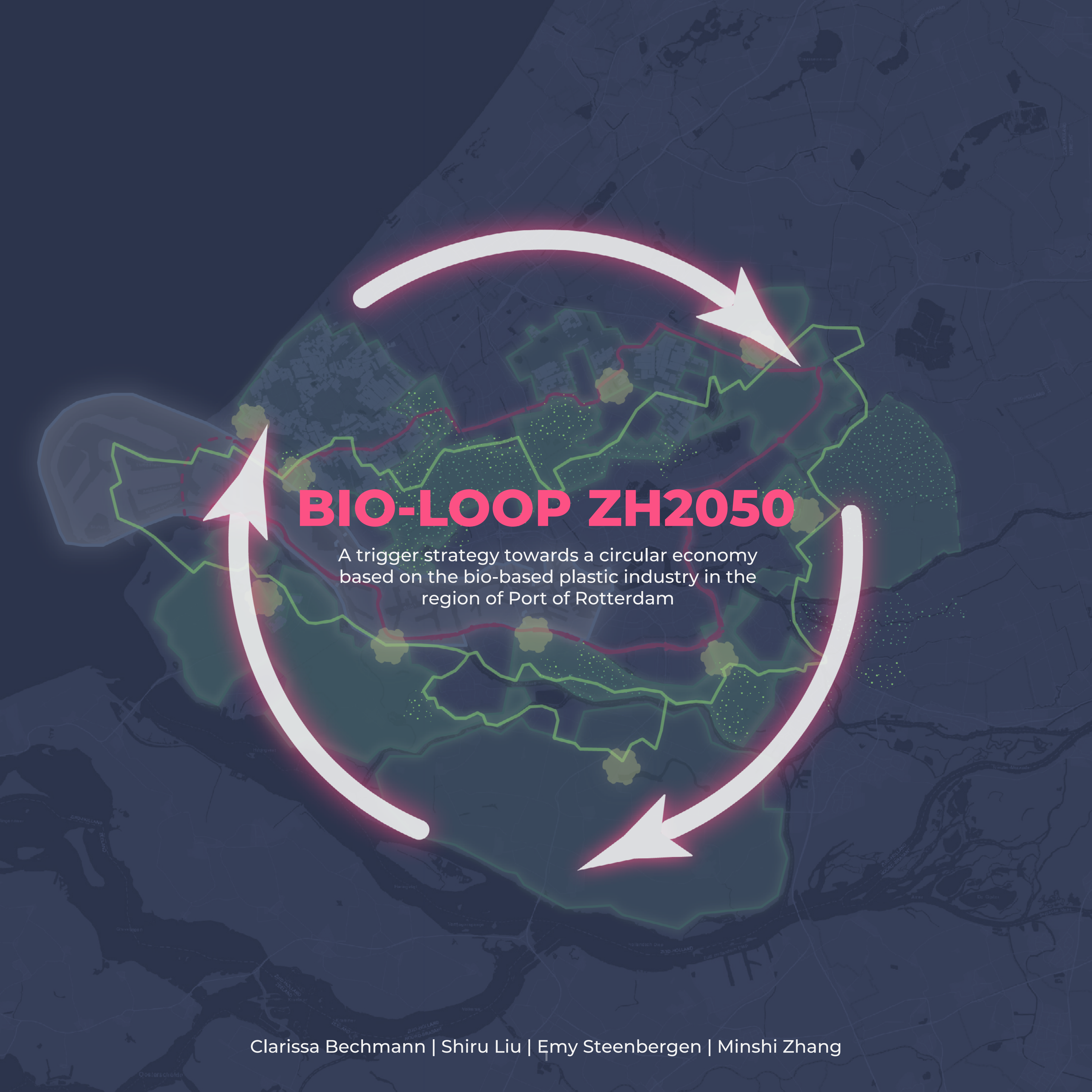

BIO-LOOP ZH2050

A trigger strategy towards a circular economy based on the bio-based plastic industry in the region of Port of Rotterdam

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PREFACE

In today's world, it is unthinkable to ban the use of plastics completely. However, climate change is a growing problem for present and future generations that needs to be tackled now. To combat climate change, it is of great importance to reduce the usage of fossil fuels and promote the use of renewable materials. By presenting our Bio-Loop ZH2050 we hope to take the first step towards a world that is less dependent on fossil fuels to move towards a bio-based circular and sustainable future. This strategy supports the transition towards a circular and futureproof economy in the Port of Rotterdam and the Province of Zuid-Holland.

In particular, we would like to thank our supervisors Dr Lei Qu, Dr Luisa Calabrese, Dr Karel van den Berghe, Dr Marcin Dabrowski and Dr Roberto Rocco. They have contributed new insights from start to finish throughout this project. We hope this report will provide new perspectives and inspiration to the reader.

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ABSTRACT

Nowadays, circular economy is of growing importance in the social, economic and environmental fields. The realisation happens on different scales. First steps towards a circular economy have already been taken, but it will take time before a circular world is reached. Also, under the Sustainable Development Goals (SDG), the bio-based concept raises more awareness.

This strengthens the aim to create a circular economy. The industry in the Port of Rotterdam is mainly based on fossil-based industries that follow the linear system. Therefore, high emissions and waste are caused. This contradicts the aims of the SDG and the idea of a circular system. **Consequently, the port area should be transformed into a flexible system that can adapt to changing future situations.** This will be realized by a circular system that contributes to the development of the bio-based industry.

This transition is triggered by the current oil- and plastic industries taking place within the Port. By treating the bio-plastic industry as a trigger industry, a strategy for the transition towards a bio-based system is created. This leads to a circular economy that depends on bio-based materials. Since the bio-based system might face future challenges, it is important to guarantee further adaptation and self-improvement over time. The final goal is to create a closed-loop within the Port region to reduce emissions and waste products using these bio-based materials.

To close this loop, the Bio-Loop ZH2050 is integrated into the Port area. A Green Belt strategy promotes the circular economy within the province of South Holland, and by implementing the Living Labs, knowledge and technologies are improved over time. The Bio-Loop ZH2050 influences the aim of the province to become 100% circular by 2050 and several SDG topics. Environmentally, this project supports the transition towards a circular bio-based system and to reduce the impact of pollution and climate change. Socially, the Bio-Loop ZH2050 creates the possibility to get society involved in the bio-based circularity. And finally, economically, the Port of Rotterdam will become the port of Europe based on the bio-based economy, which is the entrance connecting the global market and EU market.

KEYWORDS *bio-based plastic, circular economy, biomass, the Living Labs, green belt, port industry*

Fig 0.1 Current situation in the port region of Rotterdam

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Fig 0.2 The Netherlands and the province of Zuid-Holland

CHAPTER 1
INTRODUCTION

A look into the Port of Rotterdam

1.1 CONTEXT

Currently (2022), climate change is an increasing problem. The consequences of climate change are also becoming increasingly visible, such as more extreme weather situations and a higher risk for new diseases in agriculture and public health (van Minnen et al., 2012). To mitigate this change, it is of great importance to focus on sustainable solutions for people and the planet (United Nations Department of Economic and Social Affairs Sustainable Development, n.d.-b). In 2015, the Netherlands signed the Paris Agreement. The goal of the Paris Agreement is to limit global warming to a maximum of 2 degrees Celsius, but preferably to 1.5 degrees. To meet this, the Netherlands must make adjustments to its current economy. (United Nations Department of Economic and Social Affairs Sustainable Development, n.d.-a). The Dutch government introduced the Klimaatwet - Climate law. This legislation states that in 2030 there should be a reduction of 49% and in 2050 95% in CO_2 emissions compared to 1990 (Ministry of Infrastructure and Water Management, 2022).

To achieve these goals, the circular economy and the use of biomass are becoming increasingly important issues. The use of biomass is rising to replace fossil fuels (Ministry of General Affairs, 2020). The bio-based industry is already a growing concept and is also already applied within the Port of Rotterdam. This Port is currently the largest industrial cluster in the world using biomass and already gives home to 5 biofuel plants and 2 biochemical plants (Port of Rotterdam, n.d.-a).

DEFINITIONS

BIO-BASED ECONOMY 'The bio-based economy encompasses the production of renewable biological resources and the conversion of these resources, residues, by-products and side streams into value added products, such as food, feed, bio-based products, services and bioenergy. The transition towards a bio-based economy holds a great potential in terms of economic growth, rural development and decreasing fossil dependance, but requires tackling of many challenges at many levels.' (BioBasedEconomy, n.d.).

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.' (Kennisbank, 2019)

LOCATION

The Bio-Loop ZH2050 is developed for the province of Zuid-Holland in the Netherlands. With 3,726,050 inhabitants, as of 1 January 2022, it is the largest province of the Netherlands in terms of population (Allecijfers.nl, 2022). The province of Zuid-Holland gives space to a landscape in which urbanized areas, greenhouses, water, polders and nature areas come together to form a whole, visible in fig 1.1, 1.2, and 1.3. Zuid-Holland also gives home to the city of Rotterdam, the second-largest city in the Netherlands and the Port of Rotterdam, visible in fig 1.1. This port is the largest port in Europe, with a surface of more than 126 km2 (Port of Rotterdam, n.d.-d).

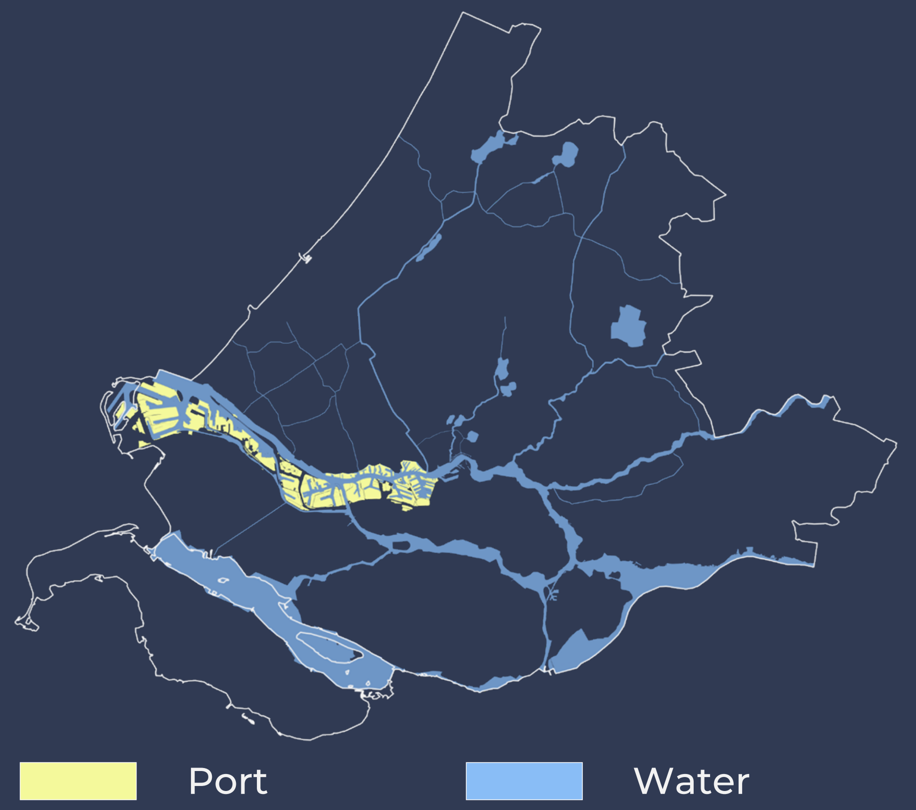


Fig 1.1 Port and water

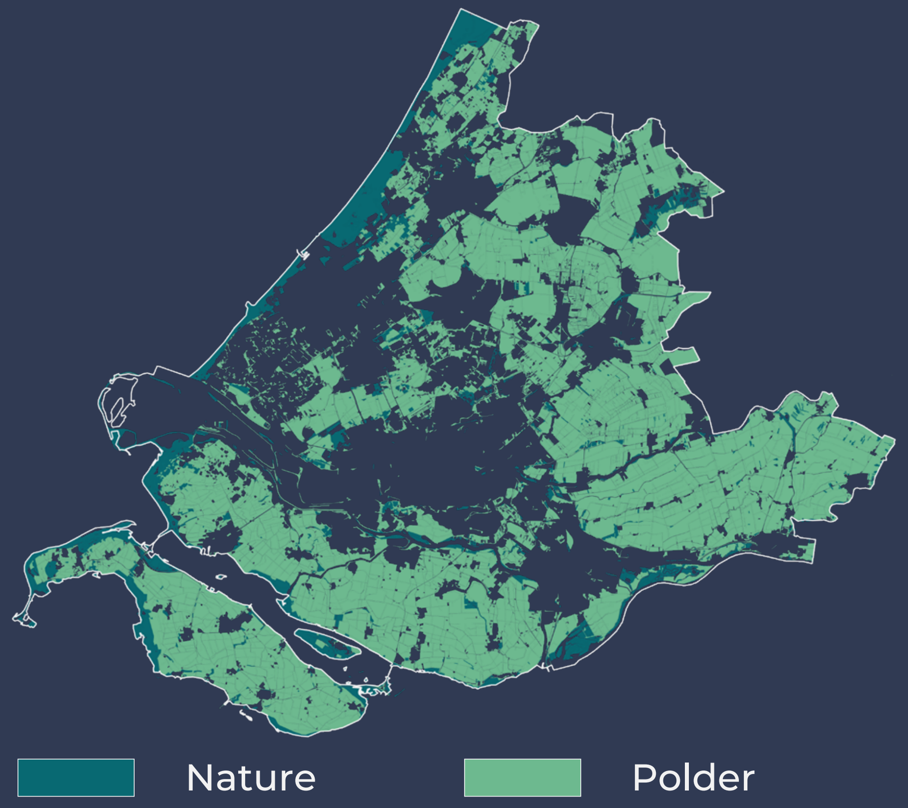


Fig 1.2 Nature and polders

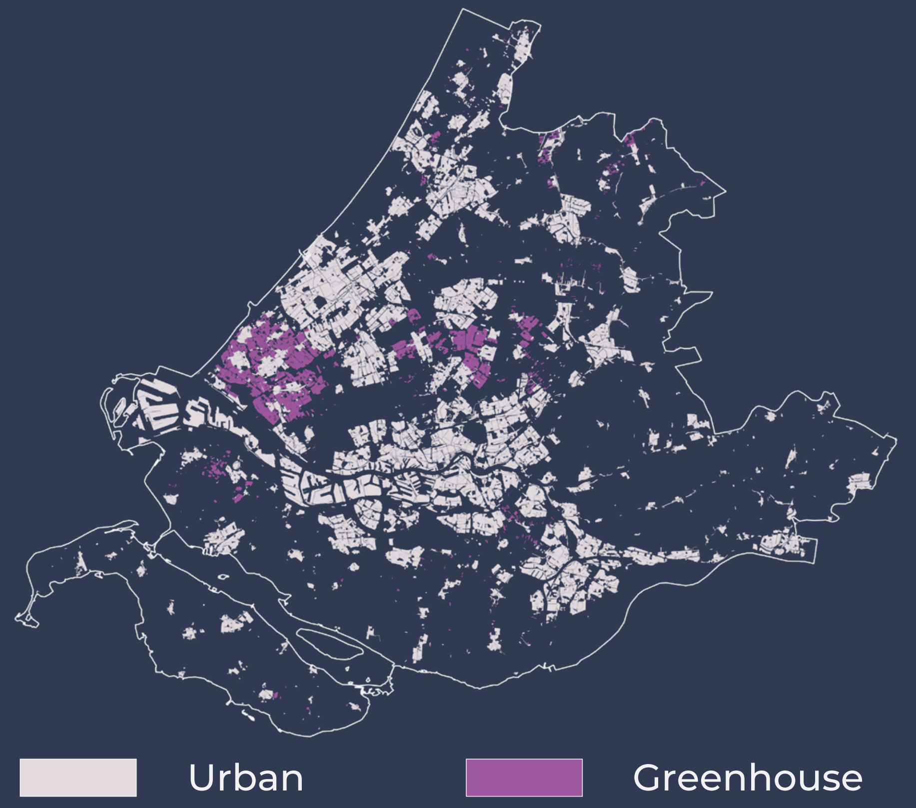


Fig 1.3 Urbanized areas and greenhouses

1.2 PROBLEM STATEMENT

The Province of Zuid-Holland aims to become a 100% circular region dependent on renewable materials by 2050 (Provincie Zuid-Holland, n.d.). The economy of this province is highly dependent on the (raw) materials and energy processed within the Port of Rotterdam.

FOSSIL-BASED INDUSTRIES

Annually, 95 – 100 million tonnes of crude oil are imported into the Port of Rotterdam (Port of Rotterdam, n.d.-b). The crude oil is partly transformed into plastic here. These plastics are mainly packaging materials (Plastics Europe & EPRO, 2020). The European demand for these plastics is visible in fig 1.4. In 2018, the Netherlands produced 1.028 kilotonnes (kt) of packaging plastic. Of these, 601 kt was used for own consumption and 427 kt for export (Warringa et al., 2021).

These numbers show the dependency of the port area on the import and export of oil and plastics. In fig 1.5 and 1.6 these imports and exports are visible. Fig 1.6 shows the dependency of the EU and other parts of the world on production in the Port of Rotterdam. Since the Port is well connected to this plastic (packaging) industry in Europe and other parts of the world, a transformation within this system could be of great importance in the global plastic industry. Therefore, a change within the system of the Port is necessary.

NOT OPTIMISED CIRCULAR SYSTEM

Currently, there is a non-circular system that makes use of non-renewable materials. In 2019, the Port of Rotterdam had a 47% recycling rate (van Barneveld et al., 2019). This is also shown in fig 1.7 For the Netherlands in general it is claimed that this number is almost 50% for packaging materials (Recycling Nederland, 2021). In the EU this was 32,5% in 2018 (Jereb et al, 2020). The increasing shortage of raw materials and the negative impact of these materials on the climate,

Fig 1.4 Plastic demand of Europe in 2019

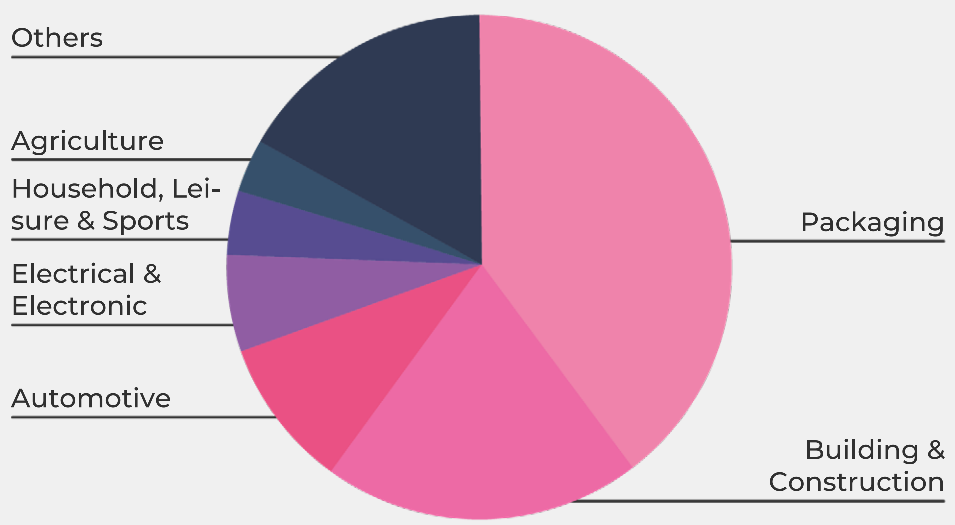
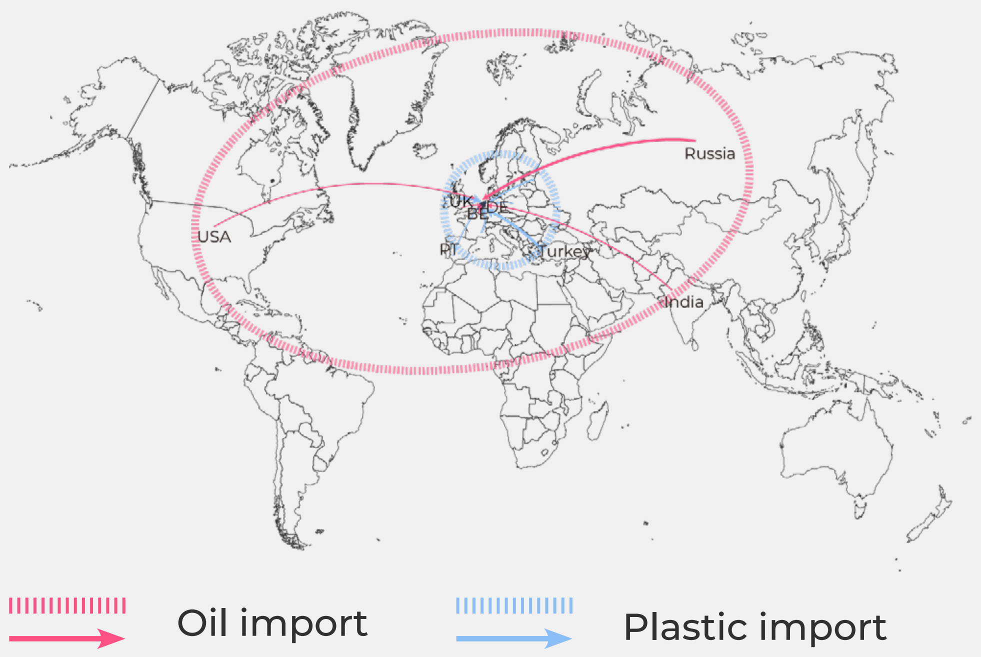


Fig 1.5 Import of oil and fossil-based plastics



biodiversity, environment and health lead to a necessary change in the system within the Port of Rotterdam (Programmateam Circulair Zuid-Holland, 2019). To pursue this aim of the province, there should be no longer any waste and all (raw) materials should be reused or recycled and renewable (Provincie Zuid-Holland, n.d.).

AWARENESS

To provide a circular system based on renewable materials, more awareness is needed in terms of bio-based and circular industries. The bio-based industry should raise more attention to citizens and education. This ensures an increase in recycling, reduction of demand, and stable improvement of technologies for this field. Also, for the Port area increased awareness is important. Improved partnerships between different stakeholders can lead to a more circular and sustainable process.

Therefore, the problem statement for the Port of Rotterdam is: **Currently, there is not an optimised circular system in the Port of Rotterdam, and its industries are mostly fossil-based. Due to an lack of awareness in the bio-based and circular industries within the Port, it is hard to make a transition to a sustainable, circular and future-proof port.**

Fig 1.6 Export of oil and fossil-based plastics

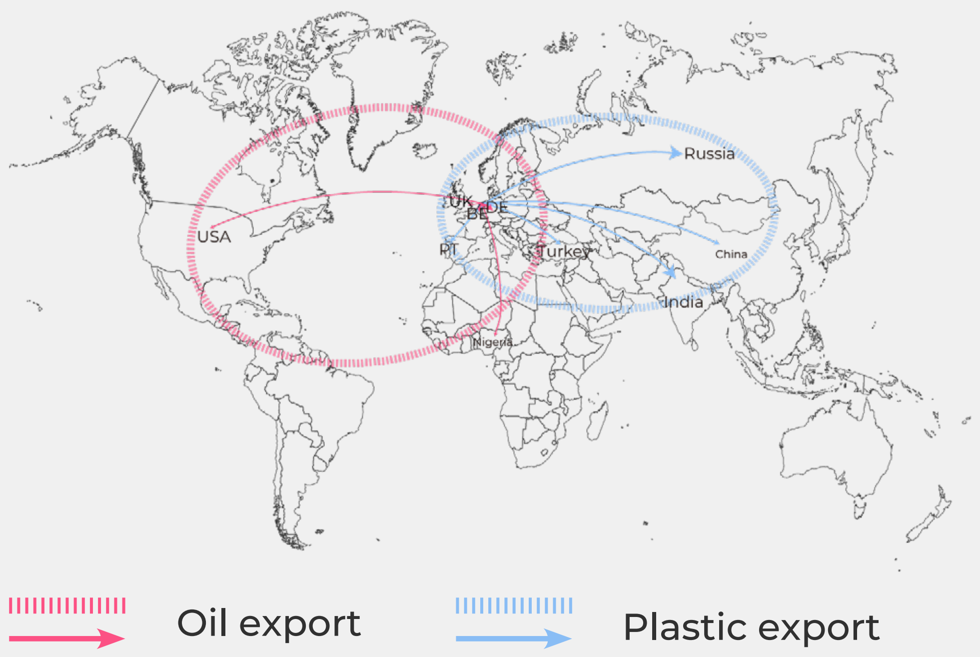
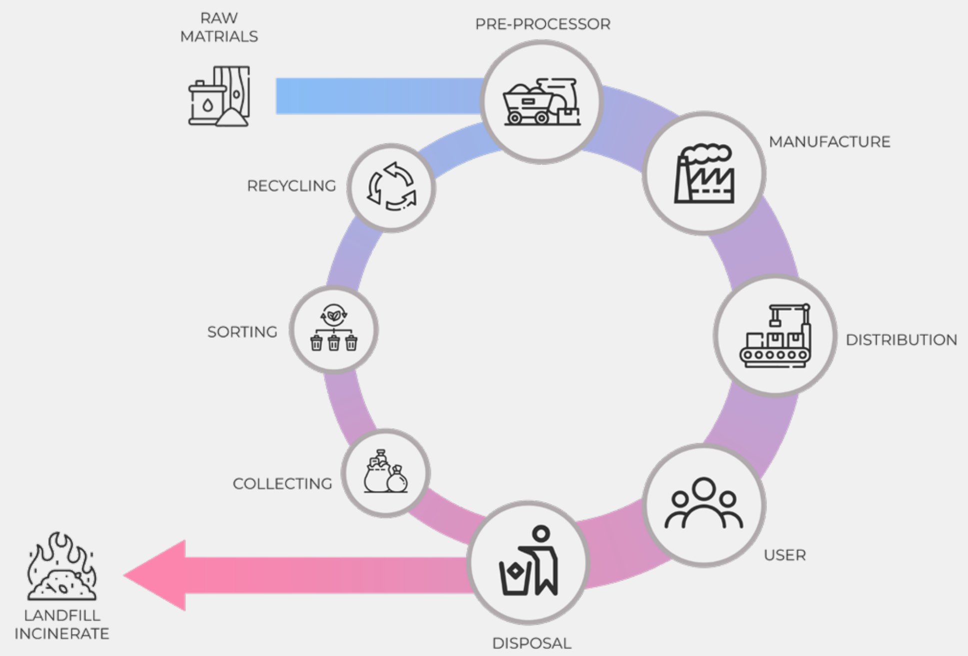


Fig 1.7 Not circular system



1.3 GOALS

This proposal aims to **create a starting point for the Port of Rotterdam that enables the transition towards a circular economy based on bio-based plastics.** In addition, this Port-area should be able to **further adapt and improve over time.** The report aims to explain the path towards a circular and bio-based port until 2050, with the starting points for the circular system being in place by 2040 and the port being carbon neutral by 2050. By then, all starting points have been realized, and the Port-region should be able to develop itself over time to become a complete circular port in the future. In addition, the Port of Rotterdam must function as an example for other ports and industrial areas around the world that have similar contexts. They can implement effective and innovative technologies and systems that are tested in the Port of Rotterdam.

SUSTAINABLE DEVELOPMENT GOALS

This goal matches some of the **Sustainable Development Goals (SDG)**, shown in fig 1.8. The SDGs are set for the 2030 Agenda for Sustainable Development. They share the importance of peace and prosperity for people and the planet, now and in the future (United Nations Department of Economic and Social Affairs Sustainable Development, n.d.-b). The SDGs that are related to this proposal are further clarified and the bullet points show the contribution for this goal in this proposal.

03 GOOD HEALTH AND WELL BEING

Ensure healthy lives and promote well-being for all at all ages.

- Contribution to the public good
- Contribution towards a better living environment
- Contribution to mental and physical health

04 QUALITY EDUCATION

Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.

- Improvement of the accessibility of education
- Opportunity for retraining

09 INDUSTRY, INNOVATION AND INFRASTRUCTURE

Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.

- Contribution to sustainable and resilient infrastructure
- Improvement of infrastructures by new technologies

11 SUSTAINABLE CITIES AND COMMUNITIES

Make cities and human settlements inclusive, safe, resilient and sustainable.

- Contribution to sustainable cities
- Improvement for urban and rural areas

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

Ensure sustainable consumption and production patterns.

- Contribution to awareness of consumption and production

13 CLIMATE ACTION

Take urgent action to combat climate change and its impacts.

- Contribution to reducing the urban heat island effect
- Contribution to the reduction of emissions

15 LIFE ON LAND

Protect, restore and promote sustainable use of terrestrial ecosystems, sustainaby manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.

- Securing protected areas
- Improvement of biodiversity
- Improvement and restoration of ecosystems

17 PARTNERSHIP FOR SUSTAINABLE DEVELOPMENT

Strengthen the means of implementation and revitalize the global partnership for sustainable development.

- Contribution to closed loops
- Contribution to less waste

Fig 1.8 Sustainable Development Goals
(Adapted by author, see sources in references)

CHAPTER 2
METHODOLOGY

Step by step

2.1 RESEARCH QUESTIONS & METHODOLOGY

2.1.1 Research questions

Based on the problem statement and defined goals, a research question and four sub-questions are formulated. The sub-questions, stated beneath, are used as guidelines during the development of the strategic vision to answer the following formulated research question:

HOW CAN WE RESTRUCTURE THE PORT REGION AS A FLEXIBLE SYSTEM THAT CAN ADAPT TO THE CHANGING FUTURE SITUATION BY FOSTERING A CIRCULAR SYSTEM, THAT CAN CONTRIBUTE TO THE DEVELOPMENT OF A CIRCULAR BIO-BASED PLASTIC INDUSTRY?

- How can the trigger industry start the transition towards a circular and bio-based economy?
- What circularity strategies are necessary for the first step of transition towards a bio-based port area?
- What kinds of spaces are needed to develop bio-based plastic industry?
- What are the social needs for building a circular system of the trigger industry?

2.2.2 Methodology

Fig 2.1 shows the process of developing the Bio-Loop ZH2050. During the project, research has been done in various ways. After exploratory research during the excursion at the start of the quarter, literary research was mainly used. This was the case until the analysis phase. During the analysis phase, also mapping and analyses of transport, materials and stakeholders are used. This mapping takes place on different scales. During the vision phase, research by design is a more used technique. Finally, the strategy is done via research by design.

Group discussion is a tool that has been used throughout the process to gain new insights to create the best possible project.

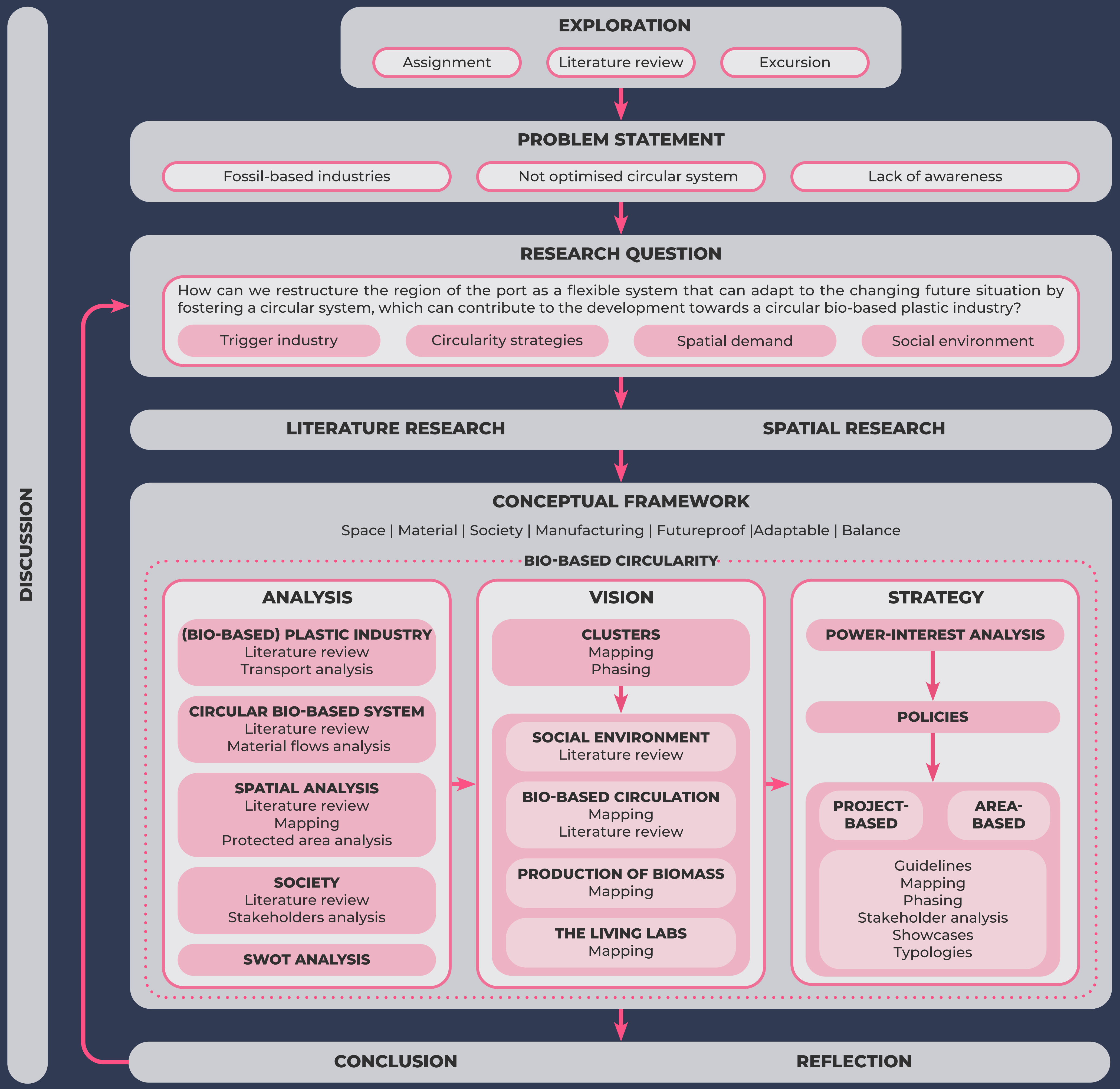


Fig 2.1 Methodology

2.2 CONCEPTUAL FRAMEWORK

Currently, the port region has mostly fossil-based industries, not an optimised circular system and only a limited awareness of the circular and bio-based industry (Port of Rotterdam, n.d.-b; van Barneveld et al., 2019). To tackle these problems, the goal is to create a circular bio-based plastic industry for the Port of Rotterdam and the province of Zuid-Holland. For this reason, the bio-based plastic industry is the central theme in the conceptual framework shown in fig 2.2.

The system is based on four pillars: space, material, society, and manufacturing. These are necessary to realize a bio-based plastic industry. In between these pillars, overlapping themes are visible. These are highly related to the bio-based plastic industry and the four pillars. Around this framework, a spiral is visible. This spiral contains three key elements: balance, futureproof, and circularity. These key elements are of systematic importance throughout the process and ensure that the vision will not only provide added value until 2050 but promotes further development in the future.

This chapter will further explain the importance of the key elements, pillars, and overlapping themes to gain a better understanding of the vision of Bio-Loop ZH2050.

CENTRAL THEME

The bio-based plastics industry is the central theme within the conceptual framework. Diminishing fossil fuels and increasing negative consequences, for people and the planet, from processing these raw materials necessitate a change within the fossil fuel-based plastic industry (Borrello et al., 2016; Storz & Vorlop, 2013). Placing the bio-based plastic industry at the centre of this vision will facilitate a transition to a more sustainable world. This contributes to the aims of the Paris Agreement of 2015, the reduction of global warming, and the Klimaatwet, zero carbon emissions by 2050 (United Nations Department of Economic and Social Affairs Sustainable Development, n.d.-a; Ministry of Infrastructure and Water Management, 2022).

KEY ELEMENTS

The first key element is balance. This balance is about the dependence and independence from other regions for the Port of Rotterdam. To develop a sustainable production process in the long term, production on a local scale is of great importance (Feenstra, 1997). However, this contradicts what the Port of Rotterdam has to offer. This port is the largest in Europe and is a market leader in terms of liquid bulk, among other things. In addition, the port infrastructure of this port has been voted the best in the world by the World Economic Forum several times. This is partly due to the extensive hinterland network that Rotterdam offers (Port of Rotterdam, n.d.-d). Due to the high position of the Port of Rotterdam within the port industry, it is not profitable to focus on complete self-sufficiency. For this reason, it is important within the vision of Bio-Loop ZH2050 to find the optimal balance between dependency and independence at every scale.

The second key element is futureproof. This theme recurs at every scale. According to the Brundtland Commission, we have to meet the needs of the present without limiting opportunities for future generations to realise sustainable development (Keeble, 1988). All decisions made in the present have an impact on the future. Therefore, the vision should be adaptable, flexible and resilient. This way the design is not only for the present time but also for the future, where future demands can be met (Georgiadou & Hacking, 2011).

The last key element is circularity. This key element flows from the first key element: futureproof. The principles of circularity are based on the prevention of waste and exhaustion and exploitation of raw materials. To prevent this, raw materials should have to be reused so that eventually no new raw materials are needed. (Suau Ibáñez, 2019). Due to an increasing global shortage of raw materials and its negative impact on climate, biodiversity, environment and health of the current extraction of raw materials, it is important to make circularity central to the vision at every scale (Programmateam Circulair Zuid-Holland, 2019).

PILLARS

The four pillars that support the transition towards a bio-based plastic industry are space, material, society and manufacturing. Each pillar has sub-themes that support the overall theme: the bio-based plastic industry. These different pillars are connected and dependent on each other. Only if each pillar and sub-theme receives sufficient attention, the transition to a bio-based plastic industry can be realized.

First of all, space. To realize the bio-based plastic industry, extra space is needed to grow crops. Food production should not be at the expense of biomass production. Using monoculture leads to high productivity as long as the biomass has high productivity (Hoffman et al., 1995). However, this does lead to reduced biodiversity (Tudge et al., 2021). In the vision for Bio-Loop ZH2050, this must be limited or compensated.

To minimise the required space, a change within society, the second pillar, is necessary. When demand for products decreases, less production space is needed. The change in society is related to improved accessibility to these production areas so that consumers can create a better awareness of use. This is also done by offering better education that can improve and promote the production of biomass and bio-based plastics.

In addition to increasing human awareness, it is also important to offer job transition among employees. This also ties in with the manufacturing aspect. Because of the new bio-based plastic industry, which in the long run will have to replace the fossil-based plastic industry, it is important to offer and promote the job transition. In this way, the current workers retain their jobs and new jobs become available.

Not only do the workers need a transition, but also the factories where the plastics are produced. To promote this, a trigger is needed. This trigger sets in motion the transition to renewable materials, the last pillar within the plastic industry.

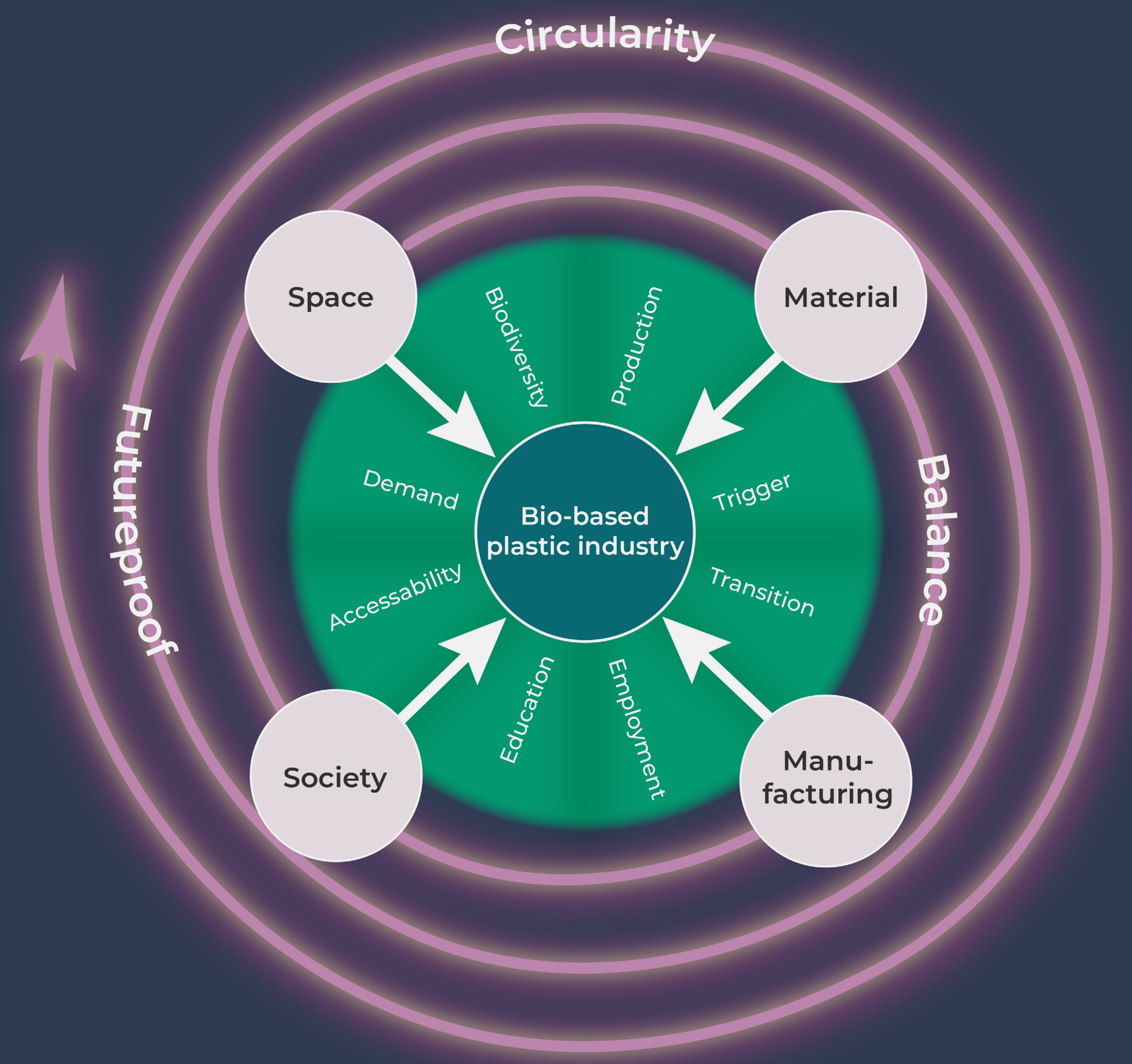


Fig 2.2 Conceptual framework

CHAPTER 3
ANALYSIS

Understanding the future of the bio-based plastic industry

3.1 THE TRIGGER INDUSTRY

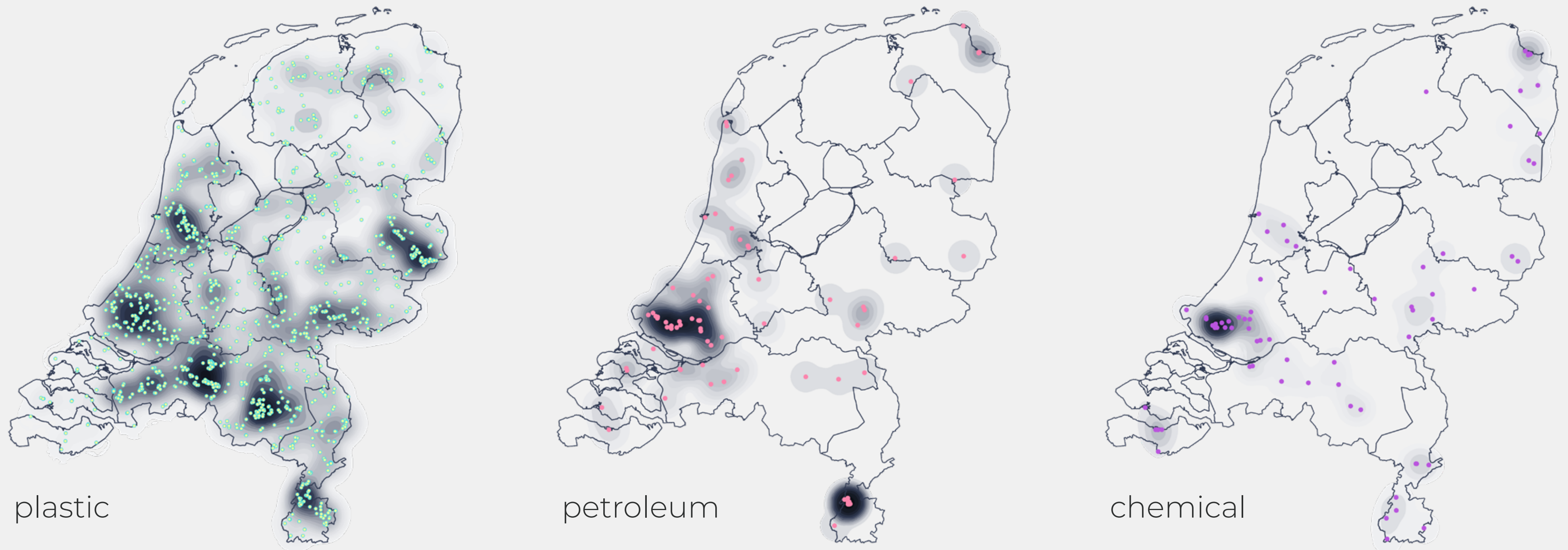
3.1.1 Manufacture related to the plastic industry

The manufacturing of plastic products is now widely spread throughout the Netherlands. In addition to the province of Zuid-Holland, several other provinces also have intensive plastics manufacturing industries, such as Noord-Holland and Noord-Brabant. The presence of these plants supports the massive demand for plastics production in the Netherlands. It shows the potential for the plastics industry to be chosen as a trigger for the transformation of the whole fossil-based industry.

The production of chemical plastic products involves processing processes in the crude oil industry and the chemical industry (fig 3.17). However, the crude oil industry and the chemical industry in the Netherlands are mainly concentrated in the province of Zuid-Holland. Therefore, the province of Zuid-Holland has the most significant potential to start the transition of the complete plastics chain.

The Port of Rotterdam carries the majority of European crude oil imports, so the Dutch oil manufacturing industry is also concentrated in the port area. Accordingly, the manufacture of chemical products is also concentrated here. Nowadays, the oil and chemical plants in the Port of Rotterdam employ a large number of workers. The concentration of resources and employees makes the Port of Rotterdam a natural advantage as the first trigger towards industrial innovation.

Fig 3.1 Distribution of different manufacturing industries in the Netherlands



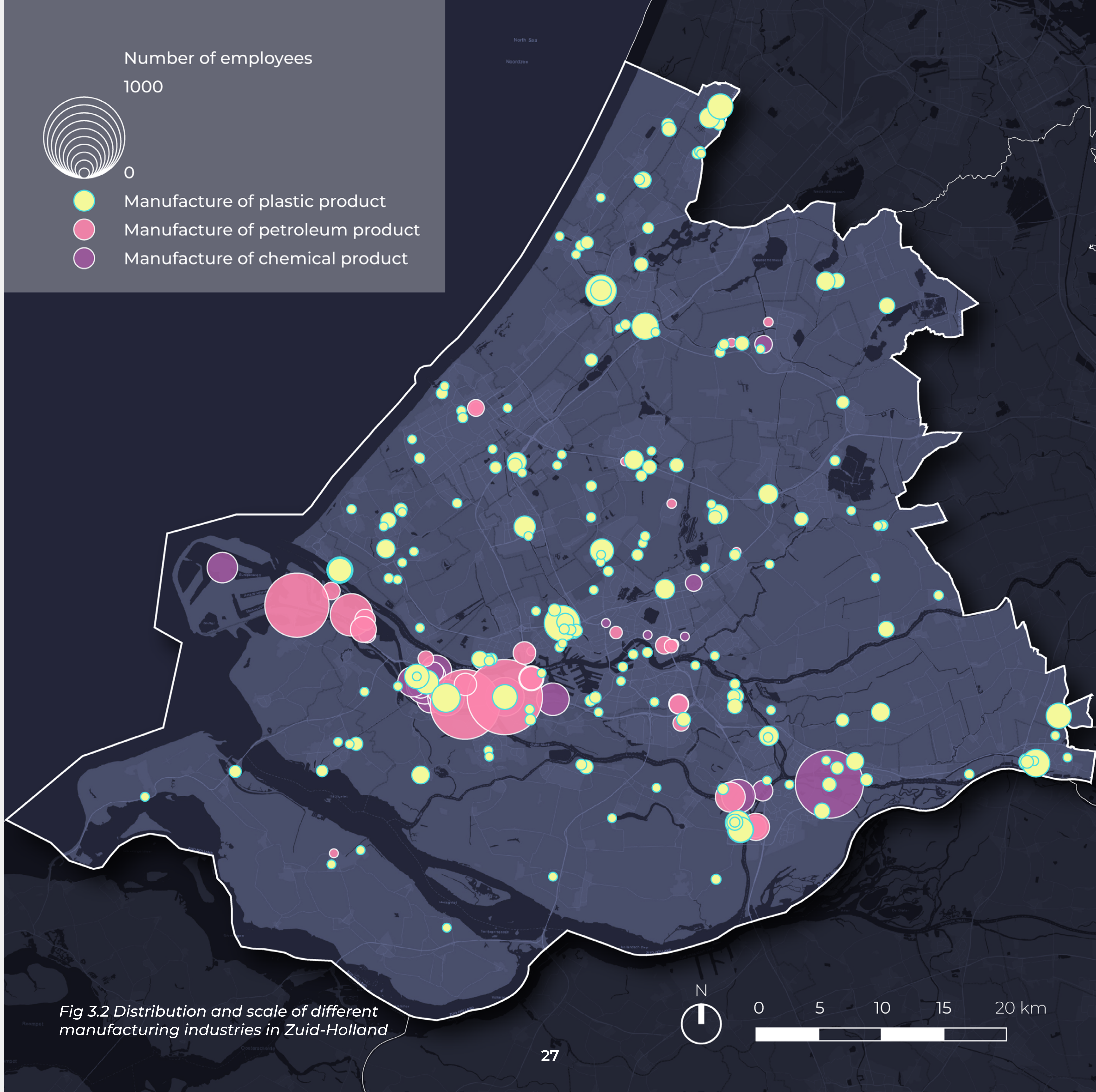


Fig 3.2 Distribution and scale of different manufacturing industries in Zuid-Holland

3.1.2 Transportation infrastructures

A large amount of import and export cargo flows through the Port of Rotterdam every day, including solid and liquid materials. The primary methods of transporting goods through the Port of Rotterdam are truck, ship, railway and pipeline (Port of Rotterdam, 2016).

For cross-border imports, shipping is a very economical way of transporting goods, especially those heavy and bulky goods. Together with the well-developed canal network in the Netherlands, cargo ships and barges can be used to transport huge cargoes. However, according to the Port Authority of Rotterdam (2016), **transportation by truck is an excellent way to move goods efficiently into and out of the Port of Rotterdam over short distances**. Therefore 54% of goods are transshipped by truck into and out of the Netherlands. More miniature goods are transported by rail over long distances.

In Zuid-Holland, the road system is well developed and complete. The truck road is the fastest and most economical way of transporting raw materials and products over short distances. In the case of the Port of Rotterdam, due to the well-developed river system within the port, barges can also be used to transport goods between factories.

Fig 3.3 Percentage of use of transportation ways

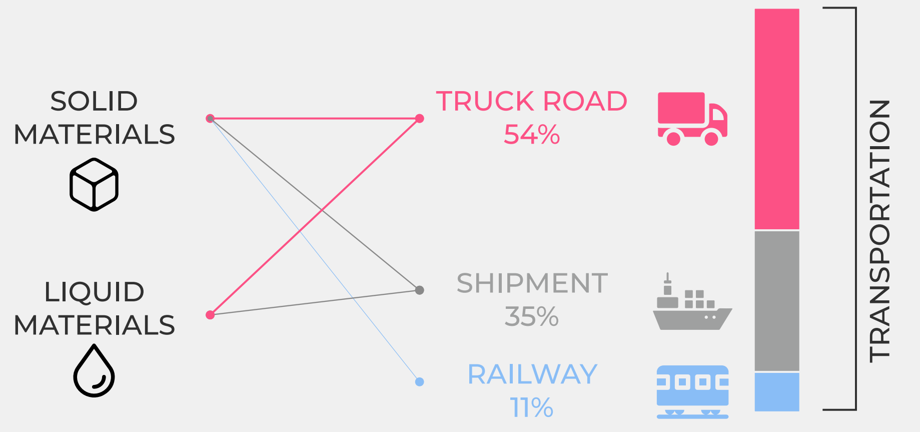


Fig 3.4 Different transportation methods in the Port of Rotterdam (Adapted by author, see sources in references)

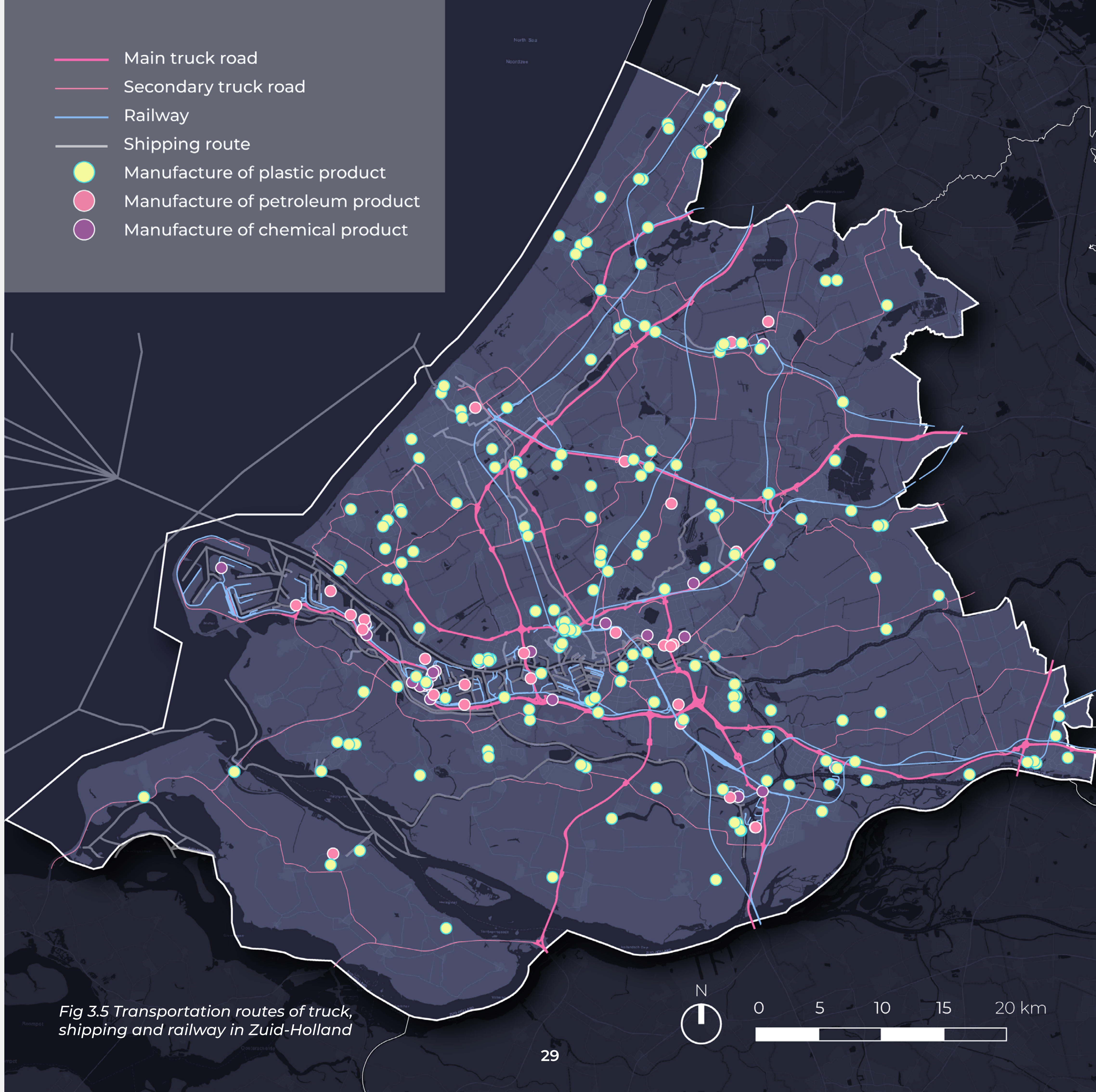


Fig 3.5 Transportation routes of truck, shipping and railway in Zuid-Holland

3.1.3 Industries in the Port of Rotterdam

The Port of Rotterdam has a total area of 12,464ha, including 7,966ha of land area and 4,498ha of water area (Port of Rotterdam, 2016). The port area is clearly divided into functional areas. The factories include refineries and chemical plants, and the cargo area includes general cargo, dry bulk, liquid bulk and so on. Currently, there are 6 oil refineries belonging to different companies in the Port of Rotterdam, which are an essential source of raw material for the fossil-based industry in the Port of Rotterdam. Therefore, **the innovation or upgrading of oil refineries** is an important part of the transition to a bio-based industry.

1 BP Raffinaderij Rotterdam
Site: 2,690,000 m²
Employees: 740

2 Gunvor Petroleum Rotterdam
Site: 1,490,000 m²
Employees: 363

3&6 Vitol B.V. Netherlands
Site: 30,000 m²
Employees: 30

4 Esso Nederland (ExxonMobil)
Site: 1,710,000 m²
Employees: 680

5 Shell Nederland Raffinaderij
Site: 3,050,000 m²
Employees: 1,458

Fig 3.6 Industrial area of the Port of Rotterdam

3.2 SOCIAL ENVIRONMENT

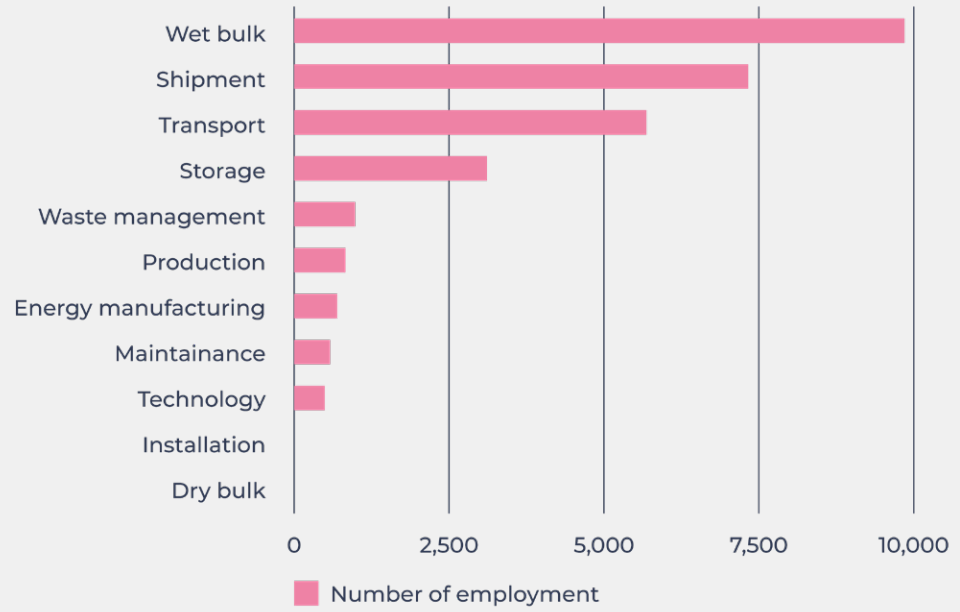
3.2.1 Job transition in the port industry

The fossil-based industry concentrated in the Port of Rotterdam is today mainly a labour-intensive secondary industry. A large number of workers has become the essential basis for the development of a well-developed oil industry. Understanding the current employment situation can help transform and develop careers of worker while the industry transforms.

THE LOGISTIC SECTOR HAS THE MOST EMPLOYEES

Currently, the Port of Rotterdam employs around 180,000 people and a growth of 10,000 additional jobs is expected by 2030 due to the construction of Maasvlakte 2 (Port of Rotterdam, n.d.-e). The majority of jobs are found in the logistic sector, whereas only a small amount of employment is related to waste management, production, and technology (fig 3.7). These three sub-sectors hold potential for future job creation within the bio-based economy.

Fig 3.7 Jobs per sub-sector in Port of Rotterdam



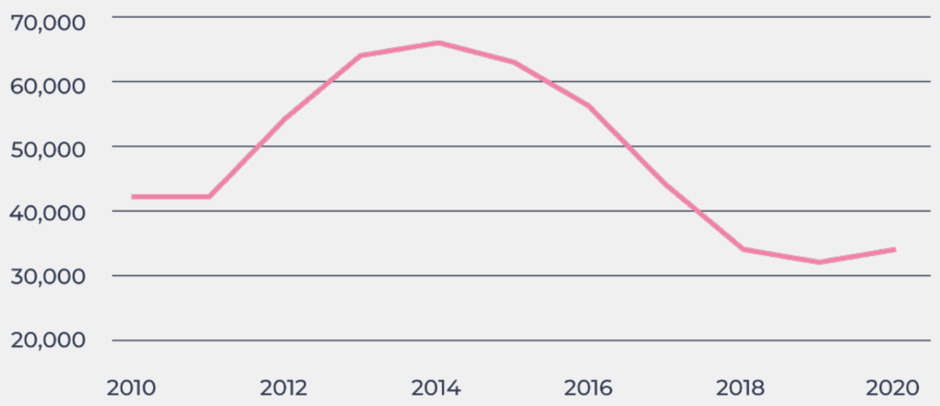
DEMAND OF SKILLS IMPROVEMENT AND NEW JOB OPPOTUNITIES

Regarding the unemployment rate in the Netherlands, fig 3.8 shows that unemployment was decreasing since 2014 and was almost steady at an amount of around 35,000 unemployed people since 2018. It shows only a small increase after 2019, which might be related to the Covid-19 pandemic.

Essential for the project is to ensure the preservation of employment even though a transition within the job field will happen, which might cause the loss of jobs.

To prevent this from happening, existing workers must be trained on-site in line with industrial progress and technological innovation. In addition, new career opportunities need to be made available. The emergence of new job oppotunities can attract more people to learn and enter the industry, giving it plenty of potential for future growth.

Fig 3.8 Unemployment in the Netherlands

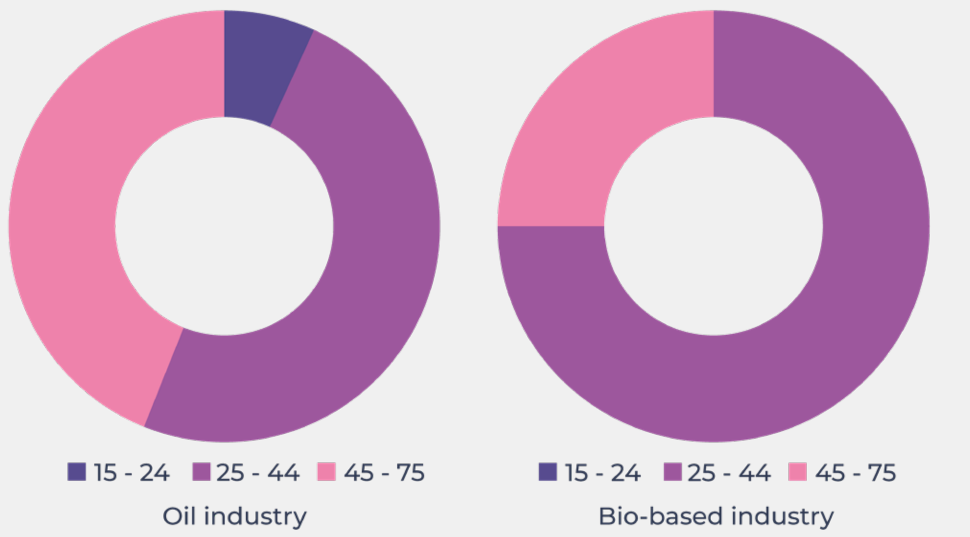


THE TREND OF AGING EMPLOYEES

Furthermore, the age of working people in the port, precisely the difference between oil and bio-based industries, were analysed (fig 3.9). In both cases, the share of people aged 25-44 was the highest. Nevertheless, workers between 45 and 75 years represent a considerable share, especially in the oil industry. Their share is almost equal to middle-aged persons. As the share of the younger generation (15-24 years) is very low in the oil industry and not represented at all in the bio-based industry, this suggests that more young people should be educated in this field.

On the one hand, this promotes the future capacity after older people retire, and on the other hand, it opens up new perspectives for education opportunities within the bio-based industry. Concerning the currently still predominant oil industry in the Port of Rotterdam, training for the established workers is needed to adapt to the industrial transition and not be left behind.

Fig 3.9 Age analysis of workers

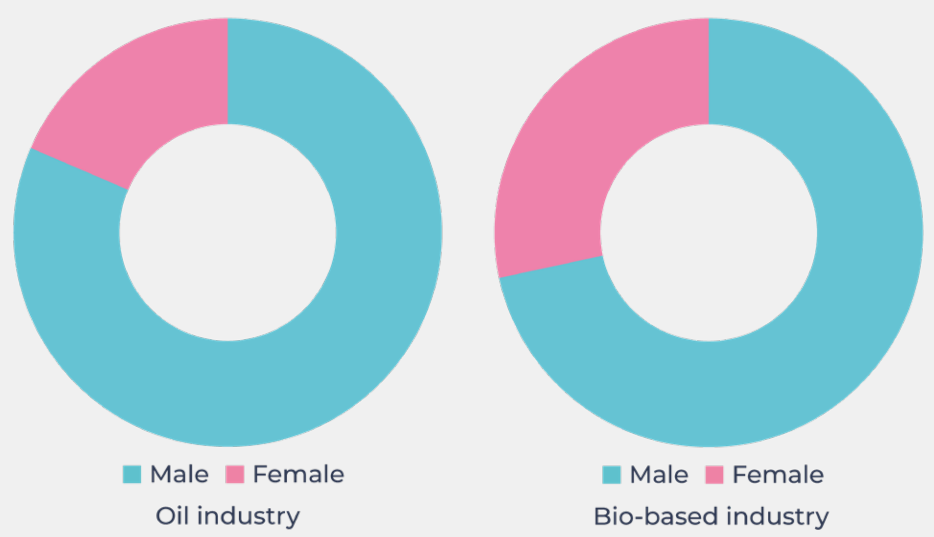


ATTRACTING FEMALE WORKERS IN THE BIO-BASED TRANSITION

Lastly, fig 3.10 illustrates the distribution of male and female workers within the oil and bio-based industries.

The percentage of men is in both industries higher. Nevertheless, in the bio-based industry, one-third of working people are women, which is 19% more than in the oil industry. This could be seen as a potential for the bio-based industry to attract more women to this field of work and create a more balanced gender distribution.

Fig 3.10 Gender analysis of workers



3.2.2 Education related to the bio-based industry

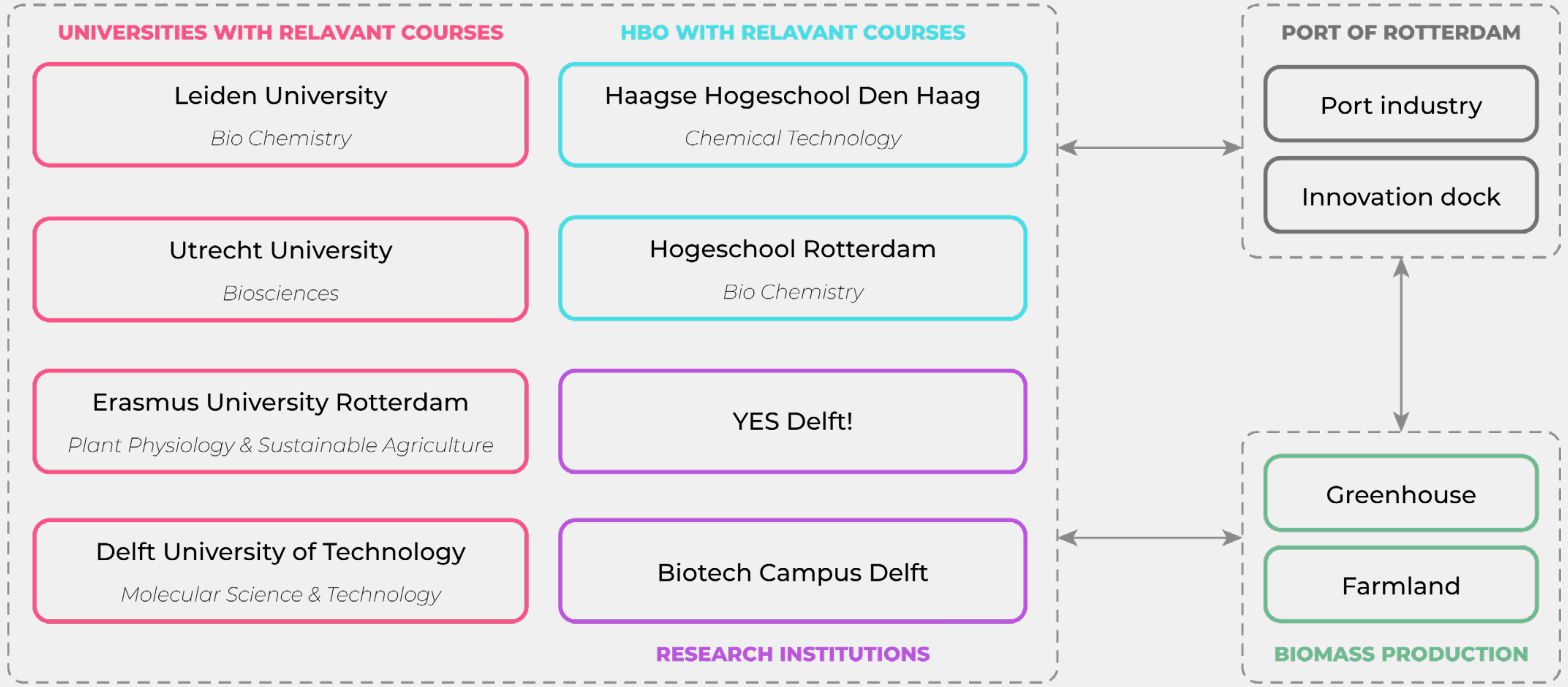
In the Netherlands and the port region, several universities and HBO studies are directly or indirectly related to the circular bio-based plastic industry (fig 3.11).

These studies are related to improving the port region in two ways. Firstly, the technical studies, such as those at Maastricht University. The Master's study in bio-based materials can contribute to the production process of bio-based plastics in the Port of Rotterdam (Maastricht University, n.d.). Then there are the courses and research aimed at agriculture and biomass, such as at Wageningen University.

Their Master's study in biology and research in biosciences can optimise the current biomass to eventually get the highest possible yield from it in the farmland and greenhouses (Wageningen University & Research, n.d.-a; Wageningen University & Research, n.d.-b)

Not only educational institutions can contribute to optimising the production process in and around the port, but also research institutions. By exchanging more knowledge between the various educational and research institutions, Bio-Loop ZH2050 can continue to improve itself over time.

Fig 3.11 Knowledge exchanging between educational institutes, industry and biomass producing area



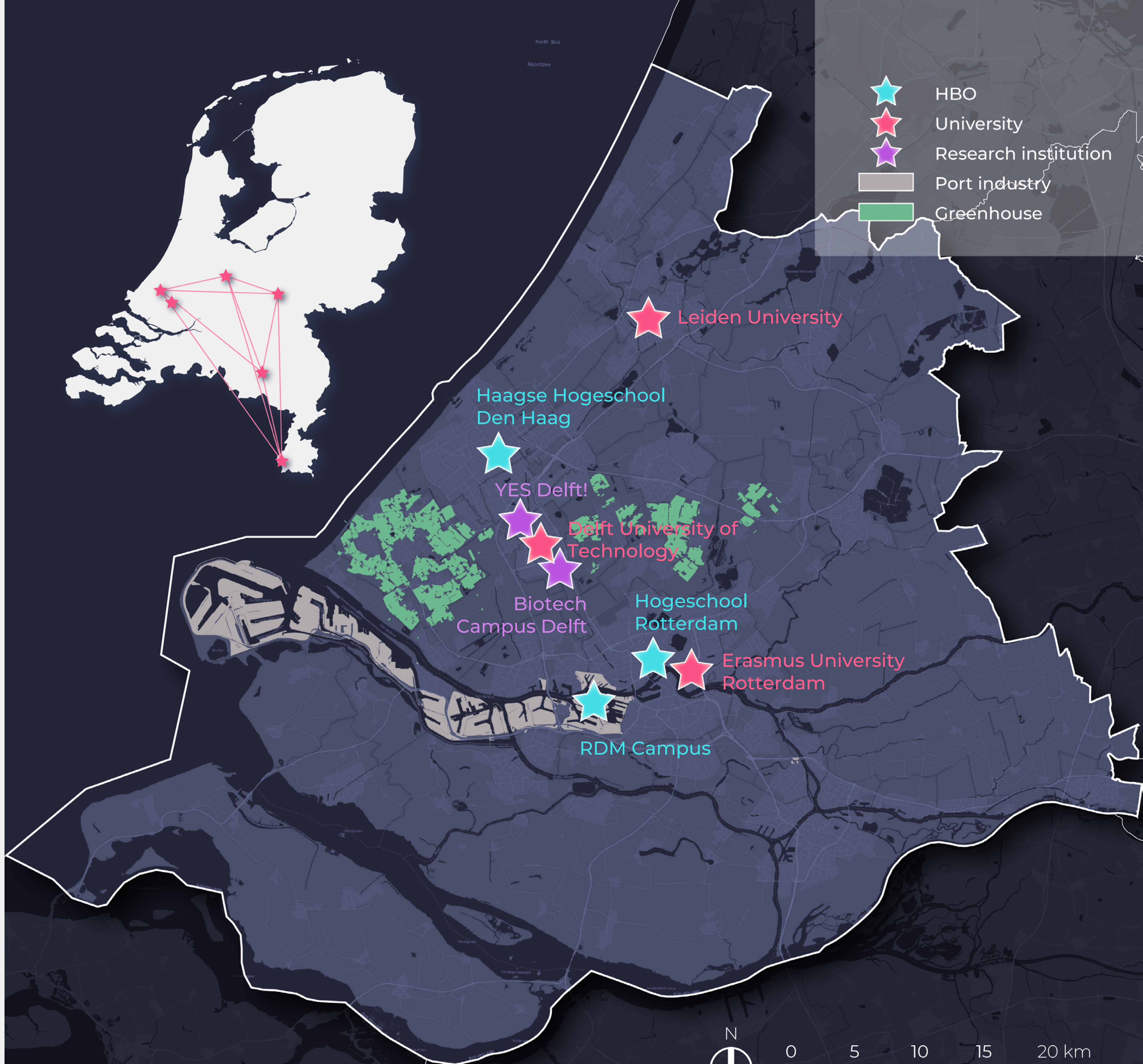


Fig 3.12 Related institutions in regional and national scales

3.2.3 The Living Labs for connecting all the stakeholders

To conclude, strategies for **connecting and bridging the different levels of society** are to be adopted. In terms of education, young students need to be educated, while current workers need on-site training. In terms of the research aspect, researchers and industry should work together to promote technological development and innovation. In terms of employment, new jobs will be created and existing jobs will be gradually transformed. In terms of citizens in the society, they are enabled to learn more about the relevant jobs in the industrial chain and thus think better about their personal development.

The Living Labs enable the clustering and communication of the different users that will take place during the transformation of the urban process, and it is an essential part of the Bio-Loop ZH2050 strategy. According to ENoLL (2018), Living Labs (LLs) are defined 'as user-centred, open innovation ecosystems based on systematic user co-creation approach, integrating research and innovation processes in real life communities and settings'. The strategy has three significant features, including real-life settings, active roles of users/researchers from multiple disciplines, and active collaboration (Maiullari, 2017).

In this scenario, **ordinary citizens, public actors, private actors, and knowledge institutions** all interact (fig 3.13, Steen & Bueren, 2017). In Bio-Loop ZH2050, researchers on industrial technologies and biomass are important innovators. Once they have completed their research, they need to communicate and disseminate the technology to workers in factories and farmers, and further enhance the technology based on feedback. People in the Living Labs will be able to interact with different stakeholders and gain new insights into the industry. Thus, the Living Labs will become a **medium and platform** for all people to communicate. At the same time, it is also a public space for people to meet each other.

Fig 3.13 Communication between the Living Labs stakeholders

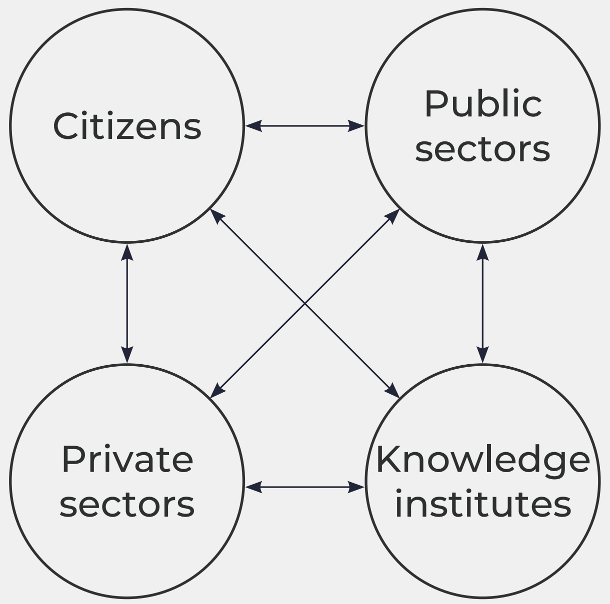
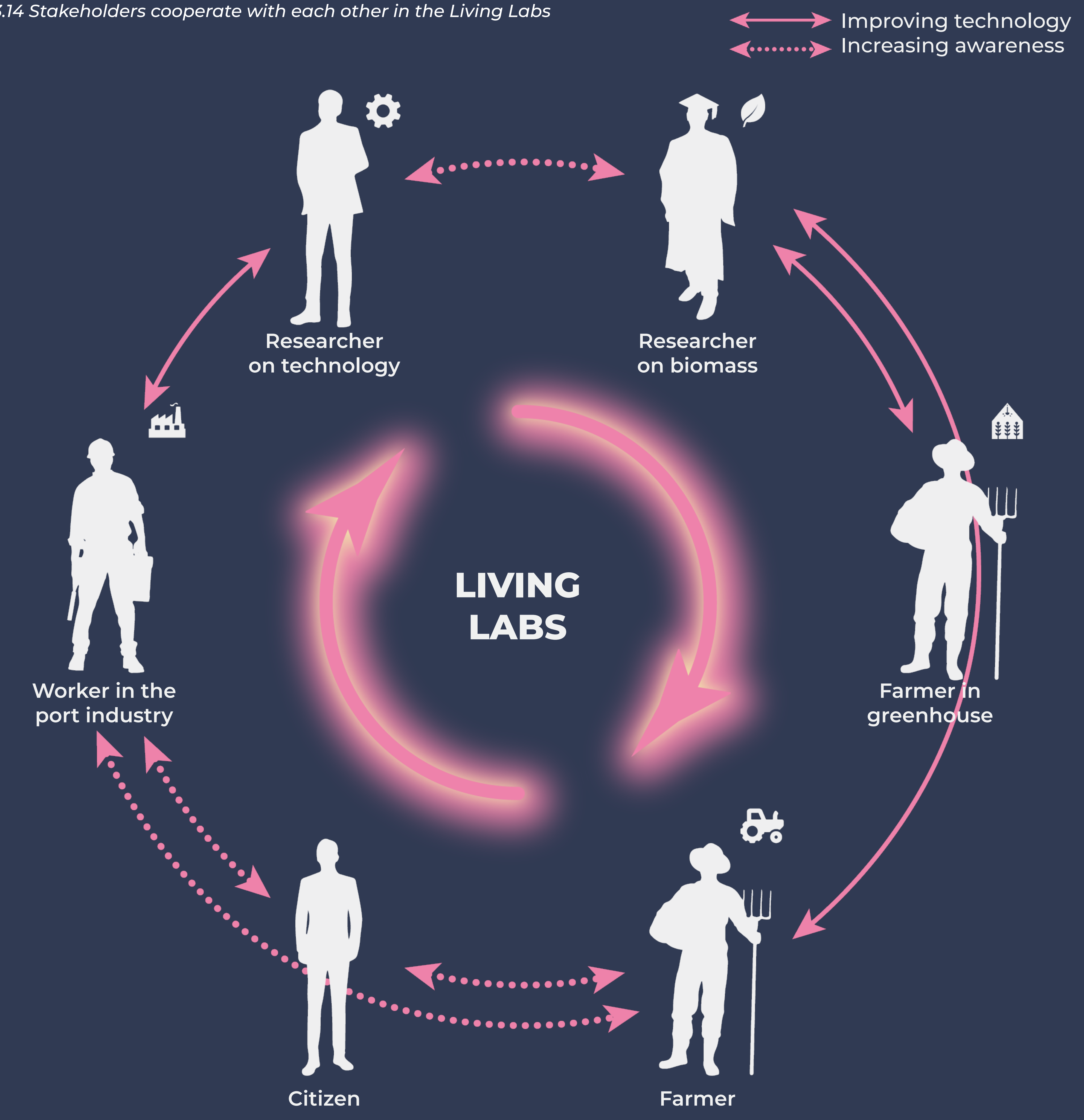


Fig 3.14 Stakeholders cooperate with each other in the Living Labs



3.3 FLOW OF MANUFACTURING

3.3.1 Current system of material flows

Today, the Netherlands has started to import biomass as one of the production feedstocks for the industry (Hoefnagels et al., 2013). However, the productivity of this part of biomass is almost negligible compared to the massive amount of crude oil. The refineries in the Port of Rotterdam have a total distillation capacity of 58 million tons (Port of Rotterdam, 2016). The crude oil they process is mainly imported worldwide. The crude oil is processed into fossil-based plastic products, which are mainly used in the Netherlands for many foods and product packaging applications. The handling of raw materials and the manufacturing process of the products are shown graphically with a section of the urbanized area.

The whole process does not form a closed loop. A large amount of residual waste from Rotterdam, of which about 50 kilos per person per year is fruit and vegetable waste, is still disposed of in landfills or incinerated. Plastic waste is still in a single-use situation, and very little can be recycled. In addition, the fossil-based industry produces large amounts of environmentally polluting carbon dioxide gas during its operations and industrial waste that is difficult to recycle. Fortunately, it can be learnt that a small proportion of the CO_2 gas produced in the factory operations is now being recycled and transported to greenhouses for use (Messenger, 2022).

Fig 3.15 Current material flow

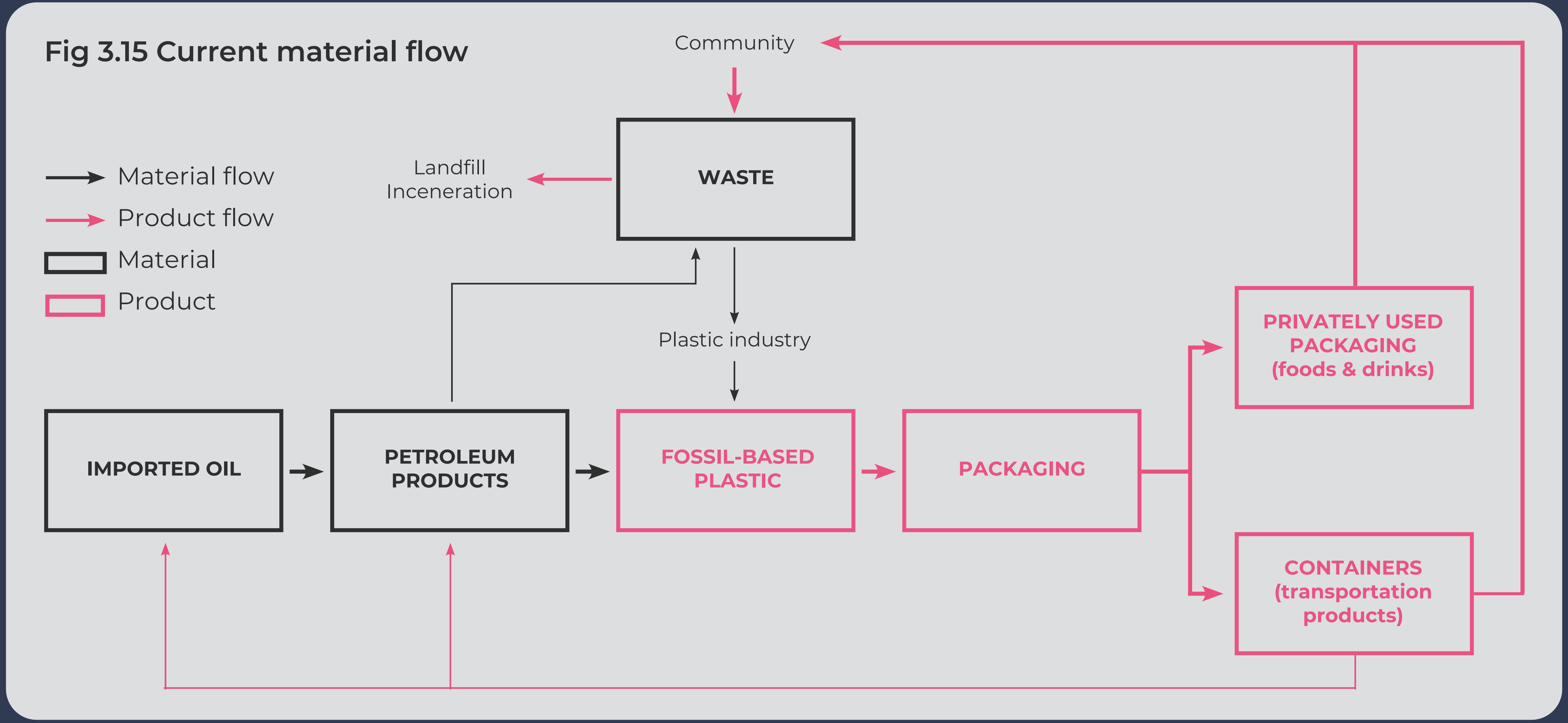
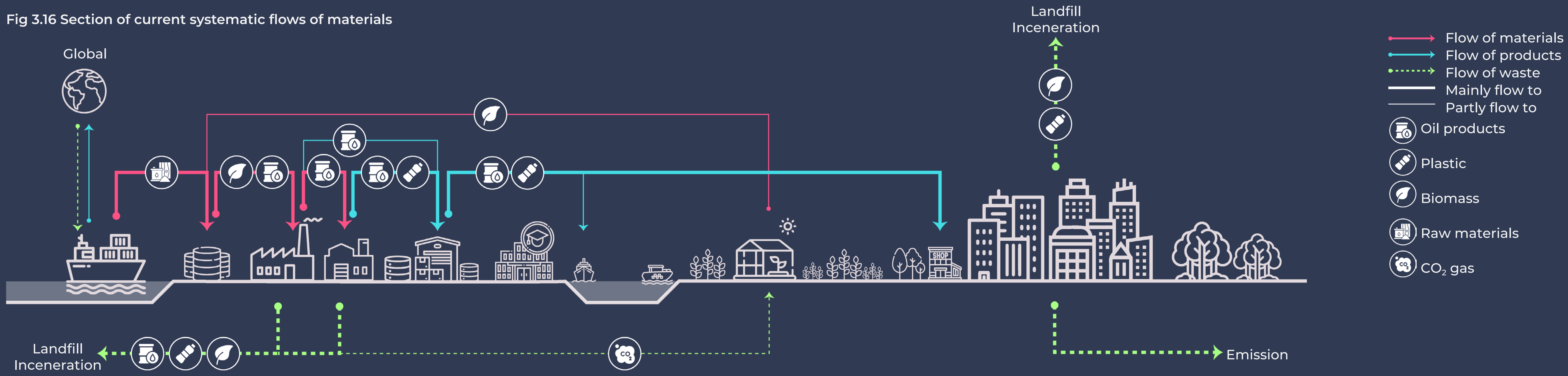


Fig 3.16 Section of current systematic flows of materials



3.3.2 Processing of plastic products

Most of the plastics used in our society today are chemically synthesised plastics. Synthetic plastics are mainly made from crude oil, natural gas or coal. Of these, the use of crude oil as a raw material for the production of plastics is the most popular as it is the most cost-effective method. (Plastic Collectors, 2020)

There are usually three steps involved in getting from raw material to plastic (fig 3.16). In the first step, the raw material is purified by putting crude oil inside a furnace and heating it. Unwanted impurities are removed, and the crude oil is transformed into different petroleum products. The second step is polymerisation, which requires a rigorous technique to control the temperature changes, thus transforming the different compounds into polymers with higher molecular weights. Finally, compounding all melting materials and using moulds to shape the plastic products. All of these steps can be done in a plastics manufacturing factory, except for the first step, which must be done in a refinery.

Compared with the process of using biomass for bio-based plastic production, their methods are generally the same (fig 3.17). The different raw materials, such as crops and sugar beets, must be cracked into chemical intermediates at high temperatures. It can also be done in the refinery. This provides an idea for the transformation of the oil refinery: we only need to upgrade the equipments, but not demolish and build a new building. Once the intermediates have been produced, they can be transferred to the individual factories to polymerise the plastic products. This process also generates by-products such as biofuels, which can be utilised in the same process.

Fig 3.17 Processing of chemical plastic products

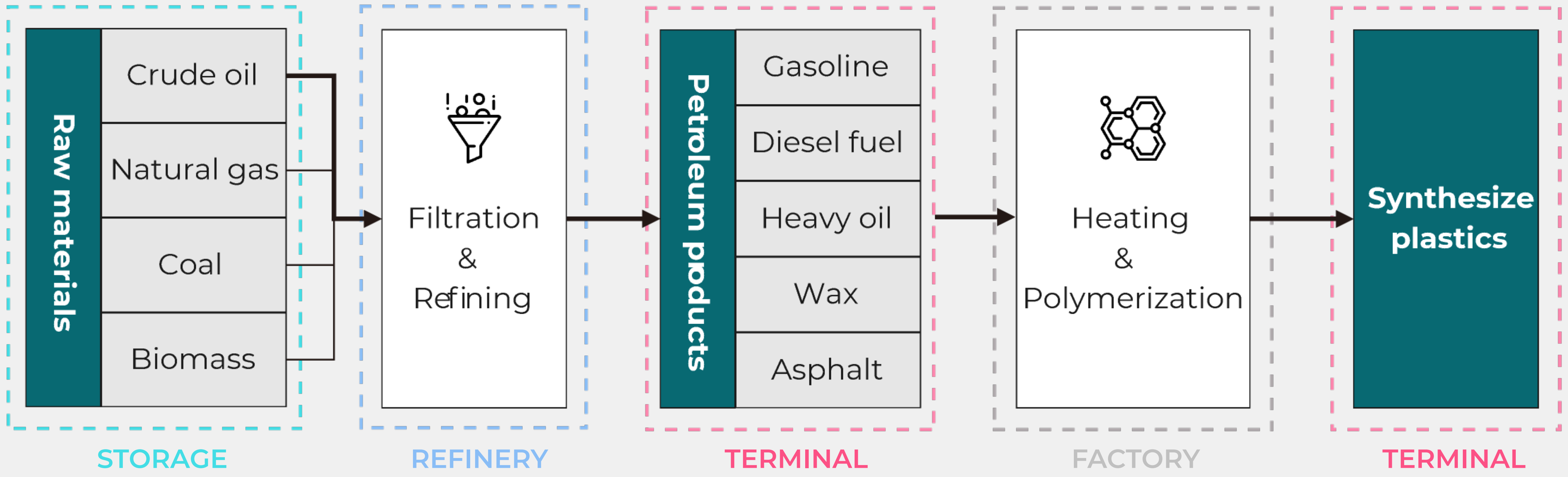
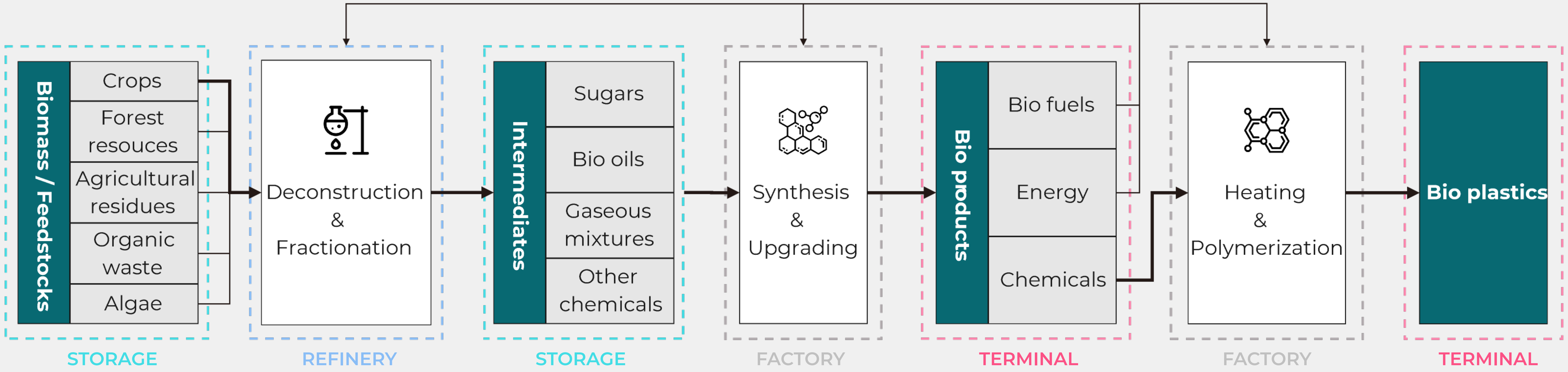
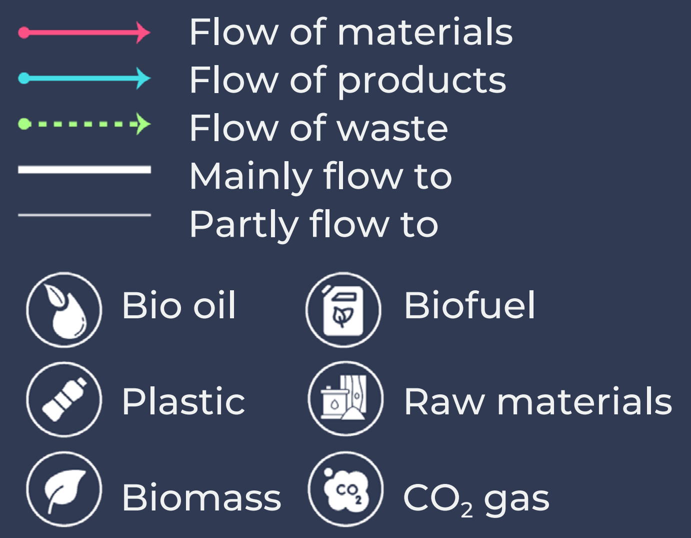


Fig 3.18 Processing of bio-based plastic products



3.3.3 Creating circularity of a bio-based system



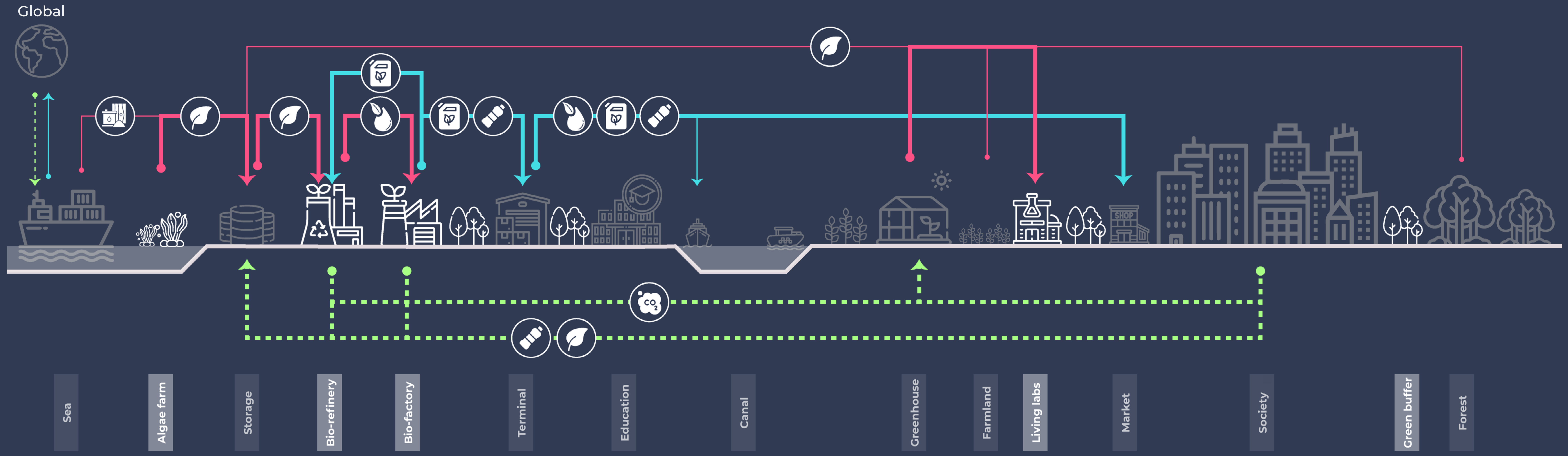
As mentioned earlier, we need to use biomass as the new raw materials for a bio-based system for processing. Biomass will be transported by truck to depots in the port for storage.

The equipment in the refineries and other related factories will be upgraded to handle biomass. This is the first step in an industry-wide transformation to bio-based manufacturing. By gradually converting refineries to bio-refineries that process biomass rather than crude oil, other manufacturing industries will be prompted to use the intermediates generated by biomass to produce their own products. Biomass feedstock will flow through bio-refineries and bio-factories to form bio-based plastic products. The biofuel produced during this process can then be used in the bio-refinery.

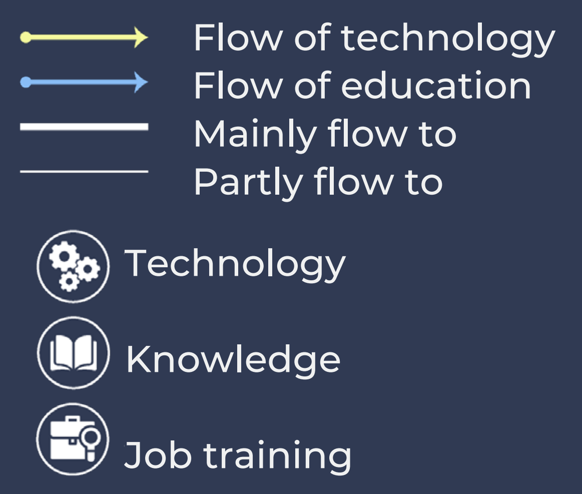
Once the plastic products have been used in society, they are recycled and processed again to form new plastics, thus forming a circular bio-based system. The CO_2 gas produced during the manufacturing process is also collected properly and transported to greenhouses for use.

All our strategies are intended to provide a context for the manufacture of bio-based products and to minimise waste generation and disposal. The aim is to create a new bio-based circular economy based on the operation of biomass raw materials.

Fig 3.19 Systematic flows of materials of future bio-based plastic industry



3.3.4 Invisible flows on the social side

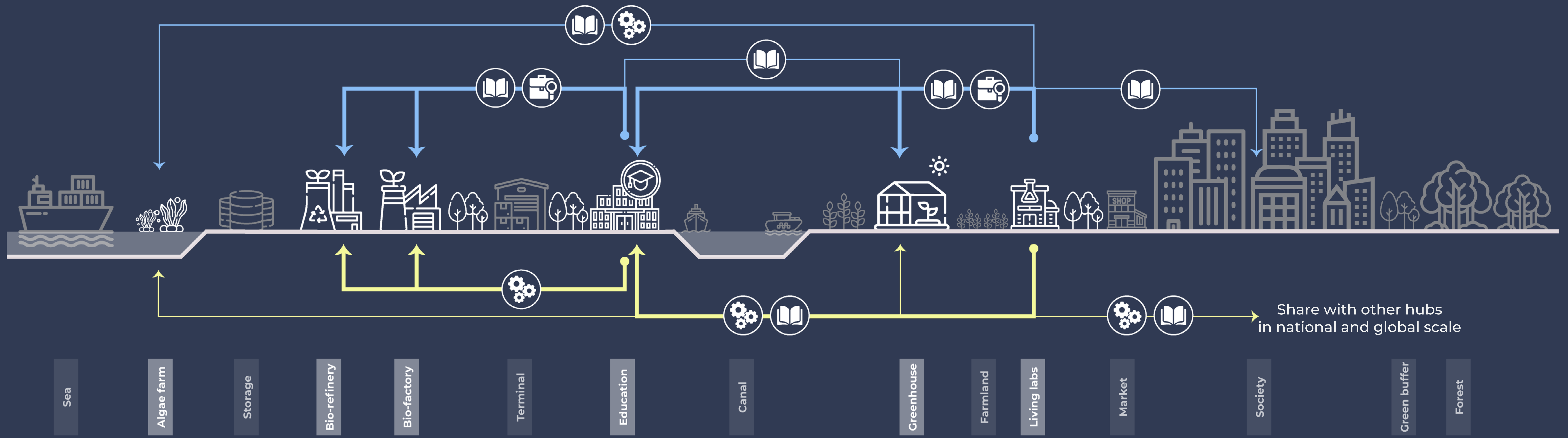


In order to complement the transformation of industry, development in educational and research institutes, professional transformation within the industry, and an increase in social awareness are all necessary. It is hoped that the social transformation will be achieved through collaboration and communication between the various sectors (fig 3.11).

The innovation dock in the RDM campus within the port will work with the Living Labs and other research institutions to provide the new technologies needed for industry transformation, which will lead to new job opportunities. Experts from these institutions will provide **on-site training** for workers in the port to help their career transition. Educational institutions can help educate more young students, enabling more young people to enter the bio-based industry in the future. On the other hand, production techniques regarding biomass will also be improved in research institutes. Research results can be shared with the different biomass production areas to **facilitate biomass production**.

The Living Labs act as an intermediary for communication between all sectors, and the social benefits it generates will spread to the development of awareness among the general public. By holding events that attract people from all walks of life to the Living Labs to disseminate knowledge in various fields, the general public will be able to learn more about the subject.

Fig 3.20 Systematic flows on the social side of future bio-based plastic industry



3.4 SPATIAL POTENTIAL OF BIOMASS

3.4.1 An overview of biomass possibilities

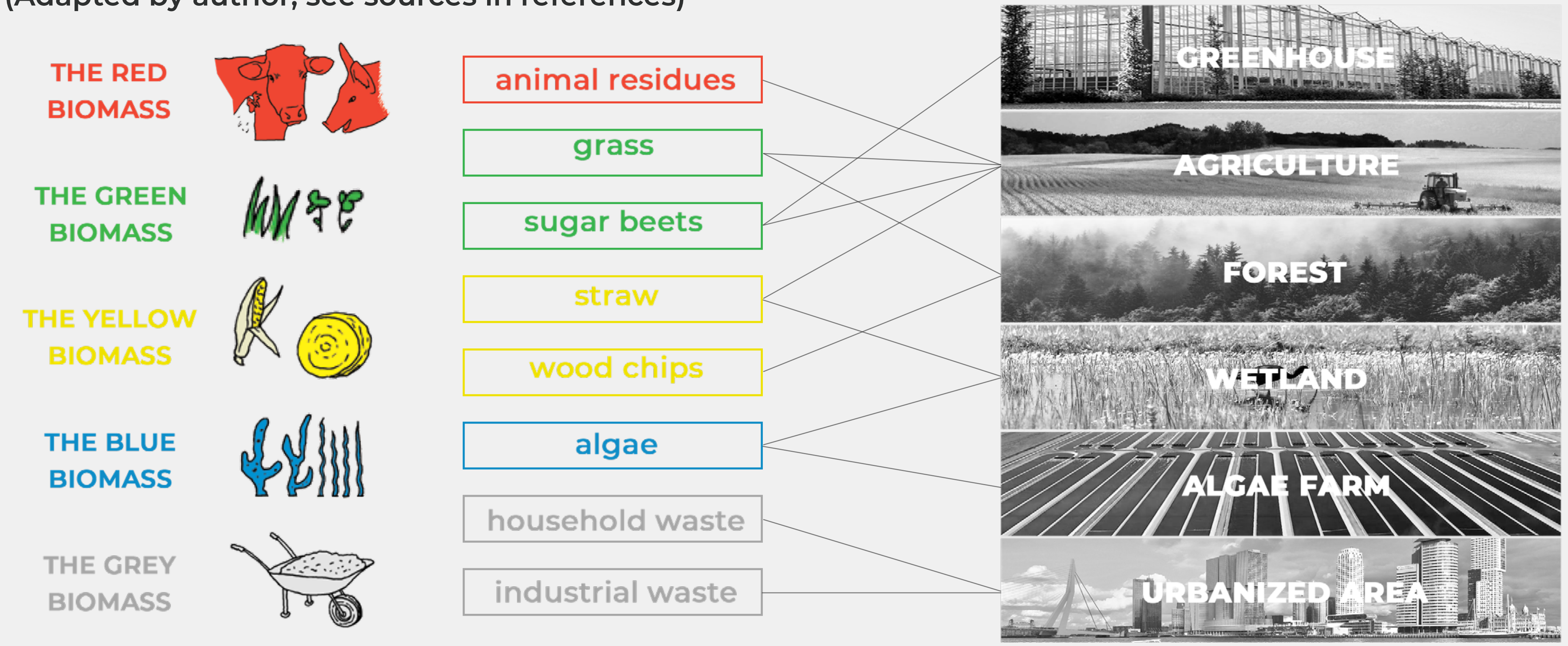
Research from Lange et al. (2016) summarises the different types of biomass and suggests that they can be roughly categorised by colour. Accordingly, we focus on the following five types of biomass (fig 3.21): 1) the red biomass from animal product residues; 2) the green biomass from grassland; 3) the yellow biomass from agriculture and forestry; 4) the blue biomass from the sea or other water bodies; and 5) the grey biomass comes from household waste and industrial waste.

All biomass has a solid potential to collect organic production and is used as feedstock for bio-based industries.

In Zuid-Holland, there are 1,454 km^2 of agricultural land and 59 km^2 of horticultural land, which represents almost 45.7% of the entire Zuid-Holland area (Statistics Netherlands, 2022). The famous greenhouses cluster, the Westland, is also closely associated with the port. This will be an essential source of biomass for the Port of Rotterdam from Zuid-Holland.

Due to the coastal location of Zuid-Holland, the North Sea also provides a possible development resource for algae production. At the same time, large cities with high population densities, such as Rotterdam and Den Hague, are able to provide a large amount of household waste.

Fig 3.21 Different biomass possibilities and spatial implications (Adapted by author, see sources in references)



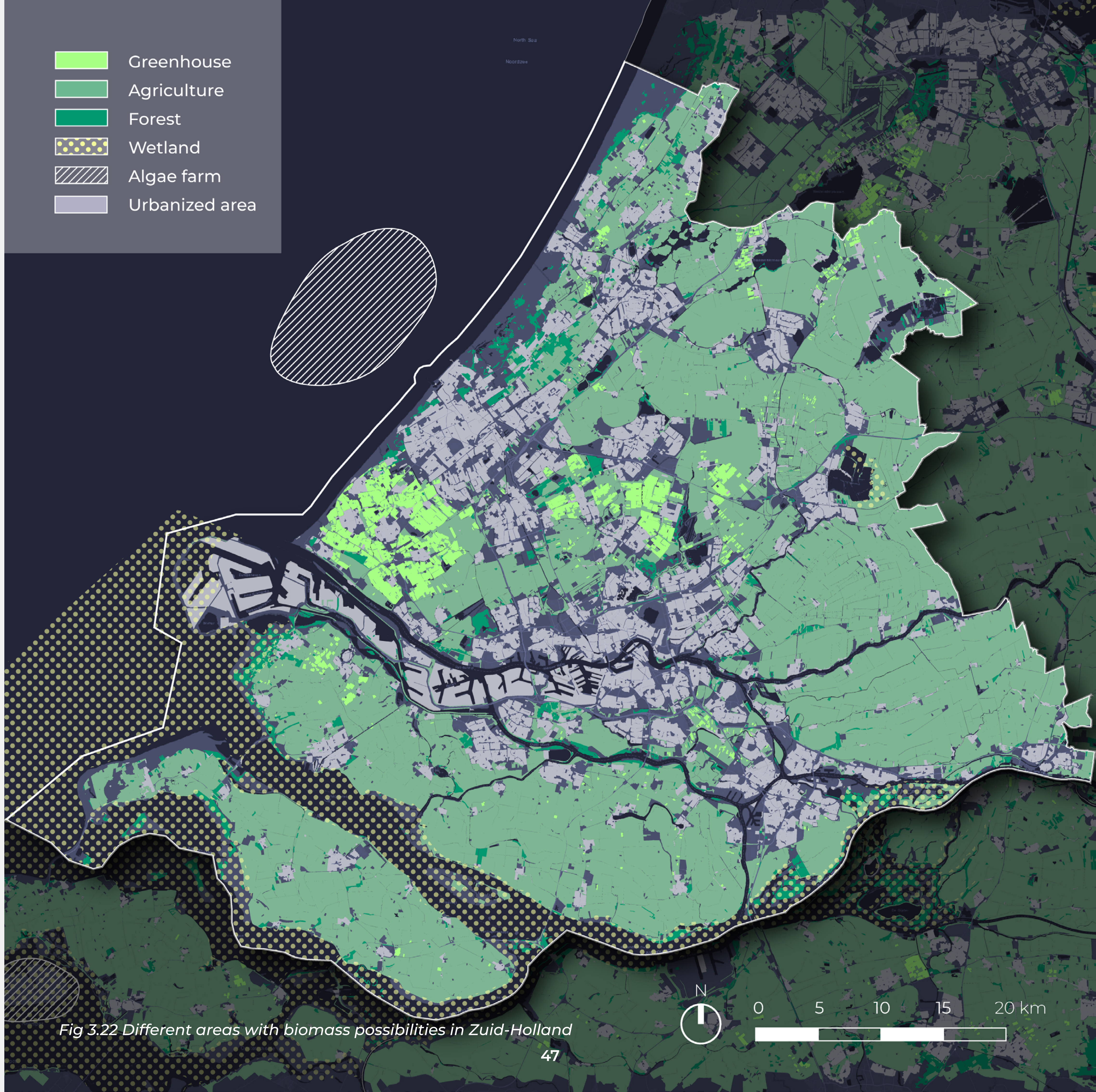


Fig 3.22 Different areas with biomass possibilities in Zuid-Holland

3.4.2 Efficiency of biomass materials

In research from Hoogwijk et al. (2013), the growth of biomass on a global scale is about 150 billion tonnes, which is five times the global energy consumption. Thus, biomass shows great potential for utilisation and development.

However, most biomass energy comes from natural resources, such as forests, which are difficult to exploit due to the need to conserve biodiversity. On the other hand, the use of harvestable farm-sourced biomass should not threaten the food market. Therefore, the search for efficient biomass materials is necessary.

SUGAR BEETS: GREENHOUSES VS FARMLANDS

In the Netherlands, sugar beet is an excellent agricultural resource used for biomass. As a temperate crop, sugar beet is able to provide cellulosic material and represents a great potential for biomass (Dale, 2003).

Fig 3.23 Sugar beets in greenhouse and farmland

Sugar beet is traditionally an arable crop grown outdoors but receives seasonal constraints and is not sufficiently productive. According to Elings et al., growing sugar beet in greenhouses is technically feasible and efficient (2012). However, due to the higher costs, forming an agglomerative scale effect of cultivation would lead to a higher potential of sugar beet as biomass material.

TRENDS IN THE USE OF BIOMASS

Currently, the use of biomass materials is focused on substances that can be converted into sugars and starches, including sugar beets and crops. In recent years, the focus on biomass has shifted towards cellulosic materials that can produce ethanol, such as wood and straws (Sanders & van der Hoeven, 2008).

Due to the unsustainability of these materials, recycling residues waste will be the trend in the future. In addition, the use of marine renewables is coming into view as one of the materials with future potential.

AGROFORESTRY: A STRATEGY FOR INCREASING YIELDS

Planting trees or shrubs on farms can provide healthier and more nutrient-rich soil, thereby increasing the yield of agricultural land (Soil Association, 2021). As the roots of the trees can penetrate deeply into the soil, they also serve to protect the soil and water.

There are currently two main types of forestry: silvo-pastoral agroforestry, which combines animal husbandry with forestry, where the animals feed the trees, and silvo-arable agroforestry, where the trees provide food and shade for the animals. The latter combines planting with forestry to help increase yields.

Fig 3.24 Agroforestry

COOPERATE WITH FOOD MARKET

As the global demand for food keeps rising, we should not take more food resources directly for biomass. More importantly, farming produces organic matter for the soil. This is beneficial for plant growth, such as biomass cultivation. Therefore, agriculture and biomass cultivation are very effective ways of working together.

Furthermore, according to Sanders & van der Hoeven (2008), the amount of agricultural waste doubles with food production, resulting in the world producing 10 billion tonnes of biomass.

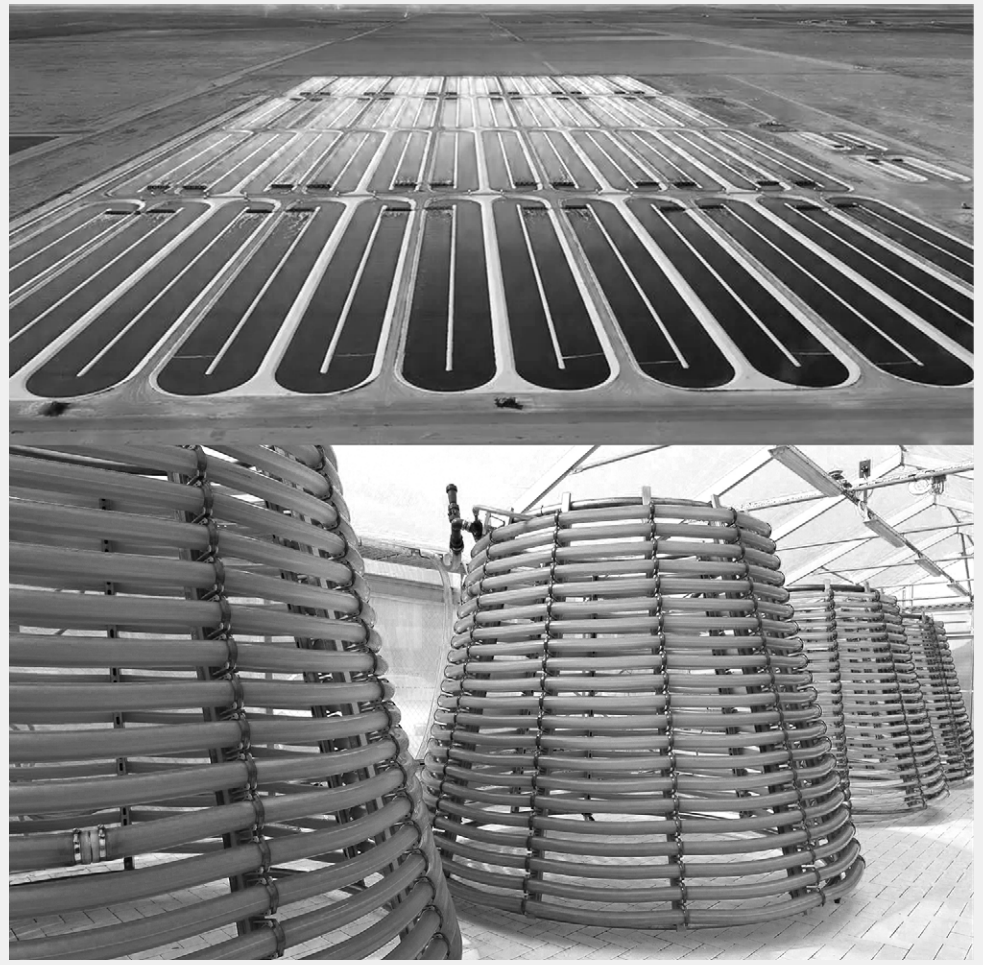
In the Netherlands, by-products from agriculture and food production can often be recycled. The large amount of residue waste generated by livestock farming has a high recycling potential. Therefore, using agricultural waste as biomass material is an essential strategy.

ALGAE AS POTENTIAL BIOMASS

The biotechnology of algae and even microalgae has continued to develop in recent decades. In recent years, large-scale commercial production of algae has been identified as a renewable and environmentally sustainable strategy for the production of biomass materials (Benedetti et al., 2018).

In Zuid-Holland, several companies are already producing algae on a large scale, with their algae farms set up in the North Sea. As algae production requires only sunlight, water and carbon dioxide, efficient production on a large scale is possible in the future.

Fig 3.25 Algae farm



3.4.3 PRESERVATION OF BIODIVERSITY

The natural environment occupies an unique and important place in the Netherlands. Landscape is defined in the European Landscape Convention (ELV) as 'an area, as perceived by humans, whose character is determined by natural and/or human factors and the interaction between them' (Council of Europe 2000, Article 1). Humans must carry out socially productive and necessary activities without destroying local biodiversity. Therefore, we need to adopt strategies that balance the emphasis on conserving the landscape with the efficient production of biomass materials.

A comprehensive understanding of the legislation relating to nature conservation is essential. There are already many initiatives to protect nature in the Netherlands, the ultimate of which is the differentiation of resource areas and the hierarchy of conservation measures (Ministry of Agriculture, Nature and Food Quality Department of Nature & Ministry Of Agriculture, 2005). According to Tisma et al. (2019), all current resource protection regimes in the Netherlands can be divided into two categories: hard and soft protection.

HARD-PROTECTED POLICIES

A policy of hard protection means that no anthropogenic disturbance is allowed in the area.

• **Natura 2000**: It is part of a network of nature reserves in the European Union that are protected under the Birds Directive (1979) and the Habitats Directive (1992), which indicates the types of habitat and species to be protected.

• **Natuur Netwerk Nederland**: It is a policy established to protect the natural development of the Netherlands. Natural areas are connected through the acquisition, development and management of adjacent agricultural land.

• **Wood Standing**: Legislation is passed to control the felling of trees. Protects mainly woods covering ten acres or more, shelterbelts to protect agricultural land and plantations for productive use.

• **Coastal Foundation**: It provides strict landscape protection for the coastline and prohibits the construction of buildings.

SOFT-PROTECTED POLICIES

A policy of soft protection allows for appropriate anthropogenic activities when the value of the activity and its environmental impact is fully assessed.

• **National Landscapes**: It aims to protect the most important qualities of the landscape while continuing to prepare the space for future development.

• **Heritage**: It focuses on preserving the core landscape qualities of the heritage and has the potential for development.

• **UNESCO Areas**: World Heritage sites are protected by government space as long as they retain or enhance the special universal values associated with the quality of the Caution.

• **Archaeological Monuments**: The aim of conservation is to preserve the archaeological heritage in situ as far as possible, even if it is underground.

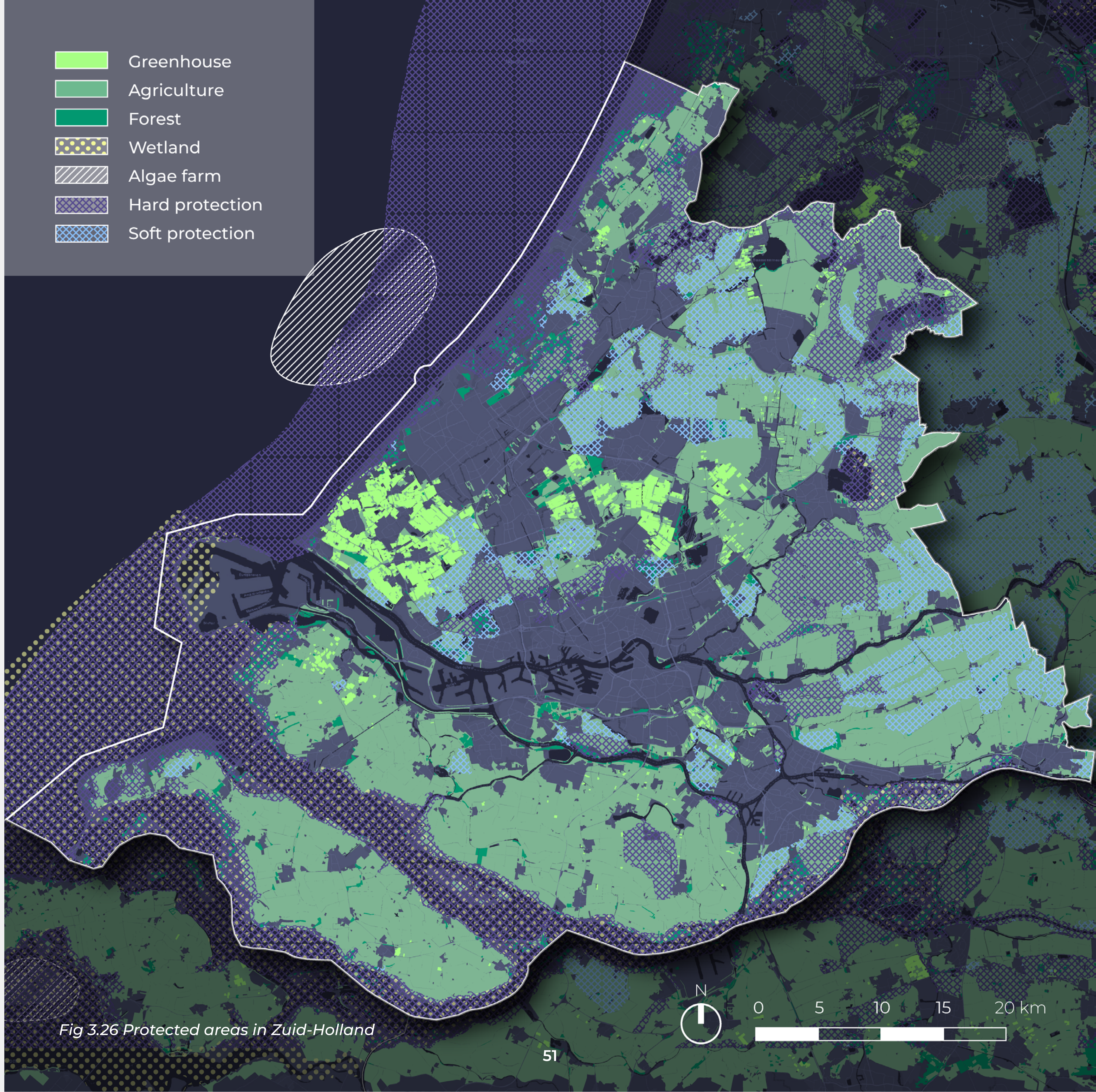


Fig 3.26 Protected areas in Zuid-Holland

3.4.4 Spatial strategies of biomass productions

Based on the above analysis, Zuid-Holland has the capacity to supply biomass to the Port of Rotterdam. It could enable the Port of Rotterdam to evolve from a fossil-based industrial area, which is still highly dependent on global markets, to **a more independent bio-based circular economy port area**.

Our spatial strategy is to follow the existing truck road network, which is the most efficient way to transport biomass raw materials and delineate available biomass production areas. The selected biomass production areas form a good spatial connection to the Port of Rotterdam and thus may provide a stable feedstock transport for the industry. Moreover, **different strategies for biomass products** will be adopted for the different protected areas.

STRATEGIES FOR HARD PROTECTION

- Recycling of organic waste from different areas as a raw material for biomass.
- Any development of the space is prohibited, and the existing ecosystem is strictly protected.

STRATEGIES FOR SOFT PROTECTION

- Recycling of organic waste from different areas as a raw material for biomass.
- Planting trees to build agroforestry and thus increase crop productivity. At the same time, the selection of trees needs to consider the conservation of biodiversity.
- The development of space for the production and research of biomass is appropriate.

STRATEGIES FOR OTHER BIOMASS PRODUCTION AREA

- Recycling of organic waste from different areas as a raw material for biomass.
- Planting trees to build agroforestry and thus increase crop productivity.
- Encouraging farmers to grow different crops to balance their output for the food market and biomass production.
- Develop and build spaces to help biomass production and research, such as the Living Labs.

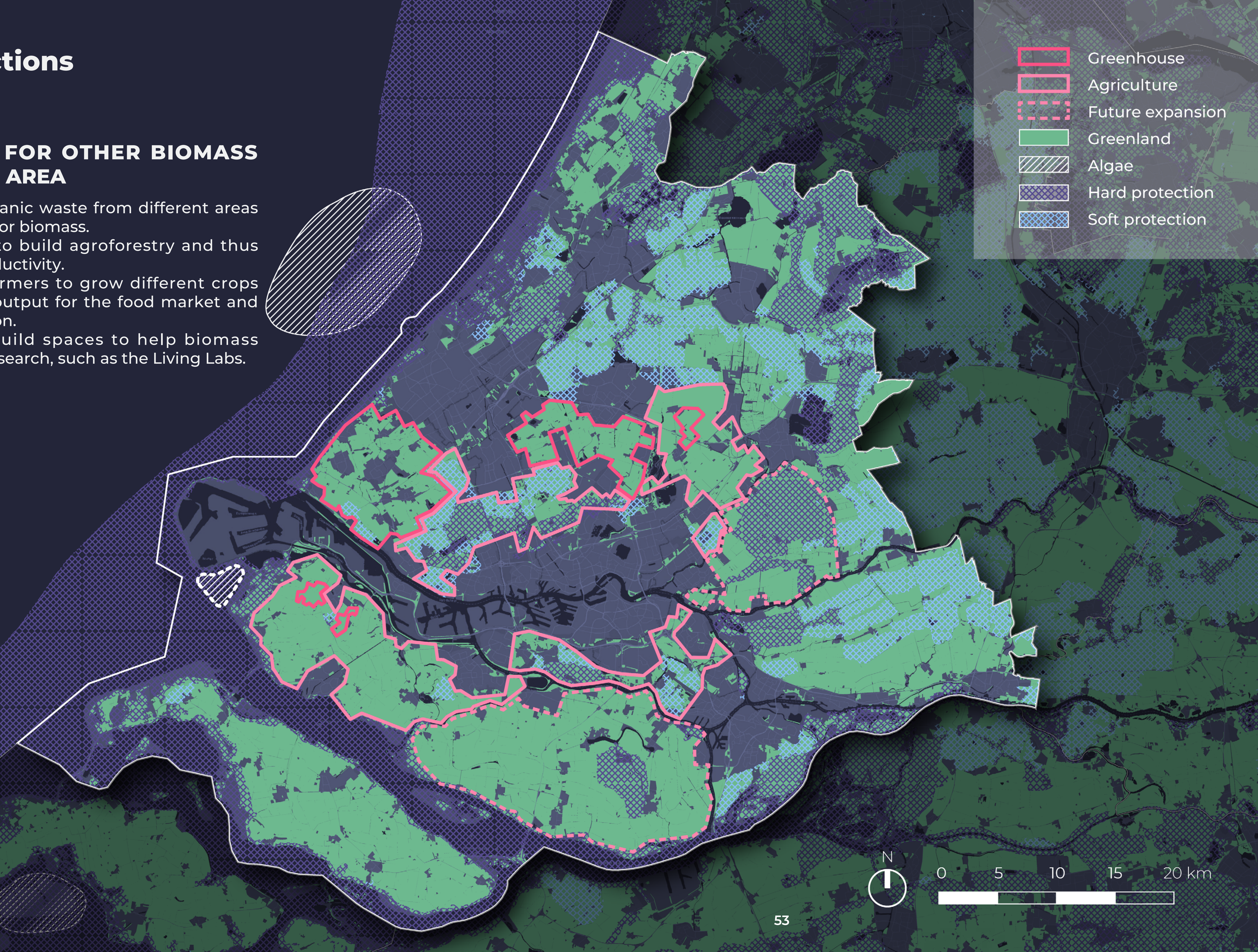


Fig 3.27 Potential of biomass production area in the Bio-Loop ZH2050

3.5 CONCLUSIONS

While the port region and province of Zuid-Holland highly hold potential for the development of a circular bio-based plastic industry, some weaknesses and threats have been identified that need to be considered when formulating the vision and strategy.

The Port of Rotterdam and the province fulfil an important social-economic position because of the enormous existing employment power due to the port industries but also regarding the agriculture, greenhouses, and grasslands. Moreover, a lot of existing innovation potential can be found. Also, the existence of complete infrastructures enables the restructuring of the existing system.

Next to that, the global position of the port on the trading market serves as a huge opportunity potential. Furthermore, the province holds immense biomass potential since various biomass sources are located here. Another aspect is the proximity to educational institutions related to the bio-based economy and offers for different educational levels and research possibilities.

Nevertheless, there is currently a high dependency on imported raw materials globally. The goal is to minimise the global dependencies and enhance local production. In addition, the space for new infrastructures in the region is insufficient due to high urbanisation. Finally, the current system of material flows is linear, including waste shipments outside of Europe and landfilling.

As factors that are difficult to influence, climate change and pollution, which hold uncertainties for future conditions, are important to mention. Regarding the employment transition, the current predominant higher age of people working in the industries might be problematic. Ultimately, there is competition on different scales, including the global competition in the bio-based economy and spatial competition concerning land use and ensuring sustainable development.

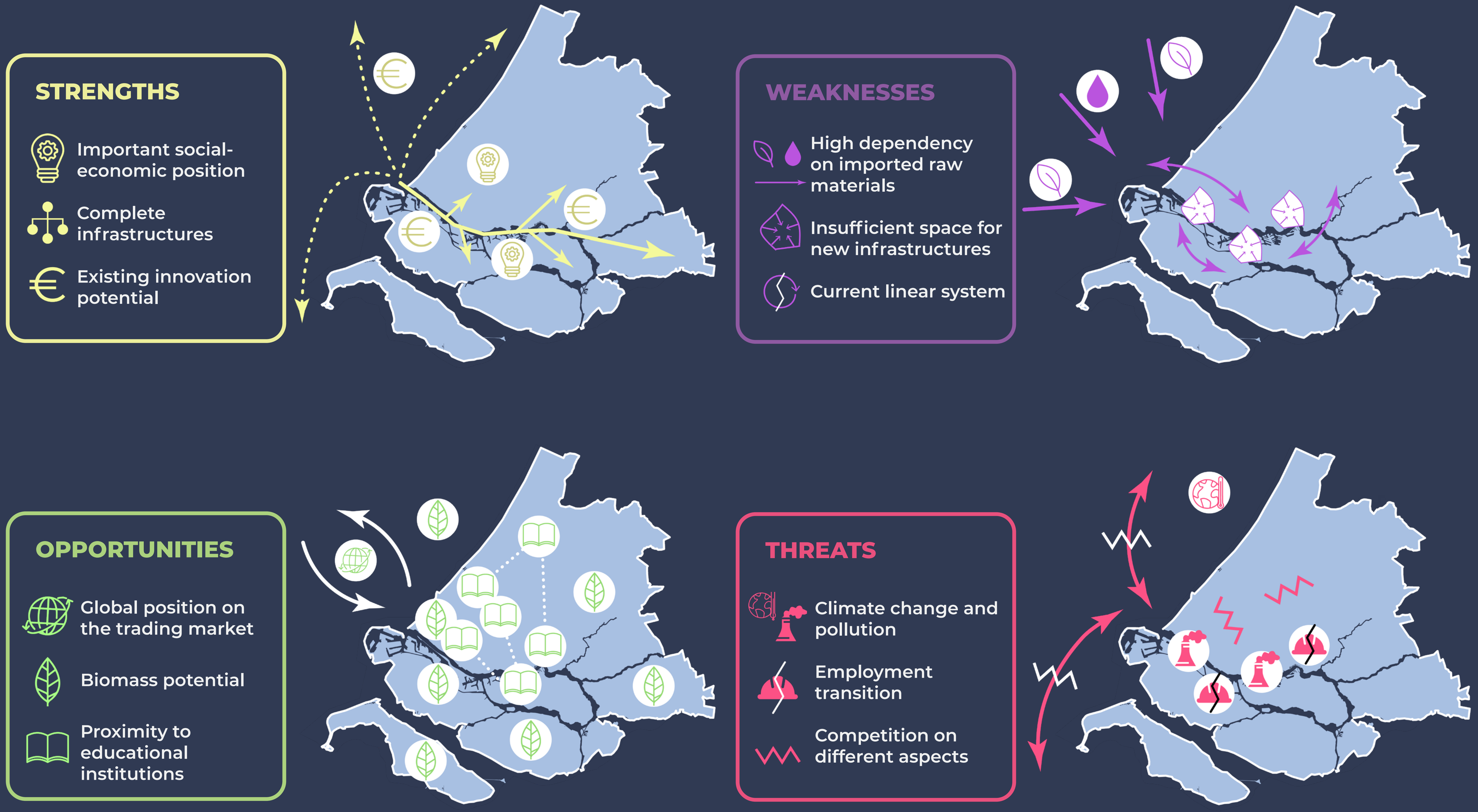


Fig 3.28 SWOT analysis

CHAPTER 4
VISION

A Bio-Loop effecting the whole region

4.1 VISION STATEMENT

4.1.1 By 2050...

The vision focuses on the Port of Rotterdam and the province of South Holland in 2050. Until then, there will be a circular economy of the bio-based plastic industry developed which is based on local and national biomass supply. The region and port will be adaptive to future demands and more independent whilst being able to improve constantly. The whole transition process is inclusive regarding social, economic, and environmental aspects, and improves the biodiversity as well as life and spatial qualities of the region.

The port region acts hereby as an innovation and testing cluster that enables the knowledge transfer to trigger the transformation of other (bio)-plastic hubs within the Netherlands and ultimately worldwide. Not only the circular production and efficient recycling of bio-based plastics and waste will be improved but also the cultivation of biomass will be optimised.

HOW?

This will be achieved by the restructuring of the manufacturing and flow systems, and the implementation of a Bio-Loop ZH2050 in form of a green belt related to the port and different clusters within the biomass production areas.

Technically, the new green belt infrastructure connects biomass supply, the Living Labs for experiments, and bio-based manufacturing in the port area as a whole. Socially, within this belt, there will be space where citizens, researchers, and workers from companies come together to advance research and to get educated within the field of the bio-based circular economy. Furthermore, the Living Labs play an important role in raising awareness about the own consumption behaviour. Finally, the green belt helps to break the barriers between port, city, and region by connecting the different areas on various scales.

Although biomass production is being increased, great emphasis is placed on not competing with the food supply. In addition, environmental conditions are being improved by diversifying agriculture and implementing agroforestry.

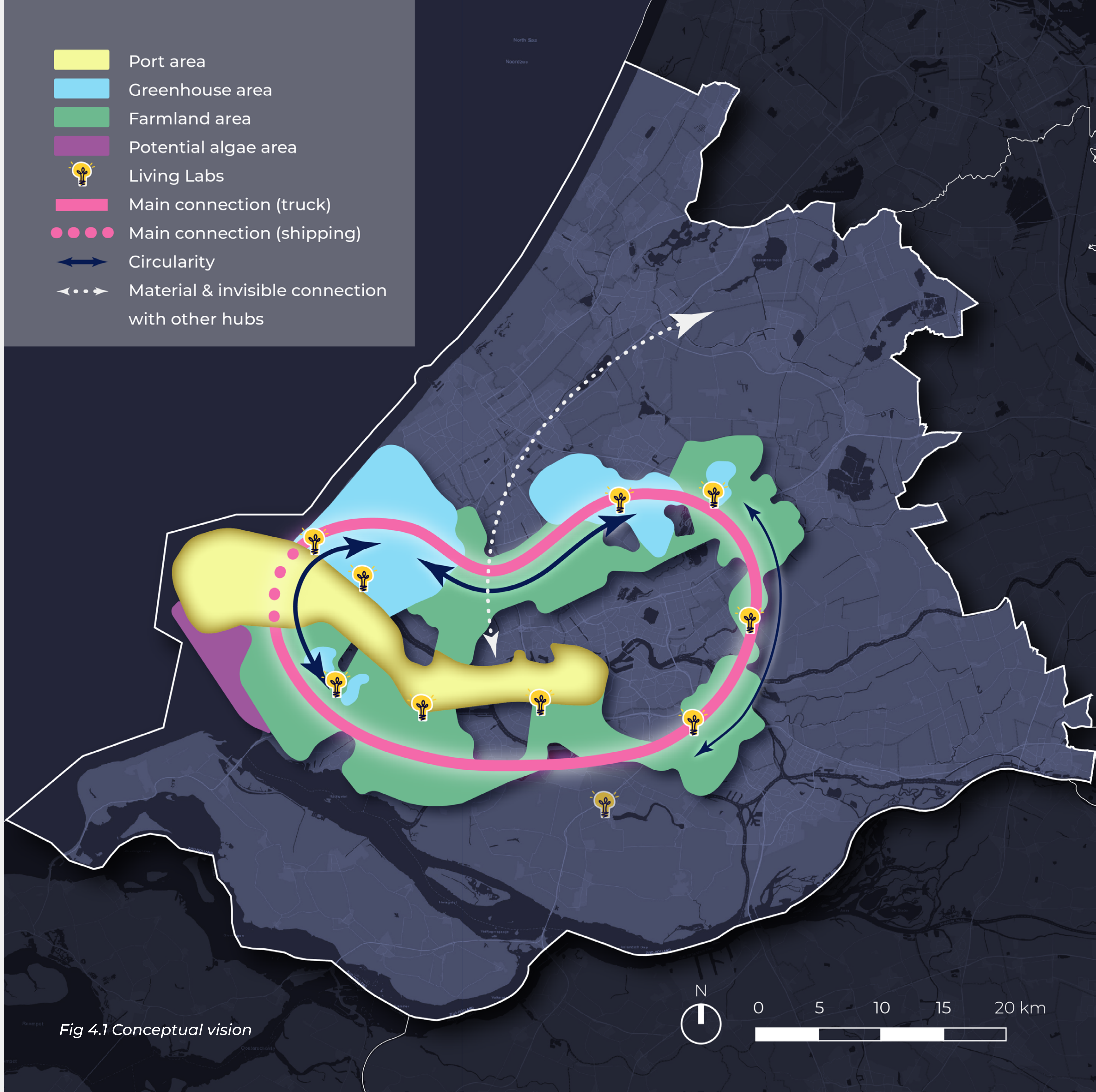
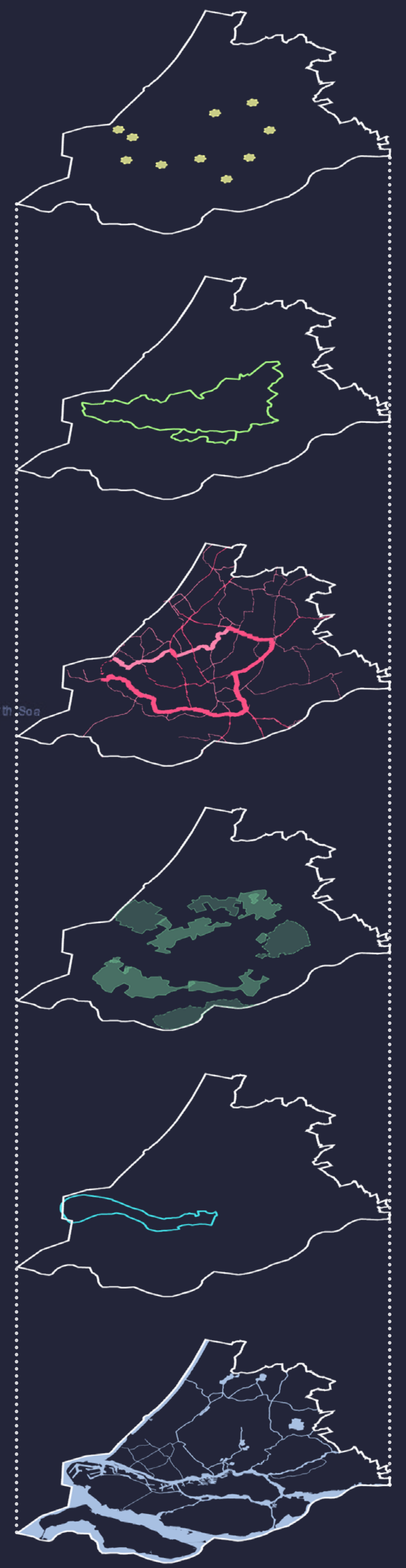


Fig 4.1 Conceptual vision

4.1.2 Spatial concept

Fig 4.2 Layers of vision



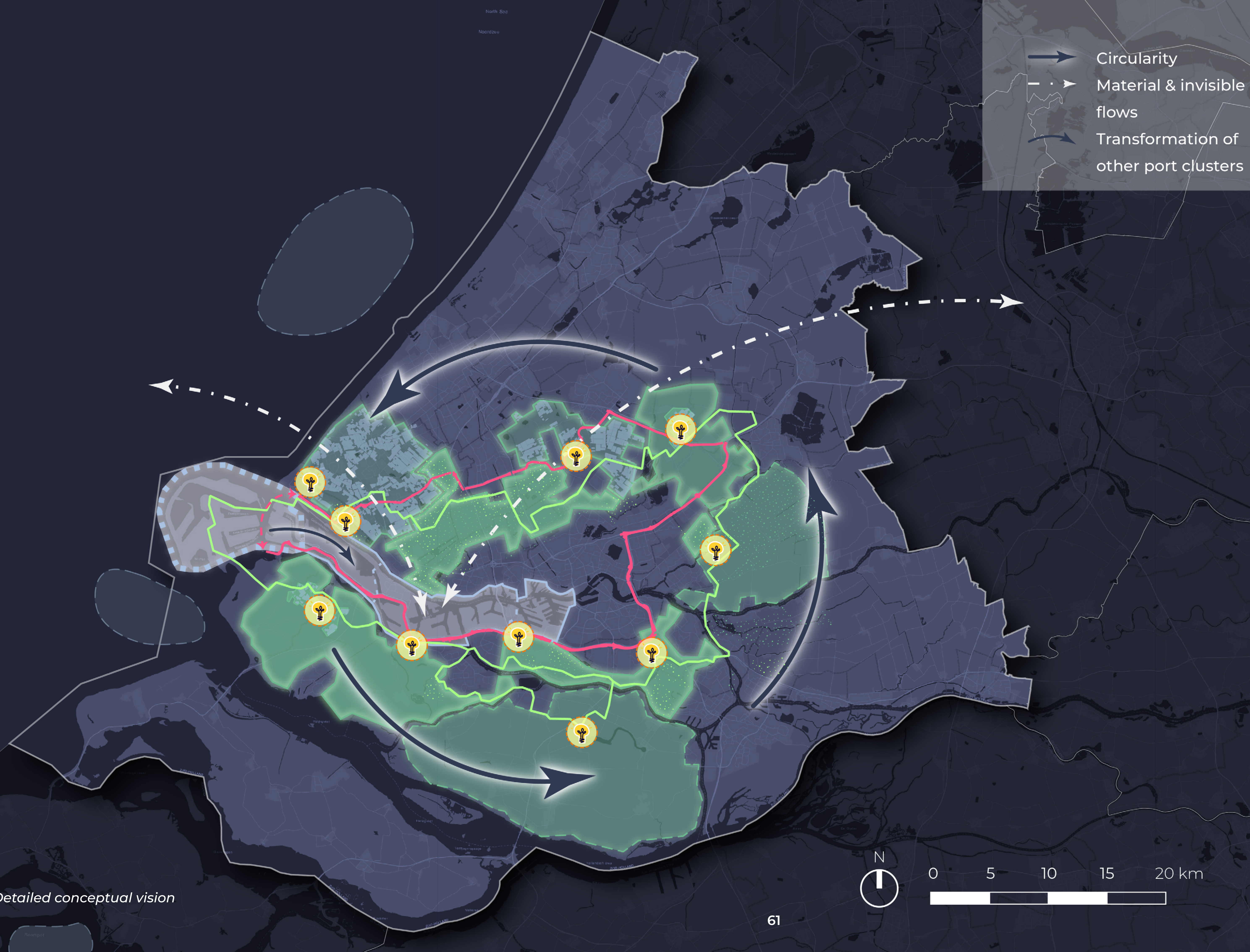


Fig 4.3 Detailed conceptual vision

4.1.3 Illustrated vision

The collage (fig 4.4) visualizes the **connection of different clusters** through the Bio-Loop ZH2050 and the **exchange** between different interest groups. Since currently the various sectors are separated spatially, we envision a green Bio-Loop that brings the areas together, which will be tangible through attractive **biking and pedestrian paths** and the establishment of **the Living Labs** along the loop.

By experiencing the changing landscape and port area, citizens gain a broader understanding of the processes related to the bio-based economy. Moreover, the **identification** with the region and awareness about **job opportunities** within the bio-based industry can be fostered.

Fig 4.4 Collage of vision

4.2 PHASING

4.2.1 Phasing timeline

The vision covers the timeframe until 2050 whilst setting three main phases with strategic goals to be reached within each phase (fig 4.5). The overarching goals are complemented by a detailed set of actions (fig 4.6) with different milestones for various spatial strategies. The five spatial strategies which will be explained in detail in chapter 5 (fig 5.6) are categorized into the three subtopics 'technology', 'knowledge' and 'social'. Furthermore, the developments in each phase are visualized in vision maps following the detailed timeline.

The first phase is dedicated to starting the transition of the bio-based plastic industry and creating the conditions for establishing a bio-based plastic industry in the Port of Rotterdam. During the second phase from 2030 to 2040 steps are taken to increase the circularity of the bio-based plastic industry.

Lastly, in the third phase, the transformation of other industries and hubs on national and global scale is triggered and the bio-based plastic industry in the port will reach carbon neutrality.

2022 – 2030

- Setting the conditions for the transformation of port industry, agriculture and logistics towards a circular bio-based economy
- Establishment of the Living Labs as places for experimentation, networking and awareness creation
- Creation of public accessible connections between clusters within Green Belt
- Start of biomass and waste collection, processing, and experimentation on technology to produce bio-plastics

2030 – 2040

- Production of bio-based plastics in larger scale using national biomass resources
- Circular loop of biomass and bio-plastic production, processing and recycling of bio-plastics
- Active research and education in Innovation Dock, the Living Labs and application of knowledge in on-site trainings
- Job transition for employees from former fossil-based plastic industry to bio-based plastic industry

2040 – 2050

- Increasing establishment of infrastructure for biomass processing reacting to demand of bio-based products
- Carbon-neutrality for the port area
- Knowledge exchange on a worldwide scale
- Optimised production of biomass on local and national level whilst secured biodiversity and habitat protection

Fig 4.5 Phasing of strategic goals

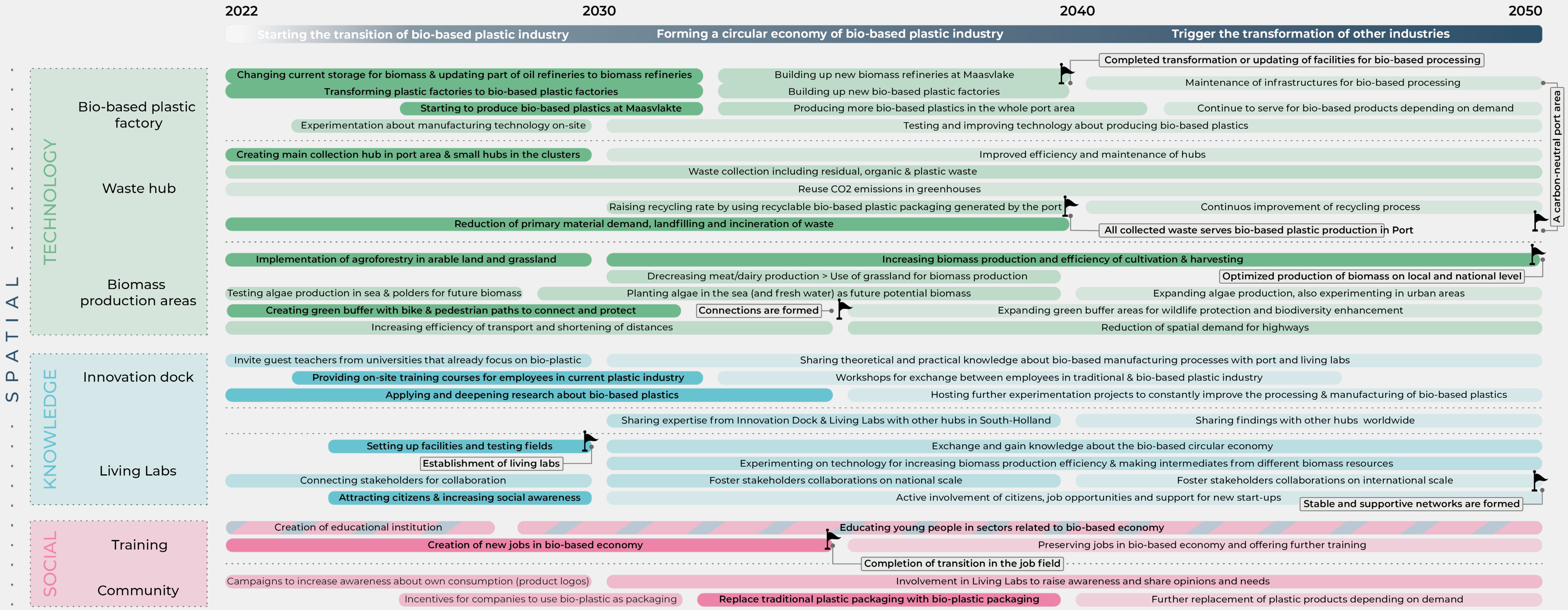


Fig 4.6 Timeline of specific actions for spatial strategies

4.2.2 Vision 2030

The first phase begins with the **transformation of the current infrastructure** of fossil-based plastic industries to bio-based plastic industries at Maasvlakte as well as of storage and refineries in other parts of the port to serve the biomass storage and processing.

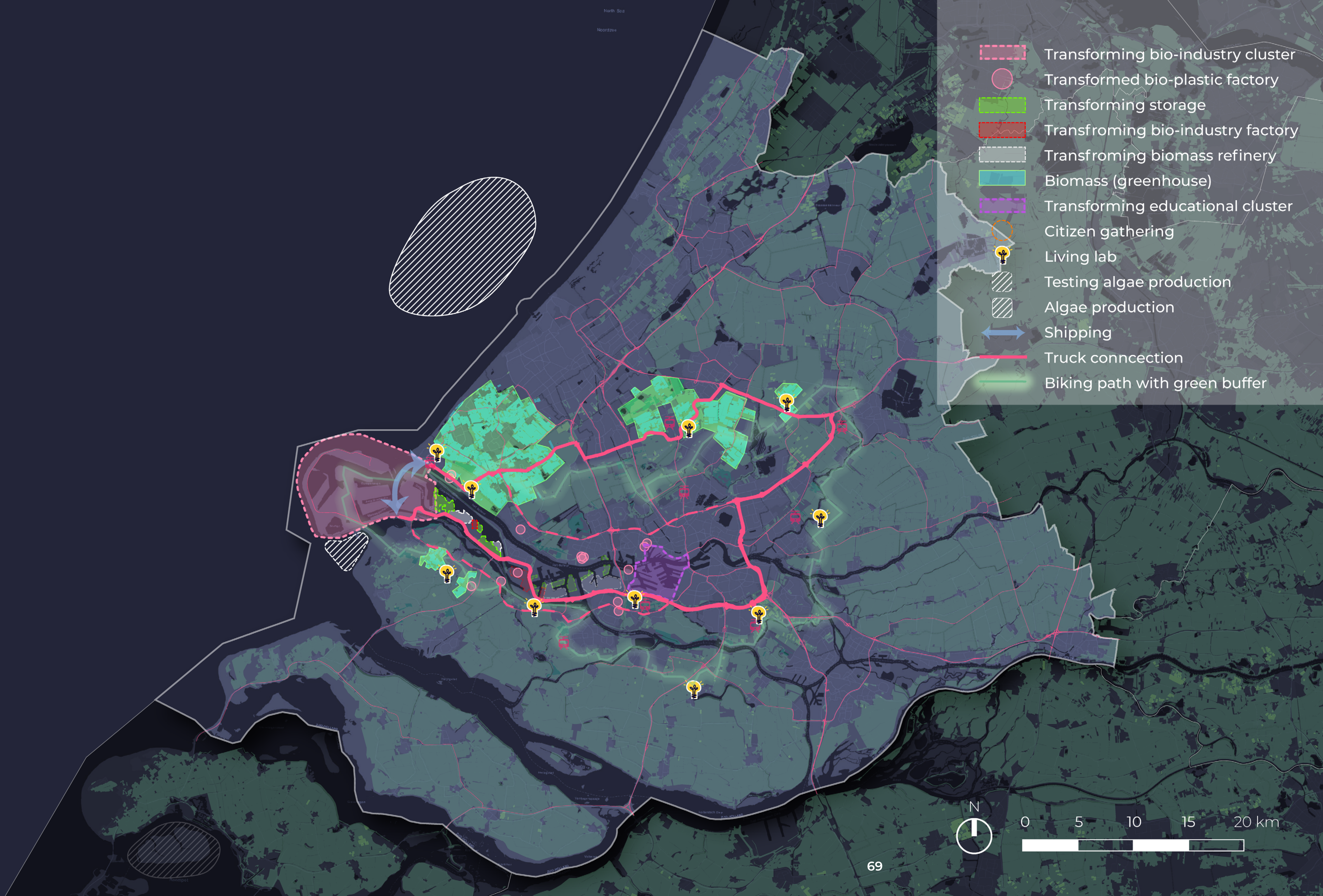
Moreover, the **collection of biomass** in form of residual and agricultural waste through existing and new waste hubs starts. Also, biomass is cultivated in greenhouses and the algae production and testing at different locations are intiated. For reaching a more diverse and biomass generating agriculture in form of agroforestry, the first trees are planted.

Supporting the **transport of biomass** to the transforming bio-based industries, the truck and shipping connections are enhanced. Together with the biking path and green buffer, the **Bio-Loop ZH2050** is formed. In this phase, also the implemention of **the Living Labs with testing fields** at strategic locations begins.

Next to that, the **educational cluster** is transformed in collaboration with the RDM campus, port industries, and the Living Labs. Therefore, on-site training for employees in the current plastic industry, as well as the creation of **new jobs** in the bio-based industry, are enabled.

Another aspect of the initial phase is the **awareness creation** within the society about the own plastic package usage and waste production. This goes along with the reduction of the primary raw material demand through optimised manufacturing methods and the **decrease in landfilling and incineration of waste**.

Fig 4.7 Vision 2030



4.2.3 Vision 2040

After setting the conditions for the transformation of the different sectors until 2030, the second phase continues by **expanding the bio-industry** cluster in the port and forming connections to other **bio-based plastic hubs in South Holland**. An increasing amount of bio-based plastic is produced as well as recycled. Until 2040, all necessary facilities for the bio-based plastic industry are updated or set. By achieving this, a growing amount of **fossil-based plastics can be replaced by bio-based plastics**. Campaigns and incentives for companies and citizens support this transition process.

Moreover, all collected waste serves the bio-based plastic production whilst continuing to decrease the raw material demand. Successfully built connections between stakeholders for the **exchange of theoretical and applied knowledge** help to further improve the bio-based plastic industry.

Furthermore, the **implementation of agroforestry is completed** in areas of arable land and started in grassland due to the decreasing meat production. The new landscape of the Bio-Loop ZH2050 surrounding the port region continues to develop.

Also, with growing experience related to the bio-based industry that is supported by the ongoing experimentation in the Living Labs, **more educational opportunities** for young people within this field arise. Consequently, more professionals are trained that can **spread their expertise to other hubs** in the province.

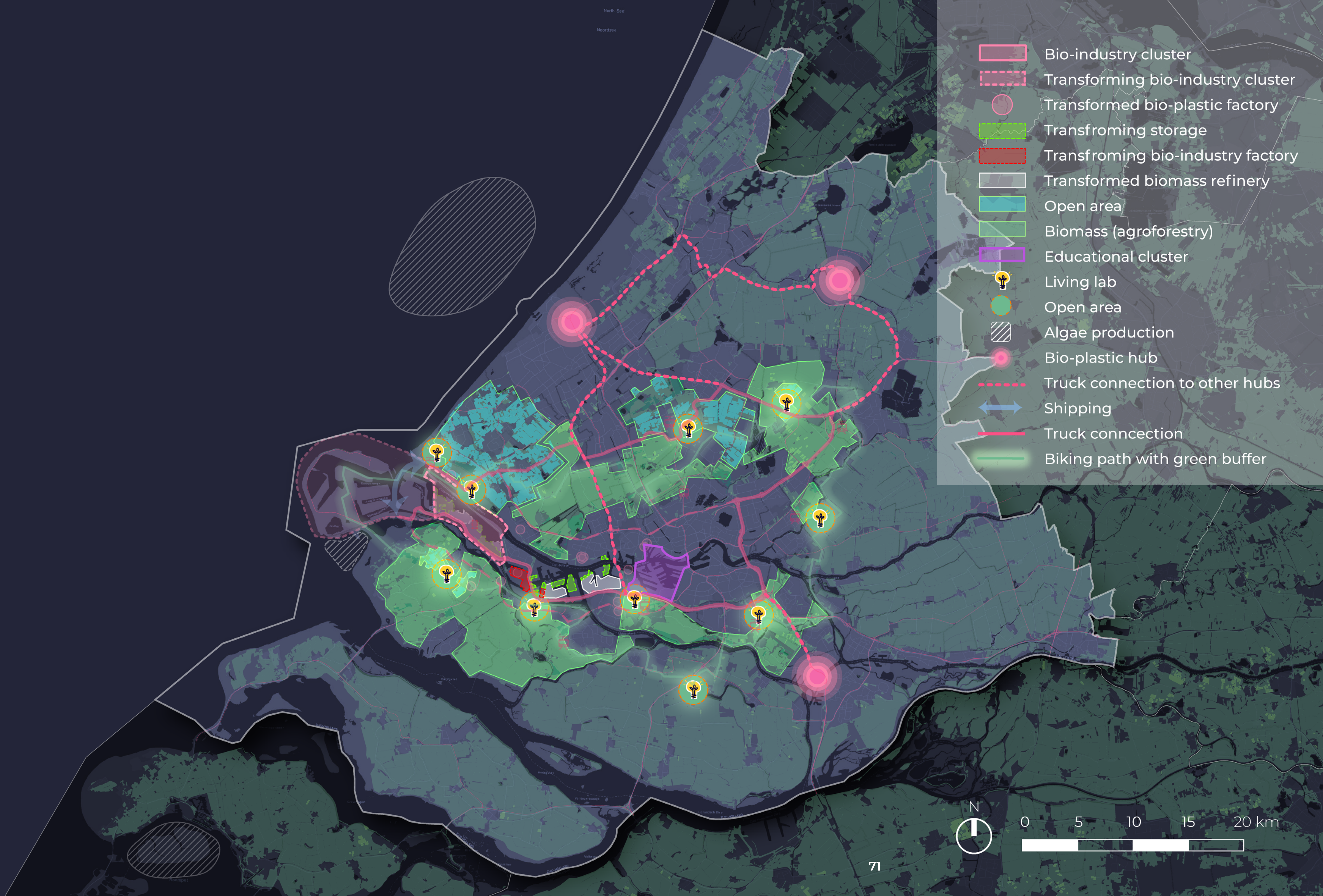


Fig 4.8 Vision 2040

4.2.4 Vision 2050

Finally, in the last phase until 2050 the whole plastic-related industry in the port serves the production of bio-based plastics following a circular system and effecting the transformation of other industries. The bio-based industry is able to react to the demand for bio-based plastic products and produces according to the current need.

Additionally, the port region is an established example of a circular bio-based plastic industry with connections to other hubs in the Netherlands and with global influence.

Due to the previous experimentation on indoor and outdoor algae production, the cultivation is optimised and serves the biomass supply together with the biomass supply areas along the Bio-Loop ZH2050 and national resources.

Overall, in the third phase, supportive and stable networks of collaboration between sectors and stakeholders are formed, also on an international scale.

Furthermore, the bio-based plastic industry within the Port of Rotterdam is carbon neutral until 2050 by following an optimised circular production and recycling process based on renewable energy and by reusing CO_2 in greenhouses.

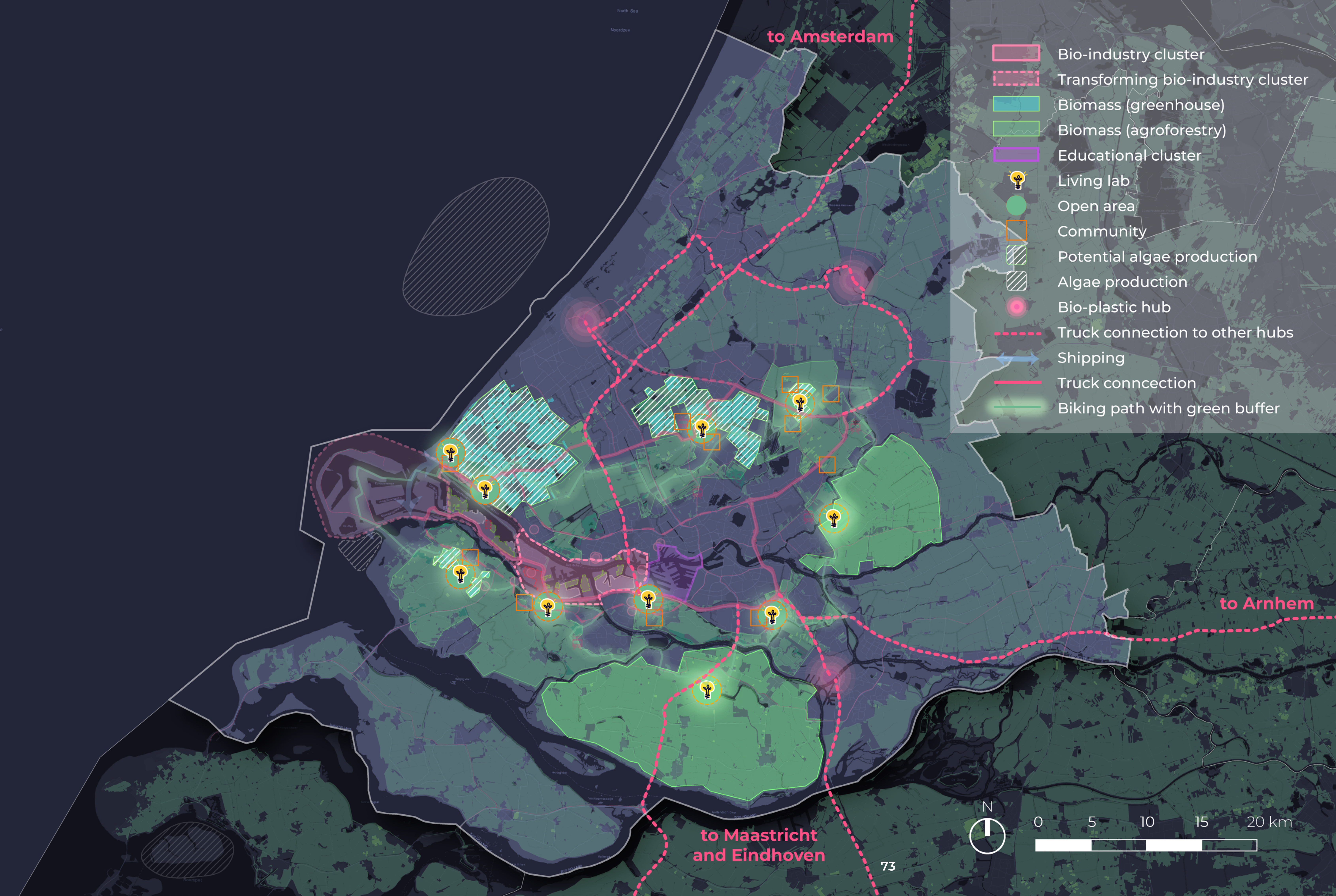


Fig 4.9 Vision 2050

4.2.5 Vision

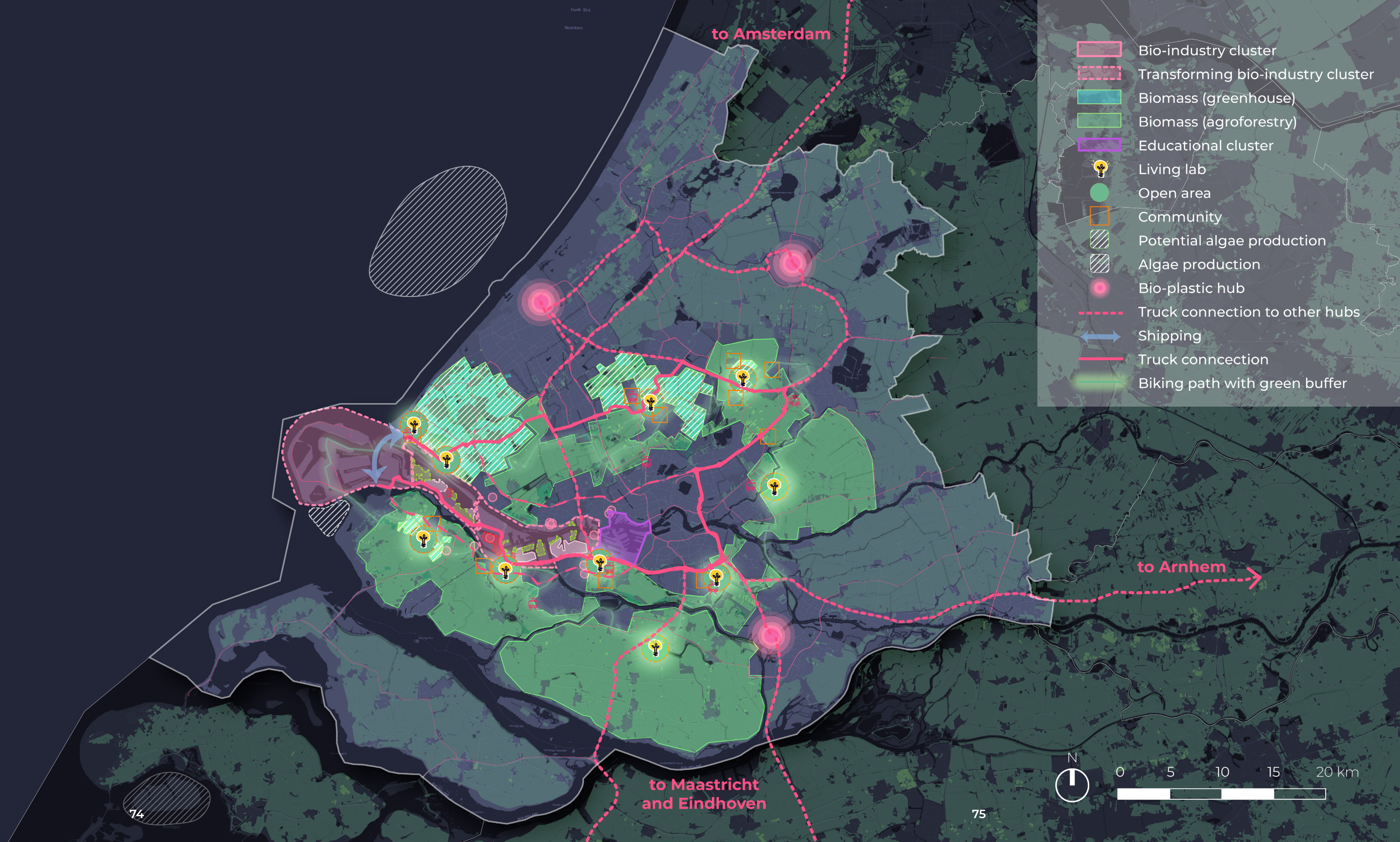


Fig 4.10 Detailed vision map

4.3 CIRCULAR ECONOMY OF BIO-BASED PLASTIC INDUSTRY

4.3.1 R-ladder

To reach the goal of creating a circular economy for the bio-based plastic industry in the Port of Rotterdam different steps along the R-ladder can be followed.

The steps in the R-ladder contain strategies to reduce the use of new resources when producing a product whereby fewer materials and resources are required for strategies that are higher on the R-ladder. Consequently, environmental effects can be minimised. The aim is to first implement those strategies, followed then by recycling which is lower on the R-ladder (PBL, 2018).

R-ladder strategies (PBL, 2018)

R0: Refuse
R1: Rethink
R2: Reduce
R3: Reuse
R4: Repair
R5: Refurbish
R6: Remanufacture
R7: Repurpose
R8: Recycle
R9: Recover energy

Landfill is avoided in circular economy.

IMPLEMENTATION OF R-LADDER STRATEGIES IN OUR VISION

Applying the R-ladder strategies to our vision for bio-based plastic production (fig 4.11), the first aim is to refuse and rethink the use of traditional petroleum products, followed by the reduced demand for imported oil products and a reduced amount of hazardous plastic waste. The use of biomass for bio-based plastic production goes then along with the strategies R3-R8.

Bio-based plastics play an essential role in replacing traditional fossil-based plastic products and can function as a trigger to influence also other industries. Next to that, the circular system is not limited to the local industry but is linked to dependencies on different scales.

Ultimately, the bio-based plastic industry transitions from a linear and waste-causing system to a circular economy with reduced primary raw material demand and decreased (until completely avoided) landfilling rate.

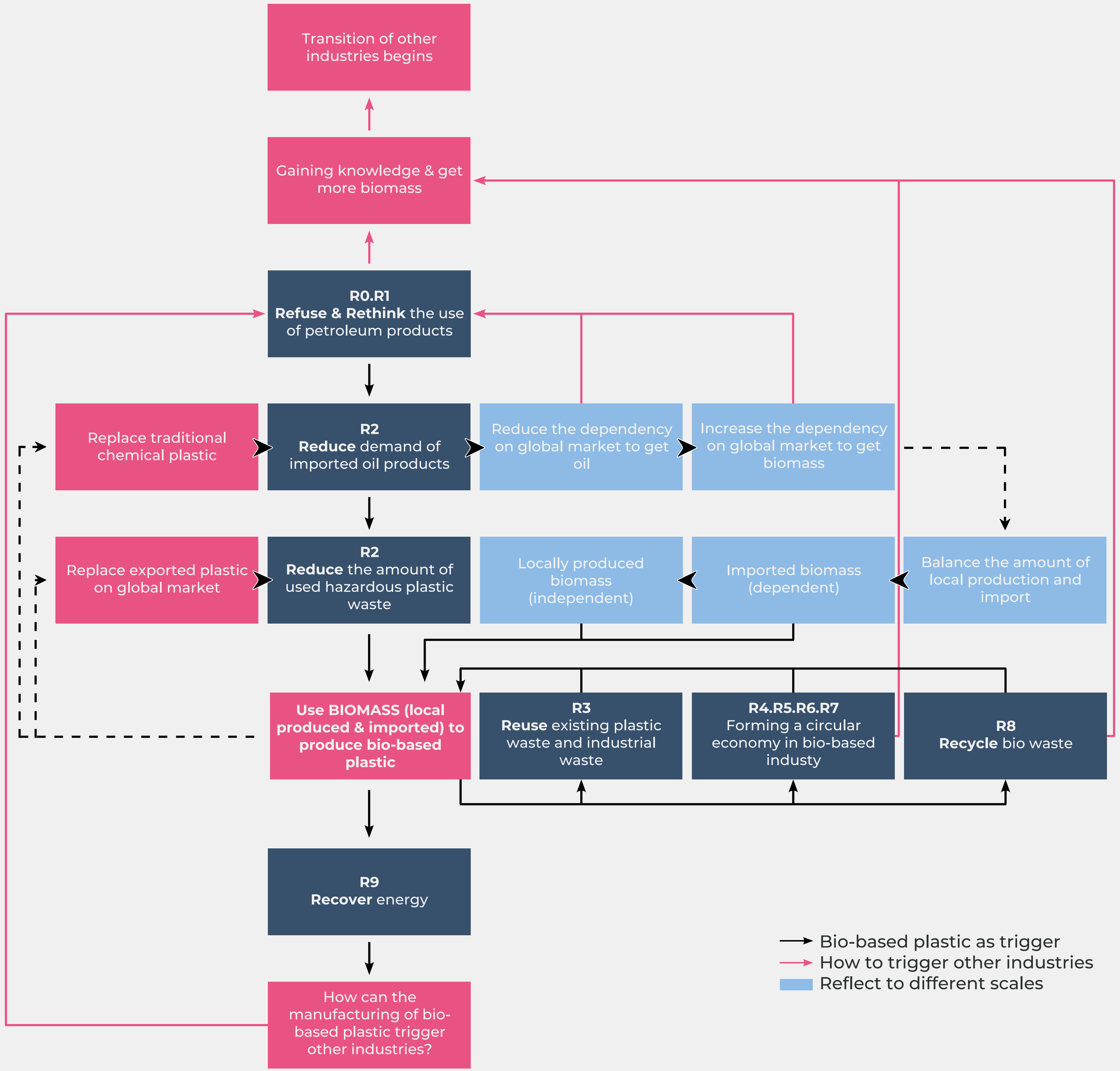


Fig 4.11 R-ladder based on bio-based plastic industry

4.3 CIRCULAR ECONOMY OF BIO-BASED PLASTIC INDUSTRY

4.3.2 Circular flows

In a circular economy, material flows follow a circular instead of a linear way with the consequence of keeping resources, materials, and products longer in the economy (European Commission, n.d.).

However, not only material but also invisible flows can be identified within our idea of the circular economy of the bio-based plastic industry (fig 4.12). Here, the invisible flows contain the exchange of knowledge and awareness creation within the society.

HOW DO THE DIFFERENT FLOWS REFLECT ON THE BIO-BASED PLASTIC INDUSTRY?

Firstly, for the production of bio-based plastics, biomass and waste are needed. They can be gained from different biomass supply areas which produce crops and agricultural waste. Moreover, instead of incinerating or landfilling residual waste generated by the communities, it serves as a biomass supply, too.

Next to the processing of those materials within the bio-based plastic industry, there are also material flows related to the products of bio-based plastic. Focussing on the packaging, it can either serve private use in form of packaging for food and drinks or on a bigger scale the transportation of products in containers.

In the first case, the bio-based plastic material flows back to the community and biomass supply areas from where it can be collected separately and brought back into the circular system for reuse or recycling.

Another aspect is fossil-based plastic which depends on imported oil and is aimed for being replaced by bio-based plastics. Until the complete replacement is finished, the goal is to keep the recycling rate as high as possible to reduce the amount of fossil raw material needed for the production.

Looking at the relations of invisible flows within the circular system, knowledge and expertise generated in the Living Labs and the Innovation Dock are shared with the bio-based plastic industry to improve biomass processing and bio-based plastic production. The knowledge is also applied to the field of biomass production to increase production efficiency.

Additionally, the exchange with the community to foster an understanding of the importance of the own use of plastic packaging and the possibilities to support the circularity of products plays an important role. Furthermore, citizens can not only learn but also contribute by sharing their experiences and ideas in the Living Labs to improve the circular system.

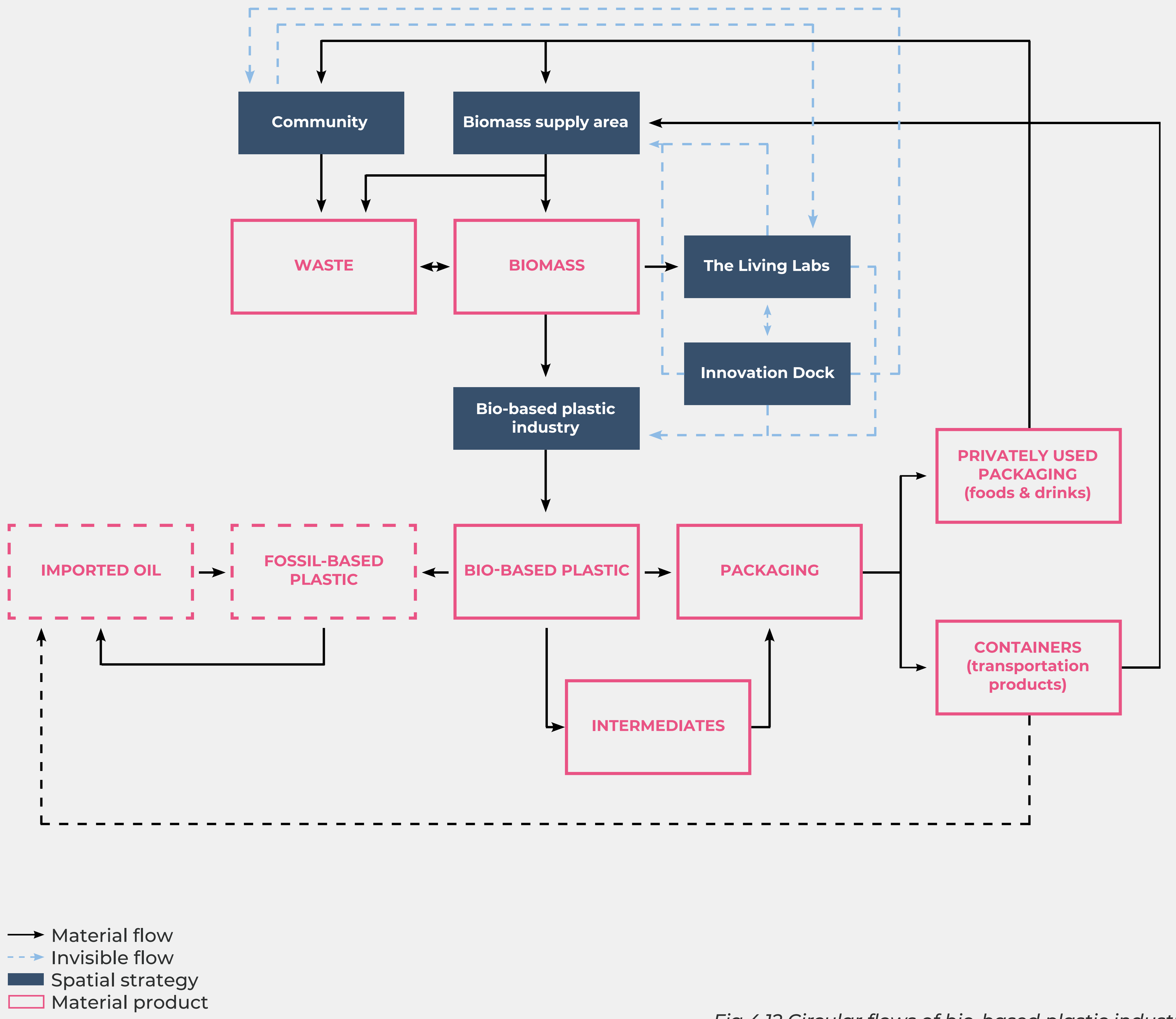


Fig 4.12 Circular flows of bio-based plastic industry

CHAPTER 5
STRATEGY

HOW TO TRIGGER THE BIO-BASED PLASTIC INDUSTRY?

5.1 TRANSFORMATION BEGINS WITHIN THE PORT

5.1.1 Phasing of forming clusters

UNTIL 2030: START THE TRANSITION

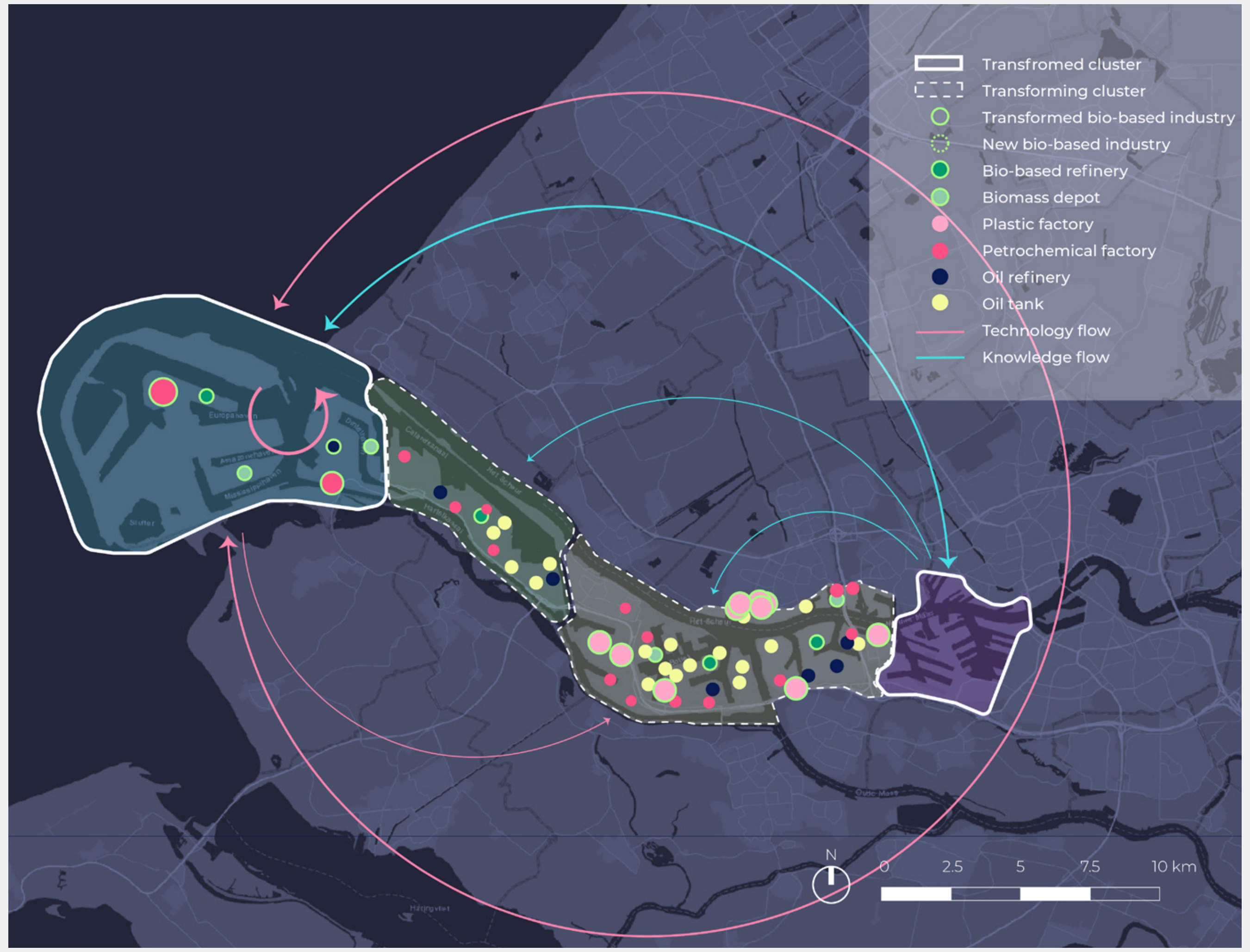
Bio-based Cluster 1 has set the condition for intermediate products and started to produce bio-based plastic.

Bio-based Cluster 2 is setting the condition for intermediate products and experimenting on the new technology.

Bio-based Cluster 3 has transformed the existing plastic factories and still uses fossil-based materials for other products.

Innovation Cluster is developing and sharing new technology.

Fig 5.1 Transformation diagram of the port - phase 1



UNTIL 2040: TRANSFORM THE INDUSTRY

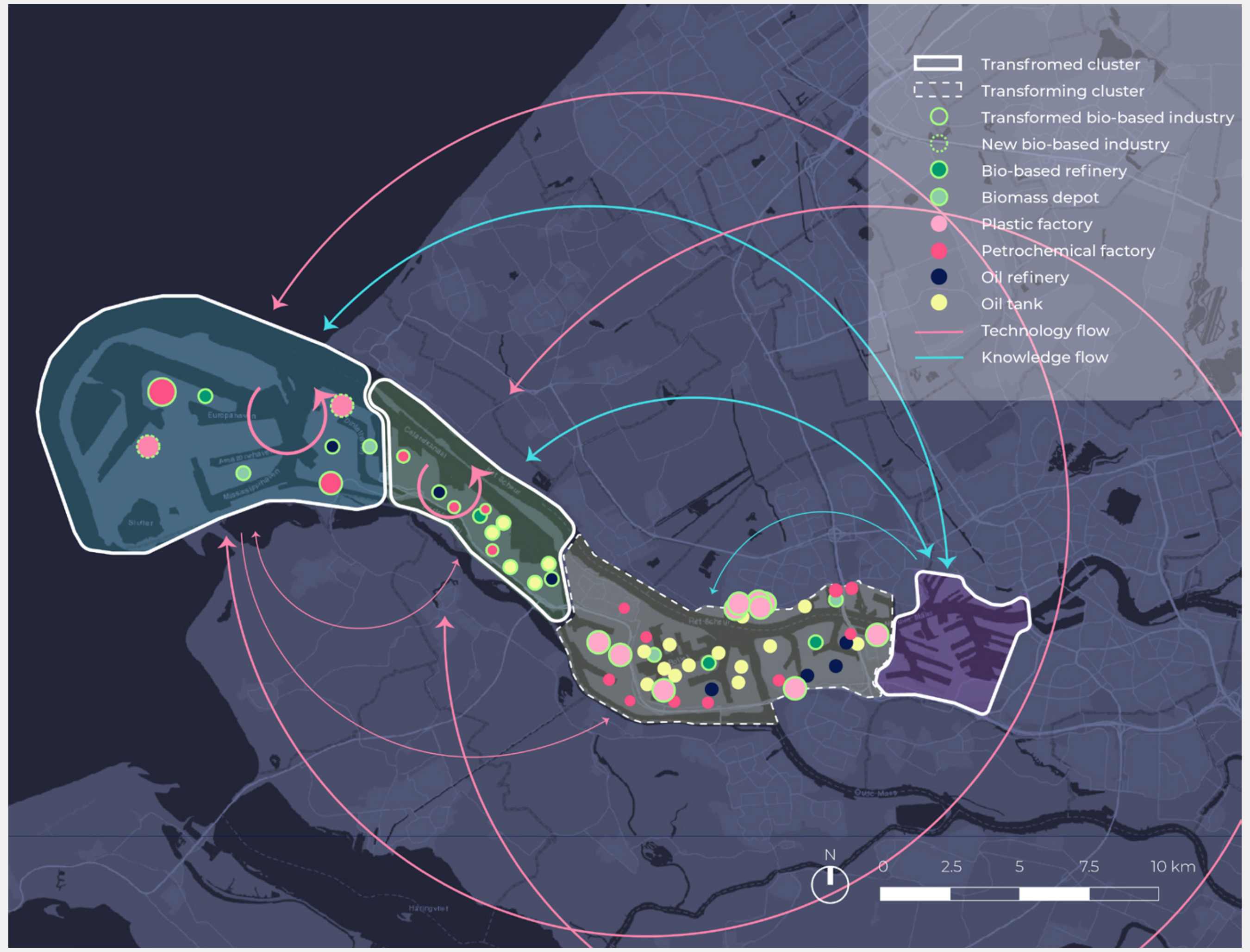
Bio-based Cluster 1 is building more new infrastructure for bio-based plastic industry.

Bio-based Cluster 2 has set the condition for intermediate products and started to produce bio-based plastic.

Bio-based Cluster 3 is setting the condition for intermediate products and experimenting on the new technology.

Innovation Cluster is receiving feedback from industries and updating technology.

Fig 5.2 Transformation diagram of the port - phase 2



UNTIL 2050: A BIO-BASED PORT

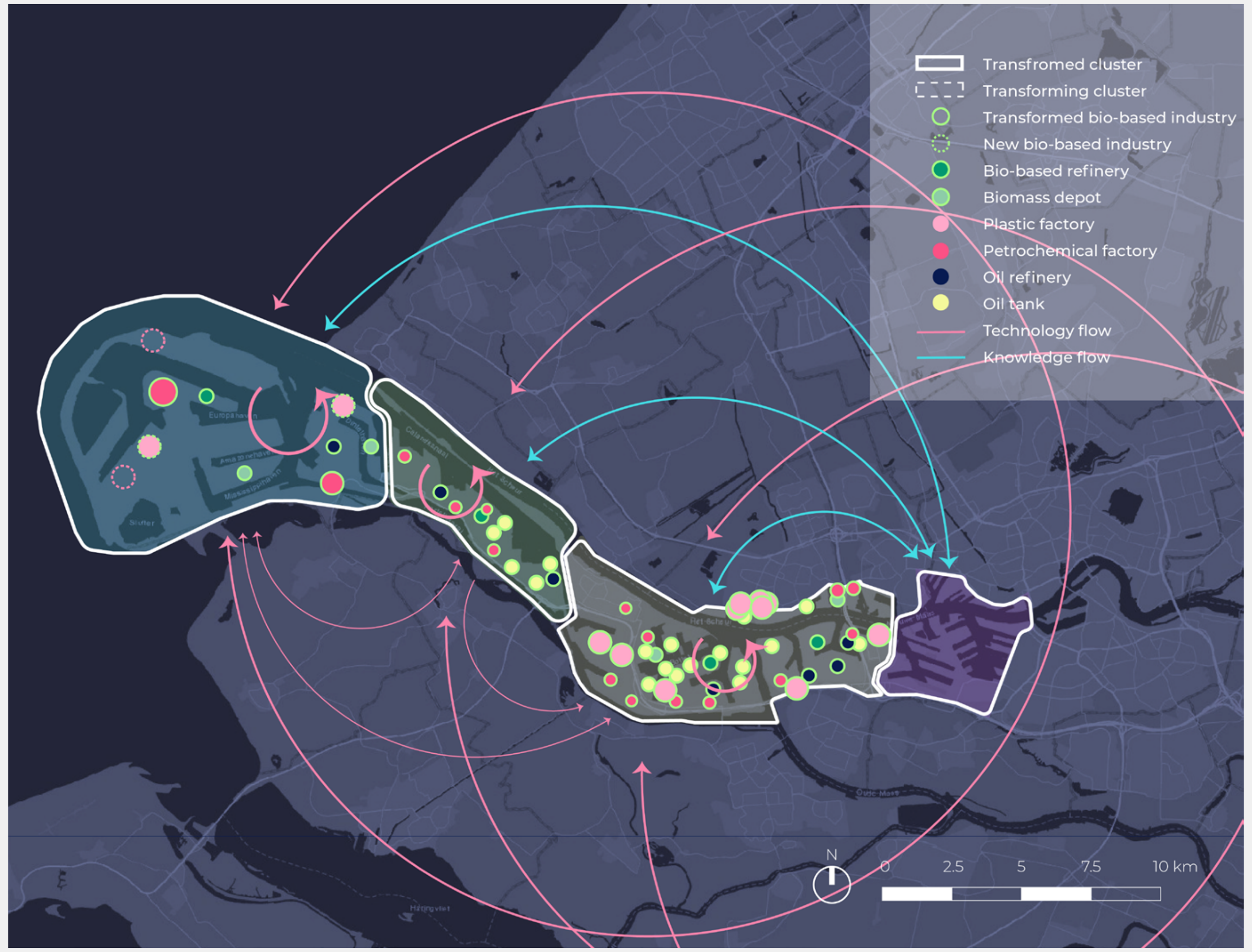
Bio-based Cluster 1 is building a leading cluster in bio-based industries.

Bio-based Cluster 2 is a complete bio-based plastic circular system.

Bio-based Cluster 3 has set the condition for intermediate products and started to produce bio-based plastic.

Innovation Cluster is receiving feedback from industries and updating technology.

Fig 5.3 Transformation diagram of the port - phase 3



5.1.2 Bio-based plastic hubs in Zuid-Holland

Chapter 4 has explored how to optimise the circular system of bio-based plastic. This section will specifically explain how the transformation of this circular system can be achieved spatially.

TRIGGER ON THE PORT SCALE

Before explaining the spatial strategies, it will be demonstrated how to apply the whole trigger strategy to facilitate the bio-based transformation. Such a transition requires spatial changes at niche, meso and macro levels, involving a transformation in raw materials, processing and distribution, and social changes.

The first trigger level is **the transformation of the bio-based plastic industry within the port.** Because Maasvlakte in the port has been reserved for innovative chemical industry based on renewable raw materials aiming to install a number of services that various bio-based businesses can use (Dirkzwager, 2013). Therefore, this cluster has the most potential as a starting point to complete the internal transformation (fig 5.1), combined with the establishment of Bio-Loop ZH2050 including biomass supply and innovation dock, providing the leading model and resources for the transformation of other clusters in the port.

Subsequently, two other bio-based clusters will also be established by updating existing infrastructure and embedding new facilities with a new industry chain based on resources and technological support from Maasvlakte and the innovation dock (fig 5.2). By 2050, the Port of Rotterdam will be a harbour with a complete bio-based manufacturing chain based on the bio-based plastic industry (fig 5.3).

TRIGGER ON THE PROVINCE SCALE

The second level of the trigger means that **the port and Bio-Loop ZH2050 will act as an innovation area for developing a circular bio-based economy in Zuid-Holland**.

Since the establishment of the bio-based port means a reduction in the supply of crude oil and an increase in biomass feedstock and infrastructure for bio-based plastic, other plastic factories in the province will be affected and driven to transform into bio-based plastic-related industries. By examining areas in Zuid-Holland where fossil-based plants, including chemical, petroleum and plastic plants, are concentrated, we defined four other fossil-based plastic hubs (fig 5.4).

At the province level, Bio-Loop ZH2050 and the port provide the biomass, the technical and labour resources for the transformation of these hubs. At the same time, the products, waste and technology from these hubs will provide feedback to the port, creating a bio-based network of independent but interconnected industrial hubs based on the backbone of transport and green space.

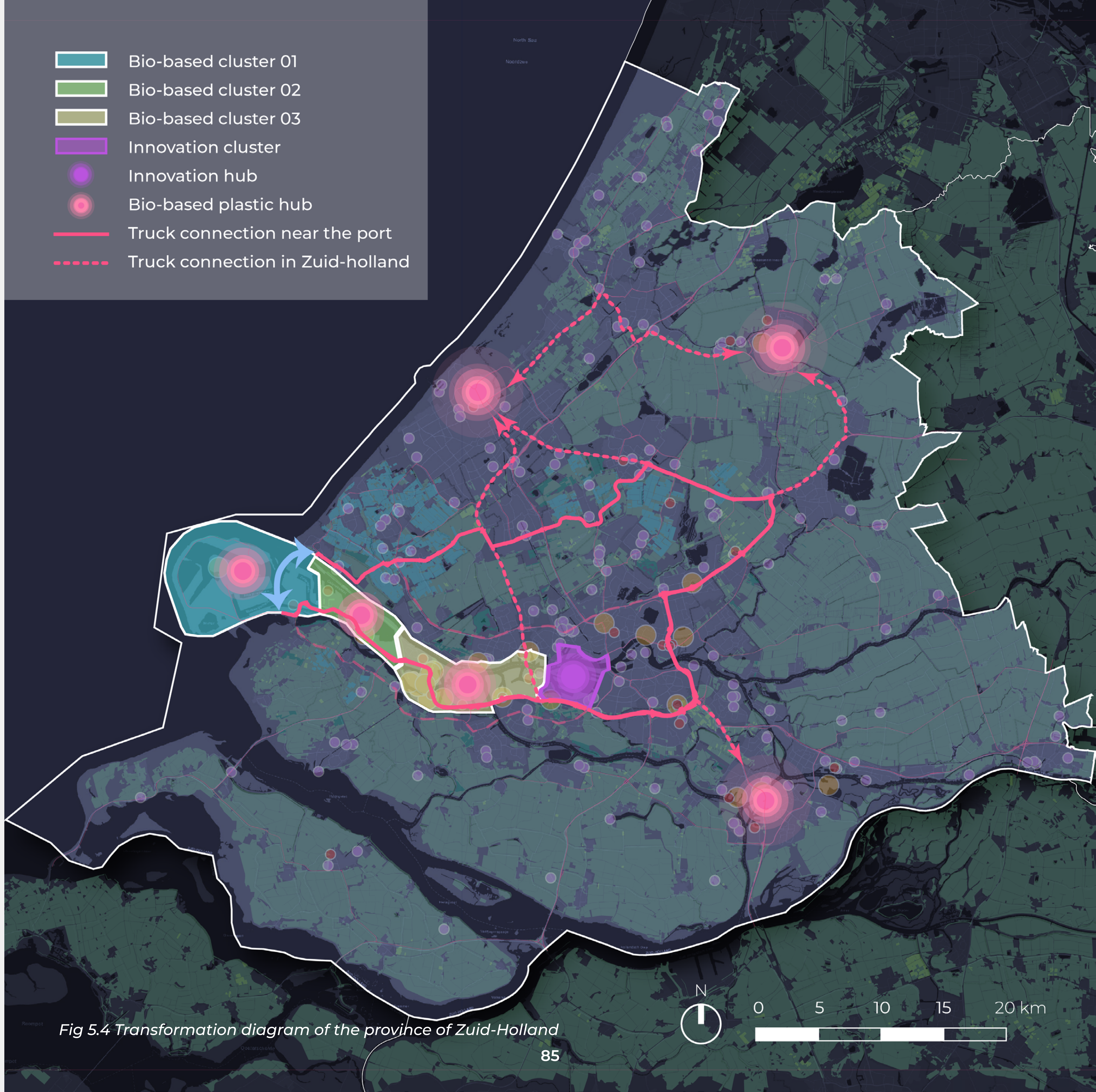


Fig 5.4 Transformation diagram of the provihce of Zuid-Holland

5.1.3 Bio-based plastic hubs on a national scale

TRIGGER ON THE NATIONAL SCALE

The final layer of the trigger strategy is that Zuid-Holland will act as a bio-based plastic hub to motivate the transformation at the national level (fig 5.5). We propose a network based on the bio-based plastic industry in the Netherlands.

Because of the solid logistical capacity and foundation of the existing biofuel production of the Port of Rotterdam, it offers the possibility to act as a trigger hub. Therefore, after completing its circular system at the province level, the Port of Rotterdam can be the first hub to start the innovation, providing technology, bio-based products, and professional workers for other areas. At the same time, the transport backbone will be enhanced by strengthening the truck connection.

By overlapping heat maps of plastic, oil-based, and chemical industries, four hubs, including Amsterdam, Arnhem, Eindhoven and Maastricht, are identified as new bio-based plastic hubs. So in the future, the Port of Rotterdam would provide raw materials (mainly imported biomass), intermediate materials, knowledge and workers to other hubs. In contrast, other hubs and the port would feed back new technologies to each other, completing the transition towards a bio-based economy on the national level based on the bio-based plastic industry.

INFLUENCE ON THE GLOBAL MARKET

The transition from fossil-based to bio-based will free the Netherlands from its high dependence on the global market and even influence the global market.

First of all, the import and export of biomass and bio-based products will become an important economic sector in the Netherlands, maintaining throughput instead of oil products. The Netherlands serves as an entry point of bio-based products to Europe, meeting the needs of nearby countries such as Belgium and Germany. The value of these commodities is estimated to be at least twice the current value of crude oil (Sanders & van der Hoeven, 2008).

The second aspect is the application of bio-based technology. The agricultural sector in the Netherlands can make a significant contribution to it, not by turning the landscape into energy crop cultivation but mainly by applying proprietary technology (Sanders & van der Hoeven, 2008). Knowledge and technology developed may later be used worldwide. Finally, the bio-based economy in the Netherlands can be promoted internationally as a paradigm, reducing dependence on oil, especially for the benefit of developing countries relying on agriculture.

Benefiting from its strong capacity in logistics, the existence of a large hinterland for the Port of Rotterdam, the combination of a strong agro-food complex and a large chemical industry as well as its know-how in all these areas, the Netherlands would have the opportunity to use its assets in the best way for the bio-based economy. The Netherlands could develop into a global trade centre for bio-based products.

Fig 5.5 Transformation diagram of the national scale

5.2 THE GREEN BELT

5.2.1 Network of circular economy

Based on the trigger strategy, the network of three levels depends on how the space is used to start the intervention within the Bio-Loop ZH2050. We expect to involve six spatial projects on the Bio-Loop ZH2050, including bio-based plastic factories, the Living Labs, biomass supply area, innovation dock, community and transport.

The core project is the bio-based plastic industry in the Port of Rotterdam. We propose using the existing infrastructure, such as the plastic plants, and using the reserved space to construct the new bio-based facility. At the same time, the cluster where the RDM campus is located will be developed as an innovation dock for bio-based research. These two projects are working together to develop and test new technologies, improving the efficiency of bio-based plastic production and recycling.

The improvement of the bio-based plastic recycling system and the application of new technologies require the support of the biomass production area. However, this new network implies the need to consider the competition with the food market, especially concerning land use. The spatial strategy does not mean using all this farmland for biomass but working with parts of the grassland and arable land, which can be used as valuable raw materials for industry without affecting basic food needs. Hence, we expect that agricultural space that is spare or not in use can be utilised for growing biomass or even developing algae production. Domestic supply cannot meet all the transition needs, so a balance between imported and local biomass is also a prerequisite when we intervene in space.

The innovation and practice of biomass technology also need physical space, so we introduce the project of a Living Lab as an innovation hub for biomass, where research, experimentation and collaboration between different fields will be realised in this complex.

The backbone of truck transport will connect all these new physical projects. In addition, the creation of the Bio-Loop ZH2050 will impact the surrounding community, so we also consider the interaction with the community. On the one hand, the Bio-Loop ZH2050 connects the Living Labs with the main biking path, creating a new public space for the citizens. On the other hand, community involvement will also create feedback on the work of the Living Labs, strengthening the social awareness of bio-based transformation and increasing the demand for bio-based products in the market.

Our spatial strategy is based on these six types of projects, creating networks and synergies in the physical space (fig 5.6).

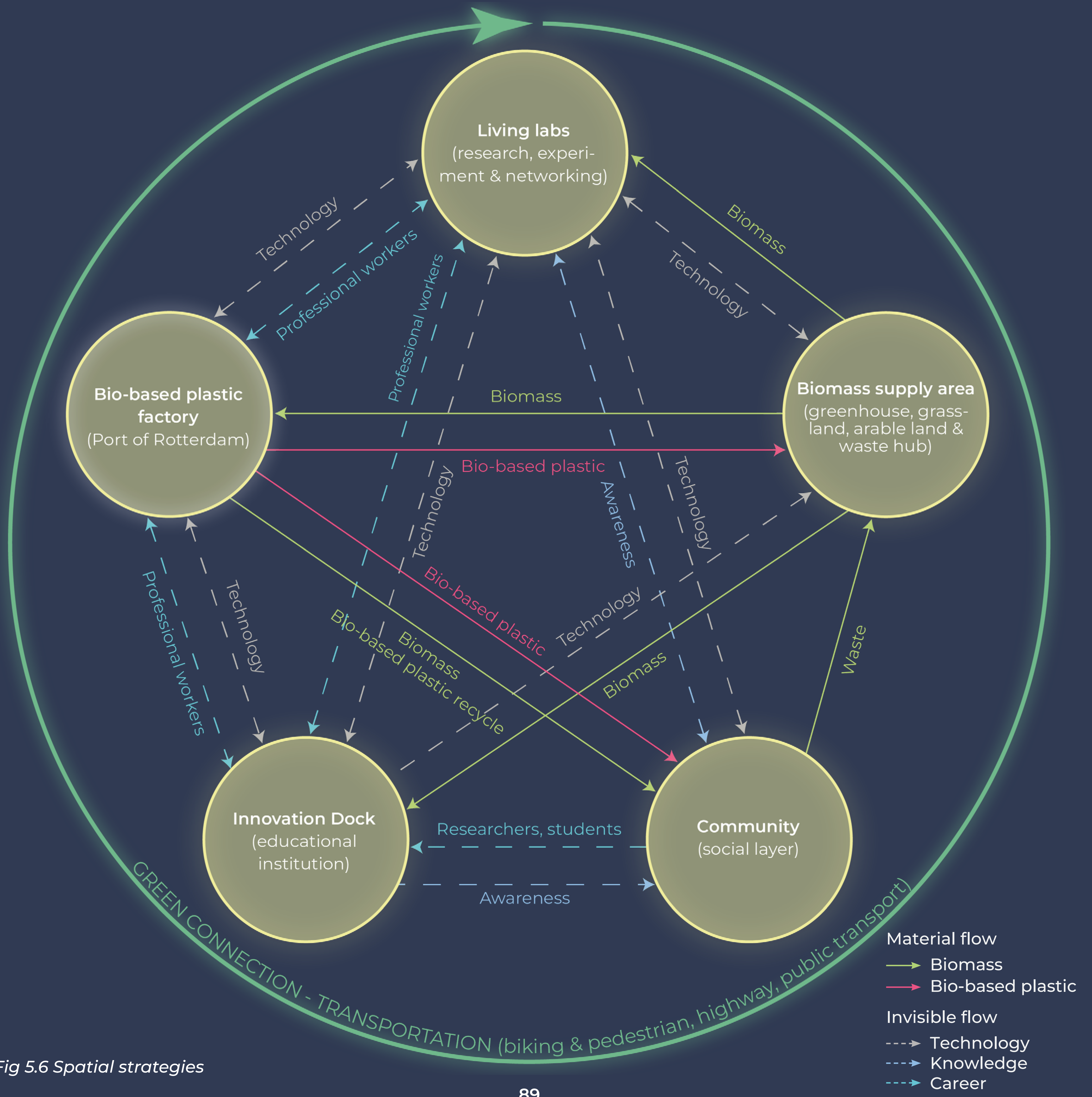


Fig 5.6 Spatial strategies

5.2.2 Toolkit of interventions

We define precisely what kinds of interventions will be used based on six projects. The toolkit of Bio-Loop ZH2050 provides the tools that can be used to achieve bio-based transformation within the province. For further development, it can not only be used as a spatial tool to guide the transformation of the Port of Rotterdam and Zuid-holland but also as a paradigm and toolkit to be applied to other hubs.

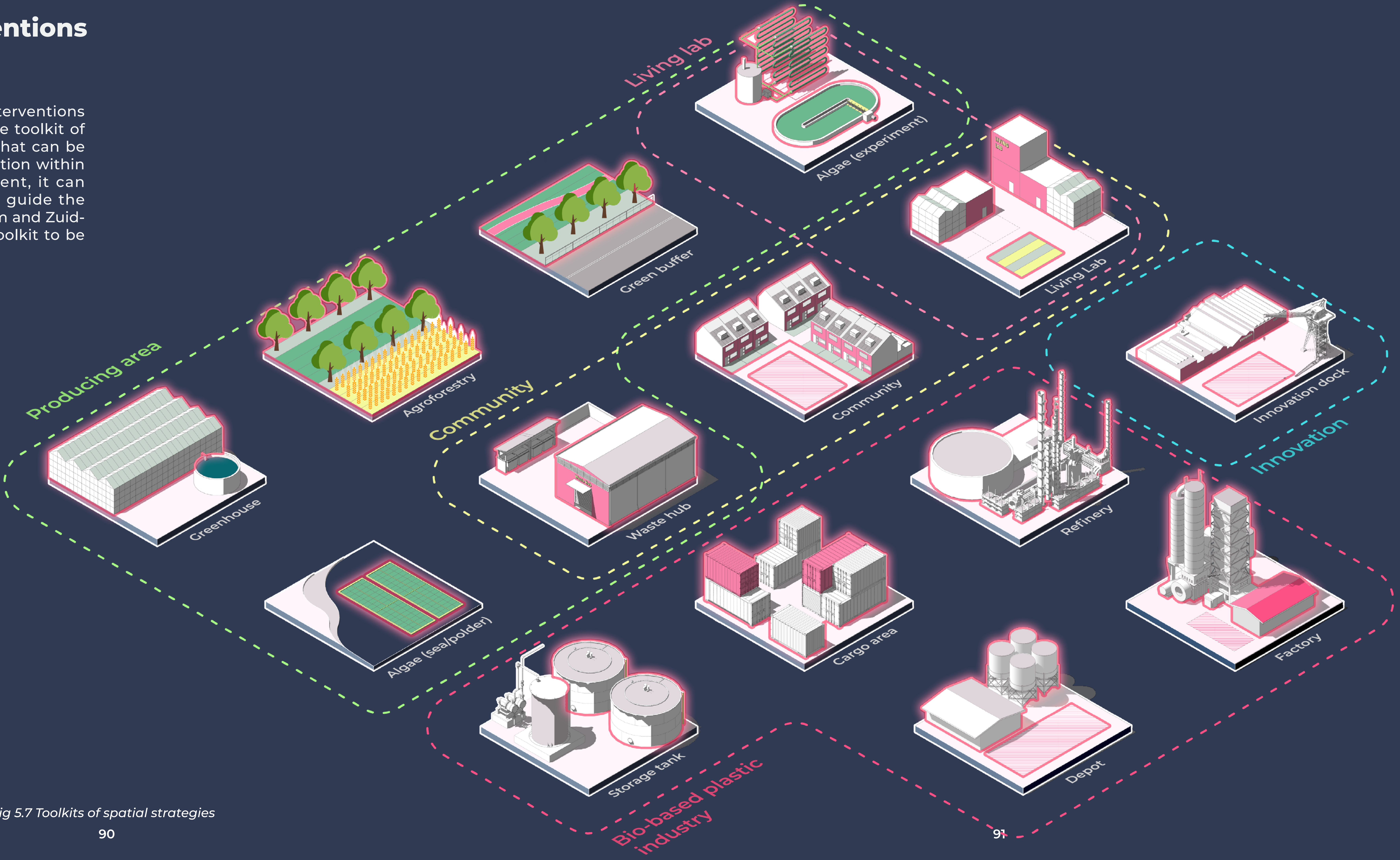


Fig 5.7 Toolkits of spatial strategies

5.2.3 Guideline

A guideline is needed to restrict the implementation of the interventions in terms of underlying services they provide and the space quality. Five specific categories of space are clarified to limit and guide, selected based on their importance to the final spatial vision.

Firstly, for the bio-based plastic industry, it is proposed to be integrated into the urban blue-green network to reduce the negative impact of industrial production in the port and limit the uncontrolled expansion of production space while maintaining production.

For the Living Labs, it aims to be spatially multi-functional and to get as many different stakeholders involved as possible.

The greenhouse and farmland mainly guide biomass production. For example, use spare facilities where possible and the placement of agroforestry in farmland to balance biodiversity and production.

There are restrictions on transport infrastructure, which is expected to be effective in protecting productive areas from the impact of highways and railways. At the same time, more public connections could also be enhanced. These guidelines will be shown in detail in the next section of the showcase.

BIO-BASED PLASTIC INDUSTRY

1. Restrict expansion of industry and permission is needed for further development

2. Implement green buffer to increase spatial quality which is involed in the urban blue and green network

3. Provide public space for workers, including spaces for on-site training and recreation

THE LIVING LABS

1. A multifunctional area whose main programs are research, meeting space for stakeholders, experimentation and training

2. Create public space for citizens and workers, including spaces for recreation area and exhibition

3. Reserve public space for campaign about bio-based and waste recycled awareness

4. Enhance the accessibility by public transport like biking and tram

GREENHOUSE

1. Restrict expansion of greenhouses

2. Use spare and antiquated greenhouses for biomass cultivation, including algae planting

3. Cooperate with greenhouses that are capable of producing biomass

4. Recycle organic and plastic waste from greenhouses

5. Reuse CO_2 gas collected from industrial area

AGROFORESTRY

1. Cultivate mixed vegetation of tree and crop types

2. Avoid using hard protection area which aims to enhance biodiversity

3. Properly use the soft protection area for agroforestry

4. Cooperate with farmland that is capable of producing biomass without competing with food market

TRANSPORTATION

1. Use green buffer to prevent the impact of highway and railway

2. Create safe and qualified pedestrian area

3. Create qualified biking path that connects the whole Bio-Loop ZH2050

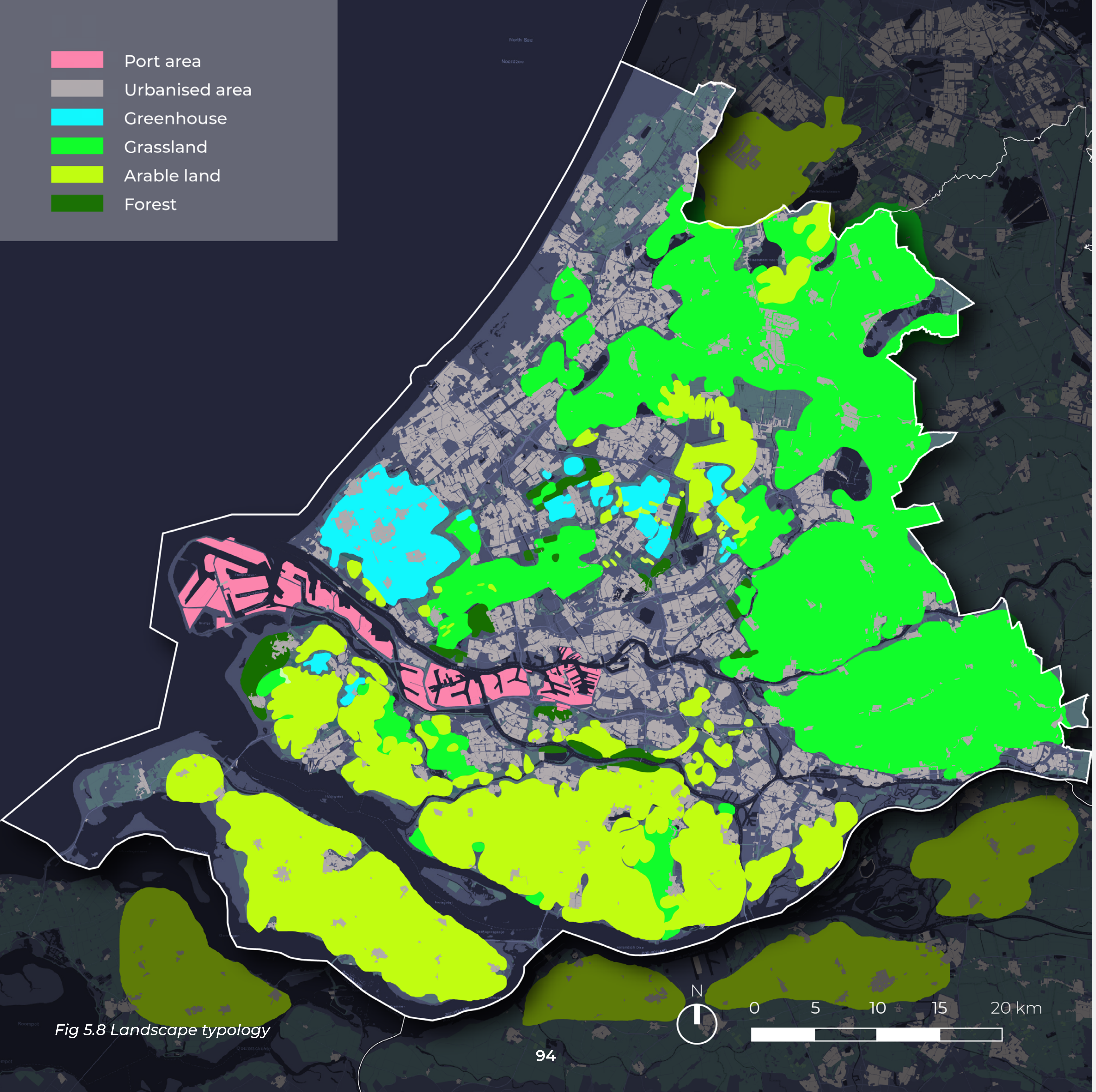


Fig 5.8 Landscape typology

5.2.4 Cluster

Based on the spatial strategies and different spatial types we have outlined in the previous section, our next step is to link them together to build a bio-based plastic system that works in synergy. Fig 5.8 shows the typology of the landscapes, divided into the port area, urbanised area, greenhouse, arable land, grassland and other green spaces.

Greenhouses already have the potential to grow biomass and could be developed for algae cultivation in the future. The arable land could be converted into a source of biomass for some crops such as sugar beat. According to the nitrogen reduction measures implemented by the government, the production of animal feedstock in the farmland will be limited and reduced so that the surplus land may be transformed into a biomass supply area (Rijksoverheid, 2022). Within the Bio-Loop ZH2050, these types of space will be used as potential biomass sources.

The port area will be an essential base for transforming bio-based plastic. Finally, the urbanised area will provide markets, raw materials and recycled products for the plastic recycling system. The definition of these five types of space helps us specify the bio-based plastic characteristics in its different locations.

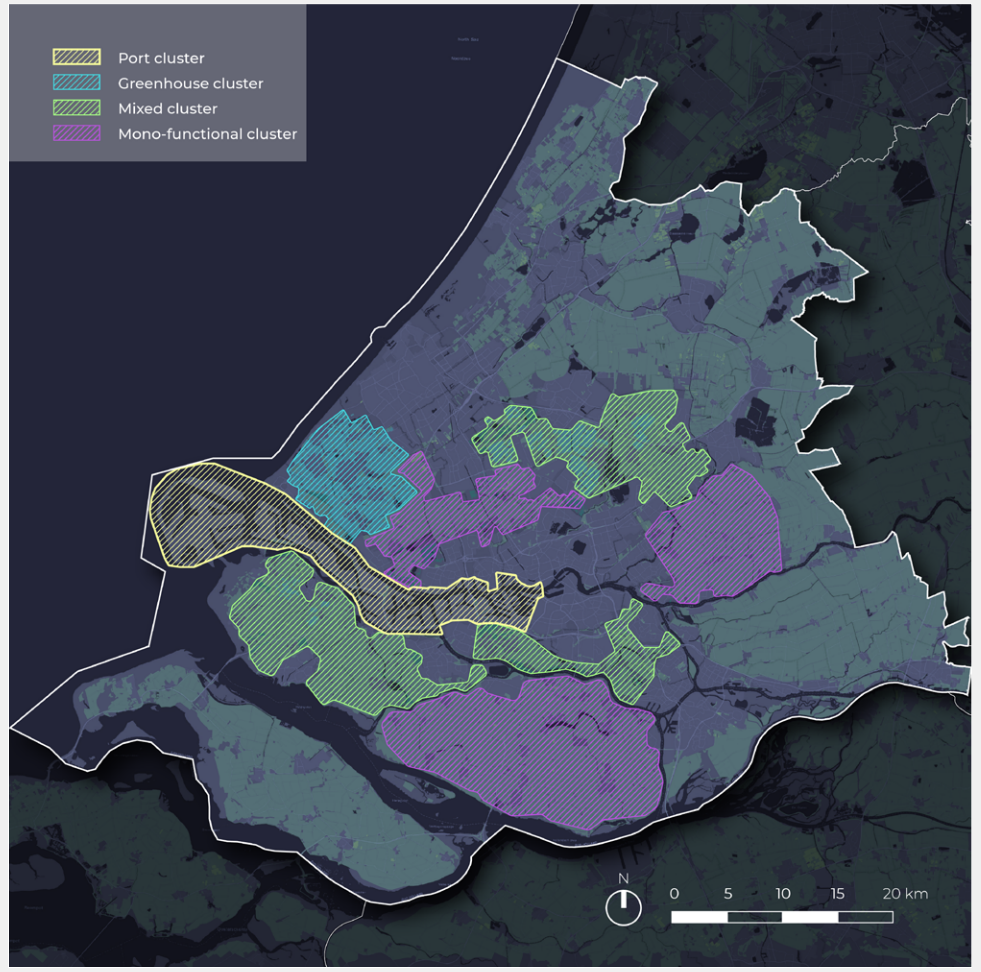
The entire Bio-Loop ZH2050 is divided into four types of clusters (fig 5.9) based on the degree of mixing of spatial types, namely port cluster, greenhouse cluster, mixed cluster and mono-functional cluster.

Mixed clusters combine the greenhouse, arable land, grassland and community, while mono-functional clusters only include arable land or grassland. So projects such as the Living Labs will play different roles in the two types of clusters.

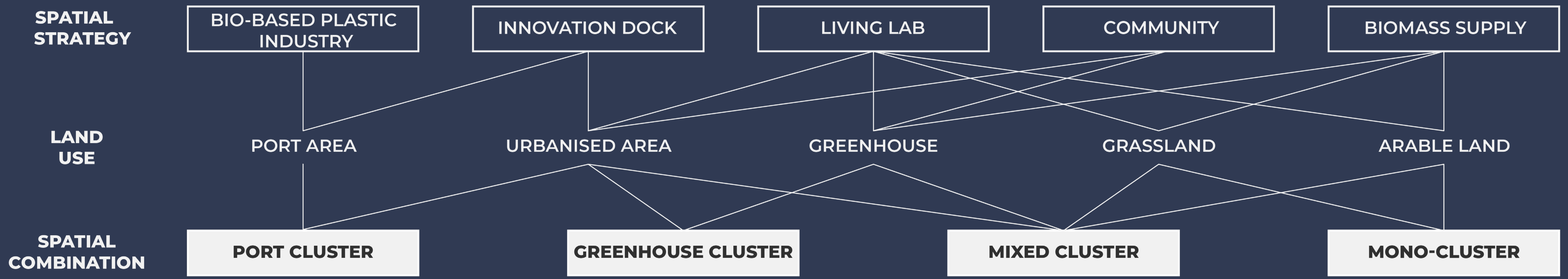
According to different properties of the clusters, we will intervene in different projects and combine them in various ways, hoping to get the most out of the spatial projects by using their advantages.

For the port cluster, we expect it to play a role in producing bio-based plastic. Cooperation with the greenhouse and collaboration between the Living Labs and farmers will be the main topic for the greenhouse cluster. The mixed cluster is about how the Living Labs can connect all the groups in the mixed area. Finally, the mono-functional cluster is more concerned with increasing productivity and protecting biodiversity through the Living Labs and agroforestry. The specific projects owned by four clusters and their combinations are shown on the next page.

Fig 5.9 Cluster identification



5.2.5 Spatial typology



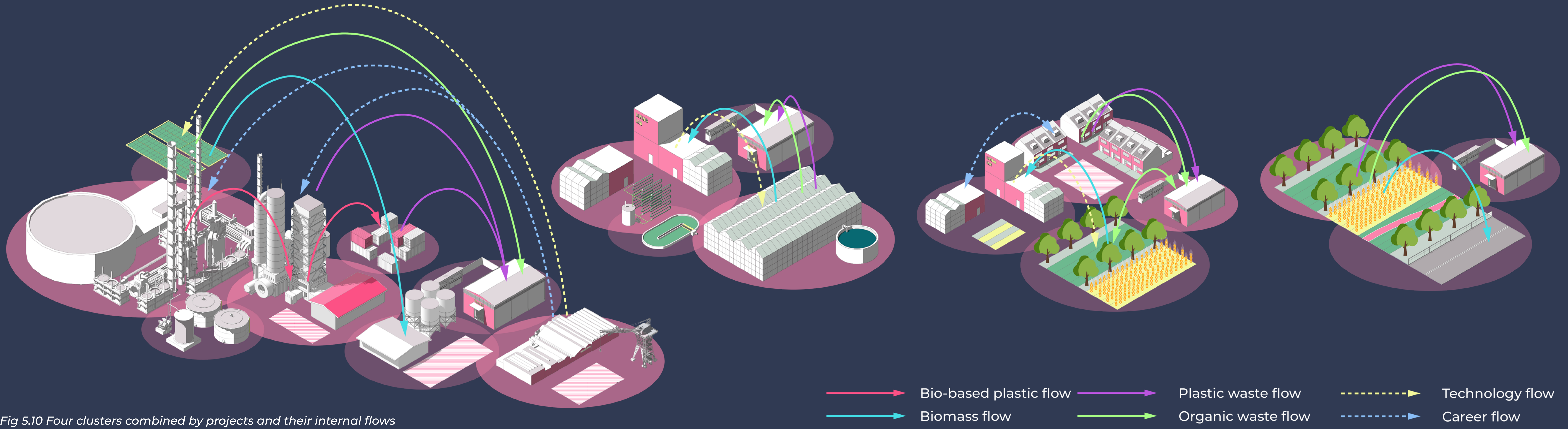


Fig 5.10 Four clusters combined by projects and their internal flows

5.2.5 Spatial typology

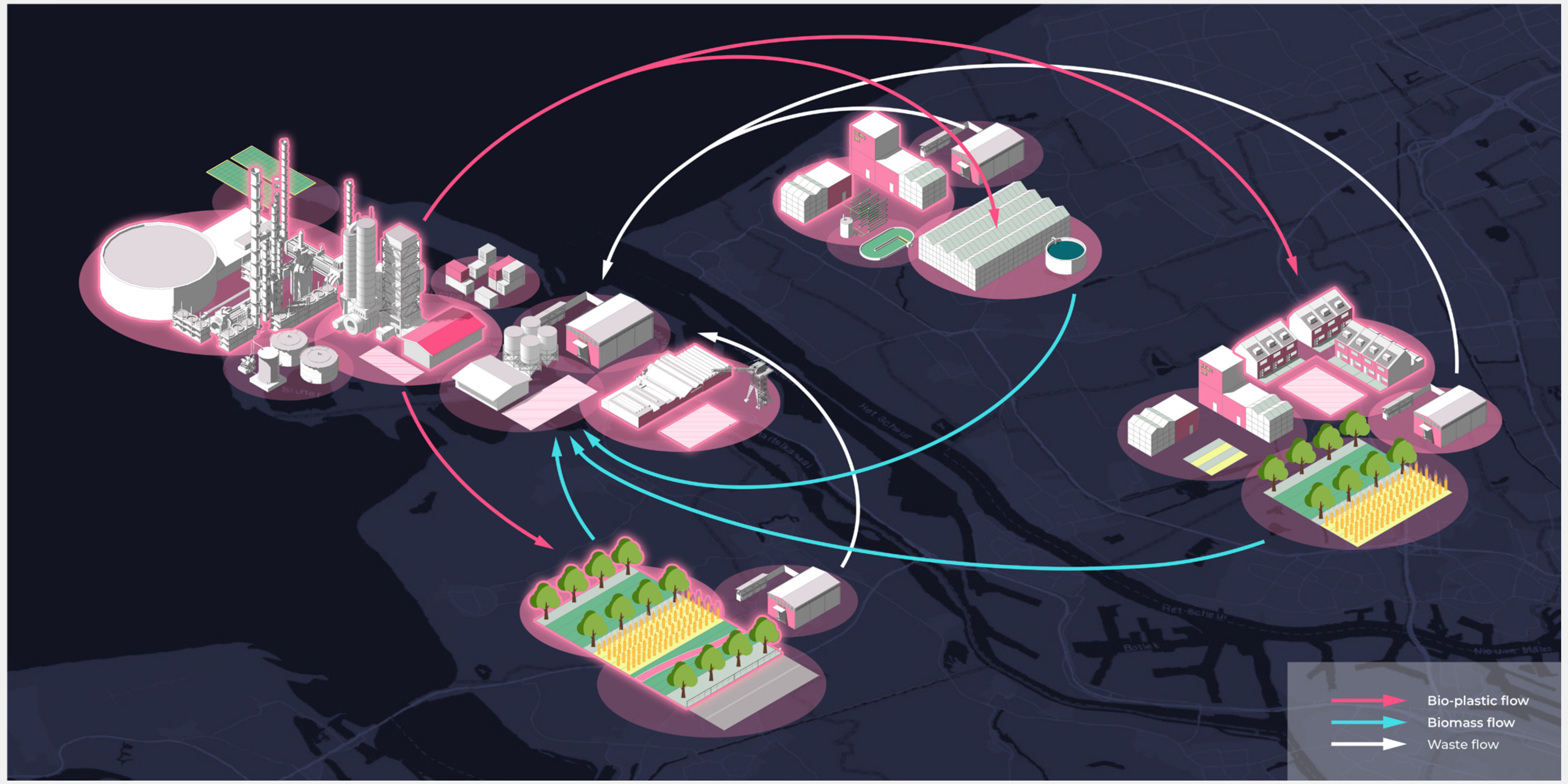
Throughout the Bio-Loop ZH2050, the four clusters work together to form a completely circular system and transport this material flows through the truck connection.

Firstly, the greenhouse, mixed, and mono-functional clusters supply the port with different biomass materials, organic, and residual waste.

As the core of the production of bio-based plastic, the port cluster supplies bio-based plastic to the other three clusters for containers used for the transport of the products and for packing their products.

Finally, the bio-based plastic generated by these products is recycled by the waste hub and transported back to the port for further use in the production of bio-based products, creating a circular chain.

Fig 5.11 Diagram of cluster connection (physical flows)



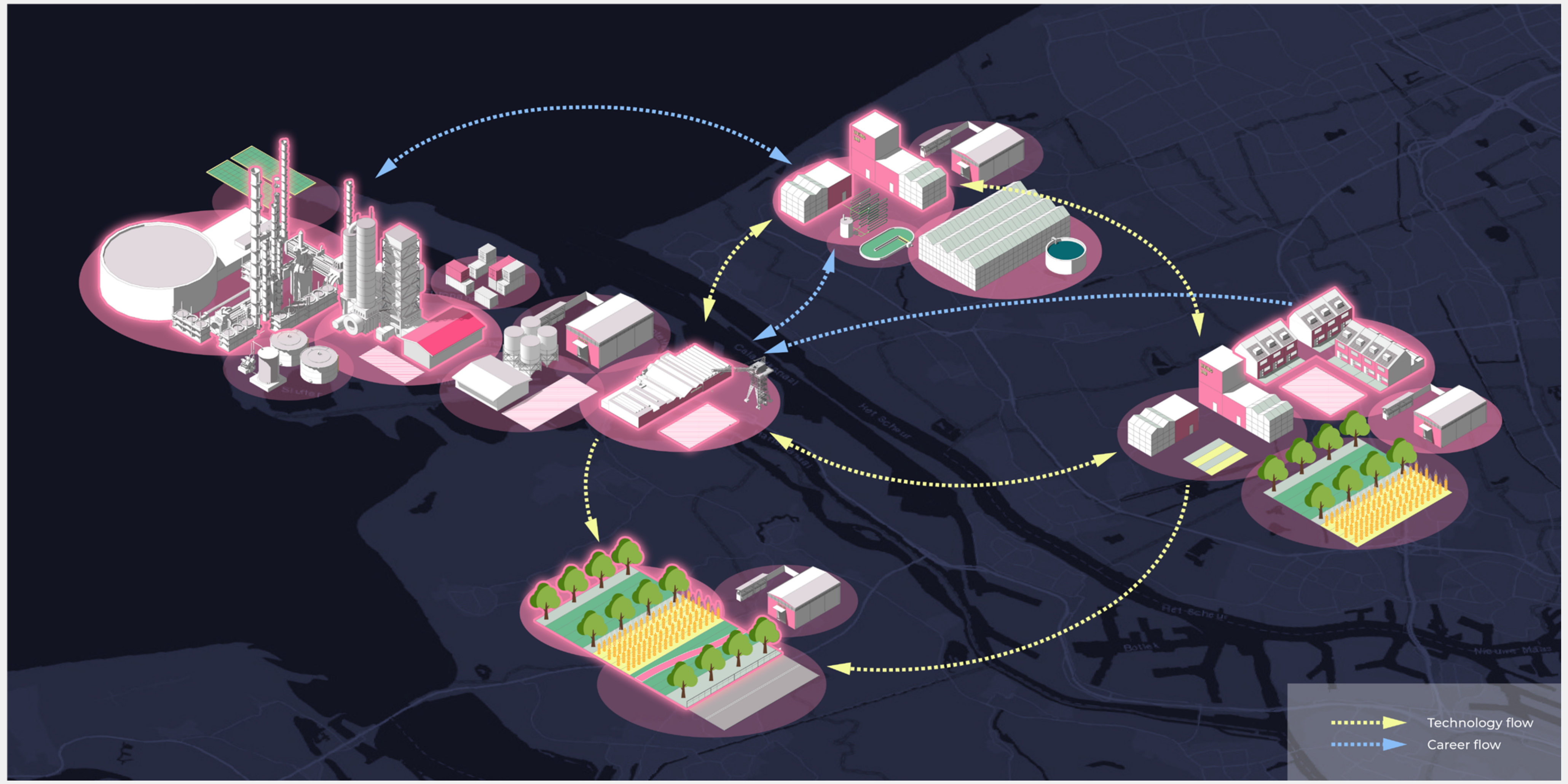
The Bio-Loop ZH2050 requires the integrity of social and technological support and circulation.

Firstly, the innovation dock in the port will play a central role in providing technical support for the other three clusters. The greenhouse and mixed clusters will benefit from the Living Labs and feedback to the port and each other with newer technologies.

At the same time, the mixed cluster will also provide experience to the mono-functional cluster based on practical experience with multiple types of farmland.

The other invisible flow is about job transition, with ports and the Living Labs as bases for on-site training and mutual exchange as industry transitions.

Fig 5.12 Diagram of cluster connection (invisible flows)



5.2.6 Connections between stakeholders

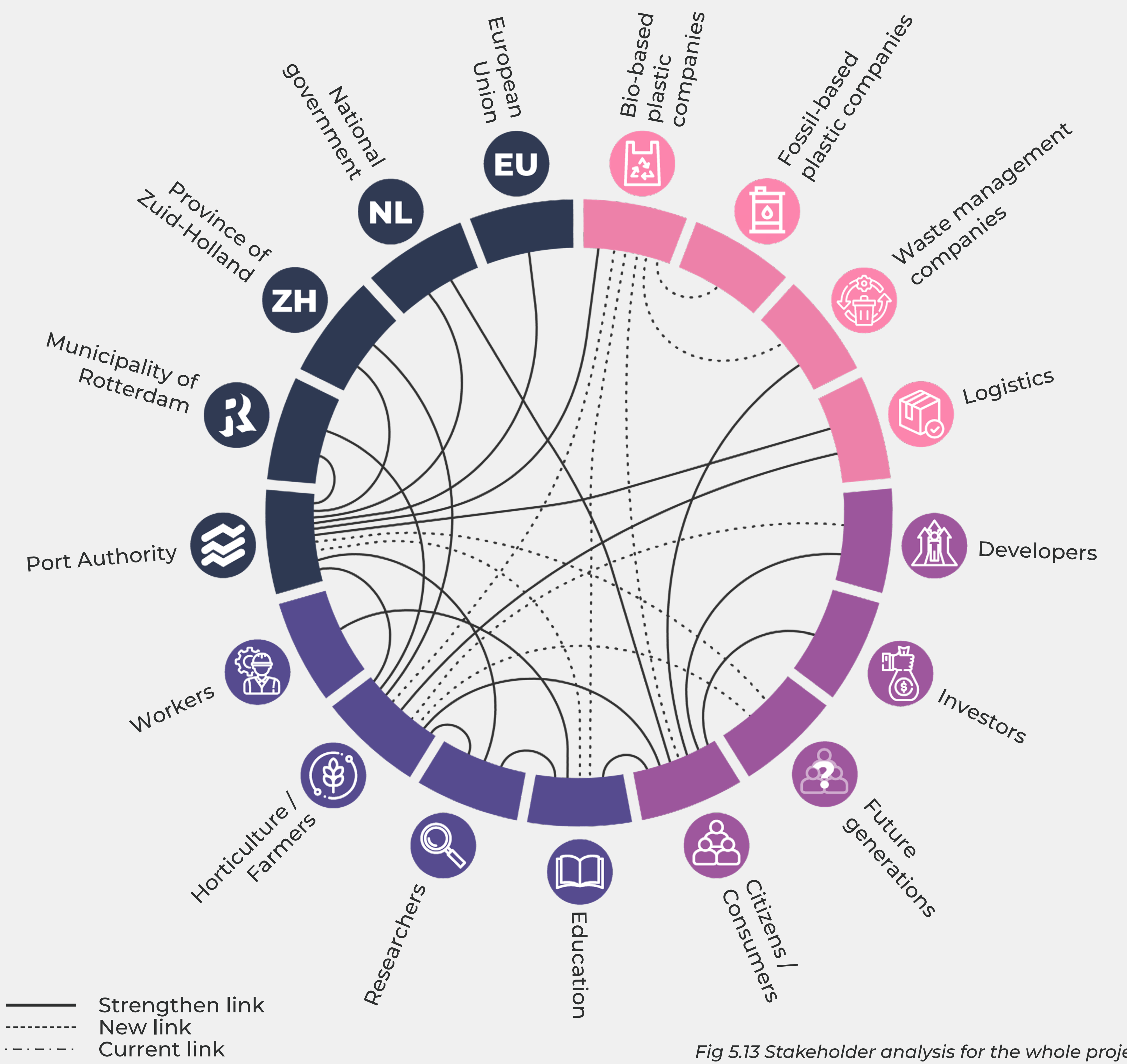


Fig 5.13 Stakeholder analysis for the whole project

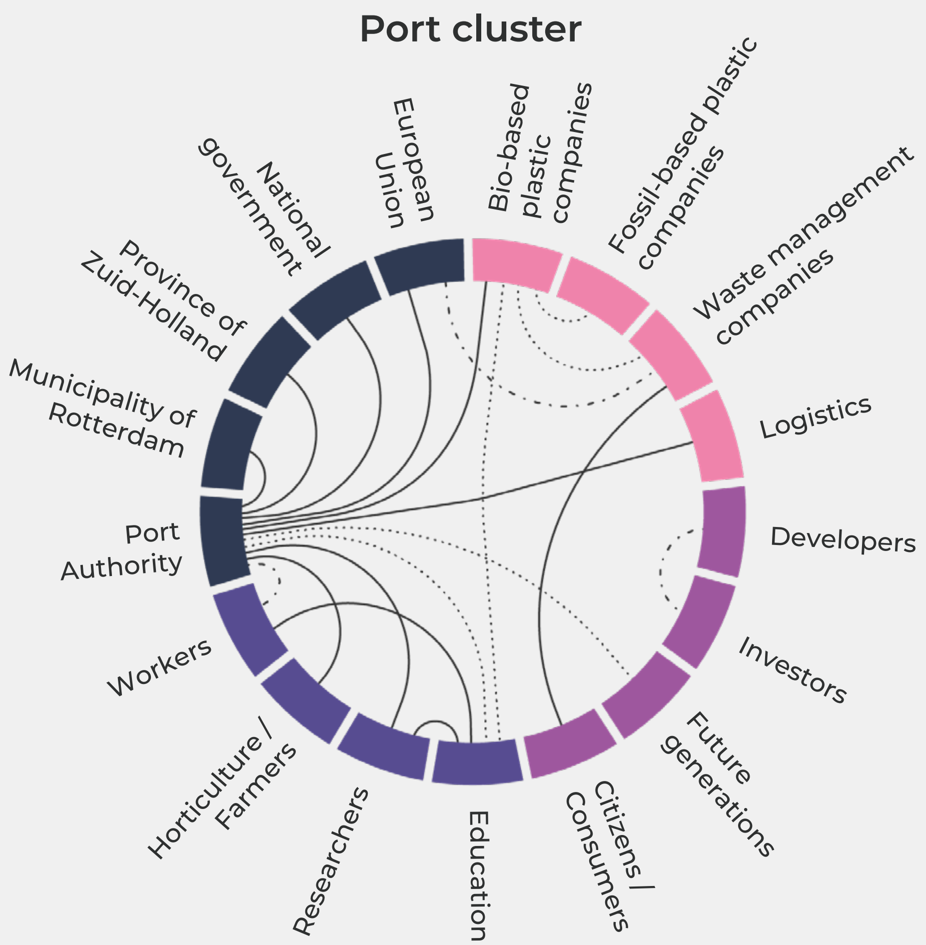


Fig 5.14 Stakeholder analysis for showcase 1

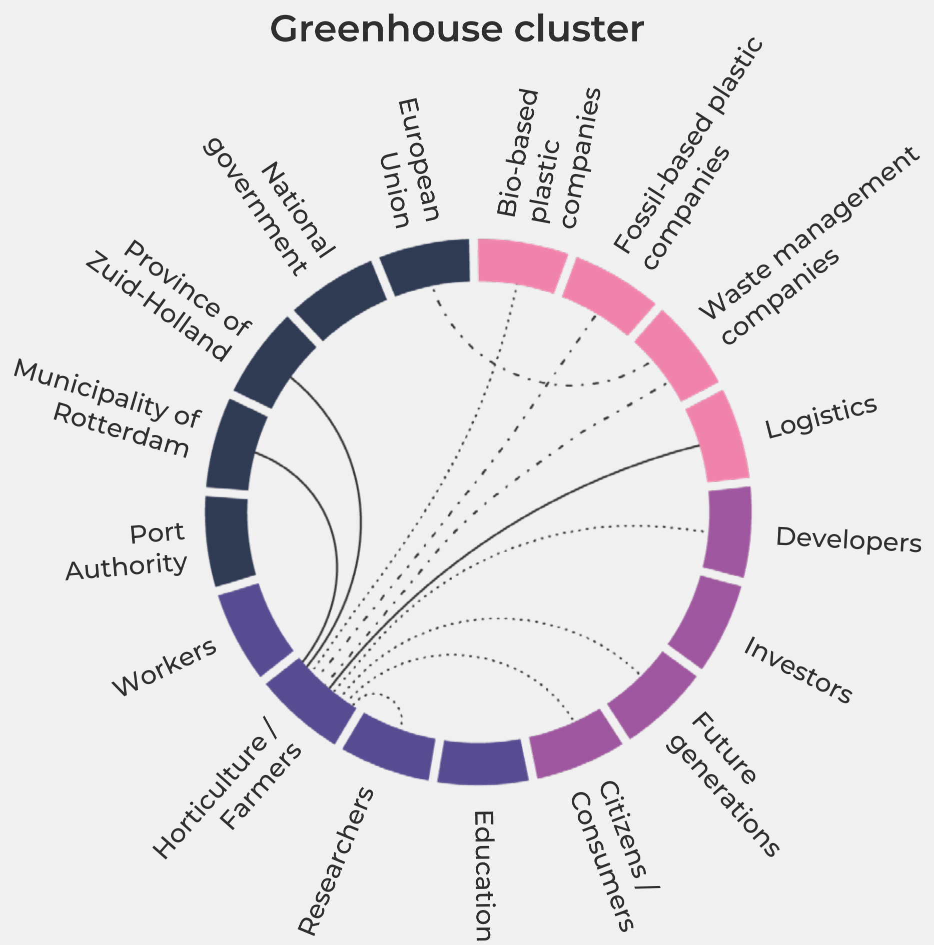


Fig 5.15 Stakeholder analysis for showcase 2

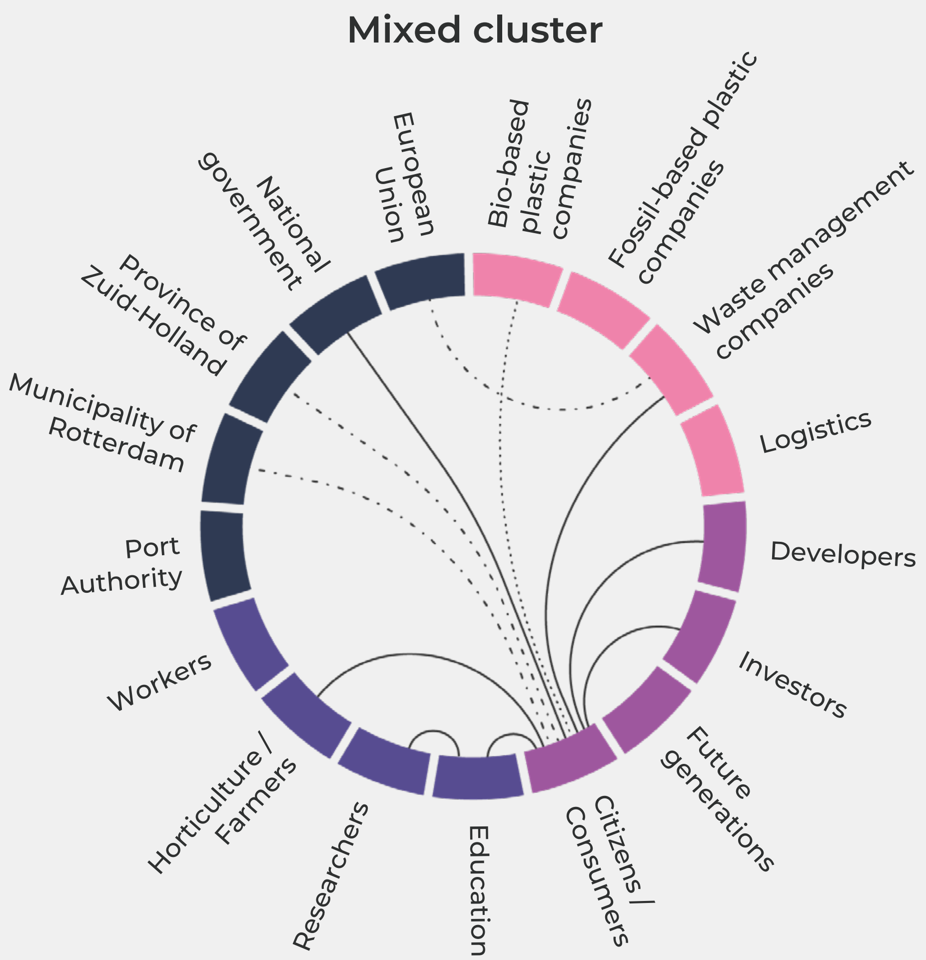


Fig 5.16 Stakeholder analysis for showcase 3

Stakeholders of clusters link in different ways. Firstly, for the Port cluster (fig 5.14), due to the relatively high power of the Port Authority, it is hard to make changes within the Port. **By strengthening the link between the Port Authority and governmental institutions, it is easier to work towards a circular and bio-based plastic industry.** The greenhouse cluster (fig 5.15) focuses on the production process of biomass for the bio-based plastics industry. To optimise this process, **connections between the farmers, bio-based plastic industry and waste hubs are relevant**. For the mixed-cluster (fig 5.16), the focus is on inhabitants and consumers. **Connections are mainly related to awareness of the circular and bio-based plastic industry**. Therefore, new connections between the bio-based plastics industry, farmers and waste hubs are relevant. Fig 5.13 shows all different stakeholders combined, which provides an overview of all stakeholders that influence this project.

5.2.7 Power and interest

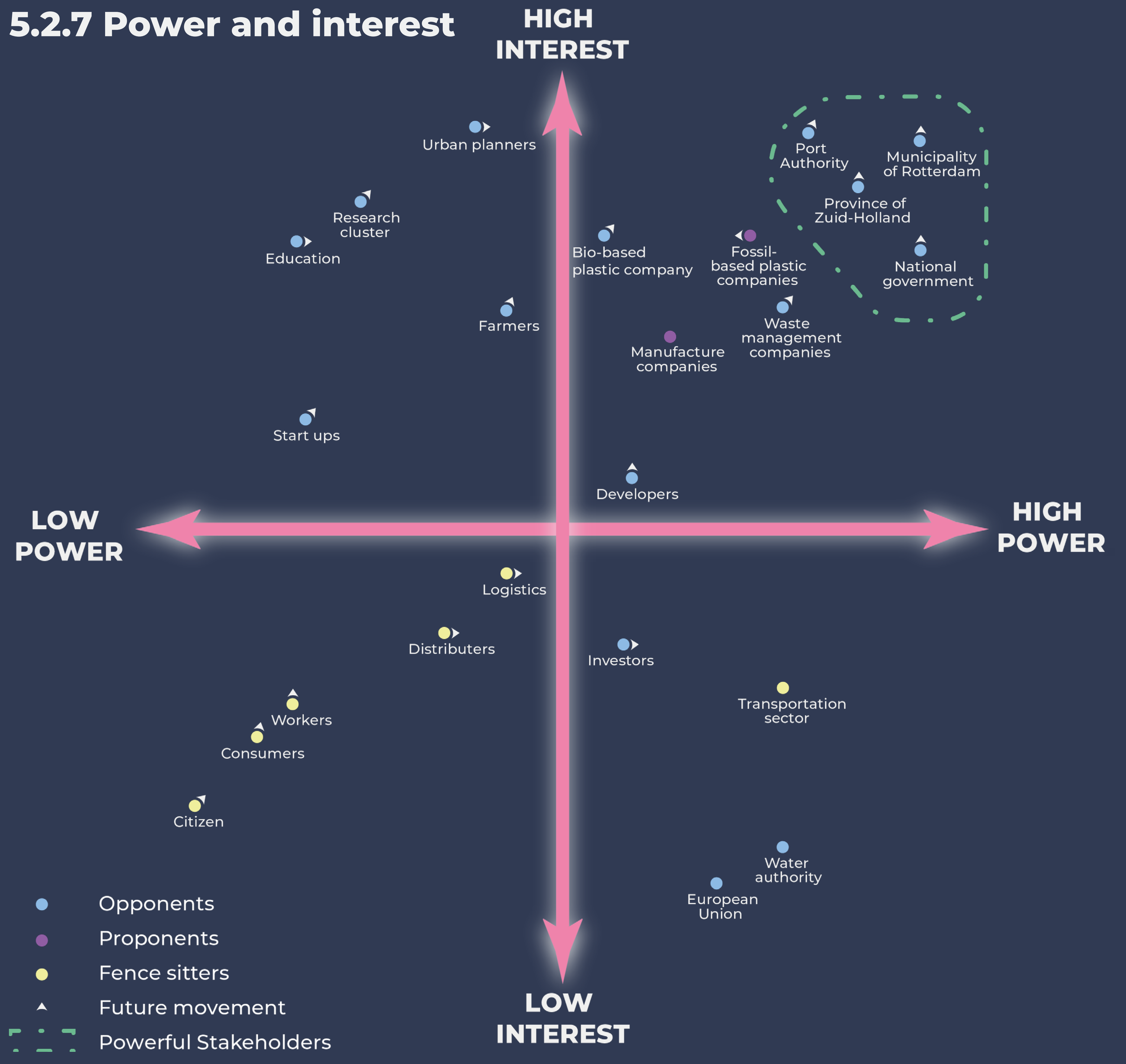


Fig 5.17 Diagram of power and interest of stakeholders

5.2.8 Policy

According to the stakeholder analysis of the whole project, the power and interest are also clarified (fig 5.17). These stakeholders are divided into three main categories: public sector, private sector, and civil society.

The public sectors include the Port Authority, the municipality of Rotterdam and so on, with high power and interest, which means that they have a significant role in driving the transformation of the port. Some regulating policies should be developed to guide these institutions towards the goal of bio-based transformation and protect the rights of other vulnerable groups. The private sectors, including bio-based plastic companies, educational institutions and waste management companies, are the main actors in the transition, driven by the public sectors. They, therefore, also need restrictive policies to ensure that they can produce bio-based products or research on bio-based technology. In the case of civil society, they have low power and interest, so it is difficult for them to have much influence on the transition. Incentives need to be created to get these people involved to participate in the recycling system through waste separation or influencing the powerful authorities by influencing the market.

The policy is divided into two main parts, regulating and stimulating, and the specific policies can be seen in fig 5.18.

Fig 5.18 Diagram of policy making

5.3 STRATEGIC PROJECTS

5.3.1 Principle for project implementation

PORT CLUSTER

Bio-based plastic industry

1. could be located in the existing oil refineries, storage tanks and petrochemical factories
2. is better to update the current plastic factories as the bio-plastic factories
3. should have empty space for development
4. should be close to the main connection (highway/railway/waterway)

Biomass

1. should have enough space suitable for algae cultivation
2. should be close to the main connection (highway/railway/waterway)

GREENHOUSE CLUSTER

The Living Labs

1. should be close to the greenhouses
2. should be close to the main connection (highway/railway)
3. have the potential to enhance public connection (biking path/pedestrian/tram)
4. have empty space for the Living Labs
5. should be close to the waste hub

Biomass

1. make use of old and abandoned greenhouses
2. should be close to the main connection (highway/railway/waterway)
3. cooperate with greenhouses

MIXED CLUSTER

The Living Labs

1. should be close to the boundary of different types of green spaces
2. should be close to the main connection (highway/railway)
3. have the potential to enhance public connection (biking path/pedestrian/tram)
4. have empty space for the Living Labs
5. should be close to the waste hub
6. is better to close to the community

Biomass

1. avoid hard protection area
2. should be close to the main connection (highway/railway/waterway)
3. cooperate with greenhouses and arable land as well as using part of grassland

MONO-FUNCTIONAL CLUSTER

Biomass

1. avoid hard protection area
2. have convenient connection
3. cooperate with arable land and grassland under the premise of avoiding competition with food market
4. properly use part of grassland

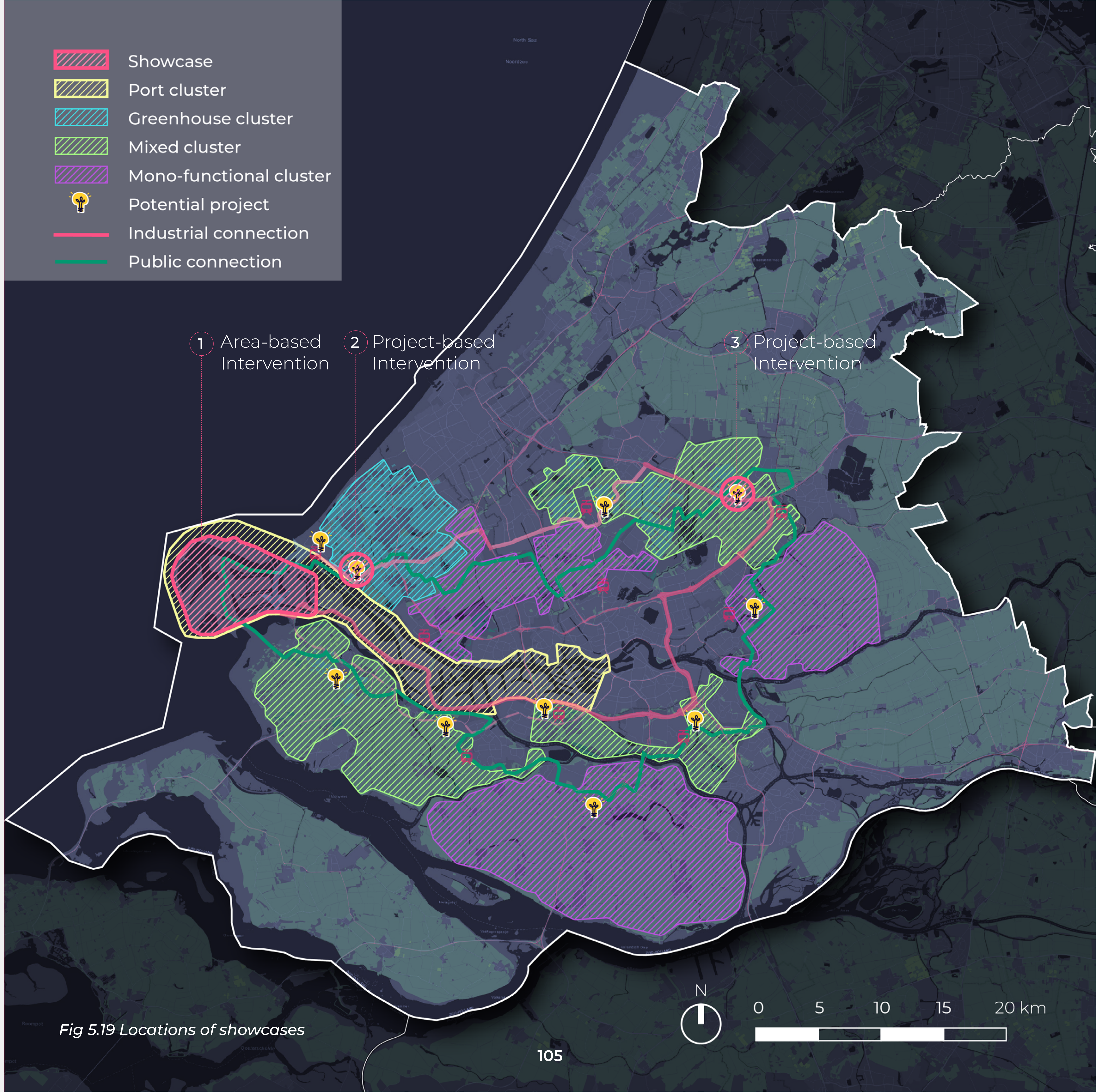


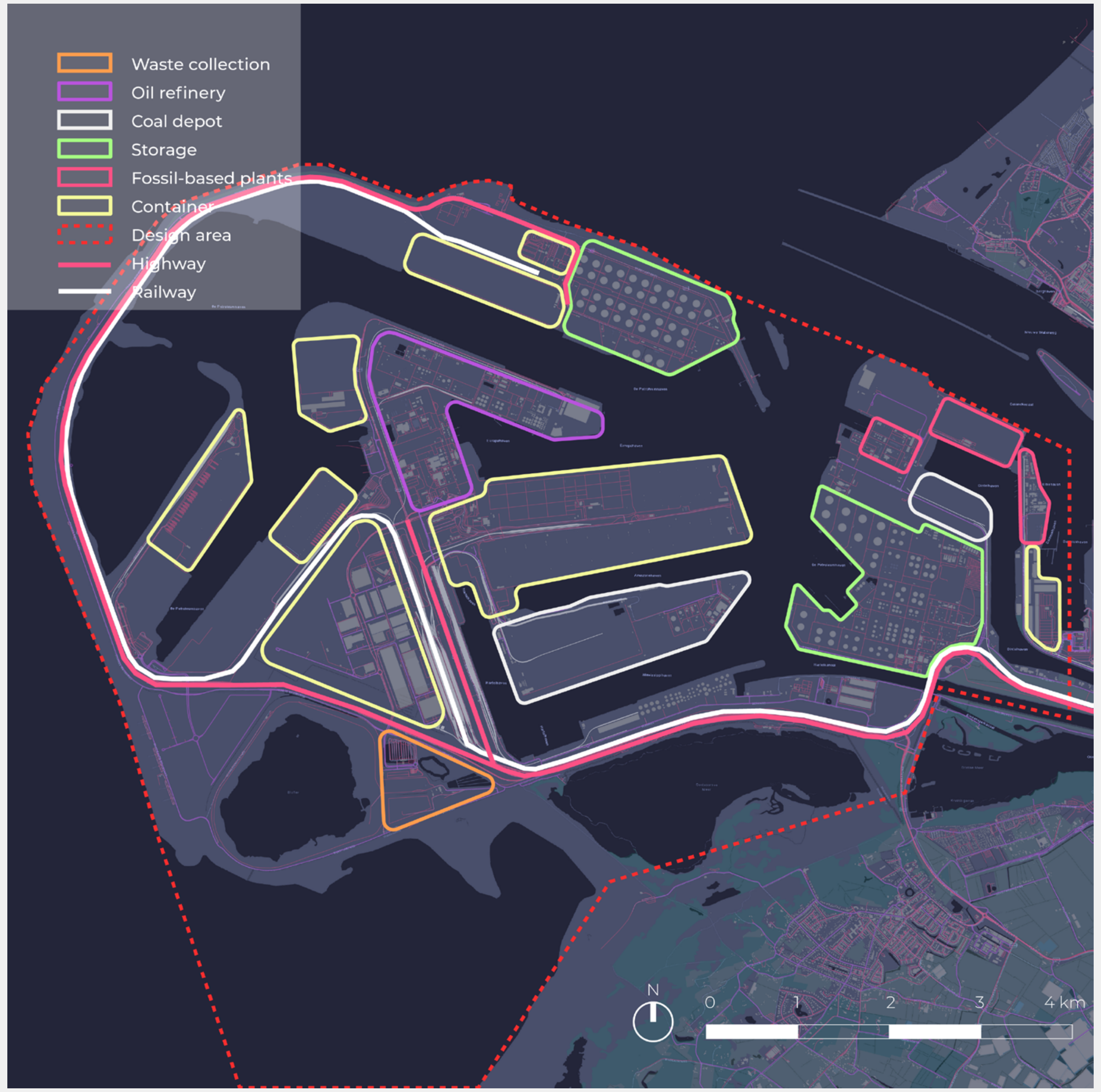
Fig 5.19 Locations of showcases

5.3.2 Current status of three showcases

AREA-BASED DESIGN IN THE PORT CLUSTER

The Maasvlakte area is an artificially reclaimed area that extends westwards from the port of Europoort and the industrial facilities within the Port of Rotterdam. Its primary function is as a container terminal and logistics centre, with many open spaces for future bio-based businesses. In our vision, this area will serve as the starting point for transforming a circular bio-based economy. So it will showcase how the area can be restructured with the bio-based plastic industry and how the industry can be transformed spatially.

Fig 5.20 Showcase 1



PROJECT-BASED DESIGN IN THE GREENHOUSE CLUSTER

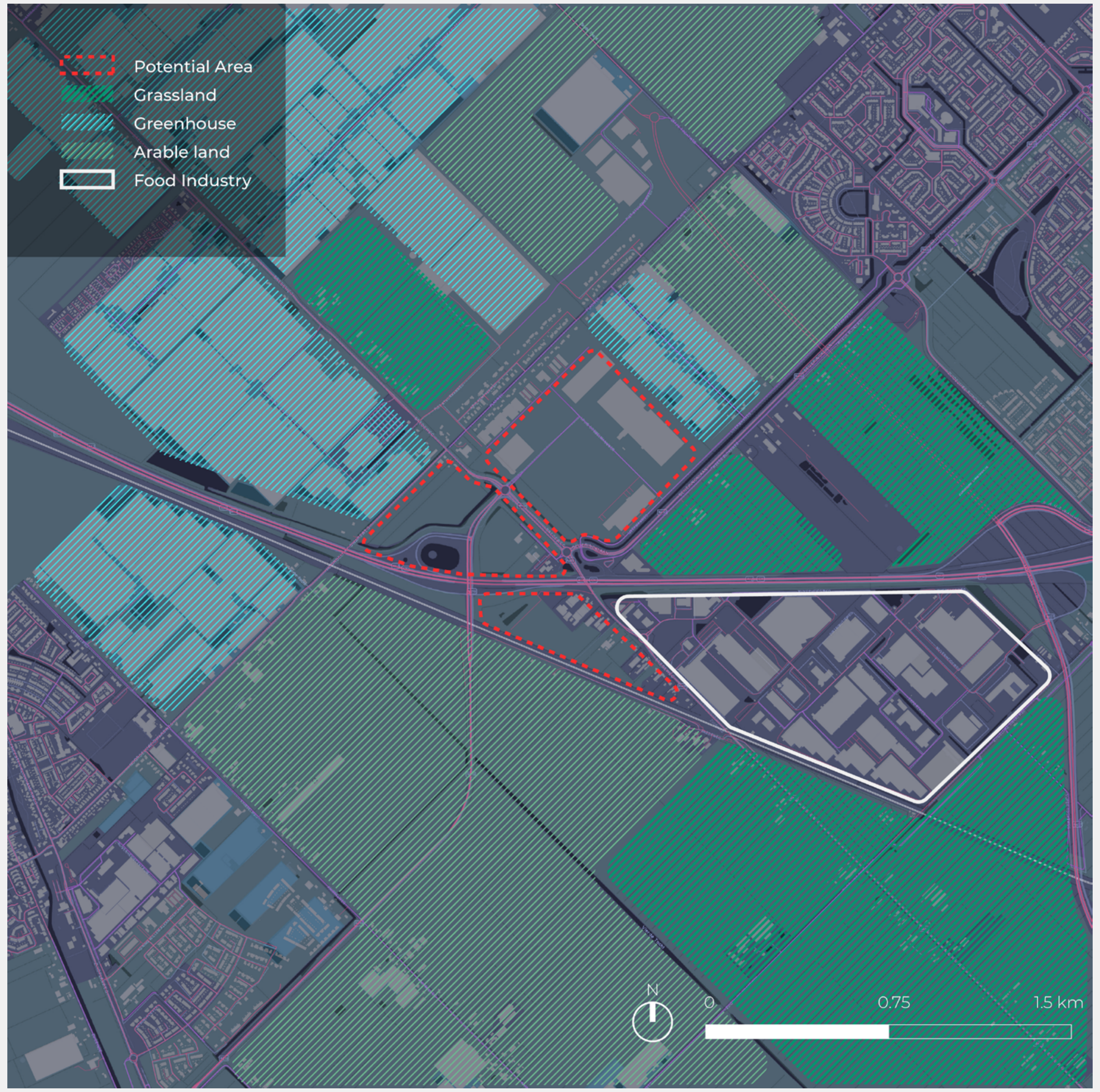
The showcase is located between Hoek van Holland and Maasdijk near the river. Currently, it is mainly space and a waste station, which is also close to arable land and greenhouses. These conditions are beneficial for the placement of the Living Labs. On the one hand, this showcase demonstrates how the intervention of the Living Labs can be used in cooperation with the greenhouse cluster. On the other hand, applying a Living Lab on the actual site can also serve as a model for other projects within the cluster.

Fig 5.21 Showcase 2

PROJECT-BASED DESIGN IN THE MIXED CLUSTER

The project will be located between Waddinxveen and Zevenhuizen within the Bio-Loop ZH2050, which is defined as a mixed area where there is a mix of greenhouses, arable land, grassland and communities. This area is also near the primary truck connection and the biking path. The showcase will demonstrate how the Living Labs can play a technical role in the diverse area and provide a new public space for the surrounding area.

Fig 5.22 Showcase 3



5.3.3 Showcase in the port cluster

The transition towards a bio-based plastic industry within the Port of Rotterdam will start in Maasvlakte area. Therefore, this vision-based design project will create innovations for the whole port and Zuid-Holland.

In the first phase, **the region will set the foundation for the transformation and be able to produce intermediate products**. The initial infrastructure transformation will have been completed, which means that the existing fossil-based depot will be used to store imported and local biomass. The waste station will be transformed into a waste hub to provide raw materials. The oil refinery will be transformed into a biomass refinery for intermediate, and storage will store these intermediate products and provide services for the whole port.

In the second phase, **the Maasvlakte area will convert existing petrochemical plants and build new facilities for bio-based plastic production**. The industrial chain and circular system based on bio-based plastic will be completed in this step.

More petrochemical plants will be transformed in the last phase, and the reserved space will be used for other bio-based products due to the demand.

In 2050, **the Maasvlakte area will have a complete bio-based plastic manufacturing chain** with a substantial storage capacity for bio-based plastic, biomass, intermediate, and become the leading cluster supporting the transformation of port area.

Fig 5.23 Phase 1: 2022 - 2030

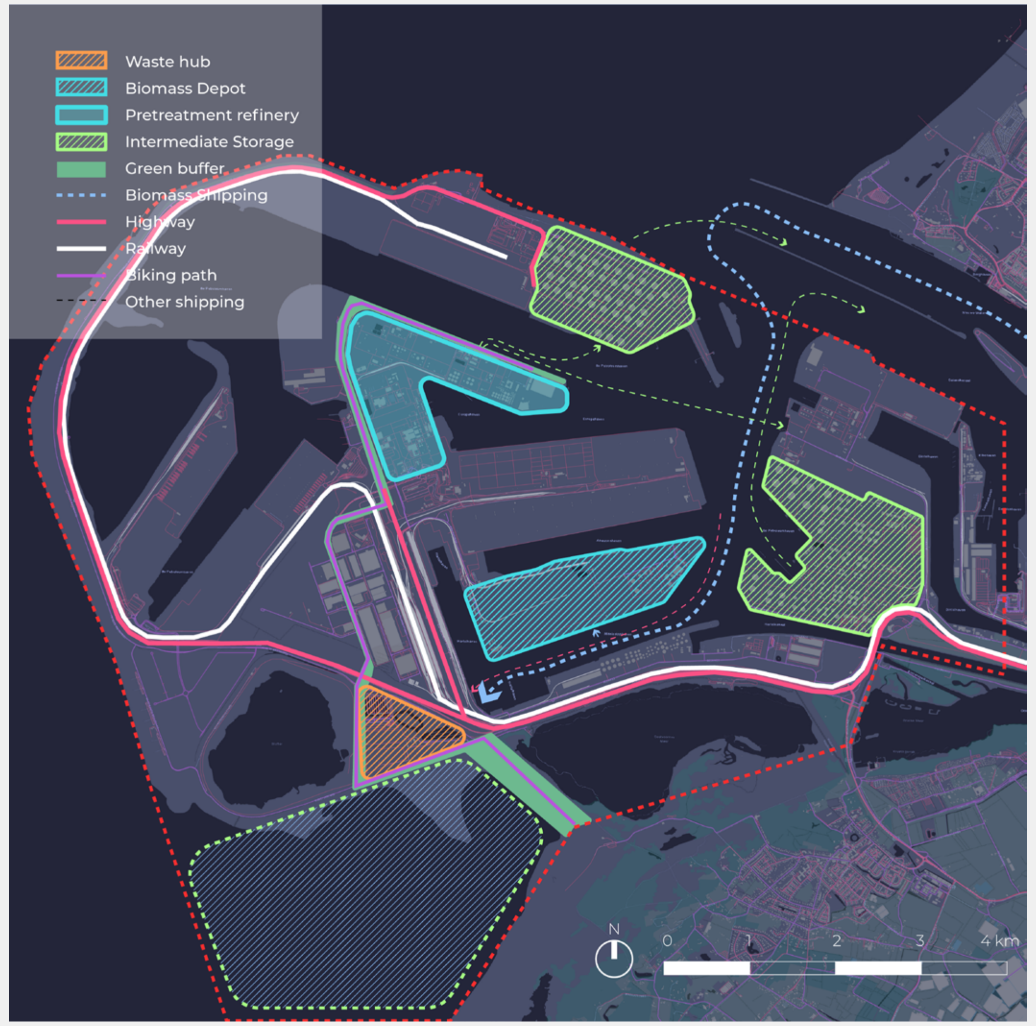


Fig 5.24 Phase 2: 2030 - 2040

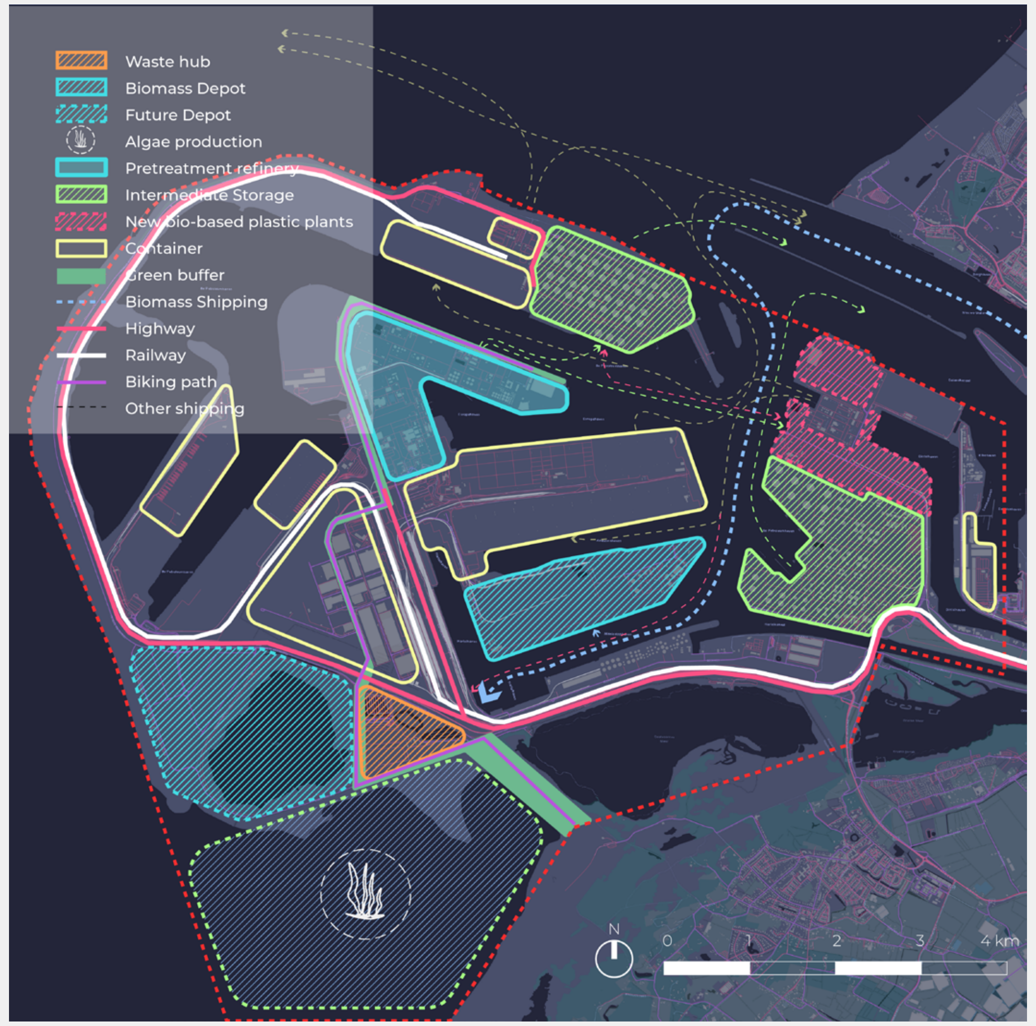
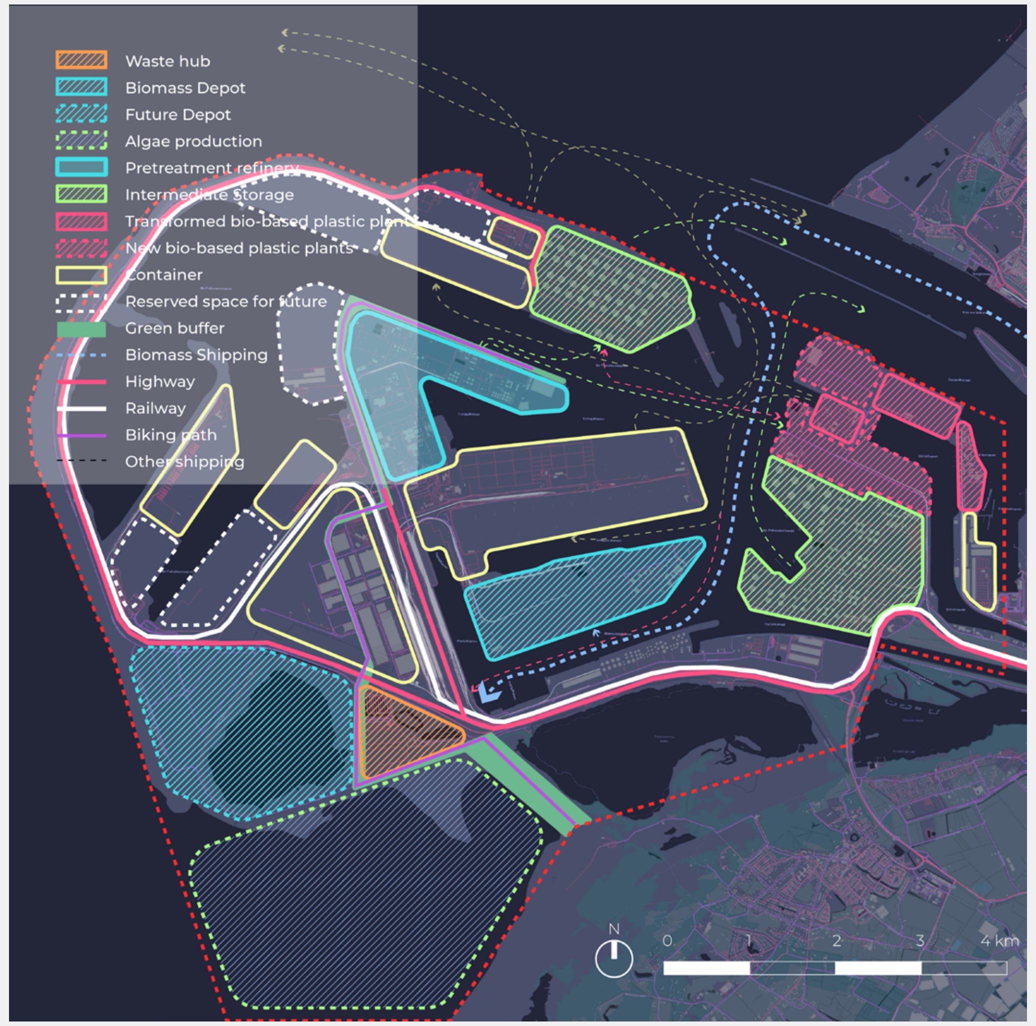
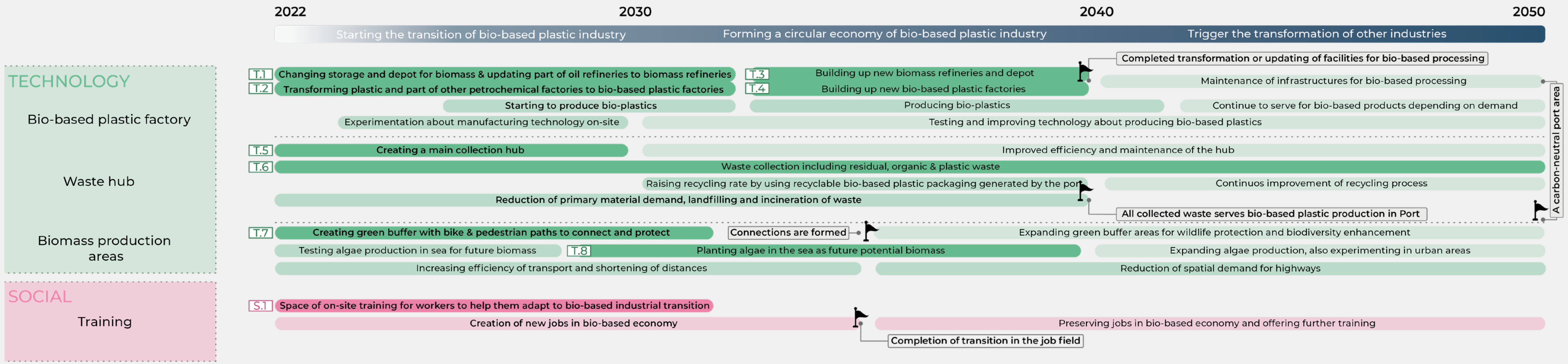


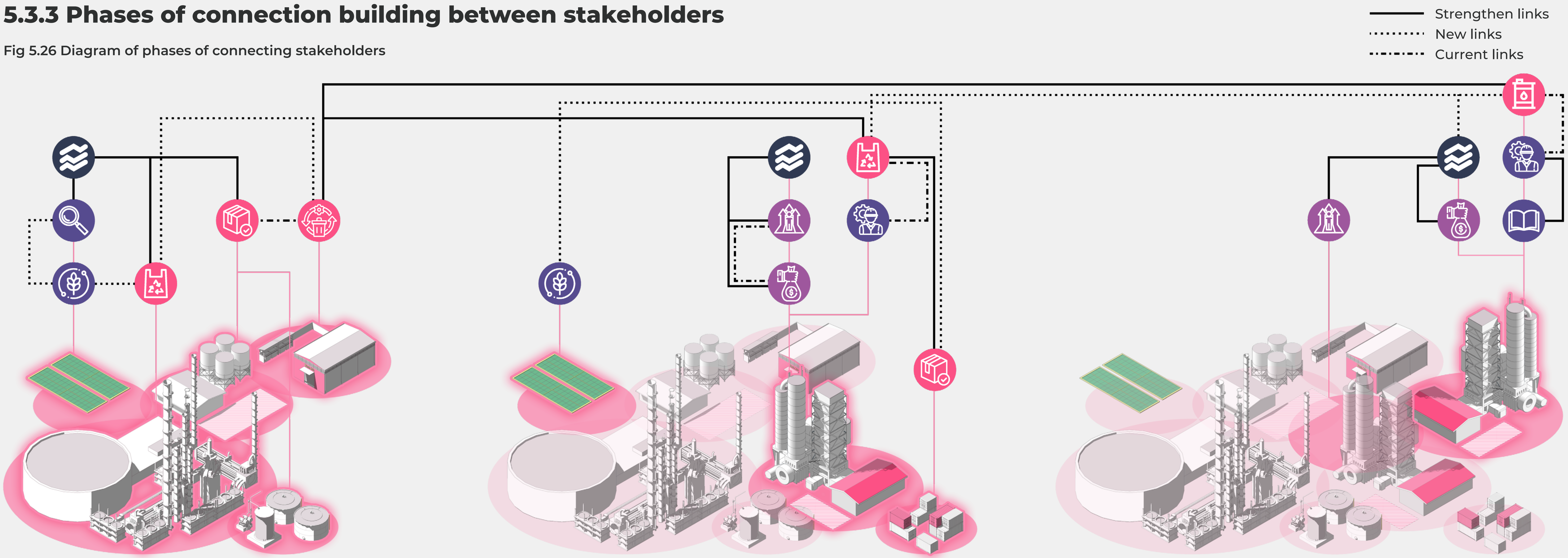
Fig 5.25 Phase 3: 2040 - 2050





5.3.3 Phases of connection building between stakeholders

Fig 5.26 Diagram of phases of connecting stakeholders



PHASE 1

Port authority starts to help other sectors to transform current facilities and flow systems to prepare for future bio-based manufacturing industry of plastic. Algae as a potential biomass material is tested by farmers and researchers. Logistic improves their management skill for storaging different materials and waste management sector starts recycling of resources.

PHASE 2

Under the cooperation of port authority, developers and investors, new bio-based plastic factory is built to produce products. After completing the whole manufacturing chain, bio-based plastic produced locally will be used as packaging in the logistic sector. Biomass including algae are transported and storaged in depot under the management of logistic sector.

PHASE 3

Current fossil-based plants are updated and transformed to bio-based factory under the guidance of port authority. Workers area trained in education sector to adapt to the industrial transformation. Port authority, developers and investors will continue working together to built new facilities or reserve space for future development of bio-based industries.

5.3.3 Collage

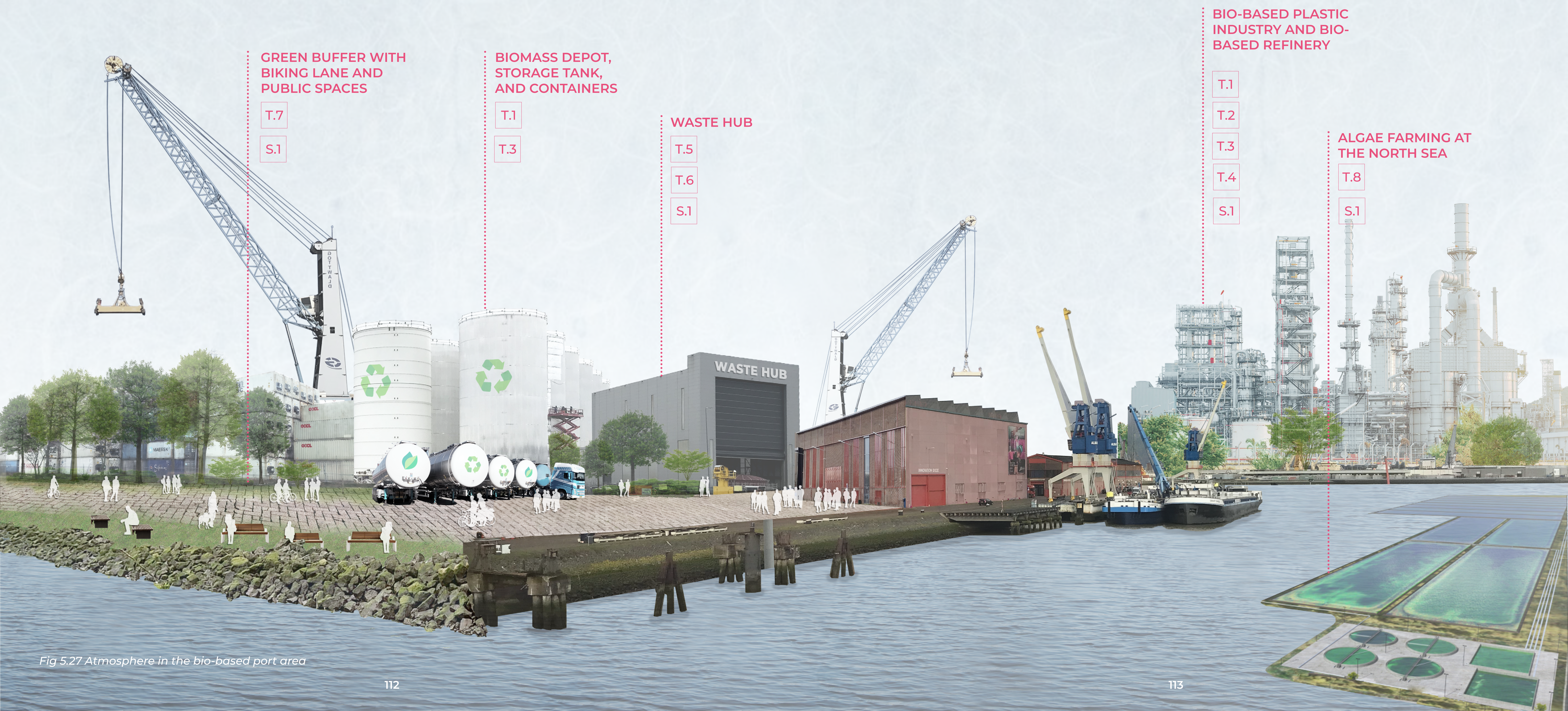


Fig 5.27 Atmosphere in the bio-based port area

5.3.4 Showcase in the greenhouse cluster

The showcase will demonstrate how the Living Lab participates in the greenhouse cluster to play the role of innovation.

In the first phase, the Living Lab will be implanted into space and use biomass produced from part of greenhouses to conduct experiments. At the same time, enhance the connection with the surrounding by strengthing the biking path and its green buffer. The Living Lab at this stage mainly works with neighbouring greenhouses and waste hubs to improve the technology with raw materials.

In the second phase, the arable land around the Living Lab has been planted with trees, so biomass from agroforestry begins to be used. Meanwhile, to enhance the publicity of the Living Lab, the green buffer around the biking path is further expanded as a public space to attract people around, especially farmers, to participate in innovation and exchange ideas. The Living Labs will serve as a research complex and provide services for the whole greenhouse cluster with a public program relevant to the greenhouse such as a flower market.

In the last stage, spare greenhouses are used to plant algae, and the waste hub around the Living Labs is expanded to meet the demand for biomass in the future.

In 2050, based on the establishment of the Living Lab project, the greenhouse cluster will continuously provide new technologies for the greenhouse, improve biomass production efficiency, and provide new public space for farmers.

Fig 5.28 Phase 1: 2022 - 2030

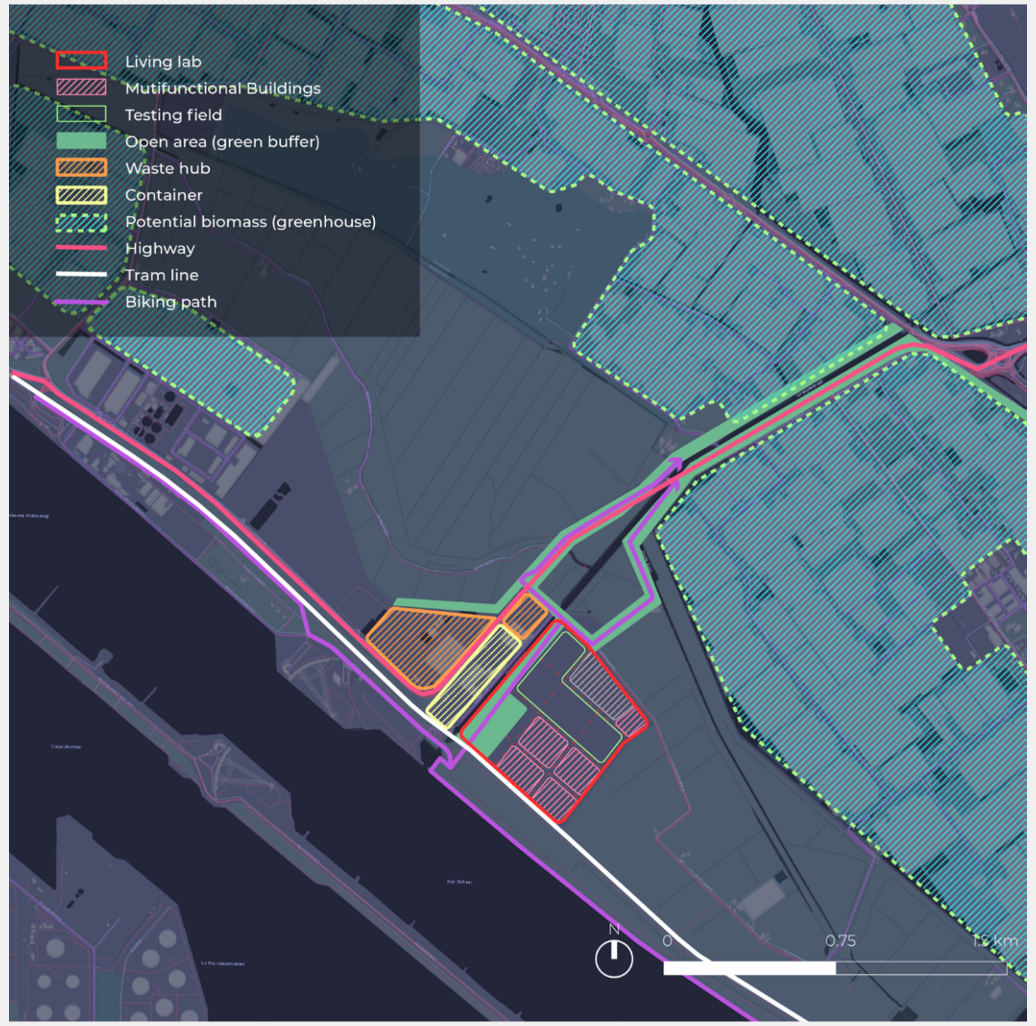


Fig 5.29 Phase 2: 2030 - 2040

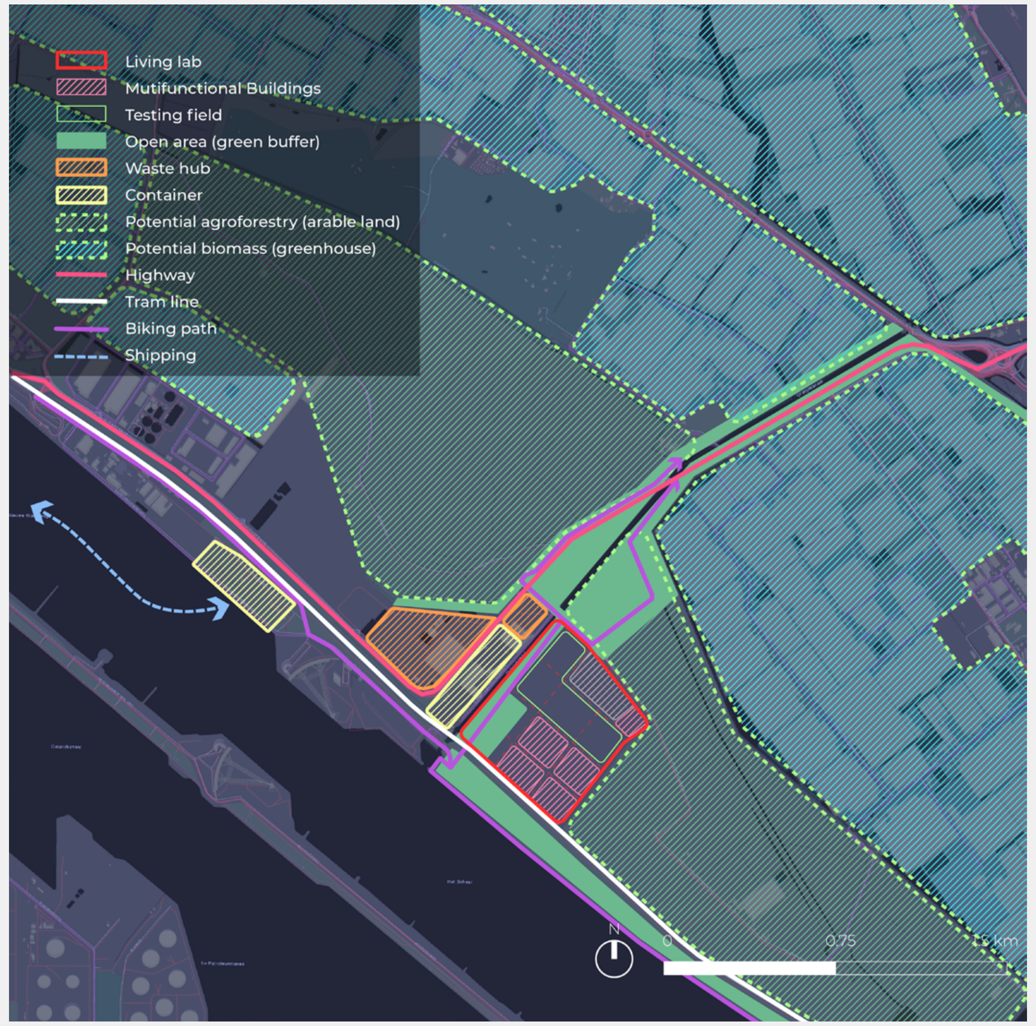
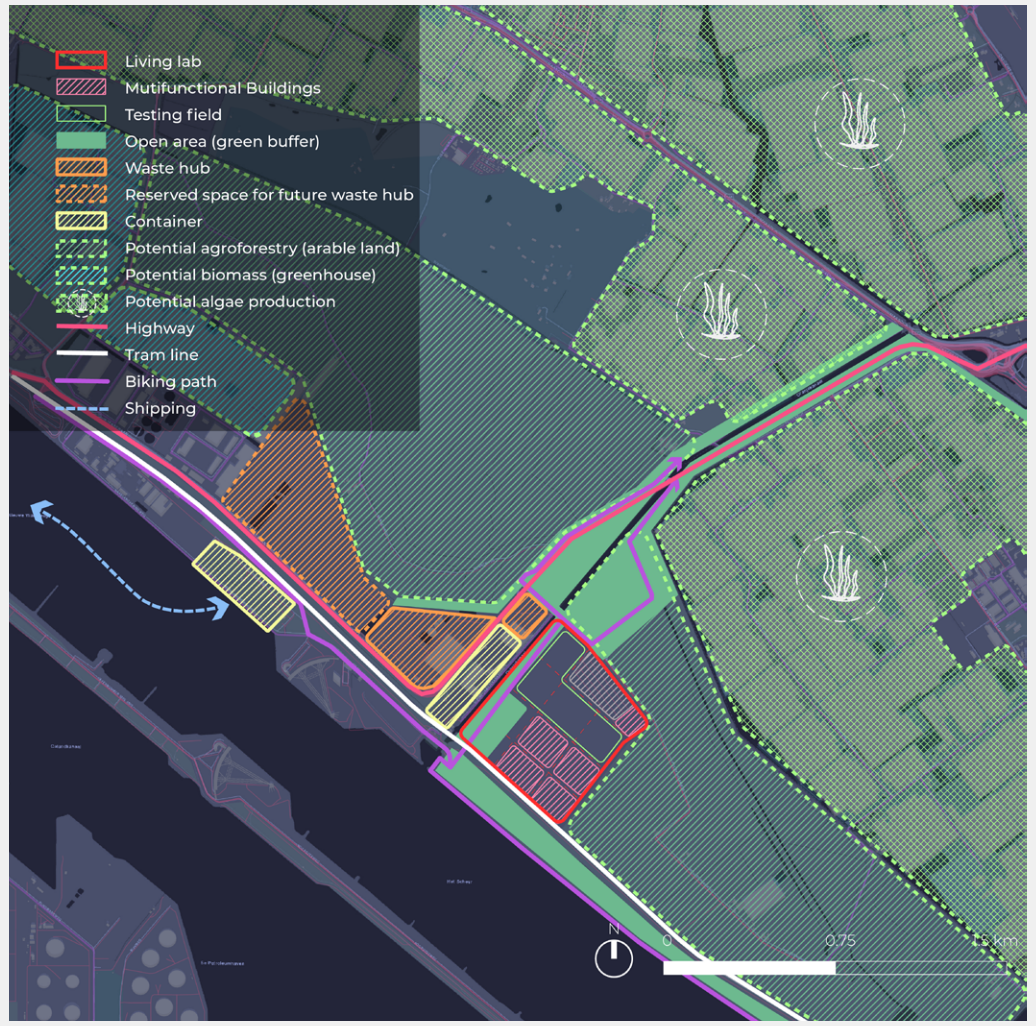
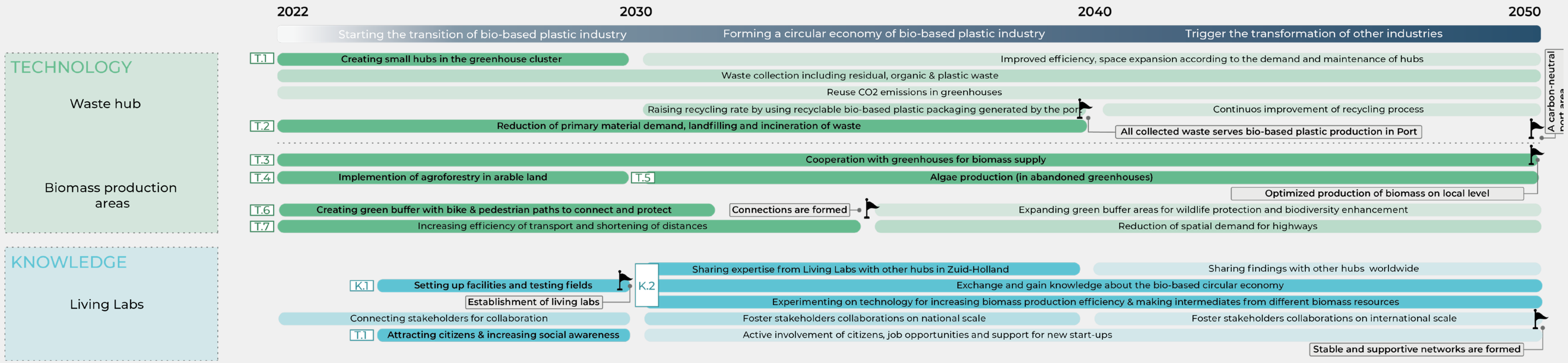


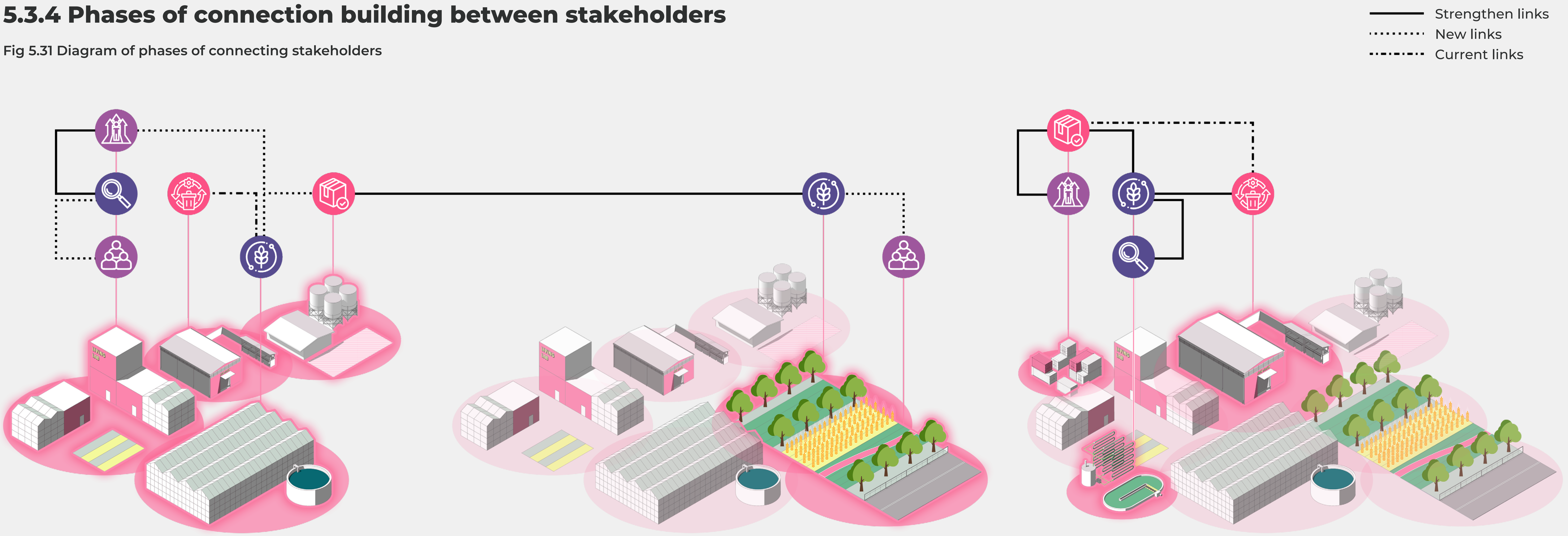
Fig 5.30 Phase 3: 2040 - 2050





5.3.4 Phases of connection building between stakeholders

Fig 5.31 Diagram of phases of connecting stakeholders



PHASE 1

Developers and researchers together set up the Living Labs for experimenting new technologies about producing biomass and exchanging knowledge between different stakeholders and also citizens. By cooperating with farmers, biomass produced in greenhouses will be used in the Living Labs or transported by logistic sector to the industries.

PHASE 2

Trees will be planted in the arable land to build agroforestry, which contributes to the production of biomass. Farmers can benefit from it and then work better. Green buffer will be implemented between green area and highway transportation. Citizens can enjoy the landscape by bike following the path set inside the green buffer.

PHASE 3

Abandoned greenhouses are transformed for planting algae so that more biomass can be produced. Farmers get educated by researchers in the Living Labs to learn producing algae efficiently. Developers and logistic can set up depot here to manage and transport biomass. Waste management sector expands the waste hub to handle more organic waste.

5.3.4 Collage

Fig 5.32 Atmosphere in the greenhouse area

5.3.5 Showcase in the mixed cluster

The mixed cluster will have a remarkable effect on the combination of the Living Labs due to its specific mixed attributes. This showcase focuses on the connection between the Living Labs and surrounding communities and different types of farmlands.

In the first phase, the construction of the Living Labs will be completed, and surrounding greenhouses will start to produce biomass which will be partly used in the Living Labs for experiment. Meanwhile, the waste hub is established in space and connected to the port through the highway.

In the second phase, biomass produced by agroforestry in the arable land and grassland will be used. The connection between the Living Labs and the surrounding will be strengthened to expand more public spaces in the community. The Living Labs and surrounding public network have been completed at this stage.

In the third phase, the community will be one of the essential participants of the living lab. A living lab and strong public connection provide new public space and communication space for residents. The greenhouse will also begin to experiment with algae cultivation.

In 2050, under the influence of a living lab, the mixed cluster will use this hub to provide rich experience and technology for biomass production of other clusters.

Fig 5.33 Phase 1: 2022 - 2030

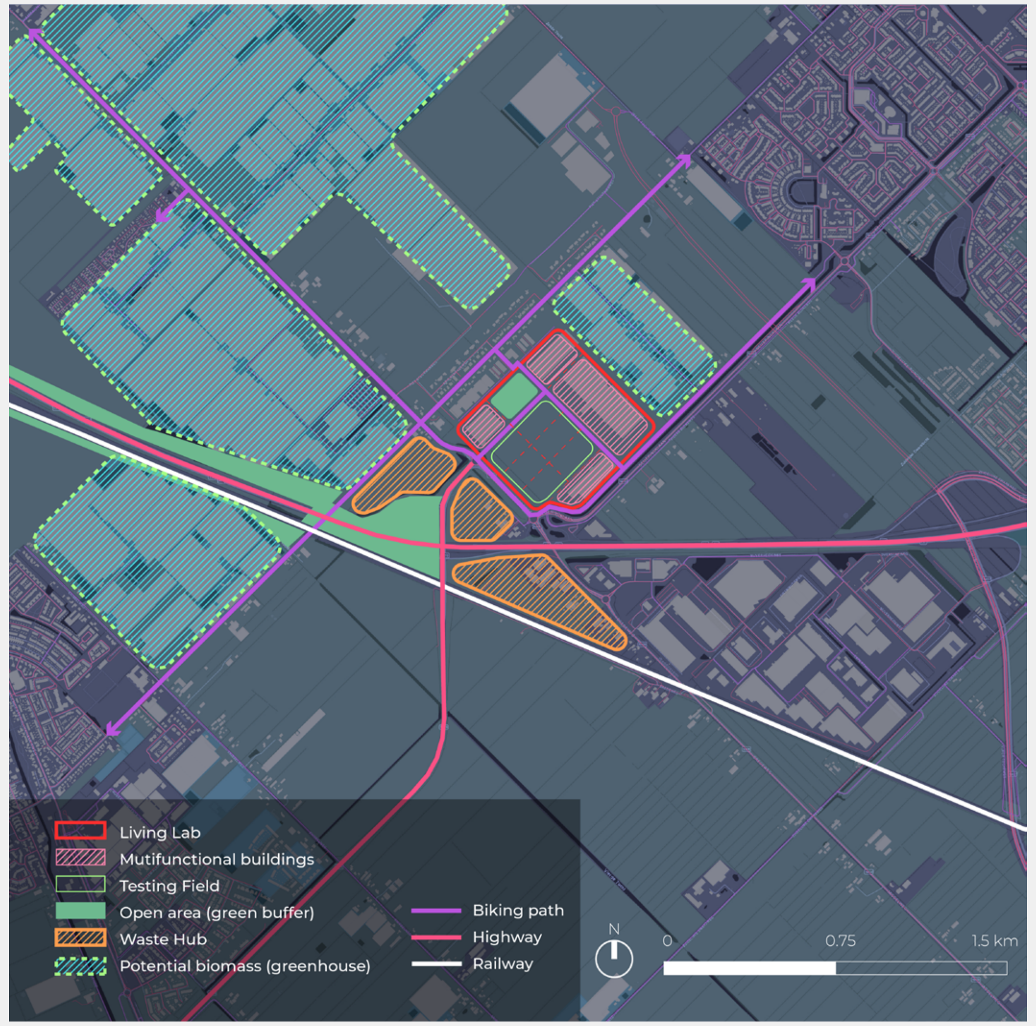


Fig 5.34 Phase 2: 2030 - 2040

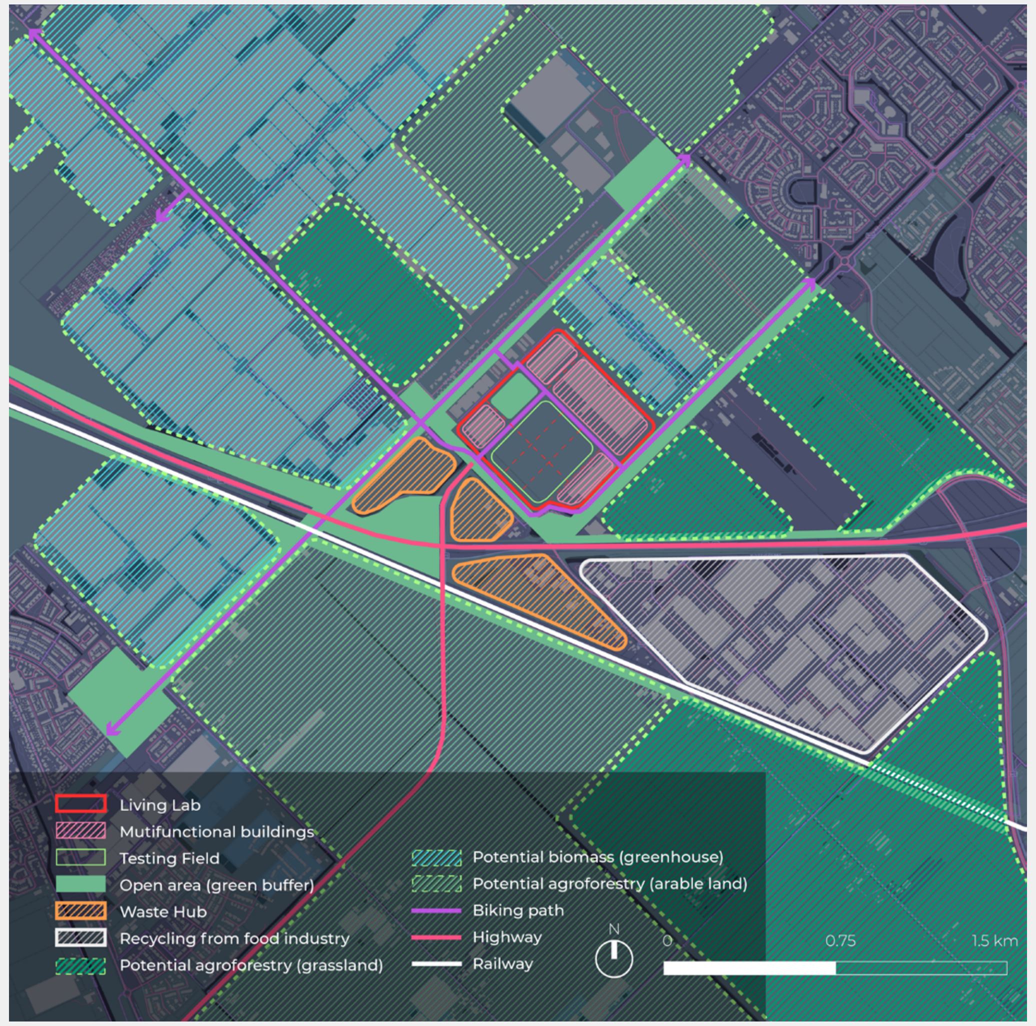
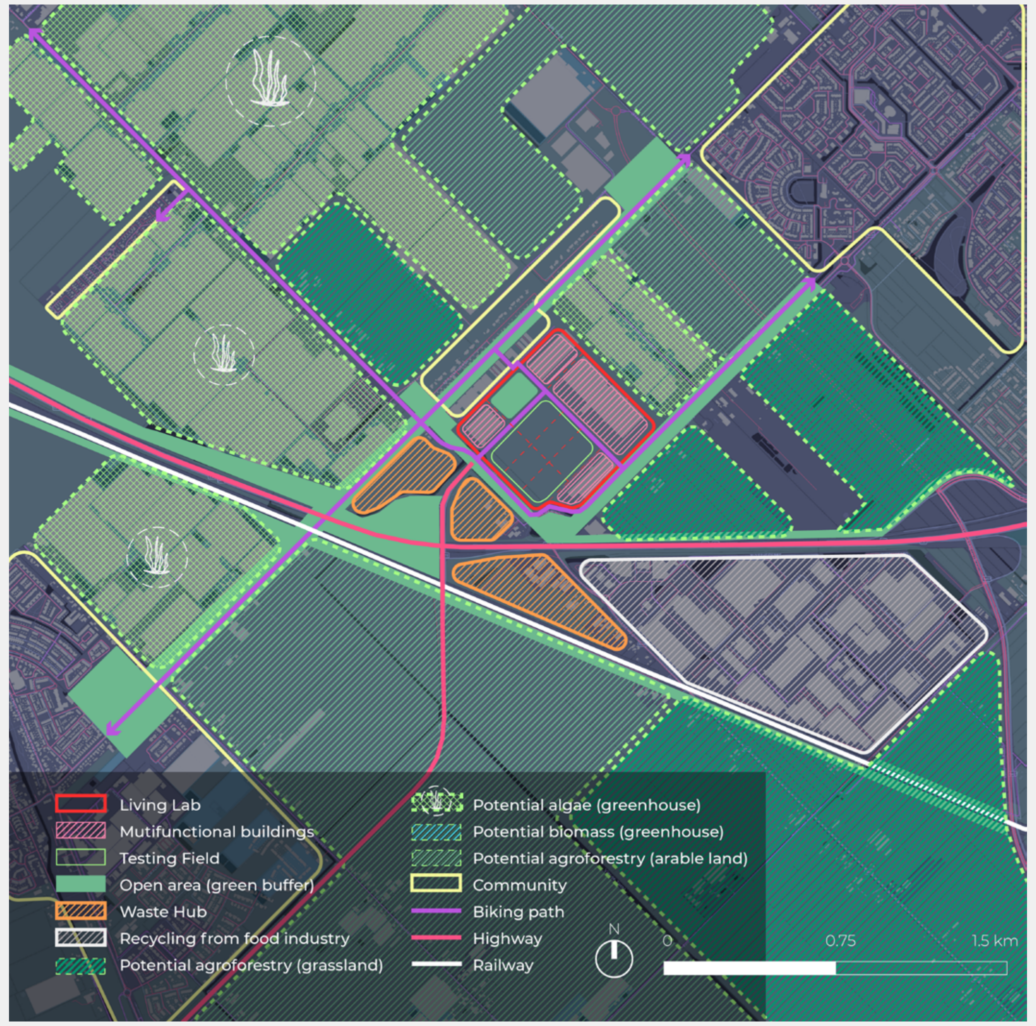
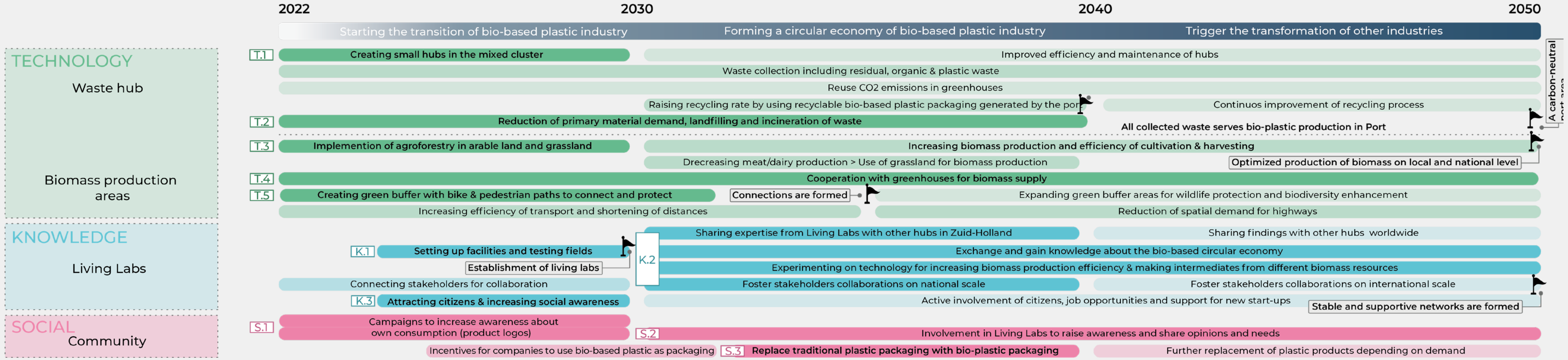


Fig 5.35 Phase 3: 2040 - 2050

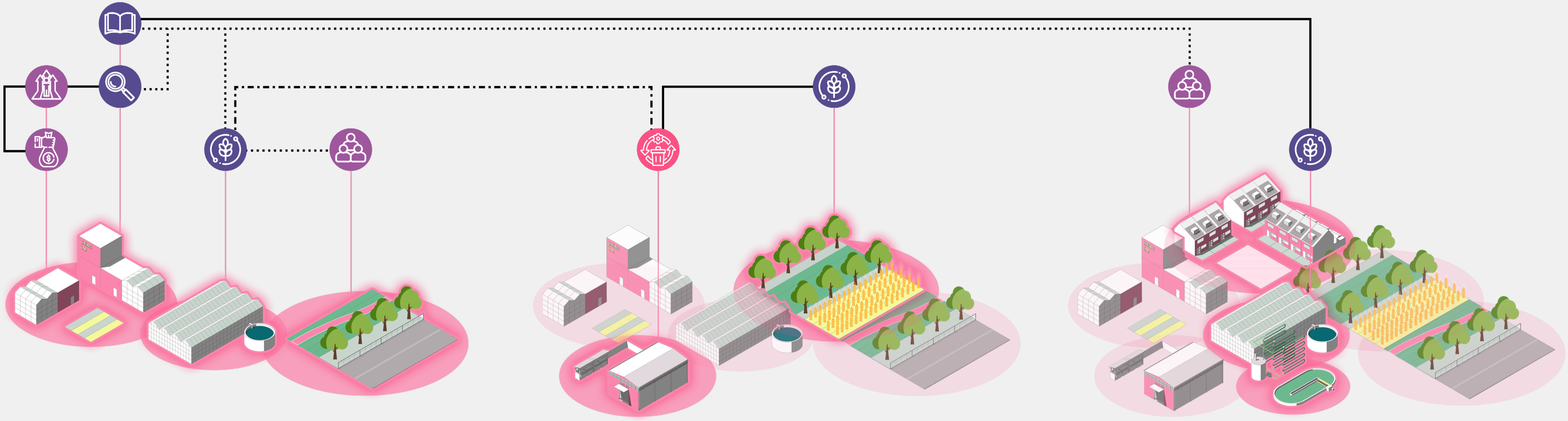




5.3.5 Phases of connection building between stakeholders

Fig 5.36 Diagram of phases of connecting stakeholders

Strengthen links
New links
Current links



PHASE 1

Developers, investors and researchers together set up living lab for exchanging knowledge while educating citizens and young students. By cooperating with farmers, biomass produced in greenhouses and farmland will be used in living lab. Citizens can enjoy the landscape by bike following the path set inside the green buffer.

PHASE 2

Trees will be planted in the arable land to build agroforestry, which contributes to the production of biomass. Farmers can benefit from it and then work better. Waste management sector expands the waste hub to handle more organic waste.

PHASE 3

Abandoned greenhouses are transformed for planting algae so that more biomass can be produced. Farmers get educated by researchers in the living labs to learn producing algae efficiently. Community nearby will get involved that young students can go to living lab to learn more about biomass. Awareness of citizens towards a bio-based future will be enhanced by education.

5.3.5 Collage

Fig 5.37 Atmosphere in the mixed area

5.4 The Bio-Loop ZH2050

CHAPTER 6

CONCLUSION

6.1 Conclusion

The Port of Rotterdam is in a strategic position to drive a change for the province of Zuid-Holland towards a circular economy, in a further step also influencing industries on a national and international level.

To achieve the goal of Zuid-Holland to become a circular economy based on renewable materials by 2050, we focused this project on a trigger industry that can essentially influence this change. As the plastic industry contributes significantly to the current waste production and thus to the waste of resources and the amplification of climate change, it is evident to focus on this industry as a starting point for the transition. Especially the packaging sector plays an important role within the plastic industry and offers a lot of potential for implementing a circular economy.

Due to the characteristics of the province with a high proportion of horticulture, agriculture, and urbanized areas, the potential of gaining biomass in form of organic waste and crops was identified.

Consequently, based on these findings, the research question stated at the beginning of the report was formulated:

'How can we restructure the port region as a flexible system that can adapt to the changing future situation by fostering a circular system that can contribute to the development of a circular bio-based plastic industry?'
To answer the question, four sub-questions were formed. It starts with the investigation **'How can the trigger industry start the transition towards a circular and bio-based economy?'**

By analysing the current situation of the port industry, different clusters could be identified.

Based on the infrastructures in the port, the Maasvlakte area was chosen as the first cluster for the transformation towards a bio-based plastic industry. Related to this starting point, other plastic industries in the port will be transformed step by step. Due to the continuous exchange between research and practice and an increased awareness creation within society, the trigger industry can drive the development of a circular bio-based economy and act as an example for other plastic hubs.

In a further step, the question **'What circularity strategies are necessary for the first step of transition towards a bio-based port area?'** was tackled.

For this, the R-ladder strategies were applied to the bio-based plastic industry with the primary goal of first reducing and rethinking the use of (traditional) plastic packaging. In further steps, the following stages are applied along the R-ladder with the aim of the final prevention of waste landfilling and a closed loop within plastic use and production. In addition, various material and invisible flows are recurrently brought into the circular system.

Furthermore, spatial demand is essential for the implementation of the idea. Accordingly, it was looked at **'What kinds of spaces are needed to develop a bio-based plastic industry?'**

The classification of clusters according to land use and the resulting demands on space led to the development of different typologies and strategies depending on the cluster. This is not only about the production of bio-based plastic, which is done in the Port of Rotterdam and later in other bio-based plastic hubs in the province and the Netherlands, but also about the production of biomass while strengthening biodiversity, the collection, and processing of waste and the establishment of Living Labs as an essential part of the circular bio-based plastic industry.

The Living Labs are also related to the last sub-question **'What are the social requirements for building a circular system in the trigger industry?'** An important aspect here is the involvement of society in the circular economy by raising awareness of the importance of changing one's plastic consumption and waste production. In addition, the education and employment fields are of great importance, as the transition also brings major changes in employment opportunities. Implementing a broad network of educational opportunities for everyone and on-site training will ensure the sustainability of the circular economy of the bioplastics industry and enable the participation and involvement of various groups.

In conclusion, the initial research question can be answered. By developing the Bio-Loop ZH2050 surrounding the region around the Port of Rotterdam, the port region will be restructured into a circular system based on the trigger industry. In addition to biomass supply for bioplastics production in the port, the Bio-Loop ZH2050 mainly serves as an experimentation and innovation field for the circular bio-based plastics industry. Here, the intersection with the social level of the project can be found again, as bicycle and pedestrian connections between the different clusters and living labs contribute to the accessibility and experience of the bio-based economy. In addition, the Bio-Loop ZH2050 responds to future needs and improves the current quality of space.

6.2 Assessment

SUSTAINABLE DEVELOPMENT GOALS

In chapter 1.3 the relevant Sustainable Development Goals of the United Nations and the contribution of the project were mentioned. In the following, the impact of the project on the goals is assessed.

03 GOOD HEALTH AND WELL BEING

By implementing the Bio-Loop ZH2050, we offer new recreation possibilities with inclusive public spaces and improved biking connections along a diversified landscape. Additionally, the transition from fossil-based to bio-based industry reduces negative impacts on the environment, leading to healthier living conditions.

04 QUALITY EDUCATION

The job transition contains risks, but we see its potential and create new employment opportunities as well as access to education within the bio-based economy for people of all educational backgrounds and ages. Moreover, lifelong learning is provided due to on-site training for new and experienced workers. Also, it is aimed at gender equality in the industry by creating more awareness of the different job possibilities already in the early stages of education.

09 INDUSTRY, INNOVATION AND INFRASTRUCTURE

Transitioning from linear fossil-based industry to circular bio-based industry leads to a more sustainable future. Along with that goes the improvement and upgrade of infrastructures by new technologies which are based on continuous research and on-site testing within the innovation cluster.

11 SUSTAINABLE CITIES AND COMMUNITIES

The restructuring of the port region enhances the quality of surrounding rural areas as well as within the Port of Rotterdam. By improving the accessibility of these areas, also in relation to the city of Rotterdam, citizens benefit from the development. Next to that, the creation of green buffer zones to protect households from highways and the offering of recreation possibilities along the Bio-Loop ZH2050, improves the quality of life for communities.

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

We ensure sustainable consumption and production patterns by raising awareness about the own plastic packaging consumption and waste production through campaigns as well as the exchange of knowledge and experience in the Living Labs. Incentives for private households and companies enhance a change to more responsible consumption and production. Furthermore, applying circularity strategies following the R-ladder leads to reduced waste of resources.

13 CLIMATE ACTION

By closing loops of material flows and the reduction, reuse, and recycling of primary raw materials as well as intermediates and final products, we reduce emissions and contribute to fighting climate change. Also, increasing the amount of CO_2 storing plants and green areas within the port as well as the reuse of CO_2 in greenhouses helps reduce the urban heat island effect.

15 LIFE ON LAND

The Bio-Loop ZH2050 improves biodiversity by changing current monofunctional agricultural land to agroforestry and creating green buffer zones. The increased diversification of plants, plantation of trees, and protection of natural habitats leads to the improvement and restoration of ecosystems. Moreover, we put emphasis on securing already protected areas.

17 PARTNERSHIP FOR SUSTAINABLE DEVELOPMENT

Creating a circular economy based on the bio-based plastic industry in the Port of Rotterdam as starting point and innovation cluster for the transition of other industries strengthens sustainable development on different scales. Since knowledge and experience gained in the region will be spread to other plastic hubs and is transferable to comparable industries, the Bio-Loop ZH2050 can support the global partnership. In addition, networking and collaboration of different stakeholders are fostered.

Fig 1.8 Sustainable Development Goals
(Adapted by author, see sources in references)

6.3 Group Reflection

Working with space as an urban and regional planner is not limited to the creation of urban environments but has reached a multi-layered dimension over the past years which includes the broad field of spatial justice, social and environmental sustainability, and the importance of democracy within the planning process. Here, spatial justice is also related to enabling equal opportunities for accessing educational, economic, and environmental opportunities and the improvement of life quality (Johnson & Kossykh, 2008).

ETHICAL ISSUES AND VALUES

In this project, emphasis was put on sustainable social and environmental development during the transition to the circular bio-based plastic industry. This takes place in different areas. First, new spatial practices are created in the context of structurally changing work by restructuring the port and the surrounding region within the Bio-Loop ZH2050 according to the requirements for the implementation of the bio-based circular economy. This includes strengthening the accessibility for citizens of the port and surrounding rural areas in relation to the city of Rotterdam.

In addition, biodiversity will be conserved and enhanced through the diversification of cultivation methods and the creation of green buffers and natural protection zones. This consequently has a positive impact on the environment and contributes to mitigating the consequences of climate change.

Furthermore, the preservation and creation of new job opportunities within the circular economy are of great importance within the project. Thus, offers are created for everyone to further educate themselves within the existing field of work as well as to reintegrate people into the professional world. Also for young people with different educational backgrounds, new educational opportunities are provided, which enable them to work in different fields within the bio-based economy.

As a unifying element of the themes of the spatial transformation of the region as well as the growing educational opportunities, the role of democracy within the planning process stands out. Within the realization of our strategies for the different clusters, we explicitly give space for exchange and participation through communication in the living labs. They act as inclusive public spaces where people of all different groups can come together.

Also, opportunities to encounter experimentation, exchange, mutual learning, and inspiration are provided. In addition, here it is possible to share one's own needs and thus advance the planning process and the implementation of different demands in practice.

RISKS

During the elaboration of the project, attention was paid to considering different dimensions and scenarios to prevent possible adverse effects. However, we are aware that some risks still exist. For example, it is of utmost importance in the implementation of the strategy to prevent biomass production from competing with food supply or land in the form of monocultures serving only biomass production.

This goes hand in hand with the vision that an increasing share of grassland areas can be used for biomass production if livestock farming decreases due to Dutch governmental measures to reduce nitrogen. However, it is beyond our control when this goal will be reached. (Rijksoverheid, n.d.). Furthermore, the project aims at reducing dependencies and increasing independence. This can be achieved on a global level, but on a local level, there will still be dependencies between different sectors that need to be monitored and can cause unpredictable difficulties.

Moreover, it is not possible to foresee or control all circumstances in the future, so decisions currently taken may need to be reviewed and revised at a later date. Therefore, the strategy aims to be adaptive and futureproof to avoid disadvantages for future generations generated through the planning.

RELEVANCE

As a research and design project, the project contributes to the current state of research on circular economy and bio-based industry, in particular how both topics can be implemented together in the province of Zuid-Holland. It also provides suggestions and concrete implementation options for transforming the fossil-based plastics industry into a circular bio-based plastics industry at an important port location and in an agricultural region, while improving the environmental, social, and economic quality.

Recommendations are also made for applying theoretical knowledge in practice and improving ongoing processes in the sectors covered. This will be achieved through simultaneous testing at the local level through the establishment of Living Labs in strategic areas of the port region. While the initial focus of the project is provincial, advice is also given on how to transfer the ideas and experiences to a larger scale. The project is therefore not only relevant for the Port of Rotterdam and Zuid-Holland but can also be applied in other port regions with similar conditions.

RECOMMENDATIONS

Finally, since we are coming from an urban and regional planning background, our knowledge is limited in the fields of chemistry, plastic production as well as horticulture. Due to literature research, a broader understanding was gained but collaboration with experts in these disciplines is needed to elaborate more on the execution of the project, especially in terms of transforming the port industries.

Another aspect is the limited period for working on the project which is the reason for the focus on the bio-based plastic industry as a starting point of the transition to a bio-based circular economy. Further research could be done on how the proposed starting point affects other industries to increase the circularity within other sectors in the province. Moreover, the current emphasis lies on the production and recycling of bio-based plastics but also biodegradability could be part of further investigation.

CHAPTER 7

APPENDIX

7.1 INDIVIDUAL REFLECTIONS

7.1 Individual reflections

CLARISSA BECHMANN

As the consequences of climate change are already experienceable in our daily lives, we are faced with the urgency of finding alternatives to current practises and changing the traditional patterns. Two lately often discussed approaches are circular economy and transitions based on biomass. Before starting the third quarter, I had only a vague idea of the meaning of these concepts. Also, my view on biomass was critical and partly shaped by biases. Thus, the lectures given at the beginning of Q3 offered a better understanding of the potential of the bio-based and circular economy whilst shaping the attention to the risks which go along with focussing on biomass. Therefore, it is important to understand that a bio-based economy is not necessarily circular nor sustainable but challenges like concurrence in land use, risk of biodiversity loss, a balance between food- and biomass production, and the spatial demand need to be considered (Arkesteijn, 2022). Furthermore, the lecture given by Bob van der Nol (2022) gave inspiration for different development possibilities for the province of Zuid-Holland by presenting various (bold) scenarios. Moreover, in our project, the creation of Living Labs plays an integral role. The idea for these spaces was partly inspired by the lecture about "Spatial conditions for Manufacturing" (Hausleitner, 2022) where hybrid maker spaces and their requirements for space were introduced.

Next to that, the booklets and lectures during the methodology course enriched the whole project to a comprehensive extent. Consequently, they shaped my attention on a broader range of challenges related to planning and I realised how far-reaching the influence of urban planners is related to social and just aspects but also in terms of governance. Also, learning about the role of visioning made me remember why and with which influence I want to become an urban planner. Thus, I am grateful for the inspiration for further thinking provided by Dr. Roberto Rocco and Dr. Marcin Dabrowski (AR2U088 Research and Design Methodology for Urbanism 2021/2022 Q3).

Comparing myself at the beginning and end of the quarter, I identify a lot of growth regarding knowledge and working methods. I entered the project having only a little experience in regional planning and no idea of circular economies. Today I can say that I gained a stronger understanding of the circular bio-based economy and circularity strategies as well as the spatial, social, and environmental difficulties related to that. Moreover, the role of connecting stakeholders and setting policies during the planning process became clearer throughout the quarter.

Even though looking from the present perspective the project seems very complete and logically coherent, the journey to get there was not always as clear. At times I had difficulties comprehending the topic since its wide-reaching scale and the difficulty to set a focus within the limited period. A very helpful tool during this process was the narrative building and structured and consistent way of working within our group. In the initial assessment, I set the goal to accomplish organised teamwork with an efficient schedule and division of work which we achieved. Even though in my opinion we discussed a bit too little in the beginning, I see an improvement over time, and it felt always safe to communicate honestly and openly within the group as well as during the studio sessions.

SHIRU LIU

Due to climate change and future shortages in the supply of fossil fuels, be it for reasons of physical shortage or political instability, reducing greenhouse gas emissions is an urgent issue that needs to be addressed worldwide. Various sectors have proposed strategies from their perspectives: circular economy, bio-based economy, energy transition and the proposal of an urban blue-green network. All of these concepts contribute to tackling environmental problems. Our challenge as urbanists is to create spatial networks that optimally provide the conditions, considering these strategies and their stakeholders. For me, this course is to explore existing strategies and develop an achievable vision whose focus moves from land development to network development (Van den Berghe, K., 2022), and to identify the direction towards which stakeholders will take their actions.

Our team develops a vision for Zuid-Holland in 2050 that attempts to use the bio-based plastic industry as a trigger, in conjunction with a green loop in the province, to realise a circular system encompassing biomass production, processing and distribution as well as recycling. In the early stages, inspired by the courses Towards a Bio-based Economy, Material Flow Workshop, Methodology, we gradually built up our research network, including collecting information, studying existing flow systems, looking for the potential for bio-based development, and identifying the social implications.

Advancing our vision is the most complex part. Inspired by the lectures after the midterm, I learned that timelines, guidelines and policies could be used as essential tools for regional design (Balz, V. 2022). Translating ambitious visions into reality requires developing policies to realise each space in the vision, connecting stakeholders and providing them with spatial tools such as spatial toolkits to guide their actions in line with our expectations. This step also helped me to think more deeply about the spatial strategies at each stage to make our projects more feasible.

In addition, I learned from this lecture that thinking about our region at different scales is an essential skill. The lecture (Viseu Cardoso, R. 2022) mentions that metropolitan is the integrated way to trigger higher agglomeration benefits. It inspires me to think about the possibility of expanding our Bio-Loop ZH2050 vision to a national scale or even global to build networks. At the same time, thinking about regional design from different scales of intervention is a process of mutual feedback. The impact of each scale of intervention will continue to renew our original network and ensure the sustainability of the design in future phases.

Finally, teamwork with my group has been very rewarding for me. We came from different countries and studied different subjects at the undergraduate level. Hence, our thinking patterns, how we gather information, and how we think about the project were very different. We learned from each other and improved our project continuously through discussion, which resulted in a good outcome. It is a very fulfilling and enjoyable project!

EMY STEENBERGEN

The decreasing availability and increasing negative impact of fossil fuels is an ongoing event. During the first lectures of Q3, Van der Nol (2022) explained that fossil fuel goes hand in hand with a linear system and that this system should become circular and bio-based. At the beginning of Q3, I had my doubts about this bio-based industry since the currently imported biomass brings negative aspects such as disruption and disappearance of ecosystems and decreasing biodiversity in other parts of the world (Arkesteijn, 2022). Van der Nol (2022) showed the possibility of local biomass production as a solution, which I previously saw as a potential concept. However, this would require a complete change in the Dutch landscape, e.g. the Green Heart will disappear to give space for arable land and fishing areas; I did not see this as an ideal outcome either. Because of this perhaps negative view on the subject by then, I thought it would be interesting to focus on the bio-based industry. I wanted to find out if this industry could have the potential for providing a sustainable and future-proof solution that takes people and the planet into account.

During the lectures, workshops and studios, it quickly became clear that this answer is not that easy. The bio-based economy has downsides not only in terms of space. Also, the number of stakeholders involved in a transition towards a bio-based industry influences the realization. Clarifying the different flows and connections between stakeholders during the workshops and during the lecture of Hein (2022) motivated us to look more outside the existing boundaries of the port area to achieve more during this project. During this project, we conducted research at many different scales to better understand flows and connections that affect the port area and the province of Zuid-Holland. Analysing those different scales and stakeholders sometimes led to confusion within our studio group, since everything is very well interrelated. Complementing, improving and correcting each other has resulted in a plan that is as integrated as possible on all the different scales.

Personally, my team members, tutors and lectures have helped me a lot. During every session, we discussed well what relations within the current phase of the project area and what could be the next step within the regional design process so as not to omit any steps or scales. During the R&D Studio of Q1, I sometimes found it hard to go through the different scales. This course helped me a lot to understand this better and to see its greater importance. I also think that within our whole group it became increasingly clear what we were working towards, which also led to a better idea of what we wanted to do and wanted to achieve. As the process followed, it became increasingly clear what the next step and its scale should be to continue and optimise the process to create an interrelated concept.

I expect that learning about regional design will help me prevent going into too much detail in the future. Additionally, I think that the knowledge and way of working on this regional design project have taught me a lot about the bio-based and circular industries. For this reason, I would find it interesting to further add something to the bio-based and circular industry in future projects.

MINSHI ZHANG

The Bio-Loop ZH2050 discusses a strategy for a bio-based development of the province of Zuid-Holland. Admittedly, the use of biomass is not entirely harmless. Biomass materials require large amounts of space to cultivate and high costs for processing. However, compared to traditional fossil-based development, using biomass has the potential for sustainable development as it values the rights of nature and promotes cooperation between the social and natural environment.

The application of the circular economy concept can be well realised in bio-based development. As Alexander Wandl mentioned in the lectures (2022), recycling non-renewable waste materials would be an essential step in narrowing the cycle of resource use in social systems to minimise systemic leakage and negative externalities in the current linear system. In this scenario, biomass, as a trigger, can gradually enter the processing system of the plastics manufacturing industry and contribute to the formation of a bio-based circular economy system. By displacing fossil-based raw materials for production, biomass and bio-based products will gradually become the main flow in the circular economy system, eventually ending up as recyclable green waste after being used.

By creating circulation on the economic level, there can be benefits for society and the environment. Less use of non-renewable resources directly reduces the demand for extracting fossil resources and thus avoids damage to the natural environment. The protection of the environment benefits all human beings equally, as fewer natural disasters will occur. A healthy economic cycle system means less economic expenditure and thus promotes social equality. From a multi-scale perspective, planning at the regional level has the potential to spread to national and even global scales. Forming a circular economy system at the local level reduces the dependence on external systems. At the same time, the external economic benefits generated can be shared and built upon, including materials, products, knowledge and technology.

Overall, the course in Q3 was exploring the process of vision planning based on methodologies, which allowed me to develop a deeper understanding of spatial development. In particular, communicative planning caught my attention during the lecture of Roberto Rocco and Marcin Dabrowski (2022). Accordingly, from the lecture by Fred Hobma (2022), learning about planning tools helped me think about how to influence different stakeholders to realise and accomplish the vision. Vision planning plays an essential role in urban development as it integrates and reflects social, economic and environmental perspectives and guides spatial development base on evidence.

From a social perspective, vision planning is a strategy for city managers to guide society and a storytelling tool to describe the future. All stakeholder voices should be heard equally, including the weakest voice in our society, and discussed critically, thus helping to build a democratic society. From an economic point of view, the wave of economic globalisation taking place for many years has started to have a negative impact. The excessive interdependence between economies will be affected by epidemics and war factors. With this in mind, I believe that the discussion of how to strike a balance between relatively independent inner-circular economy and interdependent multi-circular economic clusters is one of the priorities of planning. From an environmental perspective, the current main focus on economic and social concerns has caused most people to lose sight of the protection of the natural environment. Vision planning needs to focus on 'the rights of nature', as the built and natural environments should not be separated.

CHAPTER 8

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