Re-Functionalization

An integrated functional regeneration through biophysical restructuring of landscape

Wentong Wang
4618572

P5 Report
November 2018
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For this graduation project, the Dutch Wadden Sea Region is chosen as analysis context. It contains both the Wadden Sea and mainland near the Wadden Sea. For the coastal part, there are tidal mud flats, shoals, barrier islands and fertile marshlands. Besides, the coastal area is occupied by several villages and towns. By all of these elements, this region is known as a natural resource area and a tourism destination for the population of the urbanized areas in the interior (Otto, 2001).

The Wadden Sea Region also has rich cultural heritage, which gives evidence of interaction between human and nature. This resulted in a great diversity of geographical landscapes and a wealth of natural values (Otto, 2001). Besides, the region is important not only for nearby country, but also for few areas with comparable physical conditions, which means adaptive strategies developed here can be used as patterns and models for other development all over Europe and even the world.

Right now, this region is facing a set of environmental, social-economic and demographical problems, like: sea level rise, coastal erosion, hydrological changes, weak economic potential (less competitive and less high skilled), unemployment, population decline and survival of typical landscape elements as well as some other legacy (Wim, 2013, Britas et al., 2010, Heike et al., 2005, Otto, 2001).

In conclusion, tidal movements, extreme weather conditions and processes of erosion, sedimentation make the Wadden Sea Region very dynamic. Besides, the cultural heritage is rich and diverse. No matter nature or culture in the Wadden Sea Region, they are both characterized by continuous interaction of traditional and current needs. This region will be constantly challenged by urban innovations, economic conjunctions and political realities (Otto, 2001).
Processes in urban areas are in effect flows, movements and transport through space (Forman, 1999; Ball, 2009). Some are mainly vertical, including rainfall, evapo-transpiration, tree falls, and ecological succession. Horizontal flows generally cross heterogeneous space thus linking different land uses and habitats. (Wegner and Merriam, 1979)

-Richard T. T. Forman
Figure 1.2 Territory as a Project Symposium, by author

Figure 1.3 Territory as a Project model plan, by author
1.2 Urban-natural system (seminar)

Figure 1.4 projective image, by author
According to the UN, by 2050, 66 percent of the world's population is projected to be urban (UN, 2014). The enormous growth of urban population is always based on migration. This trend will make rural area like villages less and less dynamic. At the same time, with a concentrated urban population, nearly everything people do in urban areas has ecological implications (T. T. Forman, 2014), which means the land that people leave behind will face ecological and environmental effects. In other words, although people leave, there are still flows and movements between urbanized area and nature, especially in transition area and empty spaces. The Wadden Sea Region is an interesting study case in order to understand such processes of migration, environmental coordination and sustainable development between nature and built-up environment.

In order to understand urban and natural processes, the conceptual model is divided into two directions. For the horizontal view, it shows different urban layers and sea flows. They are interconnected in a cross way and they have interactions which are showed in vertical view. These interactions include not only nature dynamics like sedimentation and erosion, but also the impacts of dikes that Dutch built to fight with nature and green infrastructure that the project will focus on to improve ecological value of region.

For the image, it shows relation between nature and urban area, namely integration and contention. On one hand, nature and urban area simultaneously exist in the region; there are flows and movements between each other. On the other hand, nature is affecting where people live, especially for the Wadden Sea Region where most lands are below sea level. Nature may dominate this region after 200 years or more. At the same time, human activities also have impacts on nature, like CO2. So it is urgent to think about this relationship, especially when there are continuous changes within it.

Figure 1.5 relation between urban and natural system, by author
INTRODUCTION

1.3 Historical research

Agriculture and maritime trade were greatly intensified during the 17th and early 18th century, as a consequence of open-sea fisheries' economic crisis as well as climatic backlashes.

The 17th century was also the high-days of coastal shipping. During the 16th and 17th centuries, the most important open-sea fisheries came to be concentrated in Holland.

Agriculture and recurrent dyke-breaches became the exception as a result of significant improvements in drainage and irrigation. Agriculture could be intensified, and open-sea fisheries came to be concentrated in coastal shipping areas.

The Wadden Sea was one of the busiest transport routes in Europe. Between 1500 and 1650, more than 140,000 hectares have been reclaimed. Arable farming was successful in the newly reclaimed land.

Large wetland areas and river marshes were troubled by inundations due to reclamations and deforestation in the upland districts. Around 1800, more than half of the coastal marshes were being tilled.

The 1717 storm surge that struck most of the coastal area in 1738 a total of 172,000 hectares and there was a complete web of ship-caissons, towing-paths, locks, and bridges with chamber locks and drawbridges. A complete system of ship-caissons, towing-paths, locks, and bridges was established.

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Long-line fishery started in the 17th century and disappeared again in the 19th century. In the 1850s, most coastal districts had their own iron foundry, the sandy marshes and polder areas concentrated on arable farming. By the middle of the 19th century, 60 to 80% of the coastal acreage was used for arable farming. Coastal shipping declined after 1870. Coastal agriculture lost its comparative benefits. (falling prices, rising wages and costs of hydrological management)

19th-century agricultural progress was profound in the Netherlands. In the 1850s, most coastal districts had their own iron foundry, the sandy marshes and polder areas concentrated on arable farming. Coastal shipping declined after 1870. Coastal agriculture lost its comparative benefits. (falling prices, rising wages and costs of hydrological management)

The most important 19th-century industries were windmills, shipyards, and brickworks. Agricultural mechanization and scaling up went on in the 20th century, leading to the replacement of foreign workers by family members.

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New technology made the shrimp fishing become the leading industry in many smaller harbors. Because of tourism, the total island population tripled during the 20th century. Seaside tourism became a mass phenomenon, spilling over to the mainland districts.

Since 1920s, traditional drainage-mills were replaced and supplemented by windengines, which lead to the establishment of hundreds of additional drainage districts. Water-management became increasingly complex.

Local groceries disappeared, making the villages fully dependent on motorized traffic. The construction of highways, canals and railroads resulted in a reversal of the coastal infrastructure.
### 1.3 Historical research

<table>
<thead>
<tr>
<th>Year</th>
<th>Description</th>
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<tr>
<td>1500</td>
<td>The coastal population probably doubled to about 30 to 50 inhabitants per square kilometer.</td>
</tr>
<tr>
<td>1600</td>
<td>The population figures stagnated. West-Friesland they even dropped. The rural population figures even dropped by about 40%.</td>
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<tr>
<td>1700</td>
<td>Dyke-building had become fundamental for the preservation of the coastal marshes. A new type of rural settlement came into being: dyke-lock harbors planned around an artificial tidal inlet.</td>
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<tr>
<td>1750</td>
<td>The main channels and sandbanks in the Wadden Sea were marked each spring with a chain of beacons, buoys and pricks.</td>
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<tr>
<td>1800</td>
<td>Large farms were situated along the main road, whereas the former navvies settled down as cottagers along the dykes.</td>
</tr>
<tr>
<td>1850</td>
<td>In this period, most villages and towns showed a substantial growth. The number of people involved in trade and commerce was increasing. In general, urban population growth mainly took place in the 16th century. In subsequent year urban population growth stagnated until the second half of the 18th century. The upland population grew steadily, particularly since mid-18th century and because of seasonal farming. The towns got weigh-houses and specialized market places for items, and many villages got a secondary main-street with stone road surface. The western marshland districts had more industry and artisan trade than the eastern ones.</td>
</tr>
<tr>
<td>1850</td>
<td>The Early Modern Age was essential for the way in which the coastal landscape has been furnished. The polderlands, ports, peat-moor settlements, and market towns constituted additional geographic elements. Besides, this period got the specific architectural styles for farms and cottages, the modern technical implements, and introduction of new agricultural, industrial and fishing methods.</td>
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The working-class population more than doubled during the 19th century, due to the booming market for agriculture products. Cities began to outstrip the countryside. Rural change was accelerated in the 1880s because of the Great Depression (foreign productions). Steam engines caused serious seasonal unemployment and political upheaval.

The towns and villages bordering the polderlands and high-farming districts developed into working-class centers, with rows of cottages along their lanes and alleys.

It was the era of industrialization, urbanization, population growth and social upheaval.

The major innovations that promoted coastal development were subjected to diminishing returns. Eventually, coastal civilization failed to adapt to the requirements of the modern age.

The effects on landscape values were dramatic. Re-allotment schemes, infrastructural programs, and hydrological measures had a profound influence. Ditches were filled up, fields leveled and improved with subsoil ploughs. The water table was lowered considerably. The remaining salt marshes were embanked, dykes heightened to unprecedented levels, canals straightened and rivers dammed.

Farming is largely dependent on EU subsidies. Arable farming is hardly competitive due to the tough soils and the high costs of hydraulic management, leading to gradual decay.

In those districts, the redundant farm-workers could not be sufficiently absorbed by other sectors, several generations have been faced with unemployment, underschooling and lack of initiative.

Reference: The Dutch Wadden Sea Region, Haartsen, Marrewijk (2001)
1.4 Problem field

Problems of various aspects are affecting the Wadden Sea Region. The graduation studio Delta Interventions focuses on the theme of ‘Landscape of Coexistence’. It mainly deals with the spatial effects of extreme climate change scenarios. Landscape of coexistence means sustainability and adaptation, both for urban and natural system. This includes ecological and socio-economic parts and will be indicated in regional scale.
1.4 Problem field - General context field

natural conditions - elevation + population density (vulnerable to sea-level rise)

Reference: Hans van der Maarel (2010), Sandra Erkens (2013)
natural conditions - ocean current + sedimentation & erosion

LEGEND

- Water depth: 20-40m
- Water depth: 40-60m
- Water depth: 60-80m
- Ocean current
- Water flows

Reference: Maren, Kessel et al. (2015)
1.4 Problem field - General context field

natural conditions - subsidence

natural conditions - dike system, safety standard per dike-ring area

Reference: Dutch coasts in transition, Kabat, Fresco et al. (2009)
In recent years, there has been growing concern about environmental degradation and climate change since they have impact on future development. The relationship between environment and economy become extremely important for country like Netherlands, because on the one hand, near 2/3 of the territory is under sea level, on the other hand, the Netherlands is a high population density country, which means the government has to keep the natural environment good for living and at the same time guarantee there are enough economic activities to ensure people’s daily life (necessities, employment, etc.)
Nowadays, the Wadden Sea area is an important tourism destination for Netherlands as well as a ecological area, based on its role in the recent Wadden Long-Term Ecosystem Research (WaLTER) initiative (Vugteveen, van Katwijk, Rouwette & Hanssen, 2014). Apart from tourism, industry in this region mainly focuses on agriculture, such as dairy and feed factories. Besides, the main traditional industries in the Wadden Sea Region are brickworks, tile works, pottery and shipbuilding (Haartsen & van Marrewijk, 2001). Large-scale industry is located in Delfzijl, Harlingen and Eemshaven. Exploratory drilling for gas has taken place both onshore and in the Wadden Sea, and there are also some wind turbines.
1.4 Problem field - General context field

Although 90% of current economic activities are of hardly any direct risk for the environment. these are mainly jobs in the service sector, which are about 75% of the economy (van Dijk, Broersma, 2015). There are still some problems between environment and the regional economy.

Firstly, the economic development in the Wadden Sea Region has problems itself. For example, fishing activities are normal in the Wadden Sea, but the mechanical catching is very harmful for the seabed. Although fishing on cockles and mussel has been transformed to other form or banned, the shrimp fishing is still a problem for ecosystem. Besides, extraction of natural gas, oil, salt and other energy is also an important economic activity in the Wadden Sea. But this extraction is now heavily debated because of the occurrence of more and more and also heavier earthquakes which have a significant negative effect on e.g. housing and the quality of life (Van der Voort, and Vanclay, 2015). Harbor activities also have some problems since they are potentially harmful to the environment, particularly the vulnerable Wadden Sea (van Dijk, Broersma, 2015).

Secondly, no matter what kinds of economic activities, as long as the industry develop, the scale of industry will change. This means these economic activities need more space from nature for up-scaling, and at the same time, they require more transport movements that makes the landscape less attractive and fragmented. Also, it may harm the area. Agriculture, extraction of energy, tourism would be examples for this negative effect.
1.4 Problem field - General context field

Environment - Society

Not only urban areas will affect the nature, the nature also affects where people live. Shallows like the Wadden Sea develop as the result of interaction between a relative rise in sea levels and a supply of sediment (Schroor & Kuhn). This means that sea levels and sedimentation are two essential elements for people who live nearby the Wadden Sea. Besides, tidal inlets and channels often changed their course, having a far-reaching effect on neighboring islands, salt marshes and mires, thereby determining the possibilities for human survival and intervention (Knottnerus, 2001). So the problem is that nature affect the way people live and people's living condition, which makes a lot of people leave this area.

Interacting with nature, people had to adapt themselves to continuously changing circumstances, at the same time, the conflict between development and preservation occurred. It is about what land value this areas should be. On the one hand, the coasting trade came to a halt (Knottnerus, 2001) because the demand for agricultural products was inelastic as compared with industrial outputs. On the other hand, Development in or nearby the Wadden Sea can only proceed under special conditions and as long as there is no adverse effect on the carrying capacity and conservation targets. This conflict forms the main research question for this project.

20km
1.4 Problem field - General context field

**Economy - Society**

As an urban planner, the relation between economy and society is an essential issue to research. Arndt et al. indicated that the massive demographic shift due to population decline and aging will have a deep social and economic impact on the region. Besides, Enemark (2005) also stated that the Wadden area “is characterized by having a weak economic and social development with lower economic growth rates and higher unemployment rates than the average for the Wadden Sea countries”. Stakeholders always consider the management principles and the targets are often too much focused on environmental development (van Dijk, Broersma, Mehnen, 2015).

In general, there are relatively high rates of aging in the Wadden area (van Dijk, Broersma, Mehnen, 2015), this is because many people younger than 65 leave the area. Besides, employment shares by industry in the Wadden area are high in traditional industries and in tourism, but not in high-tech services, at the same time, employment has diminished the past decade. All of these indicate that the Wadden Sea Region is less competitive, less high skilled and less innovative than national.

Figure 1.10 Total population growth in 2002-2013 of the Wadden area
resource: Eurostat
### 1.4 Problem field - General context field

Another problem is that there are relatively few jobs related to people that live in the coastal area. Jobs are more often located further inland, which makes substantial commuting flows. The data shows that almost 50% of all employed workers living in municipalities on the Dutch Wadden coast had a job outside this area and were hence commuting (Broersma, 2009).

In addition, a problem associated with aging and shrinkage is that companies and institutions will eventually leave the Wadden Sea Region and move further inland if people continually leave this area and aging becomes an ongoing problem, and vice versa. This means the livability of small scale villages in the Wadden Sea Region is likely to be worsen.

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**Figure 1.11** Composition of the human population and its growth in Wadden area and on Wadden islands  
Resource: Statistics Netherlands

**Figure 1.12** Rate of aging, rejuvenation and working group in three Wadden areas relative to national levels  
Resource: van Dijk, Broersma, Mehnen, 2015

**Figure 1.13** Employment structure of jobs, 2011  
Resource: van Dijk, Broersma, Mehnen, 2015

**Figure 1.14** Labour market indicators, growth between 2011  
Resource: LISA (Netherlands)
Figure 1.15 states in the Dutch Wadden Sea and its coast by author.
1.4 Problem field - Location choice

- Groningen + Region

jobs and commute distance

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resource: CBS (Netherlands)

Firstly, this project chooses Groningen region as first scale for research. According to the data from CBS, most of jobs in Groningen province happen in Groningen city, Delfzijl and Eemsmond. All the daily commute distance in Groningen province are in a circle with a radius of 30 km. So this project chooses 30 km as a daily commute radius from Groningen city to do the research within Groningen region scale. (see the right map)
i. Groningen Region
1.4 Problem field - Location choice

ii. Eemsmond-Delfzijl Structure

resource: Provincie Groningen, Structuurvisie Eemsmond-Delfzijl
iii. Appingedam-Delfzijl (‘borrowed size’ city - E. Meijers)

Secondly, due to the importance of Eemsmond-Delfzijl structure, this project chooses such structure as the second scale for research and design (see the left map). Finally, since there are two middle-size cities within Eemsmond-Delfzijl structure, and they are crucial for both socio-economy and ecology in this Groningen Region. So this project chooses Appingedam and Delfzijl as the third scale for research and design, and uses ‘borrowed size’ city theory from E. Meijers to achieve the goals.
1.4 Problem field - Groningen Region

Figure 1.16 land use in Groningen Region
by author

Figure 1.17 main cities and middle-sized villages in Groningen Region
by author
Current urban structure

The two maps on left show the urban structure within Groningen Region. Currently, everything including jobs, infrastructure and services all concentrate on Groningen city. This is not good for regional development. This project chooses 7 main function to reveal urban characteristics within Groningen Region. They are:

- high-services
- high-technology
- education
- industry
- tourism
- culture
- recreation

From the main cities that have such urban function and the structure that connects each other, we can easily find out that Eemsmond-Delfzijl Structure are far away from the center of different functional structure except industry. This means, even though this structure is crucial for Groningen Region, they are not well developed.
1.4 Problem field - Groningen Region

Change of jobs

According to the date from CBS, Eemsmond-Delfzijl structure has much less jobs compare to Groningen city. And it also shows a decreasing trend. This means Eemsmond-Delfzijl is facing economic problems.
In conclusion, the Groningen Region (defined as Groningen city and its 30km range in this project) shows a decreasing economy in recent years, at the same time, a lot of villages and some of middle-sized cities are facing population shrinkage due to lots of social problems, like flood risk and earthquake. According to research by this project and other literature, the region lacks network of some function, especially for the Eemsmond-Delfzijl structure that lacks many urban characteristics. The region also shows uneven distribution of function and low functional complementarity within current function. From the spatial form of the Groningen Region, Groningen city shows a dominant states (monocentric system), which is not helpful for current socio-economic situation in Groningen Region. On the contrast, a polycentric system is good for mitigation and adaptation (Morrison, Adger, etc. 2017).
1.4 Problem field - Local + Regional + National vision

This map shows current Eemsmond-Delfzijl Structure Vision made by Groningen province. It focuses on the development of industry and related issues, like water safety and energy. At the same time, the EIA Committee (Environmental Impact Assessment Committee) ruled that conflicts could arise with laws and regulations in the field of nature and environment. The advice of the Committee in 2014 was: determine the maximum environmental use space and assess the effects of all development in relation to each other. According to this, it could be revealed that there are still inevitable conflicts between new development structure and environment.
This map shows the National Ecological Network in Netherlands and Nature 2000 area. The map indicates that there are a lot of ecological network out of Groningen province. In other words, this National Ecological Network vision does not include Eemsmond-Delfzijl Structure and even Groningen province. This is partly because of many agriculture fields. But for now, it needs many ecological changes to balance the conflicts for a more sustainable and resilient future.
1.4 Problem field - Local + Regional + National vision

The Dutch programme Room for the River has already created more space for the major rivers at more than thirty locations.

Figure 1.23 by author (Room for the River Program)

This map shows current the Dutch programme Room for the River Vision made by Netherlands Government. Because of the location of Eemsmond-Delfzijl structure (northeastern Groningen, Ems river delta area), this structure has to face the conflict between functional regeneration and ecological vision from nation and region (National Ecological Network, Nature 2000 area). Also this structure should deal with water-related problem from Ems river and the North Sea. Similar program, like 'room for river', does not contain such area.
Currently, there is already a rich literature on the management of the ecological system in the Wadden Sea Region (Dijk, Broersma, Mehnen, 2015). At the same time, because of climate change, there should be much more attention to integrated forms that include ecological coastal zone management and balanced socio-economic activities. These integrated forms can not only provide better environment for people living and working there, but also give more spaces and surpluses for environmental protection and conservation.
1.4 Problem field - External Challenge

*Climate scenarios*

According to the KNMI’14 climate scenarios Report, there will be four scenarios for likely changes in the climate in Netherlands. Based on this four scenarios, they observe and predict the effects of future climate change. The basic results shows below.

<table>
<thead>
<tr>
<th>Year</th>
<th>Sea level rise</th>
<th>Annual precipitation</th>
<th>Annual evaporation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2050</td>
<td>+15 to +40 cm</td>
<td>+2.5% to +5.5%</td>
<td>+3% to +7%</td>
</tr>
<tr>
<td>2100</td>
<td>+25 to +80 cm</td>
<td>+5% to +7%</td>
<td>+2.5% to +10%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Wet periods (number of wet days)</th>
<th>Drought</th>
<th>Average annual temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>2050</td>
<td>winter: -0.4% to +2.4%</td>
<td>+0.7% to +30%</td>
<td>+1 to +2.3 C</td>
</tr>
<tr>
<td></td>
<td>summer: -10% to +0.5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2100</td>
<td>winter: -1.1% to +3%</td>
<td>+1% to +50%</td>
<td>+1.3 to +3.7 C</td>
</tr>
<tr>
<td></td>
<td>winter: -16% to +2.1%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 1.27

This map shows river basin and flood-prone area in Groningen region (will be analysed in detail later) by author

resource: Water management in the Netherlands
PBL (Netherlands)
1.4 Problem field - External Challenge

Figure 1.28
This map shows salinisation and land subsidence conditions in Groningen region (will be analysed in detail later) by author.

resource: Water management in the Netherlands
PBL (Netherlands)
- Need of innovation

RIS3 for Northern Netherlands

Research and Innovation Strategy for Smart Specialization

The Northern Vision 2040
The Northern Innovation Agenda
Economic Action programme Groningen
The Operational Programme ERDF
1.5 Problem statement

The Groningen province shows a decreasing economy (Eurostat, 2017), so the National government makes some transition policy to deal with such problem. Among these policy plans, the coastal area always holds an important position. This is because the coastal area is a major industrial zone for carbon-related economy in Groningen province. Transition in coastal area is an inevitable process.

At the same time, this coast is located in a unique area with great ecological wealth due to the Wadden Sea and ecological attention according to the policy Nature 2000. The risk due to climate change, like flood-risk and scarce water resources, is affecting this coast. But the national and regional ecological visions do not include this coast.

So the challenge is how to find out potential synergies within the national and regional visions to guide local adaptation about both socio-economic transition and ecological conservation. Delfzijl is a typical site for this challenge due to the very close distance between industrial activities, city center and the Ems River.
1.6 Objectives

A new vision for Eemsmond-Delfzijl structure and Delfzijl city, which is based on an integrated functional regeneration through biophysical restructuring of landscape, at the same time guiding and validating local adaptation and regional mitigation due to climate change.

For the design phase, the precise objectives are:
- A new polycentric functional sub-region with emphasis on green infrastructure network (Eemsmond-Delfzijl structure)
- A 'borrowed size' urban system (Appingedam-Delfzijl)

1.7 Hypothesis

The Eemsmond-Delfzijl structure, as well as Delfzijl, can contribute to the ecological vision on regional and national level. By revealing potential synergies between socio-economy and ecology systematically, this could reinforce the transition process in coastal area, including functionality and values, to reach a high level of resilience.
1.8 Research question

Main research question

How to achieve a socio-economic and ecological healthier landscape and rethink the Eemsmond-Delfzijl structure under the process of functional transition and external challenges like climate change, social shifts and need of innovation through spatial planning and design?

Sub research question

- 1. What are the impacts of climate change and socio-economic shifts on Groningen region and Delfzijl?

- 2. What socio-economic and ecological elements can be used as part of potential synergies within Eemsmond-Delfzijl structure?

- 3. How to transform carbon-based industry?

- 4. What would be the new function of Delfzijl and the principles for new need, like innovation?

- 5. How to implement nature-based solution and landscape infrastructure theory to localize and enhance functional synergies?

- 6. How to add new green systems in an industry-based port city? And how to transform carbon-based industry into green economy to validate possible ecosystem services?

- 7. What biophysical and functional identity needs to be adapted to guide the transition process?

- 8. How to verify the regional mitigation by local adaptation and integrate these into the regeneration plan of Eemsmond-Delfzijl structure and Delfzijl city?

- 9. To what extent the biophysical adaptation of the Northwest area on Groningen region can meet the local functional regeneration of Eemsmond-Delfzijl structure and Delfzijl city?
INTRODUCTION

1.9 Method design process

URBAN FUNCTIONAL TRANSITION

/ ECOLOGICAL CONSERVATION

Groningen surrounding region

problem field

external challenge
- climate change
- promoting innovation and growth
- socio-economic shifts

Eemsmond-Delfzijl structure

functional synergies

urban-landscape matrix

local adaptation

localize

react / respond

external urban characteristics

coastal industry

urban character

layering
- green patches
- infrastructure
- industrial area

performance
- spatial form
- spatial operation
- spatial adaptation
- socio-spatial change

urban function of the region

planning operability (new planning processes)

urban functional transition

biophysical restructuring of landscape

Delfzijl

Dutch national scale
1.10 Time Schedule

**ANALYSIS**
- **Expected Outcomes**
  - **P5**
    - Context Analysis
  - **P4**
    - Groningen Region
  - **P3**
    - Eemsmond-Delfzijl Structure
  - **P2**
    - Appingedam-Delfzijl
  - **P1**
    - Local adaptation

**PLANNING**
- **Processes**
  - **Visualizing Presentation**
  - **Local Adaptation**
    - **Detail Design**
      - **System Design**
        - **Pattern Design**
          - **Ecosystem Services**
            - **Possible Synergies**
              - **Spatial Forms**
                - **Layering**
          - **Theme Analysis**

**DESIGN**
- **Scales**
  - **P5**
    - Appingedam-Delfzijl neighborhoods
  - **P3**
    - Eemsmond-Delfzijl Structure
  - **P2**
    - Appingedam-Delfzijl
  - **P1**
    - Groningen region
      - Eemsmond-Delfzijl Structure

**Notes**
- **P1**
  - **week 1.1-1.10**
  - General Problem Field Analysis (Context)
  - Historical analysis
  - Problem Analysis
  - Site visit, Seminar
  - thematic studies
1.11 Theoretical framework

- Nature based solution
- Landscape infrastructure
- Ecosystem services
- Water sensitive urban design
2.1 Ecological & Socio-economic states

The ecological states due to external challenge are showed in two parts: flood risk and ecology.

flood risk
The flood-prone areas are vulnerable to sea-level rise, especially those areas that are below sea level. Even though the sea level will rise 40cm by 2050 and 80cm by 2100 (according to KNMI'14 climate scenarios), they don’t have too much effects on flood risk because of well-designed dike system.

The most related problems is river discharge. On one hand, the Ems river has low river discharges, namely 80 m3/s, it even decreased 9% in winter over past century. This is not bad for flood risk, but will have effects on smaller project site. On the other hand, most areas are located at Rhine river basin that has 2300 m3/s discharge. Because of climate change, Rhine river discharge will increase 12% to 27% in summer, 40% decrease in winter and 60% decrease in autumn. The Rhine river also has drought-related problems, and at the same time, it also faces peak discharge problems.

For location 1, because of high density of main waterway and tributary, this area will face peak discharge problems that will lead to flood risk.

For location 2, because it locates in the floodplain, it will also face flood risk.

For location 3, it will face drought-related problems. This area is the smaller project site for design and intervention.

---

resource: KNMI' 14 climate scenarios
the data is from 'the effects of climate change in the Netherlands 2012', PBL (2012)
2.1 Ecological & Socio-economic states

ecology
According to the climate change scenarios, temperature will increase 1 to 2.3 °C in 2050 and 1.3 to 3.7 °C in 2100. The degree of temperature increase will affect biodiversity in this area. Some species will leave while some will come. At the same time, the annual precipitation also changes, from +2.5% to +5.5% in 2050 and from +5% to +7% in 2100. This means the groundwater level will rise. But this project site has weak water storage capacity. The ecosystem within this area will face surplus water that not only lead to drainage flood, but also make ecosystem vulnerable.

Besides, coastal sedimentation and erosion also have effects on ecology in this area. It is about nutrition and coastal water quality.

So far, there is little effect on site conditions. But from the map we can find that the two project related provinces have less parks than other provinces. At the same time, the current national parks and national landscape are facing habitat fragmentation problem. Besides, most areas are used as agricultural land. This will have negative effects on ecology in long-terms.
2.1 Ecological & Socio-economic states

The socio-economic states due to external challenge are showed in two parts:
industry and population shifts
industry
There are positive effects on agriculture because of higher temperatures that will lead to higher productivity. The data shows that a doubling of the CO2 concentration combined with a temperature rise of 3°C can raise grain yields by 8%; for beets this is 35% and for grassland 50%.

At the same time, agriculture is affected by too much water and drought-related problems, this two main issues separately happen in western and eastern part. According to Klijn et al., in the Netherlands 30% of all the available fresh water is derived from precipitation; the majority (70%) of the freshwater supply comes from the Rhine and Meuse rivers. This means the river discharges and precipitation changes (discussed before) (because of climate change) will affect agriculture to some extent. Besides, land subsidence, as well as increasing salinisation, also make the land vulnerable. Risks of surface water salinisation by saline seepage are mainly present in the Dutch lowlands, namely project site area.

For the recreation and tourism, there are some literatures show that the climate change will result in greater interest in the Netherlands as a tourist destination. But for this site, at least one negative effect can not be ignored, namely the winter activities. Besides, the increasing temperature will lead to increasing of blue algae that are harmful to human body. So recreation and tourism are also affected by water quantity due to climate change.

The climate change will also affect energy industry because of cooling-related problems. For water transportation, the water quantity and water quality, as well as sedimentation in estuary will have effects on such industry due to climate change.
From 2006 to 2011, most coastal areas are facing population shrinkage. Actually, for the Groningen Region, only Groningen city and its surrounding show population increasing.
From 2011 to 2016, most coastal areas in north of Netherlands are showing population shrinkage. For Groningen Region, this is more obvious. The coastal areas have a strong decreasing problem on population.
2.1 Ecological & Socio-economic states

population growth by medium-sized villages and main cities 2001 - 2011

This map shows more details about population growth by medium-sized villages and main cities in the north of Netherlands. For the project site, Delfzijl shows a really strong decreasing on population, Eemsmond is also shrinking.

resource & data: CBS (2016)

data comes from https://www.citypopulation.de/php/netherlands-admin.php?adm1id=NL

date is showed on right table

Figure 2.5 population density per municipality and neighborhood

resource: Statistics Netherlands
The table above shows the precise data about population growth in different municipalities. The upper one is Groningen Province, the other is Friesland Province. From the data we can find out that Groningen Province has worse situation about population change and economic growth. That is why the project chooses Groningen Region as research scale.
2.2 Possible synergies

This chapter will focus on finding out possible synergies to answer the main research question.

Functional transition

Biophysical restructuring of landscape

industry

agriculture urban area

Ems River system & Climate Change

Groningen region (innovation...)

Figure 2.6 research structure

Showing two processes of synergies that this project wants to analyse and design. The most important one is synergy between functional transition and biophysical restructuring of landscape. In order to achieve that, there will be synergies among functional transition, namely synergies among industry, agriculture and urban area. Besides, both of these two synergies are under the external challenge from Ems River system and climate change, as well as innovation need from Groningen Region.

So firstly, the project will reveal possible functional synergies for functional transition.
The next three maps show the problem states of three main functions in Eemsmond-Delfzijl structure. The SWOT analysis is based on such problem states, and will be considered to design possible synergies.

**Industry**

- States: low economic growth, industrial pollution, high unemployment rate

**Energy Industry**

- S: economic growth
- W: environmental degradation
- O: sustainable energy
- T: land subsidence, earthquake

**Storage**

- S: ensure port activities
- W: useless when no goods (off-season)
- O: economic activities
- T: noise

**Chemical Industry**

- S: economic growth
- W: environmental degradation
- O: useful chemicals
- T: pollution to urban area

**Service**

- S: jobs, better economic environment
- W: no knowledge exchange (high-service)
- O: functional transition, potential to improve
- T: less space for people's daily life
Agriculture

states:
negative to ecology
climate change risk
scarce freshwater

field crop (agriculture)
S: easy to implement
W: inelastic productions, negative impacts on ecology
O: urban farming
T: low economic productivity

grazing livestock (grassland)
S: flexible to land use
W: unplanned zone
O: urban farming, ecological value
T: waste from animal feeding
Urban area

states:
less urban collaboration
climate change risk
industrial pollution

public space

S: experience, living quality
W: quantity, distance to industry
O: urban regeneration program
T: pollution and safety problem from industry, Climate change

facilities

S: experience, living quality
W: less multifunction (industry area)
weak regional network
O: functional transition

commercial

S: economic growth
W: lack of high services
O: functional transition
T: living quality, house price

residential

S: possible to stay for employee and tourist
W: distance to industry
O: urban regeneration program
T: SLR, Climate change
Industry companys (industry function)

Figure 2.7 industry companys in Eemsmond-Delfzijl Structure, by author

Showing that two main industry area in Eemsmond-Delfzijl structure and its companys. This could be used for precise forms of synergies in this scale.
Figure 2.8 types of industry companies in Eemshaven-Delfzijl Structure, by author

They both have storage and energy industry. And for Delfzijl, the chemical industry is going to change since pollution and innovation. This trend will also happen in Eemshaven. As energy-related industry and chemical industry, they can be transferred into new energy industry to prevent pollution and earthquake in that region. Other industry, like storage, waste treatment and constructure company, they can help to support new energy industry in the future.
This map shows the basic situation of Appingedam and Delfzijl. Besides, there are 4 maps after showing density, land use, infrastructure and facilities in these two cities. When they are folded together, we will get the conclusion of urban functional structure and opportunity space for possible functional synergies.
density

land use
The open space within Appingedam-Delfzijl could be used as opportunity areas for localizing potential synergies. This is because such areas could practice nature-based solutions and be multifunctional to adjust local adaptation.
2.3 Innovation

As former research, there is external challenge about need of innovation from policy. This project will use this challenge as opportunity to help to design synergies for functional transition.

Figure 2.9 possible synergies, designed by author

This figure shows the potential synergies within industry, agriculture and urban function. There are already some collaboration between industry and urban function, as well as agriculture and industry. For industry and urban function, the project will introduce high-services to adjust missing loops. More job opportunity and smart industry will help such process. For agriculture itself, by introducing ecosystem services, there will be more benefits for both three. And ecosystem services can help improve ecological and socio-economic value of project site.
2.4 conclusion

potential synergies within functional regeneration (opportunities)

According to former analysis about three main functional variables, there will be some opportunity areas for potential synergies within functional regeneration. For each area, there are some different main functions that can be used to design the potential synergies in later chapters.
This map shows the possible challenge due to future development in Eemsmond-Delfzijl coastal area. As long as this structure develops and regenerate its function, they will have to deal with possible change of water defense system and flood risk, and make this area to be adaptive. This is due to biophysical structure of the Eemsmond-Delfzijl Structure that will be analysed next chapter.
3.1 3x3x3 analysis

Occupation

Natural landscape

2000

1850

1500

173km
The 3x3x3 analysis is part of the delta intervention graduation studio works. This needs an understanding of the territory in a multilayers manner.

This process uses tracing method to analysis the territorial formation of the project site.

In this scale, natural landscape layer is a driving force for the other layers. While infrastructure layer that shows the dikes on this scale gives the evidence of human interventions. The occupation followed construction of infrastructure.
3.1 3x3x3 analysis

occupation

natural landscape

BIOPHYSICAL STRUCTURE (local-subregion)
At this scale, the main driving force is urban development. It can be showed by both occupation and infrastructure. The regional structure became more and more complete. From the occupation map, we can get that Delfzijl is becoming more and more important than surrounding towns. But the urban development here decreased the rate of natural landscape. That is also because of booming of agriculture and other industry. The infrastructure system emerged into northern part to get a complete systems. This will increase socio-economic value for this area, while may also lead to landscape fragmentation to some extent.
3.1 3x3x3 analysis

occupation

natural landscape

BIOPHYSICAL STRUCTURE (local-subregion)
At this scale, the main driving force is urban expansion. As we can see from occupation map, there was no Delfzijl at first because this area is intertidal area. Due to technology progress and other human interventions, Delfzijl became an important harbor city for this region. Then there were more and more waterways used as transportation. And other infrastructure also got improved.
3.2 Biophysical elements

With former analysis, there are some potential synergies for functional regeneration/transition. This chapter will focus on biophysical elements in order to reveal potential synergies between functional transition and biophysical restructuring of landscape.
Clay soil often drains slowly and does not contain enough air for many plants. Nonetheless, although clay is not as versatile as loam, it is the perfect soil for a wide variety of different plants. Apple, elm, ash, willow, tamarack and many other trees thrive in clay, as do many flowers such as holly, asters and monkshood. If the clay soil is amended by adding gypsum and compost, it can be used to grow a much wider range of plants, which will benefit from clay’s rich nutrient content.

When dry, the soil forms hard clods or lumps. When wet, it is usually sticky. When moist, the soil can be rolled to a soil thread like a pointed pencil that does not readily break. When moist soil is pinched out between thumb and forefinger, it usually forms a long flexible soil ribbon that does not break under its own weight.

Peaty soil is composed largely of decomposed vegetable matter—typically sedges and mosses. It is light, easily waterlogged and highly acidic. Peaty soil, or peat soil, is typically found in low-lying areas that are susceptible to water logging. These soils are organic, nutrient-rich and fertile and may require additional drainage. They are used to grow azaleas, rhododendrons, primroses, heather and other acid-loving, or ericaceous, plants. Peat soil is also used in nurseries to adjust the pH level of soils.

These soils from frequently water-saturated sites such as wetlands are generally wet. Peat soil appears blackish and plant parts are readily identifiable. Other organic soils are commonly grayish, feel smooth, and may have a slight hydrogen-sulfide “rotten egg” smell.

It is good to acknowledge that when peat soils are drained for use in agriculture, decomposition of organic matter is accelerated leading to the mineralization of nitrogen (a vital nutrient for plant growth). This in fact is a good thing.

Some plants prefer growing in a sandy soil. These plants will usually have roots that penetrate deeply to find water way beneath the surface. Other types of plants don’t have this ability and sandy soil will have to be improved to grow them.

Sandy soils can be enormously improved by the generous addition of organic matter such as mushroom compost, composted manure, or peatmoss. Spread a layer of organic matter 3 to 4 inches (7 to 10cm) thick on the surface of the area to be improved, and then thoroughly incorporate into the soil. If you do not incorporate the organic matter, water will not percolate well and thus plants will grow poorly.

It has a lower moisture-holding capacity than other soil types and therefore must be watered more frequently. It has a lower nutrient-holding capacity than a other soil types and must be fertilized more often. When vegetative cover is lacking, it is subject to wind and water erosion.
3.2 Biophysical elements

Green and blue elements include forests, parks, wetlands, ponds and canals. Currently, there is less green and blue elements within Eemsmond-Defizijl structure. In order to improve ecological value of this structure, there must be more green and blue elements instead of single use of agriculture.
The overall trend of elevation is becoming lower from north to south except dikes and urban area. Especially, the south of Eemsmond-Delfzijl structure is really lower than other areas. This means there is an opportunity for water storage to deal with problem of scarce freshwater resources.
3.2 Biophysical elements

This map shows the soil type of this area. This is the foundation of design. With the suitable use of different soil, the design can decide what kinds of biophysical elements are better for the different area. Besides, the soil type map support the idea of biophysical restructuring of landscape in a systematic way.

resource: kaart.edugis.nl, Grondsoorten
These two maps show the pollution conditions of this structure. Because of the chemical industry in Delfzijl, there is strong pollution of SO2. The pollution of CO2 is because of urban function and lack of green space.
3.2 Biophysical elements

These three maps show possible flood risk due to different scenarios of sea level rise. From left to right, the sea level rise is 25cm, 80cm and 150cm. The darker the area is, the more possibility of flooding there will be. This means the project should consider regional mitigation and local adaptation for climate change.

resource: kaart.edugis.nl, Overstromingsrisico
3.2 Biophysical elements

Ems estuary

LEGEND

sedimentation

Source: Maren, Kessel et al. (2015)
The Ems estuary has reached a level of turbidity where oxygen production no longer takes place and where the biodiversity and biomass has dropped significantly and has led to a dying river. This has been caused by continuing technical adaptations, which have to be continued and even increased to maintain the current economic level. This in return worsens the ecological state and leads to higher maintenance costs.

The total dredging is steadily rising and is already costing 26 million euros a year, excluding deepening activities. At the same time, the oxygen level has fallen below the critical level for fish to survive (1.5 mg/l) (Talke, de Swart, 2006). This has an huge impact on socio-economic value for this area.

Also the water quantity and quality is the main issues for the whole area. This will affect ecology in this area due to climate change.
3.2 Biophysical elements
Salinisation and eutrophication of groundwater and surface water are the main ecological problems in the
project site. Due to climate change, this will increase.

For the socio-economic issues, the main one is impasse between economic progress and natural conservation. This region needs development, and there were industrial expansion in the 1970s and 1980s. These industrial developments are taking place on the Wadden scale but also, and more fiercely, on the smaller scale of the Ems. The estuary is protected and accredited as ecological important by eleven different regulations spread over nine different governmental institutions and NGO’s (CWSS, 2010), but at the same time has five industrial harbours looking for growth. This has led to a provisional standstill; both parties are unable to progress because opposing lobbies keep each other in check. Meanwhile the problem remains and even worsens.
3.3 Ecosystem services

different kinds of ecosystem services

<table>
<thead>
<tr>
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<th>Regulating</th>
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<tbody>
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<td>food</td>
<td>climate regulation</td>
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<tr>
<td>fresh water</td>
<td>water regulation</td>
</tr>
<tr>
<td>tourism</td>
<td>water purification</td>
</tr>
<tr>
<td>energy (gas)</td>
<td>waste treatment</td>
</tr>
<tr>
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<td>carbon</td>
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<table>
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<tr>
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<td>nutrient cycling</td>
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<tr>
<td>aesthetic</td>
<td>biodiversity</td>
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<tr>
<td>education</td>
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</tr>
</tbody>
</table>

resource: Millennium Ecosystem Assessment, 2005. World resources institute, Washington, DC.
3.4 conclusion

Potential synergies between functional regeneration and biophysical restructuring of landscape (opportunities)

With analysis of biophysical structure from local to sub-region and potential synergies for functional regeneration/transition, there will be some opportunity areas for potential synergies between functional regeneration/transition and biophysical restructuring of landscape. For each area, there are some different main targets that can be used to design the potential synergies in later chapters. These targets not only work for such synergies, but also deal with regional mitigation and local adaption due to climate change.
4.1 Hypotheses

This chapter will put forward main hypotheses based on former analysis about problem field and potential synergies for functional adaptation and biophysical structure both from local to sub-region.

*basic hypotheses*

- **Biophysical elements could validate the challenges and opportunities in Eemsmond-Delfzijl Structure and 'borrowed size cities' (Appingedam-Delfzijl) by maintaining existing ecosystem services and introducing new ones.**

- **Polycentric system and 'borrowed size cities' could strengthen urban collaboration, thus reinforcing function and contributing to the whole Eemsmond-Delfzijl Structure. Polycentric system is reinforced by sub-system centrality linking 'borrowed size cities'.**
objectives

A new polycentric functional sub-region with emphasis on green infrastructure network (Eemsmond-Delfzijl structure)

*includes:*

- corridors
  
  *i. ecological coastal corridor*

  *ii. north-south highway corridor*

  *iii. blue infrastructure corridor*
The government vision for Eemsmond-Delfzijl Structure has four parts, namely energy, business parks, water safety and accessibility. Precisely, the energy is about energy infrastructure and wind energy in Eemsmond and Delfzijl. And the government wants to remain current industry site and update to industry parks. The water safety targets is about improving dikes and building up some breeding islands. And finally enhancing railway connection from Eemsmond to Roodeschool, at the same time, adding a helicopter port. This Structural Vision Eemsmond-Delfzijl deals with 15 spatial projects in the Eemsdelta area.

Figure 4.1
resource: Structural Vision Eemsmond-Delfzijl Provincie Groningen.
https://groningen.tercera-ro.nl/MapViewer/Default.asp?id=NLIMRO99205VEemsmondDelfzijl-VA01
i. new form of industry park

ii. new spatial form of coastal rural area

iii. spatial form of urban area (validated by polycentric urban system - objective 2)
A ‘borrowed size’ urban system (Appingedam-Delfzijl)

This urban system is a supplement for the new polycentric functional sub-region. It is part of the three corridors mentioned before.

includes:
- corridors

i. functional corridor

ii. blue infrastructure corridor
After WWII the industrial development in Delfzijl gets a boost after the government decides that Delfzijl is to become the industrial heart of the North. To promote the region, industrials are lured to the region with subsidies and tax cuts and by being somewhat loose in its legislations: “Delfzijl is a unique place. All of the waste water can be dumped right into the Ems” (mayor Roele of Delfzijl in the fifties in: Run and Knol, 2004). This is of course a very dated quote, but it does show the way in which people thought about the Ems, namely as a place for economic use and prosperity; the ecologic importance of the connection to the Wadden Sea was not even considered.
**landscape gradients**

This two pages show the landscape gradients from urban to nature. These are the biophysical elements that can be used for local adaptation.

At this scale, different biophysical elements make up landscape structure.

For next several pages, it will show how to design potential functional synergies for the precise spatial forms and how such biophysical elements or landscape gradients help to facilitate and reinforce potential functional synergies by pilot projects.
4.2 Spatial forms

1. gas extraction + 2. agriculture + 3. wetlands

spatial form

possible synergy

agriculture

biogas treatment

wind farm

gas extraction

smart industry

waste water treatment plant

wetland

high-services

recreation park

intertidal wetland
How this works

This pilot project works on finding out synergy between gas extraction, agriculture and wetlands. Firstly, it defines where these functions are. Secondly, with former research about possible synergies, this pilot project will introduce biogas treatment, smart industry, high-service, recreation park, wind farm, waste water treatment plant and intertidal wetland to build up and reinforce the relation between different functions. Thirdly, it defines different kinds of biophysical elements that help to achieve synergies. Finally, there will be research about ecosystem services to see what kinds of ecosystem services it lacks. The design of pilot project will be shown in later chapters.
4.2 Spatial forms

1 industry + 2 port activities + 3 agriculture

spatial form

possible synergy

agriculture

port activities

industry

wetland

urban farming

high-services

recreation park

tourism

waste water treatment plant

smart industry
This pilot project works like former one.

biophysical elements

current ecosystem service (need to be regenerated)

possible ecosystem service

provisioning  regulating  cultural  supporting

river channel
unplanned land or brown space
4.2 Spatial forms

1. industry +
2. urban area +
3. port activities

spatial form

possible synergy

industry
urban area
port activities
recreation park
wetland
tourism
high-services
dynamic water defense system
urban farming
waste water treatment plant
smart industry
This pilot project works like former one.

biophysical elements
5.1 Patterns

-Ecological & Socio-economic Patterns to validate functional synergies

approach & methodology for design phase

risks

- decreasing economy
- shrinking society
- monotonous ecology

goals

industry
agriculture
flooding/ecology

update/regenerate
enhance ecological value
resilient to hidden flooding risk

potentiality of different space

challenge

functional regeneration
climate change & innovation need
biophysical restructuring of landscape

from risks to opportunities

testing / vision

part of functional network, core of bio-based economy

regional vision & structure
local + local

polycentric functional sub-region with emphasis on green infrastructure network

'borrowed size' urban system

bio-based economy & ecological environment
urban collaboration

Green corridor

ecological coastal corridor

north-south highway corridor

Blue corridor

blue infrastructure corridor

functional corridor

extended centrally-functional network and continuity

(functional backbone)

evaluation

cost-effective

key method
strategy matrix for validating functional synergies

This matrix shows how to find out and validate potential synergies. In this chapter, the project will firstly design a pattern library for the first part of strategy matrix. At the end, it will show how this pattern library works, namely how to achieve the project goals. Then with spatial conditions and system synergies, the project can get spatial programming, corridors and functional network, namely the final design goals.

bio-based economy
- energy crops
- waste collection
- biomass transition plant
- consultancy
- urban farming

system synergies
- wetland / other forms
- manmade habitat
- experimental plot
- water defense system
- urban resilient system

spatial conditions

create new ecosystem
(open disclosure...)

This matrix shows how to find out and validate potential synergies. In this chapter, the project will firstly design a pattern library for the first part of strategy matrix. At the end, it will show how this pattern library works, namely how to achieve the project goals. Then with spatial conditions and system synergies, the project can get spatial programming, corridors and functional network, namely the final design goals.
5.1 Patterns
-Ecological & Socio-economic Patterns to validate functional synergies

**bio-based economy**

> Currently, there are three opportunity space for implementing bio-based economy

existing land structure

waste collection

unplanned land
(used as biomass transition plant)
For existing land structure, there are agriculture, canals, brooks and grassland, namely polder structure. This can be transferred into biomass planting, such as crops, green biomass, woody biomass and aquatic biomass.

Current waste collection plants can be used for dealing with residual flows that are released in the field, during production and after using as products.

The unplanned land can be used for new biomass processing plants.

crops (grain, maize, sugar beet)
green biomass (grass)
woody biomass (willow, poplar, pruning and thinning wood)
aquatic biomass (algae, seaweed)

residual flows released in the field (straw, hay, manure)
residual flows released during production (residual wood, potato peelings)
residual flows released after using as products (sewage sludge, waste wood, organic waste)

grass refining plant giving partial products with higher added value protein for cattle feeding cellulose for papermaking nutrients back to the land as manure

algae farming / seaweed nursery capturing CO2 from carbon-based plants providing raw material for the chemical industry and animal feed

chemical industry by using bio-ethene, bio-prene and bio-paraxylene, 80% of the chemical industry can be greened (Agentschap NL)

biomass processing high-technology transform biomass into biofuel, biochemical products and other biobased material.
5.1 Patterns
-Ecological & Socio-economic Patterns to validate functional synergies

biophysical restructuring of landscape
-natural forms & manmade habitat

For landscape, there are two main forms, namely natural forms and manmade habitat. Both of them can be used as basement for bio-based economy, like biomass planting. Also, it is good for regional mitigation and local adaptation.

natural forms

wetland

woodland

lake/water

grassland
manmade habitat

agriculture

urban farming

park
5.1 Patterns

-Ecological & Socio-economic Patterns to validate functional synergies

**biophysical restructuring of landscape**
- water defense system

This pattern is about opening dike. For different time and space, they will be affected by different tide. With high tide, the well-defined area will always be flooded. After a few years later, there will be a ponds or lakes for water storage. With low tide, the well-defined area will be occasionally flooded. This area will become wetlands when the new dike leaves.

![Diagram of biophysical restructuring of landscape with high tide and low tide, freshwater storage (reservoir), and wetland.]
This pattern is about building up a 'harbour' on the old dike. The left one is by using natural dynamics, namely sedimentation and erosion, to form a foreshore levee for the dike. This will enhance safety of dikes. The right one is by introducing some small islands (engineering way) to facilitate the process of sedimentation and erosion. At the end, there will be some ecological islands.
5.1 **Patterns**  
-Ecological & Socio-economic Patterns to validate functional synergies

**urban resilient system**

- dynamic defense system
- multifunctional green space/urban parks
- ecosystem restoration
- sustainable urban drainage system
- water storage/carbon sequestration
- green roofs/neighborhood green space
urban resilient system

Except the left 6 patterns, there are still some, like:

- from abandoned land, underused and unused land to urban farming and community garden.

- subsequent transformation from grey infrastructure into green space.

- multifunctional neighborhood green space/urban parks.

- ecosystem restoration. (restoration of wetlands, woodlands, riverbanks, floodplains)

- green roofs.

- increasing water storage.

- reclamation of coastal areas.

- carbon sequestration for climate mitigation.

- sustainable urban drainage systems.

All the methods above will be used in local adaptation design to achieve an urban resilient system.

5.1 Patterns
-Ecological & Socio-economic Patterns to validate functional synergies

working process

natural forms

manmade habitat

energy crops

waste collection

biomass resources

biomass transition plants

practice

healthier economy
5.2 New polycentric functional sub-region

By layering occupation, infrastructure network and soil type, there will be the condition map for implementing different kinds of strategies.

resources: Sijmons, Jeroen, Ina, 2009
5.2 New polycentric functional sub-region

reference programs

- reference: oyster reef
  location: Eastern Scheldt
  resources: Eco-engineering in the Netherlands, Rijkswaterstraat and Defunes

- reference: forest area
  location: Markermeer between Hoorn and Amsterdam
  resources: Eco-engineering in the Netherlands, Rijkswaterstraat and Defunes

- reference: Zevenlenn Biobased Agriculture
  location: Zevenlenn
  resources: https://www.zevenlenn.nl/

- reference: De Eindacht (willows for producing biofuel)
  location: Apingedam
  resources: Provincie Groningen
  www.provinciegroningen.nl

- reference: Meentwijk
  location: Scheldwilde
  resources: DLG Groningen
  Inrichtingsmaatregelen natuurontwikkeling Dannemeer

- reference: Cesterdam
  location: Eastern Scheldt
  resources: Eco-engineering in the Netherlands, Rijkswaterstraat and Defunes

- reference: Wierden
  location: Noordwaard
  resources: De-polarization
  Noordwaard has major consequences, www.vd.nl
In order to be a new polycentric functional sub-region, the project divides the whole sub-region as 7 different functional units. For each of them, the project will reveal potentiality and spatial condition. Based on that, the project will put forward strategy, spatial programming, activated stakeholders and proposal. With these 7 functional units, the new polycentric functional sub-region will be implemented.
5.2 New polycentric functional sub-region

Integrate infrastructure in sub-regional scale

bio-based economy
& related strategy

This part is about integrating infrastructure in sub-regional scale. It is not only about gray infrastructure, but also main body of bio-based economy. The right map shows how these 5 functional units are connected by infrastructure.
Functional units for integrating infrastructure in sub-regional scale
5.2 New polycentric functional sub-region

By researching current land use, the project can get the potentiality for spatial intervention. The spatial condition is based on soil type and elevation of site. (Also for the next few pages)
This functional unit uses algae farming and fishery to update current agriculture. This is supported by building up foreshore levee for coastal water defense system. With such new agriculture and new energy crops, there will be more biomass that can be used for biomass processing here. Due to awareness of ecological value and negative effects from gas extraction, the industry here can be regenerated to biomass processing plants and some other bio-based industry.

The programming below shows the possibility of strategy. Then the activated stakeholders will support spatial programming and strategy. Finally, it is proposal based on strategy and spatial programming. (Also for the next few pages)

strategy (based on potentiality)

- algae farming
- fishery / oyster
- biomass processing
- agriculture
- gas extraction industry
- foreshore levee
- coastline

programming

- oyster farming
- algae farming
- biomass planting
- energy farming (tidal energy, wind energy)

activated stakeholders

- environmental organization
- food production
- energy production
- NGO

proposal

(The complete proposal will show at later chapter)
5.2 New polycentric functional sub-region

- Potentiality
- Spatial condition

Legend:
- Construction industry
- Port (tourism route)
- Agriculture land
- Electricity
- Storage
- IT industry

- Sand
- Compressed land
- Peat
This functional unit transfers some of current agriculture land into woodland and biomass planting based on spatial conditions. These woodland can be then used for tourism with the help from port function (ferry departure) or form new habitat for this area. Besides, current energy-related industry can regenerated to bio-based industry to produce bio-fuel by processing biomass from agriculture land. The reinforced infrastructure can support both tourism and industry.

strategy (based on potentiality)

programming

activated stakeholders

environmental organization
food production
energy production
NGO
tourist
surrounding residents

proposal

(The complete proposal will show at later chapter)
5.2 New polycentric functional sub-region

potentiality

spatial condition

clay

old clay
This functional unit is located near urban area, this means the project can introduce urban farming for agriculture. At the same time, since there are several unplanned land, the project can build up new biomass processing plants for primary processing of products from agriculture, grassland and woodland. The waste collection plants are also used for collecting waste from villages and urban area. Then they will send to primary industry, secondary treatment and industry park by reinforced infrastructure.

**strategy (based on potentiality)**

- **villages**
  - **urban farming**
  - **waste collection**
  - **biomass**
  - **biomass processing & storage**
  - **grassland & woodland**
  - **infrastructure**
  - **industry**

**programming**

- **biomass planting**
- **urban farming**
- **(green) industry park**

**activated stakeholders**

- environmental organization
- industry company
- food production
- NGO
- tourist
- surrounding residents

**proposal**

(The complete proposal will show at later chapter)
5.2 New polycentric functional sub-region

potentiality

spatial condition

industry
agriculture land
villages

clay
compressed land
peat
This functional unit also uses current agriculture to develop biomass planting and woodland. Since this unit is close to National Ecological Network, the woodland that built here can help this unit to connect to current ecological network. And in the future, it can help to enhance northern ecology to some extent. With these, tourism here can get well developed. Besides, the project use and regenerate current chemical industry area to build up an industry park for bio-related resources treatment. (biomass, biogas, biofuel ...)

strategy (based on potentiality)

- biomass
- biomass processing
- industry park
- National Ecological Network
- tourism
- villages
- agriculture

- enhance northern ecology
- connect to current network

programming
- biomass planting
- landscape agriculture
- tourism
- woodland
- multi-ecosystem
- tourism
- (green) industry park
- tourism

activated stakeholders
- environmental organization
- industry company
- food production
- energy production
- NGO
- tourist
- surrounding residents

proposition (The complete proposal will show at later chapter)
5.2 New polycentric functional sub-region

**integrate infrastructure in sub-regional scale**

*biophysical restructuring of landscape & related strategy*

This part is also about integrating infrastructure in sub-regional scale. It is mainly about biophysical restructuring of landscape. With the help of restructuring of landscape, there will be better ecological environment for both society and economy. The right map shows how these 2 functional units are connected by infrastructure.
Functional units for integrating infrastructure in sub-regional scale
5.2 New polycentric functional sub-region

[Diagram showing spatial condition and potentiality with labels for sand and clay areas, and symbols for agriculture land, coastal dike, and villages.]
This functional unit firstly define flood-zone and then open the dike for making agriculture land reflooded. After a few years later, some area will become fertilized land and then be agriculture again. The others will become ecological habitat through ecological rehabilitation. This will stable soil for better coastal defense system, and form new wetland for such area. Tourism will be a new elements to help develop this units after improving ecological value.

strategy (based on potentiality)

programming

activated stakeholders

proposal (The complete proposal will show at later chapter)
5.2 New polycentric functional sub-region

potentiality

spatial condition

- Clay
- Peat

Legend:
- Green: Woodland (nature)
- Orange: Agriculture land (and animal feeding)
- Blue: Villages
- Light blue: Electricity
This functional unit is somewhat same as former one. But this one will introduce new house programme since there is an opportunity for floating house near the new lake. Also, the wetland here can help to store freshwater for surround agriculture land and electricity industry.
5.2 New polycentric functional sub-region

This part is about design and plan the new polycentric functional sub-region based on my proposal above.

The right map shows existing condition of sub-region. The land use is mainly about grassland for livestock farming and agriculture. Among these agriculture lands, there are some woodland, but the quantity of woodland is really low.
5.2 New polycentric functional sub-region

Build up basement/new environment for bio-based economy

The right map shows the works within first 5 years. The main target is building up basement/environment for bio-based economy, namely woodland, grassland and energy crops for biomass resources. Also by opening the dike, the project starts building up new environment for sub-region.
5.2 New polycentric functional sub-region

Set up main body of bio-based economy

The right map shows the works within 10 years. The main target is setting up main body of bio-based economy when there are enough basements for biomass. At the phase, there will be several biomass treatment plants and waste collection in sub-region. Also, the two industry area in Eemshaven and Delfzijl will become industry park for centralized processing of bio-related resources, like biogas, biofuel and biomass. Besides, the ecological environment will change a little bit at this phase.

10 years
5.2 New polycentric functional sub-region

Sustainable development of bio-based economy as well as urban environment

The right map shows the conditions after 20 years. At this phase, the bio-based economy already has its own forms. The environment also get well prepared to mitigate effects from climate change, like wetlands, woodland, lakes, foreshore levee and ecological islands. This will help to make the sub-region an sustainable area for the Groningen Region.

20 years
5.3 sub-regional programs for mitigation and potential synergies

This chapter will show two pilot projects for former research and design. Both of them make use of current spatial forms and biophysical elements to achieve potential functional synergies for functional transition, as well as biophysical restructuring of landscape. After these pilot project, it is about timeline and programming for my proposal of new polycentric functional sub-region. Then there will be involved stakeholders.
### 5.3 sub-regional programs for mitigation and potential synergies

**Timeline**

<table>
<thead>
<tr>
<th>infrastructure</th>
<th>bio-based economy</th>
<th>biophysical structuring of landscape</th>
</tr>
</thead>
<tbody>
<tr>
<td>water defense system &amp; urban resilient system</td>
<td>energy crops &amp; waste collection &amp; biomass transition plants</td>
<td>natural forms &amp; manmade habitat</td>
</tr>
<tr>
<td>dike</td>
<td>crops</td>
<td>wetland</td>
</tr>
<tr>
<td>mobility</td>
<td>green biomass</td>
<td>woodland</td>
</tr>
<tr>
<td>water supply &amp; collection</td>
<td>woody biomass</td>
<td>water / lake</td>
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<tr>
<td>sewer</td>
<td>aquatic biomass</td>
<td>grassland</td>
</tr>
<tr>
<td>facility</td>
<td>waste collection</td>
<td>agriculture</td>
</tr>
<tr>
<td></td>
<td>biomass processing plants</td>
<td>urban farming</td>
</tr>
<tr>
<td></td>
<td>grass refining plants</td>
<td>park</td>
</tr>
<tr>
<td></td>
<td>algae farming &amp; seaweed nursery</td>
<td></td>
</tr>
<tr>
<td></td>
<td>chemical industry</td>
<td></td>
</tr>
</tbody>
</table>
sustainable development of bio-based economy as well as urban environment

multifunctional dike system

multifunctional infrastructure

connect islands

freshwater

bioswale, raingarden, sewer at wetland

tourism

dynamic landscape

dynamic with ecological

maintance

maintance

form parks

liveable wetland

ecological wetlands

forest around wetland

floating house

irrigation from reservoir

fertile area
5.3 sub-regional programs for mitigation and potential synergies

Programming

**infrastructure**
- water defense system & urban resilient system
- dike
- mobility
- water supply & collection
- sewer
- facility

**bio-based economy**
- energy crops & waste collection & biomass transition plants
- crops
- green biomass
- woody biomass
- aquatic biomass
- waste collection
- biomass processing plants
- grass refining plants
- algae farming & seaweed nursery
- chemical industry

**biophysical structuring of landscape**
- natural forms & manmade habitat
- wetland
- woodland
- water / lake
- grassland
- agriculture
- urban farming
- park
sustainable development of bio-based economy as well as urban environment

- tourist attraction
- green infrastructure
- bioswale
- bridge
- reservoir
- rural scenery
- Storage factory
- Tourism
- wetlands
- forest
- agriculture
- parks
- nursery
- chemical
- ecological
- parks
- 10 years
- 20 years
- 157
5.3 subregional programs for mitigation and potential synergies

Stakeholders

The stakeholders map shows different activated stakeholders at different project phase and different targets.

**infrastructure**
- water defense system & urban resilient system

**bio-based economy**
- energy crops & waste collection & biomass transition plants

**biophysical structuring of landscape**
- natural forms & manmade habitat

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<table>
<thead>
<tr>
<th>Groningen Province</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Municipality Delfzijl, Appingedam, Eemsmond</td>
<td>Municipality Delfzijl, Appingedam, Eemsmond</td>
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<tr>
<td>water board</td>
<td>water board</td>
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<tr>
<td>Rijkswaterstaat</td>
<td>Rijkswaterstaat</td>
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<tr>
<td>NGO</td>
<td>NGO</td>
</tr>
<tr>
<td>local residents</td>
<td>local residents</td>
</tr>
</tbody>
</table>

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| food production | energy production |
| environmental organization | NGO |
| construction and civil engineering companies (Royal HaskoningDHV...) | locomotive manufacturers |

---

<table>
<thead>
<tr>
<th>Groningen Province</th>
<th>Municipality Delfzijl, Appingedam, Eemsmond</th>
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<tbody>
<tr>
<td>food production</td>
<td>energy production</td>
</tr>
<tr>
<td>environmental organization</td>
<td>NGO</td>
</tr>
<tr>
<td>local residents</td>
<td>water board</td>
</tr>
<tr>
<td>water board</td>
<td>Rijkswaterstaat</td>
</tr>
</tbody>
</table>
set up main body of bio-based economy

Groningen Province
Municipality Delfzijl, Appingedam, Eemsmond
shipping company (Royal Wagenborg ...)
consultancy company (Arcadis ...)
NGO
local residents

10 years
sustainable development of bio-based economy as well as urban environment

Municipality Delfzijl, Appingedam, Eemsmond
construction and civil engineering companies (Royal HaskoningDHV...)
NGO
local residents

20 years

Municipality Delfzijl, Appingedam, Eemsmond
energy production
environmental organization
NGO
chemical industry (VNCI ...)
shipping company (Royal Wagenborg ...)

Municipality Delfzijl, Appingedam, Eemsmond
energy production
environmental organization
tourism company (Muzeeaquarium Delfzijl ...)

Municipality Delfzijl, Appingedam, Eemsmond
food production
environmental organization
NGO
local residents

Municipality Delfzijl, Appingedam, Eemsmond
tourism company (Munckhof Business travel Delfzijl ...)
environmental organization
NGO
local residents
This network shows the proposal of governance structure. The governance of project goes through not only time, but also scale. There are broader stakeholders from Groningen region, sub-region and urban area for a lot of actions and strategy plan goals. These goals will answer the policy goals and then tackle the accorded goals from beginning through bottom-up.

For different pilot project or detail design within urban area, this network will change according to goals. But both of them are from this network.
6.1 'borrowed size' urban system

This chapter will go deep into urban system by using 'borrowed size city' model from E. Meijers to enhance urban collaboration. This will contribute to sub-region vision.

The map below shows current condition of opportunity space. Green space, open space and office/industry can be used for local adaption. With the reinforced infrastructure network, there will be more urban collaboration between this 'borrowed size' urban system.
The next two maps show the potential corridors to connect Appingedam and Delfzijl and enhance urban collaboration between them. This will be supported by local adaption design.

- potential corridors

i. functional corridor

ii. blue infrastructure corridor
6.1 'borrowed size' urban system

This set of sections shows the spatial condition for potential corridors in such urban system. The water system is crucial for corridors.
water management & re-nature
the relation between industry and city

green infrastructure
energy crops
grassland
green space
biology processing
plants
woodland
highway
canal (transportation)
canal (leisure)
green infrastructure
6.1 'borrowed size' urban system

This map shows how to up-scale from several patches and corridors in this urban system to the new spatial structure.

- **highway** (connect north to south, production base to processing industry)
- **greening infrastructure** (connect two cities)
- **woodland & waste collection industry** (primary processing)
- **blue infrastructure** (as part of green corridor)
- **blue infrastructure** (connect industry park with a series of primary processing plants, also connect to the Groningen city)

**Biomass production base** (connect to national ecological network)
6.2 local detail design

water management & re-nature

existing condition

proposal (more than 20 years later)
abstract sections - to show functional relation of design

- current condition

- build up new dikes and infrastructure to other villages

- open the dike and reflood well-defined zone

- new ecological environment (wetlands, ecological islands, dynamic dike system)
This is about new dikes that are built up to protect villages from reflooding action. At first, this dike can help to capture surplus water when there is high tide. With underground pipeline, such water can be sent to water treatment plants. When the sluice close, this dike can be used for capturing rainfall, and then sending freshwater to agriculture land or neighborhoods.
This one is about sluice design, namely the way of opening dikes. With the sluice gate, it can control the amount of water that is introduced into mainland by the turbine. When there is too much water, this sluice gate can help to take the water away.
6.2 local detail design

water management & re-nature

This is about what the sluice looks like after 20 years later. When the reflooding process ends, the sluice will be changed to tourism center or shop. Due to the process of sedimentation, there will be some sedimentation islands with good ecological value. This can be used for better ecological environment and regional mitigation.
water management & re-nature - governance

phase 1: preparation

This part is about governance for design of water management and re-nature. It is used for aligning with new design’s policy proposal. And then guiding and localizing functional transition and biophysical restructuring of landscape.
6.2 local detail design

water management & re-nature - governance

phase 2: build up new environment
water management & re-nature - governance

phase 3: sustainable development of urban environment
6.2 local detail design

the relation between industry and city

existing condition
proposal (more than 20 years later)

abstract sections - to show functional relation of design
6.2 local detail design

the relation between industry and city

These two maps show the functional relation between industry, city and infrastructure.
6.2 local detail design

the relation between industry and city

**Diagram**: A diagram illustrating the relation between industry and city, showing the flow of water and energy within a biosystem. The elements include household, wetland, raingarden, industry, algae, wind energy, electricity network, community, regional woodland (forest), biotope, and bio-fuel industry.
the relation between industry and city

phase 1: preparation
6.2 local detail design

the relation between industry and city

phase 2: build up basement for bio-based economy
phase 3: set up main body of bio-based economy
the relation between industry and city

phase 4: sustainable development of bio-based economy
6.2 local detail design

green infrastructure

existing condition
proposal (more than 20 years later)

abstract sections - to show functional relation of design
6.2 local detail design

green infrastructure

detail design
This part is about green infrastructure in the urban system in order to achieve local adaptation. These intervention will be implemented in different locations. This one is mainly about bio-swale, bio-infiltration basin, retention basin and constructed wetlands.

bio-swale & natural swale
- filter and convey urban runoff
- promote infiltration
  (reducing saltwater intrusion)

bio-infiltration basin
- manage water quantity during storms
- flooded only during heavy rainfall
- promote infiltration
  (reducing saltwater intrusion)
Retention basin constructed wetland

- Manage water quantity during storms
- Reduce suspended sediment
- Promote infiltration (reducing saltwater intrusion)
- Provide critical wildlife habitat

Further reduce suspended sediment, in addition to nutrients, lower water borne contaminants
- Promote infiltration (reducing saltwater intrusion)
- Provide critical wildlife habitat
6.2 local detail design
green infrastructure

This part is also about green infrastructure in the urban system in order to achieve local adaptation. These interventions will be implemented in different locations. This one is mainly about green roofs and infiltration pedestrian street (permeable pavement).
manage rainfall on-site and promote infiltration

reduce runoff and promote infiltration

filtration planter to slow and filter rainwater

dense tree canopy cover to intercept and slow rainfall

rainwater collection for building and landscape use

green roof to slow and filter rainwater

filtration planter to slow and filter site runoff

add weirs to infiltration planters on steep streets to reduce speed of flow

permeable paving on sidewalk margins to reduce runoff and promote infiltration

permeable paving on parking margins

manage rainfall on-site and promote infiltration

filtration planter to slow and filter rainwater
6.2 local detail design

green infrastructure

phase 1: preparation
green infrastructure

phase 2: build up new environment
6.2 local detail design

green infrastructure

phase 3: sustainable development of urban environment
Up-scaling

from 'borrowed size' urban system to sub-region
This map shows how the 'borrowed size' urban system works with other functional units at sub-region scale. Especially, bio-based economy network and tourism show how this new polycentric functional sub-region has better performance of collaboration. Water supply, food production and protected environment reinforce and enhance regional mitigation with the local adaptation from 'borrowed size' urban system.
Up-scaling

from Eemsmond-Delfzijl structure to Groningen Region

This map shows how this new polycentric functional Eemsmond-Delfzijl structure contributes to Groningen Region. With stronger bio-based economy and healthier biophysical landscape structure, this area will have healthier socio-economy and ecology. Thus it will strengthen the missing loops in Groningen Region.
6.3 dynamic adaptive policy pathways

Phasing: Dynamic Adaptive Policy Pathways

This complex functional regeneration project is phased according to the Dynamic Adaptive Policy Pathways, this makes the project resilient for changes in political, economical or ecological context and makes it possible to start immediately. As follow, each step will be formulate according to the Dynamic Adaptive Policy Pathways.

Step 1&2: Current conditions and problem analysis

The first and second step is to describe the study area, including the system’s characteristics, the objectives, the conditions in the current situation, and potential constraints in future situations. Then, the current conditions and possible future situations are compared to the specified objectives to identify whether there are any gaps.

Objective:
• economic growth (cut back natural gas activities and update existing chemical clusters in Delfzijl)
• better biophysical environment (improve ecological value)
• better water management and relieve flood control pressure (enough fresh water resources, new defense system instead of only reinforcing dykes)

Conditions (if no action implemented)
• low economic growth (agriculture, chemical clusters, high unemployment rate)
• industry pollution and effects (pollution to nature and urban area, earthquakes, water quality in canal)
• low ecological value (agriculture)
• climate change risk (scarce fresh water resources, precipitation, land subsidence)
• less urban functional collaboration (agricultural sector, chemical and plastics infrastructure, urban function …)

Scenario (potential constraints in future situations)
• climate change
• social shifts
• economic growth
Step 3&4: Determine actions, assess efficacy, sell-by date of actions, and reassess vulnerabilities and opportunities

In the third and fourth step, this project identify possible actions that can be taken to meet the objects. They are listed in the following table and are grouped into 5 main actions: Explore the potential of existing infrastructure and land use; Set up main body of bio-based economy; Change the land use by new green infrastructure; Change the land use by new grey infrastructure; Diversify the land use.

<table>
<thead>
<tr>
<th>Action</th>
<th>Impacts</th>
<th>Sell-by date (years)</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Safety</td>
<td>Fresh water</td>
<td>Economy</td>
</tr>
<tr>
<td>Explore the potential of existing infrastructure and land use</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A1 Use the green area for water retention and detention</td>
<td>++</td>
<td>++</td>
<td>0</td>
</tr>
<tr>
<td>A2 Use the empty land for reforestation and soil conservation by planting more trees</td>
<td>++</td>
<td>++</td>
<td>0</td>
</tr>
<tr>
<td>A3 Use the public gardens and parks for green waste and organic waste from street</td>
<td>0</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>A4 Use the strong arable farming sector and plenty of room to expand livestock farming and biomass planting</td>
<td>0</td>
<td>0</td>
<td>++</td>
</tr>
<tr>
<td>Set up main body of bio-based economy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B1 Build up biomass processing plants. Primary processing plants locate near to biomass resources (plants), secondary processing plants locate in industry park</td>
<td>0</td>
<td>0</td>
<td>+++</td>
</tr>
<tr>
<td>B2 Build up grass refining plants. Using the grass from livestock farming</td>
<td>0</td>
<td>0</td>
<td>++</td>
</tr>
<tr>
<td>B3 Develop algae farming in current wetland and lake, as well as new waterbodies</td>
<td>+</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>B4 Update current chemical cluster into biochemical industry park</td>
<td>++</td>
<td>0</td>
<td>+++</td>
</tr>
<tr>
<td>Change the land use by new green infrastructure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C1 Change the land use to nature and recover preservation areas and create green spaces along canals</td>
<td>++</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>C2 Use the canal systems (brooks...) to increase fresh water supply by infiltrating vegetation (bio-swales and bio-retention ponds)</td>
<td>+</td>
<td>+++</td>
<td>0</td>
</tr>
<tr>
<td>C3 Reintroduce the sea into well-defined areas. These areas are inundated subsequently and heightened at the end. Then they will be agriculture again or nature area (wetlands...)</td>
<td>+++</td>
<td>++</td>
<td>-</td>
</tr>
<tr>
<td>C4 Introduce green space into industry and surrounding area</td>
<td>+</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Change the land use by new grey infrastructure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D1 Change some industry to bio-waste treatment plant to increase efficiency of waste management</td>
<td>0</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>D2 Create new bike lines and links</td>
<td>0</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>D3 Create local recycle center and refinery</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>D4 Create new pipeline system to transfer waste, bio-related energy (biogas, electricity, biofuel ...)</td>
<td>++</td>
<td>0</td>
<td>++</td>
</tr>
<tr>
<td>D5 Build up dykes and sluice (to protect villages and reintroduce the sea into well-defined areas)</td>
<td>++</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Diversify the land use</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>E1 Use the commercial and job centers to densify the house and office and diversify function of such areas</td>
<td>0</td>
<td>0</td>
<td>+++</td>
<td>0</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>E2 Use tourism to make use of urban and rural green space</td>
<td>0</td>
<td>0</td>
<td>+++</td>
<td>0</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>E3 Use green space as public space for leisure activities, and at the same time, catch rainfall and mitigate effects from climate change</td>
<td>++</td>
<td>+</td>
<td>0</td>
<td>++</td>
<td>++</td>
<td>+</td>
</tr>
</tbody>
</table>

Note: the data in Sell-by date is based on assumption.
6.3 dynamic adaptive policy pathways

Phasing: Dynamic Adaptive Policy Pathways

Step 5: Develop pathways

In this step, all the possible pathways are formed in the following Adaptation Pathway map. To construct the pathways, the project use the 5 main actions. Among the 5 actions, some needs years’ of preparation and can not work immediately. The next step is to add the sell-by dates and all the possible transfers to other actions that would extend the sell-by date to achieve the objective. Some illogical actions are eliminated in this map, like diversify the land use cannot deal with current ecological issues and bio-based economy target, so it can only be implemented later when the social shifts and economic growth replace climate change and bio-based economy become the main challenges of project.
Step 6: Select preferred pathways

From the Adaptation Pathways map, 5 pathways can be identified. Then, different decision makers and stakeholders can have different preferred pathways, depending on their values and beliefs.

For pathway 1&2, it is about firstly developing bio-based economy, and then developing green infrastructure to support bio-based economy as well as urban environment. At the end, when there are good environment for urban area and good basement for bio-based economy, it can go to develop bio-based economy or other business for economic growth. This is to some extent from government perspective.

For pathway 3, it begins with green infrastructure. After that, it develops bio-based economy through some biomass planting from green space and agriculture. This is to some extent from residents perspective.

For pathway 4&5, it starts with building up new grey infrastructure. With the support from infrastructure, it can reinforce business or develop bio-based economy. This is mainly from developer perspective. But the pathway 5 is not the main purpose of the project.
7.1 reflection and evaluation

The relation between the research and design (Aspect 1)

The research part of project mainly focuses on the North Sea, the Wadden Sea and Groningen region scale. The characteristics of the North Sea can help to understand the relation between built-up environment and the natural landscape. The Wadden Sea area gives the graduation project precise context. Together with the Wadden Sea, Groningen region provides the problem fields for graduation project. Besides, the urbanization process that happened along the coastline in the last centuries emphasizes the socio-economic aspects in the project region. The natural context, together with socio-economic characteristics, makes the project possible to search a new sustainable relation between built-up environment and nature. This preliminarily forms the research question, namely how to achieve a socio-economic and ecological healthier landscape. After zooming in to regional scale and local scale, the research started to find out the reason behind shrinking region (Groningen province). With that, it is easier to start a design for such region. It also forms the second half of research question, rethinking the Eemsmond-Delfzijl structure under the process of functional transition and external challenges like climate change, social shifts and need of innovation through spatial planning and design.

With the help from graduation studio group, I did the research about spatial-temporal context, namely ‘3x3x3’ analysis. This integrates three physical layers of landscape, infrastructure and occupation in temporal dimension and in different scales. Also the research about soil type and its suitable function helps to transform research into design. This is also about the Dutch layer approach that put forward by Sijmons. According to the problem field, there is a conflict between urban functional transition and ecological conservation. So the hypothesis to solve such problem is that urban functional transition have benefits and can contribute to biophysical restructuring of landscape, and vice versa. Then the research and design phase is to find out what need to be adapted to fit the combination of urban functional transition and biophysical restructuring of landscape, and how. According to literature research, there is a suitable way to achieve goals, namely building up a polycentric system with nature-base solution, as well as landscape infrastructure methods. In order to have such polycentric system, the first step is to find and design functional synergies to validate this system. Then by introduce ecosystem services, functional transition can be better connected to biophysical structure. The final outcome will be an urban-landscape matrix with local adaptation to validate it. And this will react and respond the problem field.

To emphasize the consistency in research and design, the process of design by research is to find out potential condition and method for answering research question. So at this phase, I did a lot of literature study and research about bio-based economy and engineering method for restructuring of landscape. These researches help me to do the precise design in order to achieve goals and vision of graduation project. From the whole graduation process, I can finally understand the meaning of research by design and design by research. They are cyclical relation and contribute to each other at different phase.
The relation between research group and subject of the project (Aspect 2/3)

The graduation studio Delta Interventions focuses on the theme of ‘Landscape of Coexistence’. It mainly deals with the spatial effects of extreme climate change scenarios. Landscape of coexistence means sustainability and adaptation, both for urban and natural system. This includes ecological and socio-economic parts and will be indicated in regional scale. Besides, Delta Urbanism is an interdisciplinary research group, which investigates the possibilities to combine sustainability and water management strategies with urban design, landscape design and spatial planning. These design and planning approaches and methods contribute to make urban delta landscape more sustainable, attractive and adaptive. For urban project, it is important to deal with the relation between built urban environment and natural landscape.

The subject of project is mainly about function regeneration. The way to achieve this is bio-based economy through biophysical restructuring of landscape. Within this process, it is important to considerate threaten from climate change. This provides project the request about regional mitigation and local adaptation. All these subjects correspond with the aim and discipline of research group. So they can give me great support and input during the research and design process.

Wider social and scientific framework (Aspect 4) & the potential ethical issues (Aspect 5)

social and scientific framework, as well as potential ethical issues are shown later.

[Dilemmas]

So far, with the help from my mentor team (Dr. Sepulveda and Dr. Tillie), I think the research approaches and methodology are quite clear. However, reviewing my research and design process, there were still several obstacles and dilemmas. The biggest challenge is whether the project can be operated or not in reality. I did interview with people from Delfzijl. For them, it is possible and doable to restructure landscape and regenerate industry. But it may be harmful to some other stakeholders, especially farmers. But since there are already a lot of innovation policies, ecological potentialities, as well as some pilot projects, this dilemma is easy to deal with currently or in the future.
7.1 reflection and evaluation
cost

This chapter aims at evaluating cost-benefits of the project. For the cost part, there will be calculation about change of land use and its costs. For the benefits part, there will be analysis of ecosystem services before and after project.

<table>
<thead>
<tr>
<th>FUNCTIONAL ZONE</th>
<th>AREA(KM2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>agriculture</td>
<td>46.74</td>
</tr>
<tr>
<td>grassland</td>
<td>25.78</td>
</tr>
<tr>
<td>woodland</td>
<td>1.61</td>
</tr>
</tbody>
</table>

Groningen province:
3095 mln euro in total
agriculture (20% in site) - 143 mln euro
industry - 772 mln euro

wood plantations (willow)
harvest 2-4 / years
yield: 10 tons / ha / years
market value: € 20 - 25/ton
investment in plantation: € 4000/ ha
pay-back period: 10 years

typical construction costs range from approximately €62500 - 130000 / ha

data resource: CBS, Netherlands Enterprise Agency, BMP, constructed wetland, BF environmental, etc.
<table>
<thead>
<tr>
<th>FUNCTIONAL ZONE AREA</th>
<th>AREA</th>
</tr>
</thead>
<tbody>
<tr>
<td>agriculture</td>
<td>20.77</td>
</tr>
<tr>
<td>energy crops</td>
<td>9.62</td>
</tr>
<tr>
<td>grassland for refining</td>
<td>16.71</td>
</tr>
<tr>
<td>woodland</td>
<td>15.81</td>
</tr>
<tr>
<td>bio-based industry</td>
<td>7.87</td>
</tr>
<tr>
<td>wetland</td>
<td>12.94</td>
</tr>
</tbody>
</table>

For replacing formal agriculture land as other types of lands (lose in agriculture benefits):

- subsidy

- 15 mln euro for planting forest
- 6 mln euro for constructing wetland
7.1 reflection and evaluation

benefits

provisioning

existing replacing benefits

regulating

low high

food

fresh water

climate regulation

water regulation

tourism

water purification

ergy (gas)

waste treatment

filtration areas

carbon

materials

water quality

industry park

rural area (villages, wetland)
Nowadays, because of economic restructuring, demographic change, urbanization and political transformations (ShrinkSmart, 2012; Wiechmann, 2008), Cities in Europe can no longer expect growth (Urbact II 2013; McKinsey, 2016). This means shrinkage becomes an essential problem for European country. The shrinkage is because of migration. For the Wadden Sea Region, migration phenomenon, especially shrinkage, is obvious. Besides, the Wadden Sea Region is world heritage zone, which means there will be a lot of regulations and targets related to nature preservation goals. It is important to combine nature preservation with socio-economic development. In addition, the WSF has focused on achieving a sustainable society by 2030 in which economic activity supports social development and safeguards healthy ecosystems and cultural historic landscapes throughout the Wadden Sea Region (WSF, 2010). Currently, many of studies focus mainly on the management of the ecological system in the Wadden Sea (Kabat et al. 2012). Much less attention is paid to the combination of nature targets and socio-economic development (Dijk, Broersma, Mehnen, 2015). With the studies on ecology, landscape infrastructure and adaptive design that are often used for explaining nature environment and sustainable development, this thesis can contribute to the field by providing a clear approach towards sustainable and resilient urban environment and by developing a concrete design for green infrastructure.
For this site, it is essential to consider what kinds of function the land should be. Be a complete nature reservation area or a prosperous coastal area? From the Wadden Sea point of view, this area is world heritage zone. It is famous for its rich flora and fauna, especially the Ems estuary, and it is also a rich habitat for gulls and terns. While on the other hand, most coastal areas in the world attract many people and are always centers of population. Now the current situation is that the balance has been turned aside and this will continue for an uncertain period. It is good for people to have such a gorgeous nature reservation area, but it is unfair for other big cities and local land value since people will always move to bigger cities and the land they leave behind will have no use. This is not sustainable for both ecological and socio-economic point of view. As Michael Dukakis (1978) said, “towns don’t want to be suburbs, suburbs don’t want to be cities, and cities don’t want to be wastelands.” Each towns and villages have its value within bigger urban structure, and the shrinkage will lead to social isolation, less effective social infrastructure for the villages and over-high living pressure for the big cities.

The main idea for this project is to build up a new vision for Eemsmond-Delfzijl Structure and Delfzijl city. Upon this new vision, there will be healthier ecological and socio-economic environment for local residents. Such structure and urban system will then help to reinforce the ‘shrinking’ Groningen province.
8.1 Literature and its Structure

1. What are the impacts of climate change and socio-economic shifts on Groningen region and Delfzijl?

2. What socio-economic and ecological elements can be used as part of potential synergies within Eemsmond-Delfzijl structure?

3. How to transform carbon-based industry?

4. What would be the new function of Delfzijl and the principles for new need, like innovation?

5. How to implement nature-based solution and landscape infrastructure theory to localize and enhance functional synergies?

6. How to add new green systems in an industry-based port city? And how to transform carbon-based industry into green economy to validate possible ecosystem services?

7. What biophysical and functional identity need to be adapted to guide the transition process?

8. To what extent the biophysical adaptation of the North-West area on Groningen region can meet the local functional regeneration of Eemsmund-Delfzijl structure and Delfzijl city?

Mitigation - Adaptation
(Mitigation and adaptation in polycentric systems: sources of power in the pursuit of collective goals, W. Neil Adger, etc. 2017)

Polycentric region
(Form follows function? Linking morphological and functional polycentricity, Martin Burger, Evert Meijers, 2011)

Post industrial landscape
(Part cityscape: a networked analysis of the built environment, Carola Hein, 2011)

Nature based solution
(Nature based solutions to climate change mitigation and adaptation in urban areas, Nadja Kabisch, Jutta Stadler, Horst Karr, Alekta Bann, 2016)
(Nature based solutions & Re-nature cities, European commission)

Landscape infrastructure
(Landscape infrastructure: urbanism beyond engineering, Belanger 2013)

Ecosystem services
(Ecosystems and human well-being: Wetlands and water)

Water sensitive urban design
8.1 Literature and its Structure

Each theories and researches support a set of analysis, design and evaluation process. Also, they will be used to answer Sub-research questions and finally guild and validate the main research question. The literature and general practical preference focus on the following areas:

1. Understanding the context of the Wadden Sea Region, as well as Delfzijl and surrounding environment

Lee, C. Mapping the Marine Clay Landscapes of the Wadden Sea Coast.
Lee, C. Mapping the Marine Clay Landscapes of the Wadden Sea Coast.

2. Understanding ecological and socio-economic issues due to climate change and socio-economic transition

3. Understanding theories about landscape infrastructure and adaptive design

purpose governance: a framework to make adaptive governance operational. Environmental Science & Policy, 22, 73-84.

Others (reports and projects):

Ecology of salt marshes, Jan P. Bakker
Scene, een kwartet ruimtelijke scenario’s voor Nederland, NAi Uitgevers (2003)
National water plan 2016-2021
Water management in the Netherlands, Rijkwaterstraat.
Port cityscapes: a networked analysis of the built environment, Carola Hein, 2011
River basin management plans, 2009
The effects of climate change in the Netherlands: 2012, PBL
Towards an EU Research and Innovation policy agenda for Nature-Based Solutions & Re-Naturing Cities, 2015
KNMI’14 climate scenarios for the Netherlands
Toward sustainable and resilient region

Review on ecological and adaptive design

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December 2017

Abstract – According to the UN, by 2050, 66 percent of the world’s population is projected to be urban (UN, 2014). The enormous growth of urban population is always based on migration. This trend will make rural area like villages less and less dynamic. At the same time, with a concentrated urban population, nearly everything people do in urban areas has ecological implications (T. T. Forman, 2014), which means the land that people leave behind will face ecological and environmental effects. It is now more urgent than ever to deal with such problem related to sustainable development. The Wadden Sea Region is an interesting study case in order to understand environmental coordination and sustainable development between nature and built environment. There is a rich literature on the management of the Wadden Sea (Kabat et al. 2012), much less attention is paid to more integrated forms of coastal zone management targeted to a balanced economic development that provides future prospects for people living and working there (van Dijk, Broersma, Mehnern, 2015). This is one of the motivations for this paper. Besides, the aim of this paper is to comprehend these processes and phenomenon that are occurring in urban and rural environment. The theories and methods from urban ecology and adaptive design, coped with landscape infrastructure provide an interesting and useful framework through which nature and built environment can develop in a sustainable and resilient way. In addition, the implications of this framework can also affect land value, living quality, environmental carrying capacity and so on. All of these effects will relate to people, planet and profit.

Key words – ecosystem, landscape infrastructure, adaptive design, resilience
1. Introduction

Social-demographic challenge, ecological degradation and climate change are several of the contemporary challenges of our society (Nijhuis, Jausslin, 2015). These three elements can result in socio-economic changes, and with that, they will then affect sustainability in both urban area and nature that are two main components of urban region. In order to understand sustainability and interaction, namely resilience, within urban region, we should firstly learn something about human settlements and natural characteristics. After that, the priority of research will focus on transition zone, especially where they have most conflict points, and relationship between urban area and nature.

Recently, there have been a lot of works and researches about relation between urban area and nature, including the field of landscape urbanism (Waldheim, Mostafavi, Corner, Wall, Geuze, 1997), and landscape infrastructure (Belanger, 2013). These theories focus on dealing with the loosing connection between urban area and nature and help us to build up a more systematic and interdisciplinary structure for urban planning and design. Instead of paying close attention to urban and natural characteristics, this paper aims at researching urban ecology, landscape urbanism, landscape infrastructure and adaptive design theories that can be used to strengthen the relation. This body of knowledge deals with questions such as: What kinds of lands could be nature? What kinds of lands could be urban area? What is the solution to fasten the relation between nature and built environment, and how to implement and maintain design and planning in an adaptive and resilient way because of variation and uncertainty in the future?

In order to answer these questions, this paper will firstly analyze the relation between nature and built environment from urban ecology and landscape urbanism points of views. Under this lens, this paper will research landscape infrastructure and adaptive design theories in order to implement such solutions into the graduation project in the Wadden Sea Region.

2. Relation between nature and built environment

2.1 Urban ecology

The first work about urban ecology was done by Ian McHarg in his book Design with Nature. He planned to use geomorphological characteristics to analyze and assess the best land space for developing social occupation and maintaining nature (Reed, Lister, 2014). After that, a lot of works by Spirn (1984), Forman and Godron (1986), and Hough (1989) built on this theory (Davies, P., Corkery, L., Nipperess, D. 2017).

Among these researches, Richard T. T. Forman gave a new direction in urban ecology. He define urban ecology is the scientific study of the interactions of organisms, built structures, and the physical environment, where people are concentrated (Forman, 2014). In Forman’s definition, organisms refer to plants, animals and microbes in nature; Built structures are buildings, roads and occupations that people make; The physical environments refers to air, water and soil/earth. It is important to reveal the relation between nature and built environment before implementation. Besides, his work revealed how the geographical elements support the flows and movements of ecological matter (Reed, Lister, 2014). For example, Forman described ecosystems as matrices, webs and networks, and
characterized ecosystems by adjacencies, overlaps and juxtapositions (Forman, 2014).

Recent literature about urban ecology mainly research on the concepts of ecology 'in', 'of' the cities. 'Ecology in the city' is considered as early practice of the field of urban ecology. They focused on sites that were similar to other places (Pickett, 2012). The contrasting research is 'ecology of the city'. It regarded the entire urban area as a space that is relevant to ecological processes. In other words, the urban region is an ecological system (Pickett, 2012). Within this ecosystem, network of structures and interactions is the key elements of ecology of the city. Moreover, this ecosystem also incorporates humans as drivers to communicate with nonhuman species and other components (McPhearson et al., 2016).

Ecology of the city focuses on the green patches and other undervalued places within urban areas (Pickett, 2012). And actually theories of urban ecology are all related to how to plan and manage landscape for people and biodiversity. Landscape perspective enriches the continuous trans disciplinary evolution of urban ecology (Wu, 2013).

2.2 Landscape urbanism

The theory of landscape urbanism argues that the best way to plan and manage cities is through the design of landscape, rather than buildings within cities. As Corner, Allen, and others recalled, landscape is a medium through which cities can respond to transformation, evolution and adaptation. For example, Parc de la Villette by OMA shows landscape as the basic structure for an urban transformation process. Within this project, landscape plays as a medium for expressing a layered, flexible, and strategic urbanism (Waldheim, 2016).

With the context of social-demographic challenge, ecological degradation and climate change, creating multifunctional landscapes becomes main issues of landscape urbanism. Multifunctional landscapes play an important role in developing sustainable and resilient framework (Kato, Ahern, 2009). The purpose of these multifunctional landscapes is improving number of functions and the use of vertical space and time. Greenways, ecological networks, and ecological (green) infrastructure are examples of planning concepts and strategies that can be used to achieve that purpose (Kato, Ahern, 2009).

3. Landscape infrastructure

According to this short review about urban ecology and landscape urbanism, the ecological (green) infrastructure, namely landscape infrastructure, could be key ideas and design principles to achieve sustainability and adaptability. A multi-scale approach should be done to understand patterns, processes and their relationships within ecosystems. Besides, the main emphasis of landscape infrastructure is physical and functional connectivity such as the flow of energy, materials, species and people (Ahern, 2007).

3.1 Infrastructural urbanism

There is also an understanding of infrastructure by architects. Stan Allen considered architectures as material practice that has potential to guild and structure the nature and built environment for future cities. Infrastructure is a way to construct the site itself according to geographical conditions (Allen, 1999). At the same time, it gives pre conditions and directions for future
construction of buildings and cities. Besides, infrastructures manage the flows and movements in complex systems, and they decide the density and location of different habitat (Allen, 1999). In general, Infrastructural urbanism focuses on not only architecture and spaces, but also structure of territories, namely technical infrastructure (Allen, 1999). The understanding of infrastructures raised a lot of later theory related to landscape infrastructure.

3.2 Green infrastructure

The landscape infrastructure makes sure the supply of ecosystem services in regions (Ahern, 2014). These ecosystem services, combined with benefits from landscape infrastructure, are the foundation of sustainable cities. As previously said, multifunctional landscapes concept is the key for landscape infrastructure (Kato, Ahern, 2009). This requires not only multi-functionality, but also that landscape can function at multiple scales. Plan for multiple uses can be accomplished by intertwining and combining function, as well as vertical integration (Ahern, 2007).

Specifically, there are five basic principles developed by J. Ahern. Firstly, a spatial concept is needed for imagining and understanding by the public. This can also support the planning processes. Besides, a strategic thinking, including protective, defensive, offensive or opportunistic strategies (Ahern, 1995), should be in the whole process of designing green infrastructure. The third principle is the greening of infrastructure. In this principle, infrastructure must be understood as possible means to improve and contribute to sustainability by building with nature (Ahern, 2007). In addition to that, multiple uses is considered as a key strategy for planning, as well as cost effectiveness (Ahern, 2007). The last strategy is ‘learn by doing’, which is referred to adaptive approach. That will be review later.

Furthermore, landscape infrastructure in urban regions could be considered as a way of securing ecosystem functions because of multi-functionality. Not all areas are really suitable for multiple land uses (Kato, Ahern, 2009). The conflict problems of multifunctional landscape infrastructure are competing for space, time and resources. Based on whether or not the space is limited and on the conflict with nature, different strategies such as temporal uses, vertical uses, limited access could be used to solve such problems (Kato, Ahern, 2009). This can contribute to a more sustainable landscape infrastructure.

3.3 Flowscape

Recently, the space of flows is introduced as a promotion for the concept of landscape infrastructure (Nijhuis, Jauslin, 2015). According to a lot of examples about territorial planning, water and transport infrastructures have huge effects on economic and spatial development of urban landscape. So designing and planning infrastructure as landscape has potential for additional social, economic and environmental benefits (Bacchin et al. 2014). Besides, the space of flows gives forces to urban transformation processes and explores the relation between structure and processes (Nijhuis, Jauslin, 2015).

There are at least three potential fields for landscape infrastructure design (Nijhuis, Jauslin, 2015). The first one is transport infrastructures that contain transportation,
waste treatment, as well as energy and food supply. It is fundamental infrastructures for urban development. Transport infrastructures provide conditions and a new type of public space that is essential for urban landscape (Nijhuis, Jauslin, 2015). According to that context, the design focuses on multifunctional nodes and surrounding environment. The second potential field is urban green landscape infrastructures. Green spaces provide ecosystem services, as well as social, economic and aesthetic benefits for urban environment. Green spaces include patches, corridors and matrices (Forman, 2014). And design programs focus on metropolitan park structures, agricultural landscape, urban ecology and heritage landscape (Nijhuis, Jauslin, 2015). The last one is water infrastructures. It is related to water management like coastal and river management. Besides, design of water landscape infrastructures also includes multifunctional flood defense systems, fresh water storage, wastewater treatment and so on (Nijhuis, Jauslin, 2015). According to these three potential fields, landscape infrastructure design provides a more comprehensive structure for regional development. Also, the design draws up possible connections and synergies between nature and built environment.

4. Adaptive design

Emerging from trends of urban and ecological issues, landscape infrastructure provides an operative system for regions to achieve future transformation processes (Bacchin et al. 2014). Infrastructures are flexible and in change. They work with multi-scale and through time. In other words, they are processes to the future. In terms of that, landscape infrastructure should respond to future uncertainties. It is a way of learning by doing (Ahern, 2007). The adaptive design methods and theories are considered as a future step for landscape infrastructure since the technological and theoretical knowledge to plan and design landscape infrastructure systems in evolving. These adaptive design methods and theories are inevitable support for landscape infrastructure (Ahern et al. 2014).

4.1 Adaptive governance

In order to implement adaptive design, there is a need to understand complexity and uncertainties in governance or management of systems. In general, it is because of ambiguous purposes of governance, unclear governance context and uncertain governance outcomes (Rijke et al. 2012). For landscape infrastructure, it is essential to coordinate different stakeholders since they may have different goals about spatial quality. Second, the social and physical context of ecosystems are changing, the effectiveness of landscape infrastructure is based on clear understanding of context and purpose (Rijke et al. 2012). To address the challenges for adaptive governance, Rijke et al. proposed a fit-for-purpose measure. It contains three critical steps. Firstly identifying the purpose of governance, and then mapping the context. Finally evaluating the outcome of governance mechanisms (Rijke et al. 2012). These three steps could become a preparation towards adaptive design.

4.2 Dynamic adaptive policy pathways

There are two existing adaptive planning methods, namely adaptive policymaking and adaptation pathways (Haasnoot et al. 2013). The former provides an approach for basic plan and adapting the basic plan to new information and knowledge in the future. By
setting the basic plan, increasing the basic plan and setting up monitoring system for basic plan, this adaptive policymaking approach works. When there is a trigger event, the monitoring system will react to preparing the responses for that (Haasnoot et al. 2013). The adaptation pathways provide a sequence of actions through time. It firstly analyzes current and future situations, as well as objectives. Based on that, it determines actions. When the actions no longer meet the objectives, namely the tipping points, there will be additional actions. In this way, adaptive pathways occur (Haasnoot et al. 2013).

According to these two adaptive planning approaches, Haasnoot et al. developed a dynamic adaptive policy pathways approach, which is a combination of former two adaptive approaches, to cope with deep uncertainty. This approach uses the strengths from former two approaches. It begins with analysis of study area, including a prediction of the major uncertainties that will affect decision-making. The uncertainties come from both future and current trends. Then it will analyze the problem, put forward possible actions and evaluate the actions. The difference is this approach will develop a manageable number of possible pathways. After that, it will define actions to keep each of the pathways on track in order to achieve the main objectives. Based on the whole process, a final dynamic adaptive plan will respond to the targets. Besides, the monitoring system is also working within this approach (Haasnoot et al. 2013).

4.3 Resilience

The main propose of adaptive design is to make ecosystems resilient. C. S. Holling (1973) introduced the concept of resilience (Marcus, Colding, 2014). It is a reaction to natural interference by ecosystems. Firstly, the ecosystems can bear a series of changes and remain the former structure and function. Besides, the ecosystems have a degree of self-organization and an ability to improve capacity for adaptation (Marcus, Colding, 2014). There is a loop among exploitation, conservation, release and reorganization (Holling, 1986). The processes in ecosystems all follow this circulatory system.

There are many similarities between ecosystems and urban systems, this means urban development also follow this adaptive cycle (Holling, 1986). In order to building resilient social-ecological systems, four attributes are made for explanation, including change, diversity, self-organization, and learning (Berkes et al. 2003). The change is both from inside and outside of urban system, like migration, energy flows, and so on. So cities should improve their abilities to connect their components and access to surrounding systems (Marcus, Colding, 2014). Diversity means differences in systems. Combined with change, it reveals the ability to spread risk and create adaptation in future processes. Self-organization is related to the capacity of responding to changes in a productive ways. It depends on how the spaces connect to each other and to what extent the components in spaces can be reallocated when facing changes (Marcus, Colding, 2014). Finally, learning is about the ability of developing and making up lost information after change, damage, or loss. To develop resilience in urban systems, research should be done about conceptual spatial forms in urban ecology and landscape to build resilience. Secondly, there should be methods to implement such conceptual spatial forms into urban systems. Finally, new systems that may challenge this methodology should be
explored in order to face future uncertainties. These new systems can provide a more scientifically foundations for old systems (Marcus, Colding, 2014).

5. Conclusion

According to theoretical review above, nature and urban environment must be considered as complex socio-ecological systems. Nature and built environment are interdependent. They are two essential components in an urban region. The urban region is the area of interactions between a city and its surroundings (Forman, 2008). For the Wadden Sea Region, the built environment shrinks and natural pieces expand. The result of this is that people have to deal with empty spaces that migrants leave behind, because all the urban spaces have ecological implications (Forman, 2014). If they do nothing the nature will still be degraded. Besides, nature and built environment will change, that is because of flows and movements across the land. Processes in urban areas are in effect flows, movements and transport through space (Forman, 1999; Ball, 2009). It is particularly important to analyze flows and movements across the land because they are affected by continuous human-dominated intervention. These human activities may have bad effects on flows and movements, thus both sides of flows and movements will be degraded.

Design within urban and natural area themselves are not enough when dealing with complex systems like region. The most essential thing is making the flows and movements efficient and resilient to achieve sustainable structure with a region, in other words, the works is developing new approaches to connect and shape the organization of nature and built environment for the future transformation of the whole urban regions (Bacchin, 2014). This is also what landscape infrastructure does. Besides, the value for land uses along infrastructure is not single, on the contrary, it should be multiply in order to achieve multi functionality in multi-scale.

On one hand, because of uncertainties from both nature and built environment, designing landscape infrastructure should consider adaptive design and planning. Besides, infrastructures themselves always work with time and are changeable according to different purpose in different context. On the other hand, infrastructures create connections that exist between urban and natural processes. These processes can contribute to ecosystem function. On the contrary, biophysical components within ecosystems will have benefits to nature and built environment (Pickett et al., 2014). Such cycles will also improve sustainability. In general, Combine such multifunctional systems with responding to change and risk in complex region, namely the combination of landscape infrastructure and adaptive design, will achieve the goal of sustainable and resilient region.

Bibliography


Toward sustainable and resilient region

Wentong Wang


