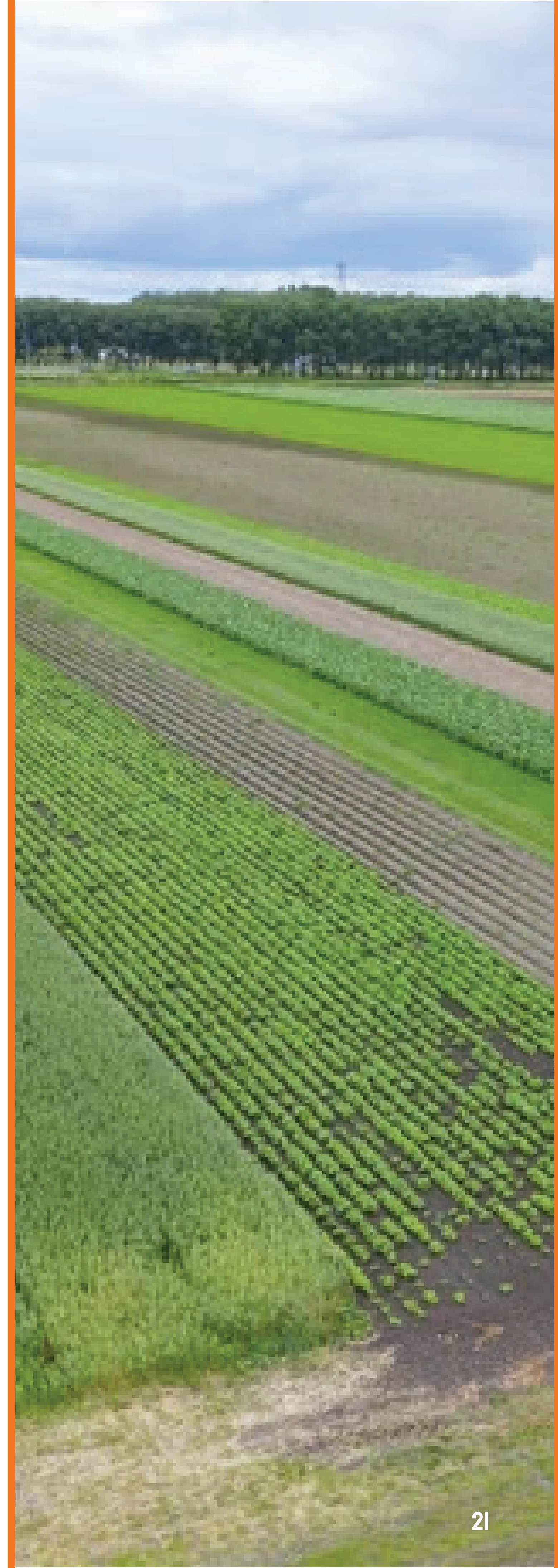


Figure 2.14 | Photo crop field *(Shutterstock, n.d.)* >>

2.3 CO_2 CYCLE

As mentioned before, the largest and least desirable output flow of the agrifood sector is the emission of CO_2. There are two main processes related to CO_2 emissions in this sector. Firstly, the heating of greenhouses by gas results in 3.6 million tons of CO_2 emissions every year (Roemers et. al., 2018). The second source of emissions is caused by the oxidation of farmland, namely peat soil. This causes 1.4 million tons of CO_2 emission per year (Pieterse *et al.*, 2015; Roemers et. al., 2018). Combined, there is about 5.0 million tons of CO_2 emission by this sector every year.

CO_2 and circularity

The first goal for achieving circularity for CO_2, according to the ladder of Lansink should be to reduce future emissions, see figure 2.15. For peat areas, this means raising the water level. Figure 2.16 shows that there is a direct relationship between the water table and the amount of CO_2 that is emitted per hectare. The lowest emissions are achieved when the water level is raised to the same height as the ground elevation (Louis Bolk Instituut, 2019). Emissions in the greenhouses can be lowered by technical innovations, such as CO_2 capturing and increasing the efficiency of gas usage.

However, for both greenhouses and peatlands, a transition to zero CO_2 emissions will not be possible. It is therefore needed to look at the possible re-use of CO_2. CO_2 is part of the carbon loop, illustrated in figure 2.17. The loop is made up out of two parts: oxidation and sequestration. On one hand, oxidation of carbon in peat and gas produces CO_2. On the other hand, CO_2 is used in the process of carbon sequestration. In the current situation, there is too much oxidation of carbon. To move towards a circular system, more sequestration is needed. Plants are ideally suitable for this job, as they need CO_2 to grow.

Figure 2.15 | Ladder of Lansink *(Lansink, 1979)*

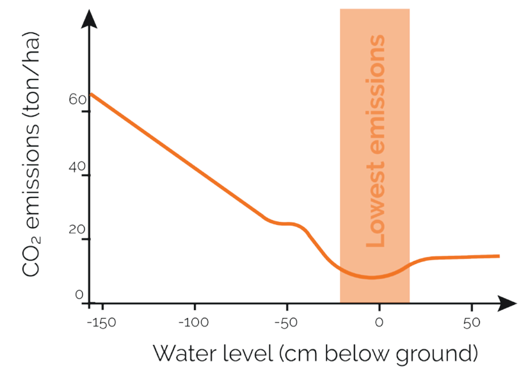


Figure 2.16 | Relation water table and CO_2 emissions *(Louis Bolk Instituut, 2019)*

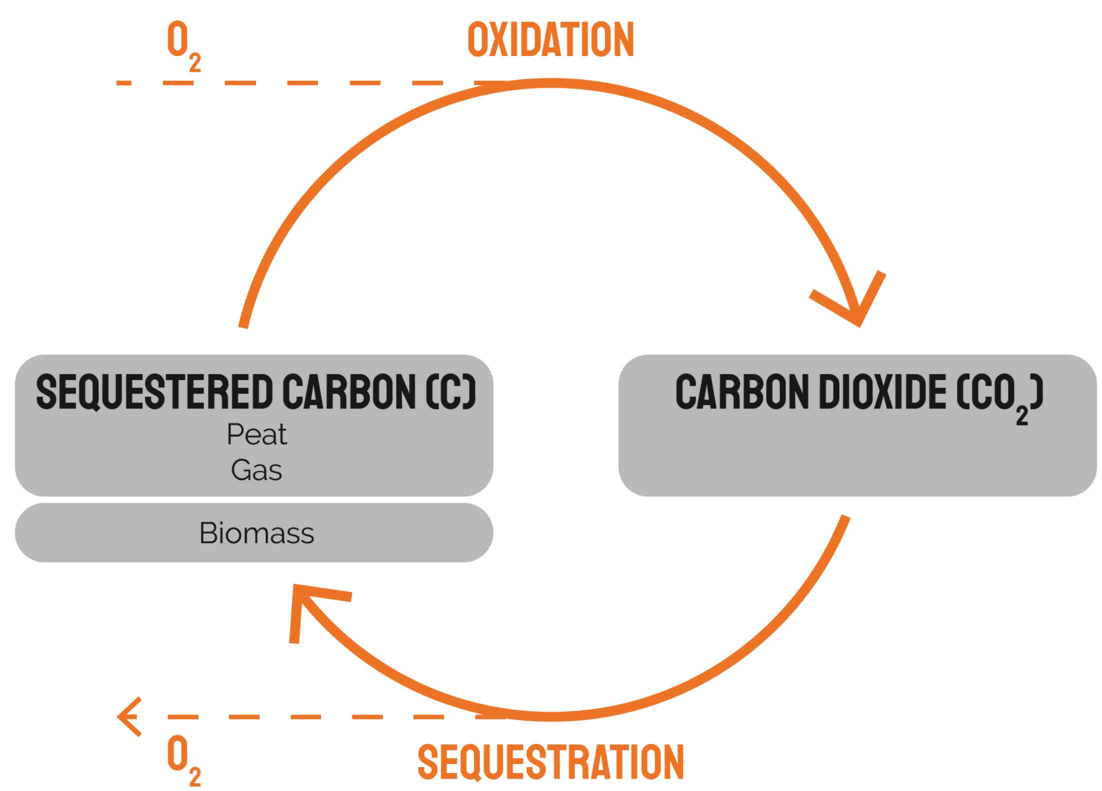


Figure 2.17 | Carbon loop *(Authors own, 2020)*

Biomass potential

An advantage of using plants for CO_2 capturing is the synergy it provides with producing biomass. Biomass can be used for the transition towards a biobased economy. This is an economy based on biobased (thus renewable) resources, as opposed to fossil non-renewable resources. Crops which are very efficient in capturing CO_2 and also useful to the biomass industry are for instance silvergrass (Miscanthus sp.) and cattail (Typha sp.). Silvergrass can take up to 44,3 tons of CO_2/ha/year and can be used in the production of flowerpots and bioplastics (Yazaki *et al.*, 2004; WPT Biobased, 2020; Wageningen University and Research, n.d.). Cattail can take up to 9.7 ton of CO_2/ha/year and can be used as an insulation material (Bonneville *et al.*, 2008; Wilhelm *et al.*, 2019). Furthermore, the province is already doing research on the possibilities of using wooden building materials, as encouraged by the Dutch government in the National Strategy on Spatial Planning and Environment (Ministerie van Binnenlandse zaken en Koninkrijksrelaties, 2019). The wood of poplar trees (Populus sp.), among many other species, was found suitable for wooden building construction materials. These trees can take up to 50,6 ton of CO_2/ha/year (Studio Marco Vermeulen, 2020). There are many more examples when it comes to biomass production. Research on the possibilities of using biobased materials has just started and it can be expected that many more suitable vegetation species and new materials will be discovered in the future.

Figure 2.18 shows the total land area that is required to compensate for the current CO_2 emissions. This again illustrates that a large spatial transition is inevitable, but also stresses the fact that there is a need to reduce the emissions in the first place.

There is another challenge related to the transition from food to food and biomass. This is the value difference between plants cultivated for food and plants cultivated for biomass (Lange *et al.*, 2012). This value difference is illustrated using the biomass value pyramid, shown in figure 2.19. This figure also shows that besides the value gap between food and materials, there is also a carbon surplus. This is because a higher volume of plants is needed to produce biobased materials when compared to food or medicines. The higher volume equals more carbon sequestration.

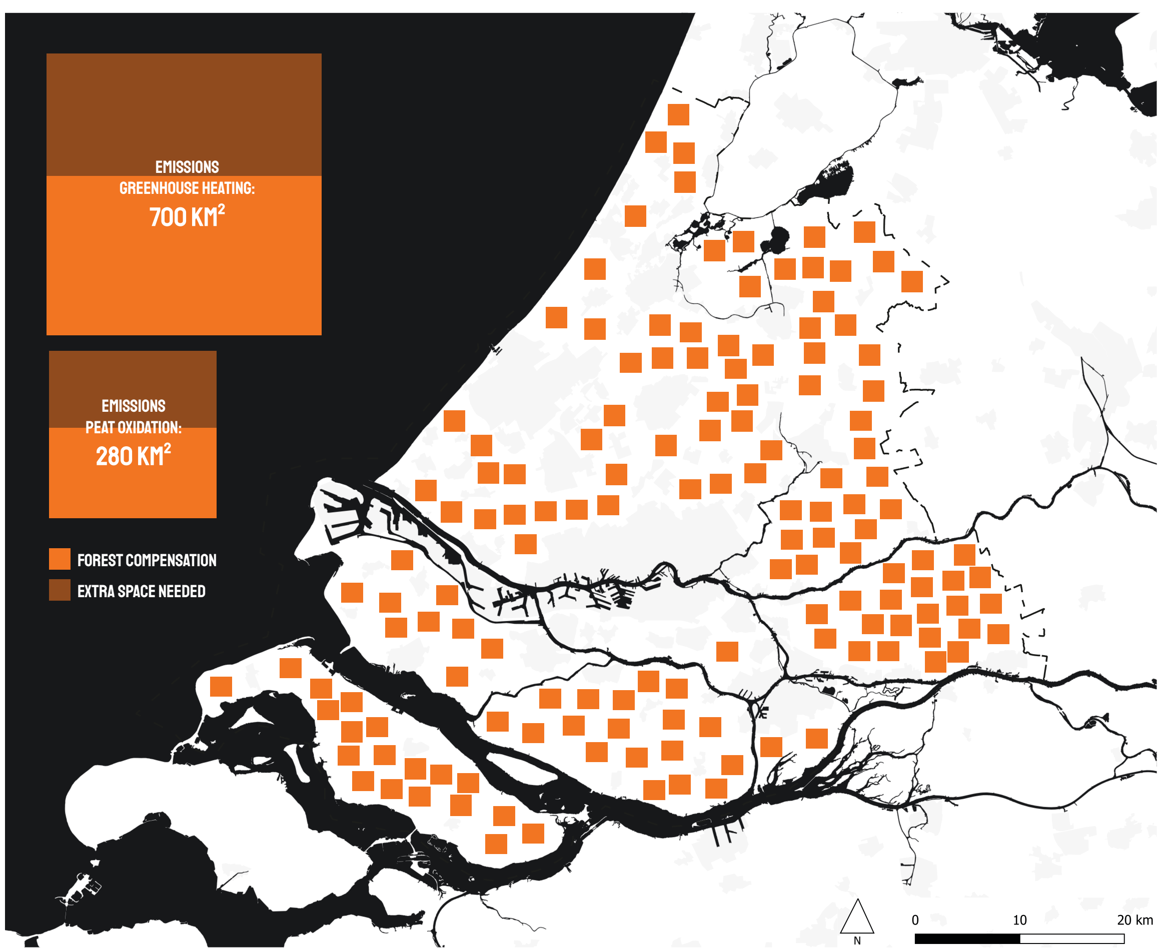


Figure 2.18 | There is not enough space for complete CO_2 compensation with popular *(Authors own, 2020)*

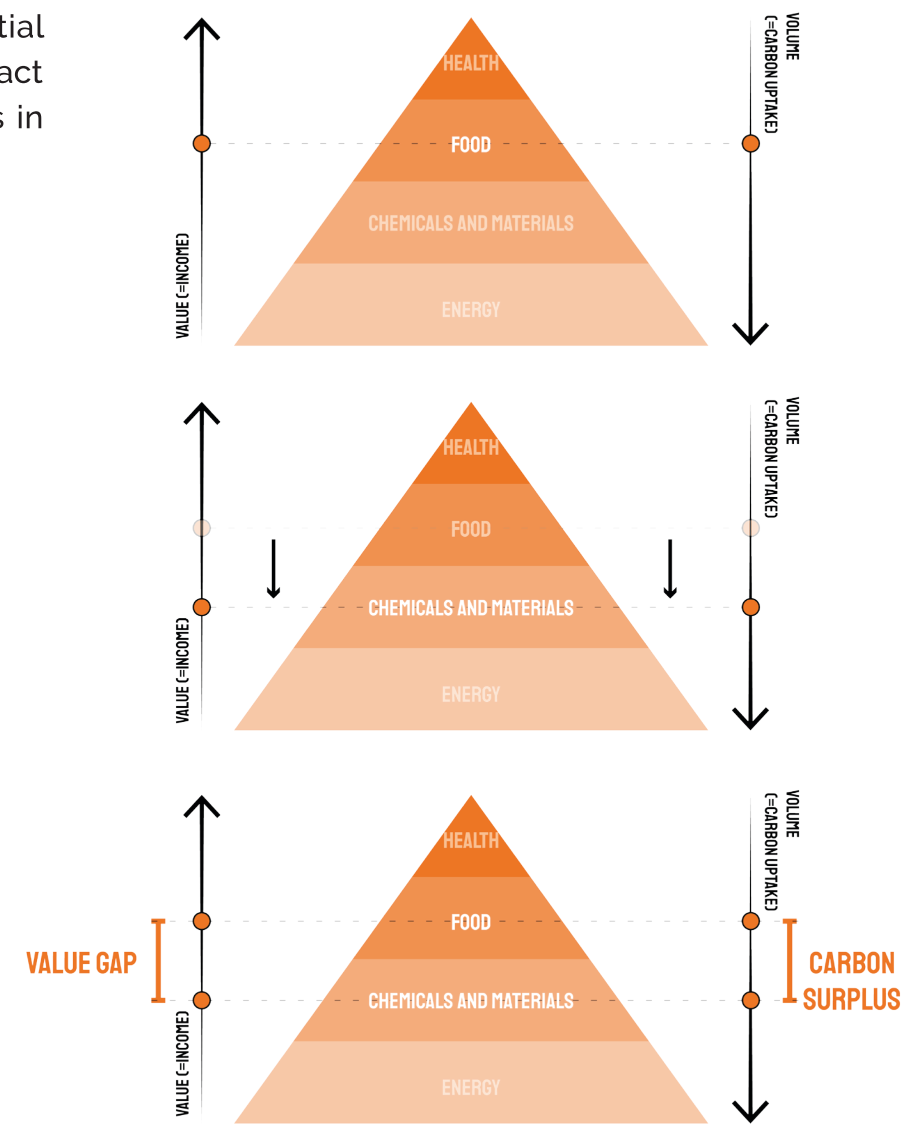


Figure 2.19 | Biomass value pyramid *(Authors own based on Lange et al., 2012)*

2.4 ADDITIONAL SPATIAL CHALLENGES

As shown on the map in figure 2.18, a large spatial transition is required. Besides the challenge of becoming CO_2 neutral, there are also other spatial challenges in the province. In this section, we explain the four most urgent spatial challenges and the spatial interventions required for solving them.

Decreasing biodiversity

Almost all agricultural production in the province is practised using a monoculture system, see figure 2.21. This means that large areas of the same crops are planted next to each other. This way of agricultural production is one of the main causes of the decrease in biodiversity in the Netherlands (Erisman *et al.*, 2016). Furthermore, more pesticides are needed to control diseases as monocultures are very vulnerable to pests (Power and Flecker, 1998). A solution to this unsustainable way of agricultural production is to cultivate a variety of species. This is called polyculture. Polyculture ecosystems are more resilient to changes and beneficial to biodiversity (Power and Flecker, 1998). This is especially true when plant species are used that are local to the area (Altieri, 1999).

Land degradation

As explained in the previous section about CO_2, farmers on peat soil have to lower the water level to create a stable soil. Apart from CO_2 emissions, this process causes subsidence of the soil too. Since farmers started draining the water in these areas in 1500, the soil has subsided by more than 3 meters (Pieterse *et al.*, 2015). The soil is still subsiding up to 5 mm/year. This process results in increased maintenance costs for all actors in the area. Since the level of the soil has already sunken below sea level, all the water needs to be pumped out by the water boards.

→

Problem:
Insufficient habitats

Solution:
Polyculture

→

Problem:
Peat subsidence

Solution:
Rising watertable

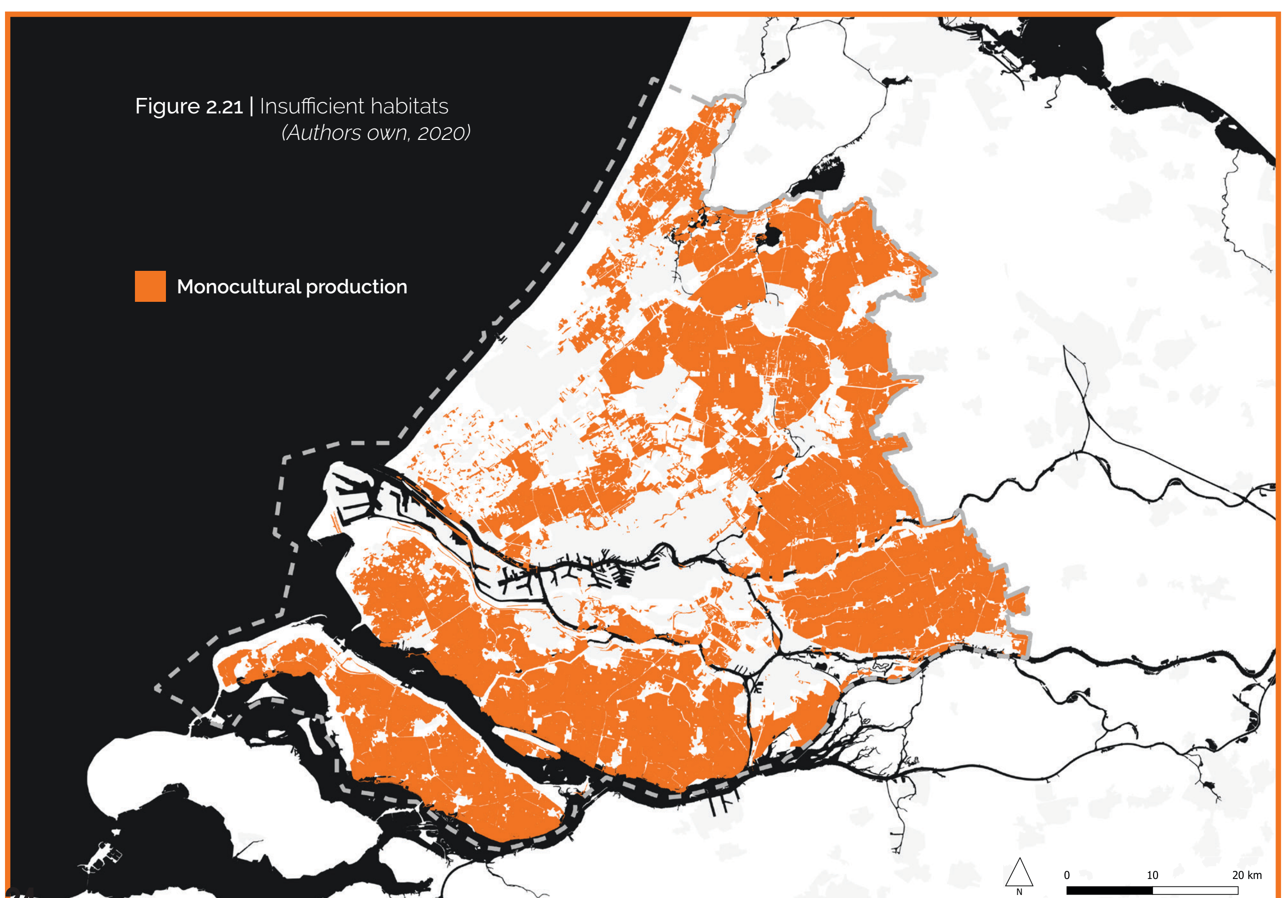


Figure 2.21 | Insufficient habitats (Authors own, 2020)

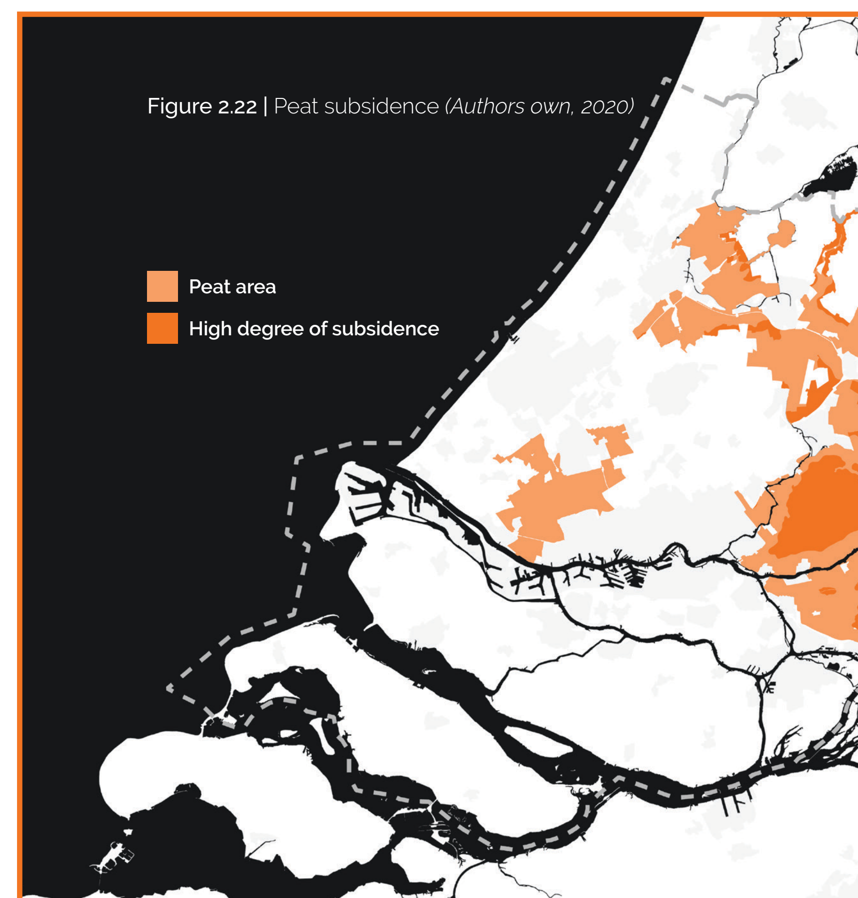


Figure 2.22 | Peat subsidence *(Authors own, 2020)*

The municipality has to make a lot of costs to replace and repair sagging sewage pipes and roads, and house owners will have to repair their homes because of the subsidence (Pieterse *et al.*, 2015). The map in figure 2.22 shows the areas in the province that are subsiding. This concerns mainly the peat areas in the east of the province. To mitigate subsidence, the oxidation of peat has to be stopped. As pointed out before, this is done by raising the water table.

Climate adaptation

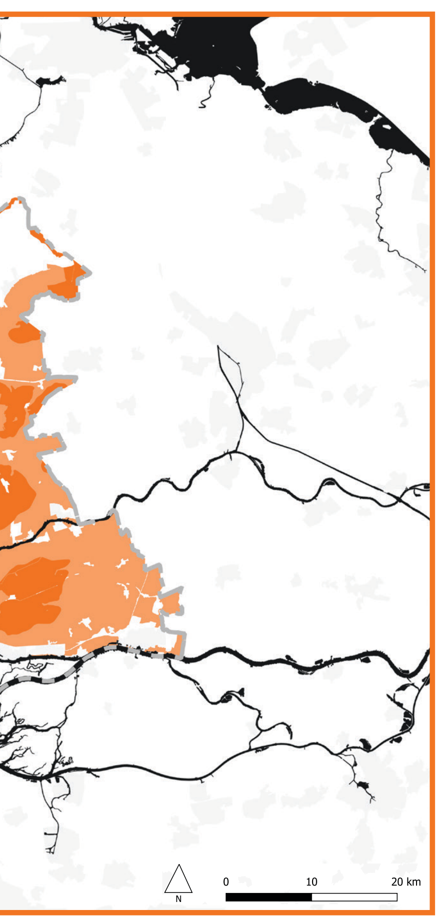
The average global temperature has risen with 1.5˚C since 1900 (Lindsey and Dahlman, 2020). This increase in temperature triggers a whole array of changes to our previously stable climate. It is expected that we will experience more heavy rainfalls and more severe droughts. Furthermore, the sea level will rise (Vermeer and Rahmstorf, 2009). This can cause floods near the sea, but also along rivers that have difficulties discharging their water. The map in figure 2.23 shows the severity of a possible flood in different areas in the province, taking all these factors into accounts.

Problem:
Vulnerability to floods

→

Solution:
Space for water

To anticipate this, there is space needed in the landscape for water. This concerns both the space for water reservoirs during dry periods, and the space for water drainage during extreme rain events (Ministerie van Binnenlandse zaken en Koninkrijksrelaties, 2019). The most space for water will be needed in the areas with the highest flooding danger.



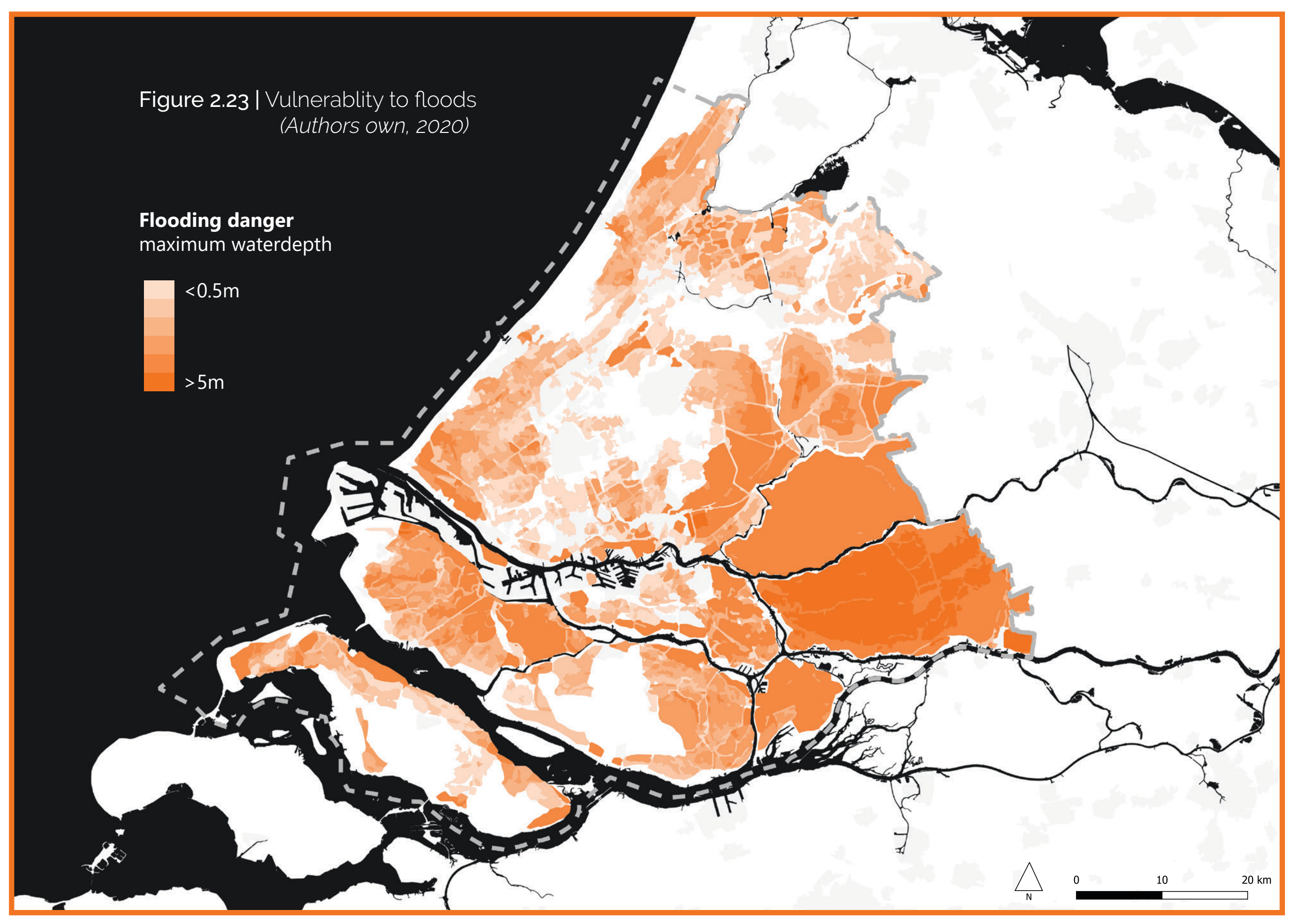


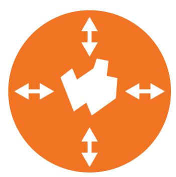
Figure 2.23 | Vulnerablity to floods
(Authors own, 2020)

Urban landscape relationship

In a world where people are increasingly more mobile, the quality of life in metropolitan areas has large implication on the talent a region attracts. In order to stay compatible with other metropolitan areas and to create an attractive environment for the people in South Holland, the municipality has expressed the desire to invest in the recreational aspect of the landscape (Provincie Zuid Holland, n.d.). The province consists of a patchwork of urban areas surrounded by natural landscapes, as can be seen in figure 2.24. It has numerous times been proven that natural areas positively affect human emotions, health and well-being (Ulrich *et al.*, 1991; Kaplan, 1995; Hartig *et al.*, 2011).

This means that it is important to connect the people in the cities with the natural landscape around it. This can be done by making the landscape more attractive to use for recreational activities, and by improving the connectivity between the landscape and the city.

→



Problem:
Underuse of recreational potential of landscape

Solution:
Connection to the city

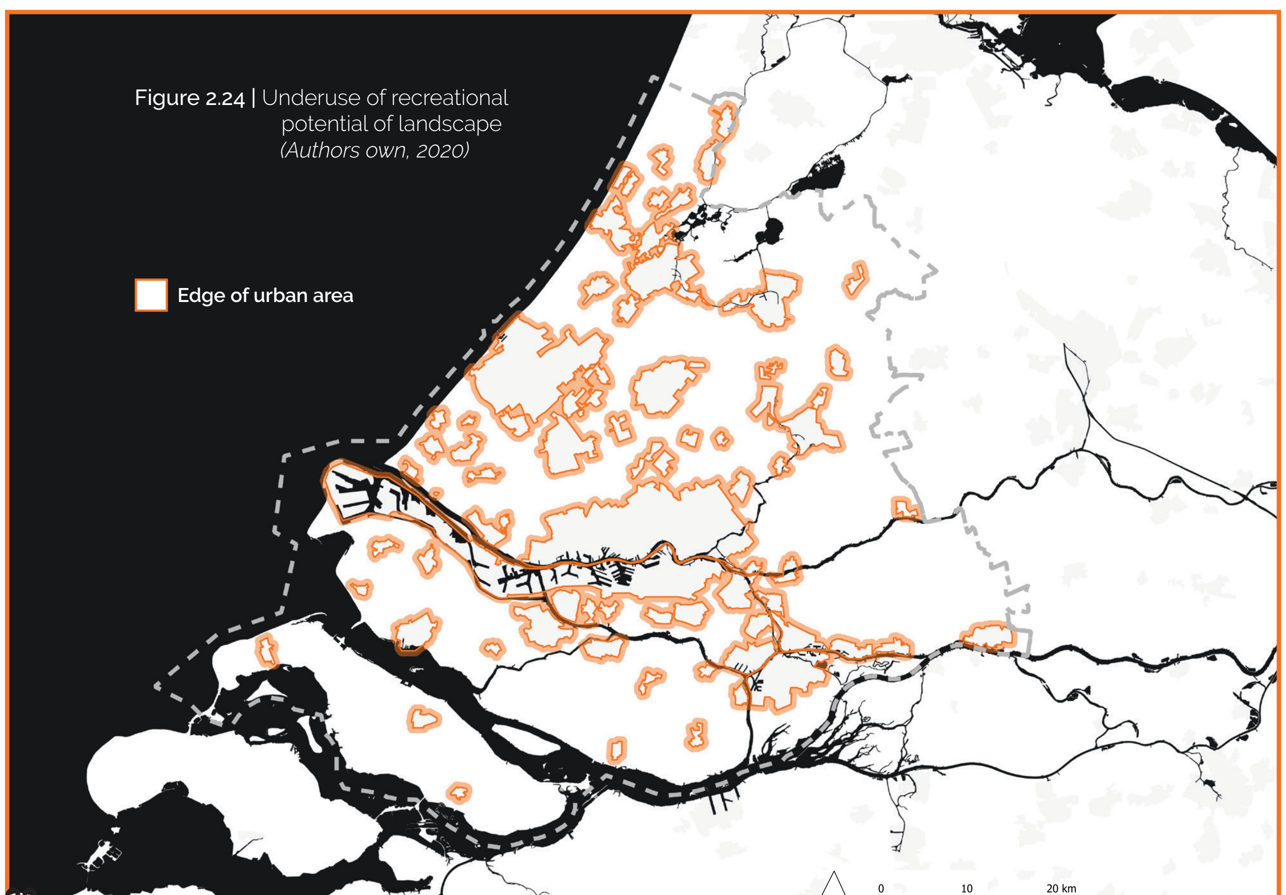


Figure 2.24 | Underuse of recreational potential of landscape *(Authors own, 2020)*

2.5 GENERAL CONCLUSION

1. How to make spatial transition towards the circularity of CO_2?

To conclude, CO_2 emission is the largest output flow in the agrifood sector, caused by the heating of greenhouses and the oxidation of peat. The output of CO_2 can be compensated by growing more biomass, but a reduction of the emissions should be priority. Especially because planting biomass will take up a lot of area in the province and has large spatial implications. Still, it is possible to become CO_2 neutral. Furthermore, planting biomass has the advantage that it will contribute to the transition to a more sustainable biobased economy. There are many opportunities to use biomass as a resource in for example bioplastics, insulation and construction materials.

2. How to mitigate other challenges in a synergetic way?

Land scarcity makes it impossible to start the transition towards a CO_2 neutral agrifood economy without taking other spatial challenges into account. This means that the production of biomass has to be combined with the solutions to other challenges, presented in the previous paragraph. Biomass can be cultivated in polyculture to increase biodiversity for example. It is also possible to combine the cultivation of biomass with an increase in the water table to mitigate peat subsidence and make the landscape more climate adaptive. Finally, synergies with biomass production and recreation in the landscape will have to be made. This can be achieved by matching biomass production to the cultural characteristics of the landscape, but also by visualy connecting the production in the landscape with the people in the cities.

3. How to guarantee spatial justice in and after the transition?

There are large differences between the three main actors from the perspective of land ownership, income per hectare and CO_2 emissions. These differences can easily lead to spatial injustice. It is therefore important that during the transition, these differences are taken into account. This means that even though the peat farmers and the greenhouse farmers both produce CO_2, it would be unfair to treat them the same way. The peat farmers have much less money and are more interlocked into an unsustainable system, while the greenhouse farmers have more financial resources to develop towards a sustainable system. On the other hand, shrinkage of the greenhouse activity is undesirable, as they greatly contribute to the economic prosperity in the province. The peat and clay farmers are, because of their land, in the position to produce more biobased materials and to compensate for the CO_2 emissions. Naturally, these actors should financially benefit from doing so. As we have seen, the economic yield per hectare for food is higher than the yield for biobased materials. It is, therefore, necessary to compensate farmers who are growing biomass, thus sequestering carbon. This will increase their financial position and in this way, spatial justice can be guaranteed in the transition.

03

VISION 2050

3.1 VISION STATEMENT

*'In 2050, the **agricultural landscape** of South Holland produces a variety of food, feed and biobased materials. This results in an attractive and diverse landscape to enjoy for the inhabitants of South Holland. CO_2 is captured on farmland in **biobased materials**, which are used in the city. The greenhouse industry is still an important engine. The agrifood industry **cooperates** to be **CO_2 neutral**'*

3.2 VISION MAP

This map shows the regional vision map for the province of South Holland, regarding the agrifood sector. The combination of different landscape types and how they transform is visualised. The way of change depends on the local conditions, but in general the attractiveness of the landscape is increased and synergies with other challenges are created.

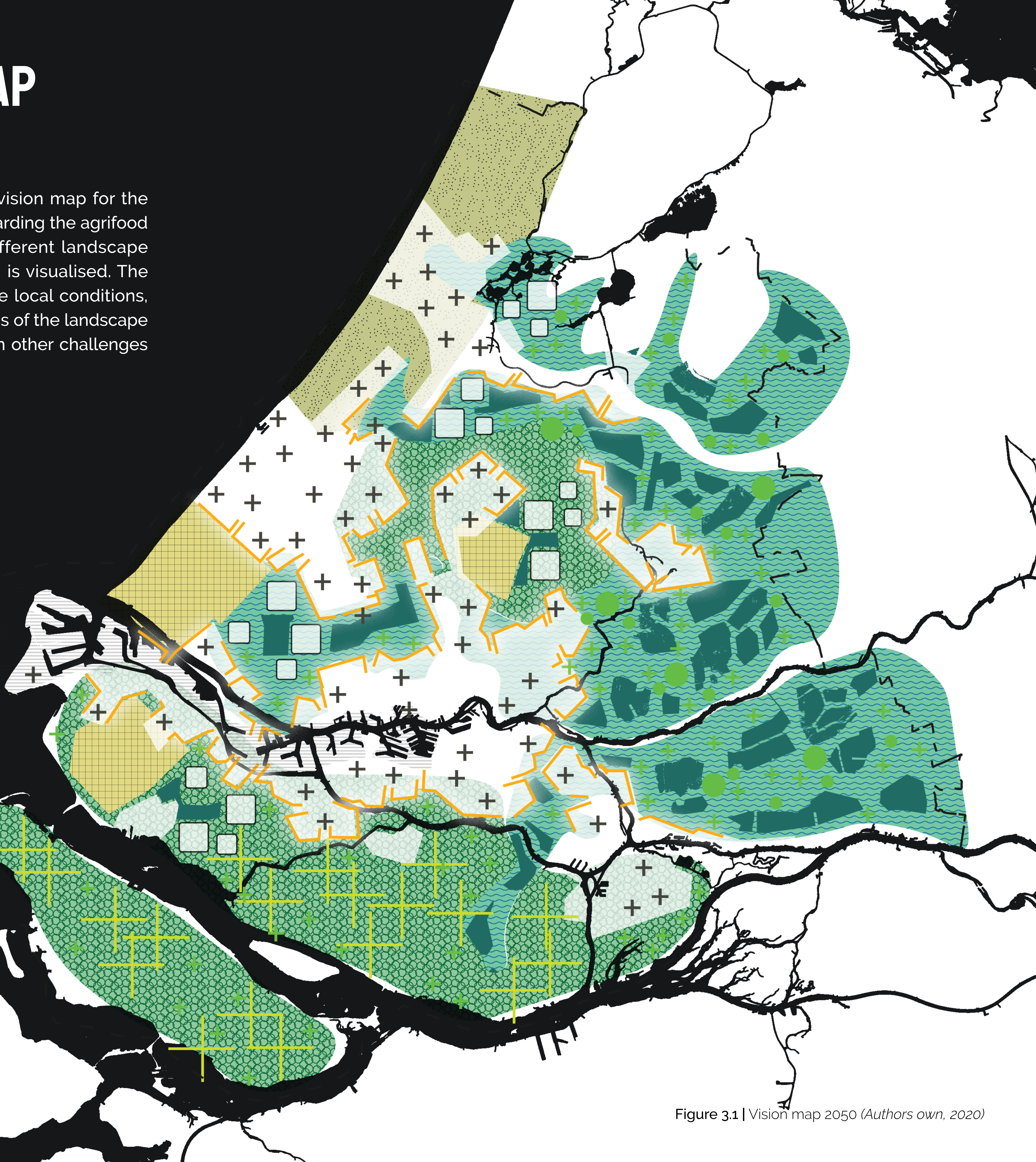


Figure 3.1 | Vision map 2050 *(Authors own, 2020)*

Figure 3.2 | Vision greenhouses *(Authors own, 2020)*

The greenhouse areas consists of the current clusters which are expanded (westland and oostland) and some newly formed clusters.

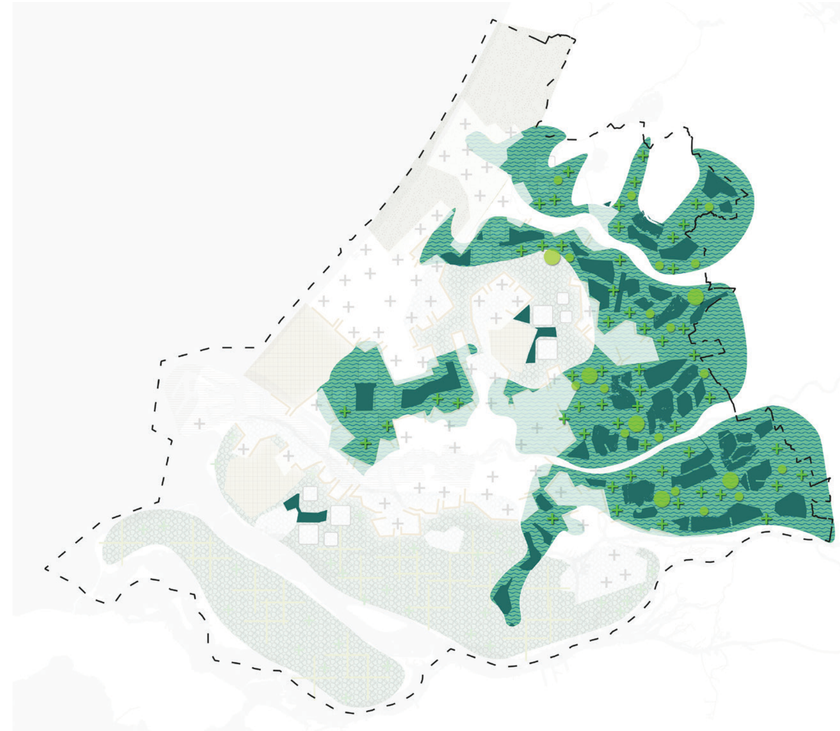


Figure 3.3 | Vision peatland *(Authors own, 2020)*

Most of the peatland area, located in the east of the province is changed in function, there is more space for the water and habitats are created to increase biodiversity.

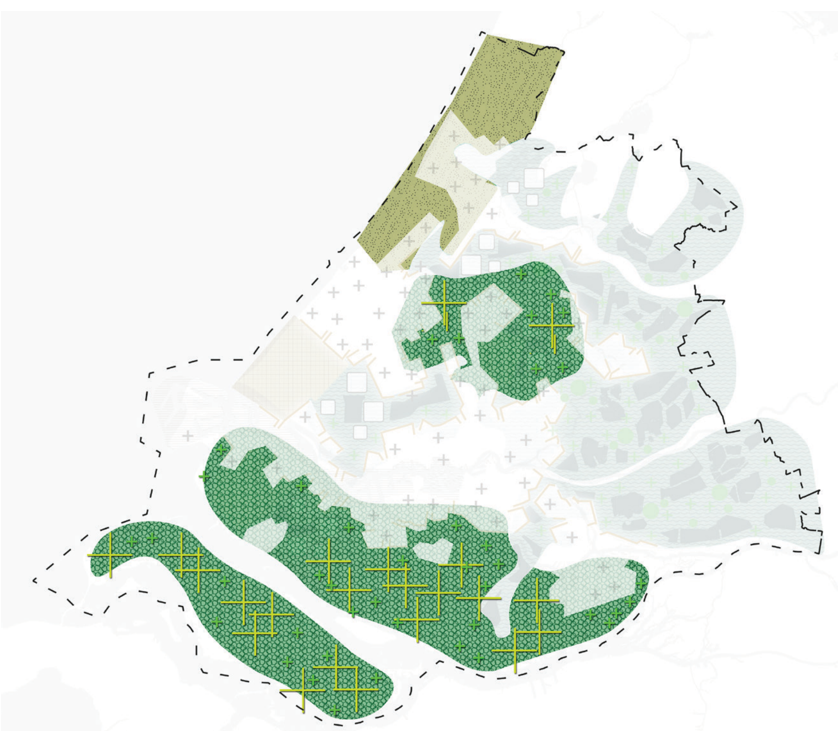


Figure 3.4 | Vision cropfarms *(Authors own, 2020)*

The agricultural lands, mostly in the southern part of the province, are adapted to a polycultural way of cultivation.

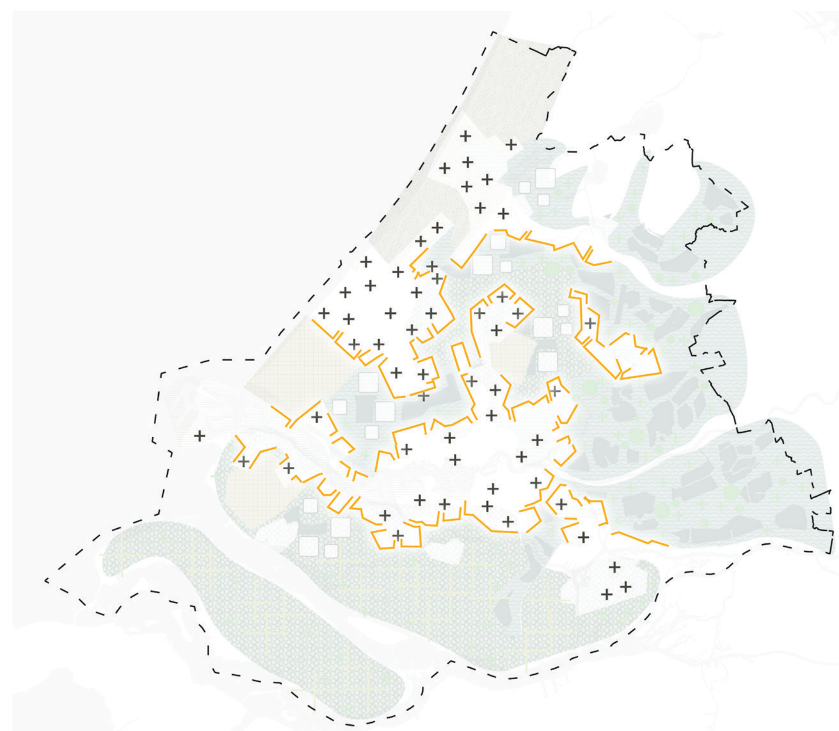


Figure 3.5 | Vision urban areas *(Authors own, 2020)*

The city is used to storage CO_2. Better transition zones with the surrounding landscape area are created at the edge of the urban areas.

3.3 PRINCIPLES FOR ACTORS

Greenhouses

In the current situation the greenhouses are responsible for a lot of CO_2 emission. In the vision the greenhouses are allowed to expand in clusters, only if they make technical improvements to reduce the CO_2 emissions. This results in dense clusters of high tech innovative efficient greenhouses, an impression of how this landscape looks like is shown in figure 3.6.

Figure 3.6 | Collage vision greenhouses *(Authors own, 2020)*

Peatland

In the current situation the peatlands emit CO_2 due to peat oxidation. In the vision the CO_2 emission is changed to CO_2 uptake, by raising the water table and the implementation of more nature. This change leads to a more biodiverse environment, an impression of how this landscape looks like is shown in figure 3.7.

Figure 3.7 | Collage vision peatlands *(Authors own, 2020)*

3.3 PRINCIPLES FOR ACTORS

Agriculture

In the current situation the agricultural fields consists of monocultural production, which leads to insufficient ecological habitats. In the vision CO_2 is captured by the production of biobased materials and the implementation of more trees. This and the transition to polyculture contribute to a more biodiverse landscape, an impression of how this landscape looks like is shown in figure 3.8.

Figure 3.8 | Collage vision crop farms *(Authors own, 2020)*

Figure 3.9 | Collage vision urban area *(Authors own, 2020)*

City

The city plays an important part in the vision to make the CO_2 cycle circular. It has the opportunity to create knowledge hubs regarding the process of carbon storage. The knowledge hubs activate the urban edges to create better transition zones with the surrounding landscape, an impression of how this landscape looks like is shown in figure 3.9.

3.4 CO_2 TRANSITION

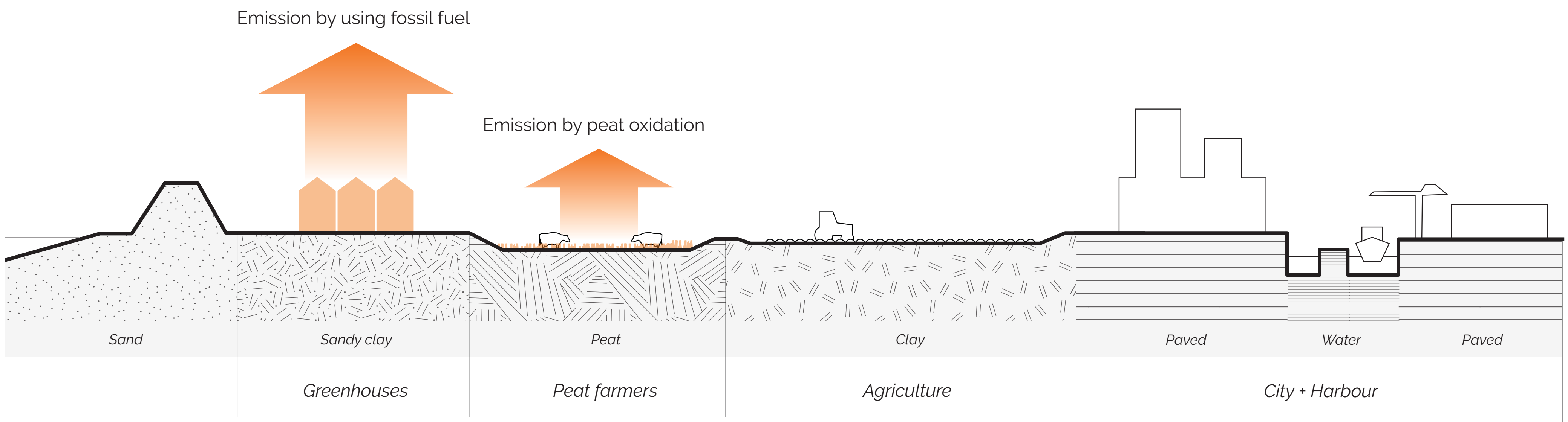


Figure 3.10 | Section status quo *(Authors own, 2020)*

Status quo

As explained in the research part there are two locations which are mostly responsible for emitting CO_2. The greenhouses emit CO_2 by using fossil fuel and the peatlands by peat oxidation.

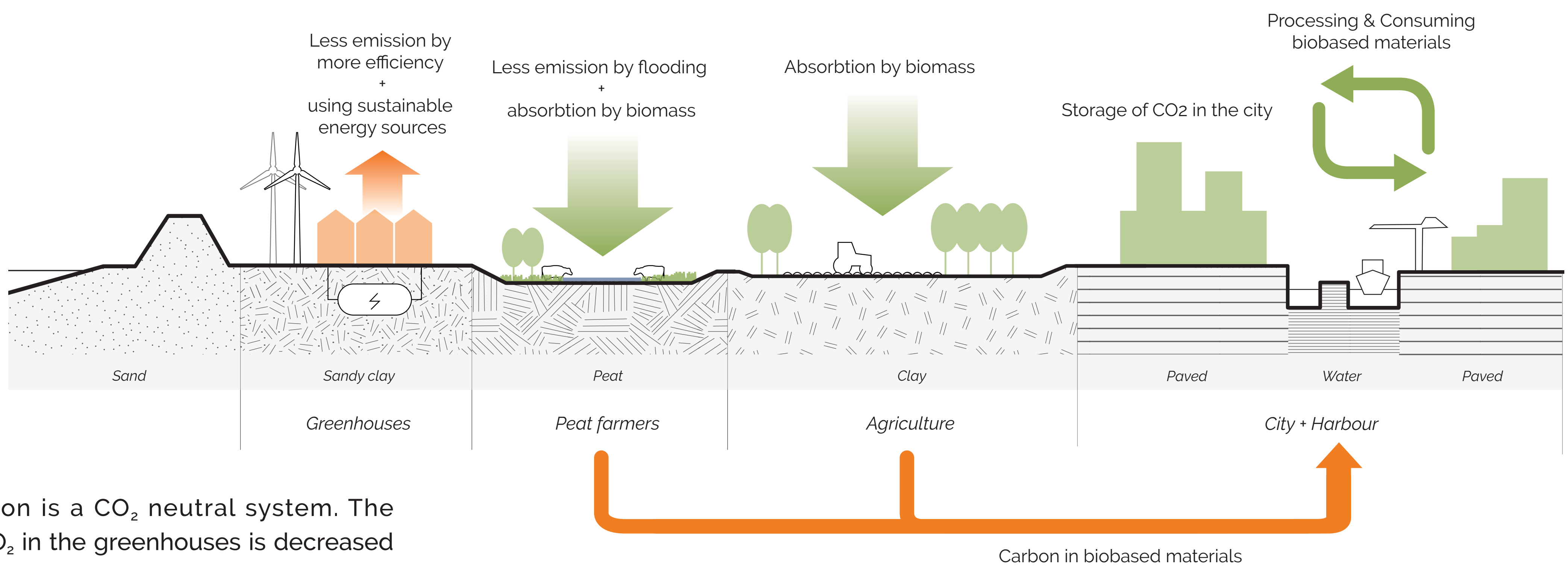
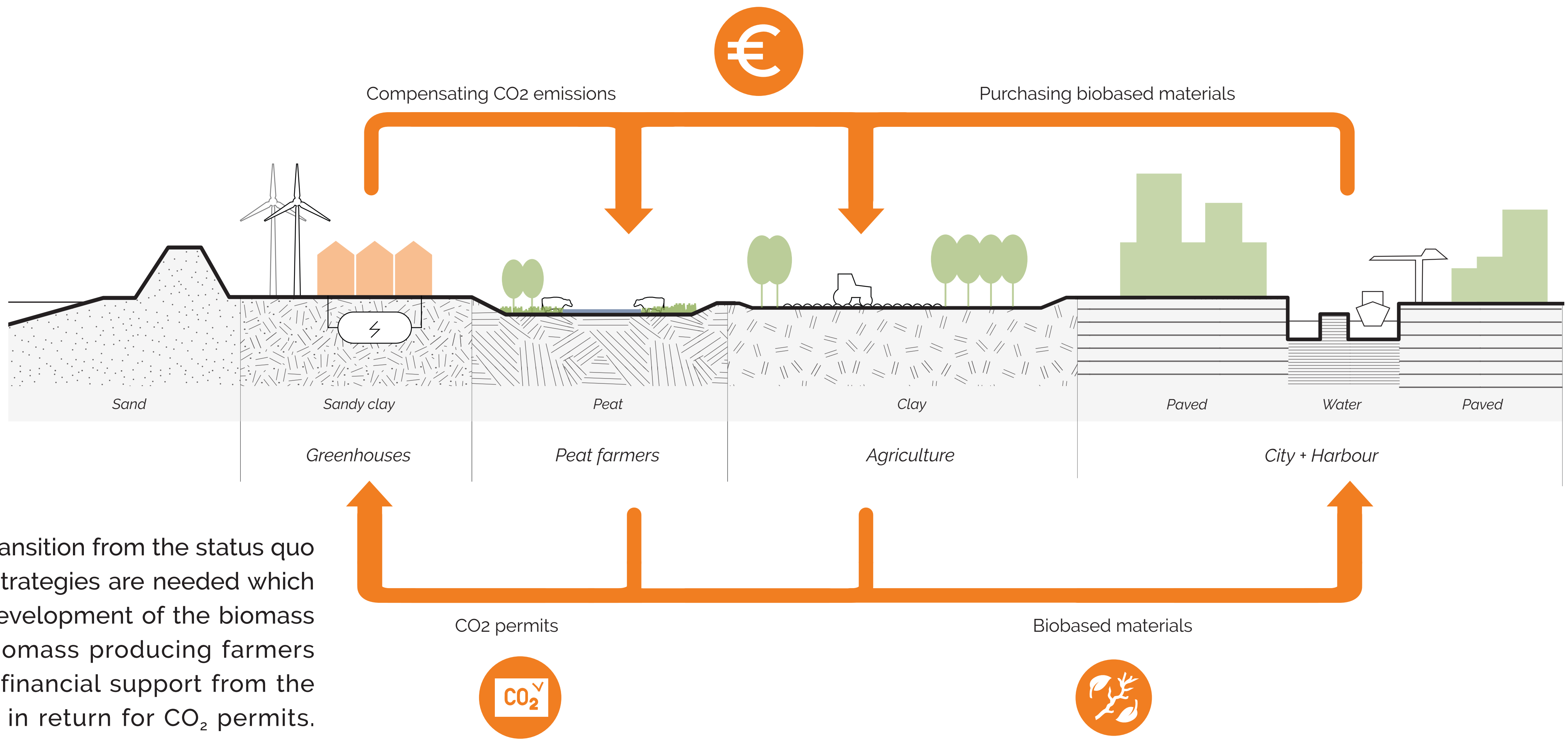


Figure 3.11 | Section vision *(Authors own, 2020)*

Vision

The 2050 vision is a CO_2 neutral system. The emission of CO_2 in the greenhouses is decreased and both the peatland and agricultural land take up CO_2 with the production of biomass. These biobased materials are flowing to the city, where they are processed and used in other sectors. Therefore, storing carbon in the city.



Strategy
To make the transition from the status quo to the vision, strategies are needed which support the development of the biomass sector. The biomass producing farmers are receiving financial support from the greenhouses, in return for CO_2 permits. From the city they receive money for the produced bio based resources.

Figure 3.12 | Section strategy *(Authors own, 2020)*

04

STRATEGY DEVELOPMENT

4.1 STRUCTURE FOR STRATEGY

Based on the vision and principles, a suit of strategies have been developed. The strategies have been set up in two chapters, as shown in figure 4.1.

Strategy 1 is policy-oriented. It is about *'establishing a policy system to create financial feasibility for the transition'*, including three tools, CO_2 policy, sustainable green houses expansion, and promoting biobased materials.

Strategy 2 is project-oriented. It is about *'establishing a supportive framework to initiate spatially for the transition'*, including the development of a biomass cultivation knowledge park, a biomass collection & processing park, a biobased consumption park, and a recreational ring connecting them together.

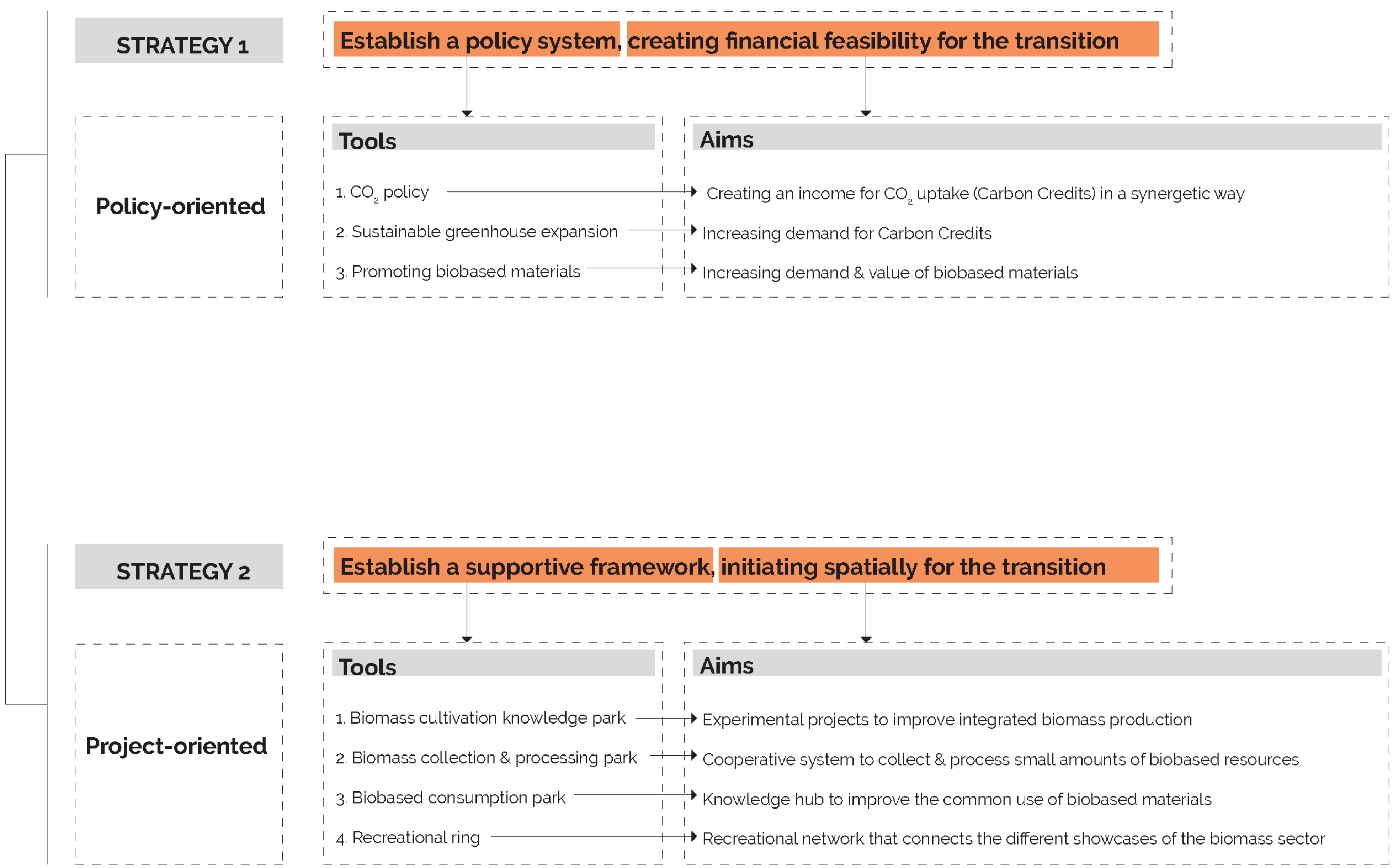


Figure 4.1 | Strategy scheme *(Authors own, 2020)*

4.2 STRATEGY I: ESTABLISH A POLICY SYSTEM

Strategy 1: Establish a policy system, creating financially feasibility for the transition

As discussed previously, a shift from food- to the biomass sector will result in a lowered production value (Lange *et al.*, 2012). This chapter explores the possible strategies to resolve the arised value gap by increasing the financial proceeds in the biomass sector. The main strategy goal is to use the CO_2 surplus as a value source by introducing a *'CO_2 policy'*, which will be discussed first. Included is the additional '*Synergetic framework*', where the implementations of the biomass production is integrated in the landscape to benefit the other spatial challenges, mentioned before. Hereafter, the supporting strategies '*Sustainable greenhouse expansion*' and '*Promoting biobased materials*' are discussed, which aim to maximise the effects of the policy. This chapter will conclude with a '*Stakeholder specific development*', to examine how the three different actor groups will react and develop within the framework of the presented strategies.

CO_2 policy: making CO_2 valuable

Connecting a financial value to the greenhouse gas CO_2 is not a new concept. The European Union has created a 'Emission Trading System', the ETS (European Commission, n.d), to create financial consequences on emitting CO_2. This incentive is supposed to activate polluting companies to minimize their emissions and reduce the negative environmental impact. This system (figure 4.2), introduced in 2005, is taken as a starting point to develop a system that will reduce and compensate CO_2 emission in the agrifood sector of South Holland.

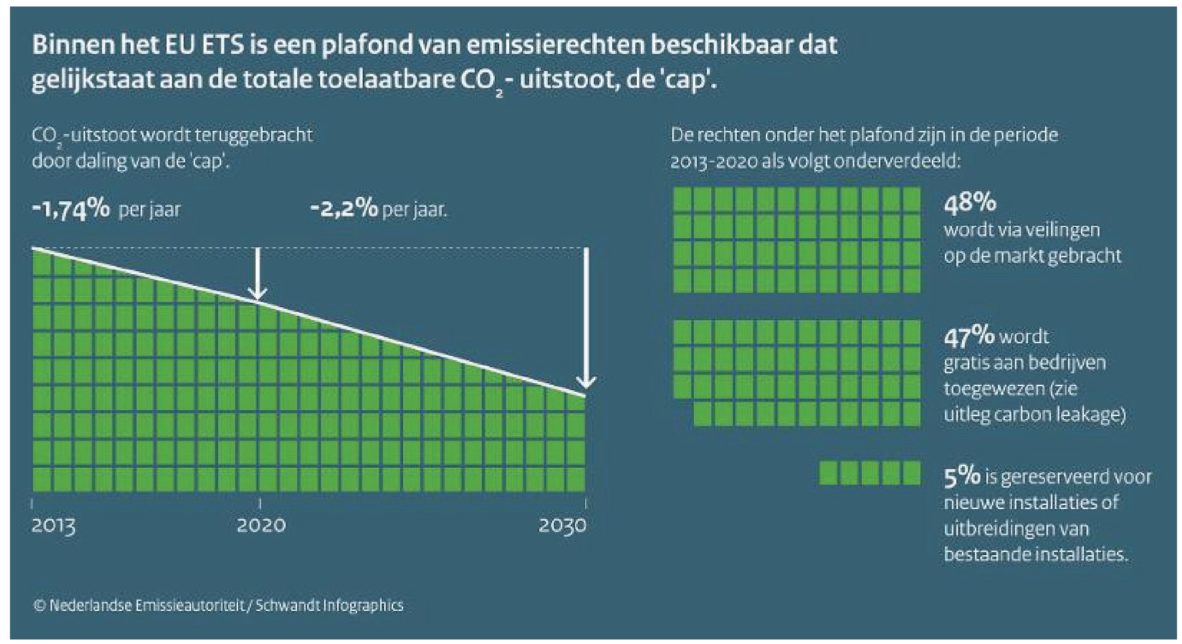


Figure 4.2 | Reference: Emission Trading System *(European Commission, n.d)*

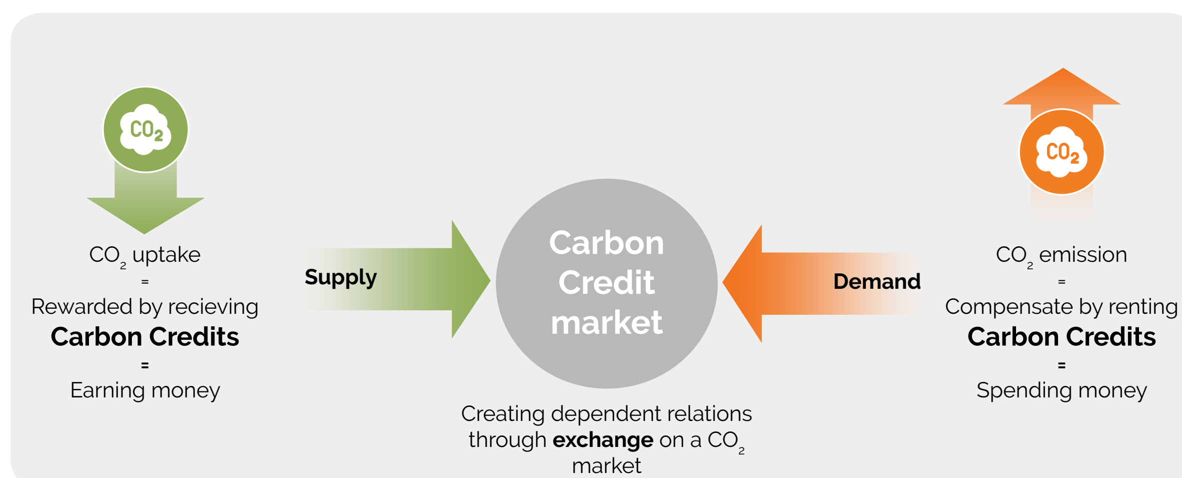


Figure 4.3 | Carbon Credit market *(Authors own, 2020)*

The concept of the policy is that the uptake of CO_2 is rewarded with Carbon Credits, a point currency that is connected to a certain uptake quantity of CO_2. At the same time CO_2 emissions need to be compensated, thus producing CO_2 is only allowed when owning Carbon Credits, covering the same quantity of emitted CO_2. On a constructed market these credits can be rented on a yearly base by farmers who produce CO_2, providing an income for the farmers who produces them (figure 4.3). This results in trade relations between different actors in the agrifood sector, which will strengthen the cooperation towards a lower nett emission. In the process the costs and benefits of emitting and taking in CO_2 are redistributed in a equal and just way over the participating actors.
The development of the system over time is shortly discussed to show the process towards a net wise CO_2 neutral agrifood sector. Over a time period of thirty years the biomass sector will develop to produce enough Carbon Credits to compensate 100% of the emitted CO_2, illustrated with the increasing green bars (figure 4.4).

However this supply of Carbon Credits needs time to develop. Besides, it is fair for actors who produce CO_2 that they are supported in the transition of compensating their emissions. Therefore, there are CO_2 rights distributed by the municipality over the CO_2 producing actors, which allow for a certain quantity of CO_2 emission (figure 4.5). These rights, illustrated with the grey bars, decrease over time, so the producers of CO_2 need to reduce their emission or compensate it by renting sufficient *Carbon Credits*. Over time, the system will cause a gradual transition from freely emitting emission with CO_2 rights, to a system where the all the emissions are compensated by owning Carbon Credits (figure 4.6).

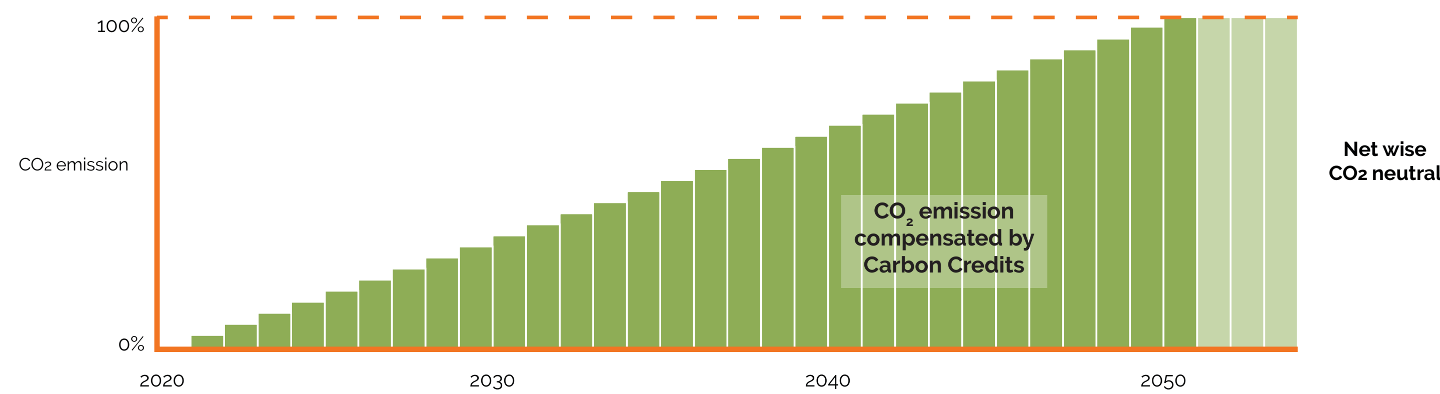


Figure 4.4 | Timeline Carbon Credits *(Authors own, 2020)*

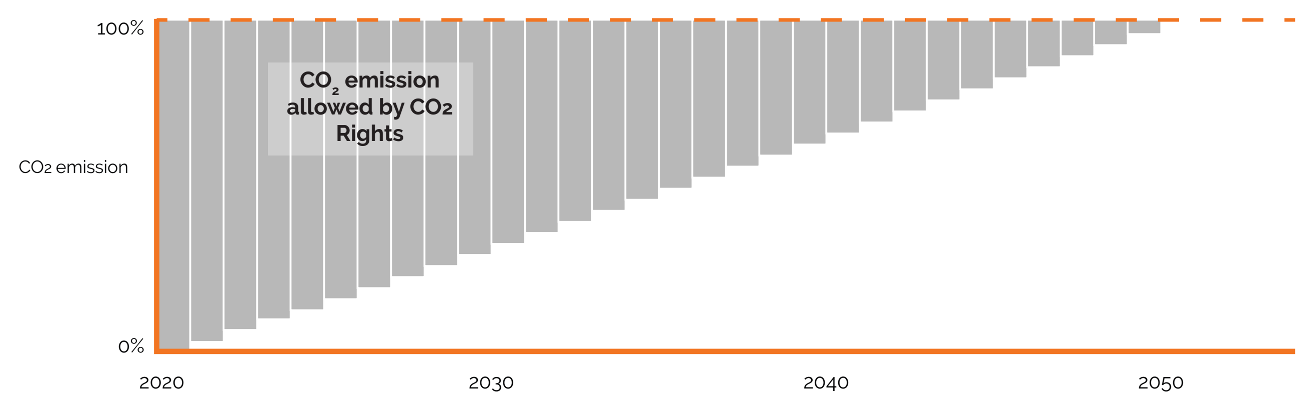


Figure 4.5 | Timeline CO_2 rights *(Authors own, 2020)*

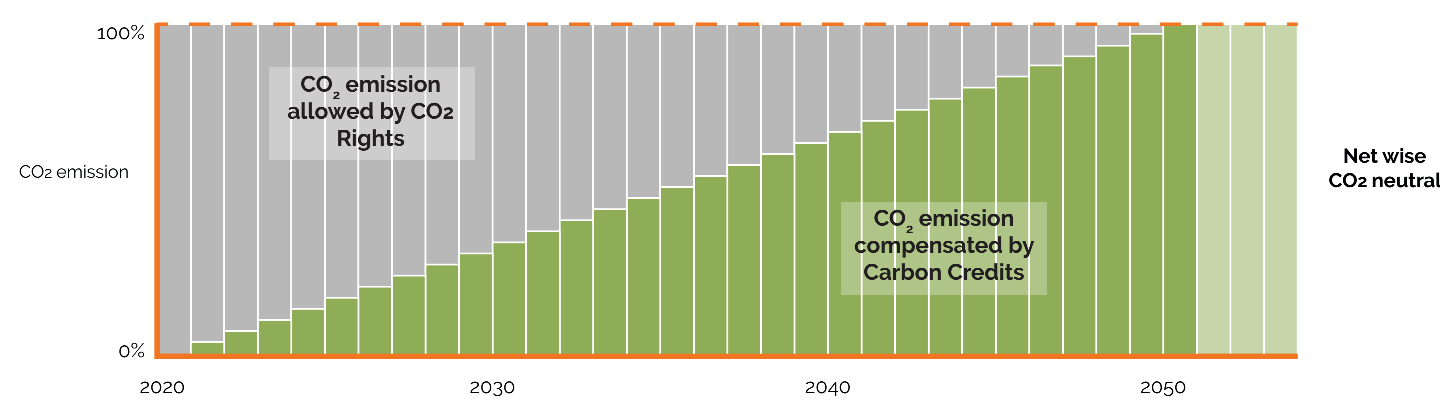


Figure 4.6 | Timeline transition system *(Authors own, 2020)*

4.2 STRATEGY I: IMPLEMENTATION

CO_2 policy: synergy framework
With the execution of the CO_2 policy more peat- and crop farmers will have financial attractive motives to introduce biomass production in their land, receiving the valuable Carbon Credits. This will result in a large spatial transformation in function, appearance and character. This transformation needs to be guided in the right direction to avoid an arbitrary transition of the agricultural landscape. At the same time the cultivation of biomass can greatly support in solving the other previously introduced challenges.

Polyculture
To guarantee such spatial synergies, additional guidelines are needed when implementing biomass production and receiving the Carbon Credits. A general requirement is that the biomass has to be cultivated in polyculture. Looking at existing biomass production landscapes in the province, they differ little from the monocultural grasslands and crop fields (figure 4.7). They might populate more specieses on first site, however, the monocultural composition of the landscape has a lack in variety within the biomass producing plant species. A key element of biodiversity is 'the totality over time, of genes, species, and ecosystems in an ecosystem or region' (Ahern et al, 2006). This variety can be achieved by polyculture, the use of more various plant species adjacent to each other. The transition from monoculture to polyculture is a critical transition to increase the biodiversity in the landscape and can be gradually transformed (figure 4.8).

Local requirements
Further requirements are more related to the specific area a farmer is located in. In this way the biomass production is responding to local challenges and supporting ecosystems. For peat areas, it is concluded that the current lowered water table causes subsidence and CO_2 emissions (Pieterse *et al.*, 2015). Biomass production should therefore happen in wetland conditions, where a raised water table creates a synergy with the other challenges. Cultivated plants that can thrive in these wetland conditions, such as willows and reeds, can be implemented to take up CO_2 and produce biomass. Secondly, the cultivated crops should be kept low to preserve the openness of the cultural landscape. Crop farmers on the clay soil experience other local challenges, but can solve these with a forest-like implementation to strengthen the ecosystems with taller plants (figure 4.9)

Additional local requirements are focused on specific sites. In flood-prone areas, biomass has to be cultivated on the water to make the landscape more climate adaptive. Areas that are bordering a protected natural area will have stricter guidelines for vegetation species and exploitation. The matching plant composition and extensive maintenance should therefore extend the ecological habitat of the natural area (figure 4.9).

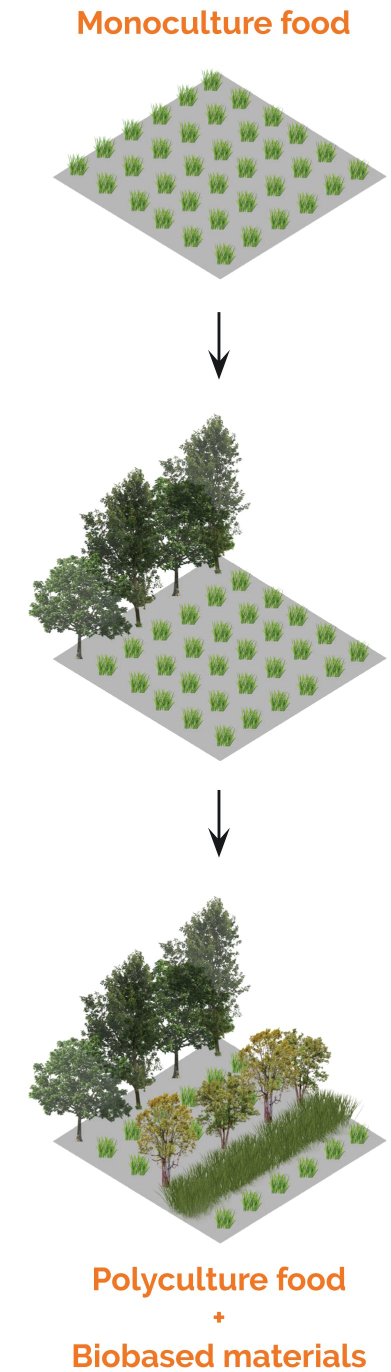


Figure 4.8 | Change in cultivation *(Authors own, 2020)*

Figure 4.7 | Monocultural biomass production *(Google Maps, 2019)*

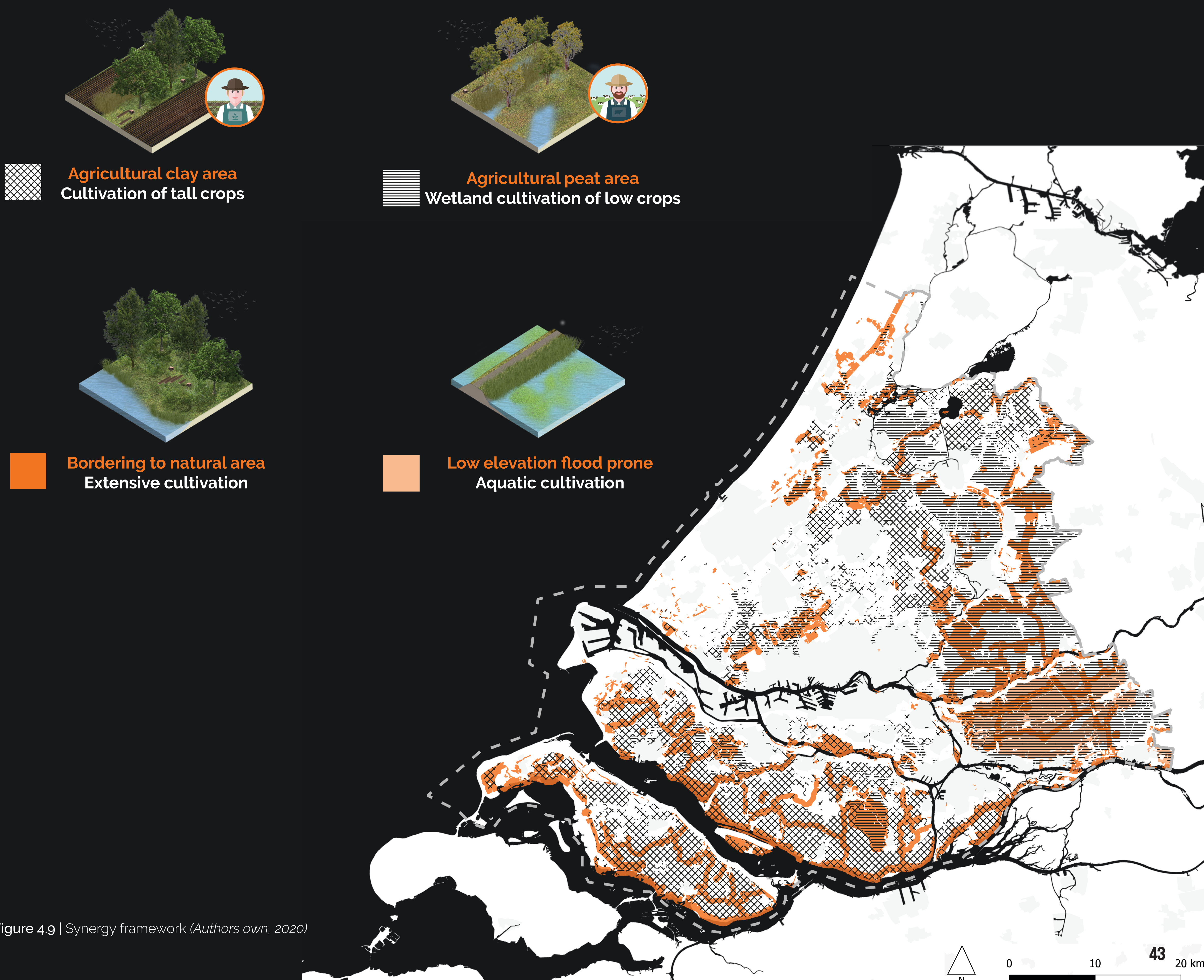


Figure 4.9 | Synergy framework *(Authors own, 2020)*

4.2 STRATEGY I: ADDITIONAL INSTRUMENTS

Sustainable greenhouse expansion
An important aspect of the CO_2 policy is that emitting CO_2 will not be prohibited or rejected within the agrifood sector. Environmentally seen this would be preferable to reach the goal of being CO_2 neutral, but the impact would be devastating for the greenhouse sector, producing most of the CO_2 emissions. This sector is a great financial engine of the province, providing income and job security for a lot of its inhabitants. However, the polluting companies need to take their responsibility by compensating the emissions, without drastically reforming the sector. The CO_2 policy offers a option to do so, while also presenting the opportunity to invest in innovative and efficient greenhouses redesign. This will reduce the total emissions, which is in line with the climate ambitions of the Greenports (Energieakkoord Greenport Westland-Oostland, 2017) Nevertheless, the financial and social importance of the greenhouse sector for the provence is acknowledged and guaranteed in this strategy.

Although some expenses are added for the greenhouse farmers, since emitting CO_2 is no longer free, the pinched sector will need support with the issue of space scarcity to provide growth benefits. More space around and nearby the existing clusters will be designated for expansion of greenhouse activity, shown in figure 4.11. According to specific principles and guidelines, the sector will have the opportunity to expand in a sustainable way (figure 4.10).

With the financial consequences of emitting CO_2 the new greenhouse module will likely by more CO_2 efficient to avoid large compensation requirements. Growth of the sector will strengthen its international position of knowledge industry and provide attractive scale benefits (Innovatiepact Greenport West-Holland, 2018).

Regarding to the new CO_2 policy the growth of greenhouses will result in a higher demand for the compensating Carbon Credits. On the established trading market the growing demand will lead to a higher price of the credits. This financial incentive will increase the income obtained from CO_2 uptake and stimulate the production of biomass. Accelerating the goal of a net wise CO_2 neutral agrifood sector.

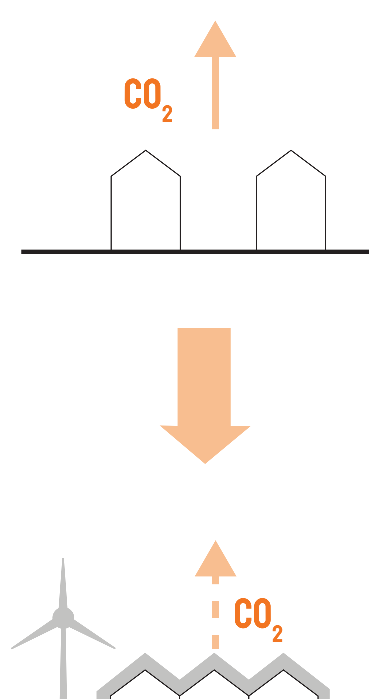
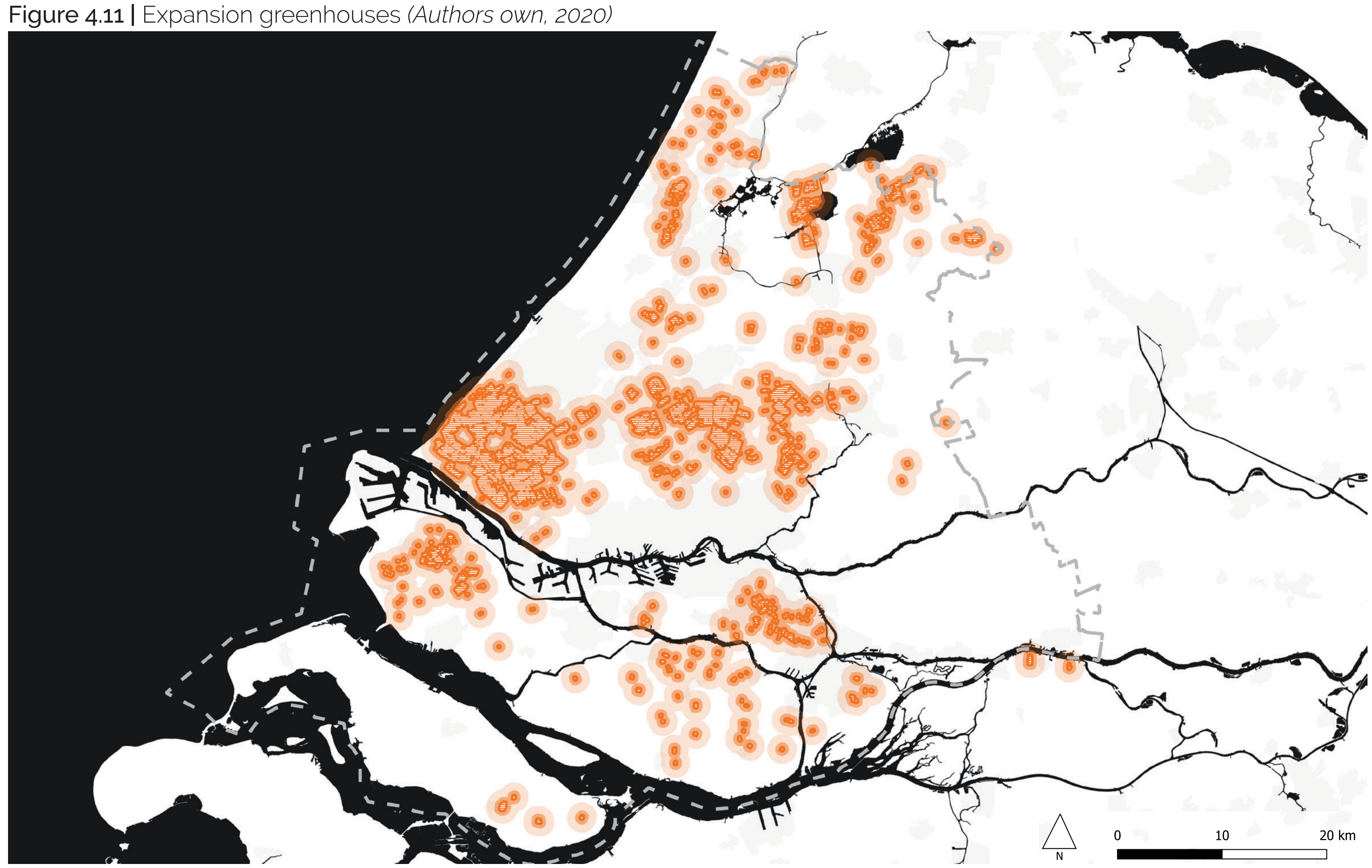


Figure 4.10 | Principle greenhouses *(Authors own, 2020)*

Figure 4.11 | Expansion greenhouses *(Authors own, 2020)*



Promoting biobased materials

The proposed CO_2 policy creates an attractive financial motive for taking up CO_2 by renting out the received Carbon Credits. At the same time, the locally produced biobased resources can also be harvested and sold for further processing and use. However, this income is of lower value than the current food and feed production, as shown in the value pyramid of biomass. A way to decrease this value gap is to increase the value of the produced biobased materials. Promoting the various use of biobased resources can lead to a higher demand, causing a larger value of the products. In various sectors like construction or packaging, unsustainable materials can be replaced by biodegradable alternatives. An integral transition towards the more common use of biobased products will result in a higher demand and a higher value of the biomass industry. As an example the planning instrument 'Certificates' is discussed to promote the use of the materials and affect the 'decision-environment' of related market actors.

A well-known method of creating awareness of the environmental impact of a certain product is through certified quality marks. The clear and easily recognizable logos show the compliance of certain environmental standards. This compliance gives information about the production process of the product, influencing the consumer towards a sustainable choice. In the current globalized world where product choice is endless, consumers are relying on such certificates to make responsible choices. The FSC quality mark for example informs that the product is produced in an environmental and social responsible way (figure 4.12). Buying these certified materials will financially support the sustainable production of wood and has become a general standard in the Netherlands. The EKO quality mark is another example which refers to biologically produced agricultural products (figure 4.12).

To promote the biobased materials, processed of locally produced biobased resources, a similar quality mark can be developed (figure 4.13). In this strategy consumers of such products will be informed about their support towards their local farmers who produce the materials. The quality mark can be used on alternatives for the commonly used plastic plant pots or building materials, used within the cities (figure 2.14). The awareness of the production process will also create a level of responsibility outside the agrifood sector, which can create a larger support base for the transition towards biobased products.

FSC
www.fsc.org
Het keurmerk voor verantwoord bosbeheer

EKO

Figure 4.12 | Reference quality marks *(FSC, 2018) (EKO, 2017)*

100% BIO-BASED MATERIALS
ZUID-HOLLAND

Figure 4.13 | Biobased quality mark *(Authors own, 2020)*

Figure 2.14 | The quality mark in use *(Authors own, 2020)* >>

4.2 STRATEGY I

The diverse package of systems, regulations, guidelines and initiatives of the first strategy will heavily affect the region and the landscape. To illustrate the spatial and social changes over time, three phases are examined through the eyes of the three most important actors of the agrifood sector: the greenhouse-, peat-, and crop farmers. The important and most contrasting phases of the strategy are '*Status quo in 2020*', the '*Transition phase in 2035*' and the '*Cooperative circular future*' in 2050'. By comparing the landscape, the attitude of the farmer and their income over time, the effect of the strategy can be more specific analysed.

2020: Status quo

Currently the greenhouses are emitting a lot of CO_2 to produce vegetables, fruit and flowers. Selling these makes up 100% of their income. The lack of space for expansion is the most striking issue in the sector, enlargement is needed to maintain their top position in the global food market. Peat farmers are also emitting a lot of CO_2 due to peat oxidation. However, there are no reliable alternatives to make an adequate income from the land than the current feed production for their cattle. The dairy production makes up 100% of their income but land subsidence is threatening this practice by the downward spiral of the drowning land. Crop farmers are not emitting CO_2 but have a negative effect on the local biodiversity through monocultural land use. However, the little income made by selling the produced vegetables leaves little space to change their production method. The desired transition to a less productive polyculture will require financial compensation to persuade the crop farmers.

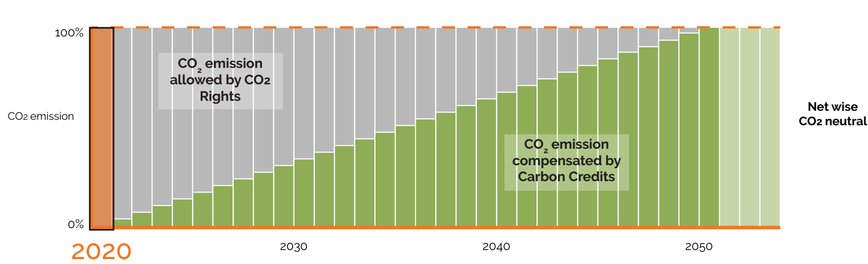
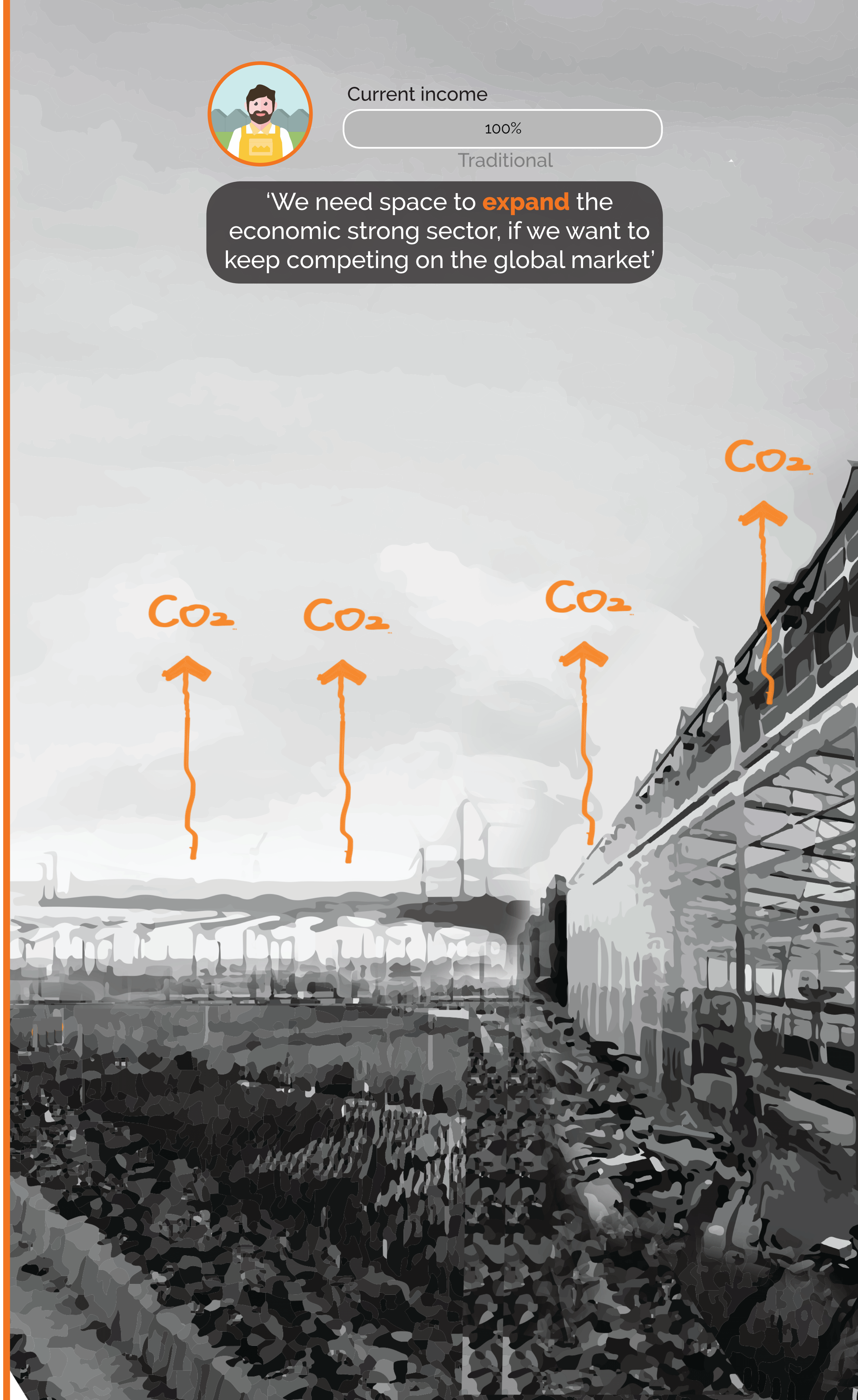


Figure 4.15 | Period in time *(Authors own, 2020)*

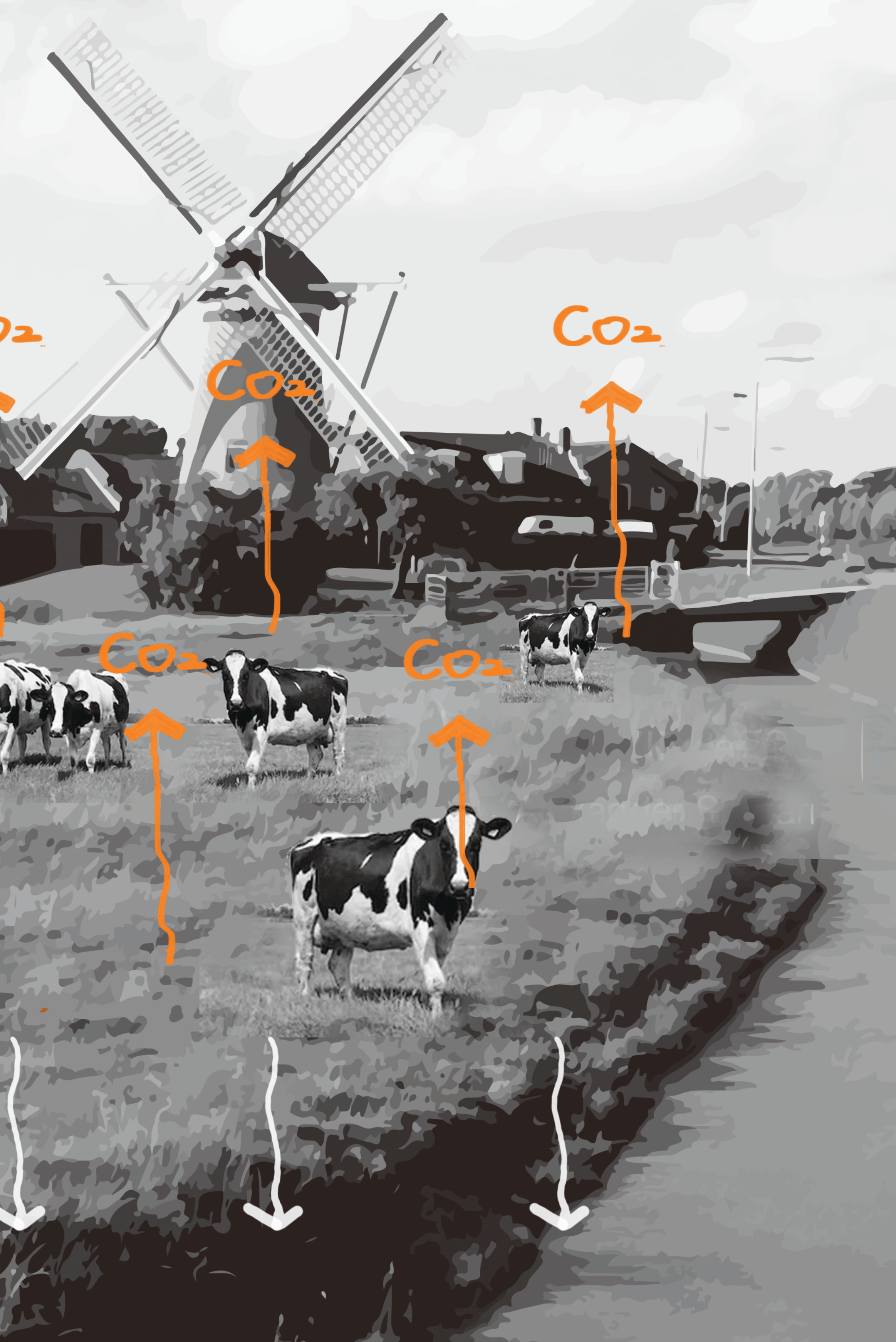


Current income

100%

Traditional

'**Land subsidence** is a constant threat for my existence, but in the current situation there are no alternatives then grassland to make an **income** of the peat land'



Current income

100%

Traditional

'The **monoculture** on my field is causing environmental issues and there is an rising opinion to change it, but for me there are **no cost effective compensations**'

4.2 STRATEGY I

2035: Transition phase

Halfway the through the transition, the greenhouse farmers are activated by the CO_2 policy to spend a small portion of their income to cover the CO_2 emissions. By renting the Carbon Credits they are still in business and the sustainable expansion framework has created opportunities to enlarge the sector and strengthen its economic position. Cooperative investments in efficient and innovative greenhouse modules will lead to less emission in the future, which will require less compensating expanses. The peat land is starting to transform, raising the water level will reduce the CO_2 emissions and prevent financial compensation actions. Implementing biomass production, according to the synergetic guidelines, adds more variety in their income by selling biomass resources and renting out the Carbon Credits. The still received CO_2 rights are not used and can therefore be rented out to cover the transition costs, made when transforming their land. The crop farmers are financially activated to implement polycultural biomass production in an ecological way. This adds a double financial source to their income by both selling the biomass resources and renting out the Carbon Credits.

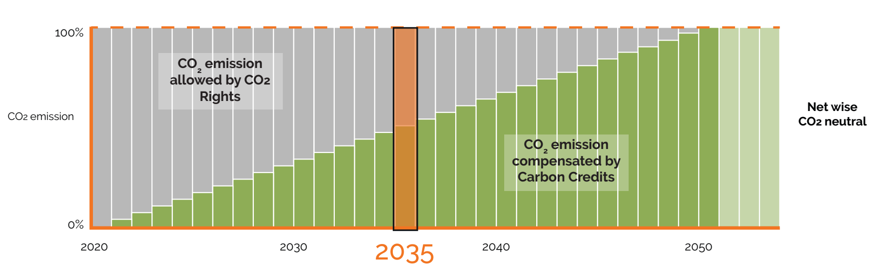
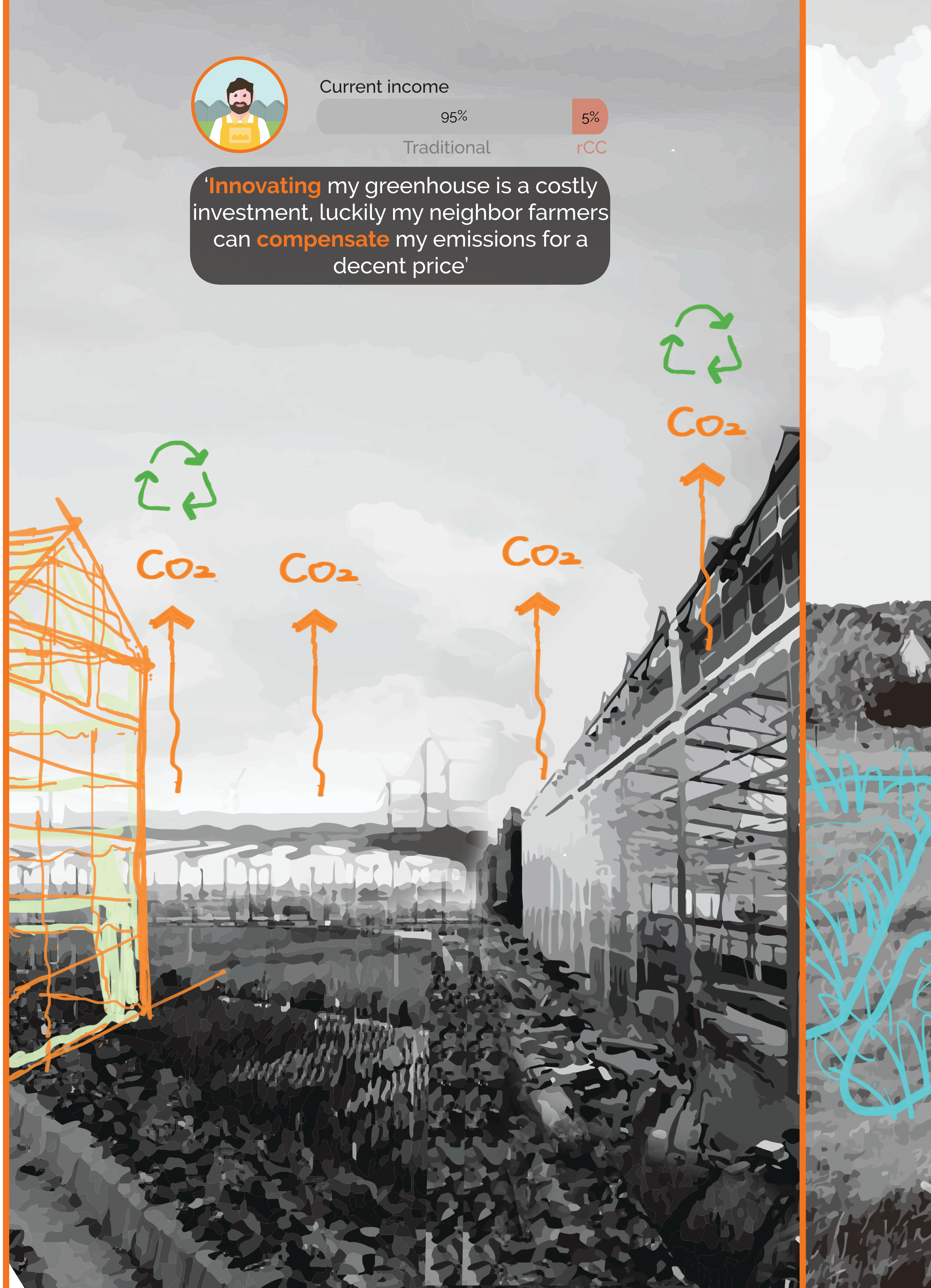
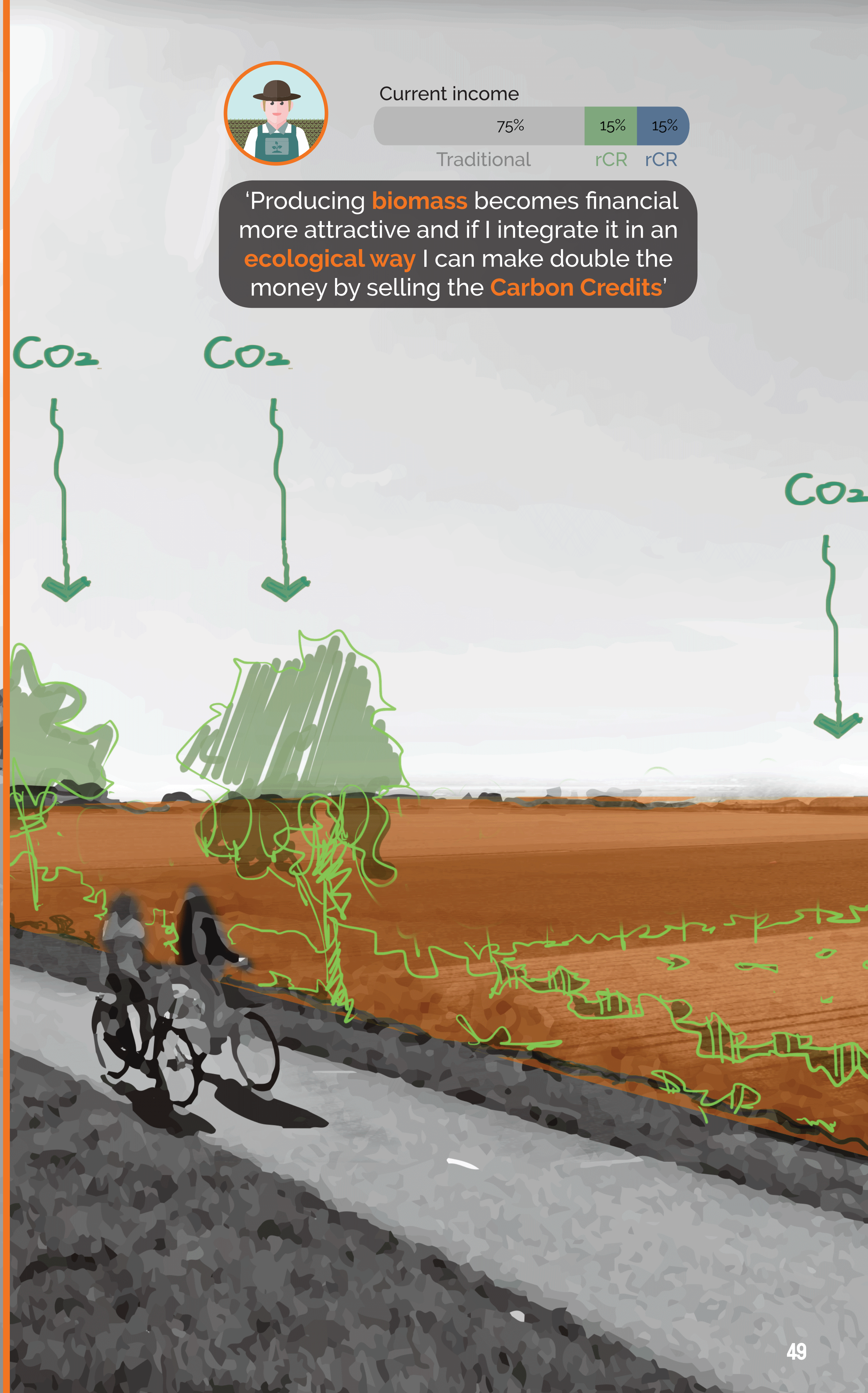


Figure 4.16 | Period in time *(Authors own, 2020)*



Current income
30%
20%
25%
25%
Traditional
rCR
rCR
rCR
'Wet agricultural cultivation becomes more financial reliable while I avoid CO_2 emission expenses. Besides, selling the surplus of CO_2 rights can cover the transition costs'
CO_2
CO_2
CO_2



Current income
75%
15%
15%
Traditional
rCR
rCR
'Producing biomass becomes financial more attractive and if I integrate it in an ecological way I can make double the money by selling the Carbon Credits'
CO_2
CO_2

4.2 STRATEGY I

2050: Cooperative circular future

In the final stage of the strategy the agrifood sector has developed into a CO_2 net neutral situation where the actors cooperate to achieve high standards regarding biodiversity, environmental resilience and spatial justice. The greenhouse farmers have, by intensive cooperation in the Greenports and strategic investments, reduced their emissions by modifying the greenhouse modules. By still allowing some CO_2 emission with compensation of the Carbon Credits, the sector is still the economic engine of the provence. The peat farmers have finished the landscape transformation into wetlands and adopted various professions to create a sustainable robust income from it. Extensive livestock farming is still possible, but represents a much smaller portion of their total income. The production of biomass resources on the wetlands and obtaining the Carbon Credits, are an important addition to their income, which is higher than before the transition. The crop farmers have integrated polyculture in their agricultural clay fields. Here an ecological valuable composition of biomass and crop production benefits the biodiversity and creates a robust landscape. In addition, renting out the Carbon Credits results in a higher income than thirty years ago.

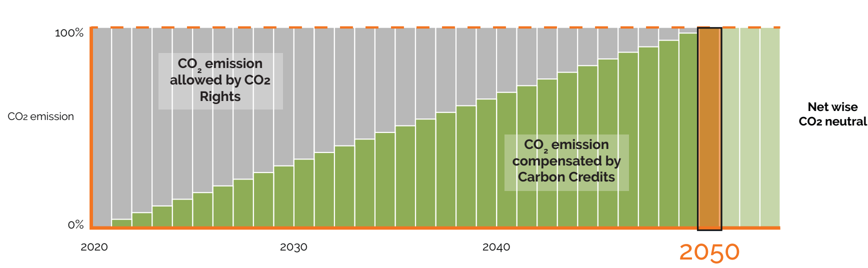
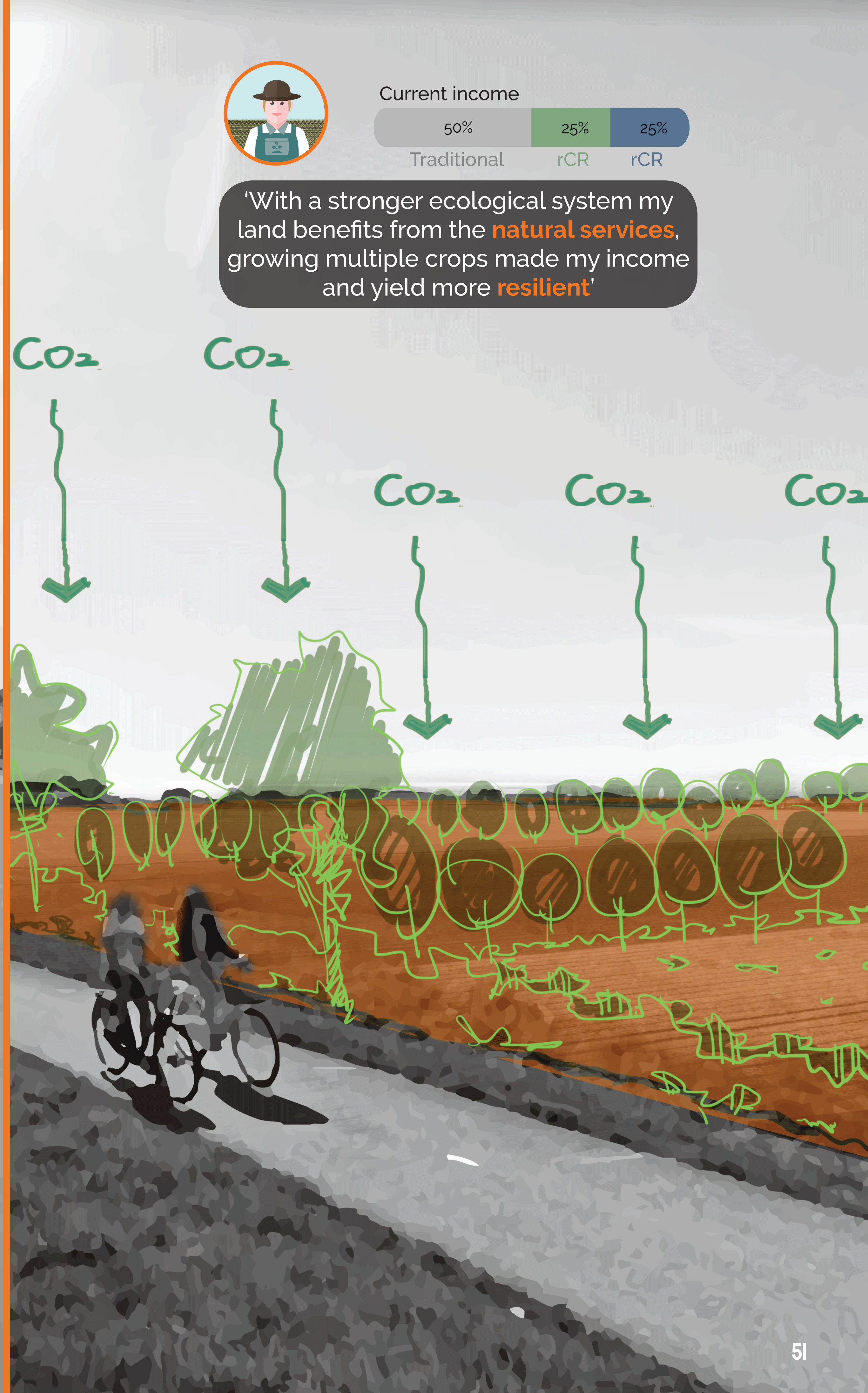


Figure 4.16 | Period in time *(Authors own, 2020)*


Current income
25%
40%
40%
Traditional
rCR
rCR
'Although my land has transformed a lot, it is providing a more robust income than ever. Most important of all: I can still be a farmer'


Current income
50%
25%
25%
Traditional
rCR
rCR
'With a stronger ecological system my land benefits from the natural services, growing multiple crops made my income and yield more resilient'
CO_2
CO_2
CO_2
CO_2
CO_2

4.3 STRATEGY 2: ESTABLISH A SUPPORTIVE FRAMEWORK

Strategy 2: Establish a supportive framework, initiating spatially for the transition

To support the transition towards biomass production in the agrifood sector an initiating framework is needed. The second strategy consists of a set of project-oriented spatial interventions which will function as a pioneering outline for further development of the biomass sector. Where strategy 1 was more policy orientated to support the circular transition, the second strategy will offer more practical handles for the specific actors. Three different knowledge parks are constructed to concentrate the knowledge development about a specific process step within the biomass sector (figuer 4.17). The '*Biomass cultivation knowledge park*' will explore the possible production opportunities of biomass production integrated on wetlands or clay soil. The '*Biomass collection & processing knowledge park*' will focus on the collection of the different biomass resources from the scattered producers. Beside, it will function as a connection with the industries who process the resources into biobased materials. The various application of the biobased materials and products is explored in a living construction lab of the '*Biobased construction knowledge park*', which will create a bridge between producers and consumers.

The intensive cooperation and knowledge development of the biomass sector will be a huge step towards a circular economy. Connecting the different knowledge parks with a '*Recreational network'* offers the possibility to present the different hubs as showcases within a circular network. By showing the different processes and opportunities, the knowledge of the biomass sector can be a new valuable export product of the provence. Providing a beneficial sustainable impact not only within, but also across its own borders.

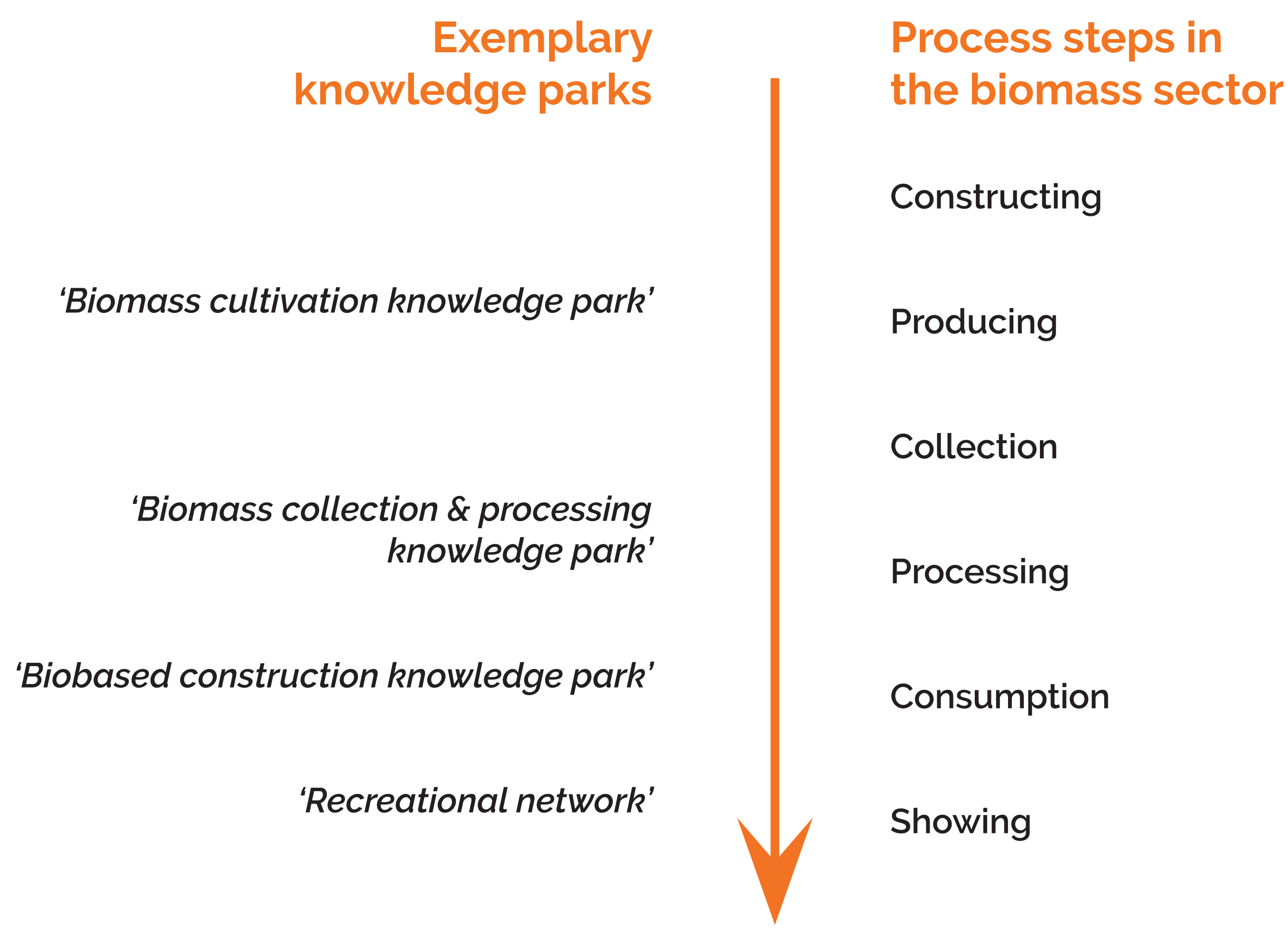


Figure 4.17 | Scheme strategy 2 *(Authors own, 2020)*

4.3 STRATEGY 2

‘Biomass cultivation knowledge park’

In the transition of the agricultural landscape visual results need to be showed on what is possible while creating synergetic designs. By having a series of practical implementations of the different production methods, concentrated on one location, farmers can be invited to experience the transition. At the same time, they are activated to take action on their own lands. For each of the two common soil types of the agricultural land, clay and peat, a biomass cultivation knowledge parks can be developed. Here showing the integrated production methods possible on the specific soil, water level and ecological circumstances. The impression shows the location of the Krimpenerwaard, a peat area that is in urgent need of change, due to heavy land subsidence. Based on the existing body of agricultural knowledge of wetland production, solutions can be implemented to show their practical use. With a raised water level extensive livestock farming in combination with the production of reed or cattail is for example a feasible solution (Louis Bolk Instituut, 2020).

The specific site of the Krimpenerwaard will therefore become a hotspot for different farmers, water boards and knowledge institutes to bridge the gap between theory and practice. In addition nature organisations can contribute by applying their knowledge about wetland nature to maximize the level of biodiversity. Better plant species compositions, late mowing schedules or phased harvesting are all of great influence on success rate of the ecosystems (Janssen *et al.*, 2018). Also companies who use the biomass resources can meet here to express their preferences from the perspective of the industrial process. With support and general overview from the Province of South Holland, which will function as a broker between all the different actors, the optimal cultivation of biomass can be developed and implemented. The list on the right shows suggested actors to involve with the development of this knowledge park.

‘Biomass collection & processing knowledge park’

The second knowledge park is focussed on the collection and processing of the biomass resources. An aspect of the implemented biomass production is that there are no large scale farms producing enormous quantity of biomass. The goal is that all the different farmers, scattered across the peat and the clay soil, are producing small amounts of biomass. This makes the relation between producers and processors much more complex, because multiple farmers will be needed to provide a reliable flow of biomass materials to a couple of industries. This collection & processing knowledge park will therefore function like a funnel, assembling the collected resources from the numerous farmers, on a centralized location. Here the different biomass resources are separated and fabricated so they are ready to be processed. Functioning of the knowledge park can be compared with a recycling facility for household waste. Here there are separate containers for glass, wood and electrical waste from where it is packaged and transported to more specific recycling factories.

A suggestion for the location is the port of Rotterdam, as illustrated on the impression. Here the existing presence of biobased factories like Plant One Rotterdam, are a logical location from where further biomass processing can develop. The labour intensive collection process can be assigned to maintenance companies, like SDW or Krinkels. These companies are active in the maintenance of the green areas in the city of Rotterdam. Such labour intensive organisations provide jobs for the more vulnerable groups of the society. Adding the biomass collection on the farms will secure more employment opportunities for these companies. Assigning these companies will also bring the opportunity to involve the processing of the flow of organic waste, collected from urban greenery.

4.3 STRATEGY 2

‘Biobased construction knowledge park’

The third knowledge park will focus on the use of the biobased materials. Here the bridge will be made between producers and consumers. By creating a wide variety of applications of the materials, consumers are activated by the versatility of the materials. Construction companies, property developers, architects and designers are for example educated on what the possibilities are for using the biobased materials in the building process. Similar to the cultivation park the practical options are displayed next to each other to visualize the potential of the biobased material in a more common use. The goal is not to come up with new products but to show how unsustainable elements, like plastic or concrete, can be replaced by more circular alternative. This is also the moment when the quality mark of the locally produced biobased materials is introduced as a recognizable logo for circular materials.

A good location would be the Merwe Vierhavens in Rotterdam, as seen in the impression. This location has already some initiatives related to the circular economy and there is a large challenge of constructing new homes. A biobased neighborhood could be a powerful showcase on how storing carbon in a should could look. At the same time the industrial character of the harbour will offer opportunities to scale up the initiatives. Finally, the harbour has already food related industries and distribution centras linked with the Greenports. These connections between the different sectors can be very useful as a starting point for the development of the knowledge park.

CONSTRUCTION COMPANIES

MUNICIPALITIES

PROPERTY DEVELOPERS

RESEARCH INSTITUTES

ARCHITECTS

BIOBASED BUILDING KNOWLEDGE GROUPS

'Recreational ring'

The development of the various knowledge park will, as explained before, function as a centralized hub where different actors come together and develop specific knowledge. Branding and promotion of theses parks is essential to reach the the right amount of attention of the different actors. By connecting the parks and nearby cities, a network can be created linking the different processes within the biomass sector. The coherent network is more easy to brand in contrast to the different parks separately. Therefore the conceptual design of a recreational ring is proposed, connecting the different parks and cities. Here citizens, tourists or professionals are able to really 'experience' the development of the biomass sector. By making a showcase out of the parks the developed knowledge can become a new valuable export product, which is in line with the existing progressive greenhouse sector already famous around the world.

With the involvement of actors like the VVV, travel agencies or bike associations a network of hiking trails and bike paths can be designed, improving the accessibility of the knowledge parks. The ring will have a various scenic character, connecting the city centres and city edges with the agricultural landscape. Along the way farmers can benefit by offering recreational facilities, like a countryside camping, shops and restaurants selling locally produced products. An important notion is that the recreational network is for slow traffic, like biking or walking only. Anyhow, what would be more typical Dutch to show the progressive knowledge economy on a bicycle with a constant headwind.

Figure 4.18 | Recreational ring *(Authors own, 2020)*

4.4 STRATEGY MAP

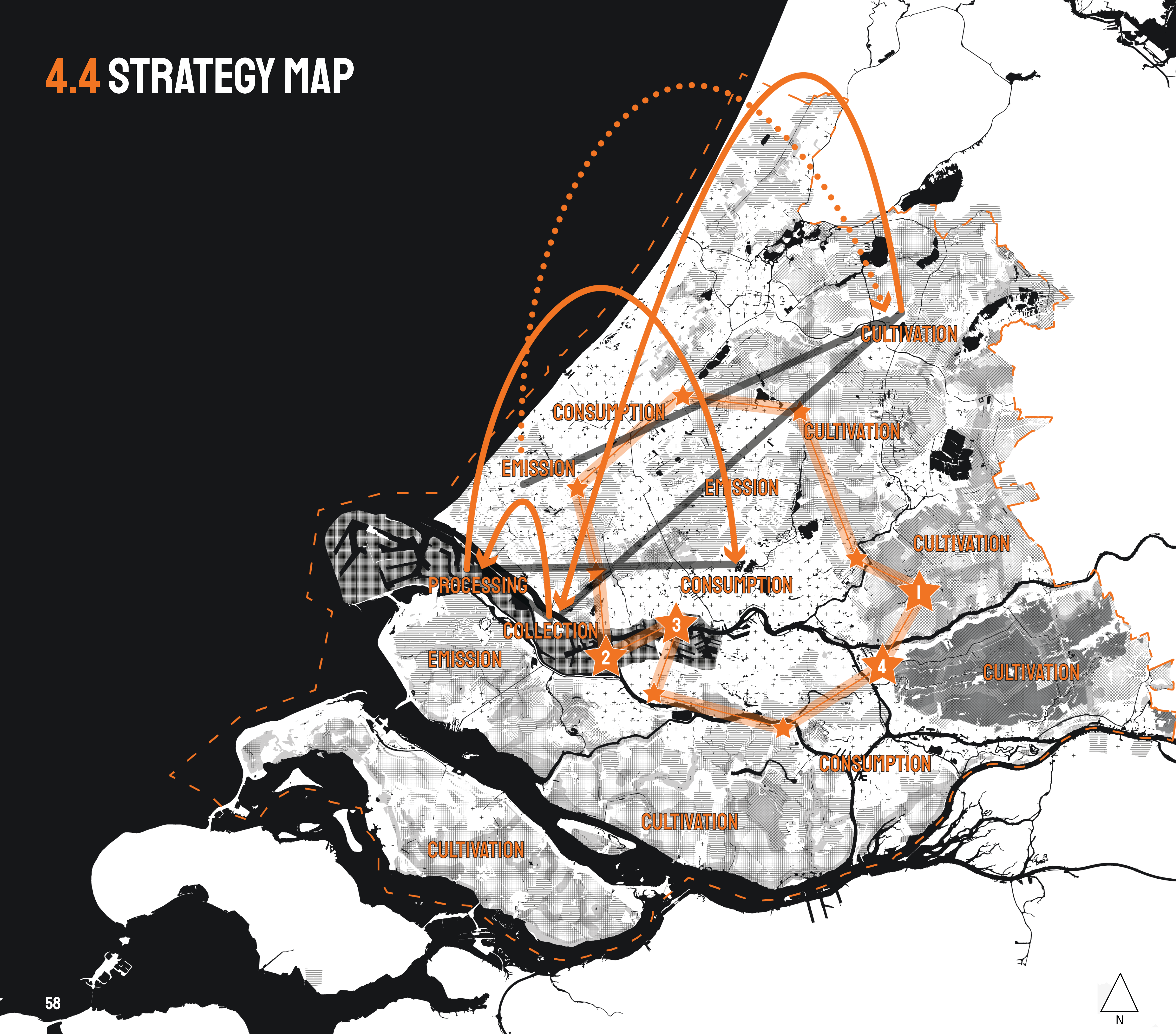


Figure 4.19 | Strategy map *(Authors own, 2020)*

The two strategies both serve the goal of developing the biomass sector, which will contribute to a CO_2 neutral agrifood sector. The first strategy focuses on instituting different policies and guidelines, while the second strategy is more project orientated, providing a pioneering support frame for its development. Both strategies are visualized on the map, explaining how they contribute to setting up a new circular flow of carbon (figure 4.19).

It starts with the emission of CO_2 in the greenhouses and the expansion areas. Hereafter, the emissions are compensated with the cultivation of biomass in the agricultural landscape. While serving the same purpose, the performance of CO_2 intake will differ locally due to the various methods and landscape conditions. Therefore, different cultivation landscapes can be distinguished, like the *Peat swamp, Clay forest, Aquaculture and Extensive cultivation*. The carbon, stored in plants, is collected and taken to processing facilities in the harbour. Finally, it is transported to the city where it is used in biobased materials. The cities are in this way functioning like a carbon sink, storing the carbon in various products and constructions.

Along the way, different knowledge parks are functioning as hubs where sector specific knowledge is developed and exemplary projects are displayed. A recreational ring network connects the cities, knowledge parks and agricultural landscape, showing the biomass sector as an integral element of the circular economy.

4.5 OPERATION + PHASING

In this chapter more details are provided concerning the implementation of the two strategies: policy- and project orientated. The diagram explains the development over time per strategy figure 4.20. Firstly three phases are distinguished, with a time period of ten years each. Hereafter, for each strategy the steps are described which will result in a related goal, as is shown in the lower half of the diagram. The sub-goals will contribute to a the main ambition of a circular CO_2 agrifood sector. The actions are generalized steps of developments that need to happen within the given time period.

The top half of the diagram illustrates schematically the organic development of the two strategies. The implementation of the policy starts with some central instituted rules and guidelines which form the center for development. In the following periods, this system will develop more complex by involving more participating actors and institutions. At the same time the process is monitored and adjustments are done to create a self sustaining trade system. Over time, the organic growth of the CO_2 policy will be integrated with all the relevant actors of the provence. The second strategy start with the initiation of the three different knowledge parks and the ring network connecting them. Over time, and by actively bringing together like-minded organisations, the hubs will grow into productive generators of specialized knowledge. While developing, interdisciplinary links could be made to operate not only within the biomass sector, but also have an influence in other sectors. International branding of the developed knowledge economy can result in a new export product for the provence, strengthening its economic position.

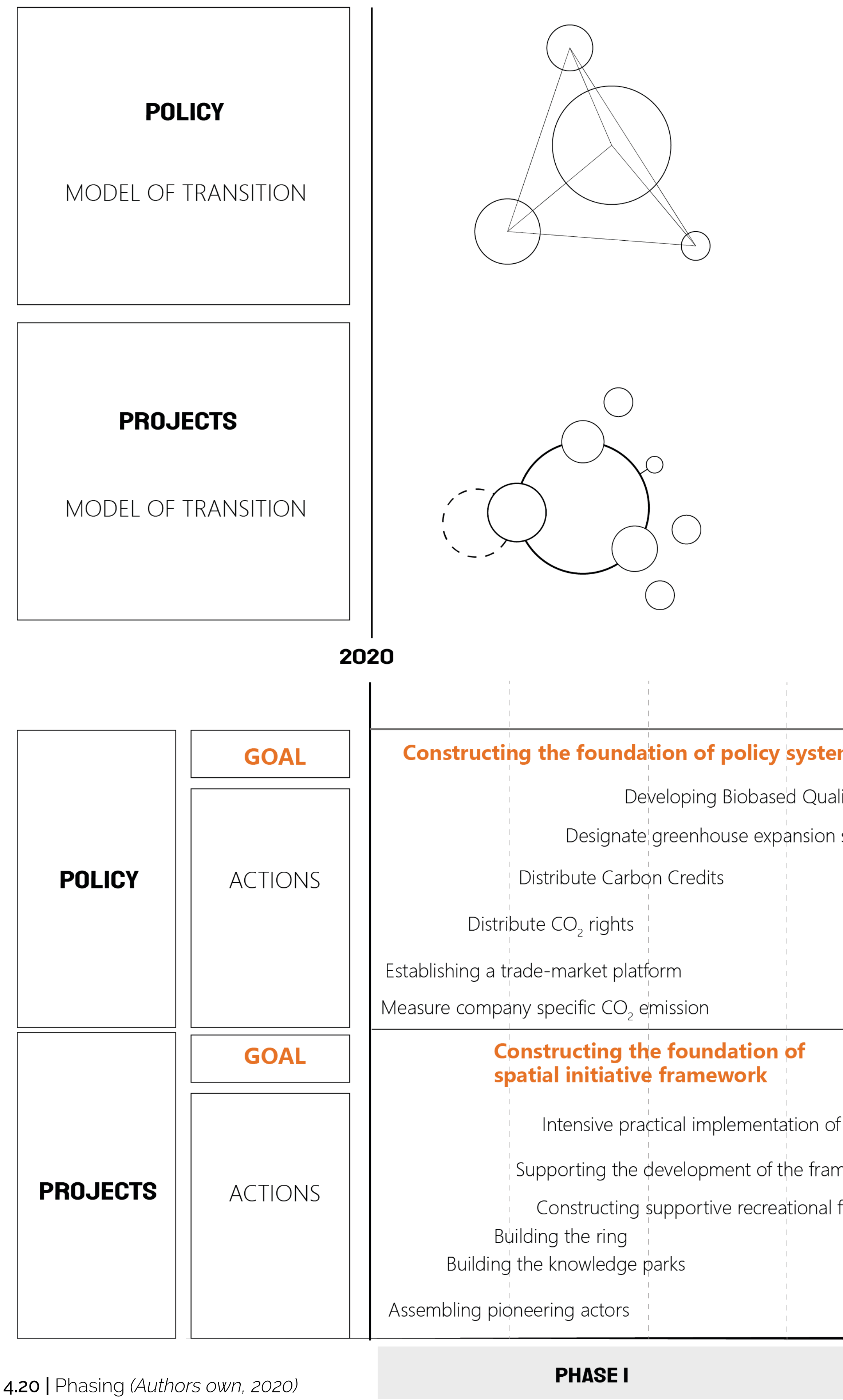
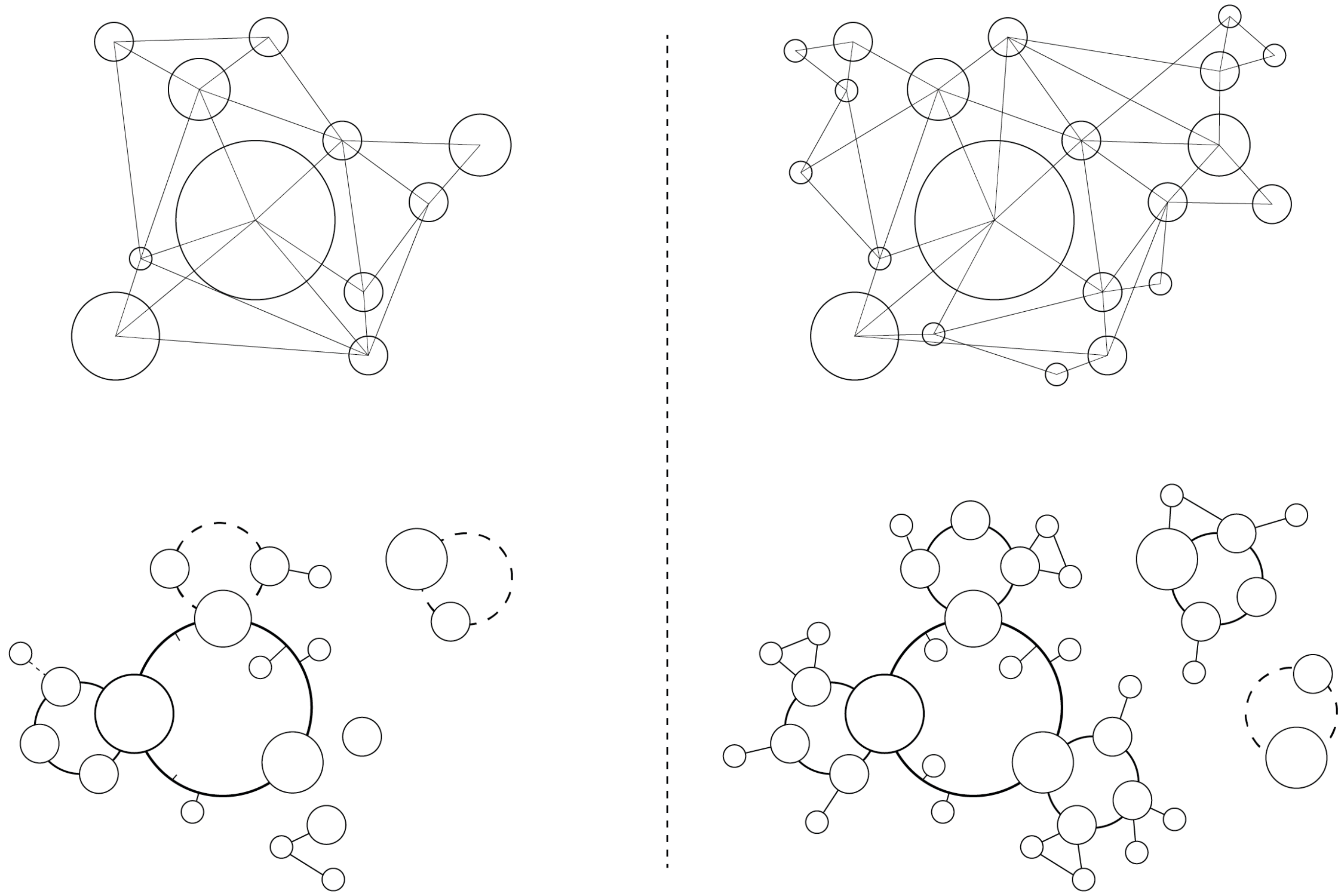


Figure 4.20 | Phasing *(Authors own, 2020)*



2030 | 2040 | 2050

m

ty mark

sites

Maintaining a self sustaining Carbon Credit market

Expanding participating actors

Upholding biodiversity guidelines

Monitoring gradually CO_2 right reduction

Adjust regulation efficiency

Achieving a stable CO_2 system

Covering all relevant actors in the whole province

Common use of Biobased Quality mark

Setting improved sustainable greenhouse standards

Taking down CO_2 rights to zero

research

nework

acilities

Specializing the centralized knowledge development

Expanding connecting network

Setting up secondary knowledge hubs

Expanding and upgrading knowledge parks

Upgrading supportive recreational facilities

Faciliated knowledge parks with specific research institutions

Intensive knowledge sharing

Establishing a world-known biomass experience

Influence interdisciplinary sectors

Fully intergrating the whole system

Optimizing supportive recreational facilities

Exporting developed knowledge

International biomass sector branding

PHASE 2 | PHASE 3

05

CONCLUSION

Research conclusion

We have seen that the agrifood sector is currently relying on non-renewable resources and that there is a large spatial transition needed to change this. From the perspective of the circular economy, the waste stream of CO_2 emissions is the largest flow and thus important to mitigate. Instead of looking at CO_2 as a waste flow, it can also be considered an important resource that is required for the growth of biomass. Hence, the transition to a circular CO_2 neutral agrifood industry is based on integrating the cultivation of biomass into the existing agricultural landscape. Because this integration has spatial implications, other spatial challenges were taken into consideration too.

We envision that in 2050, the agrifood sector is CO_2 neutral, where CO_2 is captured in biobased materials. Those materials are stored in the city, changing the city into a large carbon sink. The vision also includes solving this challenge in a synergetic way with other challenges. Mitigating multiple spatial challenges at once by creating synergies is one of the core parts of the vision and strategy. Additionally, spatial justice is taken into consideration because of the large inequalities between the three important actors: greenhouse farmers, peat farmers and crop farmers.

It can be concluded that the strategy addresses these three main subjects: becoming CO_2 neutral in the agrifood sector, creating synergies with other spatial challenges and ensure spatial justice. Both policy interventions and spatial interventions contribute to these topics. Becoming CO_2 neutral is addressed by setting up a biomass sector. Synergies are integrated into the guidelines for biomass production and the recreational aspect of the spatial interventions. Social justice is guaranteed by the introduction of Carbon Credits, ensuring equal distribution of benefits and costs, both in and after the transition.

The transition will have large implications on the landscapes, cities and people in the province of South Holland. The agrifood sector will become much more robust and sustainable by working together. With the proposed strategy, the province of South Holland is ready for a sustainable and cooperating tomorrow.

Reflection

The focus on CO_2 in the report does not mean that we have not considered other important waste and input flows, such as soy (related to deforestation), non-renewable artificial fertilizers and manure. During the process we came to the conclusion that these flows are also important to take into consideration, but that they are almost all related to farming on peat. Because the result of the policy is that the current practice of cattle farming on peat will decrease, these negative input and output flows will also decrease. This is illustrated in graphs in the appendix.

The agrifood sector in the province of South Holland is made up out of very complex systems and relations between countless actors and materials. For the purpose of this research, we have chosen to focus on three main groups of actors. These groups have the strongest relationship with the CO_2 flow that we have focussed on. It should be noted that even within groups of different actors, generalisation is impossible to prevent. We have made the division in actor groups based on the main activity: cattle farming on peat, crop farming on clay soil, and farming in greenhouses. Because we have worked with averages for these groups, some individual actors (i.e. farmers) will not be able to identify themselves with the numbers. Still, the presented numbers do reflect the position of the different actors in the best way possible.

The vision we have set out for 2050 is based upon the current position of the actors, and the prevailing paradigms in the current society. It is very likely that these will change in the future. Especially over the long time frame of 30 years. The current pandemic of the Coronavirus does illustrate how quickly a society can change. In a matter of weeks, the most powerful actor (especially greenhouse farmers that are specialised in the production of house plants) has become a very vulnerable actor because of the changes in demand. It is impossible to predict such changes for the future, and that is also why we have sought to allow for some flexibility in our vision and strategy.

The policy part of the strategy does only work well when implemented on the scale of the province. This means that the province needs to have a certain amount of power in order to implement the new rules. It is questionable if such authorization exists on the province level in the Netherlands. A partial solution would be to make the policy not mandatory but optional. Companies that want to show their customers that they operate CO_2 neutral are encouraged to buy Carbon Credits, while companies that do not care can ignore the compensating measurements. This voluntary form of compensation does already exists, such as Trees For All, but not yet for South Holland (Trees for all, 2020). We think a voluntary alternative is less desired as it is questionable whether this will create enough demand for Carbon Credits to make them valuable enough to close the biomass production gap.

Ethics

Our proposed strategy of a transitioning towards a CO_2 neutral agrifood sector has an influence on different stakeholders, this paragraph reflects on the ethics regarding social justice.

There are three main groups of stakeholders related to the core of the proposed strategies: the greenhouse farmers, the crop farmers and the peatland farmers. Each farmer group has their own way of producing an income of the land they own. However, there are large value-area ratio differences between the farmer groups, resulting in inequalities in the agrifood sector. At the same time, the agrifood sector is causing negative externalities in the environment, experienced by the whole society. CO_2 emissions and nutrient leakage are harming the local ecosystems and threatening biodiversity. Strategies must show an alternative way to solve these externalities without only punishing the responsible actors.

Among the different entrepreneurs, peatland farmers are the most disadvantaged. The wet peat can barely provide a minimum income through grassland for dairy production. At the same time, the farmers are facing land loss because of land subsidence through peat oxidation. The proposed spatial strategies must ensure an alternative reliable source of income for these farmers while preventing land loss.

In order to avoid unfair effects and remediate possible spatial injustices, a suite of relevant compensation policies bound to different groups have been introduced. In this way, the benefits and burdens of development promoted by the strategy will be fairly distributed as much as possible. Also, all the stakeholders, including those vulnerable stakeholders, could make their choices according to their specific situations and pursuits, rather than just follow a mandatory plan.

Sustainable development goals

The strategies, including the compensation policy, are schemed based on the consideration of the EU Emissions Trading System, which is an EU climate change policy to reduce CO_2 emissions cost-effectively in its industries, and the Sustainable Development Goals framework, see figure 5.1. It contributes in reference to the ‘Green Deal for Europe’ and the ‘Biobased economy value pyramid’ (Lange *et al.*, 2012). The proposed strategies contribute to the following SDGs: reduced inequalities (10), sustainable cities and communities (11), responsible consumption and production (12), climate action (13), life below water (14) and life on land (15). These goals also show the positive effect on society as it creates a pleasant sustainable living environment with enjoyable recreational landscapes. By having a combination of existing and planned references the strategies are more reliable.

Figure 5.1 | Sustainable development goals

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07

APPENDIX

7.1 REFLECTIONS

Jelle Dekker

Following a design education, like the bachelor Landscape Architecture in Wageningen and master Urbanism in Delft, as I do, often makes people question 'How is that a university education?'. Design is easily associated with sketching, modelling and tinkering. 'Where does the research part comes in?', is also something I wondered when I started studying. Soon it became clear that to design you need a interdisciplinary knowledge, and a lot of it. From water management, ecology, sociology, soil science and many more disciplines, we designers are the designated persons to combine it all and translate it into a spatial design. The proof of the relevance of interdisciplinary research is highlighted with the divers SDS lectures, like the ones about planning instruments by Fred Hobma, stakeholder analysis by Marcin Dabrowski and Urban metabolism by Nico Tillie. These all provided the needed knowledge to create a holistic understanding when working on the project.

In our project we experienced the necessity for interdisciplinary research at a very early stage. With the agricultural scope, we had to approach the landscape and transform the produced waste flows into more circular. Before we know it we were reading about how to create your own artificial fertilizer from locally produced manure and which plant species had the most efficient CO_2 uptake ratio. The new obtained agricultural knowledge resulted in creating the 'CO_2 and Nutrient cycles', which made us understand the two biggest waste flows within the agrifood sector (see the cycles in the Appendix). From this understanding we were able to find technical solutions from the literature, which were effective in closing the different loops. Implementing such solutions forms the base for making an effective and useful design, which contributes to a better environment on various levels. To illustrate this process, I will give an example. After looking into the CO_2 cycle, we discovered that much CO_2 was emitted by the peat land, which was not even included in the waste flow scheme of the provence (Metabolic & Drift, 2018). This could technically be solved be raising the water table, which became a main principle in our vision. However, as a consequence the character of the landscape would change from structured grassland to a patchy swamp area. At the same time the farmers would lose their income source with the function change. This is where we as designers are expected to create a holistic design that would satisfy all the different actors. This design challenge of combining solutions in the same space is where the creativity of the designer is addressed.

This example of an intensive connection between research and design is what, in my opinion, makes the profession of landscape and urban design so interesting. At one point you are a unknowing student and the other moment you are an agricultural expert. The fact that there is space, time and guidance to dive into the interdisciplinary knowledge is why our study is so divers.

Menno de Roode

In our story, we focus on the transition of the agrifood sector in South Holland to a CO_2 neutral sector in 2050. While this seems to be a very clear and well-defined topic now, it was far from that when we as a group started to think of our vision. The initial ideas and thoughts we had developed during one of the workshops were much less coherent. But during the process of defining a vision, you are forced to prioritise and structure your thoughts. You will have to think of the big picture and clearly define your scope. In our vision, we decided to focus on three things. The first goal is becoming CO_2 neutral in the agrifood sector. This is related to the theme of circularity. The second part is about connecting the spatial aspect of this transition to other spatial challenges. This helped us approaching the problem from a spatial perspective. The second and last part of the vision concerns the aspect of socialspatial justice. Including this aspect was suggested, but it also makes the story much more inclusive and solid. In our case, including socialspatial justice meant strengthening the financial position of the peat farmers, even though they were found to be a very large contributor to our problem statement. Yet, this actor group is also the most vulnerable, as they are locked in a system that is unsustainable. Because you are focussed on the big picture when defining a vision we could make these bold claims without worrying about the details on how to achieve such a difficult idea.

Later, during the development of a strategy, you will, of course, have to live up to those claims. But even then, a vision is quite helpful. It supports you in keeping a coherent narrative. For us, the three parts of our vision are directly tackled in the strategy. Becoming CO_2 neutral is achieved by encouraging biomass cultivation and setting up a new network of knowledge parks related to biomass. The spatial challenges are addressed by a spatial framework with principles regarding the production of biomass, and the aspect of socialspatial justice is tackled with a CO_2 exchange policy that makes the cultivation of biomass more profitable.

Because we had defined such a clear vision related to three topics, we could easily evaluate our strategies and see if they would contribute to this vision.

It goes without saying that defining the vision is a process on its own, and, as mentioned in the beginning, we did go through a lot of ups and downs in the process of formulating one. But once you have defined a destination, that dot on the horizon, it becomes much easier to work on a story and strategy that works towards getting there.

Stefan Vermeulen

The relation between research and design might seem non at first, but the opposite is true. This became clear during the SDS lectures about for example stakeholders, planning instruments and strategy development. Parallel to the lectures we were working on our project, so the learnt subjects could be taken into account immediately.

The relationship between research and design developed during our project. When we started this project neither of us had worked in such a big regional scale and we had little understanding of the agrifood sector. This is why the first few weeks of this project where mainly focused on research without the design part. The Zuid-Holland Circular report provided a clear starting point for our research with the diagram of the different flows in the agriculture sector. We further investigated the cycle of CO2 and nutrients. This research provided a clear foundation for our project, we had a (basic) understanding of how the different flows worked and what the main inputs and outputs where. This research did take up a lot of time, but it was a necessary to create an interdisciplinary project. When we found ourselves educated on the agrifood sector the design part came more into play. We saw the opportunity to create synergies with other challenges in the region, the synergy could be made through design, but in depth research about these topics was needed.

To deepen our project, we switched between scales a lot, that is where the relation also became visible. The main strategy consists of a CO_2 policy, which on the first sight could consist of just a document with text. To make the strategy realistic we zoomed in to the scale of the different farmers. An effect of the policy is that some their land needs to be changes. To stir the design of this transition into the right direction, we proposed some design principles. The principles create synergies with other challenges in the region, like climate adaptation, biodiversity and land degradation. To design the principles some in depth research on these topics is needed.

To summarize, the relation between research and design was present, but not always on the same level. The project started with research, while the design part was more present during the later stages. The design is mostly used to check and visualize the effects on the actor. When designing it should always be based on a good research foundation, as design without research is empty.

Yangzi Li

In this project, actually the governance aspect is almost invisible except for in the phasing part because from the starting point, the whole group was standing in a very neutral position. However, the related consideration from the perspective of the government is always embedded in the whole process, trying to make sure the work could be easily referenced to the government and matched with the working platform of the government.

Firstly, in problem finding and topic narrowing process, instead of trying to solve all or several waste flow issues, the work was focused on the biggest players contributing to the linear model of agrifood production and finally concentrated on CO2 emission. In this way, the government could really focused on the primary most urgent issue.

Secondly, in the applied research of agrifood economy, the research was not only focused on technical level such as improving carbon cycle performance, including CO_2 emission process, CO_2 capture and sequestration, the potential of biomass production. But more importantly, the research was also working on finding the value gap which would be caused by the change in agrifood production and trying to close it. In this way, apart from spatial justice, the focus was also on financial feasibility, which is really an important issue for the government. Also, the research on financial feasibility built up to a financially feasible vision for the government instead of a beautiful picture on the wall.

Besides, the vision was mainly focused on a macro level with more the top-down perspective than bottom-up, following with principles for development of each area. In this way, it is easier for the government to proceed other strategic work on a macro level, guiding the following projects such as designs and plans afterwards.

In strategy development process, in order to make the strategy easily referenced to the government and matched with the working platform of the government, the focus has shifted from spatial interventions development to policy making. Eventually, the main strategy, establishing a policy system to create financial feasibility for the transition, became fundamental in the whole picture, and the other one was much weaker, with a general initiative framework.

Finally, in the phasing part, the whole proposal of the design has divided into several actions with relevant milestones for the realization of the plan. This can be referenced more directly for the implementation from the perspective of the government.

However, although the consideration of the government perspective was throughout the whole project process, there were still some limitation regarding to embedding governance. Firstly, there was a lack of analysis of the governance status in the agrifood sector from the government or related departments. If the research also take this into account, the strategy could be more directly matched to the government's working field. Secondly, the phasing plan was relatively too general for directly reference of the actions to be taken.

7.2 ECONOMIC YIELD OF ACTORS IN 2018

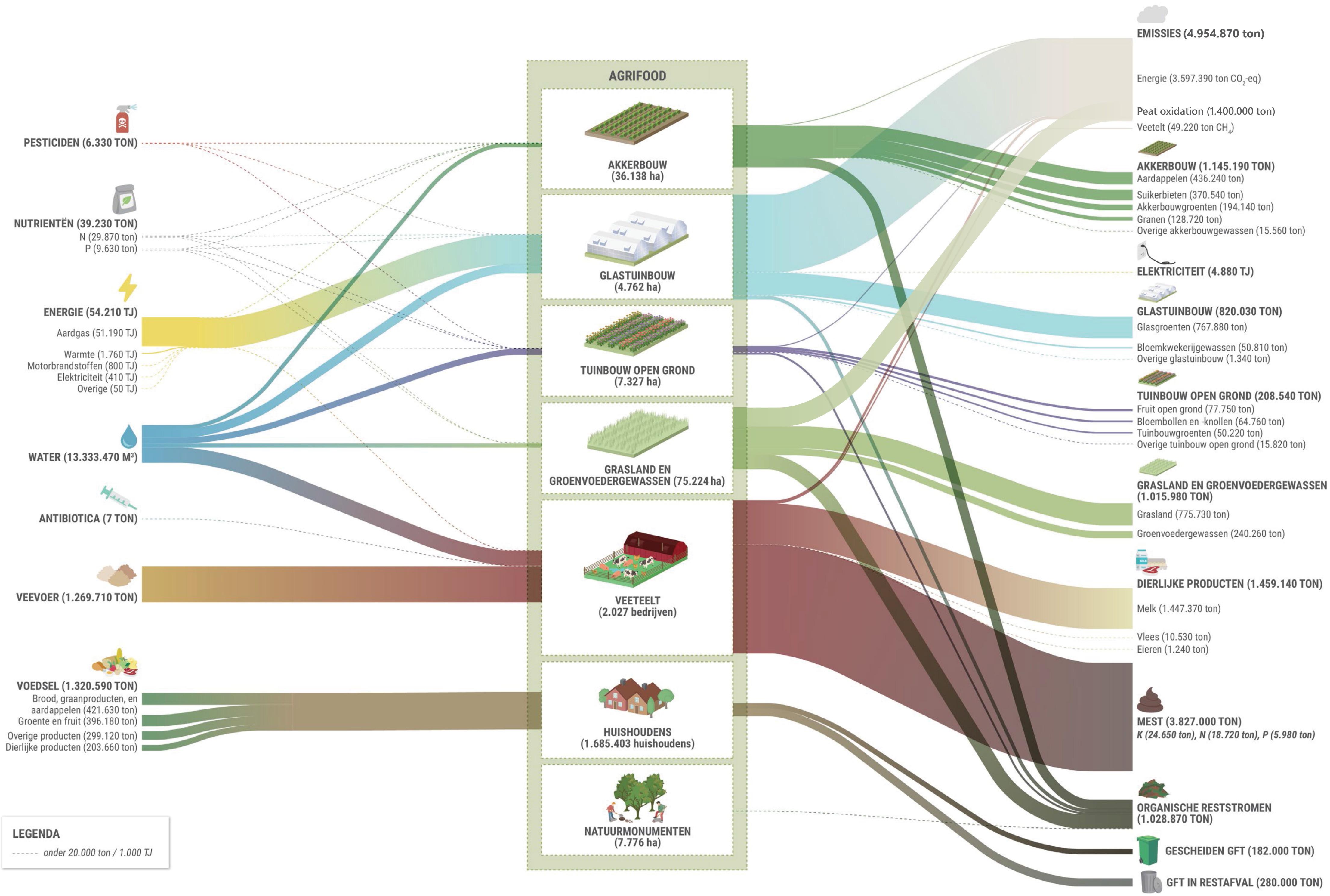
Economic yield of actors in 2018

	Netherlands				
(Actor) Agriculture type	Total economic yield (x€1000)	Total area (hectare)	Total companies	Average yield (per company x€1000)	Average yield (per hectare x€1000)
(Greenhouse farmers) Vegetables and potted plants under glass	3.408.541	6.979	1.410	€ 2.417	€ 613
(Peat farmers) Grassland grazing animals	8.112.248	1.043.904	26.895	€ 302	€ 8
(Clay farmers) Crop farming open soil	1.740.896	454.038	10.835	€ 161	€ 4
combined	13.261.685	1.504.921	39.140		

	South Holland specific							
(Actor) Agriculture type	Total companies	Total area (hectare)	Share of total area	Estimated yield (based on companies)	Estimated yield (based on area)	Estimated value (average)	Share of total value	Value/area ratio
(Greenhouse farmers) Vegetables and potted plants under glass	1382	4375	4%	€ 3.340.854	€ 2.681.513	€ 3.011.183	80%	20,44
(Peat farmers) Grassland grazing animals	2211	72344	64%	€ 666.896	€ 562.190	€ 614.543	16%	0,25
(Clay farmers) Crop farming open soil	991	35487	32%	€ 159.227	€ 144.080	€ 151.654	4%	0,13
combined	4584	112206		€ 4.166.977	€ 3.387.783	€ 3.777.380		

Source: Centraal Bureau voor de Statistiek (CBS), 2018. *Landbouw; economische omvang naar omvangsklasse, bedrijfstype.*
Retrieved from: https://opendata.cbs.nl/statline/#/CBS/nl/dataset/80785NED/table?fromstatweb

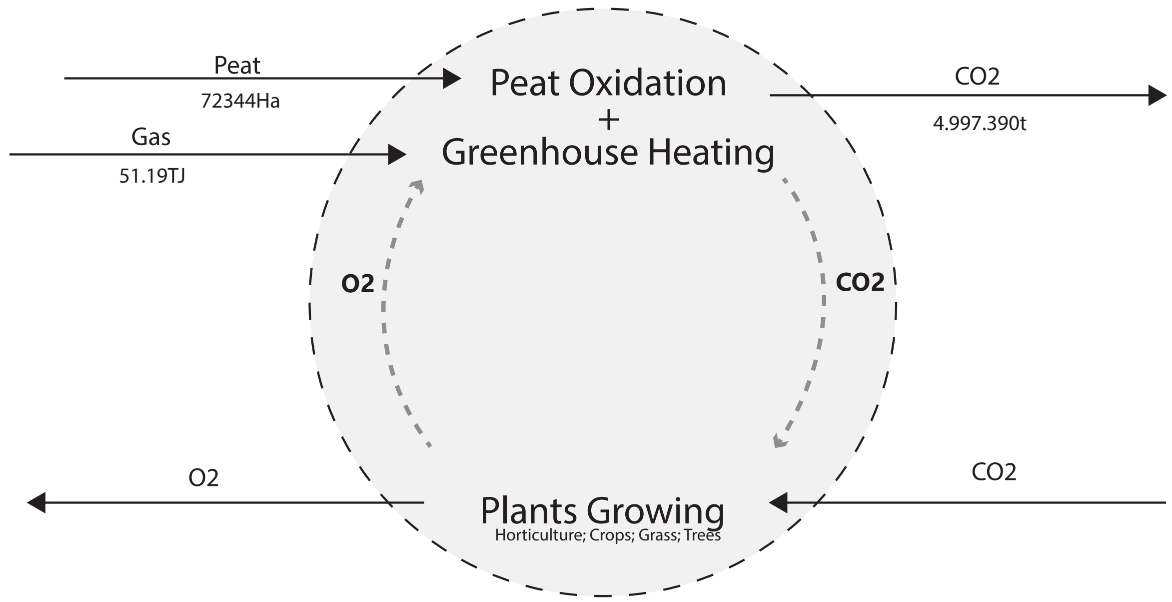
7.3 FLOW CHART AGRIFOOD SECTOR SOUTH HOLLAND



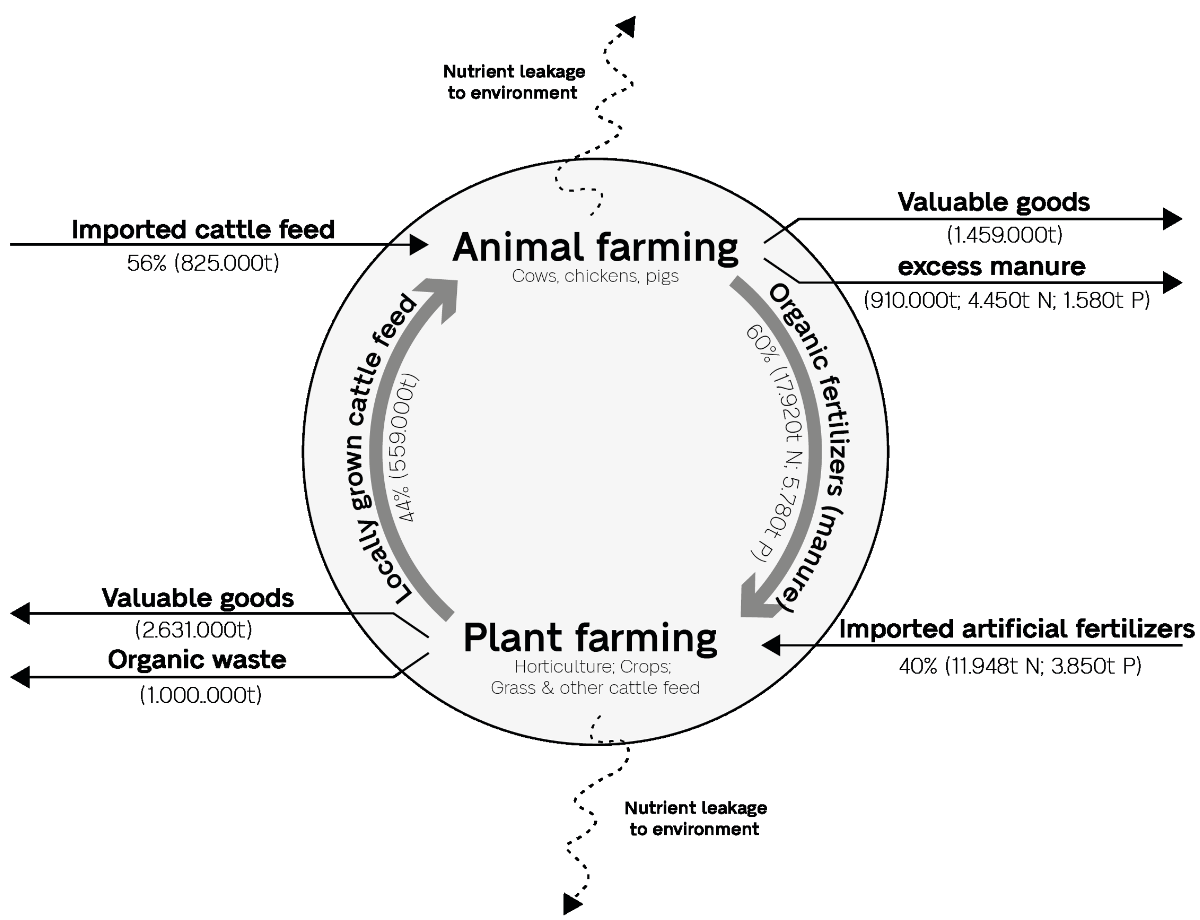
Source: adapted from Roemers *et al.*, 2019

7.4 MOST IMPORTANT CYCLES IN THE AGRIFOOD INDUSTRY

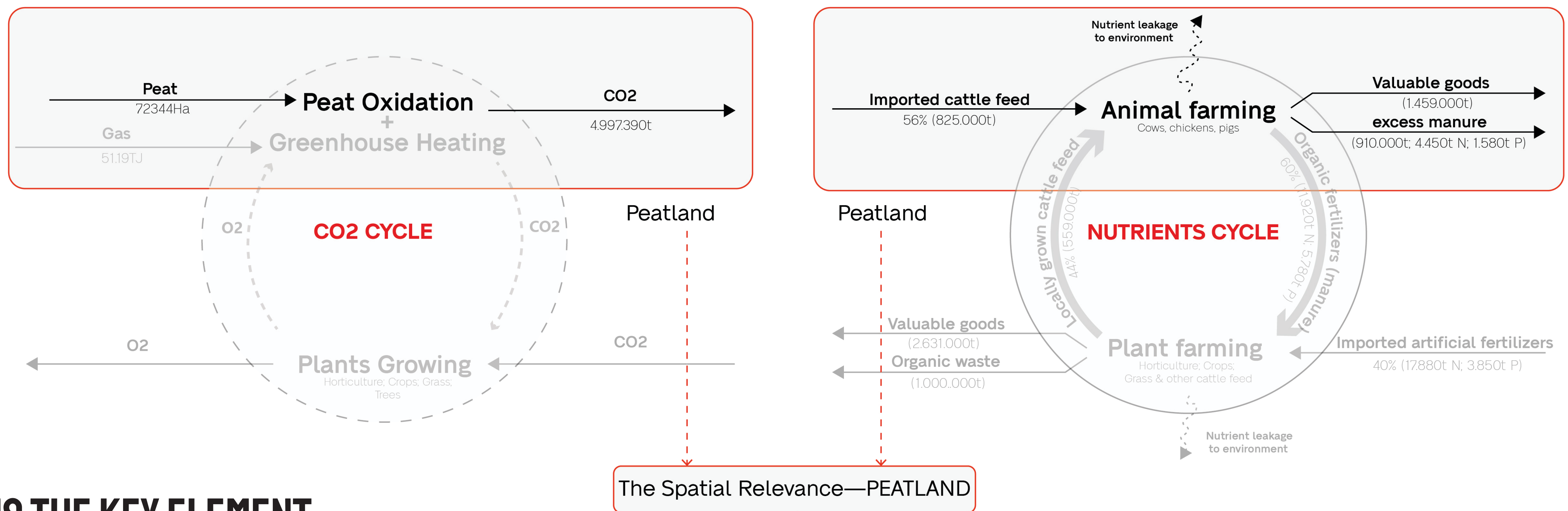
CO_2 CYCLE



NUTRIENTS CYCLE



THE TWO CYCLES ARE SPATIALLY RELATED



CO_2 IS THE KEY ELEMENT