Odsherred Insights

An introduction to Odsherred

1st Edition

31 July – 8 August 2021

GHENT UNIVERSITY

DEPARTMENT OF GEOGRAPHY

UNIVERSITY OF COPENHAGEN

Introduction

Every year, students in the Master of Science in Geography and Geomatics of Ghent University (Belgium) undertake a research trip abroad. Since 2021, the destination of this project work has been Odsherred, Denmark, in collaboration with the University of Copenhagen. This first edition took place from the 31st of July to the 8th of August 2021 in Udsigten.

Apart from excursions in Odsherred and the surrounding areas, the research trip has included an intensive geographic fieldwork project where students actively investigate the local spatial dynamics in the more rural area of Odsherred. The overall aim of this project work is to enhance students' scientific and intellectual competencies in geography through critical literature reviews, research design, fieldwork (e.g., surveys and interviews with locals), data collection, scientific analysis, and oral and written presentations. The topics investigated are all self-defined research projects, applying skills from other courses in a context abroad. The project work emphasises an interdisciplinary approach, covering different aspects (physical geography, landscape research, social and economic geography, as well as geomatics).

The students were assisted by teachers and researchers from Ghent University and the University of Copenhagen as well as people from Geopark Odsherred, the Municipality of Odsherred, and local organisations and inhabitants. Below you can find an overview of the different research projects that were undertaken.

1. Coastal dynamics

- Matthias Barbier, Robin Bekaert, Rien Boydens, Gwendolyna Minnaert, Steve van Bastelaere, and Jana Verdoodt –

Refining coastal typology and erosion risk assessment for Kattegat and Sejerø Bay: A detailed classification approach for improved Danish coastal management.

2. Coastal flood risk and perception

- Wander Demuynck, Seppe De Wit, Hannelore Fossaert, Céline Van Migerode, Maarten Verschaffelt, and Lukas Vincke –

Assessing the relation between coastal flood risk and risk perception in Sejerø Bay.

3. Nature development in agricultural landscapes

- Renée Balcaen, Lucas Demeyer, Lennard Derudder, Pieter Favoreel, Ziggy Sabbe, and Victor Soenens –

A landscape ecological approach to nature developments in Danish agricultural landscapes.

4. Municipal development in Odsherred

- Niels Gheyle, Gilles Poilvet, Lucas Van den Meersschaut, Wannes Van de Weghe, and Robbe Viville –

Towards a more thriving and enriched Odsherred: Potential developments aiming to shrink the socio-economic gap with other Danish municipalities and enrich the life of its citizens.

The 1st Edition of the Odsherred Insights was made possible by the collaboration of many people from several organisations.

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Stakeholders that were involved:

The Municipality of Odsherred
Geopark Odsherred
All interviewed locals
The local farmers' union

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Coastal dynamics

Matthias Barbier, Robin Bekaert, Rien Boydens, Gwendolyna Minnaert, Steve van Bastelaere en Jana Verdoodt

Odsherred Insights – 1st Edition
Denmark

GHENT UNIVERSITY
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1. INTRODUCTION

The coast is a very dynamic and complex system. The dynamic aspect of the coast results in very different parts of the coast. Those are not reflected well in the coastal typology map from the “Kystdirektoratet” (Danish Coastal Authority), which shows only two coastal types. Even viewing from satellite imagery shows different coastal types. In that way, this paper tries to refine the number of coastal types along the coast of Kattegat and of Sejerø Bay. This map can be additional to the policy and the coastal management. Nowadays there are many separate plans , but these are just for small zones and do not exist for the entire coastline. There will also be a focus on which attributes were used for this analysis and the dynamic processes that lead to this classification. These attributes are derived from a seascape character assessment that was made in the United Kingdom. The second part of this paper looks at how the defined coastal types compare with the “Kystatlas” (Danish Coastal Atlas). Here, a critical view on the current map and the new map will be discussed. In the last part of this paper, research will be done to identify the zones that are at risk for erosion and what the current protective measures are. This is done to get an overview of the protective measures that are in place as this is not well defined in the Danish Coastal Atlas.

2. THEORETICAL FRAMEWORK

The classification of the coast in a typology provides a description of the environment of the coast. A coastal type can be defined as an area that is relatively homogeneous in character. They are generic in nature in that they can occur in different locations, but wherever they occur, they share broadly similar combinations of geology, bathymetry, ecology, human influences, and perceptual and aesthetic properties (Natural England, 2012).

Seascape character types provide a good framework for analyzing seascape change since many influences and pressures affect seascape with similar character in similar ways. Analysis of seascape character types can provide a foundation upon which to develop coastal or marine planning or management strategies (Natural England, 2012).

The work of Natural England (2012) organized the main attributes that contribute to a seascape character assessment in a ‘seascape wheel’, see figure 2. The wheel illustrates the different aspects, which combined, create a ‘seascape character’, under the three general themes of natural, cultural/social, and perceptual and aesthetic.

Furthermore, the beach of our study area is a wave dominated beach (Short, A. D., 2012). This means that the tidal activity is very limited. This gives a first look at how the coast behaves. According to this, there is an alternation between reflective beaches with pebbles and stones (and which are relatively steep) and intermediate beaches (sand and not steep). This is also used for the classification further on.

Figure 1 shows the methodology followed in this assessment in the form of a flow chart. This method will be further elucidated in the next paragraph.

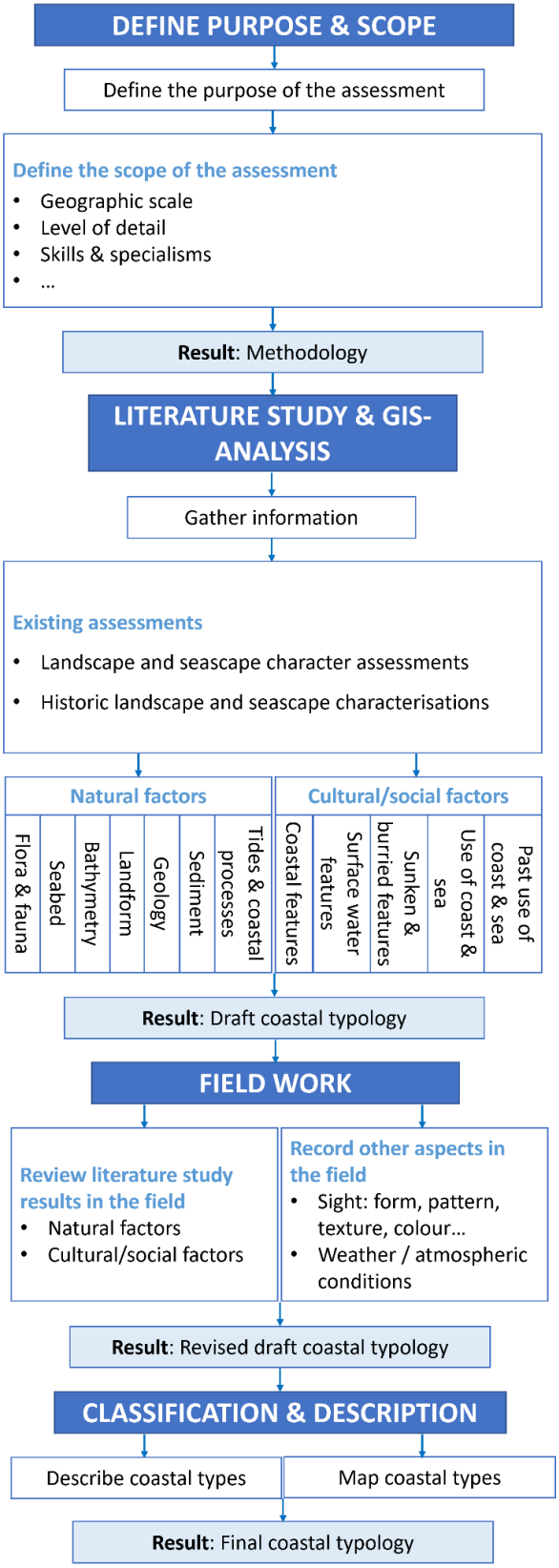

Figure 1 Flow diagram of the typology assessment methodology (Verdoodt, J., 2021 & adapted from Natural England, 2012).

3. METHODS AND SOURCES

The methodology used in this report to answer the research questions as fully as possible can be roughly divided into three parts. This first two parts took place before the field work in Odsherred and included the literature study and the GIS-analysis. The last part was the fieldwork.

3.1 Preparation

3.1.1 Literature

During the literature study it was investigated how a coast can be divided into types and which goals can be associated with this typology. These influence directly the scope of the typology and the sources that must be consulted. To get an idea of how to subdivide a coastal landscape into zones, the literature was consulted to find out which attributes are best taken into consideration. MMO (2018) already made a seascape character assessment for the Northeast Inshore and Offshore marine plan areas of the United Kingdom, using the attributes in figure 2. Inspiration was drawn from this seascape wheel when choosing the attributes that could be important in zoning the northern coast of Odsherred and Sejerø Bay.

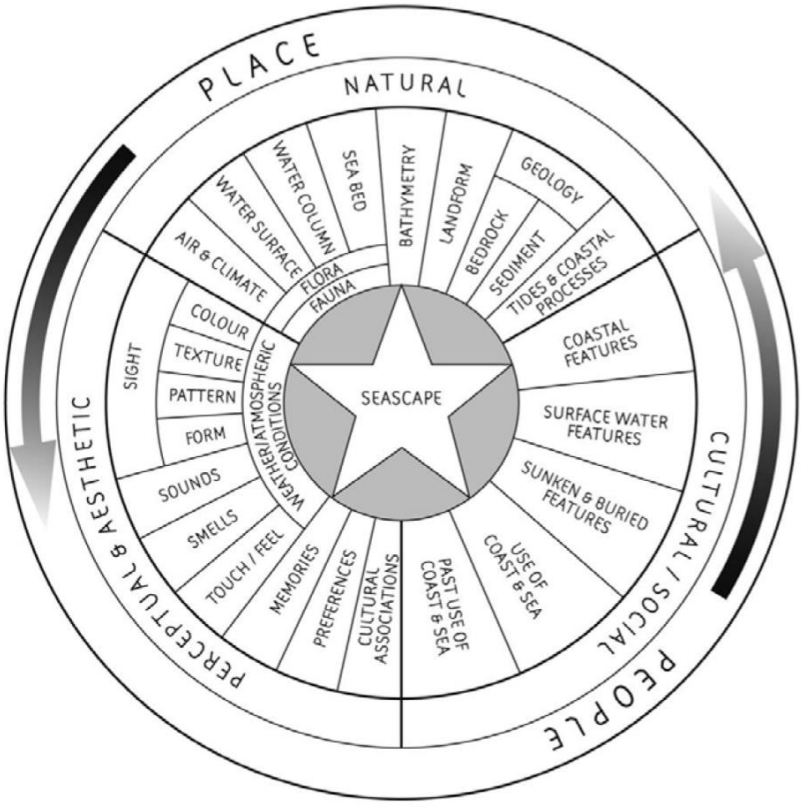

Figure 2 The seascape character wheel (Natural England, 2012).

‘Masterplan Kust en Erfgoed’ is a historic landscape and seascape characterization and describes the cultural history of the Dutch coastal area, including coastal safety or the use of the coast for the extraction of wind and tidal energy (Strootman, 2014). The report offers tools for plans and policy for each part of the coastal strip with a focus on preserving the coastal heritage. In combination with the report of Faragò *et al*. (2018) which analyses past and present coastal protection strategies in Denmark and makes a critical reflection on current practice and possible ways forward, a better picture could be formed of what coastal protection measures could be taken on the Northern coast of Odsherred and Sejerø Bay.

3.1.2 GIS-analysis

Several attributes were selected from the seascape character wheel (figure 2) and on that basis multiple data sources were collected for further analysis. Both textual and GIS data were used. Table 2 in the appendix shows the data sources per attribute together with a short description of the source.

The data sources that delivered shapefiles or TIFF files were further processed in QGIS (QGIS.org, 2021) to create a first classification of the coast based on similar patterns. This is mainly based on the texture of the beach and the topography. The other textual sources were used as additional support to compile a first draft typology of the northern coast of Odsherred and Sejerø Bay.

3.2 Fieldwork

In the field, three objectives were kept in mind. These were the development of a coastal typology, the mapping of chronic and acute erosion sites along the coastline and finally a comparison between our typology and the Danish Coastal Atlas.

3.2.1 Coastal typology

Before going on site, a first classification had already been made based on the theory. In the field, the intention was to check to what extent the zones were correctly classified. To do this, 26 sample locations along the coastline were visited to adjust or further refine the classifications made (figure 3). Some places turned out to be inaccessible because the road did not reach to the coast or the sample was located in a nature reserve. Aerial imagery was used to validate these locations (Styrelsen for Dataforsyning og Effektivisering, 2019).

Figure 3 Sample locations along the coast (own processing)

The method used to classify the final coastal types consisted of an attribute table with all attributes in the columns and the sample locations visited in the rows. At each sample location, each attribute was described in as much detail as possible based on our observations. Once the entire attribute table was completed, coastal types were assigned and named based on similar descriptions.

The combination of the earlier GIS analysis with the field attributes table resulted in a map containing the different observed coastal types. This map was created in the open-source program QGIS (QGIS.org, 2021). Other important elements such as sediment transport and the presence or absence of human impact, cliffs or beach ridges were also included on the map.

The merging of GIS data, fieldwork and aerial photos resulted in a clear picture of each coastal type. This was a perfect basis to describe each of these types in detail and to reinforce this description with the help of transects. These transects were first sketched on paper and then drawn using Microsoft PowerPoint and include the land use, topography, sediment texture and grain size.

3.2.2 Mapping chronic and acute erosion

Chronic erosion or long-term erosion occurs all year round. It takes place due to differences in sediment transports that occur parallel to the coast (longitudinal sediment transport) and in normal conditions (just wave erosion since there is no tidal activity (15-20 cm)). This is the erosion and development that will naturally occur for the coastal profile if no coastal protection is applied (Miljø- og Fødevareministeriet, 2016).

Acute erosion is the erosion that occurs in relatively rare instances, where there is both high tide and strong wave action. This can occur during a storm surge. Acute erosion occurs at intervals of several years, but when it takes place, a large part of the coastal area can be eroded. Acute erosion impacts coastal landowners the most (Miljø- og Fødevareministeriet, 2016).

Chronic erosion gives a better estimate of long-term erosion than acute erosion. In reality, erosion is a combination of both chronic and to a lesser extent, acute erosion (Miljø- og Fødevareministeriet, 2016).

The mapping of zones with a high probability of erosion was done by observations in the field and by mapping the already existing coastal defences. Existing erosion maps by the Danish Coastal Authority were also used. The acute erosion is mainly observed on site, where it was visible by the presence of cliffs. Since chronic erosion causes long-term erosion, this was difficult to detect in the field. Therefore, locations of pronounced chronic erosion are determined using GIS analysis. This is done by mapping groynes and breakwaters in the study area using satellite images and using existing erosion maps. Since groynes and breakwaters are largely constructed to combat chronic coastal erosion (Faragò *et al*., 2018), they indicate the locations where chronic erosion can play an important role.

The erosion maps used to indicate zones with a high vulnerability to erosion have been published by the Danish Coastal Authority and are part of the Danish Coastal Atlas. The erosion atlas shows the erosion that is expected to occur if no protective measures are taken for that stretch of coastline. Because coastal defences protect some parts of the coastline, there will be areas where the retreat of the coastal slope is actually less. However, the net erosion will stay the same (Miljø- og Fødevareministeriet, 2016). The erosion atlas contains layers that indicate both chronic and acute erosion.

3.2.3 Comparison with the Danish Coastal Atlas

In the Danish Coastal Atlas a wide range of information in relation to coasts and climate is available. The tool can show flood danger, erosion danger, coastal protection systems, systems in the maritime territory, orthophotos for a given location and so on. But more important for this assessment, the different Danish coastal types can also be consulted. We compared our typology to the Danish Coastal Atlas where the question was to what extent this work can be of an additional value. Therefore, the

place of occurrence of the pre-existing types was compared with our coastal typology and with our field observations along the coastline.

4. RESULTS

4.1 Field attributes table

Beforehand, 26 locations were selected based on the literature study. During the fieldwork, 25 locations were visited along the coast and one additional location from oblique aerial photographs. For each location, the observations were systematically determined and noted. This was done using an attribute table. The attribute table can be found in table 3. The attribute table consists of ten attributes that describe the coastal location. The following attributes were chosen to describe the coast in as much detail as possible: erosion or sedimentation, texture of the beach, zonation of particle sizes from sea to land, land use within 100 meters, human influence, the slope, the visibility land to the sea and vice-versa, the soil and the bathymetry. This resulted in the coastal type in the last column. Each attribute is briefly explained below.

4.1.1 Erosion / sedimentation

At each stop an observation was made whether erosion or sedimentation could be observed. The result of this can be found in table 3. An extensive analysis of the erosion that occurs along the coast can be found later in the report.

4.1.2 Texture of the beach

The texture of the beach is also taken into account when describing the different sample locations. The options ranged from (small to large) sand, gravel, pebbles, cobbles and boulders. Often a mixture of several textures was observed on the beach.

4.1.3 Zonation particle sizes (sea to land)

There was usually a certain order in particle sizes on the beach. This changed either from small particles into large ones or vice versa. Observations were always made starting from the sea to the land.

4.1.4 Land use within 100 meters

Land use was described up to 100 meters inland. Because the focus of the work was mainly on the coastal processes, this area has the greatest influence on the coastline. The most frequently observed land uses were dunes, summerhouses, agriculture and nature reserves.

4.1.5 Human influence

Human impact mainly includes summerhouses, but also some coastal defences can be seen to protect the houses or land behind them.

4.1.6 Slope

The slope was calculated using the digital terrain model from Denmark. This was also used to determine the coastal type and possible textures of the beach, as stated in the theoretical framework.

4.1.7 Visibility analysis

The visibility analysis consists of two different kinds of visibilities that were calculated. Namely to which extent sea is visible from one point on land and from how many places on land one can see a specific point at sea. For the first one, a grid of points spaced 2000 meters apart in the sea was generated and viewsheds were calculated for each point with the target height set to 1,75 meters, signifying the observer on the land. The parts on the land for all viewsheds were then summed together. For the second one, a grid of point spaced 500 meters apart on the land was generated and viewsheds were calculated for each point with the observer height set to 1,75 meters. The parts in the sea for all viewsheds were then summed together for all the viewsheds. The analysis was done using GDAL (GDAL/OGR contributors, 2021). These two maps were then used to help delineate the coastal zones. The result can be seen in figure 4.

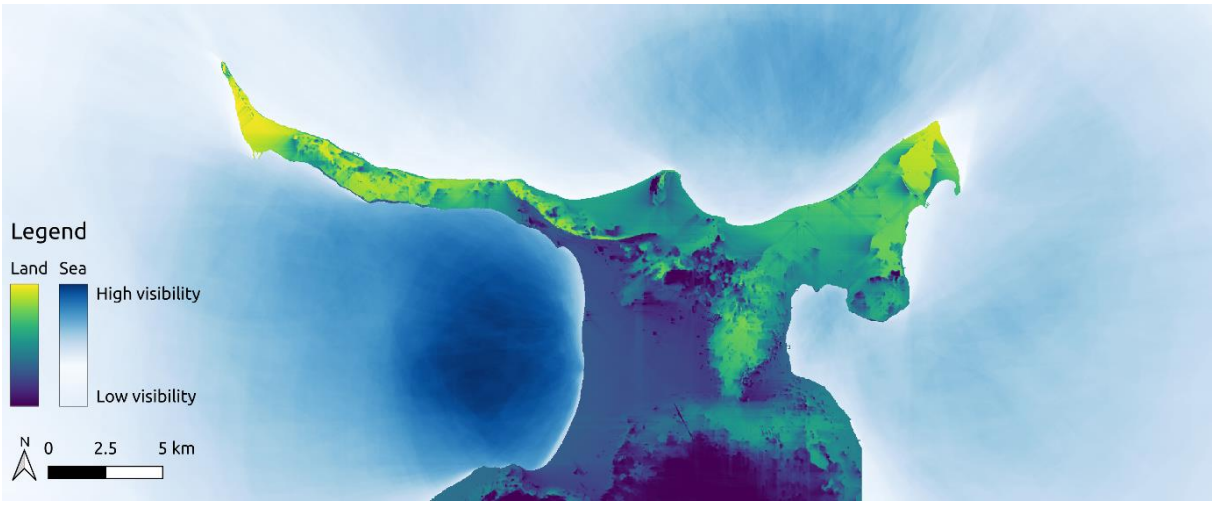

Figure 4 Visibility of Odsherred, Denmark (Boydens, R., 2021).

4.1.8 Soil

Starting from the geomorphology GIS layer (De Nationale Geologiske Undersøgelser for Danmark og Grønland, 2018), it was checked on site whether the indicated type corresponded to reality. Mainly the types from the geomorphological map were adopted, such as Marine or Aeolian plane. Additional observations in the field such as beach ridges or dunes were added.

4.1.9 Bathymetry

Bathymetry described how steep the seabed was at the sample location. This varied from very gradual to steep.

4.2 Coastal types

The locations with the same or very similar description in the attribute table were assigned to the same coastal type. By taking the similar coastal types together, six types were formed. Each with its typical characteristics, for instance beach ridges, human impact or even the presence of cliffs.

The six coastal types that came out of the attribute table are the transition zone, soft cliff sand and boulders, wavy pebbles and cobbles, plain sand, plain sand and cobbles and last cliff sand and pebbles. The names of the coastal types describe the view of the beaches. Meaning that one will be covered with sand and the other with pebbles, cobbles, boulders and so on. Below, sample points are linked with each other, which resulted in the different coastal types.

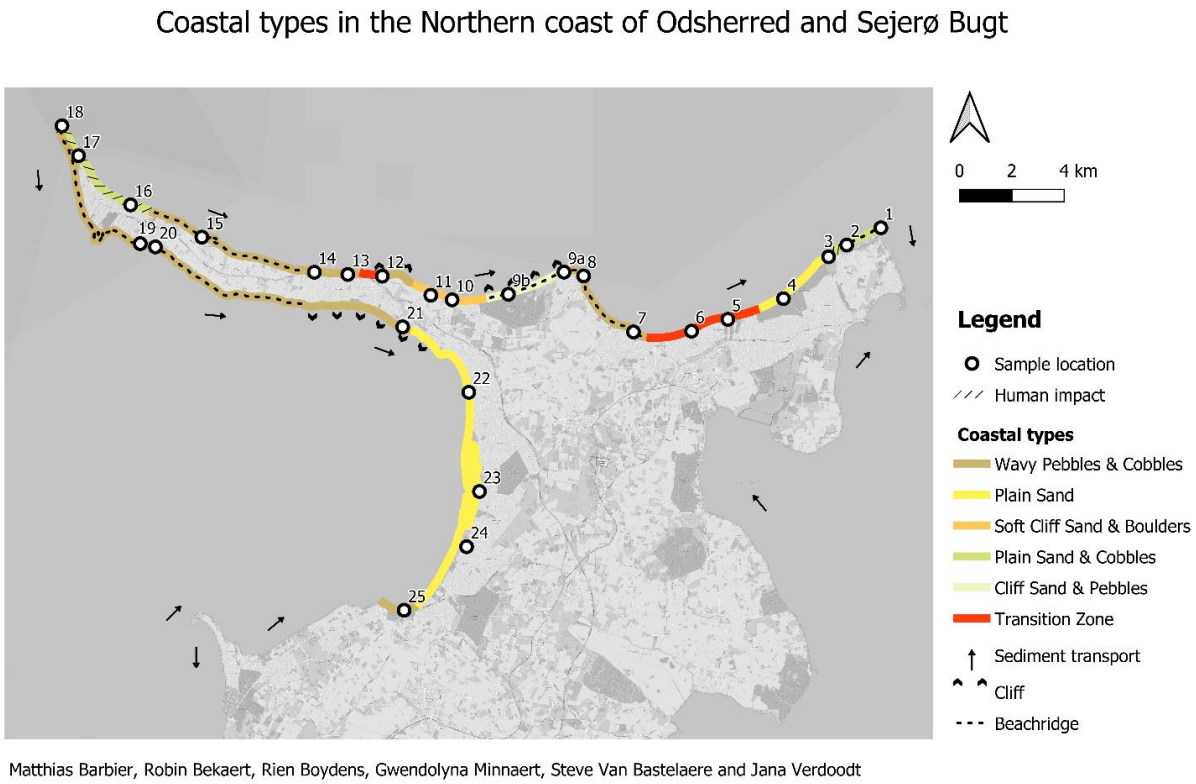

Figure 5 Coastal types with the observation points. The numbers on the map correspond to the sample places. The coastal types are thus clearly observable per sample point (own processing).

The first type that was striking from the observations are the cliffs. Observation points 9.a and 9.b are part of this near Klintebjerg, as can be seen on figure 5. The main feature of this beaches is the presence of cliffs. The visibility of the sea on land is low for both locations. The seabed is also rather steep. 9.a

is a good example of this coastal type where human influences (quarry) can be seen, while 9.b is an example of the coastal type without human influences.

The next coastal type is plain sand and cobbles. This includes observation points 1, 2, 16, 17 and partly 18, as can be seen on figure 5. On these points, there were very strong storm ridges present. 18 is only partly because this place has an abrupt transition of two types of coastal types. But 18 is still taken into this group because in this area the beach ridges predominate. Typically, this coastal type suffers from erosion. Yet during storms the cobbles are thrown on higher parts, forming some kind of terraces. The larger rocks are often found closest to the coast and the smaller ones further inland. Here the soil is mainly marine plane or beach ridge.

The third type was created on the basis of the abundance of sand on these beaches. These are the sample locations with number 3, 4, 22, 23 and 24, as can be seen on figure 5. Dunes will appear on these sample points and the beach itself is quite flat. This trend also continues offshore. The seabed has a very slight slope. This is recognizably by the waves that are breaking pretty early on the beach. Sample locations 4 and 22 are places where there are visible human influences such as coastal protection and summer houses. Sample locations 23 and 24 are examples of places where humans play no or almost no role, as a nature reserve is located here. This coastal type was named plain sand.

The fourth type is rather limited. There are boulders and sand here. The coastal strip is clearly impacted by humans, for example through agriculture or coastal defence. Cliff formation and storm ridges may be present, but not as pronounced as by the other groups. That is why this group has been given the name soft cliff sand and boulders. The sample points 10 and 11 corresponds to this group, as can be seen on figure 5. The view from land to sea is average here. When looking at the bathymetry, the seabed is very steep.

The fifth type is the most common group, namely the wavy pebbles and cobbles. This name was chosen because storm ridges also occur here, but much less pronounced than by the coastal type plain sand and cobbles. There is mainly a mixture of different large stones, sand, pebbles, cobbles and boulders. Here too, the wave action causes larger rocks to rise higher and the erosion causes smaller rocks and other sediments to erode. This is how the mixture is created here. The significance here is that these beaches are almost always used, or at least influenced by humans. Sample locations 7, 8, 12, 13, 14, 15, 19, 20 and 21 are points where human influence is present, through coastal defences, summerhouses, agriculture, harbour and so on. 25 is the only sample point that has no or almost no human influence, because there is a nature park here, as can be seen on figure 5.

As the last type, we took together all the places that showed a mixture of two coastal types. This includes points 5 and 6 as can be seen on figure 5. This coastal type differs enough from the neighbouring coastal types and are not enough to have a fully-fledged group of its own. Therefore, these different points were taken together. The name of this coastal type is transition zone. All transition zones between

coastal types are part of this. It is striking that the slope here is slight slope, the seabed is gradual with the visibility being fairly high. The texture on the beach is different between all observations.

4.2.1 Coastal type transects

Based on the coastal types, formed out of our findings from the attribute table, we made transect models for every coastal type. There are five main coastal types. For the sixth type, the transition zone, no transect model has been made. This is due to the complexity and difference between the many types of transition zones between the five major coastal types. The five main coastal types are further described by their transect.

The first coastal type is the cliff sand and pebbles. This coastal type is the easiest to recognize. There is a sharp transition from cliff to beach. The cliff is normally covered with grass and small plants. Trees can be found here and they are a bit further away from the coast. The beach texture typically consists of sand and towards the sea also pebbles. This description is made clear in the first transect (figure 6), where the pebbles are near the water and sand can be found between the cliff and the pebbles. This coastal type can be found west of Klintebjerg.

The second coastal type is the plain sand and cobbles. Here the cobbles form some kind of terraces, on which low vegetation, like sea cabbage, orchids and grasses grow. This coastal type can be found along the far west and far eastern parts of the northern coast of Odsherred (figure 7).

The third coastal type is the plain sand (figure 8). This coastal type can be found in bays where a lot of sedimentation takes place. The beach is mainly sand with inland vegetation being present. This mainly consists of grasses and other low vegetation. In the transect there is an example of human influence included. Here you can see that summerhouses can exist on the beach and that humans have undertaken protective measures by putting big boulders in front of the house so that incoming waves are broken. As a side note, the other coastal types can also be influenced by humans. To keep the transects simple, we chose to give one clear example.

The fourth coastal type is the soft cliff sand and boulders (figure 9). This coastal type can be found west of Klintebjerg. Typically you can observe big boulders with a diameter of 25 cm or more next to the vegetation. Next to the sea there is a narrow strip of sand. This kind of coastal type is one of the least common coastal types of the study area. The reason why boulders are found here is because of the deposits of large storms. The boulders are originated from Norway and Sweden and are relicts from the last ice age.

The last coastal type is the wavy pebbles and cobbles (figure 10). This coastal type is the most common coastal type and occurs mainly in the western part of the study area and an area east of Klintebjerg. The beach here typically consists of a mixture of pebbles and cobbles.

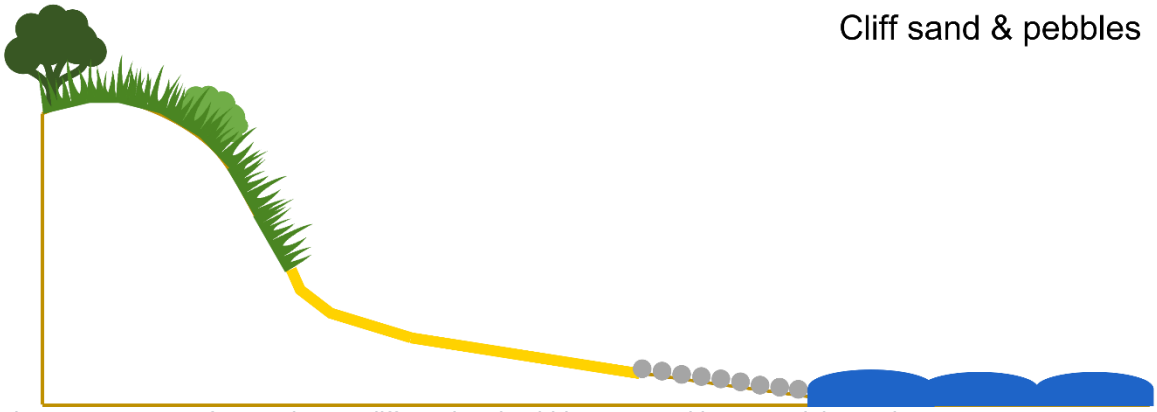

Figure 6 Transect of coastal type: cliff sand and pebbles. Created by Gwendolyna Minnaert, 2021.

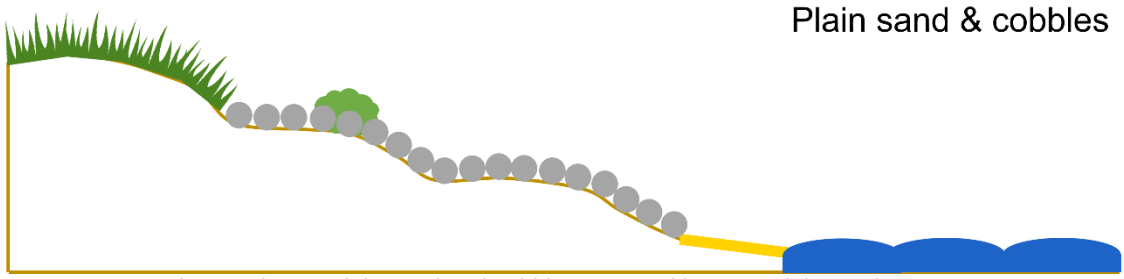

Figure 7 Transect of coastal type: plain sand and cobbles. Created by Gwendolyna Minnaert, 2021.

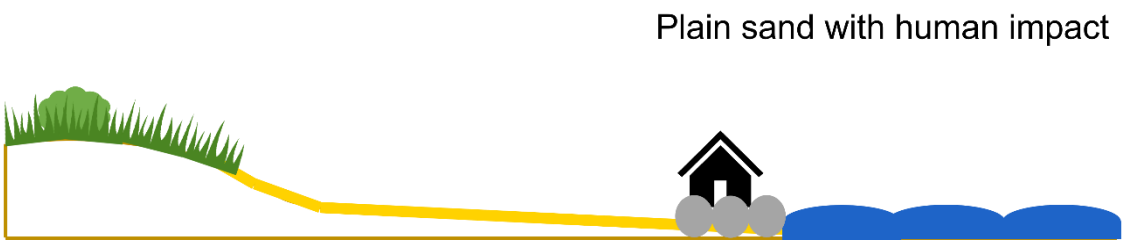

Figure 8 Transect of coastal type: plain sand. This version is one with human impact to illustrate that the coastal types can also be influenced by humans. Created by Gwendolyna Minnaert, 2021.

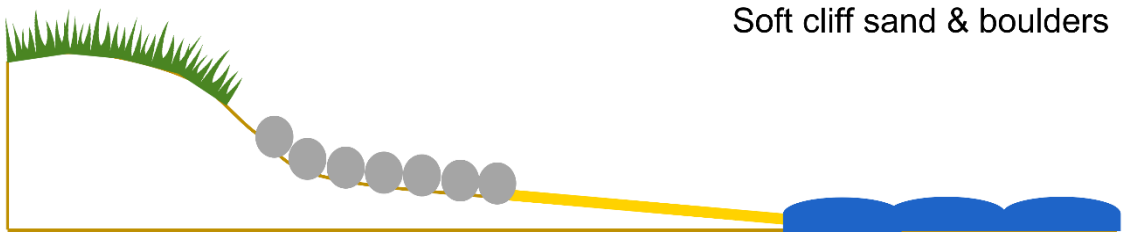

Figure 9 Transect of coastal type: soft cliff sand and boulders. Created by Gwendolyna Minnaert, 2021.

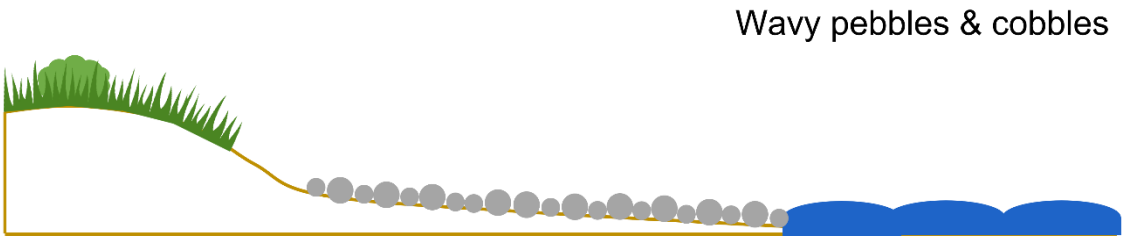

Figure 10 Transect of coastal type: wavy pebbles and cobbles. Created by Gwendolyna Minnaert, 2021.

4.3 Comparison with the Danish Coastal Atlas

Compared with limited typology of the Danish Coastal Atlas by the Coastal Directorate of Denmark, our typology does share some similarities. First, the type of “Soft cliff coast” in the Coastal Atlas is nearly identical to “Wavy pebbles and cobbles with beach ridges” in our typology. The main difference is that the coastal type “Wavy pebbles and cobbles” has more areas than the “Soft cliff coast”. The Coastal Atlas probably sees the beach ridges as soft cliffs.

The main flaw in the Danish Coastal Atlas is that the beach is too broadly classified as “Sand or dune coast”, even though most of those areas have more than sand or dune. The only regions that have sand or dunes are the regions the deepest in a bay, like the Sejerø Bay or the bay at Rørvig Beach. The western side of a peak like Klint or Korshage does still have sand or dunes, but also have way more pebbles and cobbles, to be considered just as sand or dune beaches. The area around Sonnerup has also more boulders and cliffs with pebbles to be fully sandy.

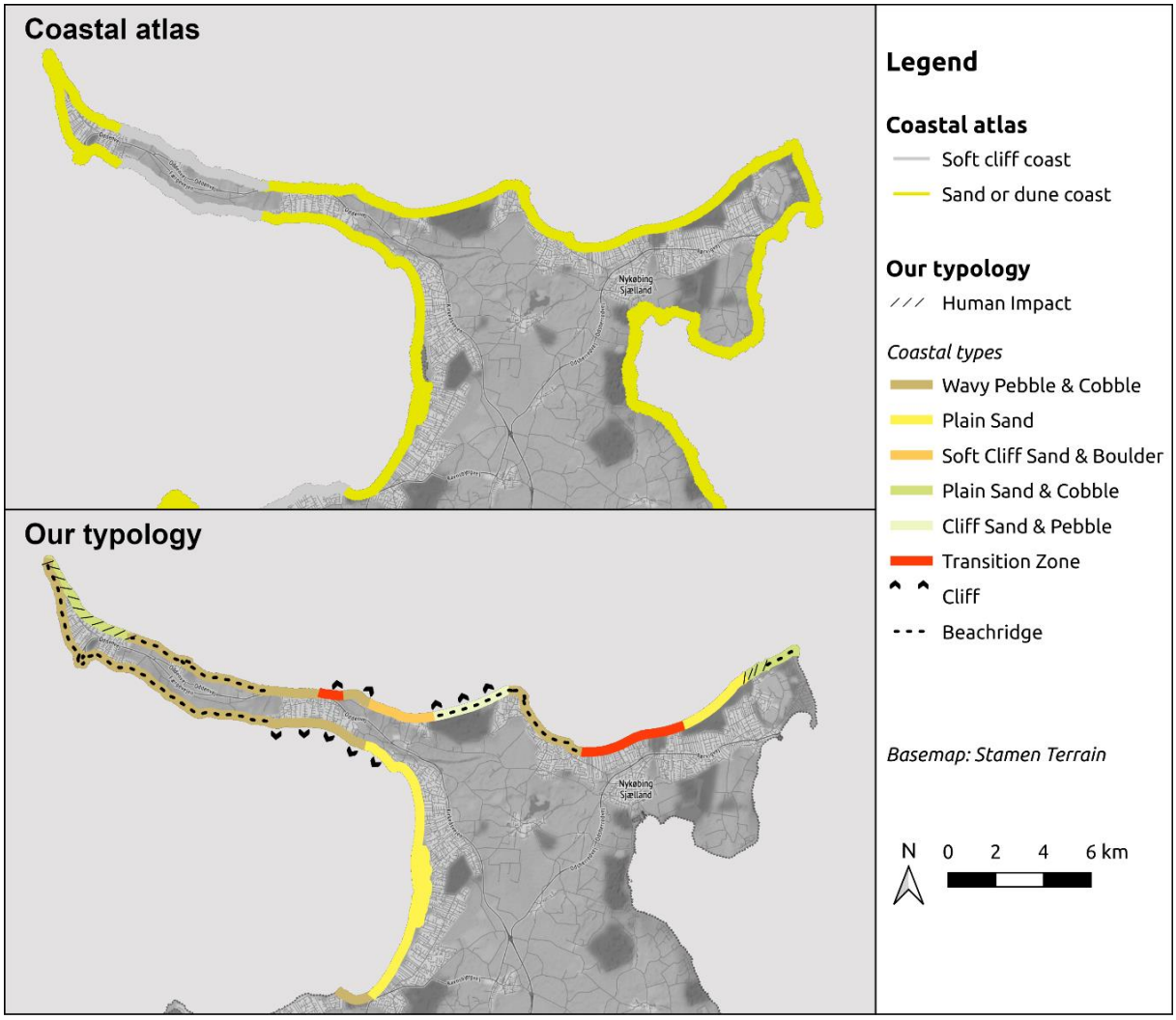

Figure 11 Comparison between the typology of the Danish Coastal Atlas and our typology (own processing, 2021)

However, the Danish Coastal Atlas did have a different goal in mind for their typology, which was much more limited compared to the aims of this study. We are also interested in the morphology of the beach like beach ridges or cliffs and the sorting of the material since that tells something more about the processes that occurred here and the human impact in the region. Our typology is thus a sort of finetuning improvement of the Danish Coastal Atlas.

4.4 Erosion

The majority of the Danish coastline is strongly affected by coastal erosion and is retreating due to erosion (Faragò *et al*., 2018; British Geological Survey, 2012). Coastal erosion is a major problem in Denmark, especially on the northwest coast of Jutland (outside the study area) and the north coast of Zealand (Miljø- og Fødevareministeriet, 2016).

The zones in the study area that are vulnerable to erosion were identified on the basis of field observations, the present coastal defences and the erosion atlas.

The present groynes and breakwaters were mapped with the use of satellite images. The result can be seen figure 21. The chronic erosion atlas is shown in figure 12. In the study area, the chronic erosion is subdivided into five categories.

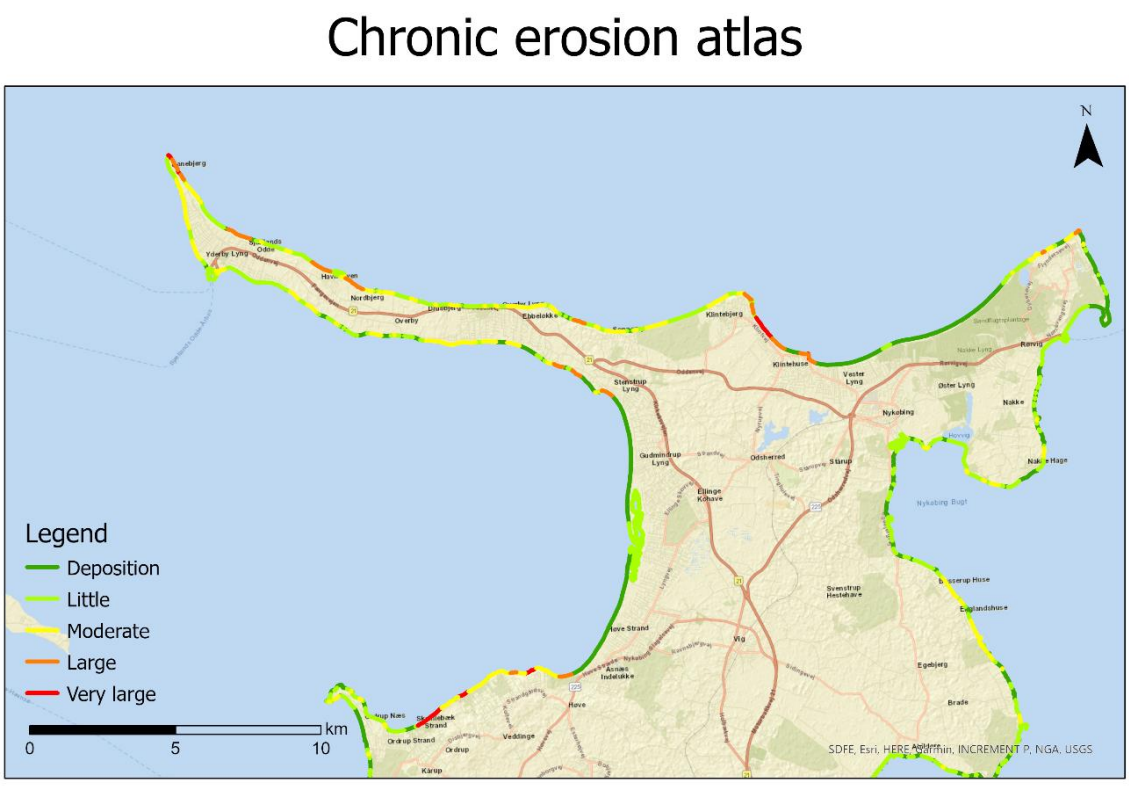

Figure 12: Chronic erosion atlas(own processing; Danish Coastal Atlas from Danish Coastal Authority, 2021)

Table 1 shows the mean annual regression for the five categories. According to the chronic erosion atlas, chronic erosion occurs most strongly on the southwest oriented coast of Sjaellands Odde, in particular on the coast of Gniben, and on the northwest oriented coast between Klint and Klintehuse. In addition, according to the atlas, strong chronic erosion also occurs on the north-facing coast of Sejerø bay.

Table 11 Categories of chronic erosion and associated annual erosion of the coast (in meters) (Miljø- og Fødevareministeriet, 2016).

Category	Annual erosion (in meters)
Deposition	0
Little	0,05
Moderate	0,30
Large	0,75
Very large	1

The acute erosion atlas is shown in figure 13. In our study area, the acute erosion is divided into two categories. According to the acute erosion atlas, there is a high probability that acute erosion takes place along the entire northern coast, but also in a large part of the Sejerø bay. Figure 14 shows an example of acute erosion on site.

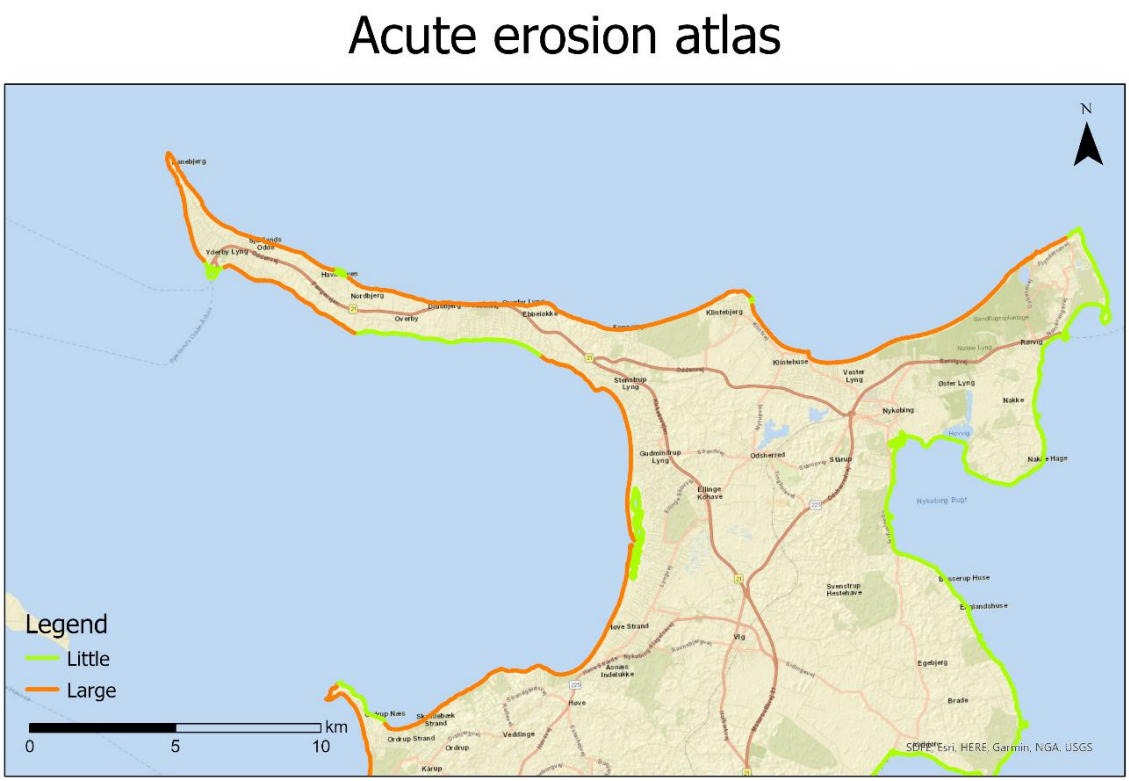

Figure 13: Acute erosion atlas (own processing; Danish Coastal Atlas from Danish Coastal Authority, 2021)

Figure 14 Acute erosion at Sonnerup Beach (Van den Driessche, J., 2021)

Based on terrain observations, the present coastal defences (groynes and breakwaters) and the erosion atlas, a map was obtained with zones that indicate a high vulnerability to chronic and acute erosion, see figure 15.

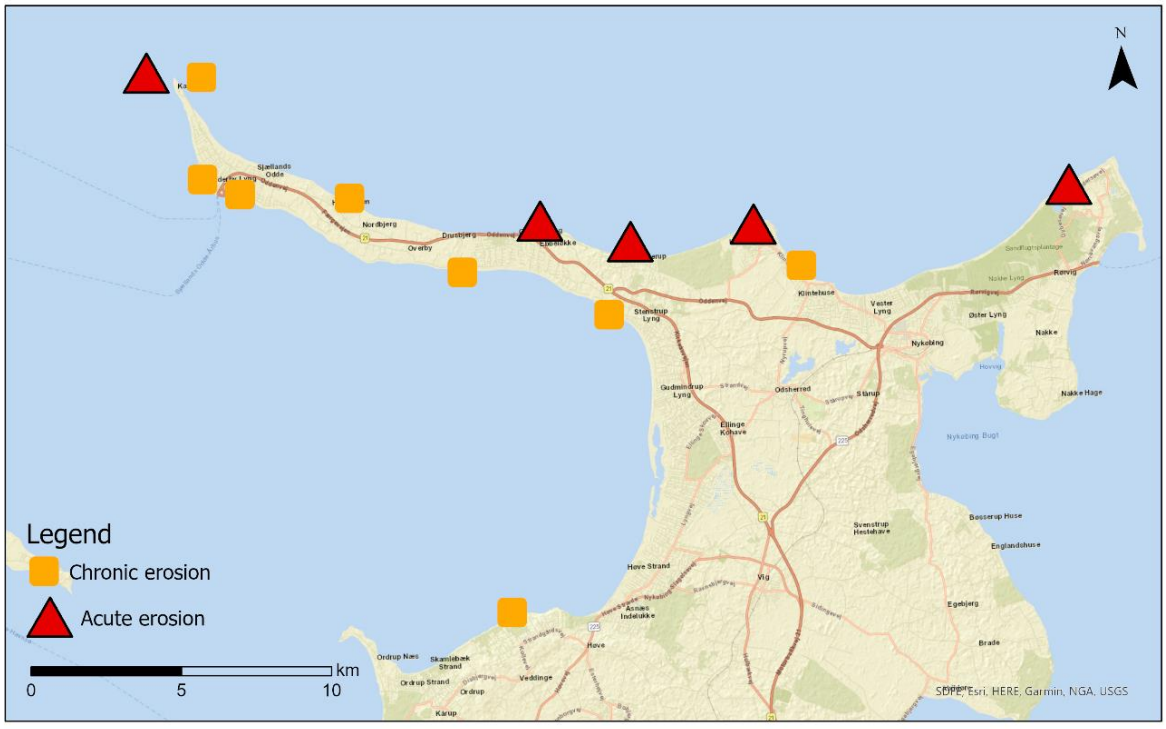

Figure 15: Locations with high erosion vulnerability (own processing, 2021)

According to figure 15, places with a high vulnerability to both acute and chronic erosion are located along the north coast. Along the north coast of Zealand, up to one meter of erosion takes place annually (Miljø- og Fødevareministeriet, 2016). On the south and north-facing coast of Sejerø bay, there are mainly locations with a high vulnerability to chronic erosion.

The sediment flows on both the north coast and in the Sejerø bay mainly move from west to east (Danish Coastal Atlas from Danish Coastal Authority, 2021). This means that eroded material will mainly move eastward. This ensures that on the west-facing coast of Sejerø bay and on the north coast from Vester Lyng to Nakke lyng mainly sedimentation takes place.

4.4.1 Erosion in the future

Climate change is already making a significant difference in the coastal erosion (Miljø- og Fødevareministeriet, 2016) and when looking at future predictions, climate change is also expected to cause the erosion potential to increase.

Sea level rise is believed to be constant across the country, but the isostatic uplift, due to the disappearance of glaciers, and profile slope can vary regionally, depending on the extent of coastal exposure. From figure 16, it is clear that the study area is raised annually by between one and 1,2 millimetres. When the sea level rises, there is increased erosion. Erosion can also increase with increasing wind speeds and/or more frequent storms as a result of climate change (Miljø- og Fødevareministeriet, 2016).

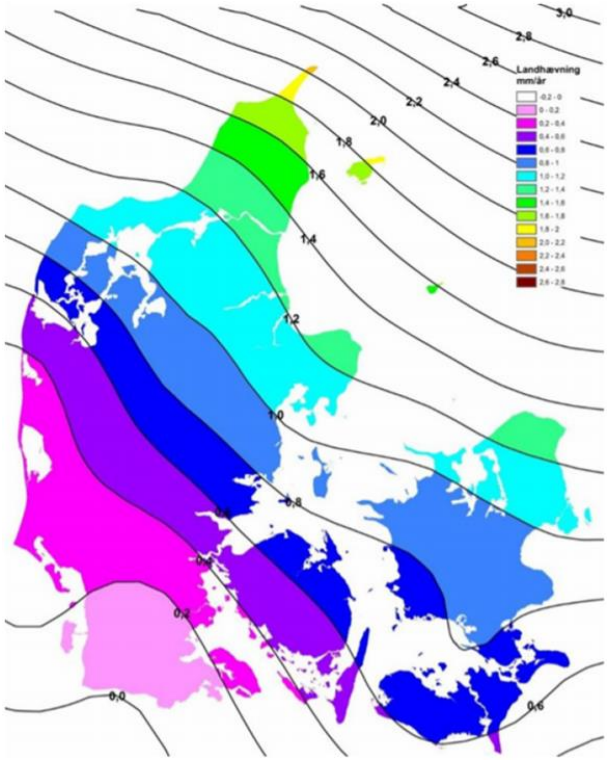

Figure 16: Land uplift Denmark in mm/year (Miljø- og Fødevareministeriet, 2016).

Climate change is not expected to change which municipalities are most at risk of erosion. In the future, the risk of erosion will remain high in the already heavily exposed municipalities of West Jutland (outside our study area) and North Zealand. In the worst affected municipalities, the risk of erosion is expected to increase to a much greater extent (Miljø- og Fødevareministeriet, 2016).

4.4.2 Case study

Around 5-6 December 2013 a strong storm passed along the coast of Denmark. This storm was called Bodil. This resulted in strong gusts from a northerly to north-westerly direction. North of the northern coast of the peninsula, there is a lot of open sea. Due to these strong winds, water was pushed to the coast and was built up along the coast, resulting in a higher-than-normal sea level (figure 17). The water was raised almost 1,5 meters alongside the northern coast according to the Danish Meteorological Institute with waves around 10 meters in height (also due to long fetch). This resulted in a lot of acute erosion. Here, some examples from the northern coast are shown.

Figure 17 Long fetch of water results in high waves and higher-than-normal sea level (own processing, 2021).

There are two ways to identify the type of erosion that took place. It is possible to go in the field and do it yourself, but a look from above can also give useful information. Standing on the ground, it is possible to see mostly the vertical erosion while from above the horizontal erosion is more visible.

The first pictures (figure 18) were taken in the vicinity of Korshage (the most eastern part of our study area). Here, there are also some coastal defences in place because some summer houses were built right along the coast. It is easy to see that the there is a lot of damage to the house and a lot of displacement of stones. This is also called beach drift. However, this type of defences, kept the house from totally destruction by the water.

Figure 18 Coastal erosion from spring 2013 to spring 2014 (skraafoto.kortforsyningen.dk, 2021)

In the next example there are also some coastal defences in place to break the waves. Before the houses, there are two small lines of rocks. These were placed to protect the houses behind them. Right next to the houses there is just one line of rocks and it's again easy to see that that part felt a lot more erosion.

Figure 19 Coastal erosion from spring 2013 to spring 2014 (skraafoto.kortforsyningen.dk, 2021)

More central in our study area is Sonnerup beach. Here, it is also clearly visible that after the storm Bodil some parts are eroded. These places are also shown on the map with erosion on figure 14.

Figure 20 Coastal erosion from spring 2013 to spring 2014 (skraafoto.kortforsyningen.dk, 2021)

4.4.3 Tackling erosion

There are various coastal protection techniques to combat erosion. The most common coastal protection techniques are beach nourishment, groynes and breakwaters. Groynes and breakwaters are referred to as hard solutions, while beach nourishment is seen more as a soft solution due to its limited visible impact on the coastal landscape. The construction of such hard solutions is often associated with higher costs (e.g. up to 1,8 million euros for the construction for a substantial breakwater). Soft coastal protective measures on the other hand may seem like a cheaper solution (beach nourishment costs approximately 140 euros per metre) but it is important to keep in mind that such soft measures need to be repeated on a frequent basis to uphold the intended level of protection. Each coastal defence technique has its advantages and disadvantages. Which coastal defence technique is most appropriate, depends on what type of erosion (chronic or acute erosion) you want to tackle and what impact these techniques have on the coastline located further downstream (Miljøministeriet Kystdirektoratet, 2021).

The study area is located in the Odsherred geopark. This means that human impact on the unique coastal landscape should be as low as possible. As a result, there are very few options for the local investment in common coastal defence techniques. An example of this is that owners of summer houses have to take responsibility for protecting their houses against erosion. A second example is that the road that was damaged by storm Bodil in Sonnerup is no longer being repaired (Miljøministeriet Kystdirektoratet, 2021).

5. DISCUSSION

The results obtained from this study provide a detailed overview of risk-prone areas and the coastal typologies along the coast of the Odsherred peninsula. This as an addition to the already existing Danish Coastal Atlas by the Danish government which, due to its lack of detail, limits the knowledge that local municipalities can base themselves on for future decision making. After the presentation of the project on the 6th of August 2021 in Denmark, it became clear that many municipalities across Denmark and certainly near Odsherred have already been taking measures individually in the past to combat erosion where human settlements are at risk of being damaged. Furthermore, recent climate and erosion action plans by the various municipalities already state that the municipalities themselves will no longer be providing coastal erosion measures to high-risk zones along the Odsherred coast and that if measures are to be taken, this should be done privately. In most cases however individual measures in one municipality can have adverse effects for coastal areas of municipalities located further along the coast. This is exactly why there is a serious necessity for a detailed coastal characterization that can be used for collective decision making on coastal protection measures by looking at the coastline at a larger scale whilst keeping the local characteristics and typologies (as described in this project) in mind.

Another important aspect to mention is that the study area is located along the coast of an UNESCO geopark and that the aim of this coastal typology overview is not to help bring all erosion and

sedimentation processes under control as this would mean interfering with the natural processes that have helped shape this unique coastal environment.

Future work based on this study could focus on presenting the findings from this project to the various affected municipalities and other stakeholders along the coast and attempt to help outline a new coastal erosion action plan that focuses on taking collective and coordinated measures whilst keeping in mind that the Odsherred coast is affected by larger natural dynamics that help shape coastlines well before and after that of the Odsherred peninsula. If the application of the methodology in Odsherred would lead to favorable results, applying the same methodology to other coastal areas with strong erosion and sedimentation dynamics (both in- or outside of Denmark) could help provide solutions further afield.

5.1 The learning process

One of the first difficulties encountered was the size of the original study area which stretched from Gniben to Helsingør. This proved to be a too large area to cover in the limited available time space so after conferring it was decided that the study area should be reduced to the northern and western coast of the Odsherred peninsula. Due to this decision a lot of preparatory work that was performed before the field work was lost but the choice to reduce the study area proved to be beneficial as it was the ideal area that could easily be covered during the study period.

Another part in the learning process from this project was that in the beginning the focus lay more on the creation of a seascape character assessment in which exact delineations are made per variable/attribute. But as the project work progressed it quickly became clear that this is rather tricky for a coastline that is dictated by various natural processes which are intertwined with each other both on a larger and a smaller scale. It proved more logical to step away from the exact quantitative delineation concept and it was decided to focus more on a qualitative approach with transition zones and taking into account the large-scale processes such as wave action and sedimentation flows. The seascape character assessment eventually turned out to be a baseline for our coastal typology assessment of Odsherred.

6. CONCLUSION

The main goals in this assessment were first to delineate and identify the different coastal types along the coast of Kattegat and of Sejerø Bay. The second objective was to investigate to what extent this typology can be an addition to the Coastal Atlas. Finally, the zones at risk of erosion were identified and possible protection measures were considered.

The typology resulted in five coastal types and one transition zone, taking into account the presence of human impact, cliffs or beach ridges. The types we identified were wavy pebble & cobble, plain sand, soft cliff sand & boulder, plain sand & cobble and cliff sand & pebble. The five types were further described in detail using transects of each type.

After comparing our typology with the Coastal Atlas, the latter was found to contain only two coastal types in the region. In addition, these did not always match our observations in the field. One reason for this could be not taking into account the geomorphology, which we did when compiling the typology.

Finally, we created a map visualizing the zones with a high vulnerability to chronic and acute erosion in the study area based on field observations, the present coastal defenses and the erosion atlas. These can help policy makers in the area to take adequate measures to protect the most vulnerable areas.

This study into the dynamic coastal environment of the Odsherred peninsula has highlighted many challenges and has answered how the municipalities can help tackle erosion in areas where human settlements are most at risk whilst still taking into account the protected environment of an UNESCO geopark. Also other areas with similar problems could draw inspiration from this work on the protection of erosion-prone sites along their coast.

Many difficulties came our way during the assessment, but thanks to the help of Professor Van Eetvelde, Lars De Sloover and their colleagues, we learned a lot from the process and were able to successfully complete the project.

7. APPENDIX

7.1 Field attributes sources

Table 2 Field attribute sources

Tides and coastal protection	
Source	**Description**
Global Opportunity Explorer. (October 26, 2018). Strategy Combines Climate Adaptation With Municipal Goals. https://goexplorer.org/climate-adaptation-odsherred/	The municipality of Odsherred has drawn up a climate adaptation plan for Nykøbing Sjælland, which combines elements such as urban development, improved nature and water quality with efforts to make the area climate-proof
Faragò, M., Rasmussen, E. S., Fryd, O., Rønde Nielsen, E., & Arnbjerg-Nielsen, K. (2018). Coastal protection technologies in a Danish context. Vand i Byer	The purpose of this report is to analyse past and present coastal protection strategies in Denmark and use this as a baseline for a critical reflection on current practice and possible ways forward.
Fauna and flora	
Source	**Description**
Styrelsen for dataforsyning og effektivisering. (2015). Natura 2000 Fuglebeskyttelse. https://www.geodata-info.dk/srv/dan/catalog.search;jsessionid=9169687D4D3786954C6EAD13F2DFBF20#/metadata/a41eda70-0705-4641-8013-bb7348383eb7	The Natura 2000 areas map consists of the habitat, bird protection and RAMSAR areas and they are designated to protect specific species and habitats. The Sejerø Bay and the north-eastern part of Rørvig are a bird protection area. Sejerø Bay is also a RAMSAR area and a Natura 2000 habitat area, while Rørvig is only a Natura 2000 habitat area. Furthermore, the bay also has several small Natura 2000 habitat areas.
UNESCO Global Geopark Odsherred. (2021). https://geoparkodsherred.dk/	The official website of the UNESCO Global Geopark Odsherred.
Seabed sediment	
Source	**Description**
De Nationale Geologiske Undersøgelser for Danmark og Grønland. (2019). Havbundssedimentkort. https://frisbee.geus.dk/geuswebshop/index.xhtml	The sediment map shows the spatial distribution of the seabed sediments in the Danish waters. The given sediment classification represents the major sediment type of the upper 0.50 meters of the seabed. Seven classes are distinguished on the map: till; sand, sand, gravel and pebbles; sandy mud/muddy sand; mud; quaternary clay and sedimentary bed rock.

Geomorphology	
Source	**Description**
De Nationale Geologiske Undersøgelser for Danmark og Grønland. (2018). Geomorfologisk kort over Danmark 1:200 000, version 2. https://frisbee.geus.dk/geuswebshop/index.xhtml	The geomorphological map shows landscape types in the Danish landscape. The specific landscape types have mutual common features, which can be associated to the formation processes that created them. The landscape types on the geomorphological map are interpreted by means of topographic maps, geological maps and very much the digital terrain model of Denmark. Furthermore, earlier interpretations of the landscape are largely considered.
Visibility land/sea	
Source	**Description**
Styrelsen for dataforsyning og effektivisering. (2016). DHM/Terræn (0,4 meter grid) https://www.geodata-info.dk/srv/dan/catalog.search#/metadata/a813e173-b580-459b-87c8-f7407175ef36	This is a model of the terrain's topography or height above sea level. Objects such as trees, houses, cars... has been removed. It has a grid point distance of 40 cm.
Bathymetry and landform	
Source	**Description**
De Nationale Geologiske Undersøgelser for Danmark og Grønland. (2006). Højde og dybde i det danske område. https://frisbee.geus.dk/geuswebshop/	The maps shows the country's altitude above sea level and the sea depth in the Danish territory with 5 meter intervals.
(Past) use of coast and sea	
Source	**Description**
Copernicus. (2021). Corine Land Cover. https://land.copernicus.eu/pan-european/corine-land-cover	The CORINE Land Cover programme introduced a method of identifying land cover from satellite images with a resolution of 10–50 m.
Kortviseren. (2021). 1725 Sjælland. https://kortviseren.dk/index.html?p=662872.93,6193604.33,72.4988&k=world;sj1725birckholtz	A historical map of Sjælland in 1725.
Maritime spatial plan. (2021). Denmark's maritime spatial plan. https://havplan.dk/en/page/info	All relevant information about both the content of the maritime spatial plan and any consultations and historical versions of the maritime spatial plan can be found here.

Erosion	
Source	**Description**
Kystdirektoratets Kystatlas. (2021). ErosionAtlas. https://kms.maps.arcgis.com/apps/webappviewer/index.html?id=8669133b3f4842b7a9a19fb24b08ffd5	The erosion atlas published by the Danish Coastal Authority and shows places with acute and chronic erosion. The shows the erosion that is expected to occur if there is no erosion protection on the track.
Kystdirektoratet. (2016). Kortlægning af erosion og oversvømmelse. Miljøministeriet. https://kyst.dk/media/80389/kortlaegningaferosionogoversvoemmelse.pdf	This report is to create a nationwide overview of the coasts of Denmark, which shows the expected incidence of erosion and flooding
Aerial imagery	
Source	**Description**
Styrelsen for Dataforsyning og Effektivisering. (2019). Skråfoto.	The oblique photo service is based on Oblivision Online from IDAN and shows Denmark in vertical and oblique photos and are free to use.
Kortviseren. (2021). Ortokort / satellitkort. https://kortviseren.dk/index.html?p=665353,6227220,585.6365&k=world	Orthophotos from 2004 to 2018 can be consulted on the website. In addition, satellite images can also be viewed on the website.

7.2 Field attributes table

Table 3 Field attributes table

Stops	Erosion or sedi-mentation	Texture of beach	Zonation particle sizes (sea to land)	Land use (100m)	Human influence	Slope	Visibility land to sea	Visibility sea to land	Soil	Bathy-metry	Coastal type
1	Erosion	Little sand, pebble, cobble	Big to small	Dunes, heather	None	Storm ridges	High	Medium low	Marine plane, beach ridge	Very gradual	Plain sand and cobbles
2	Erosion	Sand, cobble, little boulder	Big to small	Wetlands	Couple of summerhouses	Slight slope	Average	High	Marine plane	Very gradual	Plain sand and cobbles
3	Erosion	Sand, gravel, boulder, rock (by man)	Big to small	Multiple summerhouses, nature park	Multiple summerhouses with coastal defence	Small cliff	Average	High	Beach ridge, aeolian plain	Very gradual	Plain sand
4	Sedimentation	Sand	None	Dunes, beach	Coastal defence (Sand drift plantation)	Slight slope	Average	High	Aeolian plain, dune	Very gradual	Plain sand
5	Sedimentation	Sand, gravel	Alternation between sand and gravel	Dune, camping	Camping	Slight slope	Average	High	Dune	Very gradual	Transition zone

6	Sedimentation	Sand, gravel, boulder, rock	Rock, boulder, gravel, sand, alternation sand and boulder	Dune, beach, summerhouses	Summerhouses	Slight slope	Average	High	Marine plan, beach ridge	Very gradual	Transition zone
7	Erosion	Sand, gravel, cobble	Alternation between gravel and cobble	Dunes, summerhouses	Summerhouses	Storm ridges	Average	High	Beach ridge	Very gradual	Wavy pebbles and cobbles
8	Erosion	Sand, gravel, cobble, boulder	Mixed due to excavations	Harbour, town	Harbour, town	Cliffs	Average	Average	Beach ridge	Gradual	Wavy pebbles and cobbles
9.a	Erosion	Sand, cobble, boulder	Small to big	Abandoned quarry, tourist lookout	Abandoned quarry	Cliffs and sloping beach	High	Low	Marginal moraine	Slightly steep	Cliff sand and pebbles
9.b	Erosion	Sand, cobble	Small to big	Nature reserve	None	Cliffs and storm ridges	Average	Low	Marine plane, beach ridge	Steep	Cliff sand and pebbles
10	Erosion	Cobble, rock	Small to big	Summerhouses	Coastal defence	Cliffs and slightly sloping beach	Average	Low	Beach ridge	Steep	Soft cliff sand and boulders
11	Erosion	Sand, cobble, rock	Rock with sand to sand with cobble	Agriculture	Agriculture	Storm ridges	Average	Low	Marginal moraine	Steep	Soft cliff sand and boulders

12	Erosion	Sand, cobble	Small to big	Fruit orchard, summerhouses	Agriculture, summerhouses	Cliffs and storm ridges	High	Low	Beach ridge	Steep	Wavy pebbles and cobbles
13	Erosion	Sand, cobble, rock	Sand to cobble with rock	Summerhouses	Summerhouses and beach huts	Storm ridges	High	Low	Beach ridge	Steep	Wavy pebbles and cobbles
14	Erosion	Sand, cobble, rock	Small to big	Agriculture	Agriculture	Storm ridges	High	Low	Beach ridge	Steep	Wavy pebbles and cobbles
15	Erosion	Gravel, pebble, cobble	Small to big	Harbour, town	Harbour, town	Storm ridges	Average	Low	Hummocky topography	Steep	Wavy pebbles and cobbles
16	Erosion	Cobble	Cobble	Quarry, summerhouses	Quarry	Storm ridges	High	Low	Beach ridge, dune	Steep	Plain sand and cobbles
17	Erosion	Pebble, cobble, boulder	Mixed	Military area	Iron fence	Cliffs and some ridges	High	Low	Marine plane, beach ridge	Steep	Plain sand and cobbles
18	Sedimentation	Sand, gravel, pebble, cobble, boulder	Cobble, pebble, gravel, sand, boulder	Military area	Defensive rock wall	Cliffs	High	Low	Marginal moraine	Steep	Plain sand and cobbles

19	Erosion	Sand, pebble, cobble, boulder	Sand to mixed	Summerhouses	Pipe, ponton	Steep	high	Average	Beach ridge, marine plain	Gradual	Wavy pebbles and cobbles
20	Erosion	Sand, pebble, cobble, boulder	Sand to mixed	Summerhouses	Pipe, ponton	Steep	high	Average	Beach ridge	Gradual	Wavy pebbles and cobbles
21	Erosion	Gravel, pebble, cobble	Cobble, gravel, mixed	Agriculture	None	Steady	Low	High	Till plain	Very gradual	Wavy pebbles and cobbles
22	Sedimentation	Sand	None	Summerhouses	Summerhouses	Flat	Low	High	Dune	Very gradual	Plain sand
23	Sedimentation	Sand	None	Nature reserve	None	Flat	Low	High	Dune	Very gradual	Plain sand
24	Sedimentation	Sand	None	Nature reserve	None	Flat	Low	High	Dune	Very gradual	Plain sand
25	Sedimentation	Sand and more pebbles and cobbles	Sand, a few pebbles and cobbles, sand, a few pebbles and cobbles and so on	Nature park	Nature park	Almost flat	Low	High	Marine plain	Very gradual	Wavy pebbles and cobbles

7.3 Map of coastal defences

Figure 21 Coastal defences

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Assessing the relation between coastal flood risk and risk perception in Sejerø Bay

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Table of contents

1. INTRODUCTION

The consequences of anthropogenic climate change have been increasing in both intensity and frequency. One of climate change's most impactful effects is a global rise in sea level, leading to an increased vulnerability of coastal areas, especially when combined with storm surges. As Danish coastal areas are (and will be) subject to floods, it is relevant and important to provide an in-depth overview of current and future threats and to relate these to the risk perception of local inhabitants. In that respect, the aim of this research is to investigate whether expert risk calculations match local risk perception in Sejerø Bay, a summer house area located in the northwest of the Danish island Seeland. First, high and low risk areas are identified using a risk-based approach that determines the amount of risk by combining the probability of an event and the magnitude of its consequences. Secondly, a questionnaire is carried out in order to derive the risk perception and willingness to pay of local inhabitants. Based on the results, different hypotheses are tested concerning the relation between, on the one hand, the expert risk assessment and, on the other hand, both the risk perception of locals and their willingness to pay for protective adaptations.

2. FRAMEWORK

2.1 Climate change and Danish coastal areas

Climate change will impact Danish coastal zones by a rise in sea level and a change in wind climate, storminess and precipitation (e.g. an increased frequency of heavy downpours and the rising groundwater table hereby caused). As a rise in sea level and the impact of herewith associated storm surges are deemed to have the most impact on the long term, coastal floods are the main focus of this report (Piontkowitz & Sorensen, 2008; Hallegatte et al., 2011).

2.1.1 Sea level rise in Denmark

According to the Intergovernmental Panel on Climate Change (IPCC) (2007) the rise of global sea levels does not occur uniformly in space and time (Table 1). Generally, the rise in sea level is expected to increase by a factor 10 in the 21st century when compared to the 20th century (Colgan et al., 2019). More specifically, Table 1 provides an overview of current and future sea levels in three Danish cities. Two representative concentration pathways (RCPs), as defined by the IPCC (2007), are shown, denoting an intermediate emissions scenario (RCP4.5) and a more extreme and, hence, less likely one (RCP8.5). For example, a rise in sea level between 0.51 and 0.77 m relative to the 1901 – 1951 mean is predicted near Copenhagen (Colgan et al., 2019). However, because of high uncertainties and considerable spatial gradients regarding local sea level rises, global sea level forecasts (e.g. of the IPCC) are more reliable as a baseline for risk calculations, while being, nevertheless, less precise (Hallegate, 2011). Furthermore, as northern and parts of eastern Denmark are rising as a consequence of the glacio-isostatic uplift, a global sea level rise of 50 cm corresponds to a rise of 33 to 46 cm in Denmark (Duun-Christensen, 1990).

Table 1: Sea level relative to the 1901 – 1950 mean in three cities (Source: Colgan et al., 2019).

Year	IPCC scenario	Skagen	Copenhagen	Esbjerg
Circa 0	-	4	-	-1.5 ± 0.5
1980	-	-0.01 ± 0.01	0.01 ± 0.01	0.06 ± 0.01
2010	-	-0.02 ± 0.01	0.02 ± 0.01	0.10 ± 0.01
2040	RCP4.5	0.27 ± 0.15	0.21 ± 0.08	0.28 ± 0.08
	RCP8.5	0.37 ± 0.18	0.23 ± 0.09	0.31 ± 0.09
2070	RCP4.5	0.27 ± 0.15	0.37 ± 0.15	0.47 ± 0.15
	RCP8.5	0.37 ± 0.18	0.47 ± 0.18	0.57 ± 0.18
2100	RCP4.5	0.39 ± 0.21	0.51 ± 0.21	0.63 ± 0.21
	RCP8.5	0.64 ± 0.28	0.77 ± 0.28	0.89 ± 0.28

2.1.2 Storm surges

As storm surges can temporarily cause higher tides, they also form a potential threat to coastal areas (Piontkowitz & Sorensen, 2008). For example, Sorensen & Ingvardsen (2007) report 100-year extreme return heights of 148 cm for the Sjaellands Odde gauge station. However, extreme water levels, such as those caused by so-called '100-year floods', will become increasingly likely in the future. Furthermore, in order to obtain the 'true' height of a future 100-year flood, one has to take these future sea level rises into account (Piontkowitz & Sorensen, 2008). For example, with an expected sea level rise of 50 cm a storm surge of 198 cm in Sjaellands Odde would have a return time of a 100 years.

2.2 Study Area

This research focuses on the summer house area of Sejerø Bay, located in the municipality of Odsherred, one of the poorer municipalities in Denmark. The municipality contains around 23 000 summer houses (ca. 10% of all Danish summer houses), which makes tourism an important source of income. The majority of summer houses in Odsherred is located along the coast of the Sejerø Bay, extending from the town of Lumsås in the North to Høve in the South (Figure 1). The area is characterised by a series of consecutive summer house zones, in which the parcels typically form a closely-knit mosaic. More than half of the coastline is characterised by a small lagoon, which was created by the heavy winter storm of 1902 (Geopark Odsherred, n.d.). Before the 1950s, the sparsely populated area mainly consisted of grasslands with farming as the main economic activity. Afterwards, the area surrounding Ellinge became more developed, with the construction of numerous summer houses and the extensive planting of trees for example. Due to the proximity of the sea and the presence of an inland bog, the summer house area is prone to coastal floods. Specifically, the sea level is estimated to rise ca. 1.2 mm per year in Odsherred over the next 80 years (Noe-Nygaard & Hede, 2006). In order to protect the area, a low dike has already been constructed along the coast.

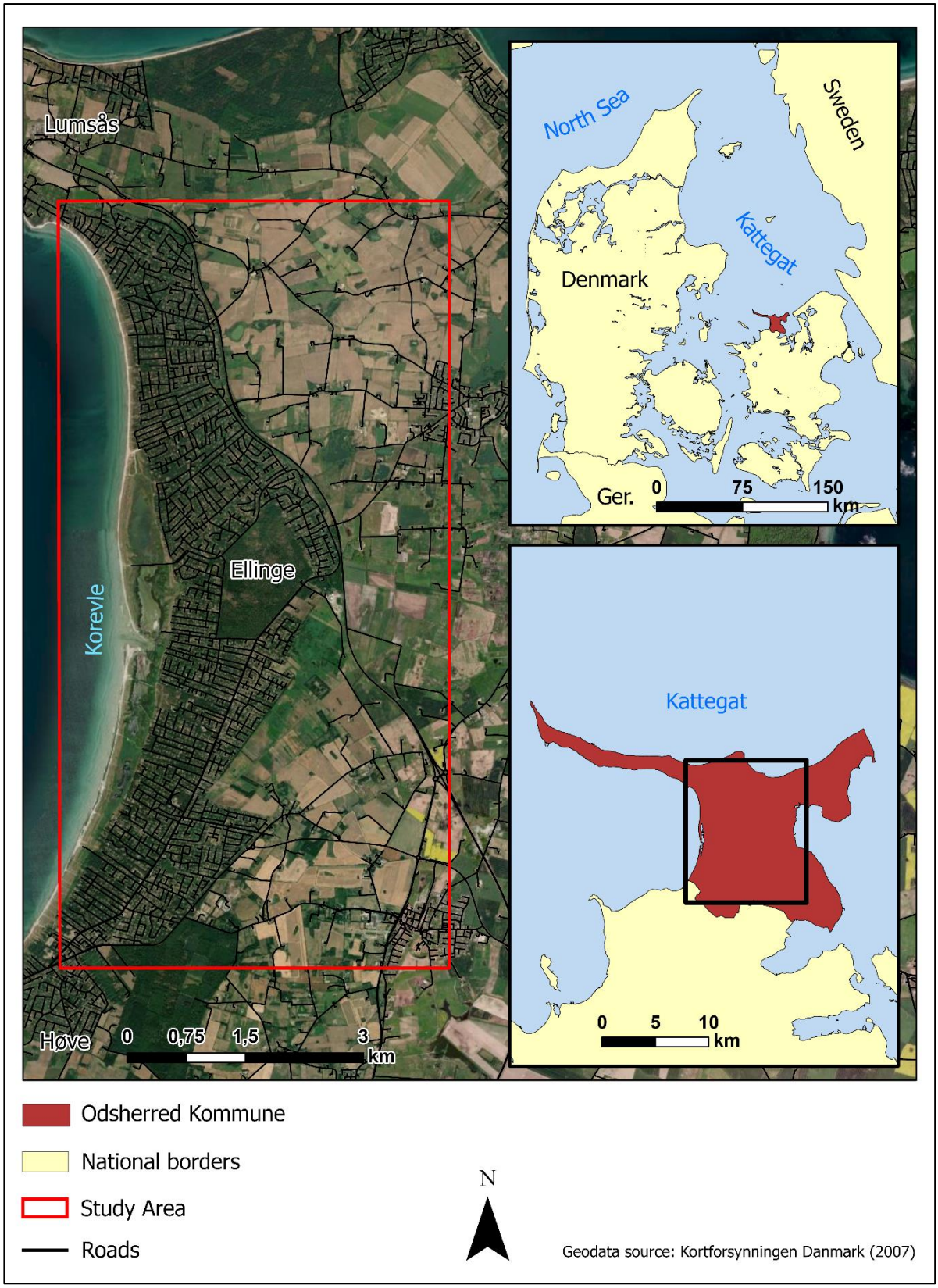

Figure 1: Overview and location of the study area in its region and Denmark.

2.3 Climate plan of Odsherred Kommune

Due to the considerable threats of climate change, the municipality developed a climate adaptation plan in 2014 (Odsherred Kommune, 2014). In this report, the hazards related to coastal floods, rising groundwater tables and heavy rain showers are estimated on a spatial and temporal scale in the form of flood, damage and risk maps, albeit on a coarse resolution of 50 m. In addition, the report points to possible adaptation and mitigation strategies. However, the financial responsibility for these strategies primarily lies with the individual landowner. Only if public interests are involved, the local government is ought to intervene. As mentioned, though, the summer house area remains a significant source of income and forms an important part of the municipality's identity. Consequently, Odsherred Kommune facilitates collaboration and coordination between citizens and other actors in vulnerable areas in the form of small assemblies (Odsherred Kommune, 2014). Some holiday houses are not sufficiently protected against coastal floods – let alone future aggravations thereof. Therefore, the municipality wants to establish a coherent and innovative protection project. Landowners in the area are encouraged to start a dialogue with each other and to initiate projects such as dike construction. As landowners themselves are responsible for protecting their property against storm surges, it is important to gain insight into their perception of possible risks and their willingness to pay for future adaptations (Odsherred Kommune, 2014).

2.4 Risk calculation

This study focuses on coastal floods, which are defined as "higher-than-normal water levels along the coast caused by tidal changes or thunderstorms that result in flooding, which can last from days to weeks." (Integrated Research on Disaster Risk, 2014). For areas that are prone to climate change and coastal floods in specific, it is important to gain insight into the potential future damage caused by these, with the aim to support decision-making and management strategies. The risk-based approach is proven to be a robust method for flood risk modelling in a variety of national contexts, both for coastal and fluvial floods (e.g. in Jonkman et al., 2008; de Moel et al., 2009; de Moel & Aerts, 2011; Kellens et al., 2013; and Van Ackere et al., 2019). In general, the risk-based approach defines flood risk as the combination of the probability of occurrence of a flood event, the flood hazard, its consequences or losses and flood vulnerability and damage (Merz & Thieken, 2004; Kellens et al., 2013). The distinction between, on the one hand, flood risk and, on the other hand, flood vulnerability and damage allows for a better understanding of flood risk, both in terms of initial quantification and later mitigation measures (Merz & Thieken, 2004).

2.5 Risk perception and willingness to pay

Risk perception refers to a person's subjective judgement about the likelihood of negative occurrences (Paek & Hove, 2017). The study of risk perception involves the examination of people's awareness, emotions, and behaviour regarding certain hazards. In addition to objective risk measures, subjective risk measurements such as risk perception have recently received more attention in flood risk management (Kellens et al., 2011). As an example, subjective risk measures are used in health and risk communication as they determine which hazards occupy people's minds (Paek & Hove, 2017). When the perceived risk of a hazard exceeds a certain threshold, targeted risk-reduction strategies can be employed (Angulo & Gil, 2007). When implementing such measures, policy makers commonly rely on cost-benefit analyses. In that respect, the concept of 'willingness to pay' for adaptation measures comes into play, as it grasps the perceived value of these measures. The willingness to pay denotes the maximum amount of money an individual is willing to spend for an adaptation structure (Entorf & Jensen, 2020).

In the context of climate change, risk perception is influenced by multiple factors. Van der Linden (2015) found the primary dimensions to be socio-demographic, cognitive, experiential and socio-cultural (Figure 2). The cognitive aspect of risk judgments is determined by knowledge about the probability that climate change will occur and the severity of its associated consequences (van der Linden, 2015). Several studies have investigated the relationship between risk perception and knowledge. Some studies find no relation (Brody et al., 2008), while others find a negative relation (Kellstedt et al., 2008). However, only subjective self-reported knowledge was investigated, which tends to be less reliable and confound different types of knowledge. Other studies have assessed the amount of 'accurate' knowledge people hold about climate change. These studies concluded that knowledge is in fact a significant and positive predictor of climate change risk perceptions (e.g. O'Connor et al., 1999; Sundblad et al., 2007; Hidalgo & Pisano, 2010; Milfont, 2012; Reser et al., 2012; Tobler et al., 2012).

The experiential factor is influenced by affective evaluations and personal experience with a threat or hazard (van der Linden, 2015). Affective evaluations indicate a more subtle form of emotion, defined as a positive or negative feeling towards external stimuli (Slovic et al., 2007). While numerous studies have shown that affect is an important predictor of climate change risk perception (e.g., Leiserowitz, 2006; Sundblad et al., 2007; Smith & Leiserowitz, 2012), others concluded that affect explains very little variance in risk perception (Sjöberg, 1998, 2006). In this study, negative affect is referred to as 'dread'. Socio-cultural factors can also influence risk perception. Several studies have found a significant relationship between 'cultural worldviews' and risk perception of climate change (e.g. Leiserowitz, 2006; Kahan et al., 2012; Smith & Leiserowitz, 2012; Akerlof et al., 2013) while it has been criticized by others due to its low explanatory power (Boholm, 1996; Sjöberg, 1997; Sjöberg, 1998; Oltedall et al., 2004) Furthermore, risk perception is influenced by social factors. The way in which people approach and evaluate risks is influenced by other people (Joffe, 2003).

Lastly, socio-demographic factors such as education, gender, political ideology and age influence risk perception. For example, a higher level of education can create an increased sense of control and thus lower levels of risk perception (Akerlof et al., 2013), but most studies find no correlation between education and risk perception of climate change (e.g. Sjöberg, 2000; Sundblad et al., 2007; Brody et al., 2008; Milfont, 2012). In addition, women generally have higher levels of risk perception than men (van der Linden, 2015). A possible explanation for this is that women are more aware of environmental risks and experience and create more vivid and intense affective imageries (Loewenstein et al., 2001). Furthermore, liberals express more concern about climate change than conservatives and often have a higher risk perception (van der Linden, 2015). However, these studies do not find a correlation between income and age and risk perception. Van der Linden (2015) argues that due to the inconsistency of socio-demographic variables, they should mainly serve as control variables to assess the net influence of cognitive, experiential and socio-cultural factors on risk perception. In this study, knowledge, affect (dread), personal experience and socio-demographic factors are investigated in order to determine risk perception.

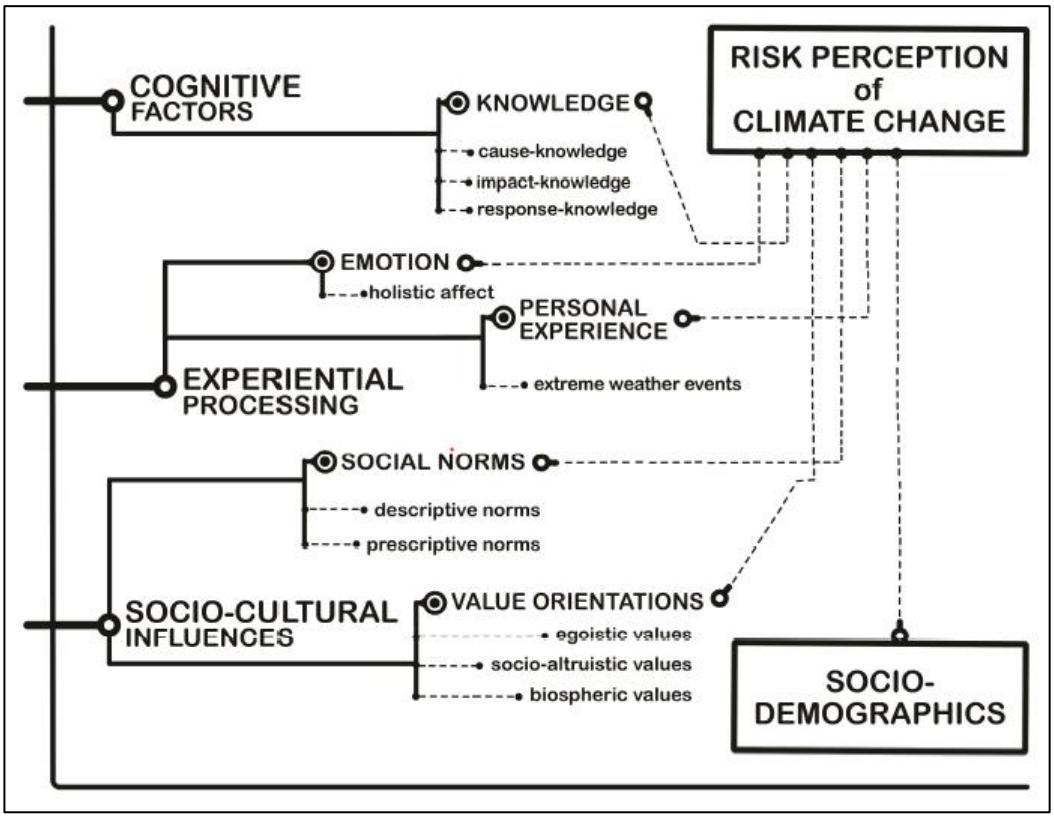

Figure 2: The climate change risk perception model (Source: van der Linden, 2015).

2.6 Adaptation strategies for sea-level rise

Multiple adaptation strategies exist in order to reduce the risks of coastal floods. The selection and timing of adaptive measures in response to sea level rise depend on the physical, social, economic, political and environmental characteristics of the affected area (IPCC, 2007). The typology of different adaptation strategies was first suggested by the IPCCs Coastal Zone Management Sub-group (2007) and includes three management options: planned retreat, accommodation or protection (Figure 3). The first strategy (planned retreat) involves no effort to protect the land from the sea. The inhabitants would abandon the coastal zone in this scenario, so ecosystems can shift landward. The second strategy (accommodation) implies the adaptation of accommodations to make infrastructure more resilient to sea-level rises and more suitable to their climatic and natural surroundings (e.g. elevating houses). In this scenario, people remain to use the land at risk but do not attempt to prevent it from being flooded. The third strategy (protection) entails to defend vulnerable areas using hard structures (e.g. dikes, seawalls) and/or soft protection measures (e.g. dune building, wetland creation). This could, however, imply a possible loss of ecosystems (IPCC, 2007).

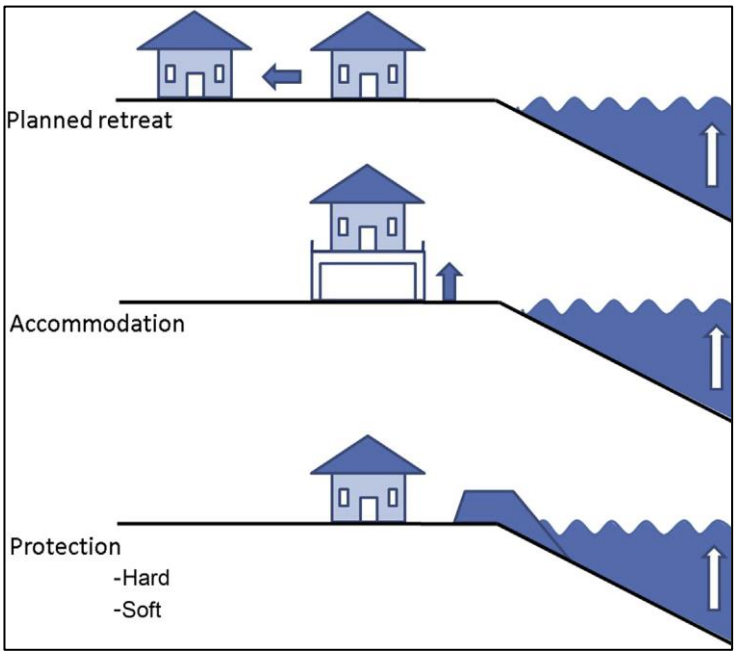

Figure 3: Generic adaptation approaches for sea-level rise (Source: Nicholls, 2015).

3. METHODS

3.1 Expert opinion: flood risk analysis

The methodology for producing a flood risk map for different scenarios consists of three phases: (i) producing multiple flood maps for storm surge heights associated with different return periods, (ii) calculating multiple damage maps based on the relation between the inundation depths and the maximum damage possible and (iii) combining these damage maps based on their probability of occurrence (Figure 4).

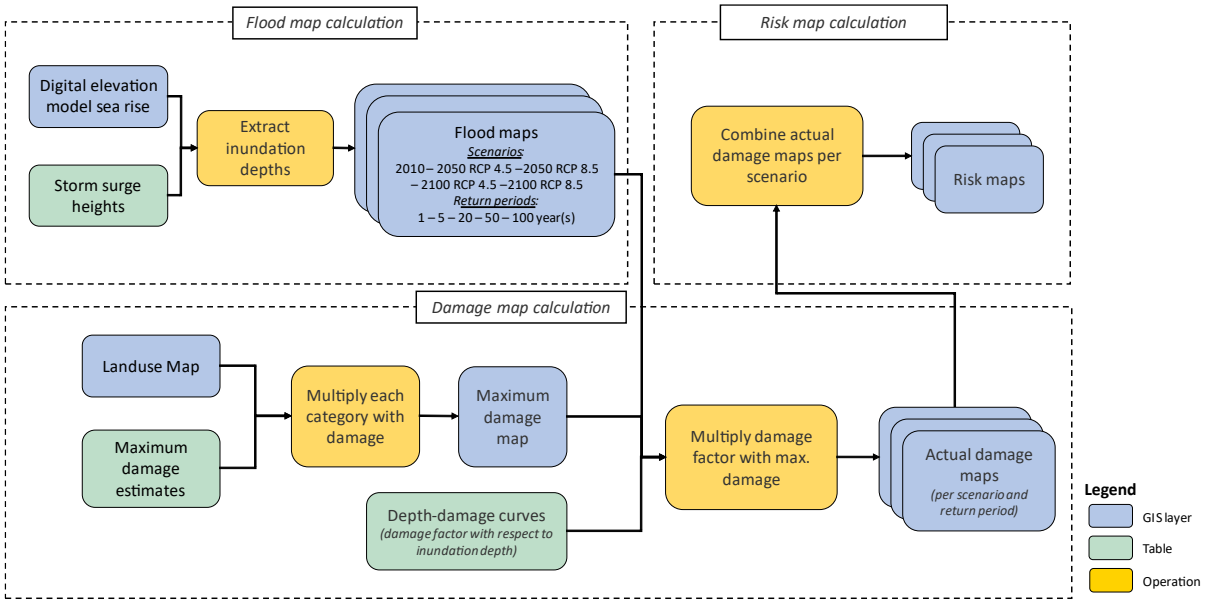

Figure 4: Conceptual cartographic model of the risk map calculation methodology.

3.1.1 Flood Map Calculation

The first step of the risk map calculation entails the construction of flood maps. The flood maps are constructed for five different return periods (1, 5, 20, 50 and 100 years) and for three different points in time (in 2010, 2050 and 2100). For the future, two scenarios are considered, RCP4.5 and RCP8.5. In addition, the situation of 2010 is also considered as it offers a useful benchmark for comparison. The associated storm surge heights for each return period in the scenarios are based on area-specific values for Sejerø Bay that have been predicted by the Danish Meteorological Institute (2021; Table 2). These predictions also take isostatic uplift into consideration.

Table 2: Storm surge heights for different RCP scenarios (Source: Danish Meteorological Institute, 2021).

		RCP scenario				
		2010	2050		2100	
		n.a.	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5
Return period	1 year	104 cm	124 cm	130 cm	137 cm	151 cm
	5 years	130 cm	148 cm	157 cm	161 cm	178 cm
	20 years	154 cm	174 cm	179 cm	186 cm	206 cm
	50 years	161 cm	181 cm	186 cm	193 cm	213 cm
	100 years	165 cm	185 cm	190 cm	197 cm	217 cm

The calculation of inundation depths is based on the DEM Sea Rise of Denmark, a 40x40 cm raster dataset (Styrelsen for Dataforsyning og Effektivisering, 2017). This dataset differs from a regular DEM as it is used to detect areas that are prone to flooding when a certain storm surge height is reached. In addition, it does not consider objects such as bridges as barriers, but as open passages for the waterflow. Each cell value thereby indicates the minimum storm surge height that must be reached for the cell to be flooded. As a result, the inundation depth of a cell for a particular storm surge height is calculated as the difference between the storm surge height and the DEM Sea Rise cell value. The resulting raster is a flood map raster that represents the inundation depth of each cell. For every storm surge height given in Table 2, a flood map is produced. Lastly, the 40x40 cm raster cells are aggregated to match the 10x10 m resolution of the land use dataset using the median inundation depth as aggregated value. These steps were automated in *ArcGIS Pro Model Builder*.

3.1.2 Damage Map Calculation

The second step in the risk map analysis entails the derivation of the maximum damage map. The damage map and the flood maps are combined to derive the expected damage for a given flood event. The maximum damage map is a map with the potential damage per surface area, where the potential damage is determined by the replacement cost. However, it is not possible to estimate the damage of each individual object. For that reason, land use categories are used as a proxy for the types of objects located in an area.

Even though several damage maps have been calculated in the past (de Moel & Aerts, 2011; Kellens et al., 2013; Odense Kommune, 2014), there are inconsistencies and disagreements about damage value estimates, that is the ratio between different categories and the methodology. For example, Odense Kommune (2014) calculated the potential value losses of different land use categories in Denmark. However, as these value losses are associated with a specific water depth and hardly any metadata was reported, the estimates cannot be used in this research. Due to these inconsistencies in the literature and the lack of metadata, the maximum damage estimates in this study are grounded on one single paper: the Flemish research of Kellens et al. (2013).

Table 3 shows the land use categories and the associated damage values in this research. The categories are defined based on the land use map of the DCE-Aarhus University (DCE-Aarhus University, 2018) by grouping similar categories together. The damage estimates are determined based on the replacement values of the corresponding categories in Kellens et al. (2013). These values do not exactly correspond to reality but are considered acceptable based on a preliminary study of the area.

Table 3: Overview of the categories and maximum damages.

Category	Combination of land use categories	Price (€/m²)	Price (DKK/m²)	Ratio	Reference	Reference category
Building	Building – low built-up; building – other built-up; building	1 000	7 437.28	100% (ref.)	Kellens *et al.* (2013)	Urban area: buildings
Furniture	*Same as building*	300	2 231.19	30%	Kellens *et al.* (2013)	Urban area: furniture
Built-up area	Low built-up; other built-up	1	7.44	0.1%	Kellens *et al.* (2013)	Urban area: open space
Industry building	Industry/business - building	250	1 859.32	25%	Kellens *et al.* (2013)	Industrial area: buildings
Industry area	Industry/business - resource extraction	100	744	10%	Kellens *et al.* (2013)	Industrial area: open space
Recreation building	Recreation area/sport ground - building	250	1 859.32	25%	*Same as industry building*	-
Recreation area	Recreation area/sport ground	0.03	0.22	0.003%	Kellens *et al.* (2013)	Recreational area
Paved road	Road - paved	1	7.44	0.1%	*Same as built-up area*	-
Unpaved road	Road - not paved	0.2	1,49	0.02%	*20% of paved road*	-
Forest	Forest	0.08	0.59	0.008%	*Same as agriculture extensive*	-
Agriculture (extensive)	Agriculture, extensive/not classified	0.08	0.59	0.008%	Kellens *et al.* (2013)	Pasture
Agriculture (intensive)	Agriculture, intensive, temporary/ permanent crops	1	7.44	0.1%	Kellens *et al.* (2013)	Cropland
Nature	Nature, dry/wet Nature, dry/wet; Agriculture extensive	0.08	0.59	0.008%	*Same as agriculture extensive*	-
Water	Lake, Stream, Sea	0	0	0%	-	-

Kellens et al. (2013) proposed a range of values for several categories. Because housing prices fluctuate in time and vary across the area, it is complex to estimate an exact value for the category *residential building*. In addition, housing prices consist of the building itself and the built-up area surrounding it. The order of magnitude of several sources differs by a factor of 10 (Odense Kommune, 2014; https://home.dk/). Since the region mainly consists of sporadically inhabited summer houses, the maximum damage per m² of building was estimated at 1 000 euro, as this is at the lower end of the range proposed by Kellens et al. (2013). Industrial buildings were assigned a value of 250 euro – also at the lower edge of the range - because the industry in the study area is rather low-tech. For the intensive agriculture area, a value of 1 euro per m² is estimated, around the average value of the range defined by Kellens et al. (2013).

Not all land use categories included in this study have a counterpart in the Flemish research study. These missing classes are associated with other categories based on similar characteristics. The damage of recreational buildings is for example estimated similar to that of industrial buildings since both are open and non-residential pieces of infrastructure. Furthermore, the damage value of different types of roads in Kellens et al. (2013) is not used for the category *paved roads*, because there is no distinction between different types of roads in the land use map and the measure unit is m compared to m² in this research. The damage of paved roads is therefore estimated as the cost of built-up area since both types of infrastructure are partially paved. Unpaved roads, however, include gravel roads and dirt roads and have a lower replacement cost. For that reason, 20% of the paved road's value is chosen. Next, Kellens et al. (2013) do not consider forested or natural land. These categories are assigned the same value as extensive agriculture land because such damage is limited to natural objects and no human infrastructure is affected. Lastly, damage to water bodies is intuitively considered non-existent.

In order to determine the actual damage caused by a flood event, the maximum damage estimate of a specific category is multiplied by a damage factor associated with a specific inundation depth. A depth-damage function is used to represent the damage factor of a land use category with respect to the inundation depth. The damage functions used for this research are shown in Figure 5. Table 4 indicates which land use categories are associated with each function. The functions are determined based on the values of Van der Sande (2001) which are also used in the study of Kellens et al. (2013) and Van Ackere et al. (2019). The relation between the damage factor and the inundation depth for the different categories are derived by the Dutch ministry of transport, public works and water management.

Table 4: Damage function per land use category.

Land use category	Function
Agriculture (extensive)	1
Agriculture (intensive)	1
Forest	1
Nature land	1
Industry building	2
Industry area	2
Recreation/sports building	2
Recreation/sports area	2
Resource extraction	2
Building (+ furniture)	3
Road paved	4
Road not paved	4
Built-up area	5
Lake, Stream, Sea	n.a.

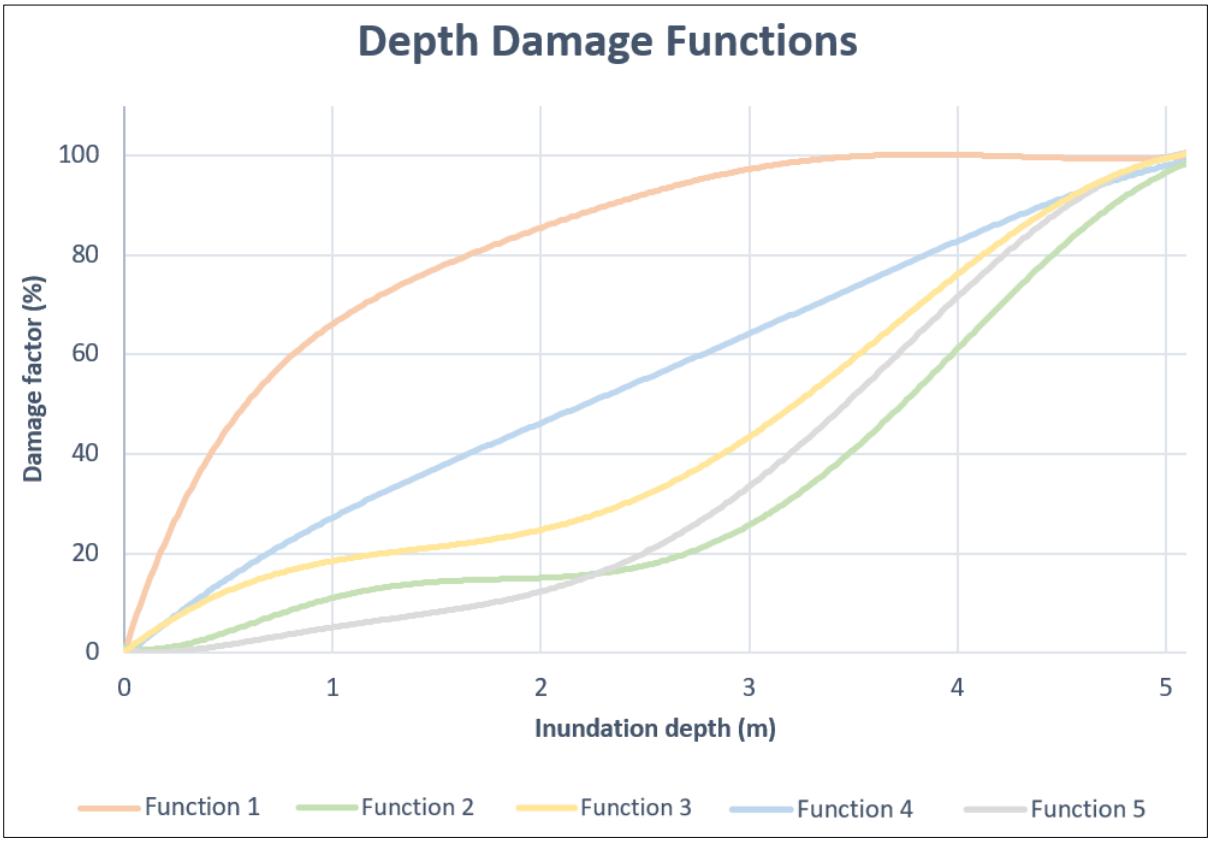

Figure 5: Damage functions (Source: Van der Sande, 2001).

This research uses five different damage functions. Function 1 is used for agriculture, forest and nature land. The function already gives a high damage factor for a relatively low water depth, because the damage does not heavily depend on the inundation depth of a flooding event. The same reasoning holds for damage done to furniture, which is incorporated in Function 3. This function can be used to

calculate the damage to buildings and the furniture within the building. The function flattens slightly between a water depth of one and two metres, because damage to furniture on the ground floor is already caused at low water depths, but damage to furniture on the second floor will only occur at high water depths. Functions 2 and 5 are similar. A flood event with a low(er) water depth will not cause nearly as much damage as one with a higher water depth. Finally, Function 4, which is used for roads, has a near-linear gradient.

The actual damage maps for the different return periods can be calculated by combining the maximum damage map, the flood maps and the depth-damage functions. For each cell, the maximum damage estimate is multiplied by the damage factor, which can be calculated by entering the inundation depth of the cell in the depth-damage function associated with the land use category of that cell. The implementation of these calculations is written in python and relies on the gdal and pandas libraries.

3.1.3 Risk Map Calculation

The final step in the risk analysis is to combine the actual damage maps of each return period into one risk map for every scenario. Risk is defined as the probability of a certain flood event, multiplied by the damage caused by the event. Risk can accordingly be calculated as the damage caused by an event with a 1-year return period, plus ½ of the difference between the damage of a 2-year event and a 1-year event, plus one third of the difference between the damage of a 3-year event and a 2-year event, etc. This is equation used for this procedure is (Deckers et al., 2010):

$$R = \sum_{i=1}^{n} \frac{1}{i} \left(S_i - S_{i-1} \right)$$

R = risk

S_i = damages related to a flood event with a return period of i years

n = highest return period

Ideally, the risk map would be calculated with flood scenarios for every return period, but as calculating, creating and validating this amount of flood maps would be a time-consuming operation, only a discrete set of flood maps was computed, for the return periods of 1, 5, 20, 50 and 100 years. To calculate the risk map based on these return times and assuming that the linear interpolation of the flood damage between two return periods is valid, the formula can be simplified as (Vanneuville et al., 2003; Deckers et al., 2010):

$$R = \frac{1}{1} S_1 + \frac{\frac{1}{2} + \frac{1}{3} + \frac{1}{4} + \frac{1}{5}}{5 - 1} (S_5 - S_1) + \frac{\frac{1}{6} + \frac{1}{7} + \ldots + \frac{1}{19} + \frac{1}{20}}{20 - 5} (S_{20} - S_5) + \ldots$$

This equation can again be simplified as:

$$R = 0.6792 \times S_1 + 0.2332 \times S_5 + 0.0576 \times S_{20} + 0.0162 \times S_{50} + 0.0138 \times S_{100}$$

The result is a risk map representing each climate change scenario. For these scenarios, the total average damage is calculated as the sum of the damage of each cell. Lastly, since these risk maps give a sense of the distribution of areas where the flood risk is relatively higher or lower compared to other parts in the study area, a generalized map distinguishing low risk and high risk areas is produced.

3.2 Public risk perception and willingness to pay

3.2.1 Questionnaire

3.2.1.1 Survey method

In order to compare the expert opinion on flood risks to the perception of the inhabitants of the study area, questionnaires aimed at evaluating the risk perception regarding coastal floods and willingness to pay are verbally carried out (see Appendix). The amount of risk perception is gauged with five questions (8-12) measured on a 5-point scale ranging from *strongly disagree* (score: 1) to *strongly agree* (score: 5) with *neither agree nor disagree* in between (score: 3). These questions are based on questionnaires carried out in function of coastal flood risk perception at the Belgian coast (Kellens et al., 2011). For each of the five questions, an evaluation is made about which aspect of risk perception (dread or knowledge) is tested most (Table 6). Willingness to pay is tested with two questions in the survey (13 & 14), measured on the same 5-point scale.

Table 6: Distribution of the risk perception questions.

Question	Dread (personal, emotional)	Knowledge (awareness in general)	Focus of the question
8. I am worried about the danger of a storm surge in the Sejerø Bugt	Local dread: 'in Sejerø Bugt'	Awareness, thought about the danger: 'worried about the danger'	**Dread** and **knowledge**
9. A storm surge can have fatal consequences for the coastal area and its inhabitants	Personal location: 'for the coastal area and its inhabitants'	Awareness, knowing consequences: 'can have fatal consequences'	**Dread** and **knowledge**
10. I experience staying at Sejerø Bugt as a threat to my safety	Personal: 'threat	Question implies knowledge about the negative consequences	Mostly **dread**
11. I expect great chances of storm surges causing floods in the coastal area	Local: 'in the coastal area'	Awareness, risk estimation: 'expect great chances'	Slightly more **knowledge**
12. When I think of floods, I feel concerned	Personal emotions: 'I feel'	General knowledge: 'concerned'	Mostly **knowledge**

Socio-demographic characteristics (questions 1-3 & 24-26), residence characteristics (5-7, 27) and information regarding past flood experiences (4) are assessed as follows. Age is measured on a continuous scale in years. Permanent residence, presence of children, personal experience with past floods, presence of a cellar, presence of more than a ground floor and whether the residence is elevated are measured as dichotomies (yes = 1, no = 0). The other attributes are also measured as dichotomies: home ownership (owner = 1, tenant = 0), gender (male = 1, female = 0), education level (highly educated (i.e., high school or university degree) = 1, low(er) level of education (i.e., primary or secondary school degree) = 0). Finally, the expert risk assessment, whether a residence is in a high or low risk area, is coded as follows: high risk = 1, low risk = 0. All these variables are further referred to as background variables.

These background variables are used for a quantitative analysis of the risk perception and the willingness to pay. A qualitative analysis is performed on the remaining questions. Questions 15-18 gauge respondents' opinions on possible adaptation structures on the same 5-point scale. Furthermore, two open questions allow for further recommendations.

Near the end of the survey, a map of the RCP4.5 scenario in 2050 is shown to the respondents. They are then asked whether these results are in line with their risk expectations (measured as dichotomy: expected = 1, not expected = 0) and whether their willingness to pay has changed after seeing the map (measured on a three point scale: pay less = 1, no impact = 2, pay more = 3) (questions 22-23). For every question, each missing value from the questionnaires is replaced by the median for that variable[1].

3.2.1.2 Sample characteristics

The total number of respondents is 82. The questionnaires are carried out in clusters throughout the high risk and low risk areas, because the interviewers went from door to door in search of possible respondents. As the questionnaire was only executed in English, there is a bias towards English speaking respondents. Table 7 displays the frequencies of the personal and residence characteristics. The distribution of people living in high risk areas (42) and people living in low risk areas (40) is almost equal. Respondents' age ranged from 21 to 79 years (mean = 54.9, SD = 13) and most of the respondents were men (58.5%). The large majority was highly educated (85.4%) which is assumed to be related to the fact only English-speaking people were interviewed. Most respondents have at least one child living at their residence (79.3%). Furthermore, nearly all respondents do not permanently stay at their residence (89%), but most of them own the summer house they are staying at (82.9%). Roughly one third of the respondents has already experienced a flood event or storm surge (29.3%).

[1] Missing values: respondent 58: questions 6 and 7, respondent 99: question 11, respondents 3, 5, 9 and 68: question 14.

Around one fourth of the properties only contains a ground floor and most of them are elevated at least 10 centimetres above the ground. As only three of the respondents' residences have a cellar, this variable is seen as an outlier and is therefore not considered in the further analysis.

Table 7: Sample Statistics.

Variable	Number	Percentage	Variable	Number	Percentage
Age			**Education level**		
16 - 30	3	3.7	High	70	85.4
31 - 45	19	23.2	Low	12	14.6
46 - 60	32	39.0	Missing	0	0.0
61 - 75	24	29.3			
76 - 90	4	4.9	**Home ownership**		
Missing	0	0.0	Owner	68	82.9
			Tenant	14	17.1
Gender			Missing	0	0.0
Male	48	58.5			
Female	34	41.5	**Permanent residence**		
Missing	0	0.0	Yes	9	11.0
			No	73	89.0
Cellar			Missing	0	0.0
Yes	3	3.7			
No	79	96.3	**Flood experience**		
Missing	0	0.0	Yes	24	29.3
			No	58	70.7
Elevated			Missing	0	0.0
Yes (> 10cm)	52	63.4			
No	29	35.4	**Ground floor**		
Missing	1	1.2	Yes	62	75.6
			No	19	23.2
Risk area			Missing	1	1.2
High	42	51.2			
Low	40	48.8	**Presence of children**		
Missing	0	0.0	Yes	65	79.3
			No	17	20.7
			Missing	0	0.0

3.2.2 *Factor analyses*

Cronbach's alpha of the five risk perception and the two willingness to pay items is 0.597 and 0.663 respectively, which indicates a relatively adequate internal consistency. Some of the variables are correlated with each other, so they partially measure the same dimensions of risk perception. However, there are some significant differences, which indicates that they manage to capture the variability in the variable.

A factor analysis is conducted to extract the underlying factors of risk perception from question 8-12. Principle Component Analysis (PCA) and Principle Factor Analysis (PAF) are two types of dimension reductions methods that are often used in psychological research to derive underlying factors from a large set of variables. PCA is a confirmatory technique which constructs components based on a linear combination of the original variables, while PAF is an exploratory analysis which assumes that original

variables are linear combinations of latent factors and residuals. PAF is often applied to extract factors that cannot be measured directly, for example prejudice, while PCA is preferred for more delineated and straightforward components (Fabrigar & Wegener, 2012). Because dread and knowledge (two of the main components of risk perception according to van der Linden, 2015) are rather vague concepts that cannot be measured directly, PAF is used. PAF is also applied to question 13-14, regarding the willingness to pay, to combine them into one factor. The factors with an eigenvalue above 1 after a varimax rotation are preserved for further analyses.

3.2.3 *Regression analyses*

Based on the expert assessment of the flood risk analysis, a distinction is made between low risk and high risk areas. In line with the hypothesis formulated and confirmed by Kellens et al. (2011), it is expected that the location of a property – either within or outside a high risk area – is related to the level of perceived risk. More precisely, people living in high risk areas are expected to have higher levels of perceived risk (H1). As argued, hypothesized and confirmed by Kellens et al. (2011), it is also expected that coastal flood risk perception is positively related with age, female gender, lower education, home ownership and permanent residence (H2). Similarly, having previous flood experience is expected to relate to greater levels of risk perception (H3).

H1: people living in high risk areas have higher levels of perceived risk.

H2: perceived risk is positively related with age, female gender, low education, home ownership and permanent residence.

H3: people with previous flood experience have higher levels of perceived risk.

The first three hypotheses are tested using multilinear regression analyses. Depending on the outcome of the risk perception factor analysis, all extracted factors are used as the dependent variables. The hypotheses are tested simultaneously by estimating the dependent variables with multiple independent variables in order to allow for additional findings. These variables include age, gender, level of education, presence of children, home ownership, permanent residence, previous flood experience, number of floors, ground floor elevation and risk area. Depending on the outcome, the regression is repeated only retaining the most significant independent variables.

As argued in section 2.6, the perceived risk of coastal floods is closely related to the willingness to pay for protective flood adaptations. In line with the first hypothesis, it is therefore expected that respondents living in a high risk area have a higher willingness to pay than those living in a low risk area (H4). Similarly, it is expected that the willingness to pay is positively related with age, female gender, lower education, home ownership and permanent residence (H5).

H4: people living in high risk areas have a higher willingness to pay for protective adaptation structures.

H5: the willingness to pay for protective adaptation structures is positively related with age, female gender, low education, home ownership and permanent residence.

Similar to the first regression analyses, hypotheses 4 and 5 are tested simultaneously with multilinear regression analyses. The same set of independent variables is used as in the first regressions, albeit with the willingness to pay factor as the dependent variable.

In addition to the regression analysis, a two way analysis of variance (ANOVA) can be executed in order to compare the mean differences between groups that have been split on two significant independent variables. The purpose of this ANOVA is to understand whether there is an interaction between two independent variables on the dependent variable. For example, by splitting the sample in terms of gender and risk area, it can be observed if the dependent variable varies in terms of gender and risk area simultaneously. All statistical analyses are executed in SPSS Statistics v.27.

4. RESULTS & DISCUSSION

4.1 Expert opinion: flood risk analysis

Figure 6 presents an overview of the flood risk within the study area in 2010, thus providing a benchmark for comparison to future scenarios. Firstly, the central lagoon area stands out, as it is a region that is very easily flooded and – since it contains nature lands – quickly reaches a large proportion of its maximum damage due to the rapidly increasing damage function. Secondly, a small strip along the coast, also classified as nature, is flooded. However, the largest proportion of the total damage is the result of the flooding of houses directly inland of the lagoon, as their maximum damage is significantly larger than other land use categories. The inset map highlights the high level of damage that occurs in these small patches of buildings. In addition, the built-up area in between the buildings is also prone to flooding, albeit with little associated damage. The westernmost depression thereby contains a patch of intensive agricultural land, which stands out due to its slightly higher damage potential. The expected annual damage of the whole study area totals at 0.49 million euro.

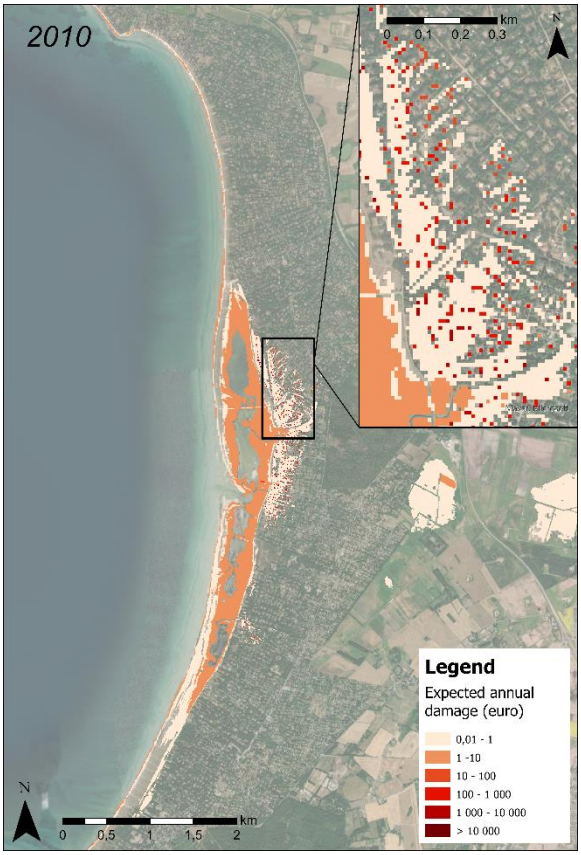

Figure 6: Flood risk map for the benchmark situation in 2010.

Table 8: Total expected annual damage within the study area per scenario.

Scenario	Total expected annual damage (million euro)
2010	0.49
2050 – RCP 4.5	1.42
2050 – RCP 8.5	1.96
2100 – RCP 4.5	2.54
2100 – RCP 8.5	4.78

For the first scenario in 2050 (RCP4.5), the total cost would increase by approximately one million euro when compared to the 2010 benchmark scenario. Even though the extent of the flooded area has not increased drastically, the additional damage is mainly the result of larger inundation depths of houses and the built-up area in between, as shown in the inset map (Figure 7). Notable changes are a few low-lying inland areas which would experience limited damage. Based on this scenario, low and high risk areas are identified in the bay area (Figure 8). Compared to the first scenario in 2050, the additional damage done in the most extreme climate scenario (RCP8.5) remains rather limited. This is in accordance with the relatively small difference in total cost compared to other differences. The inset maps for the two scenarios in 2050 are similar as well. A few summer houses in the south of the bay would experience additional costs in the RCP8.5 scenario, but it can be concluded that the worst-case carbon emission scenario would have a minimal impact compared to the intermediate scenario.

The total expected annual damage of the RCP4.5 scenario in 2100 amounts to 2.54 million euros, which is slightly upwards of 1 million euro extra compared to the same scenario in 2050. The additional damage mainly results from increased flooding of the houses directly inland of the lagoon. In addition, the expected damage in the inland depressions increases due to greater inundation depths. In the worst-case scenario (RCP8.5), the total expected annual damage drastically increases to 4.78 million euro, which is nearly double the amount of the intermediate scenario (RCP4.5) in the same year. In other words, even though the difference between both climate change scenarios is fairly limited in 2050, the increased flood risk and associated economic cost becomes far more apparent over time. Again, this increase is mainly caused by greater inundation depths in buildings close to the lagoon. For example, water levels can rise up to 80 cm in some of these houses for a 5-year event.

Field work identified, however, that the risks associated to local floods caused by heavy downpours or periods of prolonged rainfall and rising ground water tables cannot be ignored, and that these are felt (by local landowners who participated in the survey) to cause, at the moment, more nuisance than coastal floods and storm surges. However, this does not change the view that, as mentioned in the theoretical framework, coastal floods and storm surges could pose more considerable challenges and threats to the area on the mid- to long term.

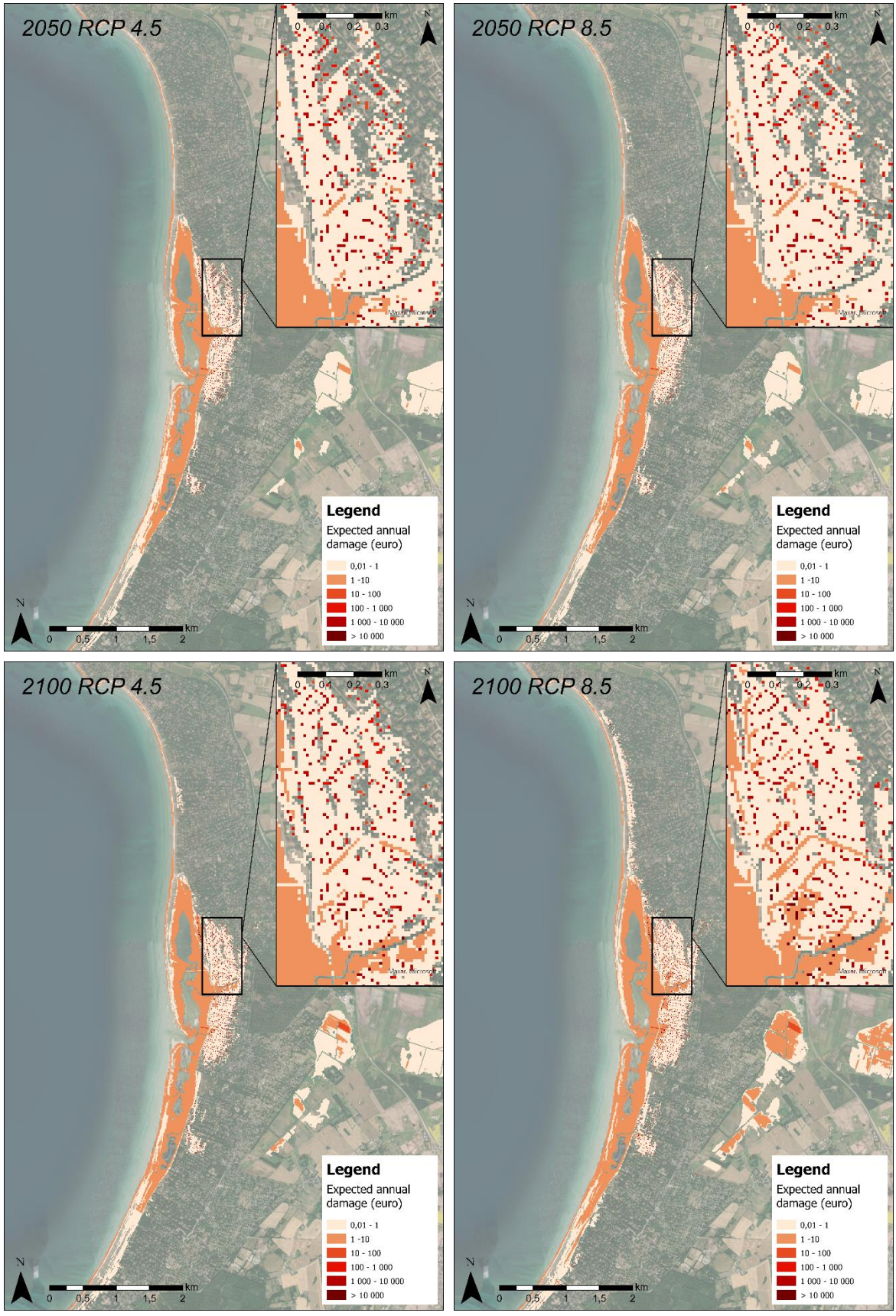

Figure 7: Flood risk maps for the RCP 4.5 and RCP 8.5 scenario in 2050 and 2100.

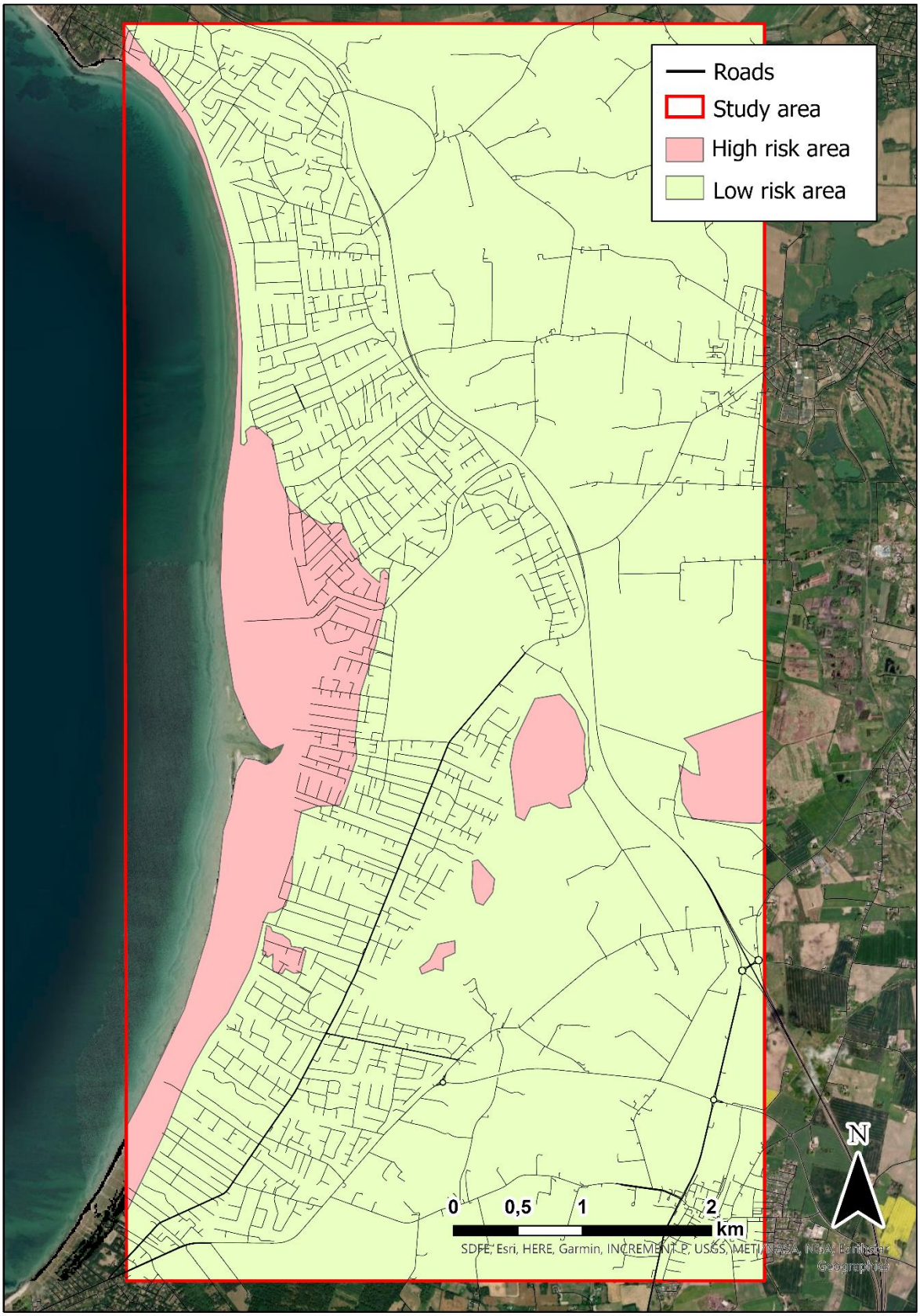

Figure 8: Spatial extent of the low and high-risk areas identified in this analysis.

4.2 Public risk perception and willingness to pay

4.2.1 Factor analyses

The scree plot in Figure 9 indicates that two factors have an eigenvalue of 1 or higher. These two factors explained 42.392% of the original variance and are kept for further analyses. The rotated factor matrix of the five risk perception variables can be found in Table 9. The first factor mostly consists of question 8 and 9. These questions focus both on dread and knowledge (see Table 6), so the resulting factor contains both the understanding of the flood risk and the negative emotions and feeling of fear and danger. The first factor was therefore named *apprehension*, which is defined by Oxford Learner's Dictionary as "worry or fear that something unpleasant may happen". Questions 8, 11 and 12 have the highest factor loading for the second factor. These questions focused more on the respondent's knowledge and awareness related to flood risks. Therefore, the second factor was named *awareness*. Based on the questionnaire, the two main components of risk perception in the study area are identified as apprehension and awareness. In the remainder of this research, risk perception is decomposed into these two factors. The factor analysis of question 13 and 14 resulted in one single factor which is, logically, named *willingness to pay*.

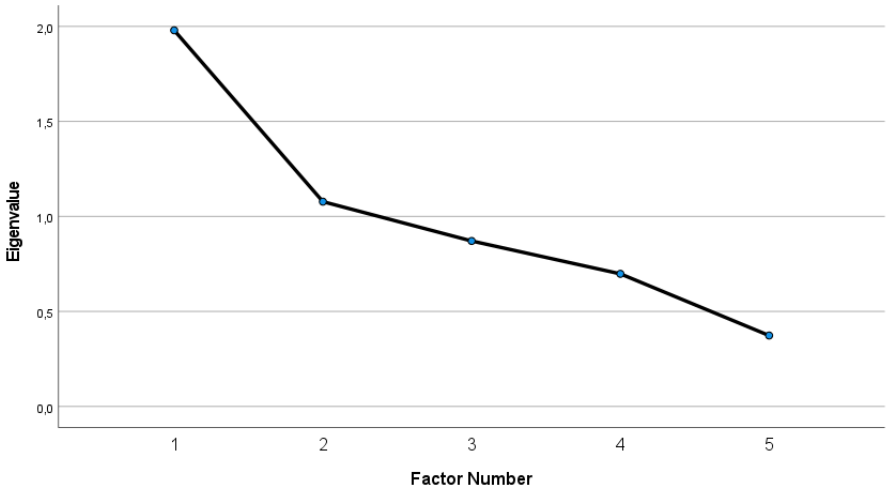

Figure 9: Scree plot of the factor analysis of the risk perception variables.

Table 9: Rotated Factor Matrix of the risk perception variables.

	Factor	
	1	2
8. worried	.454	.610
9. fatal_consequences	.943	
10. threat		
11. expect_changes		.488
12. concerned		.441

Extraction Method: Principal Axis Factoring.
Rotation Method: Varimax with Kaiser Normalization
Rotation converged in 3 iterations.
Coefficients below 0.4 are supressed.

4.2.2 Regression analyses

4.2.2.1 Risk perception: apprehension

The first regression analyses are conducted with apprehension as the dependent variable. Using all background variables as explaining variables, the model has an R^2 equal to 0.204. However, the adjusted R^2 is significantly lower with a value of 0.079, indicating that more than half of the explained variance originates from the large number of variables. As a result, only 3 out of 11 variables are significant on the 0.1 level, that is risk area, gender and ownership.

The regression was therefore repeated using only these three variables as independent variables. Only 13.2% of all variance is explained by the model. This is, however, quite similar to Kellens' et al. (2011) findings of a variance of 9.9%. The low values nevertheless indicate that estimating flood risk perception, and apprehension in particular, is subject to high levels of variability (Kellens et al., 2011). However, the adjusted R^2 value increases to 0.099, indicating that the remaining variables could be the most useful. Both risk area and ownership are now significant on the 0.05 level, whereas gender has a p-value slightly above 0.1 (Table 10).

Table 10: Coefficients of the regression model with apprehension as dependent variable.

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.529	.279		1.897	.062
	Risk area	-.522	.200	-.278	-2.615	.011
	Gender	.332	.203	.174	1.634	.106
	Ownership	-.549	.264	-.220	-2.079	.041

In general, respondents with a property located in a high risk area have a lower apprehension of risk, as indicated by the negative B-value (-0.552). Thus, the first hypothesis is rejected in terms of apprehension as the component of risk perception and, in fact, the opposite is true. In other words, it can be expected that the level of risk of the area in which a person decides to buy or rent a property is the result of their (lack of) apprehension regarding risk. A person that is less apprehensive about the risk of flooding is more likely to buy a property in a high risk area. In fact, Weinstein (1989) refers to this phenomenon as the "optimism bias", which is the erroneous belief that others are more likely to be affected by the same risk. Risk originating from climate change in specific is thereby characterized as psychologically distant in both spatial and temporal terms, i.e. happening in the future and to other people (van der Linden, 2015). Since the location of the property (either in a low or high risk area) is the most significant explanatory variable and the sample of this variable is equally balanced, a two-way ANOVA is executed with risk area as the splitting variable. In this respect, insight is gained in the effect of gender and ownership on apprehension, while accounting for possible mediating effects of flood risk.

Furthermore, the sociodemographic variables mentioned in the second hypothesis are insignificant. Therefore, the second hypothesis is rejected. However, the explanatory power of gender is just slightly insignificant. Surprisingly, its effect even opposes that of the hypothesis: as indicated by the positive B-value, men have a better apprehension regarding flood risk than women. Based on local insights, it could be argued that this is caused by the fact that the study area mainly consists of summer houses which are generally not permanently inhabited. Since the summer houses are located far from home, the man in the household might be more likely to be in charge of them and are thus also more likely to be confronted with the risk associated to the upkeep of the houses in case of an emergency. There is however insufficient information to prove this assumption. In addition, men residing in a low risk area have the greatest apprehension of flood risk (Figure 10).

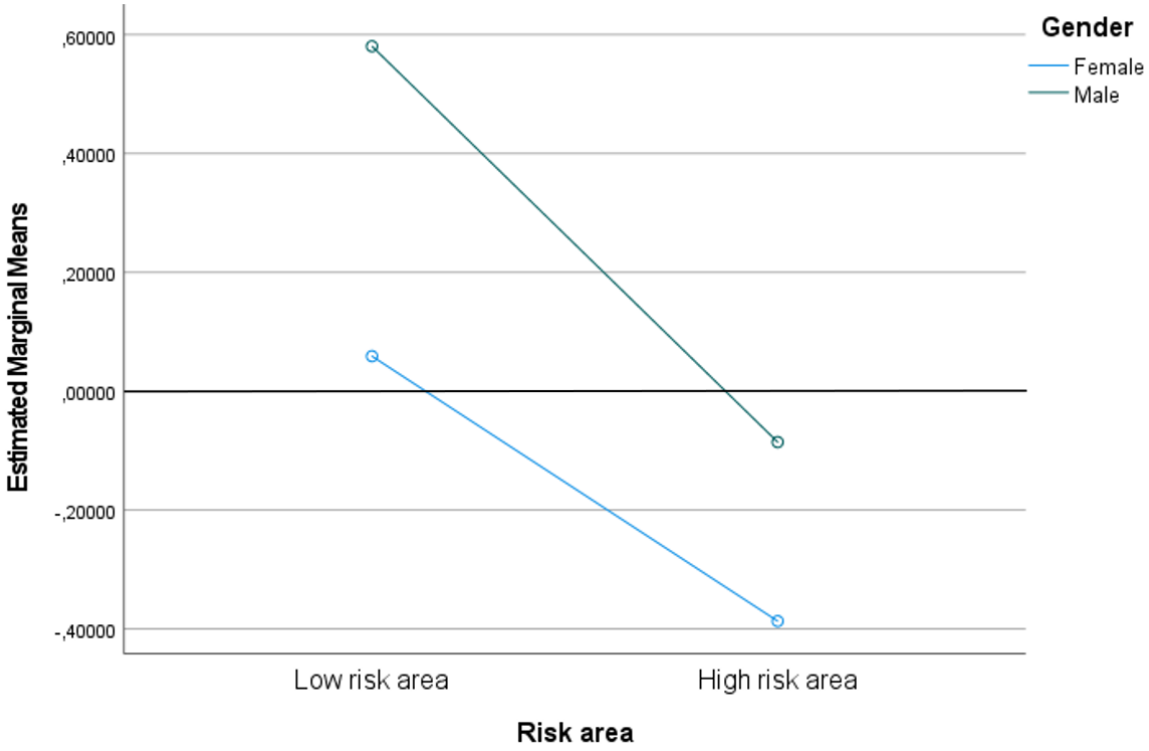

Figure 10: Estimated marginal means of apprehension regarding gender, divided by risk area (two-way ANOVA).

Continuing, respondents owning their summer house are less apprehensive of flood risks than tenants, as indicated by the negative B-value (Table 10). More specifically, this result is only true for high risk areas. As indicated in Figure 11, owners residing in a low risk area have an above average apprehension about flood risk. In addition, their apprehension is quite similar to that of tenants renting a summer house in a high risk area, indicating that they are the same group of people in terms of apprehension. Considering that tenants are potential owners, a possible interpretation for this finding is that this group would not take the risk of buying a house in a high risk area, whereas they are fine with renting a house in a high risk area temporarily. This interpretation is also confirmed by four encounters during the questionnaire.

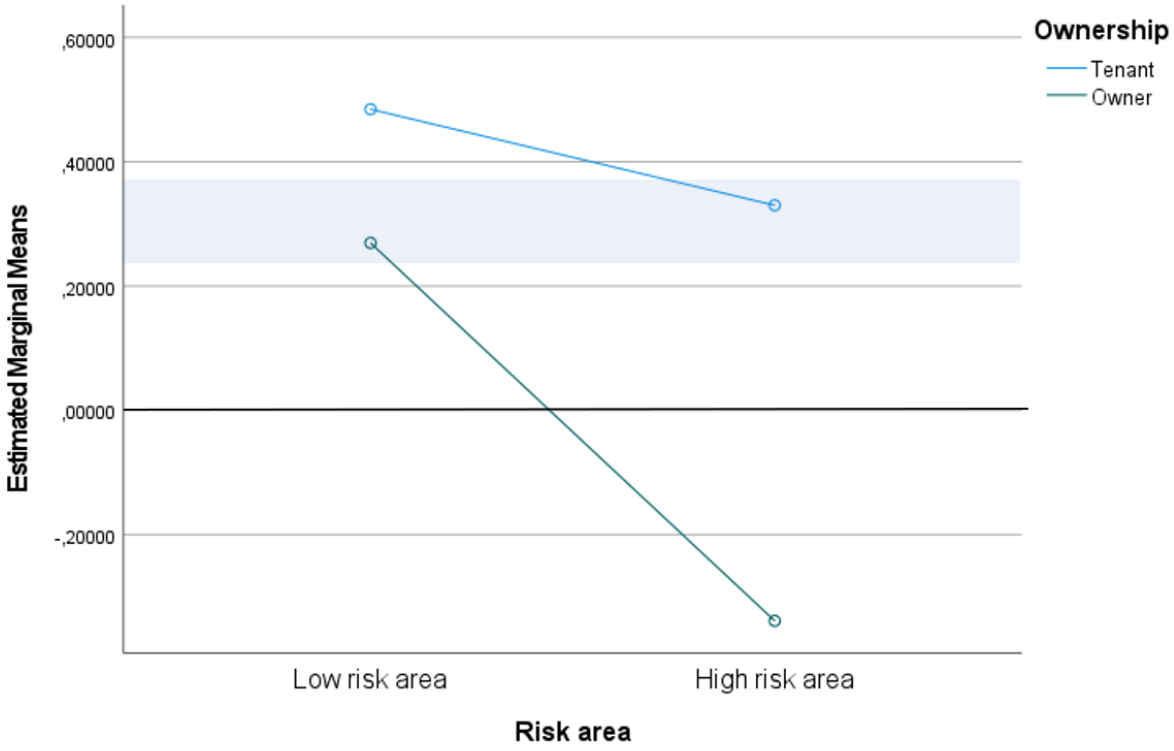

Figure 11: Estimated marginal means of apprehension regarding ownership, divided by risk area (two-way ANOVA).

4.2.2.2 Risk perception: awareness

The regression analysis with awareness as the dependent variable and all background variables as independent variables has an R^2 value of 0.087 and an adjusted R^2 of -0.41. This indicates that the model cannot predict the awareness and has no explanatory power. So, the first two hypotheses are rejected considering awareness as a factor of risk perception. In the regression analysis with flood experience as the independent variable, R^2 is equal to 0.055 and the adjusted R^2 is equal to 0.043. The flood experience however is significant with a p-value of 0.034 (Table 11). This indicates that respondents who have flood experience have a higher awareness than respondents that do not have previous flood experience. Therefore, the third hypothesis regarding the relation between flood experience and risk perception can be accepted with respect to the factor awareness. This can be explained by the phenomenon 'availability heuristic', which states that people who have previously experienced an important event (i.e. a coastal flood) can recall it more readily and are more aware of the magnitude of the consequences of that event (Tversky & Kahneman, 1974). However, previous flood experience has no significant impact on apprehension. This is not as expected, since apprehension contains an emotional component and having experienced a flood in the past can be considered as a personal experience.

Table 11: Coefficient of the regression model with awareness as dependent variable.

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-.116	.099		-1.168	.246
	Flood experience	.396	.184	.235	2.160	.034

4.2.2.3 Willingness to pay

The regression analysis with willingness to pay as the dependent variable and all the background variables as independent variables has an R^2 of 0.100 and an adjusted R^2 of 0.040. This indicates again that the independent variables cannot significantly predict the willingness to pay. However, gender and residence do have a significant coefficient. Therefore, another regression model is executed with only gender and residence as independent variables (see Table 12). In this model, the residence variable is not significant anymore (p-value > 0.1). Gender is the only significant variable, so the fourth and fifth hypothesis regarding the risk areas and socio-economic variables in relation to the willingness to pay can be rejected. Based on local insights, the positive relation between the male gender and the willingness to pay could be explained by the fact that men in a household might be more likely to be in charge of the budget and money in general and are thus also more likely to have a higher willingness to pay. There is however insufficient information to prove this assumption.

Table 12: Coefficients of the regression model with willingness to pay as dependent variable.

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-.177	.140		-1.268	.209
	Gender	.379	.177	.231	2.136	.036
	Residence	-.408	.280	-.157	-1.458	.149

4.2.3 Adaptation measures

The last part of the questionnaire focused on the perspective of people towards adaptation measures to reduce the risk of flooding in the area. Most respondents had no suggestions about possible adaptation strategies that could protect the area against floods. They stated that they never thought about it, as they have never felt unsafe in the area (see question 9). These respondents lived in both high and low risk areas. 32 respondents did suggest some possible measures, of which 19 pointed to dikes as a possible solution. The survey further indicated that most people would prefer larger adaptation strategies to protect the whole area rather than smaller, more indivudual, measures. Consequently, the second protection strategy of the IPCC to adapt the accommodation seems less appropriate than the third. The questionnaire also showed that the ecological value of the area and the accessibility of the beach are important factors for local inhabitants. Therefore, ‘soft’ structural solutions would be the most appropriate adaptation structures for the Sejerø Bay area.

13 out of the 82 respondents had already taken measures to reduce the risk of flooding, the majority of them (11) living in a high risk area. Small adaptation measures include buying a pump for excess water and constructing a better drainage system. However, some respondents stated that they also took these measures due to the problems with heavy rainfall and the rising groundwater table in the area (also seen in 4.1). Four people who were living in a lower risk area pointed out that they bought their house specifically for the lower risk, which matches the conclusion of the first hypothesis.

4.3 Limitations

During the questionnaire some limitations were encountered. First, the answers on questions 8-13 and 15-18 are subjective. For example, the difference between 'agree' and 'strongly agree' was estimated by the investigators based on the reaction of the correspondents. This may cause slightly different values for the risk perception and willingness to pay. Secondly, the formulation of question 15 was too complex, as it contained two different parts and had a negative questioning. Originally this question would have been used to analyse the willingness to pay of the respondents. Since it was unclear and difficult for the correspondents to interpret and answer the question, the results were not incorporated in the analysis. Question 19 was also not incorporated, as it overlapped with questions 13 and 14 and aimed at the same answer. Furthermore, the flood risk maps are generated with a relatively high resolution (10x10m), which was a time-consuming operation. However, only the subdivision between high and low risk areas was used in the second part of the analysis. Therefore, it would have been sufficient to make a risk map with a coarser resolution. Lastly, more thought should have been given to the construction of the hypotheses, as they were adopted blindly from Kellens et al. (2011) and the reverse was mostly found to be true. Not considering socio-cultural differences between Belgians and Danes is identified as one of the main weaknesses of this research. Assessing such differences would be an interesting starting point for future research.

5. CONCLUSION

The risk calculations resulting from this research showed that the coastline and the central lagoon area are most prone to coastal flooding. In 2050, the area at risk expands and the yearly estimated cost increases, but the difference between the mild and worst-case climate change scenarios remains relatively limited. By 2100, the area at risk will again expand and the difference between the mild and worst-case scenarios is stronger, indicating that the effects of climate change aggravate exponentially over time. Based on the 2050 RCP4.5 risk calculation, a low and high risk zone was delineated. The relation between these risk zones and the risk perception of the local inhabitants was investigated by means of a questionnaire. Two components of risk perception were identified, apprehension and awareness. Based on statistical analyses, low apprehension was related to a high risk zone and vice-versa. This relation was more pronounced for male residents and owners of a property. A comparable relation was, however, not found for the component 'awareness'. This indicates that the personal, emotional and affective component is important to stimulate people to live in a low risk area. In order to effectively influence the behaviour and the residential selection of the local inhabitants, providing more knowledge about potential risks does not suffice. Messages aimed at activating local citizens should therefore also contain an emotional and personal component. For example, by stating that 'a storm surge can cause a flood in the area of Sejerø Bay' (awareness of the risk), the inhabitants will not necessarily realize that they live in a high risk area. Based on the results of this research, a more favourable way of enhancing people's risk perception could be to state that 'due to a flood event, the water level in *your* house will be 10 centimetres'. By speaking to people's emotions regarding their personal dread, they could have a better perception of the expert risk assessment. Apart from the psychological manner of "protecting" people from coastal floods, based on the input of the respondents, recommended physical adaptation strategies for coastal floods could be larger 'soft' structural solutions such as artificial dunes.

In addition to coastal floods, other risks associated to flooding, such as heavy showers and rising groundwater tables, also pose a considerable threat to the summer house area. It could therefore be useful to include a more thorough study of these hazards in future research. It should be noted that the methodology of this analysis could serve as a basis for further study concerning other types of floods and their consequences. More specifically, the maximum damage map and the depth-damage curves could be reused in other flood risk analyses. Lastly, future research could validate the findings of this analysis and assess whether these are applicable to flood risk in general.

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ADAPTING TO SEA-LEVEL RISE(S) IN SEJERØ BAY

One of climate change's most impactful effect is the global rise in sea level, making coastal areas extra vulnerable. To investigate these effects, the universities of Ghent and Copenhagen started a collaboration. A damage map of Sejerø Bugt was made. In order to evaluate the risk perception and willingness to act of residents in Sejerø Bugt, this questionnaire was made. All information is handled anonymously. The investigation is part of an assignment for the course 'International Projectwork' and will only be used internally by these universities.

1. Are you owner of the property or tenant?

Owner	Tenant
o	o

2. Residing permanently?

Yes	No
o	o

3. Presence of children at the property?

Yes	No
o	o

4. Do you have a direct personal experience with past storm surges and floods?

Yes	No
o	o

5. Do you have a cellar?

Yes	No
o	o

6. Does the property have more than a ground floor (excluding cellar)?

Yes (more than a ground floor)	No (just a ground floor)
o	o

7. Is this residence elevated (floor to ground)?

Yes (> 10 cm)	No (0 - 10 cm)
o	o

8. I am worried about the danger of a storm surge in the Sejerø Bugt

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
o	o	o	o	o

9. A storm surge can have fatal consequences for the coastal area and its inhabitants

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
o	o	o	o	o

10. I experience staying at Sejerø Bugt as a threat to my safety

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
o	o	o	o	o

11. I expect great chances of storm surges causing floods in the coastal area

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
o	o	o	o	o

12. When I think of floods, I feel concerned

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
o	o	o	o	o

13. I am prepared to pay with the aim to reduce the risk of flooding

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
o	o	o	o	o

14. I am prepared to pay …% of the property value to protect against the risk of a flood

0%	0 – 5%	5 – 10%	10 – 20%	> 20%
o	o	o	o	o

15. I am prepared to pay for larger adaptation structures against flooding in the municipality, even if not every citizen is willing to

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
o	o	o	o	o

16. I think it is important that possible new adaptations take into account the values of local ecosystems

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
o	o	o	o	o

17. I think it is important that possible new adaptations will not hinder the accessibility of the beach

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
o	o	o	o	o

18. I prefer to pay for adaptations to my own house rather than larger scale adaptations e.g. dunes, dikes …

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
o	o	o	o	o

19. I prefer to pay for flooding adaptation on my own rather than paying extra taxes to the municipality to protect the community against flooding?

Yes	No
o	o

20. Which adaptation strategies do you think would be useful to prevent flooding in Sejerø Bugt?

_____
_____
_____
_____

21. Is there anything you already do to protect your property against the risk of flooding?

_____
_____
_____
_____

Look at the map

22. Is this the risk that you expected for your property?

Yes	No
o	o

23. How does this impact your willingness to pay?

I am prepared to pay less	No impact	I am prepared to pay more
o	o	o

24. What is your age?

_____

25. Gender

Male	Female	X
o	o	o

26. Education level (yes = highly educated/no = low(er) level of education)

Yes	No
o	o

27. Is the residence located in a high risk area or low risk area?

High risk	Low risk
o	o

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A LANDSCAPE ECOLOGICAL APPROACH TO NATURE DEVELOPMENTS IN DANISH AGRICULTURAL LANDSCAPES

Renée Balcaen, Lucas Demeyer, Lennard Derudder, Pieter Favoreel, Ziggy Sabbe & Victor Soenens

Odsherred Insights – 1st Edition
Denmark

GHENT UNIVERSITY
UNIVERSITY OF COPENHAGEN
ODSHERRED KOMMUNE
Geopark Odsherred
- UNESCO Global Geopark

1 INTRODUCTION

Danish biodiversity and ecosystems are under pressure. According to the 'State of nature in the EU' report more than 70 % of the habitats and more than 30 % of the species in Denmark are showing a bad conservation status (European Environment Agency, 2020). Different strategies, such as nature national parks ('naturnationalparker'), nature management plans and the establishment of the Danish Nature Foundation, have been proposed by the government to reverse the degradation of the natural environment (The Danish Government, 2014). Given that 61% of Denmark's total area is used for agricultural purposes (Danish Agriculture & Food Council, 2019), this challenge also applies for landscapes that are characterized by agricultural production. In order to improve the ecological values within Danish landscapes, the municipalities were tasked with designating nature areas on a Green Map of Denmark in their municipal plans of 2017. This map shows both existing and potential natural areas and "serve[s] as a kind of green compass that gathers existing initiatives and stakes out a common way forward" (The Danish Government, 2014). Although these plans in many ways can be seen as a step in the right direction, they fail to take into account the land use potential and instead build upon the unsustainable economic subdivision of Danish agricultural landscapes which is a remnant of the land reforms at the end of the 18th century (Svenningsen & Christensen, 2021).

Therefore, this study examined how ecological values and biodiversity can be improved in a Danish agricultural landscape by adopting a landscape ecological approach. The main objective was to create an ecological network that does not take the existing property structure as a starting point, but instead follows the ecological gradients in the landscape in order to increase the connectivity of natural areas. In other words, a more unbiased approach to environmental planning. First, the study area and its historical and political context will be described. Land sharing and land sparing strategies will also be explained in the theoretical framework. Second, the methodology will be presented of both the Multi-criteria Evaluation (MCE) and the interviews with various stakeholders. Third, the resulting maps from the MCE and the interviews will be combined in order to create a more unbiased ecological network map, containing both land sharing and land sparing practices. Finally, these results will be compared to the Green Map of the study area in order to decide whether the existing plans have adequately identified the most suitable areas for agriculture, on the one hand, and the most suitable areas for nature, on the other.

2 THEORETICAL FRAMEWORK

2.1 Study area

The study area roughly comprises the northernmost inland parts of Odsherred municipality. It is mostly centered around the small hamlet of Stenstrup, which has a typical feudal structure as was common in pre-industrialisation Denmark. The defining characteristic of this is the ring-shaped structure, with all houses-farms centered around a central square, with their respective lands extending from this center like a star. This can still easily be seen in the parcel structure around the hamlet. Stenstrup is the first eco-village in all of Odsherred (source: information board in the village). In general, the study area has more or less natural borders. In the west, it is delimited by the Kirkeåsvejen which connects the Sjællands Odde peninsula to the rest of Zealand. The north and northeast are similar in this regard: here, the border is formed by the summer houses and Sonnerup forest. Originally, this forest would also be included in the study, but it didn't really comply with the aim of the project, so this was scrapped. In the northwest and southeast, the village edges of Højby and Lumsås marked the study area. In the south and east, the borders were more artificial; here, the Nyrupvej and Lyngvej roads were chosen. The study area totals around 18.7 km^2, making for an array of agricultural landscapes which is quite diverse in terms of land use, population geography, topography and soils.

As only three days were spent on the terrain, of which a large part was taken by on-the-ground interviews, it was not possible to make a detailed, quantitative survey of the whole study area; only a quick qualitative survey was possible. As such, a short overview will be given on how the study area can be divided (Table 1). All images in the table were made during the exploration of the study area.

Table 1: Overview of the study area

Part of the study area	Images
Marshlands Especially in the south and east of the study area, there are a lot of pools in low-lying area, often surrounded by marshlands with lots of reed and small forest patches. Most pools appear to be natural, but some, like the Højby Sø, were man-made.	
Southern fields In the middle and southwest of the study area, population is a little sparser, and parcels are rather large. Mostly grain is grown here. There are small instances of nature, like hedges or individual trees, but these are not large enough to carry much ecological significance.	

Central hills The east, center and northwest of the study area is dominated by hills of glacial origin. Apart from the northwest-southeast axis, there is little definite structure in them. The hills are mostly used for agriculture, though the steeper parts are more likely to feature forest patches or meadows for livestock. The hills are similar overall to the southern fields, albeit a little more densely populated, featuring the hamlet of Stenstrup itself for example.	
Klinte Sø The Klinte Sø in the northeast of the study area is a former lake which was dried out in the 1850s to make room for agriculture (Hansen, S.D.). Because of its former status, it's still a very flat area, showing almost no topographical prominencies. The area is delimited by a canal on the southern side and is mostly used for agriculture. There might be plans to reflood it soon.	
North The north of the study area, near Lumsås en Sonnerup is closest to the sea. It is less dominated by crops like grain, and more by horticulture, forests and meadows. Because of this, it has a much greener appearance than the rest of the study area. Parcels are generally not as large as in the rest of the study area.	

2.2 Historical context

As was the case in the whole of Western Europe over the past 200 years, the land use in Denmark changed substantially in favour of agriculture. Along with an expansion of the used agricultural area came an intensification which is still in place today. This was all part of the enclosure movement (1760-1820) which saw the erasure of the outdated medieval land use structure with small parcels in favour of the aforementioned agricultural expansion and bigger parcels. This also continued further throughout the 19th- and 20th-century in Denmark and was accompanied with a large scale afforestation (Svenningsen et al., 2015). The decrease of forest cover however was halted and was even reversed since the early 1800's where the total land cover of forests was only 2-3% or 100.000 hectares compared to the 14,1% (Forests of the World, n.d.) or over 400.000 hectares (Madsen et al., n.d.) it is today. Land uses In Denmark that were impacted the most and are still less present today than before the start of the enclosure movement are

heathlands, wetlands and meadows (semi-natural grasslands). This can be seen on cadastral maps made at the end of the 18th century which show a significantly higher rate of semi-natural grasslands than appear nowadays. These cadastral maps were produced with a double basis in mind: "(1) a backward-looking, descriptive component, describing the conditions and landscape at the time of mapping – the result of past land management; and (2) a forward-looking prescriptive component, defining new properties – the action space of future land management." (Svenningsen & Christensen, 2021). This formed the basis of the idea of the Danish government to "restructure the local properties to obtain an optimal balance between local preconditions and the authoritative political wish for change" (Svenningsen & Christensen, 2021). This forward-looking prescriptive component led to a mismatch between the current cadastral structure and the geo-ecology of the landscape. In Figure 1 you can see an example of how land use has not been adapted to the landscape but rather follows cadastral delineations which makes it difficult for farmers today to manage the land in an adaptative, ecologically targeted manner. This is also the case in the study area around the village of Stenstrup.

As can be seen in Figure 2, a discrepancy exists between the area around the village in 1788 and what the area looks like today. The map of 1788 shows a much bigger area of semi-natural grasslands than can be seen on a satellite picture and in the current landscape. These same areas that are marked as red in Figure 2 can be seen on all the following cadastral maps made in the years 1788, 1860 and 1878, but seem to disappear completely from the cadastral maps starting in 1947 and onwards. This doesn't mean that they suddenly got erased from existence, but rather that the definition of what constitutes a semi-natural grassland or meadow had changed. The definition changed from covering general land use and the presence of grass to a more biologically oriented definition about the presence and absence of certain species. In that way, a lot of semi-natural grasslands seem to have disappeared physically and now experience a different land use, but in truth were never really there in the first place (Svenningsen et al., 2015). This holds true in an important amount of cases, but cannot completely explain the stark decline of semi-natural grasslands in the past centuries. Another important factor in the disappearance of these semi-natural grasslands is, as mentioned earlier, the forward-looking component of the cadastral maps made up from 1788 onwards. These new cadastral layouts were indeed based upon previous cadastral delineations, but before the making of the maps, few of these delineations had been physically present in the real world. It was these cadastral maps that paved the way for farmers to build physical borders around the newly given parcels so that what was written on paper (i.e. the cadastral maps) could be made visible in the real world. It was these physical borders that cut through many of the previously present semi-natural grasslands that helped their disappearance because they were suddenly very much in the way of the farmers who wanted to use every piece of land in their possession (Svenningsen & Christensen, 2021).

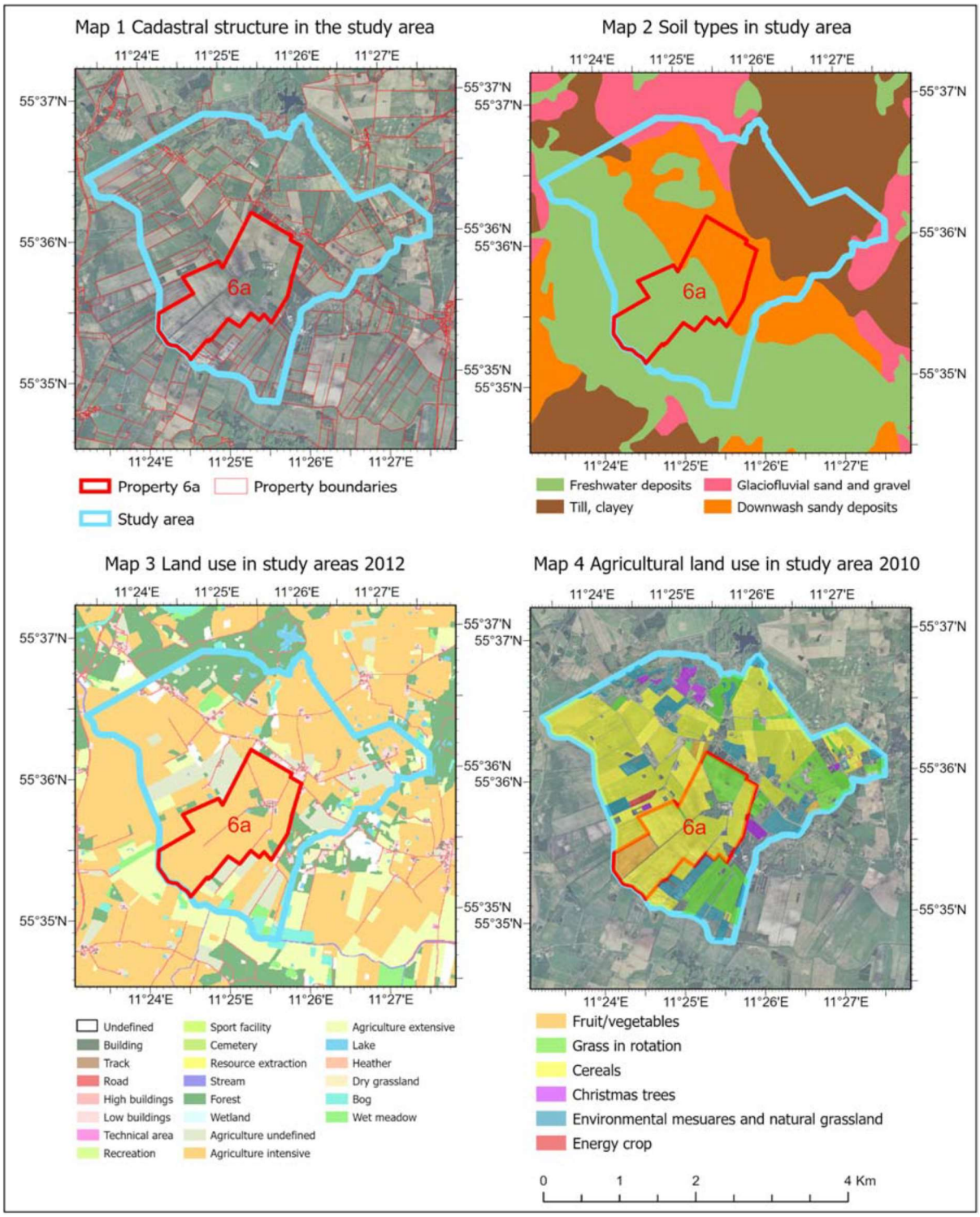

Figure 1: A comparison of cadastral subdivision, soil, land use, and agricultural practices, illustrating how land use has not been adapted to the landscape but follows cadastral delineations in the areas of Aamose by and Brokob by (Svenningsen & Christensen, 2021).

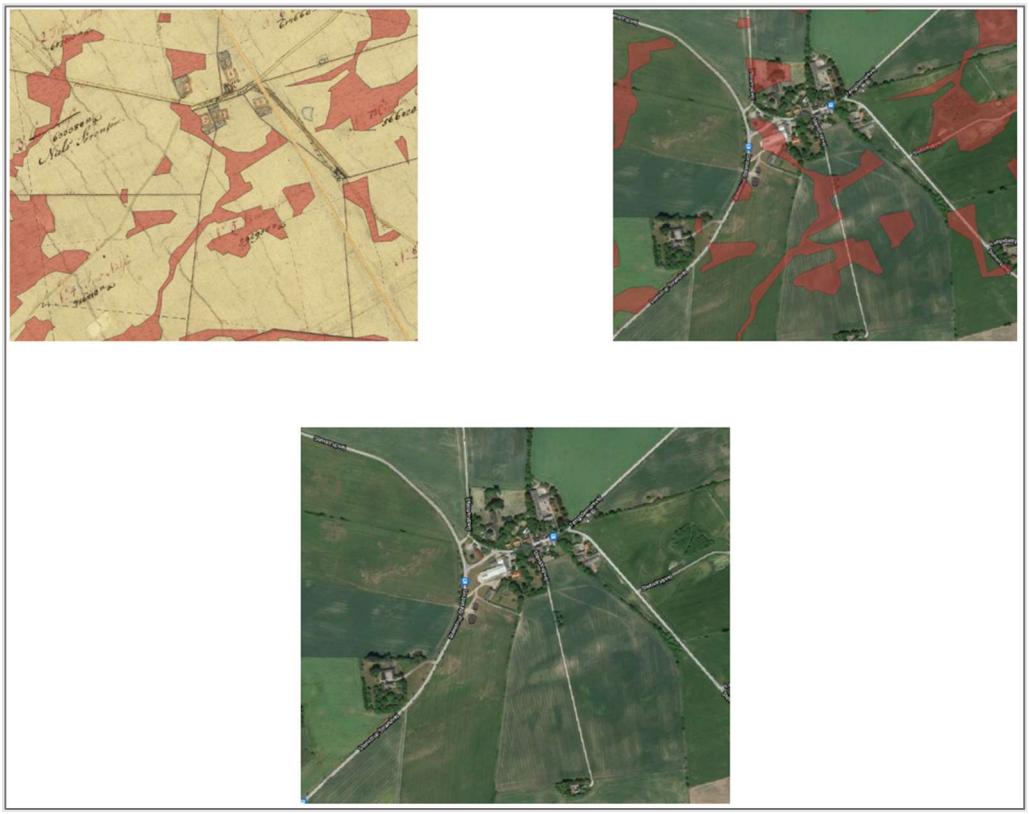

Figure 2: comparison of the village of Stenstrup in 1788 with semi-natural grasslands marked in red (top left) (Juel, A. 1788), Stenstrup on a satellite image of 2020 with the same areas marked in red (Google Maps, 2020), and Stenstrup on a satellite image of 2020 without the red areas.

This mismatch between the current cadastral landscape and the geo-ecology poses problems in land management that can only be solved with intensive cooperation across cadastral boundaries or with a restructuring of the existing cadastral landscape (Svenningsen & Christensen, 2021). This paper tries to propose some form of restructuring in the area around the village of Stenstrup based on the concepts of Land Sharing and Land Sparing by using the output of a Multi-Criteria Evaluation. These concepts will be further explained in this paper as well as the necessary policy context to better understand the possibilities for the cadastral restructuring in the area around Stenstrup.

2.3 Policy context

Increasing biodiversity and the ecological value of agricultural landscapes has been a recent hot topic in Denmark. Both nationally and locally, plans and visions are created to increase the natural value of Danish landscapes (Odsherred Municipality, 2017; Vogdrup-Schmidt et al., 2019). Additionally, the municipality created a working group to develop a strategy and to increase awareness on (the future of) biodiversity in the municipality (Grüttner et al., 2021). Odsherred has little nature compared to the national Danish average. Therefore, the municipality itself has already explored possibilities to create more nature. Certainly the (former) wet areas such as bogs and meadows receive extra attention due to their ability to remove nitrogen and increase biodiversity in the region. In the study area, the policy plans and visions focus

on a former lake named Klint and lots of small water-suffering areas on agricultural fields. Besides restoring natural wet areas, also restorations of natural dry areas such as heathlands are on the agenda (Grüttner et al., 2021). Furthermore, the Green Map of Denmark is an important guideline it shows habitats of species, such as Natura 2000 areas and conserved areas by article 3 of the Nature Conservation Act, which are of great importance to Denmark and Europe. The map forms the basis for Odsherred's vision on nature creation as their priority is to counteract fragmentation by creating connections between existing nature areas (Odsherred Municipality, 2017).

The goal of this project is to identify places for nature. Therefore, it seems interesting to gather more information on useful instruments. So, the identified places for nature not only meet the theoretical criteria, but are also realization-oriented. The instruments considered for this project can be classified in either a land sparing or land sharing-related-method. Land sparing methods include selling a parcel for nature development or participating in a land consolidation project. While land sharing instruments include creation of small nature patches on agricultural fields or applying less destructive agricultural methods.

Land consolidation is often used to facilitate the fast-changing dynamics of a landscape (Johansen et al., 2018). Characteristic to a land consolidation project is the involvement of many stakeholders making it a very complex process. To be successful a common agenda among the different stakeholders needs to be formulated. This common goal could be sustainable land use planning, where all stakeholders can develop their potential (Johansen et al., 2018). However, there needs to be a sound communication and objective data available to all, to enhance dialogue among stakeholders (Kania & Kramer, 2011). Therefore, this project can be seen as a provider of more objective data to stimulate land consolidation in the future. Land consolidation is not new in Denmark, since the end of the 18th century this activity has been exploited (Latruffe and Piet, 2014). From an agricultural economic perspective this measure is interesting for those small, irregular shaped and remote located fields which increase labour costs, decrease crop choices and use of machinery resulting in higher productivity costs (Olsen et al., 2016).

In the past land consolidation in Denmark mostly took place to benefit the involved farmers, however nowadays it mostly happens to increase ecosystem services of the landscape (Johansen et al., 2018). Therefore, farmers no longer only experience the benefits of the measure, but increasingly have to deal with land use restrictions and land expropriations. In exchange they receive financial compensation (Hartvigsen, 2014). In Denmark land consolidation can only happen voluntarily. Landowners can start the process alone, but often a central planner is assigned to coordinate between different landowners. This central planner can be a private consultant or someone from the Division of Land Consolidation employed by the Ministry of Environment and Food (Johansen et al., 2018). Besides the instrument of land consolidation, recently in 2020 the Multifunctional Land Redistribution Fund was launched. The focus is on enhancing multifunctionality on a local level while farmers can obtain better farmland allocations (Danish Agency for Agriculture, 2021b). Such a project can only be initiated by the local municipality or by the Nature Agency. Additionally, funding will only be provided to projects where at least one European Union Directive for

environment is implemented and the project must support three national interests (Danish Agency for Agriculture, 2021a; Bondgaard, n.d.).

Within the study area there are already many small nature patches in the arable land. Those include burial mounds, ditches, hedges, pastures, old earth and stone dikes, field roads etc. and function as habitats or steppingstones for multiple species (Grüttner et al., 2021). Those small landscape elements are not protected by article 3 of the Nature Conservation Act, although some such as hedges and dikes can be protected by the Museum Act. However, the Museum Act only takes into account the cultural value of these elements making allowing them to be easily removed (Pedersen, n.d.). Lakes and ponds in agricultural fields are protected as nature areas by article 3 of the Nature Conservation Act. As a result, lakes and ponds are not at risk to disappear from the landscape. Nevertheless, they are often infiltrated with chemical pesticides and fertilizers which reduces their ecological value. Therefore, more thoughtful agricultural methods on fields surrounding these lakes and ponds should be considered (Grüttner et al., 2021).

The working group on biodiversity of the municipality also advocates to use less destructive agricultural methods (Grüttner et al., 2021). These methods include reducing chemical pesticide use, planting flower strips, cultivating diverse crops and applying organic manure. These recommendations are inspired by research of Tamburini et al. (2020) where 5.100 studies were analysed to conclude that fields who implemented these measures did not suffer yield loss compared to intensively cultivated fields (Tamburini et al., 2020). The working group of Odsherred aims to cooperate with the local agricultural organization who can recommend such measures to their members (Grüttner et al., 2021).

2.4 Land-sharing and/or land-sparing

Biodiversity is of crucial importance for the functioning of ecosystems and human well-being (Brunbjerg et al., 2016). Halting the global biodiversity loss has therefore been a central policy target for several years but has by no means been achieved yet. According to the United Nations (United Nations, 2021), an 'ambitious' policy agenda is needed that calls for conservation initiatives across all sectors, including the agriculture sector since farmed areas represent a large part of the landscape, especially in Europe (Brunbjerg et al, 2016). Hence, one of the major challenges for the European agriculture sector is trying to reconcile biodiversity conservation goals with agricultural production. A long-running discourse that addresses this challenge is the 'land-sharing vs land-sparing' debate (Fischer et al., 2013; Grass et al., 2019; Grass et al., 2020). However, recently the debate has shifted away from the dichotomy of either-or-solutions towards more integrative perspectives that consider the benefits and synergies arising from combining both approaches in the same landscape (Grass et al., 2019; Grass et al., 2020). (Brunbjerg et al., 2016). Halting the global biodiversity loss has therefore been a central policy target for several years but has by no means been achieved yet.

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2.4.1 Land-sharing

The land-sharing strategy represents the 'traditional 'European approach' and aims at integrating biodiversity conservation into agricultural production systems on the same area of land by employing less intensive, wildlife-friendly, farming practices It thereby reflects the concept of a multifunctional agriculture system, which assigns a series of functions to farmland including production, resource protection, cultural services, etc (Fischer et al., 2013; Herzog & Schüepp, 2013, Grass et al., 2020). However, to achieve similar yields compared to highly intensified production systems, land-sharing production systems typically require larger footprints, potentially at the expense of natural lands in the vicinity. Nonetheless, these extensively managed systems are needed to preserve the 'ordinary' farmland species which play a crucial role in the provisioning of ecosystem services (Grass et al., 2020). Moreover, these lands can hold some of the highest biodiversity levels per unit area, plus can provide crucial refuges for plants and invertebrates of highest conservation concern. However, their maintenance requires constant extensive usage (for example by mowing or grazing with livestock) to avoid succession of woody vegetation, which can only be realized in a land-sharing context (Grass et al., 2019).

Land-sharing is thus primarily used in landscapes that are dominated by agriculture, as agricultural production is linked to the local 'agrobiodiversity'. The agrobiodiversity includes the 'planned biodiversity' (for example the cultivated crop species or planted trees for shade management) as well as the 'associated biodiversity' (for example species using crop resources or living in the agricultural matrix adjacent to production areas). These species provide ecosystem services that are crucial for the agricultural production. Two of the most important services for agricultural production are crop pollination and biological pest control, which are easily promoted by land-sharing practices (Grass et al., 2019; Grass et al., 2020). Although not all pollinator or natural enemy species may be conserved on these agricultural lands, land-sharing landscapes can maintain high numbers of generalist species on which ecosystem services depend. Land-sharing may be particularly efficient if the associated measures span multiple scales from small-scale infield solutions (for example intercropping, beetle banks within the fields, hedgerows, flower strips, etc.) to large-scale structurally diverse agricultural matrices. (Grass et al., 2019).

2.4.2 Land-sparing

In contrast, the land-sparing approach focusses on conservation of natural land that is spared from human land use. Hence, land-sparing leads to a spatial segregation between biodiversity conservation and agricultural production (Grass et al., 2019; Grass et al., 2020). This because, according to the land-sparing strategy, the goal of biodiversity conservation is easier achieved by intensifying the agricultural production

in one place (attaining higher yields per hectare), so more land would be available for biodiversity conservation elsewhere (Fischer et al., 2013; Herzog & Schüepp, 2013).

Even though land-sharing conserves high species richness, studies have shown that species' populations often decline when compared to natural habitats, favouring a land-sparing strategy to reconcile biodiversity conservation with agricultural production (Grass et al., 2019). Therefore, there should be no doubt for local, regional and international policies to protect the pristine natural areas that still exist today despite the increasing pressure from human land use. Such undisturbed natural land supports high biodiversity and high levels of endangered species that need protection to mitigate current global biodiversity loss (Grass et al., 2019; Grass et al., 2020). Also, for species that that require undisturbed natural habitats and are thus incompatible with agriculture, land-sparing is the only way for in situ conservation. Here, large and continuous habitat blocks that minimize negative effects of habitat fragmentation are most preferable, particularly for conservation of species that avoid habitat edges or that are associated with native habitats (Grass 2019).

Lastly, for land-sparing practices to be successful, good governance of protected areas and efficient management of productive land are key. However, also the social-cultural and political context of the concerned region needs to be considered. Excluding traditional inhabitants or land-users from protected areas may be ethically objectionable; this could lead to the destruction of cultural identity (e.g., nomadic herders) and might negatively impact the ecosystem in questions (e.g., through lack of management) (Grass 2019; Grass et al., 2020).

2.4.3 Combining land-sharing and land-sparing

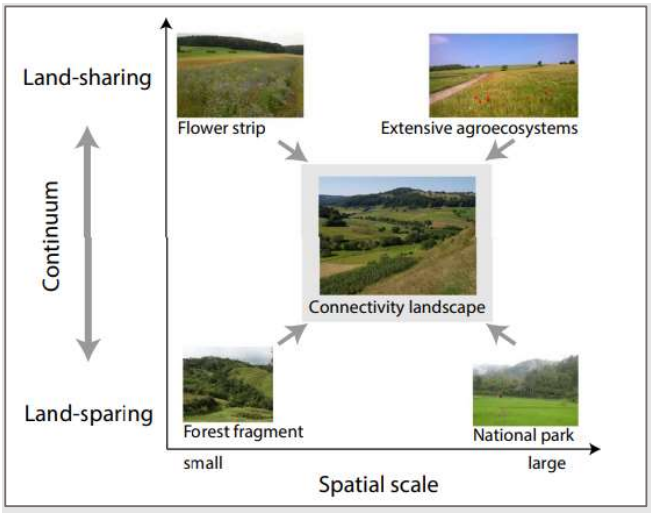
Today, it has become clear that the traditional land-sharing vs land-sparing dichotomy fails to capture the real-world complexity of nature conservation and agricultural practices. (Grass et al., 2019; Grass et al., 2020). For example, most extensive grasslands are semi-natural habitats that have a high ecological value that require constant agricultural management for their maintenance to avoid succession, which puts them on the land-sharing side of the dichotomy. However, these grasslands can vary greatly in agricultural productivity and ecological value, with some resembling more clearly land-sharing strategies (for example organically managed pastures) and others lending more towards the land-sparing side (for example calcareous grasslands that provide insignificant agricultural returns, that are managed for nature conservation only) (Grass et al., 2020). Instead, it is argued by scholars (Grass et al., 2019; Grass et al., 2020) that land-sharing and land-sparing are simply the extreme endpoints of a 'share-spare-continuum'.

Furthermore, both land management strategies are needed to really reconcile biodiversity conservation with agricultural production in European farmlands. While land-sparing is needed to preserve the last of Europe's wilderness, land-sparing is equally necessary to conserve the traditional agroecosystems which are also of outstanding ecological value (Grass et al., 2019; Grass et al., 2020). However, for all measures to be effective, they need to be strongly integrated into the landscape. Hereby, high connectivity of the

landscape matrix is required to facilitate frequent dispersal and colonization of habitat patches by species. Here, it will be crucial to create the necessary ecological steppingstones and corridors between agricultural land and large patches of spared natural land, to ensure the connectivity in the landscape (Grass et al., 2019).

In conclusion, and as illustrated in Figure 3, the successful management of multifunctional agricultural landscapes, where biodiversity conservation and agricultural production are harmonized with each other, requires the combination of context-specific land-sharing and land-sparing measures within spatially well-connected landscape mosaics, resulting in the so-called (land-sharing/- sparing) 'connectivity landscapes' (Grass et al., 2019; Grass et al., 2020).

(A)



(B)

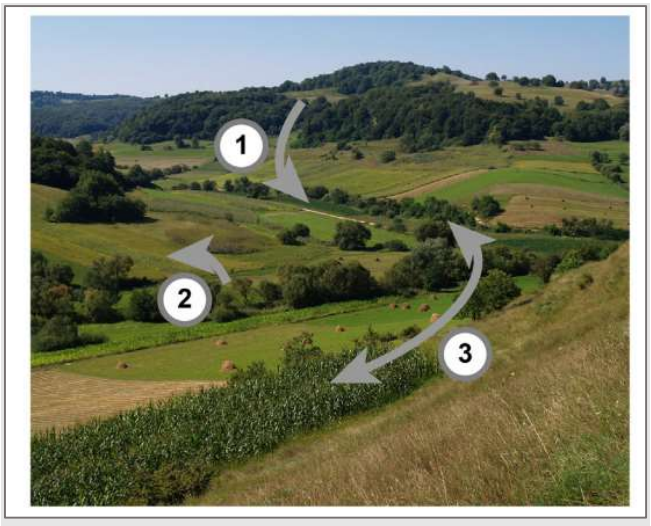


Figure 3: Land-sharing/-sparing connectivity landscapes. (A) These landscapes combine land-sharing and land-sparing measures across spatial scales and extent to promote biodiversity conservation and ecosystem services provisioning. (B) A structurally diverse landscape matrix promotes landscape connectivity to ensure spillover from (1) spared landscape elements (for example natural habitats) and (2) shared elements (for example crop boundaries) to agroecosystems and vice versa. Additionally, (3) high landscape connectivity facilitates immigration and emigration processes that are essential to counter extinctions in fragmented landscapes (Grass et al., 2019; Grass et al., 2020)

3 METHODS AND SOURCES

3.1 Methodological framework

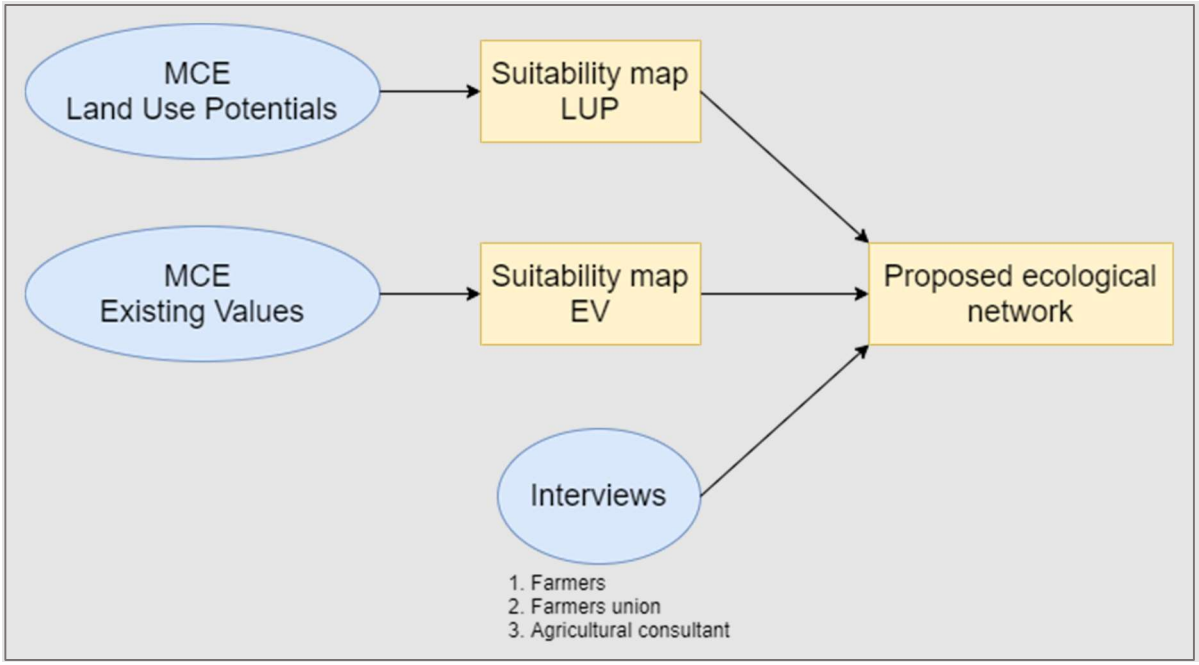


Figure 4: Methodological flowchart (Lennard Derudder, 2021)

There were two major components in this project: a more technical, GIS-based part constituting of two Multi-criteria Evaluations (MCEs), and a series of more qualitative research methods constituting of interviews with local stakeholders (Figure 4). The Multi-criteria Evaluations are based on several non-intercorrelated layers, provided by various Danish sources. Due to the limited timeframe and the limited number of stakeholders, a truly quantitative survey proved to be impossible; therefore, more qualitative and in-depth interviews of various stakeholders had to be opted for. Both the MCEs and the interviews serve as major inputs for the proposed ecological network map. This network map will mostly be a qualitative one since firstly not all the input is quantitative, and secondly a qualitative proposal consisting of zones and corridors in which nature could be developed is much easier to interpret than a map which shows a plan for every individual parcel.

3.2 Multi-criteria Evaluations (MCEs)

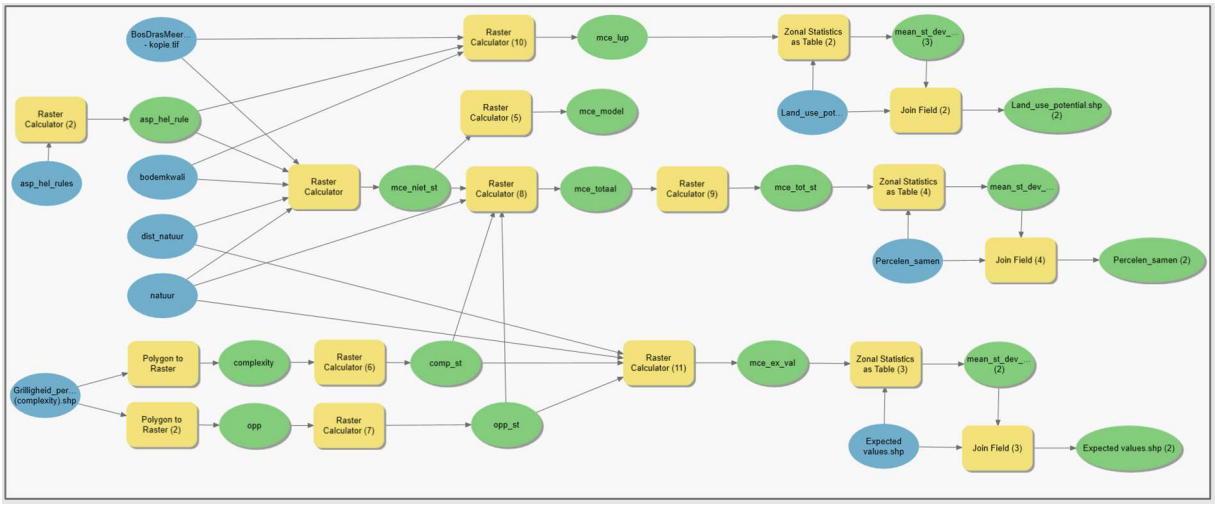


Figure 5: Cartographic model of the MCE (Lennard Derudder, 2021)

Multi-criteria Evaluations are used to assess the suitability of each element of a dataset for a certain purpose based on several factors, in which each of the elements has a certain value. In geographical research projects like this one, MCEs are usually applied to raster GIS datasets in which a value per pixel is calculated. In this project, the suitability for agricultural purposes of every pixel in a raster of the study area is calculated. The main reasoning used is that parcels being better suited for agricultural uses implies that they're less suited for giving back to nature, et vice versa. As it's always about striking a balance between conserving and improving the state of nature on one side and preserving agricultural interests on the other hand, MCEs might be a very helpful tool.

Since the resulting proposed ecological network map needs to be as unbiased as possible (i.e. it needs to factor in the potential of the land and not reinforce the existing imbalance), two MCEs were carried out. The first one, dubbed "land use potentials", only uses factors which are natural or at least independent from the existing parcel structure, and is supposed to approach the land as it's supposed to be in its natural state. The second, dubbed "existing values", does take the parcel structure into account and hence starts from the parcels as they are and might as such offer the more practical solutions of both. Both can be compared and used to assess the potential for constructing ecological zones and corridors in the study area. More so, they can be very helpful as a guide for future policymakers in the area.

The resulting suitability maps can be used to identify which parts of the study area are better left as agricultural areas and which parts can be used to create, expand or connect nature. Several factors and constraints were considered, eventually resulting in three factors for the "land use potentials" MCE and three factors and one constraint for the "existing values" MCE. Both MCEs use entirely different factors and constraints because of their nature. Johansen et al. (2018) proposed five factors: "farm economics" , "environmental protection", "biodiversity conservation", "outdoor recreation" and "rural development" - these were used as a guideline for which MCE factors to use in the project. Eventually, a few similar variables

were chosen that have a similar scope and explaining factor. The factors and constraints are represented in Table 2 below.

Table 2: Indicators and datasets used in the Multi-Criteria Evaluations

MCE	Criteria	Indicator	Data source	MCE weight
Land use potentials	Factors	Historical wetlands	Geodatastyrelsen (s.d.), hkpn.gst.dk	-0.1
		Slope-aspect	Styrelsen for Dataforsyning og Effektivisering (2007), https://download.kortforsyningen.dk/content/dhm-2007overflade-16-m-grid	0.2
		Soil quality map	GEUS (2011), https://www.geus.dk/produkter-ydelser-og-faciliteter/data-og-kort/danske-kort.	0.4
Existing parcels	Factors	Distance to nature	Miljøstyrelsen (2018), https://mst.dk/service/miljoegis/hent-data/	0.3
		Parcel size	Danish Agency for Agriculture (2019), https://kortdata.fvm.dk/download/Index?page=Markblokke_Marker	0.05
		Parcel complexity	Danish Agency for Agriculture (2019), https://kortdata.fvm.dk/download/Index?page=Markblokke_Marker	0.15
	Constraint	Existing nature	Miljøstyrelsen (2018), https://mst.dk/service/miljoegis/hent-data/	N/A

3.2.1 Land use potentials MCE

Historical wetlands

The historical wetlands were used as an indicator of which lands are easily flooded, keeping in mind that if a certain area couldn't be drained at the end of the 18th century with the available techniques, it was and still is most likely an area that is naturally prone to flooding. The locations of these wetlands are based on the historical cadastral maps mentioned in section §2.2 and were made at the end of the 18th century from 1782 to 1788. These maps were downloaded from the *Historiske Kort På Nettet* website (hkpn.gst.dk, s.d.) and were imported and georeferenced in QGIS. In order to make them suitable for an MCE, the wetlands were first polygonised and then rasterized with a 10-meter resolution. This resolution was chosen since some location insecurity was presence in both the cadastral maps and the georeferencing. An example of

how the historical wetlands were polygonised can be seen in Figure 2. As for the land use potentials suitability map, if a pixel shows the presence of a historical wetland, it will be less suited for agriculture than a pixel without the presence of a historical wetland.

Soil factor

In order to identify the main indicators for analyzing **soil quality**, some contextual information about Denmark's soil map is needed. According to Adhikari et *al.* (2014), nearly two-thirds of Denmark's land surface is used for intensive mechanized agriculture. These activities are facilitated by a relatively flat and smooth topography, albeit the land surface is rather complex in nature. The genesis of the soils can be traced back to the Weichselian geological stage (0,116-0,0117 Ma) in which multiple glaciations, late glacial and post glacial-marine transgressions formed the current topography (Adhikari et *al.*, 2014). Most of the eastern and central parts of Denmark are developed in moraine landforms with loamy soils, rich in soil clay content, more precisely luvisols and cambisols when based on the FAO 1990 legend (Adhikari et al., 2014). The study area is covered with luvisols.

After analyzing the GEUS soil map (2011) of the study area, seven **soil types** can be distinguished: Aeolian sand, freshwater deposits, marine sand and clay, beach ridges, till – clayey and fine sandy, glaciofluvial sand and gravel and downwash sandy deposits. An ordinal scale must be made to sort the soil types from least (0) to most (6) usable for agriculture (see Table 3) primarily based on soil particle texture. To draw up an ordinal score, four indicators are used: Contents/texture (GEUS, 2011), general topography (GEUS, 2011), erosion by wind and wind (Schjønning et al., 2009) and soil used agriculture (GEUS, 2011). All, except for the last indicator, tend to lead to an unbiased classification. As can be seen in Table 3, per indicator and for each soil type, a score is assigned, resulting in a total score when all the partial scores for each soil type are summed up. A raster file is required for the further development of the MCE. When the soil map is converted into a raster map, each pixel contains the value of the soil type based on the location on the GEUS soil map.

Table 3: Quantifying the soil quality of the study area, based on GEUS (2011)[1,2,4] and Schjønning et al. (2014)[3].

Soil classification (GEUS, s.d.)	**Aeolian sand**	**Freshwater deposits**	**Marine sand and clay**	**Beach ridges**	**Till, clayey and fine-sandy**	**Glaciofluvial sand and gravel**	**Downwash sandy deposits**
General soil quality parameters							
Contents/ Texture[1] (/2)	sand	*peat, gyttja,* clay, silt, sand	clay, sand	gravel, coarse sand	clay, fine sand	gravel, sand	sand
	0	**2**	**1**	**0**	**1**	**0**	**0**
gen. topography based on alt.[2] **(/1)**	low	high	low	low	high	low	high
	0	**1**	**0**	**0**	**1**	**0**	**1**
Erosion by water and wind[3] **(/1)**	Highly erodible	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
	0	**1**	**1**	**1**	**1**	**1**	**1**
Soil used in agriculture[4] (/2)	No	Yes	Partly	No	Yes	Partly	Yes
	0	**2**	**1**	**0**	**2**	**1**	**2**
Total score	**0**	**6**	**3**	**1**	**5**	**2**	**4**

Negative scores raster file:
- Score -1: villages
- Score -2: lakes (water)
- Score -3: error

Slope and aspect

Also important are the slope and aspect parameters, because these have a defining impact on whether a parcel is suitable for agriculture or not; especially for crop farming (Vogdrup-Schmidt *et al.*, 2019). The steeper a parcel is, the sooner it will suffer from adverse effects of erosion, and the harder it will be to maintain crops on it. Also, the more a parcel is oriented towards the north, the less sunlight it will receive and hence, the less productive it will be – especially in areas with relatively higher latitudes like Denmark.

However, it does not make sense to treat both variables as separate factors in the MCE, for the simple reason that "slope" has a crucial impact on "aspect". A complete absence of any form of topographic irregularities will nullify the impact of the aspect ratio. Therefore, it is recommended to bundle these two variables into one: "slope-aspect". Originally, a more continuous calculation was used, building from a self-defined formula, but eventually, a more discrete classification based on the "Aspect-Slope" function in ArcGIS Pro was opted for, because the results were easier to interpret. This latter function assigns discrete values based on a combination of both aspect and slope. These values were then rescaled to the [0;1] interval so that north facing and steeper parcels get a value of 0 and that flat and south-facing parcels get higher values. This result does not need standardisation and can thus directly be used in the MCE.

3.2.2 Existing parcels MCE

Parcel size and parcel regularity

Because of the nature of agriculture, it is argued that larger parcels with more regular shapes are better suited for agriculture because they're easier to cultivate and maintain. Smaller parcels with more complex shapes are less suitable for agriculture. Thus, both were used as two separate factors in the "existing values" MCE. The **parcel size** can easily be calculated using ArcGIS Pro, the **parcel regularity** is calculated using a self-defined index:

$$\text{Parcel regularity} = \frac{A_{\text{parcel}}}{A_{\text{convex hull}}} \cdot \frac{A_{\text{parcel}}}{A_{\text{circumscribed circle}}}$$

With "A" being "area". This index is based on the convex hull and circumscribed circle of any of the parcels and ensures that parcels don't have many protrusions on one hand and are not too elongated on the other hand – a perfectly round parcel will have a score of 1, a very complex parcel a score nearing 0. Parcel regularity doesn't need standardisation, parcel size does, by linear stretch. Because some very big parcels have a disproportionate effect on this standardisation, they aren't included in the standardisation and instead given a value of 1.

Nature indices

An important part of the Existing Values MCE is the distance to existing nature. Because nature areas are already sparse in the study area, it was reasoned that no nature parcels should be readressed as agricultural areas. Because of this, **existing nature** patches are treated as constraints. Next, it was reasoned that the closer a parcel is to an existing nature patch, the better it is to readress this land as nature. Lands which are located far from existing nature patches are thus deemed to be more suitable for agriculture, giving rise to the **distance to existing nature** factor.

3.3 Interviews

A considerate share of the fieldwork in Odsherred went to taking interviews. By doing qualitative research, we want to get an insight on how the local stakeholders perceive the topic of nature conservation in an agricultural context. For that reason, we wanted to interview several farmers and provide a general idea of the stakeholder's opinion. The goal was to interrogate five farmers and to preserve our objectivity, we interviewed other stakeholder groups as well. For instance, a chairman of a local farmers' union and an agricultural consultant of a non-profit organization. These stakeholders will be grouped as the 'policy-makers'. To get this more nuanced image about the points of view of all stakeholders, we needed to keep the questions to different kinds of stakeholder's groups as similar as possible, so that a nuanced comparison of the answers would be possible.

To structure our interviews, we used different themes as a tool around which we built our questions. Firstly, we posed several (personal) questions about the interviewees, varying from age to occupation and involvement within the community. In addition to that, we asked the farmers how much land they manage and if they could point out all the parcels they own and/or manage. Secondly, we asked about the (already taken) nature measures on the agricultural lands: what regulations enforced by local and national governments they must take into account or how the less productive soils are being managed. Lastly, several questions on how participation in a land consolidation project or creating nature would take place. For instance: their position on land swapping projects, designing small biotopes in the municipality's parcels or their opinion if the municipality would buy the least productive parcels to give room to nature development. In addition to that, we specifically asked farmers if they are already implementing measures to improve nature.

4 RESULTS

4.1 Multi-Criteria Evaluations (MCE)

Since two MCE's were carried out, two resulting suitability maps were produced. The result of the MCE that only considered existing values (i.e., the parcel size, parcel complexity, distance to existing nature and existing nature itself) can be seen in Figure 6.

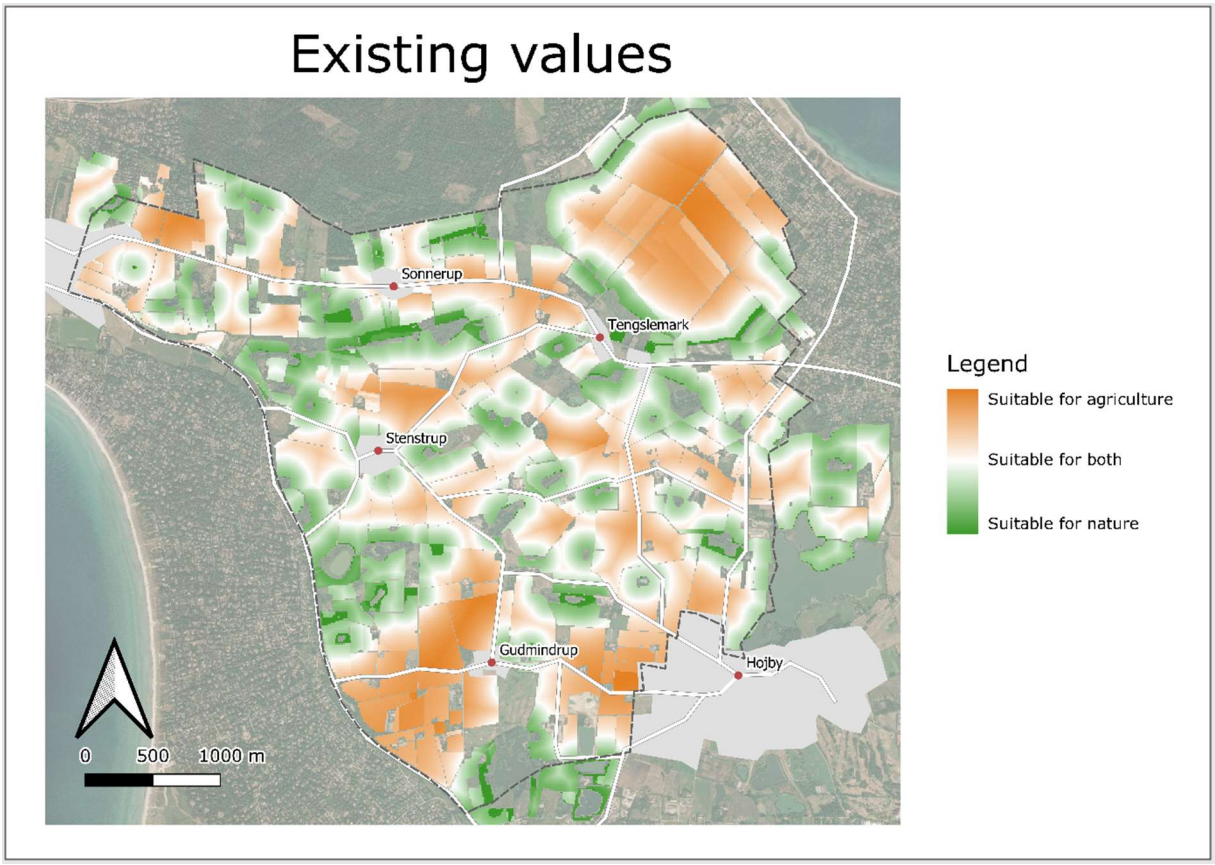


Figure 6: Output of the MCE that takes into account the existing values (Lennard Derudder, 2021)

This MCE clearly shows the existence of good agricultural land in the northeast where the former lake *Klinte Sø, which* got drained in the 19th century (Hansen, s.d.), used to be located. This is due to the big size of these parcels and the fact that they are mostly of a uniform shape. The absence of existing nature patches also plays a big role. In the southwest around Gudmindrup, a big patch of favourable agricultural land can also be found. The favourability here is mainly due to the absence of existing big nature patches, but the parcels themselves don't seem to be that big or uniform in shape. As for land suitable for nature, some clusters can be found in the south and along the western part of the study area. These suitability spots for nature are mainly due to the abundance and relative proximity of existing nature patches which gives them a low suitability score for agriculture. The rest of the study area is mainly of mixed suitability.

The results of the MCE that only covered land use potentials (i.e. soil quality, historical wetlands and a combination of aspect and slope) can be seen in Figure 7. In the output of this MCE, the area of the *Klinte Sø* is suddenly a lot less favourable for agriculture and together with its surrounding lands is now more suitable for land sparing. This trend is found along the entire northern part of the study area which consists of bad soils and historically wet areas. The rest of the study area is mostly a mix of good land for agriculture and land that's good for both nature and agriculture in which land sharing would be preferable.

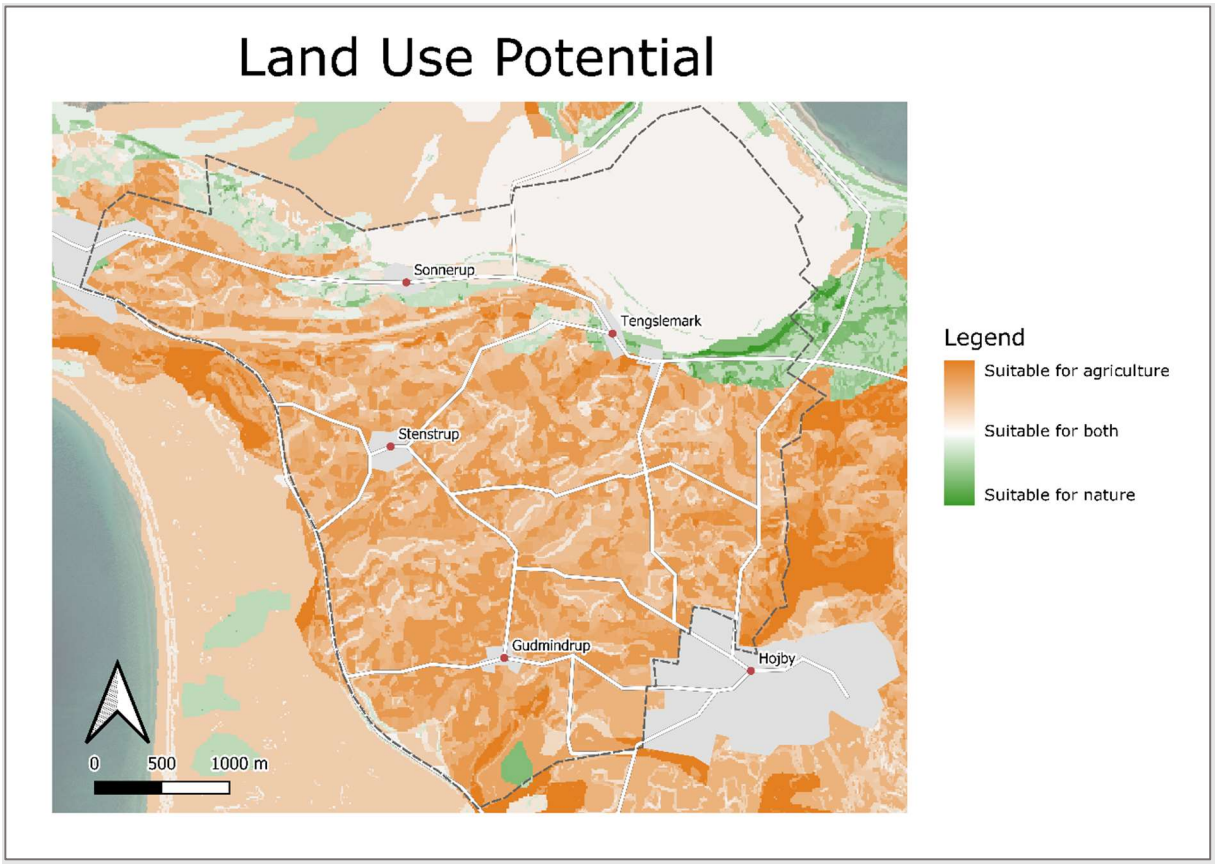


Figure 7: Output of the MCE that takes into account the land use potential (Lennard Derudder, 2021)

4.2 Interviews policymakers

The policymakers consist of two different stakeholders: the chairman of the local farmers' union and an agricultural consultant of a non-profit agricultural advocacy organization. In general, we asked five questions and afterwards, we collected all other input that we think will be useful to mention. When we asked about the role of the local/national governments about nature conservation in the area, our respondents both replied that no immediate action is taken by the local government due to lack of resources. In very rare cases, the local government might convert very specific parcels into nature patches. The national government, on the other hand, generally follows the EU-funded programs: for instance, agricultural firms are funded when they do not use fertilizers.

The following question is about methods in stimulating of farmers in creating nature: our respondents' task is to facilitate the farmers in improving biodiversity. The main purpose for informing the farmers about enhancing biodiversity is (better) crop growth. For instance, giving workshops or providing seeds to plant near the parcel (concrete action in improving biodiversity). When talking about parcel swapping, both respondents are in favor. However, they argue that swapping parcels is common over time, but only for the parcels with good soil quality. Even then, parcels are only swapped for practical reasons. For instance, when a parcel is situated closer to the farm. In any case, swapping is encouraged by the Danish government: if more than three persons agree to swap parcels, no additional taxes must be paid to the Danish government. Our respondents also argue that, over time, the agricultural firms are getting fewer and larger.

The fourth question is about creating small biotopes within the context of an agricultural landscape: both respondents argued that these biotopes are generally created for hunting activities. In this case, biodiversity is a convenient 'accidental consequence', meaning that the biodiversity isn't primarily seen as a priority. In addition to that, one respondent told us that lots of restrictions rise when creating biotopes: for instance, protected fences that cannot be moved. Also, a respondent argued that biotopes are already partly implemented but it should be structured more coherent in, for example, a biotope plan. Finally, we asked the respondents what they would think if the municipality would buy less productive soils to give room to nature development. Both respondents think it would be a good idea, but at the same time they are convinced that it does not happen much, because it has no short-term economic value and, moreover, it is very expensive: the municipality would have to buy the land and convert the parcel into a nature patch is expensive as well.

Other remarks that we think would be useful to mention: According to our respondents, agriculture is the main economic sector and nature conservation has, over the years, become popular in the Danish public opinion. Still, few actions are taken mostly due to budget shortages in local/national governments. Moreover, the agricultural economy of Denmark produces more goods than needed for the (domestic) population. That's why agricultural goods have to be exported abroad. Even then, export is difficult due to relative high prices of the Danish goods on the European markets. In this case, according to the stakeholders, 'farming for farming' is not a good idea; farming without any economic value is not a good idea. To summarize, mostly the local farmers take the initiative in improving biodiversity; the local governments are not much involved in the process.

4.3 Interviews farmers

4.3.1 Contextual information of the interviewed farmers

Logically landowners need to be involved in this project, as the goal is to create nature on parcels which are privately owned. As agricultural land is targeted in this project, those landowners will be mostly farmers, or they will be at least the land users. Therefore, it is important to hear farmers perception on the landscape and possible landscape changes. In total five farmers were interviewed; the profile of those farmers can be

observed in Table 4. As mentioned earlier the farmers were also asked to mark their parcels on a map, the result of these map questions can be seen on Figure 8.

In Odsherred professional agriculture mostly consists of cultivating crops, the share of livestock farming is rather small (Odsherred Municipality, 2017). Similar results were found during the interviews, three of the four active farmers cultivated crops. Furthermore, these three farmers used to be livestock farmers, but had to stop due to competition of much larger farms. For example, "I had pigs for 12 years, but decided to stop because I needed more land and had to build a new stable [to be able to compete]" (Farmer). Another observation is the presence of two organic farmers in the interviewee sample. Organic products are popular with the Danish population, as Denmark's market share of organic products is worldwide the highest (Danish Agriculture & Food Council, n.d.). Consequently, organic production has been increasing and counts now for 12 percent of the Danish farmland (Danish Agriculture & Food Council, 2019). For both the interviewed organic farmers, a higher price for their products formed the main incentive to switch to organic farming. Additionally, the Danish government financially supports farmers who switch to organic farming: "When you change to organic farming, you get some extra money for the changing period [of two years] and the price of our [organic] products is higher" (Farmer).

The farm sizes of the interviewed farmers exceeded the average farm size in the municipality of Odsherred which is 30 hectares. This relatively small average can be declared by the presence of many hobby and leisure farms in the region, approximately 74 percent of all the holdings (Odsherred Municipality, 2017). Hobby farmers as defined by the Food and Agricultural Organization of the United Nations (FAO) are "usually small in size, whose agricultural activity is not the primary source of income. […] Often, hobby farms are not seen as businesses but as leisure activities and are run on a not-for-profit basis." (FAO, 2018; p. 67). Although two of the five farmers did not work fulltime as a farmer, their income did depend on their farming activities. Therefore, they are not considered as hobby farmers. The lack of hobby farmers present in this small sample of farmers must be perceived as a valuable missing opinion. Their perception on landscape values has proven to be different from professional farmers. For example, Orsini et al. (2013) noticed that professional farmers perceived the economical and production value of a landscape as the primary evaluator while hobby farmers perceived the cultural value of a landscape as more important. For the purpose of this project, it would have been useful to compare their perceptions on nature creation in an agricultural landscape to identify opportunities.

Table 4: Context information on the five interviewed farmers

	Farmer 1	**Farmer 2**	**Farmer 3**	**Farmer 4**	**Farmer 5**
Age	61	65	57	69	35
Type of farming	Organic crops	Crops	Crops	Dairy	Organic dairy
Farm size (ha)	100	60	50	(85)	300
Employment type	Part-time	Fulltime	Part-time	Retired	Fulltime

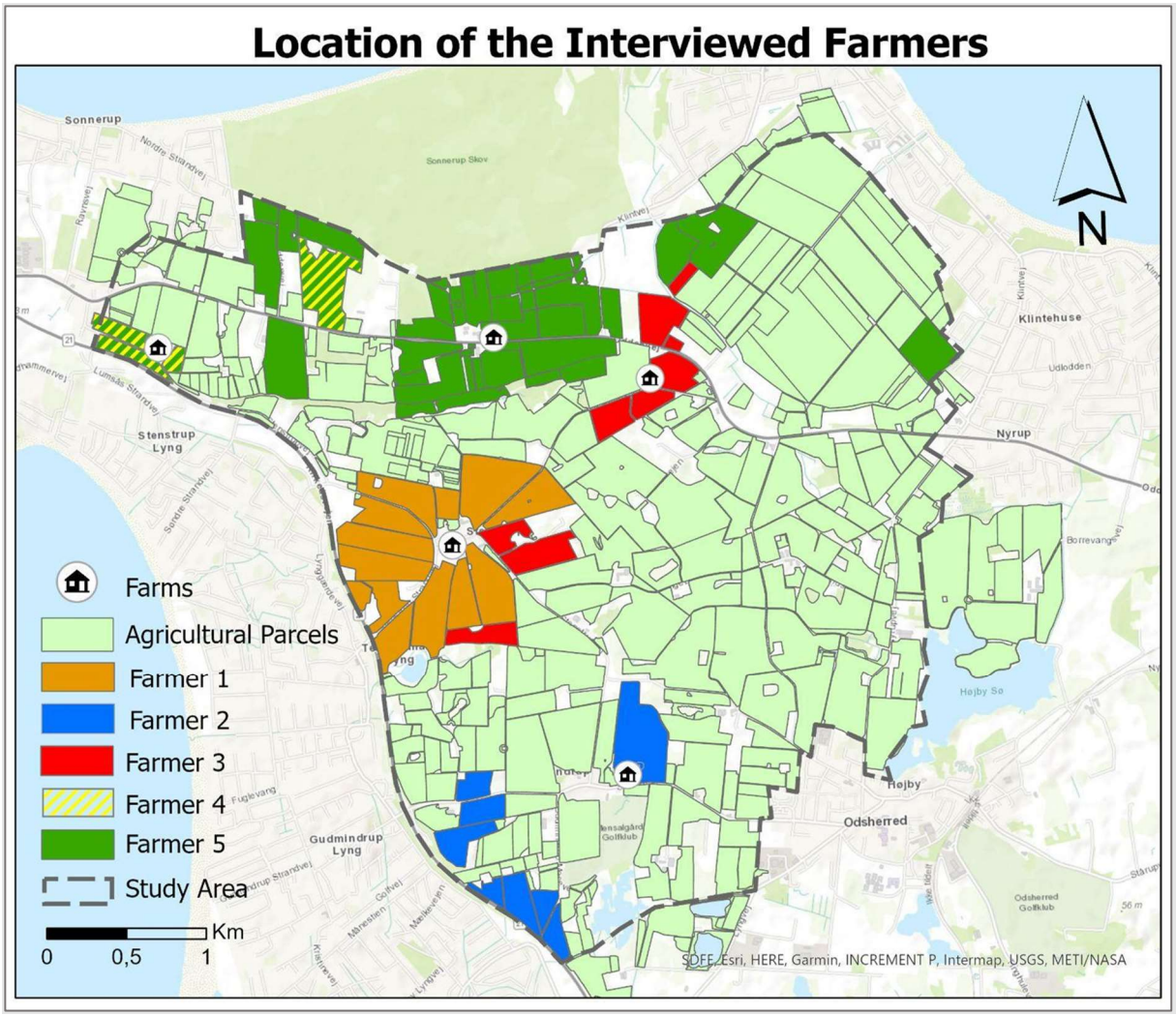


Figure 8: Location of the agricultural parcels and farms of the interviewed farmers (Farmer 4 recently retired and marked his previously owned parcels, which he sold to famer 5) (Renée Balcaen, 2021).

4.3.2 Farmers perception on nature creation

The main focus of the interviews was to get an insight in how farmers perceive nature in an agricultural landscape. Next, the interviews tried to obtain more information on farmers willingness to implement nature-improving measurements. However, there has to be noted that just five opinions were gathered, meaning that only a glimpse of the landscape dynamics in the study area was captured.

First, the farmers were asked whether they already implemented some nature-improving measurements. As mentioned before, organic farming was applied by two farmers by their own chose, since 2008 and 1999. They were motivated by the higher product price and environmental-friendly-practices. Other measures that were taken included planting flower strips and creating a small pond (see Figure 9). Those small initiatives are implemented voluntary by multiple farmers in the region, for different reasons:

> "These [initiatives] are things that [farmers] are doing of their own free will. It is good for [the farmers] image" (Farmer)

> "We have some birds that can live in [these nature patches]" (Farmer)

> "Some [farmers] make small [biotopes] for hunting" (Farmer)

Secondly, farmers were questioned about their management of less productive soils. This was relevant as the goal of the MCE is to identify those less productive soils for agriculture. One of the farmers who owned parcels in the former lake, Klinte, marked them as less productive due them being too wet when heavy rain events occurred. Currently the lake is drained by a pump and a canal, when asking the farmer whether rewetting the lake could be a future possibility, the following answer was formed:

> "If the water isn't pumped away, it will become a problem for the summer houses. I think there will be a new problem if the pump stops, so I think that we should go on with doing farming out there and analyze what [nutrients] are in the water, such as the amount of fertilizer." (Farmer)

Furthermore, another farmer recognized as well that he had some less productive soils. However, they were valuable to him due the nearby location of the parcels and to let his cows graze on them: "We need land for the cows, it's too expensive to buy organic-approved feed. And it's cheap land up here." (Farmer).

Thirdly, the willingness of the farmers to create new nature was questioned. Two of the instruments which were questioned related more to land sparing, such as swapping and selling of parcels. The third instrument referred to creating small nature patches within the fields which could function as steppingstones and relates more to land sharing. In general, all farmers showed some interest in the possibility to swap less productive or bad located parcels for more productive and better located parcels. However, there was a genuine disbelieve whether this would be realistic in the region. In contrast, selling parcels to the government to create nature received a low willingness. Only the two biggest farms were willing to sell some parcels under certain conditions:

> "Yes [I would be willing to sell some parcels, but] it depends on how much money [I would receive] and the piece of land has to be away from the farm." (Farmer)

Lastly, creating small nature patches within the agricultural fields was proposed as a possible nature-improving measure to the farmers. One farmer had already installed a small pond in the past, to drain his field. However, he was rather reluctant to install new nature patches: "The problem with making small water holes is that you cannot use the land around it. A few years after I had done it, they came to say that I cannot use the land around it of about 10 meters" (Farmer). The farmer lost more land than he initially anticipated, because he needed to install a buffer afterwards. Other farmers fear to experience similar situations when creating small nature patches or installing less extensive use on the fields: "We had some

land which was too wet to do anything, besides cutting it and grazing it. But now they took it in for some nature [project]. [...] That's why we plough everything, because when you don't do it by time the government takes it. Even if ploughing is a bad idea, bad business, but if we don't do it and they take it then the bank says that this land isn't worth anything. [...] It's bad for business." (Farmer). Especially Danish farmers aspire to have a certain certitude on the amount and quality of their agricultural land. As banks in Denmark historically value a farmer's land to assess loans and the interest rate of loans. Additionally, the financial crisis of 2007-2008 made Danish banks more cautious when lending to farmers, resulting in more extensive business assessments. While land prices in Denmark are decreasing causing higher financial costs and increasing the need for loans (Grivins et al., 2021).

Overall, the interviewed farmers opinion on nature creation within an agricultural landscape variated. For example, one farmer even planned to give two of his parcels, Figure 9, back to nature as they are already surrounded by a small biotope. Furthermore, this farmer had brainstormed with his business partner to transform all his parcels into forest after they retired. In contrast, another farmer evaluated the landscape as being rather rich in nature: "It sounds stupid to take out more land here. Because there are [already] lots of small nature patches and boundaries. I understand that they would do it in Jutland where all the parcels are like 80 ha."

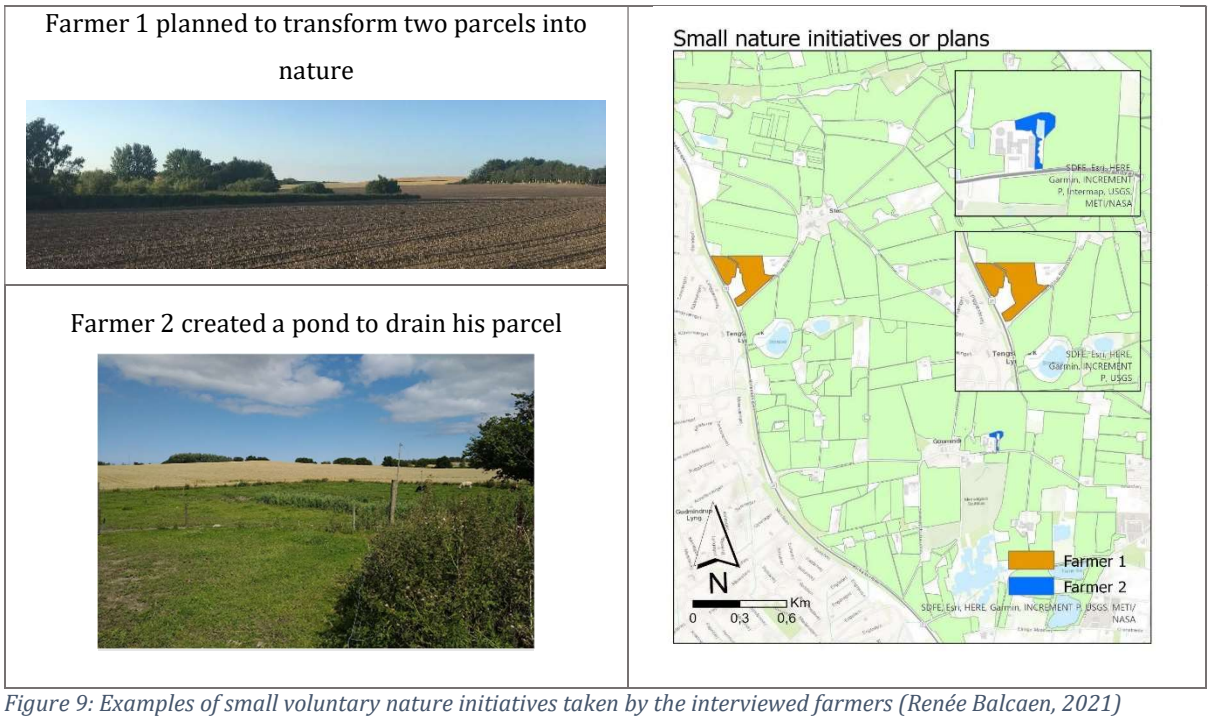


Figure 9: Examples of small voluntary nature initiatives taken by the interviewed farmers (Renée Balcaen, 2021)

4.4 Combining MCE's and interviews

When the information from the MCE's and the interviews are combined, a map can be created that displays a proposed ecological network of new nature zones and corridors in which land sparing could best take place. This map can be seen in Figure 10. While designing the proposed ecological network, the notion of

'connectivity landscapes' (as discussed in section §2.4) was kept in mind and used as the theoretical basis to build the proposed ecological network. The areas around the former *Klinte Sø* were chosen to be given back to nature since it gets a relatively bad score for agriculture in the Land Use Potentials MCE, and according to the interviews is still heavily drained using an artificial pump system on the northeast coast of the former lake just outside the study area. According to the Green Map of Odsherred (http://kort.plandata.dk, consulted on August 5, 2021) there should already be an existing patch of nature in this part of the study area, but field observations showed that this was not the case.

In the western part of the study area, two patches can be seen that are proposed to be given back to nature. This, because they are mostly located around areas that already have a greater density of existing nature patches and don't have the best land for agriculture on the Land Use Potential MCE. The patches indicated by Farmer 1 in Figure 9 would also be given back to nature since this is already the plan anyway. The centre of the study area shows two proposed corridors that run west-southwest to northeast and from south to north. These corridors don't have to be completely given back to nature, but it is proposed that these corridors contain patches that are close enough to each other to make it possible for species to travel from one patch of proposed nature to another without putting the species in danger. The rest of the study area would still be used for agriculture to keep a balance between nature and agriculture that was initially forgotten when the cadastral maps were drawn at the end of the 18th century. Some form of land sharing is still recommended.

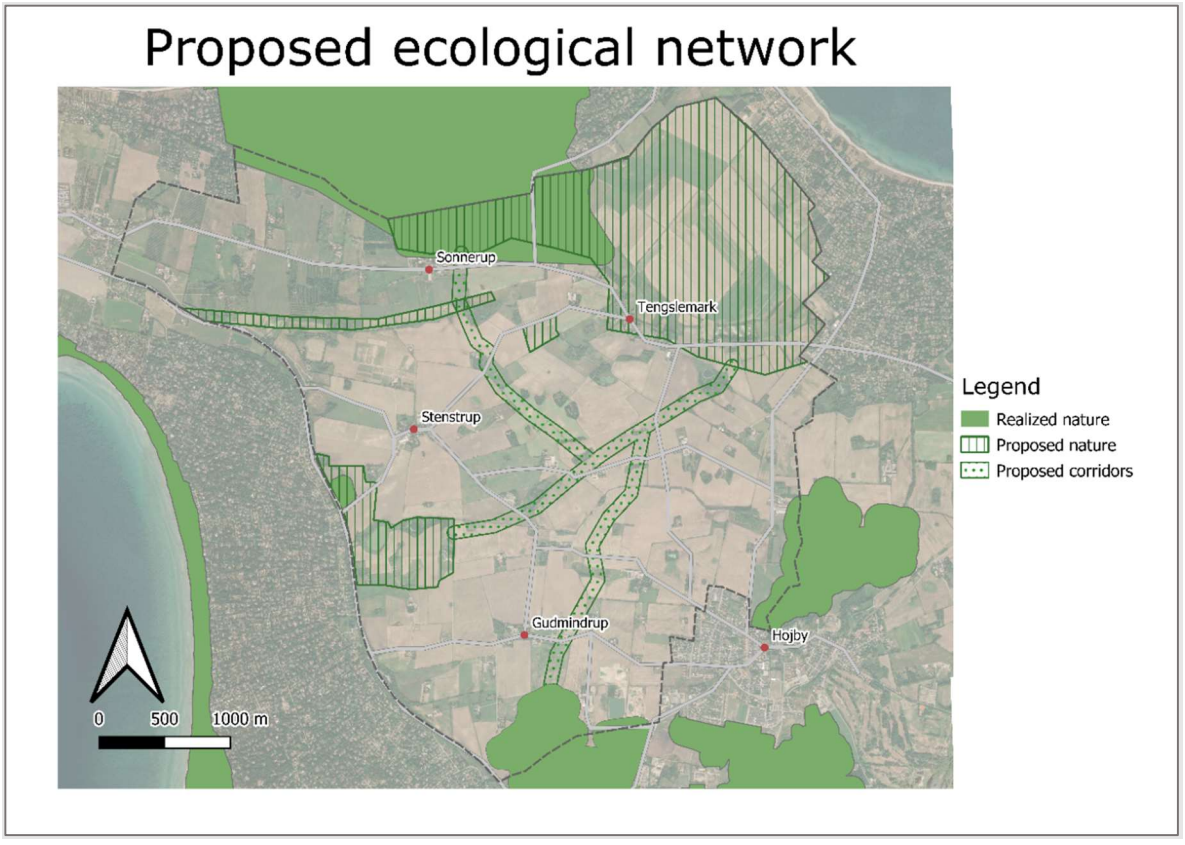


Figure 10: Proposed ecological network in the study area in which information from the MCE's and the interviews is combined (Lennard Derudder, 2021).

5 DISCUSSION

When the proposed ecological network (Figure 10) is compared to the Green Map of Odsherred (Figure 11) there are certain similarities, such as the potential rewetting of *Klinte Sø,* but also many notable differences. For example, the potential ecological corridors do not follow the same trajectory. This can easily be explained by the fact that the corridors on the Green Map of Odsherred follow existing parcel structures, whereas the corridors on the proposed ecological network map are in the most suitable areas for nature. By using the land use potential map (Figure 7) as a basis for creating ecological networks instead of the existing values map (Figure 6), land use practices could be more in line with the biophysical and visual characteristics of the landscape. In combination with the interviews, such a landscape ecological approach could promote the development of sustainable agricultural landscapes in Denmark (Antrop *et al.*, 2013). This could, for example, form the basis for regional or national property restructuring plans that in turn would create more ecologically adapted land-use practices.

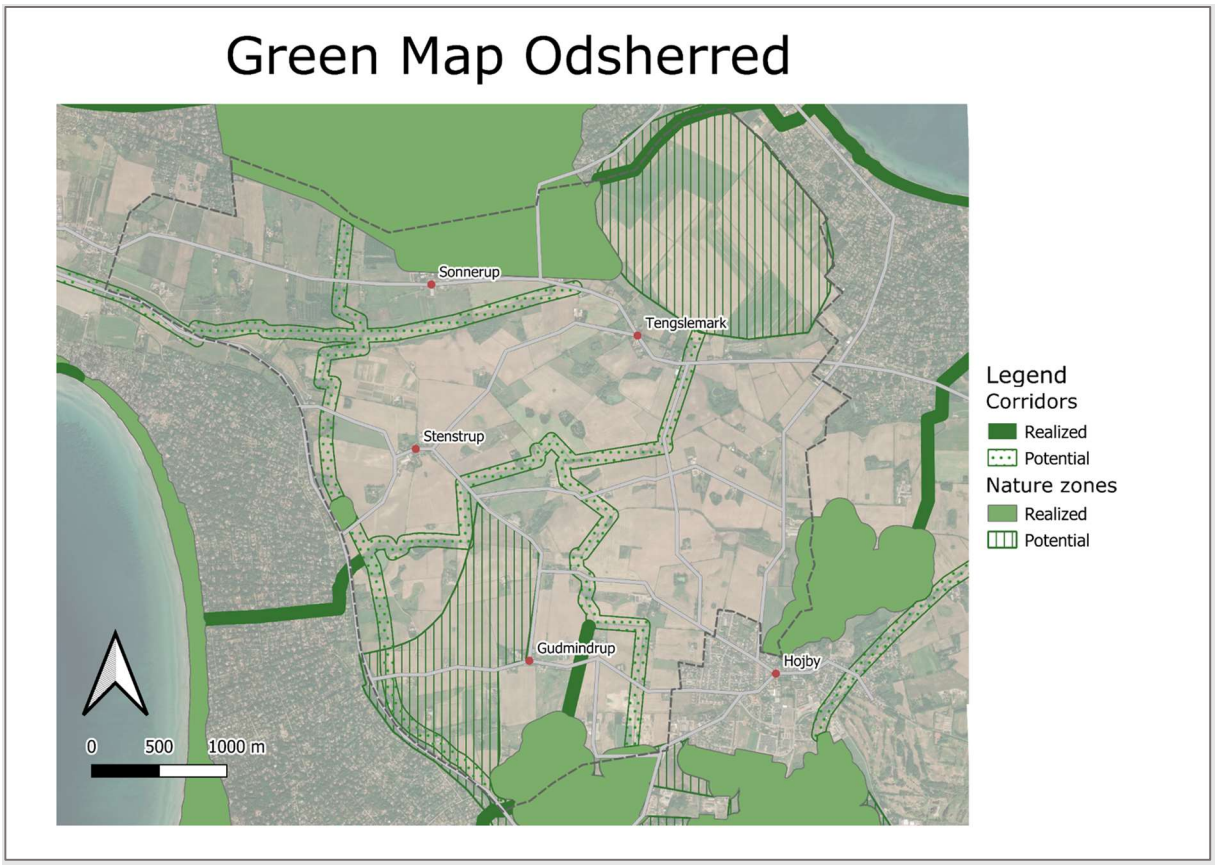


Figure 11: Green Map of Odsherred (Lennard Derudder, 2021)

In addition, the MCE that resulted in the land use potential map could be further improved. First, different data could be used for similar criteria in the MCE in order to make the ecological network more unbiased. For example, there is another soil map (DSPM06) that gives more detailed observations of the soil quality, and the Topographic Wetness Index (TWI) could replace the historical wetlands map, which was used as an indicator for the TWI. It would even be an interesting study to compare the historical wetlands with the

TWI in order to determine to what extent land use was adapted to the landscape conditions 200 years ago. Second, additional ecological or biophysical data could increase the accuracy of the suitability maps. The High Nature Value (HNV) map, the biodiversity map or the map of carbon-rich low-lying areas are examples of maps that could further improve the MCE. Finally, data should be used that takes the possible effects of climate change into account. The most recent IPCC report has revealed that also Northern Europe will experience more extreme weather events in the future (Intergovernmental Panel on Climate Change, 2021). For example, more heavy precipitation events in combination with longer periods of drought could have major implications for agriculture.

Future research should also examine the role of small biotopes in creating more unbiased ecological networks. These small uncultivated areas have played an important role in Danish agricultural landscapes and their patterns are strongly related to changes in agricultural production. "More than three-fourths of […] [the] small biotopes can be traced to having been established with a definite agricultural purpose" (Agger & Brandt, 1988, p. 236). Yet, processes of reallotment at the end of the 18th century in combination with the industrialization of agricultural production after the second world war, have "led to the widespread and in many places still ongoing removal of interstitial habitats and small biotopes in areas of intense agricultural development" (Svenningsen & Christensen, 2021, p. 2). Better monitoring and mapping of small biotopes could be crucial in promoting more sustainable Danish agricultural landscapes. These structures do not only strengthen ecological or agricultural processes in the landscape, but also "are important for the amenity, cultural value, and accessibility of the landscape and, hence, for its recreational potential" (Agger & Brandt, 1988, p. 227). In this study, the main focus has been on balancing ecological and agricultural functions in the landscape. Future studies should also take into account the many other functions within these multifunctional agricultural landscapes.

6 CONCLUSION

This study has shown how the development of GIS, with its layered representation of reality, has made it easier for people, and landscape ecologists in particular, to establish a holistic perspective of the landscape (Christensen *et al.*, 2017; Svenningsen & Christensen, 2021). In addition, by combining GIS-analyses and interviews, it was possible to form a better understanding of the complex social-ecological interactions that influence Danish agricultural landscapes. According to Svenningsen and Christensen (2021) "many of today's environmental problems may be related to the mismatch between cadastral structure and the geo-ecology of the landscape" (p. 13). It is thus of great importance that environmental planners examine the land use potential of the landscape without being influenced by the existing property structure which has been inherited through the cadastral history of Denmark. The results show that a more unbiased, landscape ecological approach is able to create an ecological network that not only increases the ecological values, connectivity and biodiversity, but also recognizes the trade-offs and synergies between the many different functions of the landscape. In this way, both agriculture and nature conservation can simultaneously benefit from future landscape changes.

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8 APPENDIX

8.1 Interview guide farmers

Interview guide (farmers):

Interview number: Date:

Interviewers: students of the Geography department of Ghent University, Belgium.

Purpose of our project: We are students of the Geography department of Ghent University in Belgium and we are doing a research project in cooperation with the University of Copenhagen about the agricultural landscape around Stenstrup. We would like to get an insight into how local stakeholders think that nature and agriculture can coexist.

The municipality (Odsherred Kommune) plans to reconcile agricultural production with nature conservation in the area of Stenstrup and surroundings (Odsherred). We would like to consider the local's opinion in these plans, in order to check if the municipality plan (2017-2029) could be improved in any way. Interviews are thus a key part in this research, so we absolutely value your opinion.

Methods: Interviews are processed anonymously. Ask the interviewee if the session can be recorded. Why? Recording an interview is useful for acquiring a nuanced image of the interviewee's point of view. It is also convenient for using citations for the final report. Important tools within our research are the interviews, the plan of the municipality, our own plan, and so on.

A. Understanding the contextual information about the farmer

1. When did you start with your agricultural occupation?
2. What is your age?
3. What are your main agricultural activities?
   (livestock, crops)
4. How much land do you manage?
   (rented or owned, arable/graze land [hectares])
   4.1. Map question: Can you indicate your parcels on the map?
   (Do you experience difficulties accessing some of your parcels due to the distance?)
   (Would you like your parcels to be more clustered?)

B. Gathering information on nature measurements/agricultural land

1. Are there certain regulations enforced by the national or local government or farmers union that you have to take into account on your parcels? (examples: protected nature areas, cultural-historical conservation value, etc.)
2. How do you manage less productive soils?
    2.1. What are the difficulties you experienced with these soils?
    2.2. Map question: Where are those parcels located?

C. Willingness to participate in a land consolidation project/create nature

1. Do you already implement some measurements to improve nature? (examples: nature strips, organic farming, minimizing pesticide use, etc.)
    1.1. Is this your own initiative or imposed by the municipality or government?
2. Would you be interested in swapping some of your parcels for better located parcels? (examples: to decrease fragmentation, to decrease the distance you need to travel, etc.)
3. Would you be interested in selling some of the least productive parcels to create new natural areas?
4. Would you be interested to include small nature patches in your parcels? (with financial compensation) (examples: nature strips, ponds, hedges surrounding the parcels, etc.)
5. Are there other measurements to improve nature that you would like to undertake?

8.2 Interview guide other stakeholders

Interview guide (other stakeholders):

Interview number: Date:

Interviewers: students of the Geography department of Ghent University, Belgium.

Purpose of our project: We are students of the Geography department of Ghent University in Belgium and we are doing a research project in cooperation with the University of Copenhagen about the agricultural landscape around Stenstrup. We would like to get an insight into how local stakeholders think that nature and agriculture can coexist.

The municipality (Odsherred Kommune) plans to reconcile agricultural production with nature conservation in the area of Stenstrup and surroundings (Odsherred). We would like to consider the local's opinion in these plans, in order to check if the municipality plan (2017-2029) could be improved in any way. Interviews are thus a key part in this research, so we absolutely value your opinion.

Methods: Interviews are processed anonymously. Ask the interviewee if the session can be recorded. Why? Recording an interview is useful for acquiring a nuanced image of the interviewee's point of view. It is also convenient for using citations for the final report. Important tools within our research are the interviews, the plan of the municipality, our own plan, and so on.

A. Understanding the contextual information about the person

1. Do you live in the municipality?
2. What is your age?
3. How long do you do your current job in the municipality?
4. What's your function within the municipality?

B. Gathering information on nature measurements

1. How does the municipality introduce and or encourage measurements to improve nature in agricultural land?
   (examples: nature strips, organic farming, minimizing pesticide use, etc.)
   1.1. Is this your own initiative or imposed by the municipality or government?
2. Are you planning on stimulating farmers to improve the natural value in their lands in the future, and or enforcing certain regulations? (examples: protected nature areas, cultural-historical conservation value, etc.)
3. How are less productive soils being managed?
   3.1. What difficulties are experienced with these soils?
   3.2. Map question: Where are those parcels located?

4. One way to improve nature in agricultural land is swapping less suitable parcels for agriculture for more suitable parcels to make room for nature. Is this something you see happening in the municipality? (examples: to decrease fragmentation, to decrease the distance you need to travel, etc.)

5. Another way is to include small biotopes in municipality's parcels? Is that a possibility in the municipality?
   (with financial compensation) (examples: nature strips, ponds, hedges surrounding the parcels, etc.).

6. Would it be a good idea that the municipality buys some of the least productive parcels to create new natural areas?
   6.1. For instance if the municipality disposes of a larger budget so that it would be able to spend a larger share to nature conservation in the municipality.

7. Are there other measurements to improve nature that you would like to undertake in the future?

8.3 Overview interviews with farmers (own notes)

	Farmer 1	Farmer 2	Farmer 3	Farmer 4	Farmer 5
Age	61	65	57	69	35
Area (ha)	100	60	50	(85)	300 ha
Type	Organic crop farmer together with brother (for last 24 years)	Crop farmer (and plants, fruit and vegetable shop)	Crop farmer (owns and rents parcels)	Crop farmer	Organic farmer (milk, 150 cows, crops) - together with parents
Farmer since	1984 (bought land from father)	30 years ago	Bought farm in 1990	1974	Since he was 5 years old
Former agricultural activities	Former livestock farmer (until 2008)	Former livestock farmer	Former livestock farmer (pigs for 12 years, but decided to stop because he needed more land and had to build a new stable)	Former livestock farmer (140 milk cows)	/
Job	Part time farmer (gardener, brother factory worker)	Fulltime	Part time farmer (factory worker in Højby)	Retired (he sold all his property 5 years ago to the organic dairy farmer (farmer 5). Now he rents his own house and some land)	Fulltime
Fragmentation of parcels	No fragmentation	More clustered parcels would be handier, but at the moment it is manageable	Are fragmented, but no problem		No fragmentation (with exception of few parcels)
Following of regulations	It is not easy to farm organically without livestock (need to import manure from other organic farms) - this needs to follow the criteria to be an organic farm - example: they needed to use an organic seed, although they thought a		Follows regulations of Danish government - example: spray that is allowed to be used ("other people don't want to use the sprayer, they do it another way. But, when the Danish government decided that we could use that	Always used the new techniques for farming (proposed by the farmers union) - example: machines (automatic milking machine)	A lot of regulations have to be followed for organic farming (EU, Danish government and dairy company Arla) and there is also the welfare for the cows (imposed by the Danish government)

	hybrid seed would be better BUT policy sometimes has little understanding of the ground reality ("Things produced by a desk [worker] don't make sense with what happens out here.") Regulations are only enforced by national government (not local) → there is a lot of interaction between farmers and the government ("Denmark is a land of a lot of rules. We have a saying that you can't get through a day without breaking a rule.")		[spray] product, it is okay for me.") He is in contact with a person of the EU, who tells them about what can be used or not (example: if a certain crop can be sprayed with a certain product) and helps them by informing them about new technologies		"A lot of rules, but you get more money for the milk"
Current nature initiatives	Organic farming + nature strips Things are changing because of climate change. ("These [initiatives] are things that [farmers] are doing of their own free will. It is good for [the farmers] image" - example: organic seeds are sponsored by different companies	Nature strips (some flowers) and pond (voluntary, he doesn't receive any financial compensation for this) "We have some birds that can live in [these patches]" → Not that much	None ("No I don't take any measures, I just look at the other parcels and look at how they do it".)	None	Organic farming (started in 1999) "We haven't done much such as taking land out and turning it into forest. But in our area there is already a lot of [nature] […] so if you take more out for nature there is nothing else. So I'm afraid of doing it." The small nature patches (such as wetlands) were not

					created ("it is normally just like that
Future plans regarding nature	He and his brother talked about converting all their land to forest once they are finished ("but you are not allowed to do it before you get a lot of paperwork or maybe you are not allowed anyways. But, maybe there should be a few fields. I think it could be funny." - They might might give two parcels back to nature, which are close to the summer houses ("they might get a meaning that way")	More nature strips	None	None	Some small wet patches for irrigation ("You think about it and you don't want to dig a hole or make a [nature patch] because then they say you have to cover 10 meters next to them and then suddenly you can't use it. That's what we are afraid of. Every farmer is thinking this." "You try to keep as many roads open for the next ten - fifteen years"
Swapping	Their parcels are closely located to them already, so better located parcels wouldn't be possible	He would be interested in having more parcels closer to his farm (there is no problem with the soil being bad for agriculture)	Farmer does not really know whether he is interested	"It is difficult to find a better parcel" "I would be interested in swapping the less productive hilly parcels for better parcels"	Yes, the ones that are least productive (parcels in the former lake)
Selling	Would be willing to sell them, but it depends on the money that they would receive for it.	"No money, I need land"	"No, not really"	No	"Yes, it depends on how much money. And the piece of land has to be away from the farm." "Here the land is very cheap, 13.500 euro/ha while in the South its between 27.000 euro/ha to 40.500 euro/ha"

					"We need land for the cows to feed on, it is too expensive to buy organic-approved feed"
Small nature patches (nature strips, ponds, etc.)	"Maybe, but we did not talk about that yet."	Due to a past experience (with the pond) he is not really interested in doing this ("the problem with making small water holes is that you must then not use the land around it. A few years after I had done it, they came to say that I must not use the land around it of about 10 meter") → There needs to be a buffer of 10 meter around nature patches	Maybe, "if the prices are high [enough]"	No	
Constraint	Lots of administration, bureaucratic process ("I see [nature and agriculture] for sure as one, but I think of different examples that I read about. Farmers who want to make a big pond or small lake, but it's drowning in paperwork") He thinks that the local government should help in regulating nature initiatives in agriculture (at the moment it is too				"We had some land which was too wet to do anything, besides cutting it and grazing it. But, now they took it in for some nature [project]. [...] That's why we plough everything, because when you don't do it by time the government takes it. Even if ploughing is a bad idea, bad business, but if we don't do it and they take it then the bank says that this land

	"stiff" when organized by the national government) Financial compensation "We need to be honest about it and say we have to see some money. [...] This doesn't have to be one to one with the money, but is some kind of way."				isn't worth anything. [...] It's bad for business."
Willingness to increase the nature value in the agricultural landscapes (this is our own interpretation)	High willingness, wanted to transform two parcels into nature. After he retired he was thinking of planting forest on his parcels.	Medium willingness, willing to add more nature strips but no more ponds due to the 10 meter buffer that was imposed by the government	Low willingness, leave Klinte Sø as an agricultural area (colleges have the same opinion)	Low willingness	Medium willingness, "We do not take land out, if you take more out than everything will be lost"
Quotes / remarkable things	The land/parcels around Stenstrup used to be farmed by five separate farms, but now only by two farms ("it's a picture of what Danish farming has developed to") Changing to organic farming was their own choice ("When you change to organic farming, you get some extra money for changing period [of 2 years] and the price of our [organic] products is higher")	There shouldn't be a financial compensation to stimulate farmers to include more nature in their land ("a lot of [farmers] do it for themselves and I think it's good")	Has two parcels in Klinte Sø (the drained lake) - these are often too wet (because of a lot of rain) → measures: water canals and a pump Q: rewetting the lake? A: "Yes, some people are talking about [stopping the pumps]. But, not to me. → he is concerned about the summer houses: if the water isn't pumped away, it will become a problem for the summer houses. ("I think there will be a new problem if the	No one asked him to implement nature measures, "but it is possible if I want to do it" "Some [farmers] make small [biotopes] for hunting"	They bought about 140 ha in the past 5 years ("We need land for the cows, it's too expensive to buy the [manure]. And it's cheap land up here") In the former lake area there is a big farmer that sprays his crops. "He is trying to make organic carrots on a piece of my land. Because he is afraid of turning all his land to organic [...] at once."

	- Q: Was this a good decision to change? "You get some challenges, all the time, and you can't [use] chemicals to solve the problem. So, sometimes you've just got to say: this field is [...] shit this year" BUT it's a learning process, after a while you get a grip on it (although you can't control the weather, which can be different every year) There is not that much organic farming in the region (more in for example Jutland and Samsø, where they have more cattle farming) and "you affect your neighbor (farmers) in a way" - they work together with the other organic farm in the region (farmer 5); they give some grass and get some manure "It is irritating for the conventional farmers that we [organic		pump stops, so I think that we should go on with doing farming out there and seeing what it is in the water, such as the fertilizer" He knows all the other owners of the agricultural parcels in Klinte Sø (because they have meetings to talk about the pumps, etc.) He even painted the pump house last weekend. According to him they share the same opinion as him.		"Our land is not the best for crops, but it's good for grass and I like to have cows. [...] It's easier to be an organic farmer when you have animals." He doesn't think that all farmers will become organic farmers ("[the government] is making new rules, so now you can't get much manure from the normal farmers. So, the ones that only have crops, find it hard to make it work." "It sounds stupid to take out more land here. Because there are [already] lots of small nature patches and boundaries. I understand that they would do it in Jutland where all the parcels are like 80 ha." "If it would not be about the money, I could see the good thing about [creating nature]. [...] **The bank knows how much land we have. And if they see, oh this**

	farmers] get a higher price"				**is nature, then it is worth nothing. And people do not have the money to do that. It is all about the money but the Danish government is not going to put any money [in our hands], they are just trying to take it. That is how farmers feel. If you just pay for it farmers will do it, because it is also better for the farm. Because it gets better for hunting, better for [...] The government does not pay enough [for creating nature in our fields]. The land is cheaper here, so maybe that is why they do it."** **When I put nature here close by the stable, they will say that my cows produce too much nitrate.**

8.4 Overview interviews with other stakeholders (own notes)

	Local farmers union chairman	Agriculture consultant	**General**
Resident Odsherred	Yes, born and raised	No, but knows the region very well (regional agricultural consultant)	/
Age	55 (1966)	62	/
Current job	> 3 y board member local union > 1 y chairman of union > CEO of IT-company	-25 years as agric consultant	/
Role of mun. and/or governments	> Local gov: not much action (no resources) > Nat. viewpoint: EU-funded programs > Bonus to farmers if fertilizer is not used	Not much encouragement Sometimes for very specific parcels to make nature	**> Local government: not much action** **> National government: follow and comply with the EU-agricultural regulations**
Stimulation of farmers in creating nature		"Not my job" to initiate. Will try to help farmers if they come to me.	**> Inform the farmers in order to improve the biodiversity in the parcels (because it's better for crop growth)** **> Giving workshops, seeds to plant (to increase biodiversity)**
Manage less productive soils		> used for cattle crop > used as grazeland > rarely forest	**Rarely forest, mostly used for cattle crops or grazeland**
Swapping parcels	> **Yes**, more efficient (Denmark is built up out of small parcels > Swapping land is encouraged (more than 3 p swapping: no taxes to Danish gov) > Swapping lands is very common over time	Not very much; It's done between 'intensive' parcels to make it easier for the farmer, but not between 'worse' and 'better' parcels.	**> Swapping is common over time only for parcels with good quality, and mostly for practical reasons (parcels closer to the farm).** **> Swapping is encouraged by Danish gov. (more than 3 p; no taxes have to be paid)** **> Firms are getting fewer and larger**
Small biotopes	> Lots of restrictions: protected fences e.a. cannot be moved, small biotopes created with local trees > Already partly implemented but it should be more coherent (plans) > Nature in balance (choose between process and pattern management)	Yes, especially 'game stripes'. Main goal is to facilitate the hunting. The improved natural value is an 'accidental' benefit.	**Generally created for hunting activities. Biodiversity is a convenient 'accidental' consequence**

Mun. buys less productive soils	> Maintain nature: support cattle farmers (in order to maintain the fields). > Bigger master plan in nature conservation: no short-term solutions	Yes, but doesn't happen a lot, land is expensive + making nature is also expensive.	**Yes, but it doesn't happen much because: (1) it has no real short-term economical value (2) it is expensive (land + making nature)**
Quotes	> EU: decrease use in fertilizers and nitrogen. > Parcels are losing value (20pc. in 3y), in Denmark more production than necessary	How to improve biodiversity? - pesticides free stripes around the parcels + buffer (VALUE FOR MONEY) - integrated pest management, only take action when necessary (real economic benefit) - taking out parcels that don't have a real economic value, not farming for farming Farming country, everybody shouts for nature, but not many want to pay. Farmers who love to shoot > municipality for nature development (but mainly for themselves, nature is an accidental benefit). More knowledge of the landscape. No tradition of taking initiative by the municipality for nature.	**> EU-decree: decrease use in fertilizers and nitrogen.** **> Danish agricultural economy produces more than needed for the Danish population. Also, it is not very easy to export the goods because they're more expensive abroad.** **'Farming for farming' is not a good idea** **> Agriculture is (has been historically) one of the main economic sectors in Denmark.** **In recent years, conserving nature has become more and more important but few actual actions have been taken in Odsherred, mostly because of budget shortage.** **> The local farmers are taking the initiative in improving the biodiversity on their lands. A municipal and national policy to improve nature in agricultural lands supporting the farmers is missing.**

Possible themes: Swapping parcels, small biotopes, converting agriculture parcels to nature areas, use of fertilizers and nutrients, production of agricultural goods, value of the parcels, average area of an agricultural firm.

TOWARDS A MORE THRIVING AND ENRICHED ODSHERRED

Potential developments aiming to shrink the socio-economic gap with other Danish municipalities and enrich the life of its citizens

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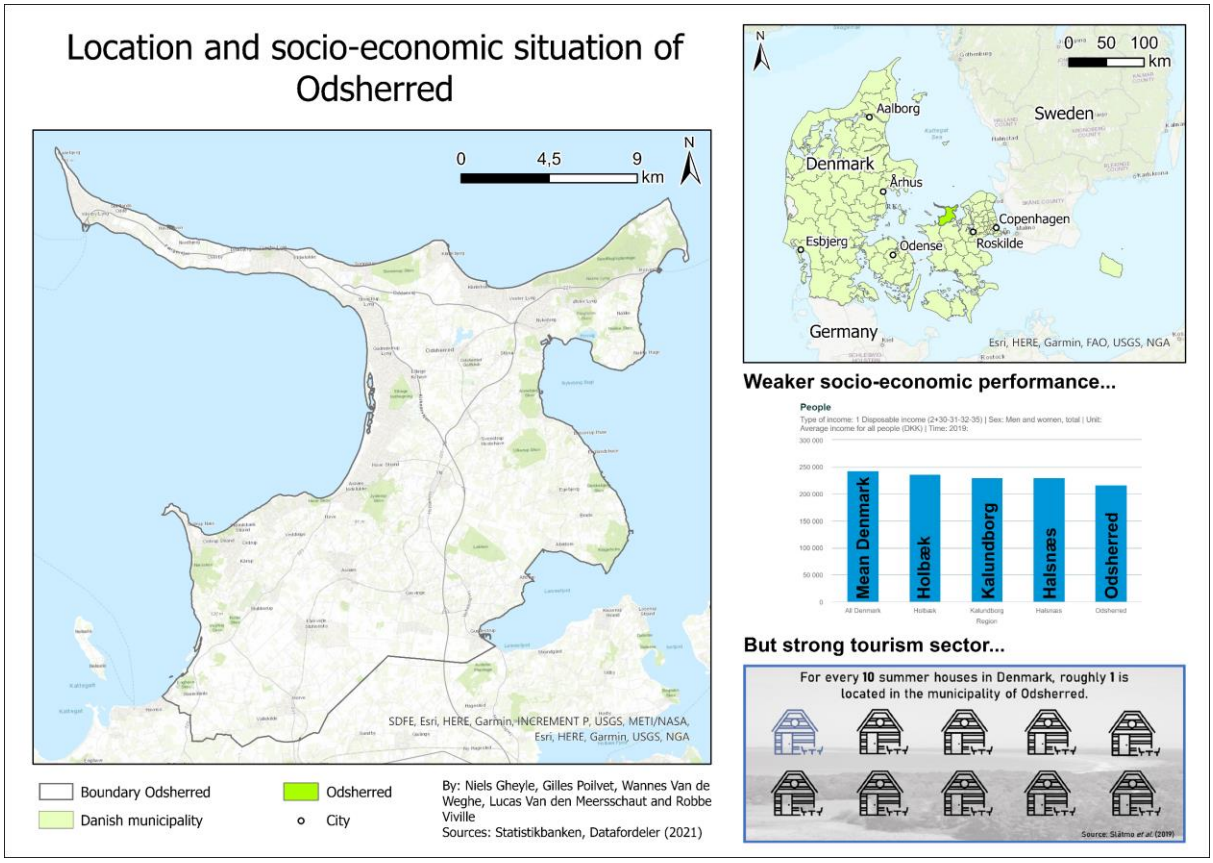
TABLE OF CONTENT

1. INTRODUCTION

For every ten summer houses in Denmark, roughly one is located in the municipality of Odsherred. In absolute figures, this means that around 23 500 summer houses are situated in this municipality in the north of the island of Sjælland (map 1). This makes it the municipality with the highest number of summerhouses in Denmark. A direct consequence is the significant importance of the tourist industry for the municipality's economy. It is estimated that 1 second home has the same meaning for the local economy as one permanent citizen has on average for an entire year (Slätmo et al., 2019). This estimate is representative of the high dependence of the municipality on tourism. However, a (too) high reliance also has certain disadvantages, both in economic and social context. Overall, looking at those contexts, the municipality performs poorly compared to many other Danish municipalities. In order to counteract the existing problems and reinforce current strengths in Odsherred, some spatial developments can underpin the future path. In this study, therefore, a master plan was developed for the municipality, consisting of potential actions and projects, whilst taking into account the spatial context. First of all, relevant planning theory based on the ideas of the Belgian urban planner Allaert (2010) is described. The institutional framework of Denmark is also considered in more detail. These two facets form the theoretical framework that provides important insights for the elaboration of the research method and the ensuing results. Several steps are taken to finally reach 5 (spatial) projects, which could be linked to specific spatial locations by means of MCEs. Feedback from permanent residents and summerhouse inhabitants on the site enriched the research with a stakeholder view on the proposals. The scientific view and its results were also compared with the existing Kommuneplan of Odsherred (2017-2029). Based on this, the relations between the expert, local and planning view were exposed. Finally, a critical discussion, built on both theory and own results, leads to a critical reflection of a specific and argued outline of a master plan that could allow the municipality of Odsherred to take important socio-economic steps forward in the future. At the end, this project thus tries to give an answer to the question: How can the daily life and the prosperity of the municipality of Odsherred be improved through specific spatial socio-economic developments?



Map 1: Situation Odsherred

2. THEORETICAL FRAMEWORK

2.1 Spatial-economic positioning

The socio-economic and spatial positioning of the region is constructed according to 5 pillars, as described by Allaert (2010). The positioning of the project region is being built up out of 5 elements, these are:

1. The socio-economic situation;
2. The business-economic situation;
3. The real estate dynamics;
4. The mobility and related infrastructure;
5. Business parks.

Based on these 5 pillars a profound analysis of the project region can be elaborated in the socio-economic and spatial spectra. What follows is a brief summary of what will be analysed for every pillar in the following study.

2.1.1 The socio-economic situation

To get a better understanding of the socio-economic situation of a region, a thorough statistical analysis of the region is needed. Classical items in such statistical analysis are the following: population dynamics, labour market, employment, commute, attendance index, sectoral distribution of employment creation and leisure market and touristic infrastructure (Allaert, 2010). Some of these items are important to get a better view of the dynamics and the characteristics of Odsherred and Nykøbing Sj. and will be analysed in the study. It is of importance to analyse the trends and evolution of all the elements.

2.1.2 The business-economic situation

A first step to gain insights into the business dynamics of Odsherred and Nykøbing Sj. is to explore which companies and businesses are present in the municipality. Another interesting parameter to determine the strength of the businesses in Odsherred is the total share of turnover they have in comparison to the national average.

2.1.3 The real estate dynamics

The socio-economic context of the region can be linked to the real estate dynamics in the wider region. The magnitude and course of the real estate market can co-determine the socio-economic dynamics in the region. The real estate market of Odsherred, and wider Nykøbing, will be analysed. The most interesting parameters are the dominant typologies of housing and the evolution of the house prices in the region that is studied.

2.1.4 The mobility and related infrastructures

In order to have a thorough view on the mobility and transport infrastructure in the wider region a total of four topics will be analysed, these are:

- The commute from and to the municipality of Odsherred;
- Infrastructural characteristics of the region;
- Public transport (infrastructure and intensity);
- Modal split (for daily transportation).

2.1.5 Business landscape

In order to have a broad analysis of the business landscape we based the analysis on three parameters which signify the characteristics of the (clusters of) businesses. The three parameters are the following (Allaert, 2010):

- Concentration (of business parks);
- Clustering (of business parks);
- Complementarity (of business parks).

This analysis of the business landscape is limited to the municipality of Odsherred.

2.2 Institutional background

In addition the institutional background of the project region and the Denmark planning system needs to be taken into account. As a result of the Danish Urban and Rural Areas Act of 1970, the territory of Denmark was divided into three types of zones;

- Urban areas
- Rural areas
- Recreational areas

The construction of "second homes" is only permitted in the recreational areas. The summer months as the period of dominant usage is also defined by law. Second homes may therefore not be used for overnight stays in the winter months, except for shorter holidays. An exception to this rule is made for retirees. In this way, an attempt is made to prevent certain holiday homes from being used permanently. In addition, the protection of the environment and landscape in these zones is considered. Recreational zones can therefore, according to the rules, only be used for recreation and leisure activities and this prevents the pressure to create new recreational areas.

In 2017, the rules regarding second homes were eased to encourage positive developments in rural areas. From then on, pensioners were given the right to use their second home as a permanent residence if they had owned it for 1 year (previously this was 8 years). The number of weeks that a second residence could be used was also increased by 8 weeks (from 26 to 34 weeks). The creation of new recreational zones in coastal areas was made possible as well, under the condition that other zones were rezoned as rural areas (Slätmo et al., 2019).

2.3 Driving forces

Allaert (2010) describes six driving forces that can be used to plan and manage the environment. The six driving forces are: space for water, space for logistics, greenports & countryside, creative places like brainports and research parks, leisure time & retail and finally space for adolescents. In the scope of this research however, space for water is not included. The meaning of the listed forces is as follows.

2.3.1 Giving space for logistics

Logistics can be seen as the management of goods and services with three criteria in mind: a short as possible travel time, good company placement (mostly market driven) and the quality maintenance of resources and finished products (Allaert, 2010). The spatial aspect however looks at the fact that there is always a need for appropriate infrastructure and the interplay of different travel modi. One interesting application of this is a so-called logistics zone. A logistics zone is a zone where good imports and exports are done by a common hub. This hub can make use of a navigable waterway, a railtrack or a well suited road network. Crucial here is that companies share the transport modi, the warehouses, and

other specialised equipment (Allaert, 2010). If well executed there should be a clear cost reduction seen for all enterprises involved. The surrounding area also profits as there is considerably less traffic.

2.3.2 Greenports and the countryside

The countryside is nowadays plagued by trends such as upscaling, production intensification, non-regional specialization of production types and others. This while the (social) connection between farmers and the surrounding population is at an all time low (Allaert, 2010). Allaert proposes to give more attention to landscape identity and occurring dynamics. Agriculture has, according to him, a central role in the maintenance and preservation of valuable historical landscapes. Agriculture has an important role in socio-economical development of rural communities. Further does Allaert state that there are three pillars of capital who always should be taken into account, these are cultural, economic and historical capital. Finally he proposes to roll out walking and bicycle routes, to reconnect farmers with the villagers, to evolve to sustainable transport and energy modes, to promote citizens' initiatives who incorporate agricultural production and consumption and to reconnect agriculture with surrounding cities.

2.3.3 Creative places: the brainports

The focus here lies on the brainports. Brainports are, according to Allaert (2010), places with a high degree of knowledge concentration. This knowledge concentration envelopes primarily higher education and enterprise driven research parks. As such technology, tolerance (of all kinds) and talent are things to stimulate and protect in such places.

Allaert (2010) stresses that the step between research-and-design and innovative developments must be expanded. He argues that the production scale as well as the product specialisation should be augmented. To make a brainport viable, the embedment is crucial. He stresses that leadership of individual companies as well as the leadership of a brainport should regularly communicate about the ongoing opportunities and struggles. Finally, the brainport has some benefits: it is a (big) generator of jobs and it (inherently) creates products and techniques that benefit (the local) society.

2.3.4 Developing leisure time and retail

Developing leisure time and retail cannot be seen without taking into account the recent developments. Allaert (2010) sums some key trends. People have overall less time and tend to spend it more qualitatively. However there is a differentiation going on between social groups. Low educated people tend to spend their free time in their living environment, high educated and/or childless people tend to spend time in the city and (interestingly) families tend to spend time in suburbs and in the countryside. This means also that on average people tend to travel further for their free time. Which also means that the leisure market is no longer local but regional or even international. Next trend is glocalisation. Glocalisation is the physical but also organisational amalgamation of leisure companies and retail. The

goal is to make a more unique feel and unique advantages for customers. However paradoxically this creates homogenisation of the market. Allaert (2010) reacts with following suggestions: In the countryside farms should be seen as central points of experience. Secondly, he addresses the value of cities as places of 'funshopping', where if done right, can create unique experiences for visitors.

2.3.5 Giving space for adolescents

The title can be interpreted quite literally, there is, as Allaert (2010) points out, a great need for living space for adolescents. There is a space needed where they can meet and enjoy themselves. This space is nowadays a much needed extension of so called cyberspace. Cyberspace in this context refers to social media and other online platforms. Both spaces are essential for the formation of the youth and their modern identity. Allaert (2010) continues by stating that there are two pathways that should be looked into to create space. The first is the central role of culture centres, playgrounds and overall leisure activities. Secondly is giving them the needed access to it. Frequently travel time and road safety are big refrains of (social) activity. Allaert (2010) for that reason argues that safe travel corridors and affordability of transport modes are essential.

3. METHODS AND SOURCES

The goal of this research is to build a masterplan for the municipality of Odsherred which consists of concrete projects and actions in terms of spatial-economics and developments. The method consists of three main steps: strategy building, a multi-criteria evaluation (MCE) and a field study. The strategy building is based on the book *Wegwijs in ruimtelijke economie* (Allaert, 2010) and consists of four important steps: a mission statement (see 1. Introduction), strategical analysis, goal formulation & anticipation of strengths and weaknesses, and finally the concrete projects. The MCE will determine the most suitable locations for these projects and propose potential alternatives. During the field study these locations will be visually inspected to control if they are suitable in reality. Lastly, a survey will be presented to groups of stakeholders during the field study to receive feedback on the project actions and locations. The final result will be a masterplan with both a scientific vision and the vision of local stakeholders which should enable the decision makers to make thorough choices when determining the social, economic and spatial future of Odsherred. In the following paragraphs the different steps are explained in more detail. Illustration 1 gives an overview of the used method.

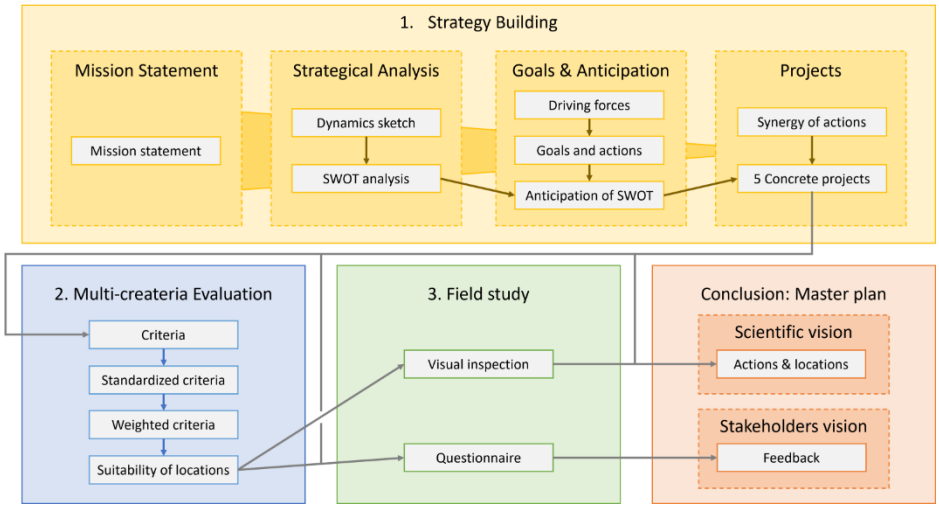


Figure 1: Diagram of the method

The first step of strategy building is creating a mission statement. It expresses the collective ambition of the strategy builders of what exactly is trying to be achieved by the new spatial and economical strategy. The second step is the strategical analysis, which starts with a sketch of the dynamics within Odsherred (see 2.1 and 2.2). This sketch consists of five different themes: social-economic dynamics, business-economic dynamics, real estate dynamics, mobility & infrastructure, and business parks. In this sketch the present, historic and future situation related to these five themes are analysed. This is followed by a SWOT-analysis: an analysis which describes the intern strengths and weaknesses of the municipality, and the extern opportunities and strengths. The dynamics sketch is used to perform the SWOT analysis and forms the basis to formulate the different strengths, weaknesses, opportunities and threats in Odsherred. The third step of the strategy building is the formulation of goals and anticipation of strengths and weaknesses. Five driving forces are the guideline through this step: logistics, greenport & countryside, retail & recreation, youth and brainport. First, a theoretical frame of these driving forces is created based on Allaert, 2010. For every driving force, social goals are formulated and potential actions on how these goals can be achieved are described. These concrete actions will then be combined with the SWOT analysis. The result of this step is a matrix, with concrete actions separated by driving force on how to exploit opportunities and defend against threats using the strengths of Odsherred, how to use weaknesses to strengthen the opportunities and how to control damage potential threats and weaknesses could cause. Every driving force is given a score based on how well the actions proposed for the driving score anticipate on strengths, weaknesses, opportunities and threats. The fourth and last step of strategy building is creating concrete projects. These are created by seeking synergy (combined power) in actions between pairs of the different driving forces. Each pair is given a score based on the combined score of its two driving forces. The five pairs with the highest score and their synergetic actions are the concrete projects and result of the strategy building.

Five multi-criteria evaluations (MCE) are performed to find the most suitable locations for the different projects. The first step of the MCE is formulating the different criteria which will determine how suitable a location is for the project. They are clearly described and measurable. Then these criteria are

standardized, so that the different criteria can be compared with each other. A raster for every criterium is placed over the municipality and each raster cell gets a score between 0 and 1 depending on the standardized value of the criterium at the location of the cell. Different formulas can be used for standardization, a detailed overview of the used standardization formulas is given in the cartographic model (see annex 7). The third step of the MCE is giving a weight to the different criteria. Analytical Hierarchy Process (AHP) is used as a method to give the scores. The different criteria are being compared and given a score in every possible couple of criteria. Based on these scores and overall weight between 0 and 1 of every criterium is created. The sum of all weights equals 1. The last step of the MCE is combining the scores on the different criteria. Each raster is multiplied by the score of its criterium. The sum of all rasters gives a suitability score for the project to each raster cell.

The last important step is a field study which consists of two parts: a visual inspection and a questionnaire (by means of ArcGIS Survey123). During the visual inspection, the most suitable locations for every project are visited. During these visits the results of the MCE are compared with the situation in reality to determine if the proposed best location and alternative locations for every project are suitable. The questionnaire consists of questions (Annex 8: questionnaire) about the proposed actions for every project and their location. The questionnaire is presented to local (summer)residents and businesses. The answers and their feedback is used to create a stakeholders (local) vision of residents, summerhouse inhabitants and businesses. It is included along the scientific approach in the final masterplan to enable decision makers to execute the projects, possibly change the actions depending on how they value the stakeholders feedback, or choose for one of the alternative best locations for each project. Apart from the scientific view and stakeholders view, the (municipal) planning system view will be taken into the account by searching for similarities and conflicts as compared to the scientific insights of the strategy building, as well as its spatial translations. The three fundamental views and corresponding relations are schematized in figure 2.

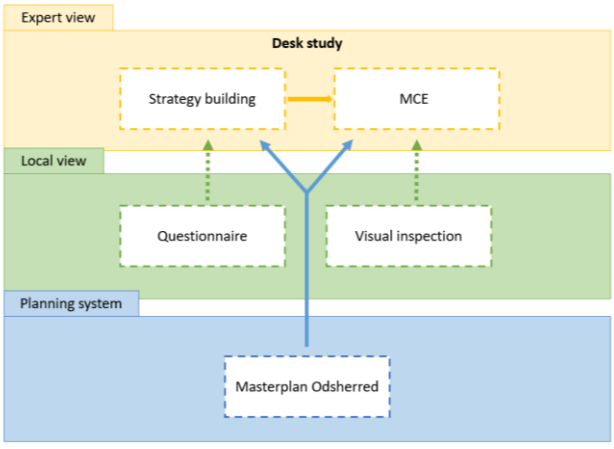


Figure 2: Three views incorporated in this research

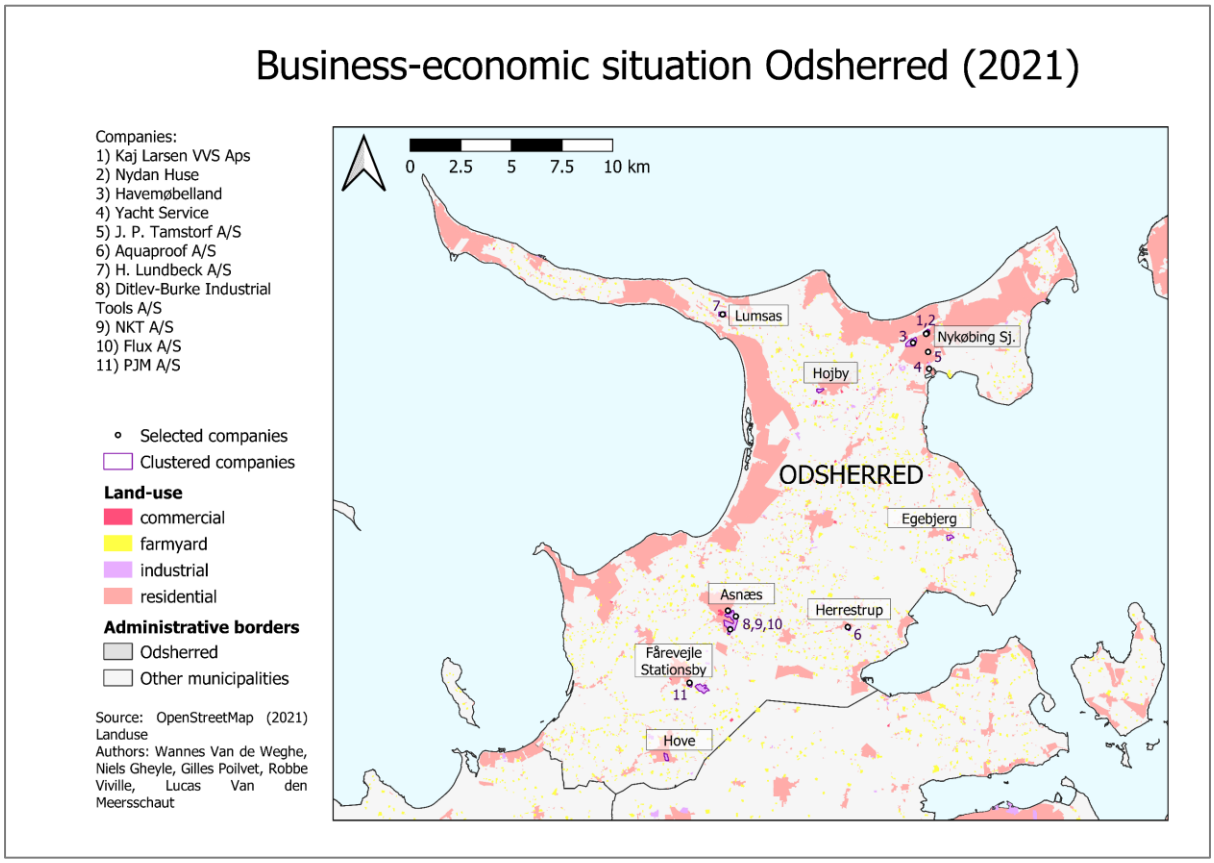
4. RESULTS

4.1 Dynamics sketch

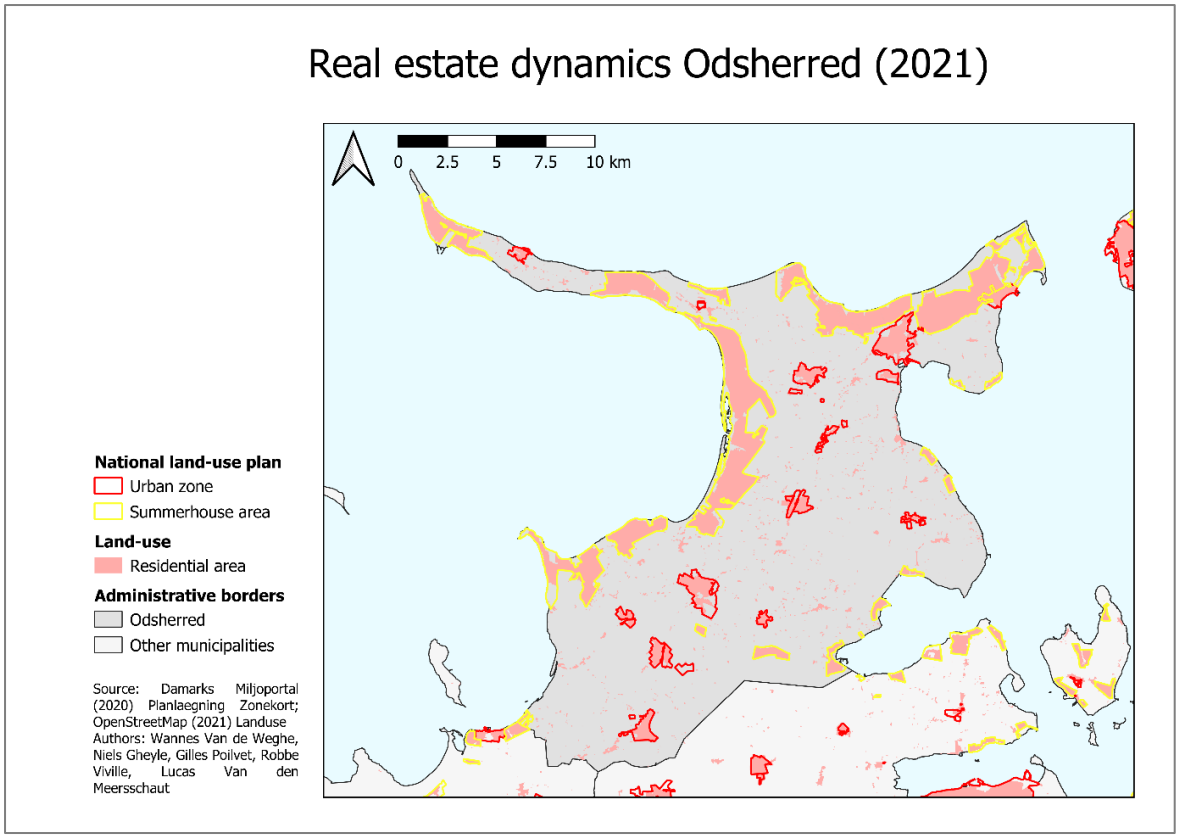
The current dynamics in the municipality of Odsherred (5 pillars of the socio-economic and spatial positioning) can be summarized as follows:

- A shrinking, poorer, older, less active and lower educated population compared to rest of Denmark
- Plenty construction-related companies, supermarkets, garages and second-hand stores in small clusters which rarely transcend local context and which are seldom knowledge-intensive
- Very low establishment rate of new companies (low entrepreneurship)
- Low housing prices; prices of summerhouses exceed prices of single-family houses
- Largest number of summerhouses of whole Denmark and increased popularity
- Relatively close to Copenhagen and Roskilde, railway present, but car is dominant

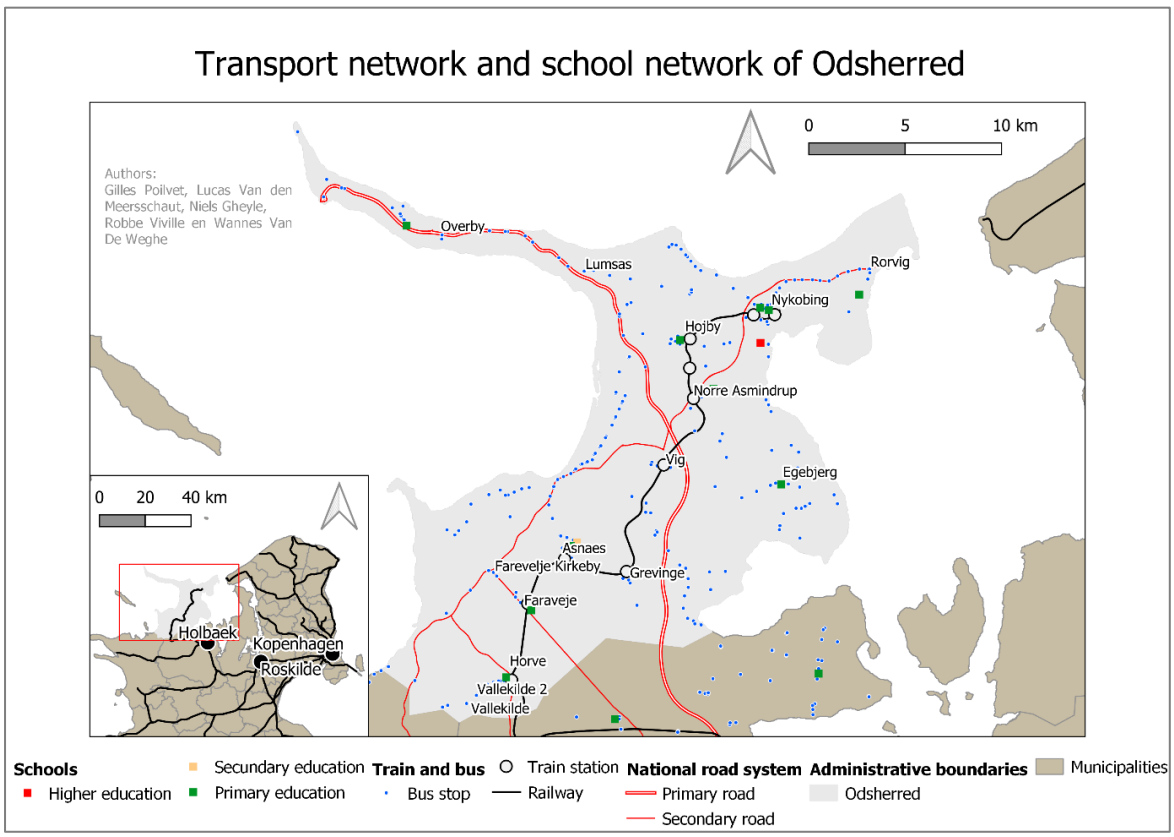
The most relevant (spatial) info of the dynamics sketch is visualised on map 1, 2 and 3. A more extensive dynamics sketch can be found in annex 1.



Map 2: Business-economic situation Odsherred



Map 3: Real estate dynamics Odsherred



Map 4: Transport dynamics Odsherred

4.2 SWOT analysis

Based on the dynamics sketch, a SWOT table was made (see outer cells Annex 2). Because of the scale of the table itself, only a few features will be mentioned here. First topic here are the strengths. Odsherred sees nowadays an increased rate of immigration, it has a strong and sturdy summerhouse market, the (normal) house market is exceptionally cheap, and companies are growing similarly as the rest of Sealand. Some key weaknesses are the growing share of elderly people, the overall stagnant population growth and the high share of low-skilled inhabitants. Some key opportunities are the growing demand of professionalised labour and an increasing demand for summerhouses (particularly now during the COVID-19 pandemic). Finally, there were some threats observed: a decreasing number of schools (since there is a decline in number of children) and a decrease in the number of jobs.

4.3 Goals and actions from the driving forces

In this phase every driving force gets specific goals and actions (see annex 3). This is to make sure that not only some clear measures are mentioned, but that their specific goals are also clearly stated. Since (again) the size of those goals and actions is rather large, only one example will be mentioned. Take for example the driving force ‘space for youth’. The actions for this driving force are creating and expanding youth hang out facilities, organising activities and/or festivals, maintaining a good youth centre and giving the youth a clear voice. The goals related to this driving force are then the following: creating social growth and job opportunities for the youth, encouraging entrepreneurship and as mentioned, creating more, and more valuable youth spaces.

4.4 Anticipation of the swot

Based on the SWOT-analysis (see outer cells Annex 2) an anticipation-of-the-SWOT table was created (see inner cells of annex 2). Based on the table combinations of Strength, Weakness, Opportunities and Threats, four main anticipation groups were defined. Within each of those groups, it was stated what could be done for each driving force. Those four anticipations groups can be labelled as Attack, Defend, Strengthen and Damage control. The driving force ‘space for youth’ is taken as the example here. In terms of the Attack-aspect, it is stated that the youth should be familiarised with the local tourism sector because it is a major job pool. It is also mentioned that the public transport is (and stays) attractive to the youth. For the Defend-aspect it is stated that the amount of (well placed) schools should be maintained and that there should be more hangout facilities for the youth. For Strenghten and Damage control there were no anticipations penned for this driving force.

4.5 Synergy of actions

To form specific potential developments a synergy table was made with as starting point the driving forces. The full table can be found in annex 4. Based on the dynamic sketch of Odsherred a score was given for each synergy of driving forces (see table 1). Only the five highest were used in the further research process. Those five synergies are: 1) Tourism and recreation x Greenport, 2) Logistics x

Tourism and recreation, 3) Tourism and recreation x Brainport, 4) Tourism and recreation x Youth and finally 5) Logistics x Greenport.

Table 1: Suitable synergies between driving forces

		Logistics	Greenport	Tourism and recreation	Youth	Brainport
		0,109384	0,255168	0,457332353	0,085384	0,092732
Logistics	0,109384		**0,027911**	**0,050024813**	0,00934	0,010143
Greenport	0,255168			**0,116696674**	0,021787	0,023662
Tourism and recreation	0,457332				**0,039049**	**0,042409**
Youth	0,085384					0,007918
Brainport	0,092732					

Based on these five synergies concrete actions were stated:

1) Tourism and recreation x Greenport: **Agricultural tourist centre**
2) Logistics x Tourism and recreation: **Logistics centre**
3) Tourism and recreation x Brainport: **Brainport**
4) Tourism and recreation x Youth: **Youth hangout places**
5) Logistics x Greenport: **Farmer's market**

4.6 Potential developments

The five potential developments resulting from looking at the synergies of actions will be considered in more detail. First of all, an introductory explanation is given about the development itself. The selected factors and constraints used for the MCEs (to translate the development to a specific location) are listed, with a focus on the reason why these criteria were chosen. It is important to note in advance that the three zones of the Danish national planning context are not closely followed in the spatial translation of the developments. In doing so, a wider range of locations could be obtained and at the same time the planning system could be questioned/critically examined. The sources used for the MCEs can be found in annex 5. Finally, some possible supporting measures and the insights/evaluation on terrain are discussed in more detail.

4.6.1 Agricultural tourist centre

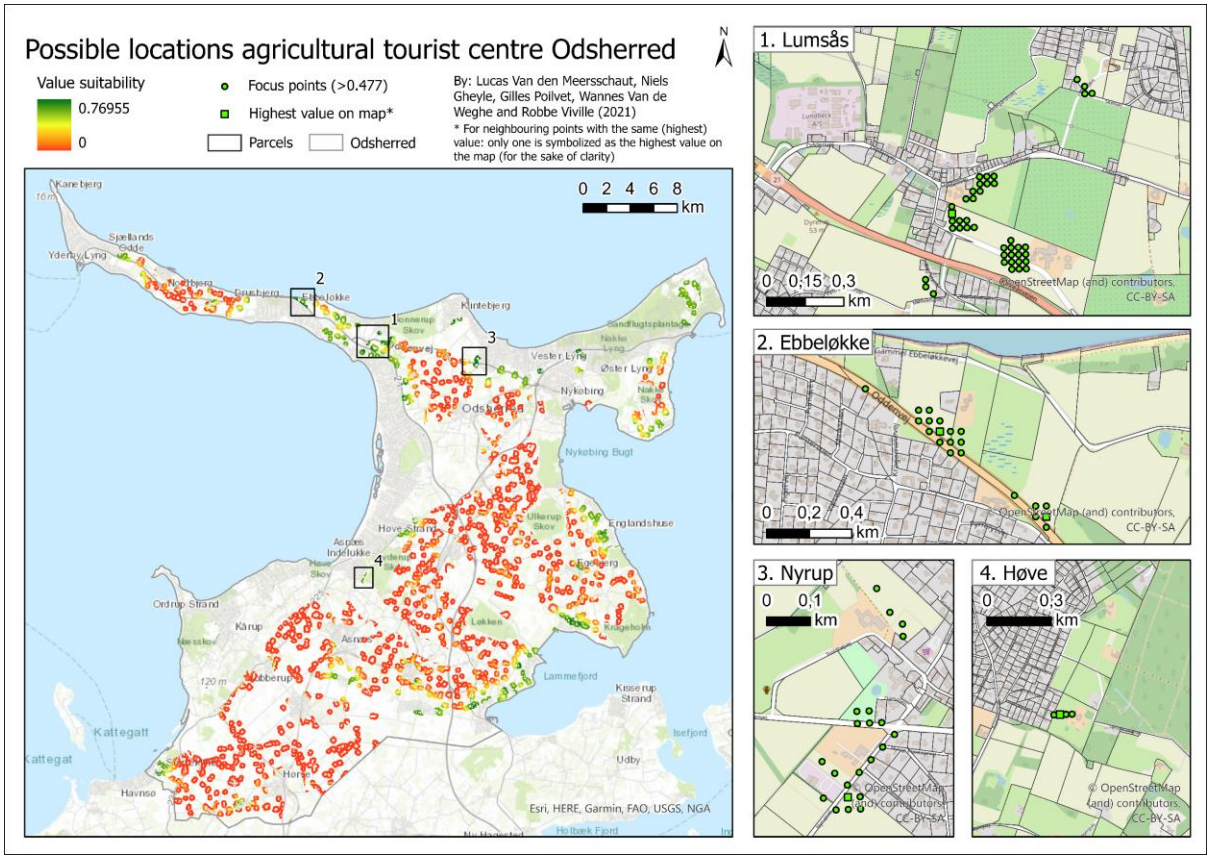
Based on the SWOT-analysis and SWOT-anticipation actions concerning the driving forces ‘Recreation and retail’ and ‘Greenport’ turned out to have the highest priority. Inspired by the theory of Allaert, 2010 a spatial development and supporting measures from synergies between these driving forces are proposed. The result is an agricultural tourist centre. This is a place where both locals and tourists can meet and learn more about the agriculture of Odsherred. It should be an attractive and vibrant place,

where people can for example receive information about the history and local traditions of agriculture, taste local products or start a hiking or bicycle trip along the fields and farms in the municipality.

4.6.1.1 The spatial development

Several factors and constraints are chosen to determine the most suitable locations for this agricultural tourist centre. The factors mainly relate to the accessibility. The distance to summerhouse areas received the highest weight (0.38) in the MCE. It is important for the agricultural tourist centre to be close to the summerhouse areas because the centre is an important link between the summer residents and the municipality. Informing the temporary residents, who are often from the urbanized region of Copenhagen, about local traditions and agriculture should tighten the gap between them and the local inhabitants. The factor with the second highest weight is the distance to a village (0.30). This way the centre is attractive to permanent residents as well and makes it possible for the permanent and summerhouse inhabitants to meet in a direct way. The third factor is the distance to a train station (0.22). The train is an important means of public transport in the municipality and an important link to nearby cities in Sealand. Being close to a train station should make it possible for the agricultural tourist centre to welcome visitors from other villages and cities in the vicinity as well as tourists or permanent inhabitants who don't own a car. The last factor is the distance to a bus stop (0.10). Odsherred has an extensive bus network that serves as a supplementary form of public transport to the train line. Being close to a bus stop is important for the centre to be accessible for people that don't live or stay near the train line.

Four constraints are taken into account when determining the most suitable locations for the agricultural tourist centre. The centre cannot be built in an area with heigh nature value, must be in on an unbuilt lot, should be in an agricultural area and must be close to the farm. The distance to an existing farm cannot be more than 100m. This way the centre and a farm can be connected and visitors can visit and experience the real farm.



Map 5: Suitability map agricultural tourist centre

4.6.1.2 Supporting measures

Although an agricultural tourist centre is an important step, supporting measures are needed with regard to tourism and agriculture to reach the goal of an *enriched* Odsherred. The first measure is an interfarm-chain: a link between the different farms and agricultural companies in the municipality. Different forms are possible, for example cycling routes or a product chain. A chain between the different farms and agricultural companies should enable synergy between them and strengthen the role of agriculture in the local economy. A tourist centre already exists in Nykøbing. Good cooperation and communication between the tourist centre and the agricultural centre is a second measure. Both centres should work together and each fulfil a different role for the tourism in the region. The third measure is preserving the open space, nature and agricultural land in the municipality. The fourth measure is supporting active transport for recreational mobility. An increase in tourism in the region should not lead to an increase in traffic, more parking, etc. This would be bad for the environment and the tranquil character of the municipality. Instead existing roads should be upgraded to safely accommodate cyclists and pedestrians. The fifth measure is a dual role for farmers. Farms should in the first place focus on agricultural activities but they can also take part in the local tourism. For example as a restaurant or bed and breakfast. This way tourism can increase without the need to build new hotels, restaurants… and can tourism and agriculture be more intertwined. The last supporting measure is branding the local agriculture as a unique experience. People can experience tourism in some way in the whole country

of Denmark. The way tourists can experience agriculture in Odsherred should be unique and different from other places to convince them to choose for Odsherred as their leisure destination.

4.6.1.3 Terrain evaluation

The four most suitable locations for the agricultural tourist centre were evaluated on terrain and local (summerhouse) inhabitants were questioned about the plans of the centre. The first location in Lumsås was the most suitable in the MCE and was the most preferred location by locals (37.5%). It had a nearby abandoned building which could be used to accommodate the centre. The location in Ebbeløkke was preferred by 33.3% of the locals but is far away from a village. The location in Nyrup (preferred by 8.3%) turned out not to be suitable, as the farm nearby is now a construction company and the bus stop is not frequently served. The location in Høve was preferred by 20.8% of the locals but is in reality far away from a village and public transport and is difficult to access by car because the streets near the location aren't paved.

The concept of an agricultural tourist centre received a mean score of 3.58/5 (with standard deviation of 1.26/5) from the locals. Some remarks were given by multiple interviewees. Multiple tourist centres would reflect better the variety of the local specialties of the different parts of the municipality. Secondly the centre should be branded and advertised well in order for the concept to work. Different people also noted that the relation with the Geopark is important as well. Lastly, at Lammefjorden there is already a 'visitors field' that people can visit to learn more about the local agriculture. People note that the agricultural tourist center could work together with this visitors field, or that the centre should be situated in Lammefjorden.

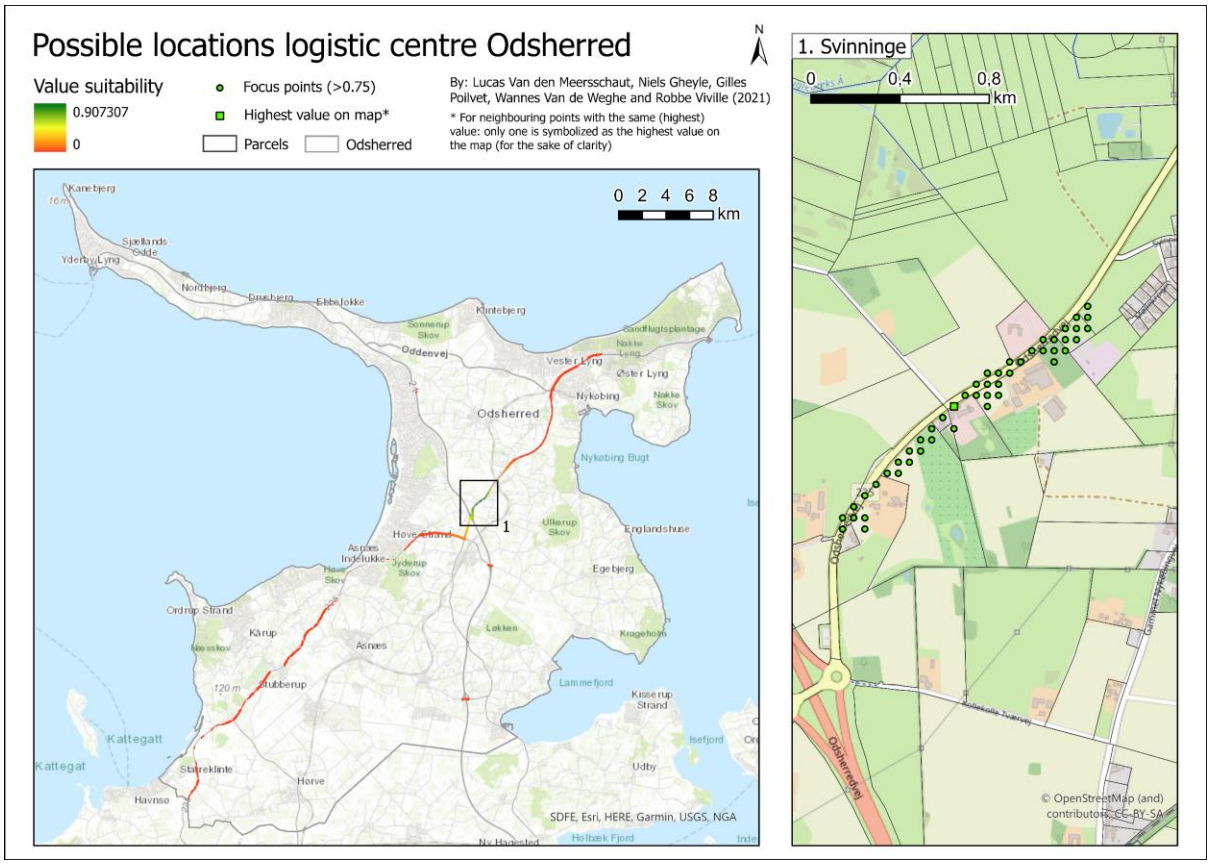
4.6.2 Logistic centre

Second best development, according to the expert view, is the logistics centre. This development is a synergetic combination of the driving forces "Space for logistics" and "Space for Recreation and retail". This implies that the characteristics of this development are the result of a combination of both. So it will be a logistics park with a focus on the existing tourism and leisure companies in the municipality. In this sense the centre will provide a centralized distribution (in and export) of goods to the local companies so that there is a more efficient transport of goods.

4.6.2.1 The spatial development

Here the main spatial factors and constraints are shown. The factors are a relative proximity to hospitability industries and being along well-suited driving ways 21 and 225. For the proximity to hospitability industry, the centroid was calculated based on the coordinates of all existing hospitability industries in Odsherred. From that centroid a network analyse was done with a maximum road distance of five kilometres. The roads 21 and 225 were chosen with the idea that the closer the enterprises are

the more efficient transport would be. The goal here is to alleviate as much as possible traffic from smaller roads. Next there are the constraints. The constraints of this development are that it must be out of urban, summerhouse or natural reserve areas in the municipality of Odsherred. From vej 21, which is an expressway, all exit points where chosen. From vej 225, which is a more regular connection road, the whole trajectory was used. This because of the simple fact that it is generally impossible to connect directly to an expressway such as vej 21.



Map 6: Suitability map of logistic centre

4.6.2.2 Supporting measures

To make the logistics park viable it is also important to fulfil the criteria with some non-spatial measures. First measure here is to ensure the existence of already existing hospitability industries like hotels, restaurants, cafés and others. Even though this seems plausible, the high volatility of this market in a rural region makes it the more vulnerable to sudden socio-economic changes. Especially the ones in city centres who have an increasing competition with road centred companies. Next measure is to incorporate new hospitability industries along walking and biking trails (as well in the city centres) so that there is bigger ease and a clear (cognitive) connection. Lastly, emission free transport from the logistic park should be subsidized so that there is a good incentive to go green for the logistical companies.

4.6.2.3 Terrain evaluation

As map 5 shows, there was only one location found to be ideal and that's the intersection of vej 21 with vej 225 near the hamlet of Svinninge. When asked to the people they seem to agree that this location was indeed ideal for a logistics park. However, the idea itself scores rather low. It had a score of 3.16/5 (with standard deviation of 1.25/5). They also mentioned some interesting facts. Apparently, the site of Svinninge is very close to an archaeological site with a high emotional value for the municipality. The people would prefer if there was as little disturbance as possible around this archaeological site. They also said that the most hospitability industries work with local partners, so that could lead to the negative situation where the local supply linkages are disturbed by the logistics centre.

4.6.3 Brainport

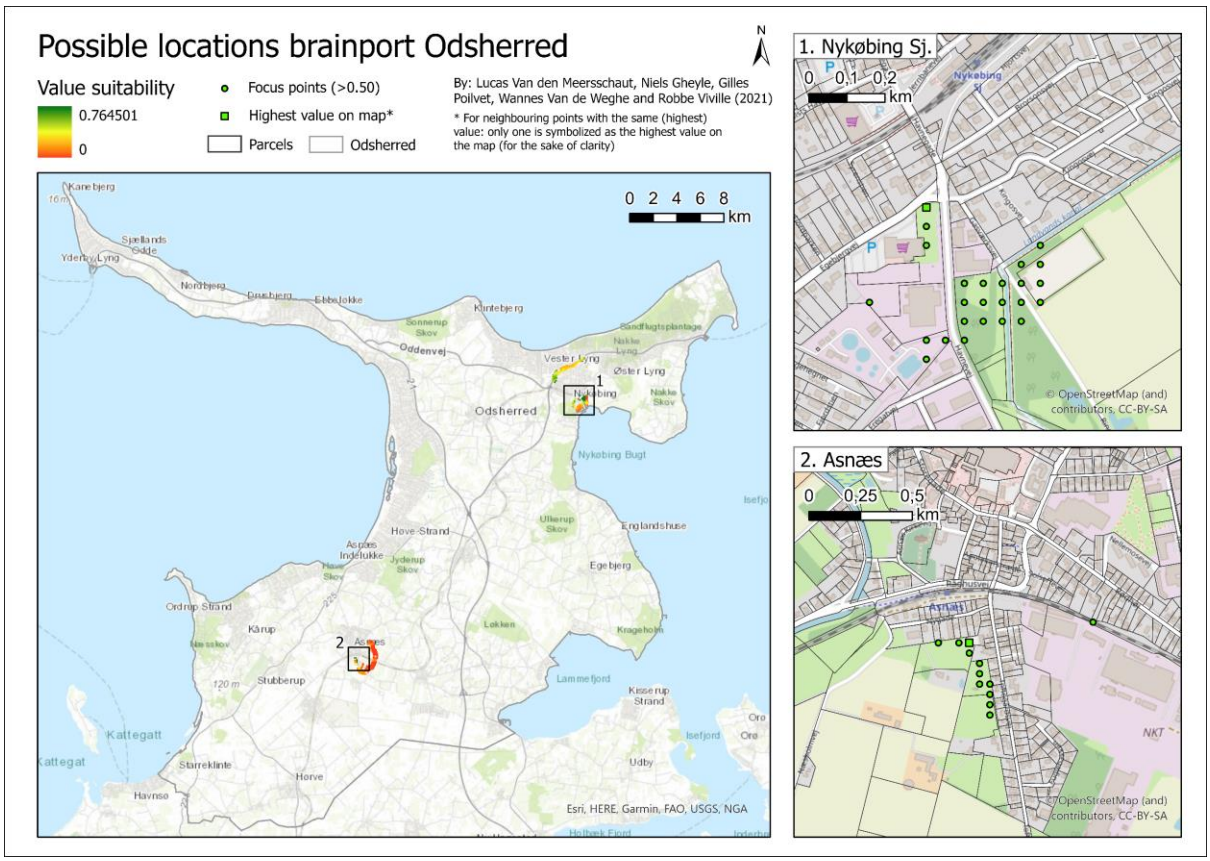
The co-existence and interrelation of companies and educational entities in a spatial cluster creates a brainport. The goal of such brainport is the creation of synergetic relationships between education and the companies located. In the municipality of Odsherred it is the aim to create more educational and career options. The concept of a brainport is based on the synergetic relationships of actions, mainly between education (brainport) & recreation and retail.

4.6.3.1 The spatial development

Several factors and constraints are chosen to determine the most suitable locations for this brainport. The factors mainly relate to the accessibility of the location and proximity to an urban cluster. A permanent, more accessible and synergetic form of education should foresee a more qualitative education to the permanent residents in Odsherred. This could close the gap between the lower educated population of the municipality and the rest of Denmark. The factor with the highest weight in the MCE is the accessibility by public transport. Firstly, this is accessibility by train which comes down to the proximity to a train station and mostly an urban cluster (0.59). Secondly, accessibility by bus was taken into account (0.19). It is important for the brainport to be close to public transport because a sustainable and broad modal split supports a wider accessibility of the brainport, as well causes a sustainable transport model with minimal impact on the existing road network. The proximity to an urban cluster is also a factor with positive influence, this way the brainport is attractive to permanent residents and employees where the social and recreational functions of an urban cluster can support and expand the brainport as a living organism on itself. The brainport on itself can provide a broader set of functions for the nearby urban cluster. The proximity to a school received the third highest weight (0.13) in the MCE. Since the brainport leans on the relationships between companies and education, the proximity of a school has a relative high influence on the chance of the brainport succeeding as a new development. The third factor is the distance to summerhouses (0.09). The proximity to summerhouses is less relevant for the success of the brainport on itself, yet implementing the brainport nearby

summerhouses could initiate the cohesion between the permanent residents and the summerhouse residents in the region.

A set of constraints are taken into account when determining the most suitable locations for the brainport. The brainport needs to be nearby an urban cluster or settlement, the selected location also needs to an unbuilt area. The brainport needs to connect with nearby existing industrial clusters and can't be located in a valuable area. Ideally this new development is implemented nearby summerhouses too, this to unlock the brainport as a meeting place for permanent residents and temporal residents. This measure however was not included as a constraint but as a factor.



Map 7: Suitability map brainport

4.6.3.2 Supporting measures

A brainport can form a great opportunity for the municipality and can add a lot of value to the daily life in the municipality. In order to guarantee the overall success of such brainport a number of supporting measures can be taken, such as the promotion of interrelationship and synergy between companies and education, accommodating recreational and social life in the area and the supporting of an expansion of recreational and social life.

The promoting of interrelationship and synergetic relations between the companies and educational entities is needed because a spatial clustering on itself doesn't initiate these interrelations. Regional incentives need to initiate these synergetic relationships. In order to do so there needs to be a close communication between educational entities and the located companies, this can be done through the policy makers in the municipality.

The brainport on itself can bring more residents to the location of the development, still there needs to be a vibrant recreational and social life in the direct area of the brainport in order to accommodate informal relationships between companies, educational staff and policy makers. Innovations grow in informal atmospheres. The accommodation of this recreational life can be done through the municipality itself. Clustering recreational and social services/functions near the brainport can transform the area into a vibrant learning-working-living hub.

When a basic recreational and social life is present near the brainport, this brainport can then initiate a growth and support an expansion of the recreational/social life in the surrounding area. The presence of more students, educational staff and workers can bring a vibrant social life and create an attractive informal atmosphere.

4.6.3.3 Terrain evaluation

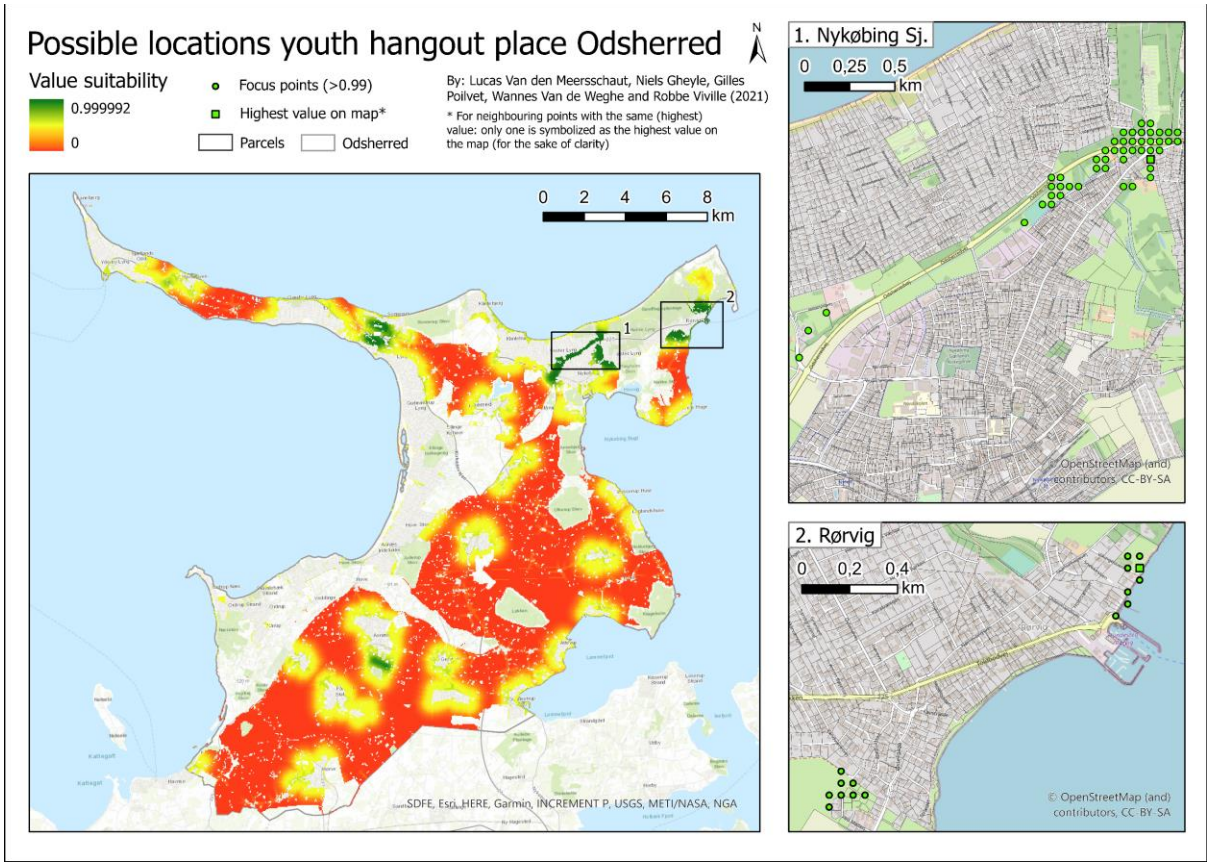
The mean approval rating of a brainport by the respondents was relatively high with 3.79/5 (and standard deviation of 0.91/5). The two most suitable locations for the brainport were evaluated on terrain and local (summerhouse) inhabitants were questioned about the plans of the development. The first location in Asnaes was the most suitable in the MCE and was the most preferred location by locals (66.67%). The location was unbuilt and has a very high frequency of busses. The train station of Asnaes is also to be found in the immediate vicinity. The location with the highest score was however located behind a housing row, this might be less favorable to provide the brainport of a decent access with a minimum of nuisance. The second location in Nykøbing Sj. was preferred by 33.3% of the locals but is far away from summerhouses. Apart from the expert view, the local inhabitants noted that a link with an existing university is important in order to optimize the strength of the brainport.

4.6.4 Youth hangout place

The fourth potential socio-economic development is a 'youth hangout place'. These are places in open space with recreation possibilities for the youth. The main goal is to prevent the youth of going away to Holbæk (or Copenhagen) to loosen up. This could be accomplished by building infrastructure such as a skate park or a youth centre were young people from both the summerhouses and the permanent residents can meet. These 'youth hangout places' are the result of the fourth biggest synergy between two driving forces: 'Recreation and retail' and 'Youth'.

4.6.4.1 The spatial development

To obtain the most suitable locations for this development, a multi criteria evaluation was executed. Multiple factors and constraints were used to get several possible locations to execute the development of 'youth hangout places'. In total there were three factors, one of them is the proximity to summerhouse zones. This is relevant because there is a need to increase the interaction between the youth from the summerhouses and the youth from the permanent residential areas. This leads automatically to the second factor which is proximity to settlements. These two factors both were assigned the same weight (0.46) after standardizing them. To end, the distance to a bus stop was also used as a factor. Because the youth is not that mobile, caused by the lack of a drivers' license. This factor had a smaller weight (0.05) because it seemed to be less important than the first two. Besides these three factors, one constraint was used to become the most suitable locations for this development: the actualizing of 'youth hangout places' cannot happen in valuable natural areas.



Map 8: Suitability map youth hangout place

4.6.4.2 Supporting measures

Now that the spatial context is clear, supporting measures can be really helpful to realize this socio-economic development. These are measures that the municipality could take to support the spatial development of the project. One of the measures the municipality of Odsherred could implement is the organization of unique events for the youth. This could encourage youth from all around the region to

come to Odsherred to recreate. A second important measure is increasing the involvement of young people in organizing the events. These events are targeted at both the youth and tourists, in this way there is an interaction between the local youth and the youth from the summerhouses. An example of such an activity could be a youth camp. The last supporting measure is to give the local youth a voice in the tourism and recreation in the region of Odsherred. What do the young people expect from touristic activities?

4.6.4.3 Terrain evaluation

The execution of the multi criteria evaluation resulted in two suitable locations where the development could take place. The site with the highest score was located in Nykøbing, the one with the second highest score was situated in Rørvig. Both villages are located in the north of Odsherred and have a little harbour. The site in Nykøbing fulfilled the expectations of the multi criteria evaluation. It was also preferred by 87.5% of the locals, which strengthens the outcome of the desk analysis. At the site of Rørvig some important field observations were made when going on terrain. There were two possible locations in Rørvig that were seen as possible locations for the development. The one in the north turned out to be situated in a busy and touristic area of the village, which is not ideal for a youth hangout place. The other proposed location in Rørvig was located in the south, but here there are also some remarks that came out of the terrain visit. Nevertheless, the fact that the site is located near new houses where potentially young people live, it lies further from the summerhouses than expected which makes it less ideal as a location for a development. The location in Rørvig was only preferred by 12.5% of the people that were interviewed. The persons which answered the questionnaires also gave interesting input on the project of 'youth hangout places'. Something that was mentioned several times is the fact that the youth in Odsherred are in need of more than one hangout place, because they are in most cases less mobile than adults. Another aspect that came up was the idea that the young people in the municipality need more than hangout places to keep them here and prevent them to go to big cities such as Copenhagen and Holbæk. The overall mean approval rate of this development by the interviewees was 3.79/5 (and standard deviation of 1.15/5), which makes it the shared second most approved.

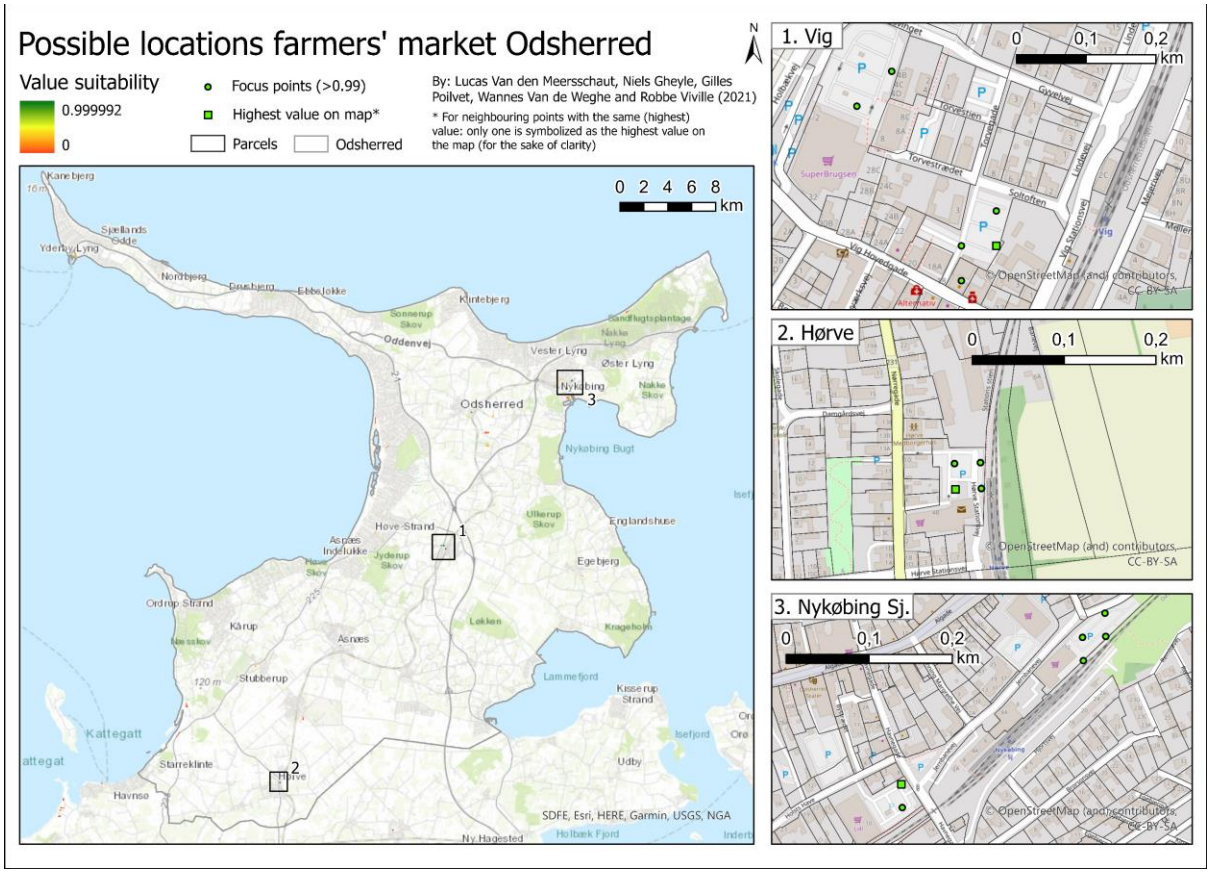
4.6.5 Farmers' market

The synergy between greenport and space for logistics was seen as the fifth most relevant in the expert view and is discussed in detail as the last synergy. A potential project is a farmers' market, where farmers can sell their products directly, without third parties, to the inhabitants of the municipality. This could be a catalyst for more liveliness in a community, but could also increase the name recognition of local farmers and improve social cohesion between farmers and non-farmers in the community.

4.6.5.1 The spatial development

The factors that lead to lower or higher suitability are related to accessibility. Both bus and train accessibility are considered relevant, ensuring that the place where the farmers' market takes place is (easily) accessible by public transport and does not require the use of a private car. The distance to a train stop is given a weight of 0.70 and is thus considered more relevant than the factor 'distance to a bus stop' that is given a weight of 0.30. The higher relevance of the train stop is related to the wish that also people from outside the municipality should be able to experience the farmers' market in Odsherred.

The farmers' market could best take place on a square that is large enough. In the case of the constraints, therefore, only squares with a minimum size of 2000 m^2 in the municipality are retained as possible locations.



Map 9: Suitability map farmers' market

4.6.5.2 Supporting measures

As with the four previous potential projects, supporting measures are necessary to place the idea of the proposed farmers' market in a sustainable and realistic framework. First of all, taking into account the context of the current environmental problems, priority should be given to local sustainable and

traditional farmers. For example, sustainable farmers should pay less for their stands than conventional farmers. More extreme measures such as excluding conventional farmers (who have a more negative impact on the local environment) could also be an option. Related to this is the provision of economic (subsidies) and social (training) support to farmers who commit to traditional and sustainable agriculture. Finally, non-agriculture related issues must be prevented from taking over the farmers' market. This can be done by banning non-agricultural stands.

4.6.5.3 Terrain evaluation

Three possible locations for the farmers' market emerged from the MCE: Vig, Hørve and Nykøbing Sj. The location in Vig, that came out best from the GIS analysis, was also identified as the most optimal location by an overwhelming majority (87.50%) of the respondents. Field observations also revealed additional strengths of this location. For example, there is a covered market with benches nearby, where people can rest. The square itself is a public car park and can therefore easily be closed off for activities such as a farmers' market. There are also other car parks in the vicinity, where people can park their cars if necessary (if train and bus are not an option). In general, the settlement itself, with its lively shopping street, is also a pleasant setting for a farmers' market. A synergy between the existing shopping street and its shops and the future farmers' market is therefore possible.

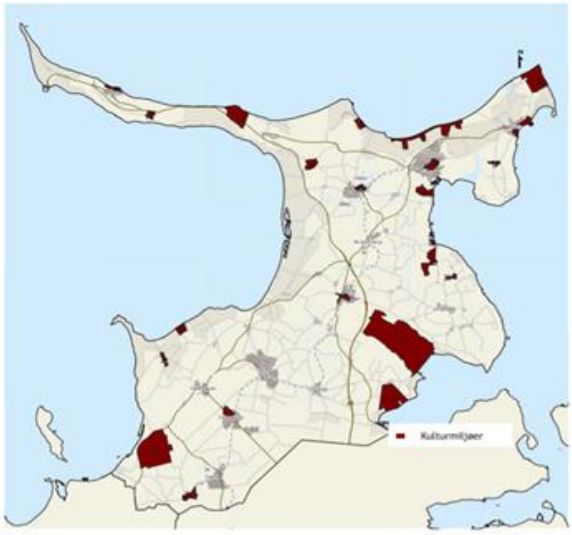
The locations in Hørve and Nykøbing Sj. were much less popular and also turned out to be supermarket car parks. The supermarkets are open every day, so the organisation of the farmers' market at these locations has little chance of success.

The concept itself was very much liked by the people surveyed. With an average approval rating of 3.88 out of 5 (and a standard deviation of 1.30/5), it was the most 'popular' proposed project. For local residents, a farmers' market could lead to a more efficient and fun shopping experience, as farmers nowadays sell their goods in small shops on their farms. By clustering the farmers' sales activities, there would be less commuting involved. Nevertheless, the public evaluation showed that there are doubts about the concept, as there are already such small-scale markets in the municipality. A potential farmers' market in Vig would therefore have to offer something special in order to stand out from the existing markets and thus have a chance of survival.

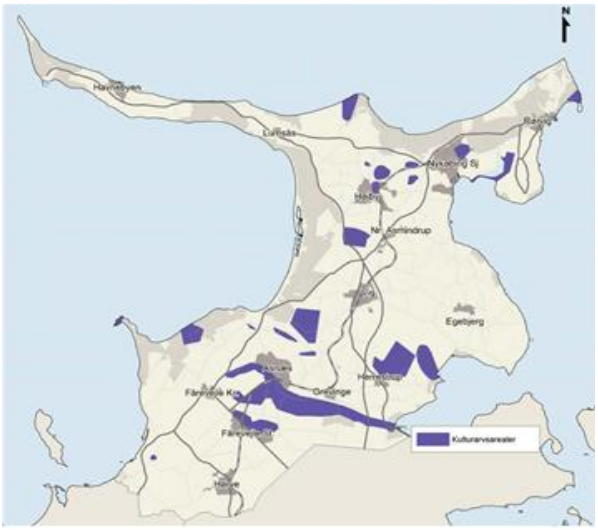
4.7 Planning context

In order to get a feeling with the feasibility of the suggested projects, the planning context of the municipality is (briefly) taken into account. Due to time management, we couldn’t analyse the complete Kommuneplan (2017-2029) of the municipality, but the main future development goals are considered. In what follows we selected the most relevant development goals noted in the Kommuneplan and tested these against the above suggested developments (Odsherred Kommune, 2017a; Odsherred Kommune, 2017b; Odsherred Kommune, 2017c). The following relevant theses were selected:

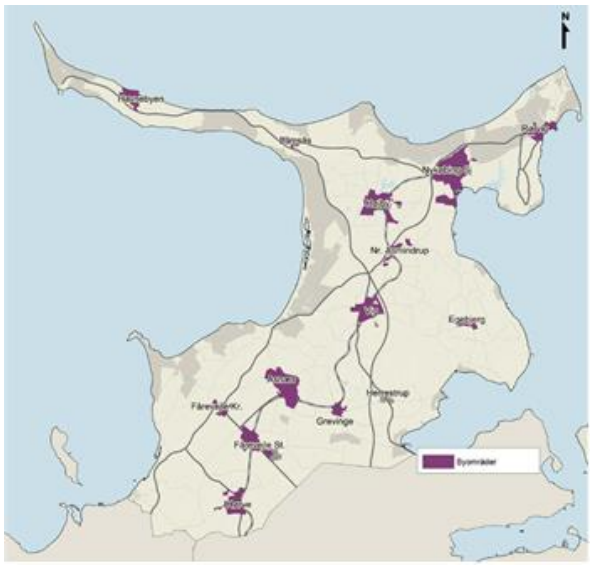
1. There is no change allowed in cultural environments (see map 9) unless the change doesn't create any negative effects on the environment.
2. No conversion to city of traffic placement, large installations and afforestation is allowed in cultural heritage sites (see map 10) unless the overall feel of the landscape doesn't change.
3. New knowledge and service enterprises should be located in city areas (see map 11) in order to minimize further fragmentation of the open landscape.
4. No now industrial or commercial activities are allowed in summerhouse areas.
5. New schools with community related functions should be located in Asnæs.
6. New cultural and recreational developments should be in walking distance to a train station in order to support a sustainable modal split, not solely focussed on car use.



Map 10: Synthesis of the cultural environments in Odsherred (Odsherred Kommune, 2017b)



Map 11: Synthesis of the cultural heritage sites in Odsherred (Odsherred Kommune, 2017b)



Map 12: Synthesis of the city areas in Odsherred (Odsherred Kommune, 2017b)

When analysing these six statements from the Kommuneplan (2017-2029) some conflicts can be seen between the above suggested developments and the developments goals of the municipality.

Concerning the cultural environments and cultural heritage sites, we see no conflicts for the suggested projects. Also, no new developments are suggested within summerhouse areas which is also according to the development goals of the municipality.

When looking at the suggested optimal location for the logistic centre. The location, based on optimal accessibility through the main roads in the municipality, is located in a rural area. This causes a conflict with the third development these of the municipality.
The suggested optimal locations for the agricultural tourism centre according to the MCE are all not in walking distance of a train station. This conclusion conflicts with the sixth development these coming from the Kommuneplan. The consideration needs to be made if the multimodal accessibility is more important than the proximity to farms and the rural landscape, and with this the overall experience of the agriculture.

The most optimal location for the suggested brainport, according to the expert and local view, is Asnæs. This is in fact a great coincidence since the fifth development these states that new schools need to be located around Asnæs. This result from the analysis is consequently in line with the predetermined developments views of the municipality.

Overall, the consideration needs to be made if the planning context is to be definitive and binding, or if certain aberrations should be allowed when these are very well substantiated.

5. DISCUSSION

In general, the potential developments were received with a predominantly positive response by the respondents, as no project had an average approval rating lower than 2.5 out of 5 hearts. This indicates an individual willingness of the people to welcome new projects to the municipality. However, certain projects turned out to be more desirable than others, relying on the context the respondents experience every day and which could not be captured in the rather theory-based expert view. For example, taking into account the average approval ratings, a centralised logistics park appears at first glance to be less desirable than the other four suggestions. Moreover, the standard deviations of the given scores can provide interesting additional insights. The scores given for the agricultural tourist centre, the logistics park and the farmers' market all have a standard deviation between 1.25/5 and 1.30/5. This indicates that the respondents are not all equally convinced by these ideas, despite the relatively high scores. The other two potential developments had a shared score of 3.79/5, but show different standard deviations. The standard deviation on the mean score of the brainport (0.91/5) is smaller than the standard deviation on the mean score of the youth hangout place (1.15/5). It can be deduced from this, that the idea of a youth hangout place evokes contradictory reactions to a greater extent than the idea of a brainport.

However, some reactions from permanent residents who considered the concepts valuable, but were negative about the collective desirability and chances of success specific for the context of Odsherred, were striking. Some of them seem to accept the less favourable socio-economic situation and have little faith that any development can bring about a turnaround. This is also reflected in the fact that the average approval ratings for four of the five potential developments are lower among the permanent residents than among the summerhouse residents (see figure 3). A possible explanation is that the lives of the permanent residents are largely centred in the municipality, so there is less knowledge and incentives from other municipalities and successful projects there. Summerhouse residents also have a different (living and working) location and can therefore more easily compare different situations in different parts of the country.

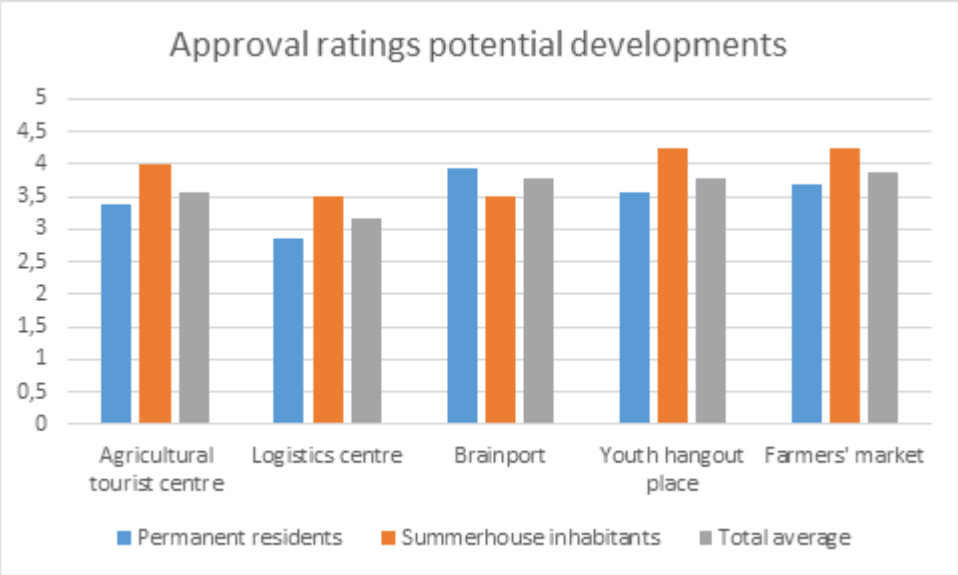


Figure 3: Approval rating potential developments

Additionally, a coincidence during the research showed that the permanent residents are more willing to undergo the situation and are less inclined to think about concrete developments themselves. During the second and third interview day, when mainly permanent residents were questioned, the question where they could propose developments themselves was asked first and this generally resulted in less response. On the first day, however, where there was a greater balance between interviewed summerhouse residents and permanent residents, this question was asked last, after they were allowed to evaluate the proposed projects, and yielded a more detailed response. A possible explanation for this is the fact that, during the interviews, they were made to get out of their comfort zone by thinking about projects they would not normally get involved in. However, the possibility that this was due to coincidence should also be considered.

Nevertheless, the open question at the end provided relevant input in some cases. In addition to concrete developments, the provision of basic services such as doctors, police, public transport, etc., must be improved in the municipality. The cultural aspect also appeared to play a major role in the lives

of the respondents. The expansion of the cultural sector is mentioned by many of the interviewees (e.g. a museum in Rørvig about the former toll plaza for the passage of the fjord). The importance of cultural facilities is also often mentioned in the theory. A strengthening of the cultural sector can lead to a more creative region and a favourable climate for the formation of a regional identity. On the one hand, the presence of a strong creative class/sector is linked to two aspects of economic growth, namely talent and innovation. On the other hand, a stronger regional identity, leading to a so-called unique 'couleur locale', can be advantageous for the socio-economic situation of a municipality (Allaert, 2010). According to the interviewees, efforts should also be made to beautify/redevelop existing neighbourhoods (e.g. port of Nykøbing), to improve physical connections and networks between different neighbourhoods (e.g. town centre and port of Nykøbing) and to build unique experiences/monuments (e.g. landmark). These developments can increase the added value of locations/land in the municipality, contribute to regional image building and thus have a positive impact on prosperity and well-being (Allaert, 2010). Conflicts between permanent residents and summerhouse residents also come to the fore (e.g. the idea that the shops today are too focused on the tourists), which proves the importance of this research, which proposes new projects and has as one of its aims to reduce the existing gap between these two groups.

An important note is that no statistical analyses were carried out, which means that the significance of certain statements cannot yet be proven. The research conducted was therefore purely exploratory and qualitative, with the focus on obtaining an initial insight into the desirability of new *enriching* developments and not on detecting statistical differences. If the sample were to be further enlarged, statistical analyses may have potential in scientific follow-up studies. If possible, the municipality itself could conduct extensive surveys of its residents and thus pursue a broad participatory future-oriented policy.

The existing master plan of the municipality, the so-called kommuneplan 2017-2029, should be approached from a critical angle based on new insights from both this research and follow-up studies and surveys. In this way, an answer can be given to the question of whether the master plan is (still) relevant to the future (local) needs and wishes.

If the foundations for the future policy based on the three relevant views (expert, local and planning) are established, a certain roadmap for the implementation of the concrete actions/activities/projects can be defined. In doing so, several well-founded choices will have to be made. For example, with regard to financing, the question will have to be asked whether the investments will come from the public sector, private parties or a combination of both (PCC). This will be a starting point for a phase of supporting, but no less important, research projects.

6. CONCLUSION

The desk study showed that the municipality of Odsherred lags behind many other Danish municipalities in socio-economic terms (e.g. low-educated population), but also has some strengths that distinguish it from other regions (e.g. large number of summerhouses and tourism). On the basis of this dynamics sketch, a SWOT analysis could be drawn up, from which it became clear that, despite certain threats and numerous weaknesses, a relatively large number of strengths and opportunities could also be noted. The driving forces described by Allaert (space for logistics, greenport and countryside, retail and recreation, space for young people and brainport) and the resulting actions and goals specified for the municipality could be used in the next step as an anticipation of the SWOT analysis. As certain synergies between the driving forces and resulting actions could be even more valuable than each action separately, 5 potential developments were retained, using the insights from SWOT analysis. These were: agricultural tourist centre (synergy greenport and recreation), logistics centre (synergy logistics and recreation), brainport (synergy brainport and recreation), youth hangout place (synergy youth and recreation) and finally farmers' market (synergy greenport and logistics). Theoretically, these five developments can play a role in attacking opportunities, defending against threats, strengthening strengths and limiting damage in the region. In a next step, MCEs were carried out to give these developments a spatial translation. The intermediate result obtained was largely theory-based and could not yet capture the local views of residents. The local view was thus implemented in this research by means of a site study, in which a visual inspection of the locations of the developments took place and a questionnaire provided valuable feedback from the residents. While certain locations of the developments were found to be the best both on site and in the surveys (e.g. farmers' Market in Vig), other locations could be eliminated based on site insights. In general, the response to the developments was positive, but there were doubts about the collective desirability in the municipality and the long-term success. Interviews also revealed pessimism among a relatively large proportion of permanent residents. Approval ratings were lower among the permanent residents compared to the summerhouse residents and most of them could not list many developments that were desirable for them on their own. These feelings of 'being subjected to the situation' contrasted with the real socio-economic disadvantage that Odsherred has compared to many other Danish municipalities. The more personal input therefore remained mainly superficial, but was no less valuable (i.e. importance of culture, solving conflicts between the two large population groups, extra services, etc.). Finally, the municipal view was captured in this research by comparing the existing master plan with the strategy building and results of the MCEs of the expert view. Certain conflicts appeared to exist, such as the recommendation that new recreational developments should be located within walking distance of train stations conflicts with the location(s) of the agricultural tourist centre.

The theoretical background, the (evaluation of the) examined potential developments, the input of the residents and the planning context resulted in initial insights on how to improve day-to-day life and wellbeing in the municipality of Odsherred. At the end, this structure around the three different views (expert, local and planning) proved valuable. It thus remains relevant for prospective studies to look at each of these three views in detail, as each has its specific value and role in underpinning Odsherred's

future path. The municipality of Odsherred provides many opportunities for future socio-economic developments, but it is important that all three views correspond if we want to make the municipality more attractive on every level. By doing so, a more thriving an *enriched* Odsherred could become reality.

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8. APPENDIX

Annex 1: Full text of the socio-economic sketch

A) Socio-economic situation

A.1 Population dynamics

In the first quarter of 2021, approximately 33 000 people were living in the municipality of Odsherred. The last years there is a succession of periods of population decreases and recoveries of these declines. The population density is around 91 persons/km2, which makes it one of the more sparsely inhabited municipalities of Denmark (statbank.dk, 4/04/21a). An important sidenote here is that only permanent residents (and not the seasonal summerhouse inhabitants) are considered in these figures.

In terms of the age-structure, there is a trend of an ageing population. The amount of people with an age greater than 50 is increasing every year, whilst the share of population with an age of 49 or lower is decreasing. In addition, the mean age is the sixth highest of whole Denmark, namely 49.1. This is 7.1 years more than the mean age of the whole country of Denmark (statbank.dk, 5/04/21c).

A.2 Labour market, employment and sectoral distribution of employment creation

Both the economic activity rate (i.e. the ratio of the total labour force to the population of working age) and employment rate (i.e. the ratio between the labour force in work and the population of working age) were lower than the national average in 2021 (De Mulder & Druant, 2011; statbank.dk, 5/04/21b; Clausen & Andersen, 2020, 5/04/21).

When looking at the specific statistics, there were approximately 1 877 workplaces in the municipality itself in 2018, which led to a total of 11 309 jobs. Only a minority of these jobs can be labelled as self-employed. Very noticeable is the declining number of self-employed people since 2008. The same is also happening in the public sector, whilst the number of jobs in the private sector is recovering since 2015. Consequently, the total jobs in Odsherred is now 10% lower than in 2008. Compared to the region of Sjaeland, where the number of jobs is almost at the same level as in 2008, Odsherred does worse). In addition, the amount of uneducated or low educated people in Odsherred is higher compared to the rest of the region (vaekstanalyse.dk, 5/04/21). The lower share of highly educated men and women is also reflected in the sectoral distribution of employment creation; health, trade, construction, industry and education are the most relevant sectors in the municipality (vaekstanalyse.dk, 6/04/21).

A.3 Commuting and attendance index

The attendance index (i.e. the amount of people who find work in their own municipality) is declining. In 2019, the amount of people living and working in Odsherred was only slightly higher than the amount of people working elsewhere: 8 249 compared to 6 193. About 3000 people from outside the

municipality commute to Odsherred for their job (statbank.dk, 7/04/21b; Clausen & Andersen, 2020, 6/04/21).

B) Business-economic situation

B.1 Exploration

A first step to gain insights into the business dynamics of Odsherred and Nykøbing Sj. is to explore which companies and businesses are present in the municipality.

On the outskirts of Nykøbing Sj. are several construction-related shops, supermarkets, second-hand shops and car garages present. In fact, one could speak of a certain clustering of the construction-related shops in the northwest of the city. At the small harbour, some boat-related businesses can also be found. In and around the centre, the locals can find general facilities (e.g. pharmacies, restaurants, sweetshops, cheese shop, bank, café, bookshop, clothes shop, etc.). Tourist facilities can be found in the centre as well.

A special case is the settlement of Asnæs. Apart from the general facilities that are present, as in the other villages, the activity is special in two particular dimensions. Firstly, the centre of the settlement is taken up by a shopping centre, the so-called Asnæs Centret, where a wide variety of speciality shops can be found. The second remarkable feature is the 'clustering' of larger companies (e.g. Ditlev-Burke Industrial Tools A/S).

In the hamlets, business activity is rather limited. However, it is remarkable that almost every settlement has a (small) supermarket (e.g. Nyrup, Lumsås, Egebjerg). In some of the hamlets, there is an outlier to be found. For instance, there is a large swimming pool company in Herrestrup and a large pharmaceutical company near the centre of Lumsås.
In the larger villages (e.g. Vig, Højby) the economic activity is higher. The supermarkets are bigger and there is more diversity in facilities and specialty shops (e.g. clothing shops).

Settlements close to summerhouse zones (e.g. Rørvig) are also heavily influenced by the tourist sector, which leads to a combination of both general facilities (e.g. supermarket) and tourist facilities (e.g. street food).

Between the settlements, agricultural activities dominate. Cultivation (of trees and flowers), farms, agricultural houses (e.g. Skelbjerggaard Gårdbutik), etc. characterise the specific economic situation in these rural areas (google.be/maps, 28/02/21).

B.2 In more detail

The 1872 companies headquartered in Odsherred generate about DDK 7.084 billion in turnover (about 950 million euros). This means an average of DKK 3.8 million (500 000 euros) per company (Clausen & Andersen, 2020).

On the other hand, the annual turnover of tourism is approximately DKK 1.6 billion (approximately 215 million euros), of which DKK 1.1 billion (147 million euros) is related to the presence of second homes (Slätmo et al., 2019). These figures show the importance of tourism to Odsherred.

Of the 1872 companies headquartered in the municipality, only 137 are exporting. Most companies are therefore mainly involved in import and resale and are thus less export-oriented. The industrial sector, which has a limited presence in Odsherred, provides the most export-oriented companies. In addition the number of employees per company is low. On average, each company has 2.3 employees. The proportion of smaller businesses is therefore higher than the average for the Sjaelland region (Clausen & Andersen, 2020).

The municipality of Odsherred has a rather limited trend towards internationalisation. In Odsherred, there are some (but not much) continental/global companies such as NKT A/S and H. Lundbeck A/S and ‘knowledge intensive’ companies like Ditlev-Burke Industrial tools. The dominant (global) economic-technological trends are thus applicable in a lower extent to the municipality of Odsherred.

The survival rate of the companies in a period of 5 years after establishment does appear to be in line with the average of the region. However, it is striking that in comparison with the other municipalities in Sjaelland, the establishment rate of companies is one of the lowest. In fact, Odsherred has the second lowest rate in the region, after Lolland (Clausen & Andersen, 2020).

C) Real estate dynamics

C.1 Real estate market

Odsherred ends up in the bottom quarter of Danish municipalities ranked on real estate market value (statbank.dk, 3/04/21). Furthermore, the average real estate value based on official valuations (what taxes are based on (homelight.com, 3/04/21)) in Odsherred is the fifth lowest in the municipalities rank (statbank.dk, 3/04/21a). The evolution of real estate market and official values in Odsherred is similar to the Danish average, although the crisis of 2008 had a bigger impact in the municipality compared to the Danish average. The market value of real estate has risen in both Odsherred and the whole of Denmark in the last ten years but the recovery started later in Odsherred, and unlike the Danish average the market value has not reached the value of 2008 yet. The official real estate values have been stable

since 2013 but the difference between Odsherred and the country average is bigger than pre-2008 (statbank.dk, 3/04/21a).

A large share of the real estate in Odsherred consists of summerhouses. In 2020, there were a total of 37 151, whereas 23 273 summerhouses (62.6%). Odsherred has the highest ratio of summerhouses compared to permanent residential properties, and is the only municipality where summerhouses double the amount of permanent residences. While the average market value of single-family houses in Odsherred is well below the Danish average and is one of the lowest in Denmark, the average market value of summerhouses is higher than the Danish average. Since the crisis of 2008, prices of summerhouses exceed prices of single-family houses (statbank.dk, 3/04/21a).

4.1.3.2 Buying and renovating

The coronavirus has a big impact on the renovation market in Denmark. Demand is very high and for many people wanting to renovate it is hard to find a craftsman. In Odsherred, waiting times can run up to several months and prices for a renovation have risen steeply. COVID-19 also caused in a growth in the market itself. Employment in the industry is three percent higher than before COVID-19, and a growth of the renovation market of eight percent is expected in 2021 (Andreassen, 3/04/21; Borbiconi, 3/04/21).

C.2 Future trends

Some recent trends can be seen that might influence the real estate market in Nykøbing. The Danish house tax system is being reformed and this might lead to an increase in housing prices in the Danish outer municipalities such as Odsherred. Taxes in these municipality have apparently been too high in the last few years. Apart from the prospected increased value based on official valuations, the market value will also increase due to the lower house tax for the potential future buyer. In Odsherred, an increase is expected of 17% percent or 182 500 DKK (24 500 euro), which is the highest relative expected increase in Denmark (Risager, 3/04/21).

On the summerhouse market there have been two important factors that lead to an increase in demand. The first one is a relaxation of loan rules in 2017 that intended to recover the summerhouse market after the 2008 crisis. People can now finance up to 75 percent of a summerhouse with a mortgage loan, compared to 60 percent pre-2017. Since than prices of summerhouses have gone up, even steeper than these of permanent residences (Kastberg, 3/04/21a). The second important factor is the COVID-19 virus. The lockdowns cause many city dwellers to look for their own piece of nature. In 2020, sales of summerhouses were 55% higher compared to 2019 and today it is difficult to find a summerhouse for sale (Kastberg, 3/04/21b).

A last trend in the real estate market is a local construction boom in the municipality itself. Local realtors reported that the current housing market did not meet demand. 600 new home are planned, of which 200 in Nykøbing. This will increase the amount of permanent residences by 17%. The new houses will be smaller and more sustainable. The local government is hoping to welcome 1000 new inhabitants. The new houses are being targeted towards the local elderly, so that the present villas will come vacant for new families with children. The new developments are planned to be finished by 2026 but some of the houses are already under construction (N.N., 3/04/21).

D) Mobility and related infrastructure

D.1 Commuting

In terms of working adults, there is a relatively high percentage of long commute with at least 20% of the working population travelling on a daily basis for more than 50 kilometres to their workplace. On the opposite side, 62% of the people work closer than 20 kilometres away from their work (Vækstvilkår, 2016; odsherred.dk, 9/04/21).

When focussing on the youth, Odsherred has a high number of primary schools which are well spread over the municipality. This makes that young children usually don't have to travel that far to attend class. For secondary education, there is only one facility located in the municipality (in Asnæs). Furthermore, the higher education facilities are located in Roskilde, Aarhus or Copenhagen with the exception of an arts school in Moseby, close to Nykøbing Sj. (google.be/maps, 3/04/21; ddsks.dk, 9/04/21). These institutions are easily more than 30 kilometers away which makes them exceptionally only accessible by car or public transport. This last two facts make Odsherred not the ideal location to live for families with school going kids older than 12.

D.2 Infrastructure

D.2.1 Car

Due to the extensive road network and the good maintenance of the network, Odsherred is easily accessible by car. From the municipality, other important cities of Sjaelland such as Holbæk, Kalundborg, Roskilde, Copenhagen,… fall within the theoretical maximum travel time of one and half hour. The cities on the mainland are less-well connected with Odsherred (google.be/maps, 3/04/21).

D.2.2 Train

There is one railway line which passes through the municipality. Odsherred and more specifically Nykøbing is located at the end of Odsherredsbanen a rail track owned by the local train service company Lokaltog. From Holbæk there is a direct connection to Kalundborg (but is run by the state-owned Danske Statsbaner shortened as DSB), Roskilde (which further connects to Copenhagen is also run by DSB) and with Slagelse (run by Lokaltog) (lokaltog.dk, 9/04/21b).

Nykøbing Sj. and by extension Odsherred have a very limited train connection, with only Holbæk being shorter than one hour travel and most other destinations easily exceeding one hour and 30 minutes of travel time. As a result, the train has no time advantage compared to car travel. There is however something positive. Important student cities as Roskilde and Copenhagen have not an exceedingly high travel time, with each being close to one hour and 30 minutes of travel time (dsb.dk, 9/04/21; lokaltog.dk, 9/04/21a).

D.2.3 Bus

The commune of Odsherred has an extensive bus network run by DOT (which stands for Din Offentige Tansport). And which connects all villages to the rail network previously mentioned (dinoffentligetransport.dk, 9/04/21).

D.2.4 Bike

In Odsherred the country roads serve as bike ways. There are some bike lanes located along arterial roads and in the towns like Nykøbing (google.be/maps, 3/04/21).

D.3 Modal split

There are no statistics available on the modal split for Odsherred. Since the bicycle infrastructure and the bus and train network is not very extensive, it can be argued, with some degree of uncertainty, that the car is the dominant mode of transport in Odsherred.

E) Business parks

After a brief analysis of the business landscape of Odsherred we found following concentration/clustering of business parks (google.be/maps, 28/02/21):

- Nykøbing Sj.: small scale business park north of the city centre, retail store cluster northwest of the city centre.
- Lumsås: characterised by a large-scale pharmaceutical company adjacent to the centre of the village.
- Højby: houses the city hall of Odsherred, no defined business parks, some small-scale companies surrounding the city centre.
- Egebjerg: small-scale business park southeast of the city centre.
- Herrestrup: small shopping cluster near the centre of the village.
- Asnæs: business park which is centred around the train station.
- Fårevejle Stationsby: clustering of companies in the southeast.
- Høve: small-scale business park south of the centre of the village.

After analysing the business landscape of the municipality of Odsherred, very few business park clusters were found. Therefore, there are very few complementarities between different companies in the region. Synergetic relationships between business parks and/or companies are almost non-existent.

This makes that there are very few economies of scale, which gives the region a lot of opportunities for optimalisation (google.be/maps, 28/02/21).

Annex 2: Table of SWOT analysis of the current processes in the municipality and anticipation of the SWOT

	Opportunities **Socio-economic** • Increasing employment in Denmark **Business Economics** • Increasing demand for professionalized labour • Increase in teleworking and online marketing • Big tourist market Copenhagen • Export-oriented companies are doing well • Industrial companies have a high number of employees **Building dynamics** • Demand for summerhouses increased during Corona • Lower tax and better loan conditions on summerhouses • Growing renovation market **Mobility and infrastructure** • Car commuting increases **Business parks** • Advantages of concentration, clustering and complementarity	**Threats** **Socio-economic** • Closing schools with too few students • Increasing aging in the region and Denmark • Regional decline in employment **Business Economics** • Decreasing tourism (due to e.g. Corona or economic crisis) **Building dynamics** • Possible real estate crisis **Infrastructure** • Closing unprofitable railways **Business parks** • Existing corporate culture is not based on close partnerships. If these partnerships are not established, a large added value creation will be lost.
Strenghts **Socio-economic** • Increased immigration (Danes and non-Danes) => Is the cause why the population is no longer declining • The elderly are the largest share and and their share is increasing, could be a strength if you deal with them correctly (e.g.: residential care centres) • Strong tourism **Business Economics** • Low percentage of knowledge-intensive sectors fits well with the local job market	**Attack** ○ Stimulating small start-ups ○ Letting holiday home owners actively participate in the municipality could have positive consequences for corporate culture, commercial life and cultural life => Survey among holidaymakers ○ Expansion of summerhouses bringing certainty for the municipality ○ Using the renovation market to have higher quality homes ○ The specialized business offer (construction sector) and tourism means that a further deepening and/or specialization in these sectors is offered. The	**Defend** ○ Using low house prices to attract young families ○ Expansion of summerhouses that are more robust during a crisis situation ○ Change focus on tourism, to strengthen the role of non-tourist **Room for logistics** ○ Protect local bus network (the bus as an important mode for young people to go to school) **Greenport**

• Strong tourism and related activities (e.g. construction and design.) • Strong service sector • Shopping facilities in almost every settlement ("local" shops, even in small settlements, survive) ~ tourism • Certain companies present whose importance exceeds that of the municipality, despite the rural context • Business survival is in line with the region • Majority of companies is strongly intertwined with local and seasonal market • Knowledge-intensive companies do well **Building dynamics** • Cheap housing: can be a low threshold for new residents • Large share of summerhouses > can be a boost for local tourism • Summerhouses in Odsherred have quite a high value compared to the Danish average • Value of summerhouses quite robust during real estate crisis • Growing renovation market • Local government supports housing construction, current trend of expansion present **Mobility and infrastructure** • There is public transport available (train and bus network) • Accessibility by car • Ferry service **Business parks** • Due to the geographical spread in the landscape, the municipality has a broad	available know-how can initiate a favorable sectoral corporate culture. ○ The geographical spread of the various companies makes it possible to plan well-considered, large-scale clustering, connected to the existing road network. ○ Clustering companies with the aim of achieving agglomeration advantages and synergetic relations means that the employment sectors have great optimization potential. ○ Future activities can respond to the geographical/geological values of the area: natural values, scientific research (e.g. knowledge cluster). But also: location-independent work (e.g. digital services) and/or eliminating seasonal differences (e.g. winter tourism) ○ Cutting into Copenhagen tourist market **Space for logistics** ○ Using extensive road network for transport and developments . **Greenport** ○ Further support local facilities ○ Enable winter tourism and day tourism (e.g. open farm day) ○ Tackle Copenhagen's tourist market as a municipality with sustainable agriculture and countryside with character ○ Can provide a 4-season liveliness in the municipality and thus stimulate longer stays in the summerhouses ○ Future business can respond even more to its own region-specific geographical/biological/ geological values **Tourism & recreation** ○ Tourism already established in the area; sector is strong and related economic activities (construction, design) are present ○ Companies survive in the region so doing business is possible	○ 'Broadening' the tourism sector and related sectors **Tourism & recreation** ○ Further investment in tourism can turn the tide and create more businesses and employment ○ Higher demand for public transport can prevent the railway from closing **Space for young people** ○ Focusing on young people can prevent the closure of primary schools ○ The aging of the population can be countered by giving attention and space to young people and thus ensuring that they remain in Odsherred ○ Counter the closing of unprofitable railways by making public transport attractive for young people (e.g. : cheap train subscription for young people) **Brainport** ○ The clustering of activities and intersectoral collaborations can break through the existing solitary corporate culture and initiate cooperation.

'coverage' of companies and associated services. • Multiplicity of locations makes it possible in the future to cluster close to built-up areas. There is no need to further build up the open space. • The share of manufacturing industry (construction sector) and tourism is strongly represented in the area.	○ Many summerhouses are already present, which are well established > the demand side for tourism is already present, developments within recreation & retail can make good use of the summerhouse residents ○ Train connection with cities such as Copenhagen and good accessibility by car > there is the possibility to attract city dwellers and day tourists ○ Spatially spreading different companies > many opportunities for cluster development ○ Day tourism can provide more tourism balanced over the whole year ○ Day tourism makes more use of the opportunity for all-round tourism (tourism throughout the year) ○ Opportunity for to use summerhouse residents in local economy ○ Developing tourism provides a good climate for new start-ups ○ Exploit 100% of the potential for tourism development that is already well established; know-how is already available, better interaction possible, well-considered clustering possible ○ Responding to the landscape: the touristic value of the area (quiet nature, beach) ○ Sectoral cooperation to have high competitiveness **Space for young people** ○ Giving young people a taste of the tourism sector, by making them enthusiastic about holiday jobs in the sector ○ Increased employment is positive for young people in the future and can stimulate policy makers to engage with young people ○ The existing public transport use by making it attractive to young people (e.g. rail pass) **Brainport** ○ Existing, well-connected business clusters can be further expanded while preserving valuable open space.	

	○ Clustering of activities and sectors can undo the existing fragmentation of the landscape. ○ Countering fragmentation of landscape can strengthen eco- and geo- tourism. ○ Clustering of activity and different sectors can create inter- and intra- sectoral synergies. ○ Clustering of activities results in a more limited traffic load on the existing traffic network. ○ Clustering of activity makes it possible to initiate a modal shift cost-effectively, both for people and for goods. ○ Activity clusters can attract educational institutions to establish near clusters	
Weaknesses **Socio-economic** • The number of 20 to 50 year old people is decreasing + low birth rate => decline in the number of births • Stagnant population • Higher share of low-skilled (unskilled and low-skilled) workers • Increasing number of elderly (ageing) • Number of self-employed jobs is decreasing • Number of jobs in public sector is decreasing • Fewer and fewer residents of Odsherred are working in Odsherred itself **Business Economics** • Relatively high unemployment rate, which is particularly pronounced among young adults. • Low mean income in Odsherred • Seasonally changing labor market (trade, tourism (hotels	**Strengthen** ○ Eliminate the lack of clustering and collaboration between sectors and companies to capitalize on the opportunities of the 3Cs **Space for logistics** ○ Transport as a source of employment for young and low-skilled job seekers. **Greenport** ○ Low-skilled workers can turn to (organic) agriculture and agro/eco-tourism for technical/professionalized work ○ (Organic) agriculture can provide a new momentum for the agricultural sector + new farms can be established ○ Regional (agricultural) products can be exported to areas where they are not regional => more export orientation ○ Focusing on innovative ideas such as sustainable countryside and greenports can increase the local/national awareness of the municipality and possibly attract new companies **Tourism & recreation** ○ Using older population for tourism as e.g. Local guide, showing crafts, etc.	**Damage Control** ○ Not artificially increasing the number of homes or summerhouses in order to avoid a price collapse during a crisis and, in the case of summerhouses, not to make the village more dependent on tourism **Greenport** ○ 'Green ports' and sustainable countryside increase the (living) quality of a certain area and can therefore increase/anchored prices of homes ○ More awareness for area => demand for permanent residence may increase ○ Potential for future clustering around multiplicity of prime business locations would cause limited access to open space and thus protect the countryside ○ Older people can enjoy a vibrant community and active transport networks and this could be an incentive to stay active ○ Attracting young families can prevent (primary) schools closing

restaurants) vs education, health, agriculture) • Decreasing number of entrepreneurs (including farmers) • Not export-oriented • Relatively low industry presence • Relatively low start-up rate of new companies • The average number of employees per company is very low (compared to the averages of the region) **Building dynamics** • Low value homes compared to the rest of Denmark: what is reason for low price > Demand is not high • 2008 showed that house prices here are more vulnerable during a real estate crisis • It is more difficult for the housing market to recover after a crisis ○ Permanent residencies in Odsherred especially suffer during crisis • Twice as many summerhouses as permanent residences > no balance between off- and on-season • Overloaded renovation market • The housing market today does not match the demand of new potential residents • Demand summerhouses much larger than supply **Mobility and infrastructure** • Limited provisioning (distant secondary and higher education which cannot be shuttled daily, most daily needs aren't met: pharmacy, clothing stores, cafes, ...) • Difficult to reach in terms of public transport from the rest of Denmark **Business parks**	○ Using unskilled people in tourism **Space for young people** ○ By focusing on young people and ensuring that they continue to live in the municipality, this can in the long run ensure that the number of 20-50 year old people will increase again + the stagnant population will be countered ○ Improve the level of facilities (secondary and primary education) making it more pleasant for young people to grow up in Odsherred **Brainport** ○ Breaking through the broad geographic distribution of companies and providing them in clusters in designated business parks (based on accessibility and restriction of nuisance) can create a favorable business culture with agglomeration advantages, intersectoral partnerships and synergies.	○ Create new jobs in (formerly) deprived agriculture **Brainport** ○ The relocation of businesses along roads with the highest category of roads and near public transport nodes (station, bus lines) can minimize impact of the activity on the broader landscape by encouraging a modal shift.

• The broad geographical spread of the companies means that no clustering occurs and therefore no agglomeration advantages and/or synergetic relationships. • The share of knowledge industries (pharmacy, medicine, sciences, etc.) is very low. • The different number of sectors in the business offer is very low. The majority concerns catering, contractors, transport companies and companies for building materials. The construction and tourism sector is strongly represented in Odsherred while only a small mix of other sectors is present. • This narrow, rather specialized range of companies means that there is no intersectoral synergy.		

Annex 3: Table of the different scenarios and their according actions and goals

Scenario	Actions	Goals
Space for logistics	• Logistic parks where transport companies cluster for the supply of goods to companies in the municipality (transfer point or truck hub with 3PL)	• Promoting local employment (jobs for low-educated youth) to offer an answer to the high unemployment rate • Business synergies through clustering around the logistics park (developing extensive costumer services and cost savings through shared logistics) • Reduction in number of trips and more efficient trips

Greenport & countryside	• Working bottom-up as an alternative for the current top-down '3 zones plan' (pursuing the principle of subsidiarity)
	• Encouraging social connectedness with internals and externals (e.g. involve residents and 'tourists' in agriculture, support for new/young farmers)
	• Extend physical networks which do no interfere with the agricultural activities (cycling and walking routes to let the tourists and residents build a greater connection with each other and the landscape and agriculture)
	• Contributing to a sustainable environment:
	  ○ Stimulate active transport
	  ○ Stimulate renewable energy
	  ○ Attention to water (e.g. eutrophication)
	  ○ Attention to soil (e.g. erosion)
	  ○ Attention to biodiversity (e.g. rows of hedges)
	  ○ Attention to crop diversity
	  ○ Avoid further expansion of recreational zones
	• New initiatives that fit into traditional context (e.g. care companies, farm visits by children, open farm days, farmers market, agriculture schools, hiking and bicycle days with quest element,…)
		• Integration of the historical, cultural and economic capital of agriculture in the region with current needs and trends
		• Extra growth opportunities for agricultural production by introducing people to sustainable regional agriculture
		• Avoiding conflicts between various stakeholders, because they can focus on (sustainable) agriculture with historical-cultural foundations and not on global big-scale trends
		• More opportunity for new ideas (innovation), faster response when problems through collaborations, introductions of new people, direct contact with costumers,…
		• New collaborations between businesses/ new businesses by striving for a diversity in crops
		• Attracting outsiders (e.g. tourists) and getting people interested in the (sustainable) agriculture sector
		• Enhancing the cooperation between countryside and city
		• Combining the green (environment) and red (social) aspects of agriculture
		• Modal shift towards more sustainable travel modes
		• Maintaining character and identity of the region
		• Keeping older population active and attracting young people (with green fingers for example)

Recreation and retail	• Expansion of a retail/recreation cluster (local entrepreneurs who together can offer an unique form of recreation and experience) with focus on accessibility: ○ Near centre/station: funshopping and experiencing the pleasant city life	• Creating added value for the whole place by combining different experiences in a region which may not be that unique in a broader context • Better cooperation (because clustering) • Growth opportunities and innovations • Creating extra (low-skilled) jobs in tourism sector

	○ Along edge settlements: larger complexes (e.g. sports centre), mainly aimed at families from wider region ○ Along summer houses: shops catering to daily needs of summerhouse residents ○ Around Moseby: enrich present museums with catering, retail to create a total experience ○ Around agricultural business: agrotourism ○ Around sports spaces (water activities, adventure forest park,…) • Development of chains (tourist routes between entrepreneurs): organised combination of museums, shopping, beach tourism,…	
Space for youth	• Expanding existing youth facilities (e.g. Nykøbing Sjælland Svømmehal) • Developing new youth facilities/hangout places (e.g. outdoor fitness) • Organising outdoor-activities/festivals aimed for the youth • Good functioning youth centre • Temporary trendy activities during vacations (e.g. pop-up summer bar during summer vacation) • Giving a voice/a vote to the youth	• By focusing on young people, they can develop better, which creates a lot of potential on the labour market and growth opportunities • Young people who have experienced good development and well-being are more likely to be innovative • Encouraging entrepreneurship • Improving quantity and quality of safe and social space specifically aimed for the youth
Brainport	• Developing knowledge cluster around existing themes (e.g. scientific knowledge cluster focused on geology and geography (geopark), art cluster around current art school in Moseby) • Promoting/supporting multimodal accessibility which is a precondition for a knowledge cluster and makes connection-building with other relevant places (e.g. university towns) easier • Establishing a social network between internal residents and external investors/academics • Implement sustainability vision into the activities present (sustainable development of the knowledge cluster which leads to a win-win situation) • Attuning the supply of facilities to the wider population of the core close to the knowledge cluster	• Optimising and broadening knowledge in the region, preventing a brain drain to other regions in Denmark; • Initiate high-quality interaction between business activity and knowledge clusters in order to allow innovation in both sectors. • Implementation of a modal shift so that multimodal access becomes the rule (high-quality public transport network); • Creating an attractive living environment through an extensive range of facilities (trade, services, recreation) geared to all sections of the population.

Annex 4: Table of the synergies between different actions

Synergy between…	Space for logistics	Greenport & countryside	Recreation & retail	Space for youth	Brainport
Space for logistics		• Let farmers sell their products locally => **(5) Farmers' market**	• Third party logistics: third party provides transport between a distribution centre and the clustered tourism and recreation businesses => **(2) Logistic centre**	• A more efficient supply of goods leads to a more safe environment for active transport	• Good accessibility and transhipment of goods creates an attractive and competitive business culture. An attractive business culture and high-quality accessibility encourage the establishment of activity and knowledge clusters
Greenport & countryside			• Create recreational areas where locals and summerhouse residents interact • Promoting tourist trips with active transport • Double role for farm businesses: agriculture and tourism: offering tourist activities, catering and accommodation in farm businesses • Playing off the unique character of traditional agriculture as a unique recreational experience • Build chains: walking and cycling routes between farms • Agrotourism: new initiatives that fit into a 'traditional context' and make the area special => **(1) Agricultural tourist centre**	• Combining agriculture and education => Agriculture school • An environment that is safe for active transport (cycling, sports, etc.) and associated infrastructure	• A brainport can align its knowledge domain with the agro-sciences and landscape sciences. The potential in the geological characteristics of the landscape means that both scenarios can work together. => Scientific knowledge cluster on nature/agriculture/geography

Recreation & retail				• Recreational cluster with sufficient (unique) activities for young people • Give young people a role in local tourism and recreation: what do they want? => **(4) Youth hangout place**	• Use the research institutes present in tourism: fun and educational visits that allow tourists to learn about the geopark, for example, in a unique way • If brainport around art academy: tourist activities organised in cooperation with the academy • An attractive recreational and retail offer ensures that an active, vibrant and attractive 'leisure life' is present alongside the brainport. A broad recreational offer increases the quality of life in the area and attracts new inhabitants and talents. • The brainport, in turn, can support the extensive recreational and retail offerings, on the one hand because of the large number of residents/ students/ researchers that the brainport attracts. On the other hand, knowledge specialisations can be applied to develop recreation and retail in a lucrative and high-quality manner. => **(3) Brainport (linked to strengths municipality)**
Space for youth					• A brainport attracts new inhabitants and young people to the knowledge cluster and strengthens the youth offer while the target group increases in size • An attractive space for young people means that more young people are attracted to stay and/or settle in the region. Retaining this young, potentially rich age group makes the brainport more likely to succeed due to greater interest and the presence of a young target group.

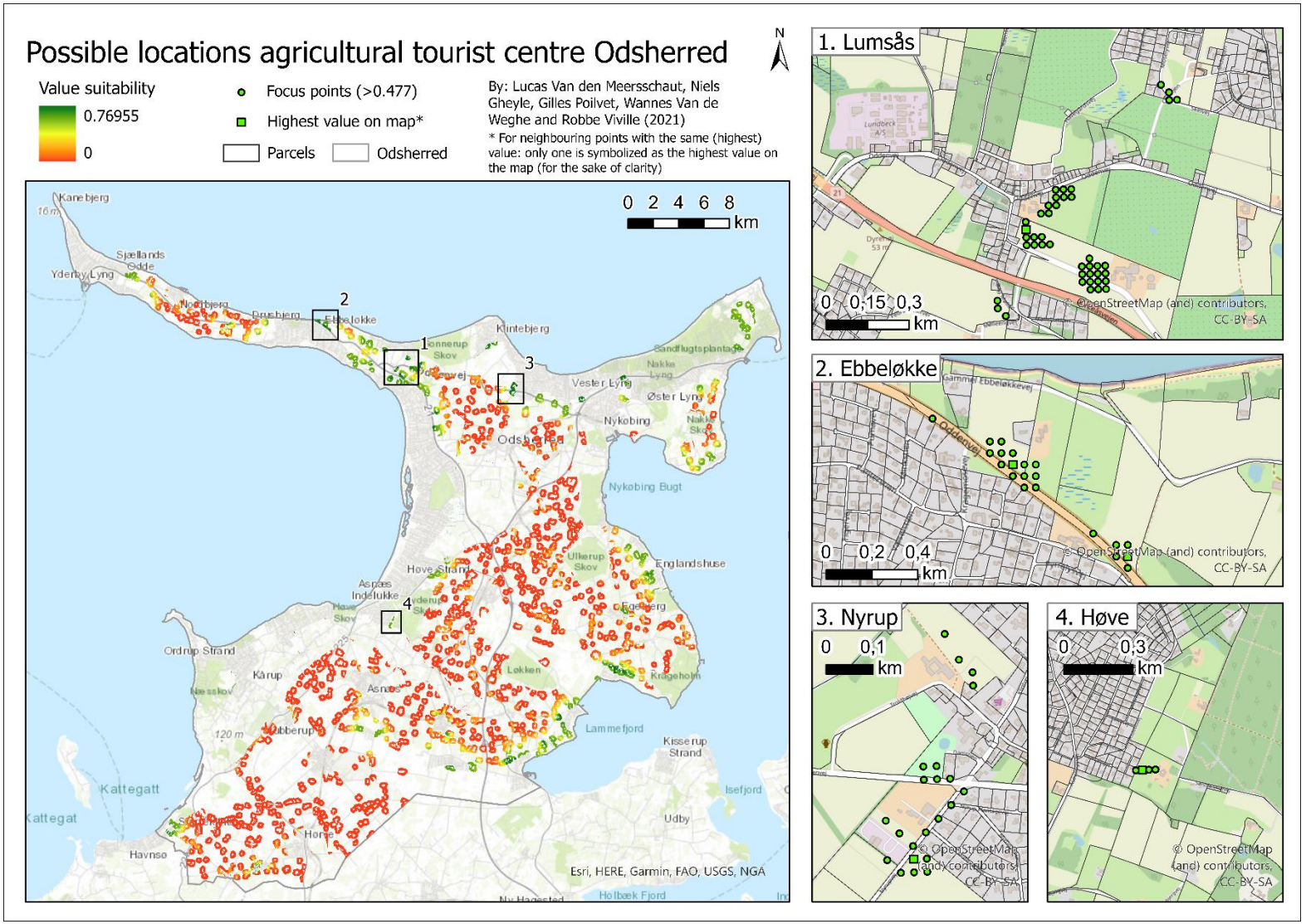
Brainport					

Annex 5: Table with data used for MCEs

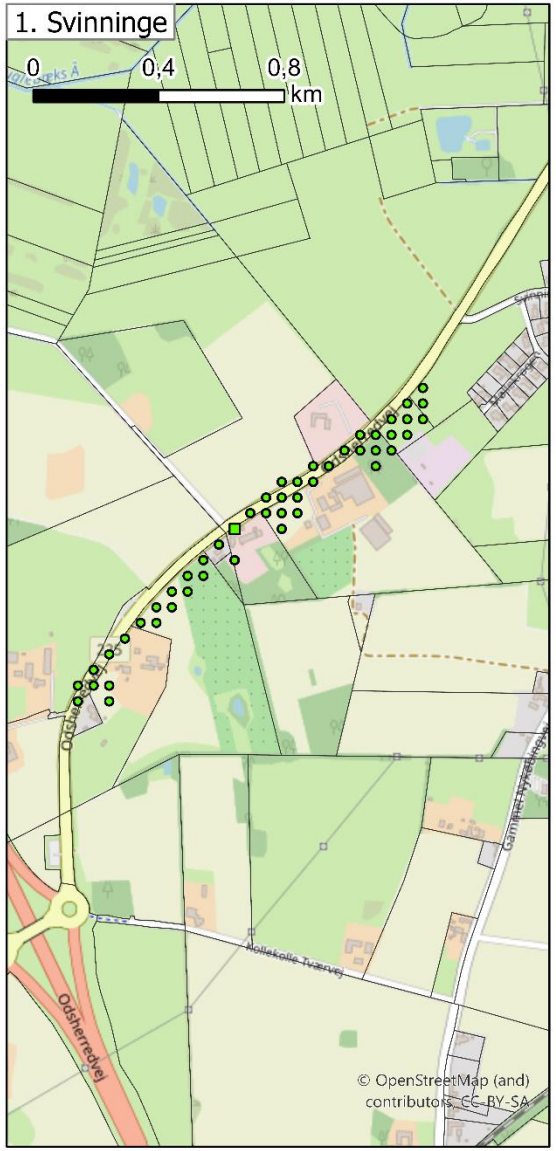
Name	Source	Used for…				
		Tourist centre	Logistic centre	Brainport	Youth centre	Farmers' market
Odsherred.shp	Kortforsyningen					
Structural_plan.shp	Miljøportal					
Valuable_Nature_Ods.shp	Plandata.dk					
Built_area.shp	OSM (turbo bypass)					
Roads_Odsherred.shp	Geofabrik					
Bus_stations.shp	GTFS data					
Train_stations.shp	OSM (turbo bypass)					
Nucleus_village.shp	Self-digitization of locations churches of a (historical) settlements while taking into account historical context settlements (except Nørre Asmindrup, there the railway station is chosen because the church is located outside the current centre) (based on OSM churches and Høje målebordsblade 1842 - 1899).					
Farmyards.shp	OSM (turbo bypass)					
Hospitality_industry.shp	OSM (turbo bypass)					
Nykobing_and_Asnaes.shp	Derived from built_area.shp					
Company_clusters.shp	Self-digitization (based on OSM and Google Maps)					
Schools.shp	Self-digitization (based on OSM and Google Maps)					
Squares_Odsherred.shp	OSM (turbo bypass)					

Important Note: Data from OSM and self-digitized data can potentially not be fully accurate, but it does give a good approximation of the different themes and was therefore useful to obtain certain data.

Annex 6: Suitability maps



Possible locations logistic centre Odsherred



Possible locations brainport Odsherred

Value suitability

0.764501

0

Focus points (>0.50)

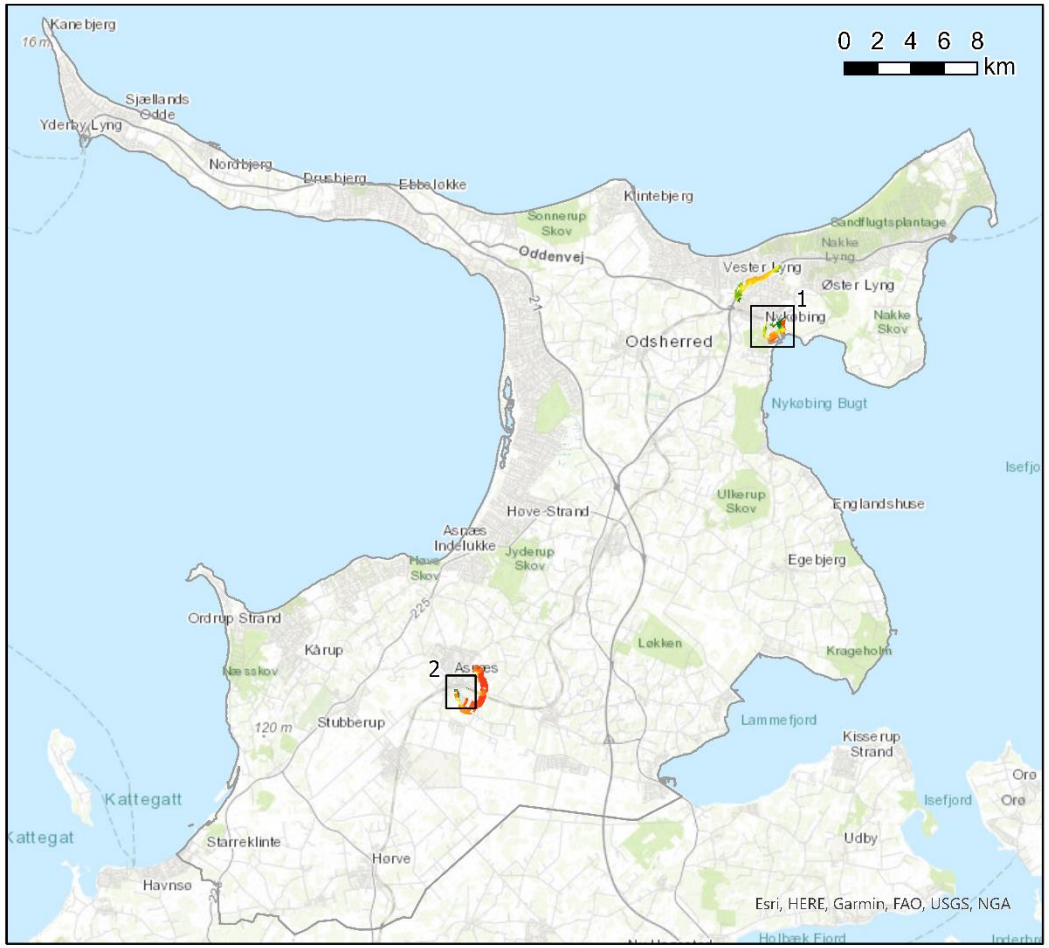
Highest value on map*

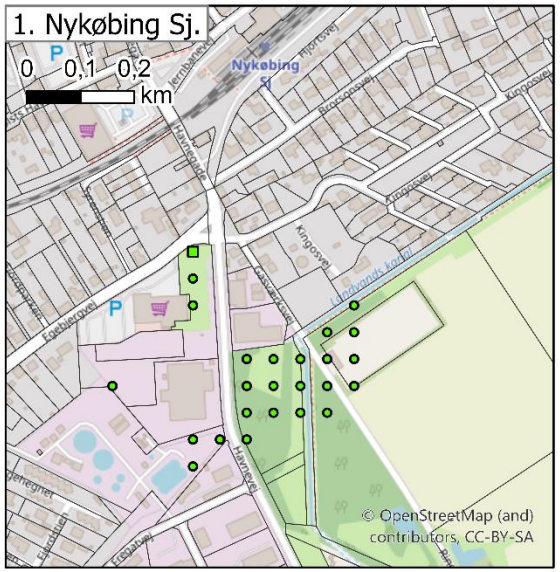
Parcels

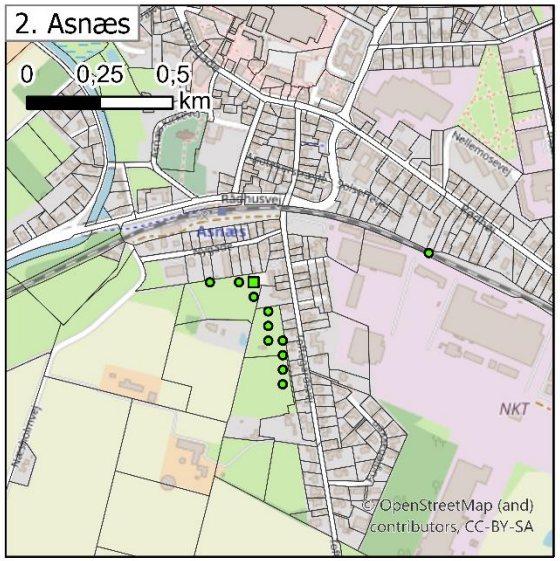
Odsherred

By: Lucas Van den Meersschaut, Niels Gheyle, Gilles Poilvet, Wannes Van de Weghe and Robbe Viville (2021)

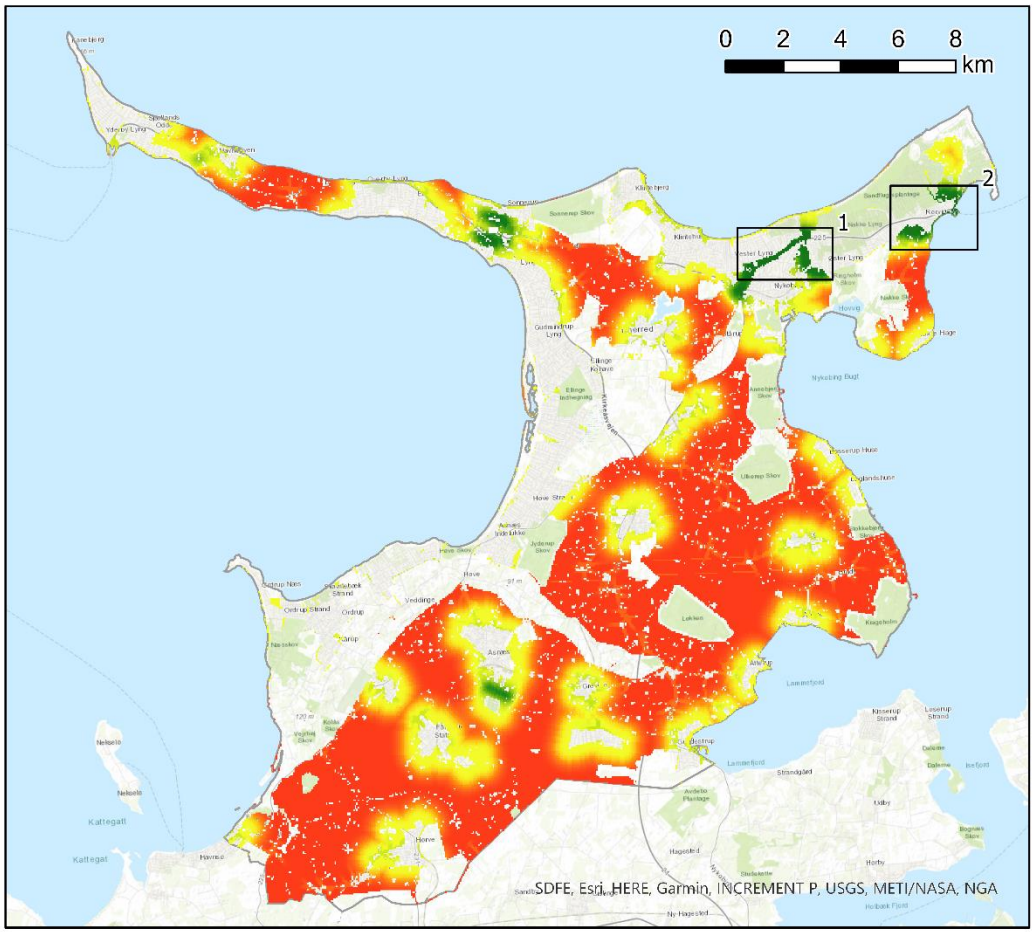
* For neighbouring points with the same (highest) value: only one is symbolized as the highest value on the map (for the sake of clarity)

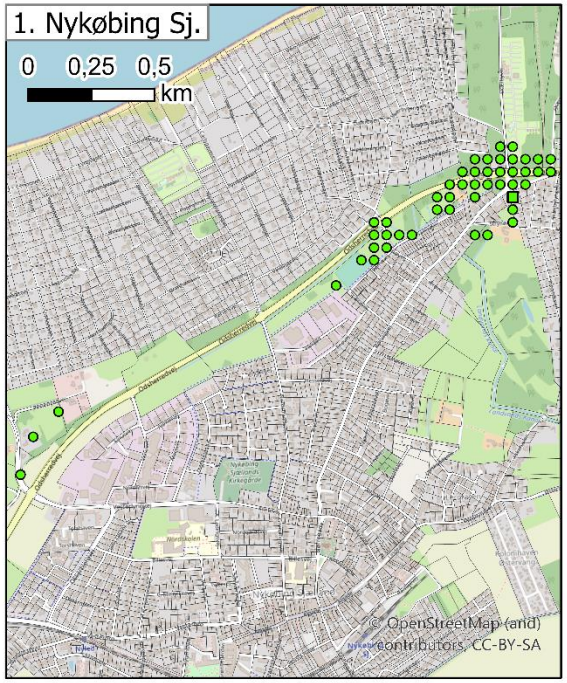


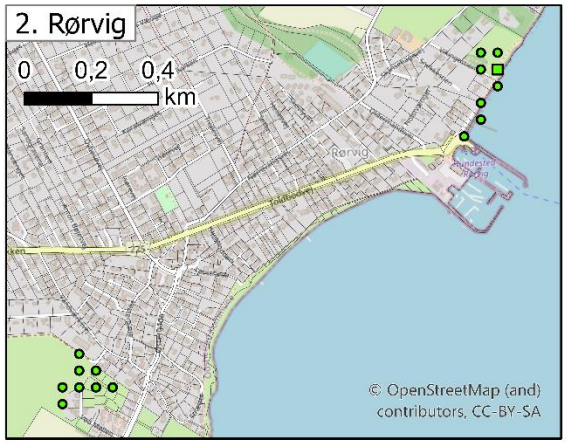


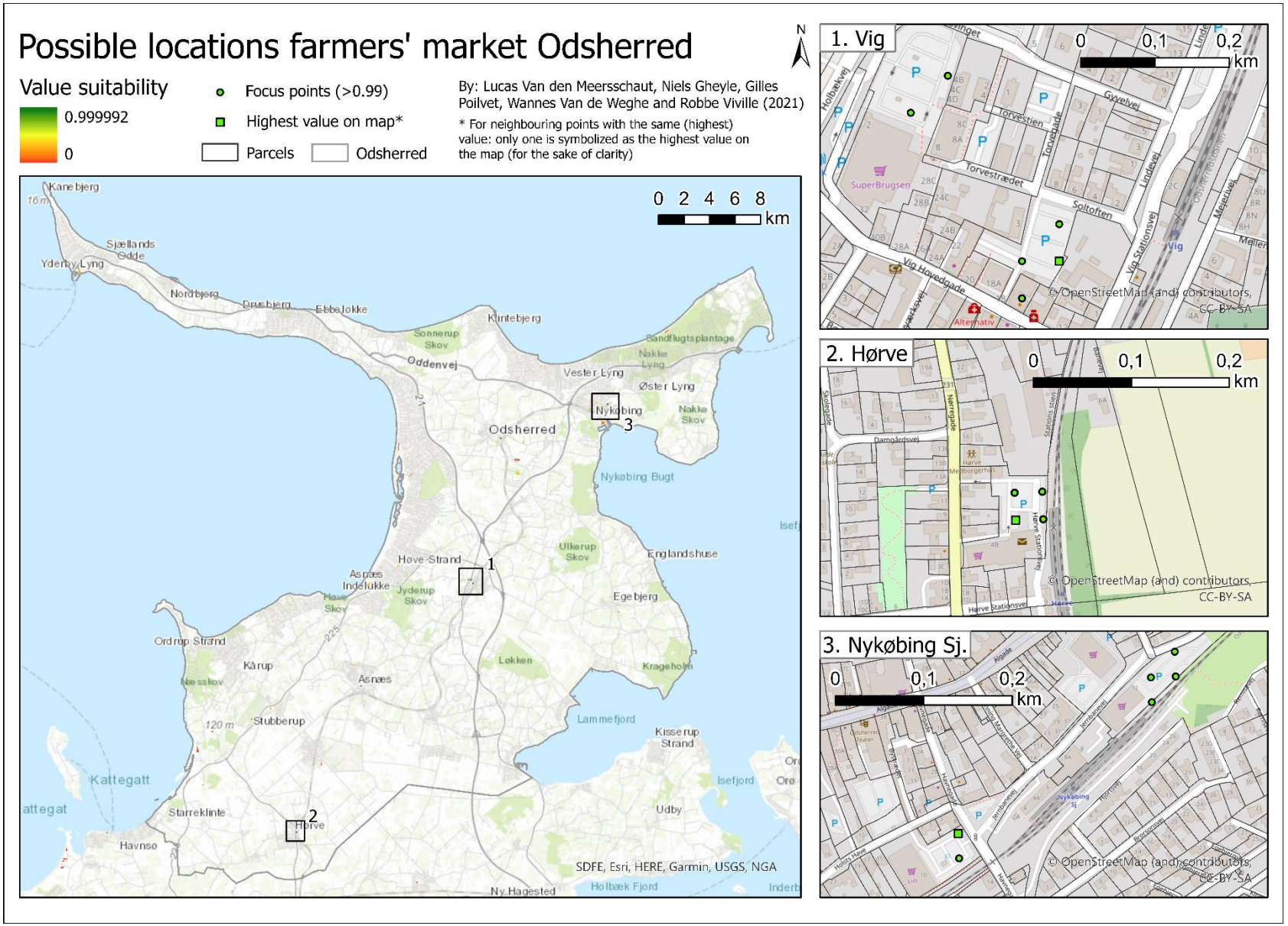


Possible locations youth hangout place Odsherred

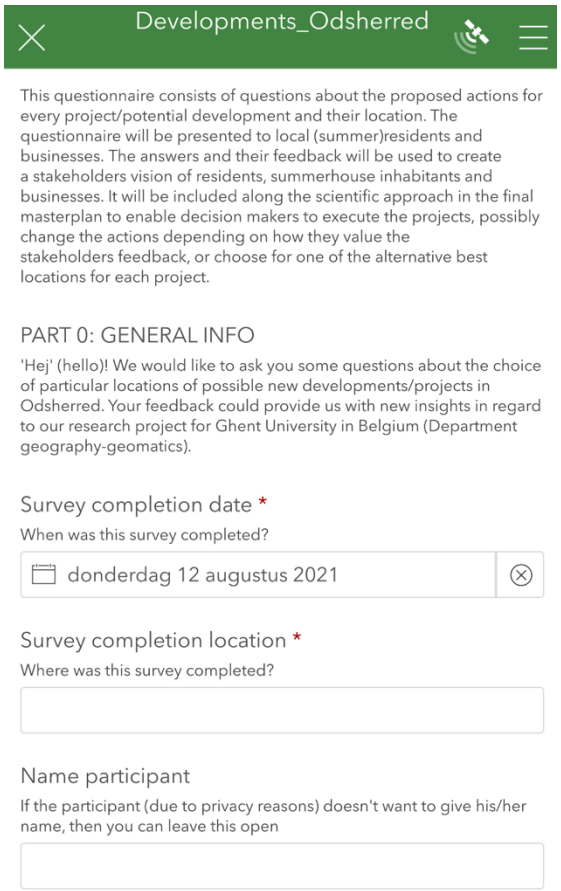


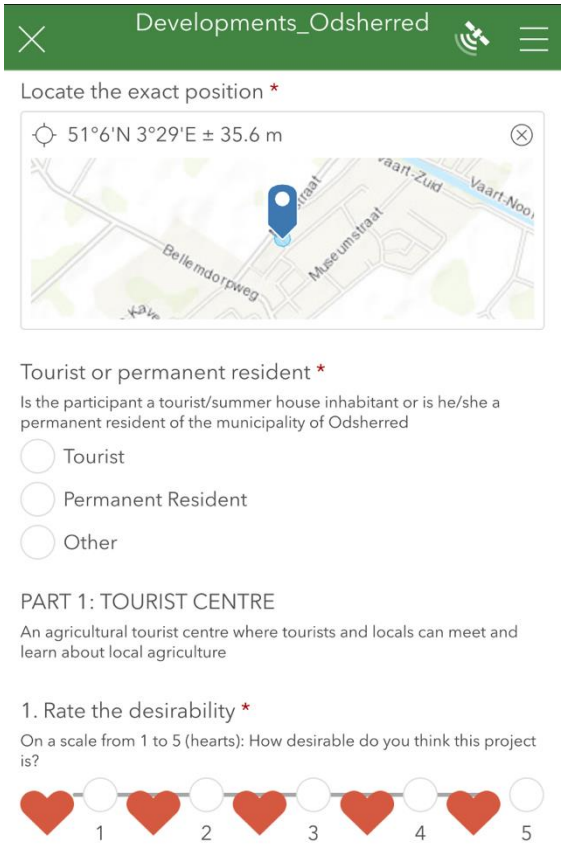


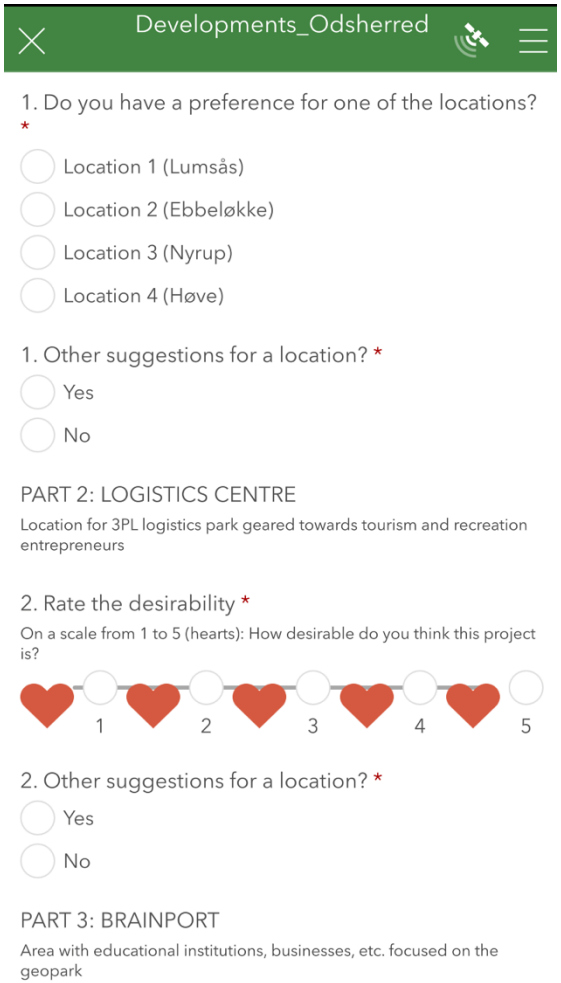



Possible locations farmers' market Odsherred
Value suitability
0.999992
0
Focus points (>0.99)
Highest value on map*
Parcels
Odsherred
By: Lucas Van den Meersschaut, Niels Gheyle, Gilles Poilvet, Wannes Van de Weghe and Robbe Viville (2021)
* For neighbouring points with the same (highest) value: only one is symbolized as the highest value on the map (for the sake of clarity)
N
0 2 4 6 8 km
Kanebjerg
Sjællands Odde
Ydernæs Lyng
Nordbjerg
Drusbjerg
Ebbeløkke
Klintebjerg
Sonnerup Skov
Oddenvej
Sandflugtsplantage
Nakke Lyng
Vester Lyng
Øster Lyng
Nakke Skov
Nykøbing
3
Odsherred
Nykøbing Bugt
Hove Strand
1
Asnæs Indelukke
Jyderup Skov
Ulkerup Skov
Englandshuse
Egebjerg
Ordrup Strand
Kårup
Asnæs
Løkken
Krageholm
Lammefjord
Stubberup
120 m
Kisserup Strand
Kattegatt
Starreklinte
2
Hørve
Havnsø
Udby
Isefjord
Ny Hagested
Holbæk Fjord
SDFE, Esri, HERE, Garmin, USGS, NGA
1. Vig
0 0,1 0,2 km
Holbækvej
Gyvelvej
Torvestien
Torvestræde
Torvegade
Lindevej
Vig Stationsvej
Vig Hovedgade
Søltoften
SuperBrugsen
Vig
Alternativ
© OpenStreetMap (and) contributors, CC-BY-SA
2. Hørve
0 0,1 0,2 km
Nørregade
Damgårdsvej
Hørve Stationsvej
Hørve Station
Hørve
© OpenStreetMap (and) contributors, CC-BY-SA
3. Nykøbing Sj.
0 0,1 0,2 km
Algade
Jernbanevej
Nykøbing Sj
© OpenStreetMap (and) contributors, CC-BY-SA

Annex 7: Questionnaire







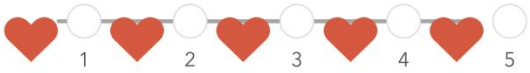
Developments_Odsherred

PART 3: BRAINPORT

Area with educational institutions, businesses, etc. focused on the geopark

3. Rate the desirability *

On a scale from 1 to 5 (hearts): How desirable do you think this project is?



3. Do you have a preference for one of the locations? *

- Location 1 (Nykøbing Sj.)
- Location 2 (Asnæs)

3. Other suggestions for a location? *

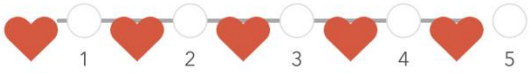
- Yes
- No

PART 4: YOUTH CENTRE

Open space with sufficient recreational facilities for young people (playground, football field, skate park, basketball court,...) that is also easily accessible to the summerhouse youth and tourists

4. Rate the desirability *

On a scale from 1 to 5 (hearts): How desirable do you think this project is?



Developments_Odsherred

4. Do you have a preference for one of the locations? *

- Location 1 (Nykøbing Sj.)
- Location 2 (Rorvig)

4. Other suggestions for a location? *

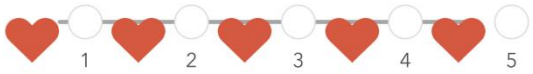
- Yes
- No

PART 5: FARMERS MARKET

Weekly market where farmers can sell their products directly (without intermediaries) and where contact between farmers and non-farmers can be strengthened.

5. Rate the desirability *

On a scale from 1 to 5 (hearts): How desirable do you think this project is?



5. Do you have a preference for one of the locations? *

- Location 1 (Vig)
- Location 2 (Hørve)
- Location 3 (Nykøbing Sj.)

5. Other suggestions for a location? *

- Yes
- No

Developments_Odsherred

5. Do you have a preference for one of the locations? *

- Location 1 (Vig)
- Location 2 (Hørve)
- Location 3 (Nykøbing Sj.)

5. Other suggestions for a location? *

- Yes
- No

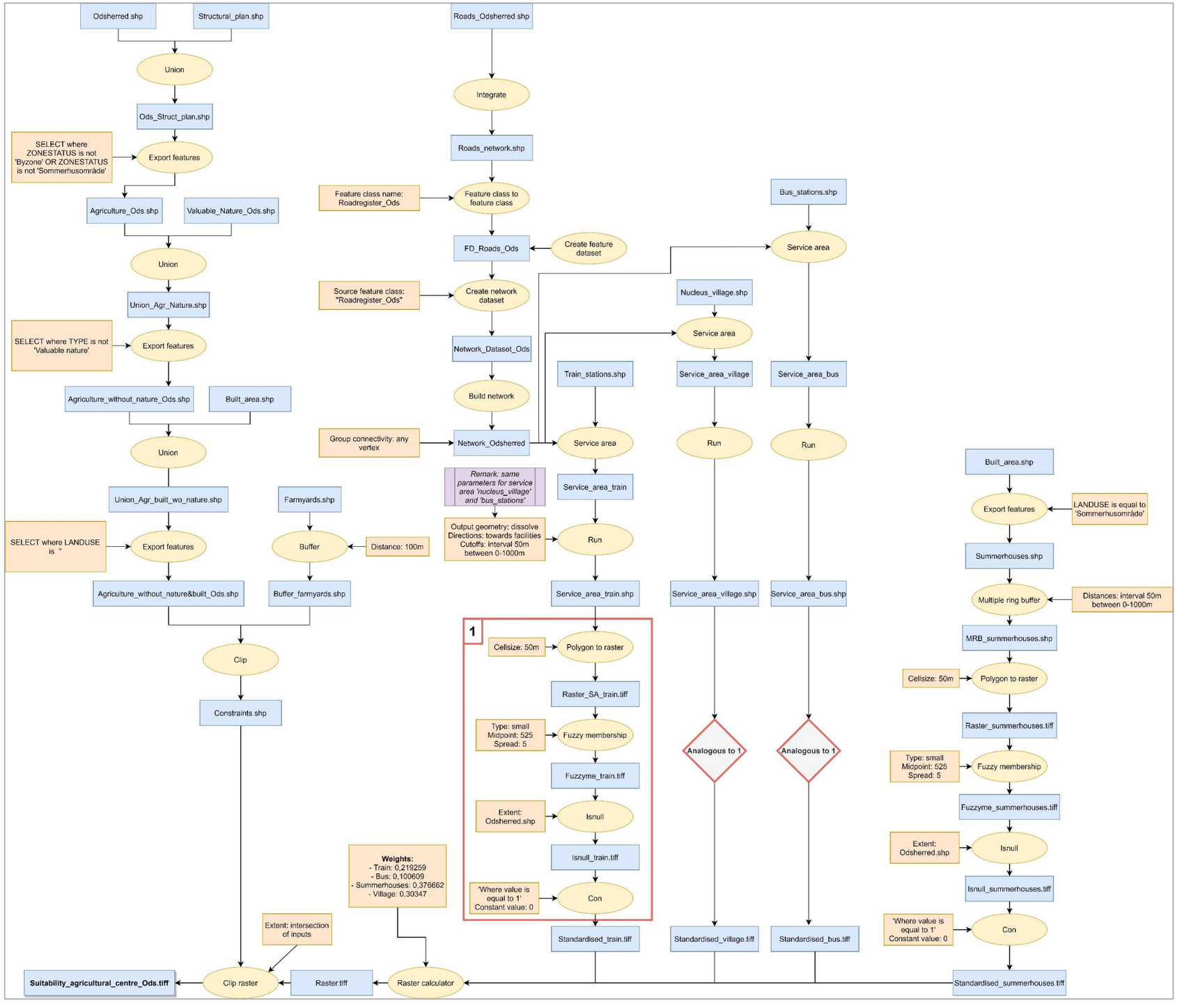
PART 6: CLOSING REMARKS

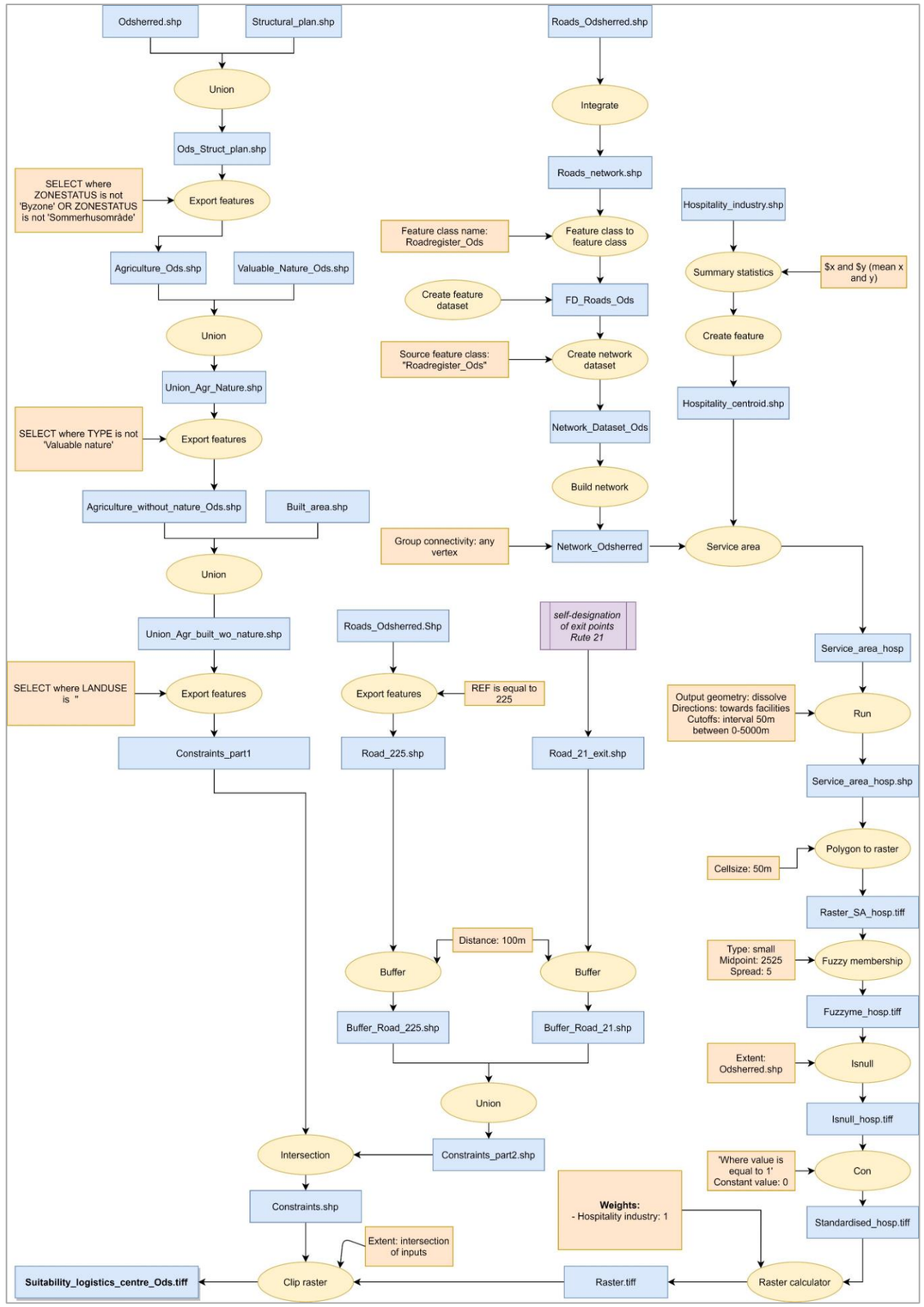
Are there other municipal projects/developments that you think are necessary to make the municipality more liveable/better?

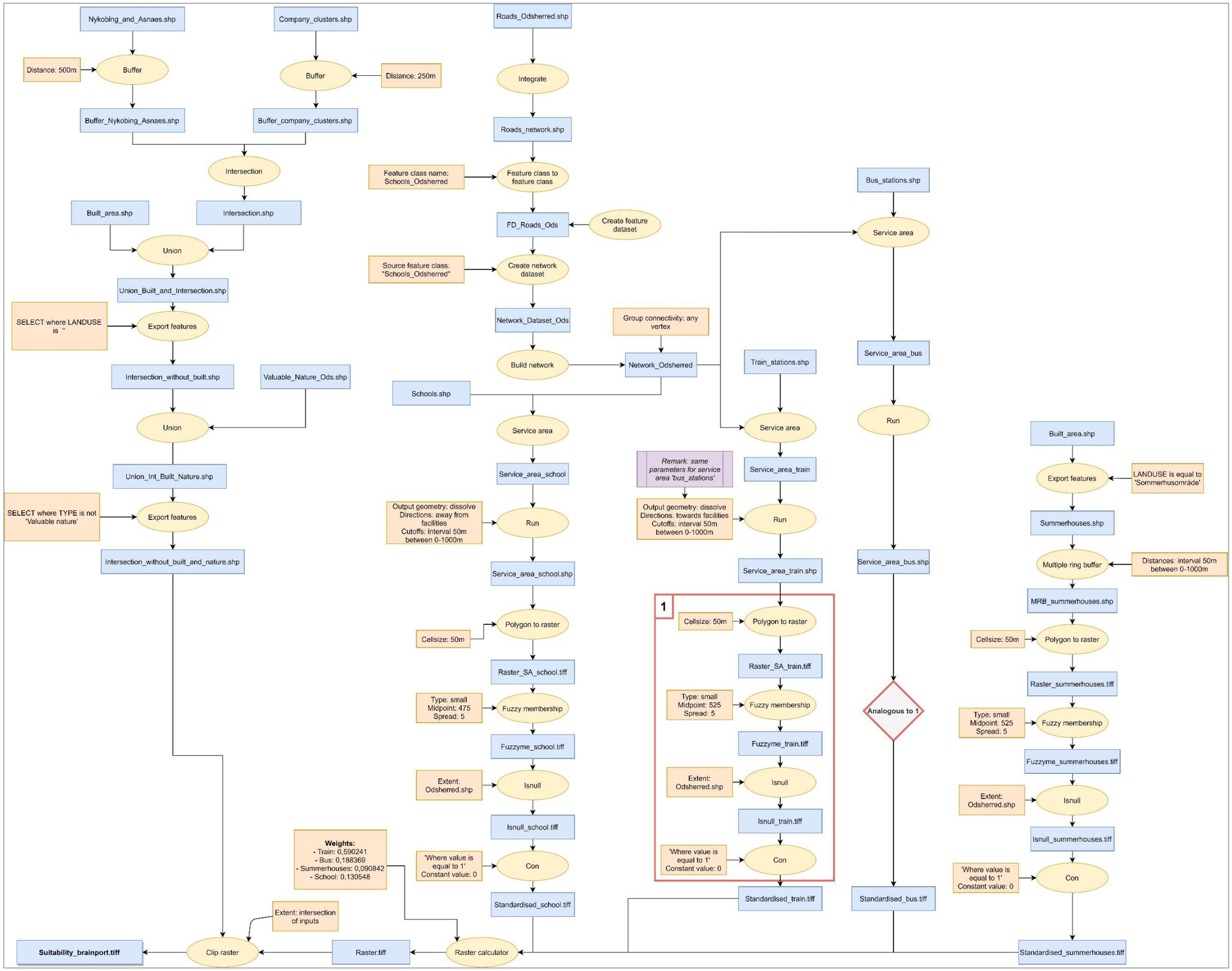
Additional comments

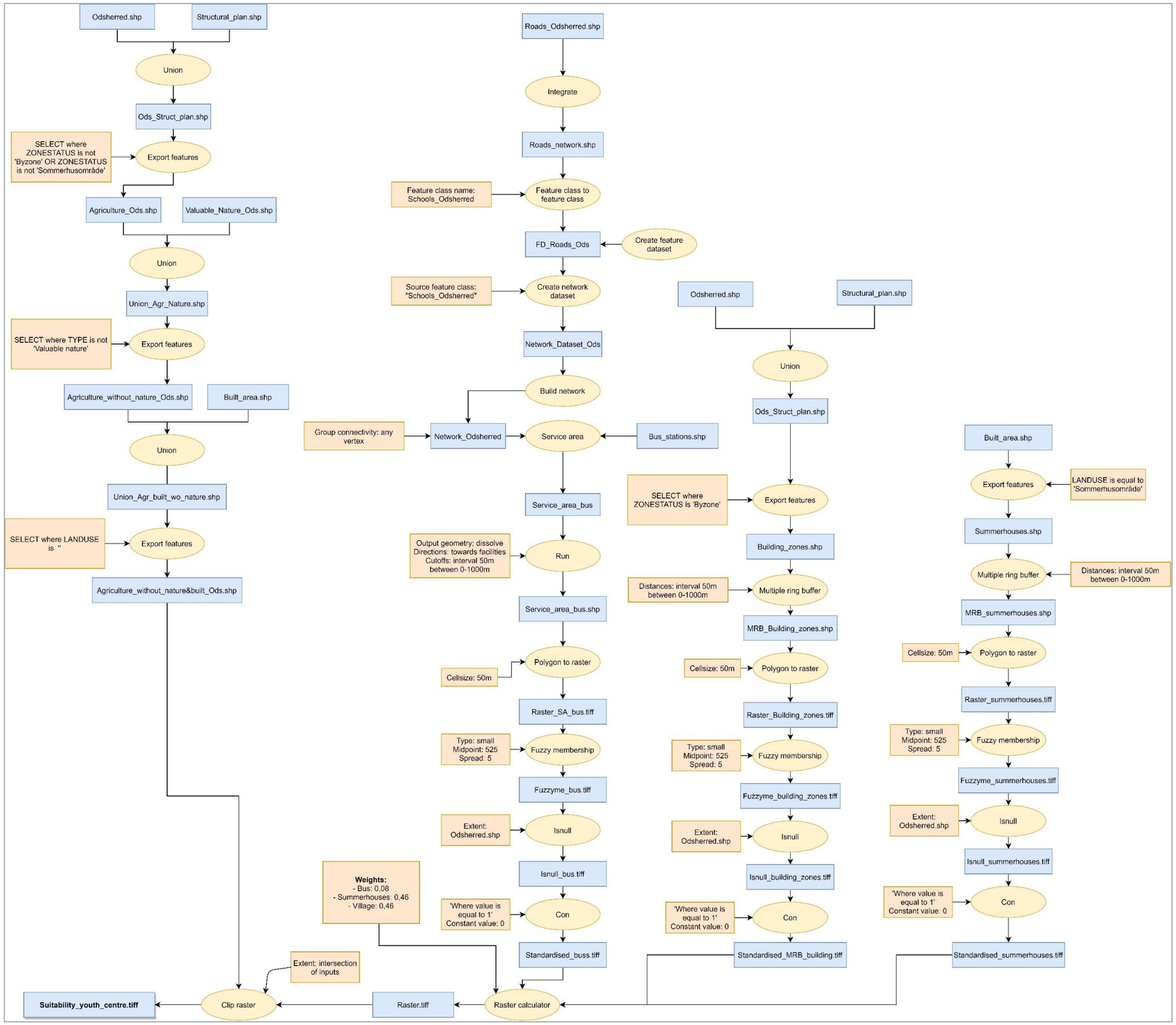
'Tak' (thank you) for completing this questionnaire (Hav en god dag)

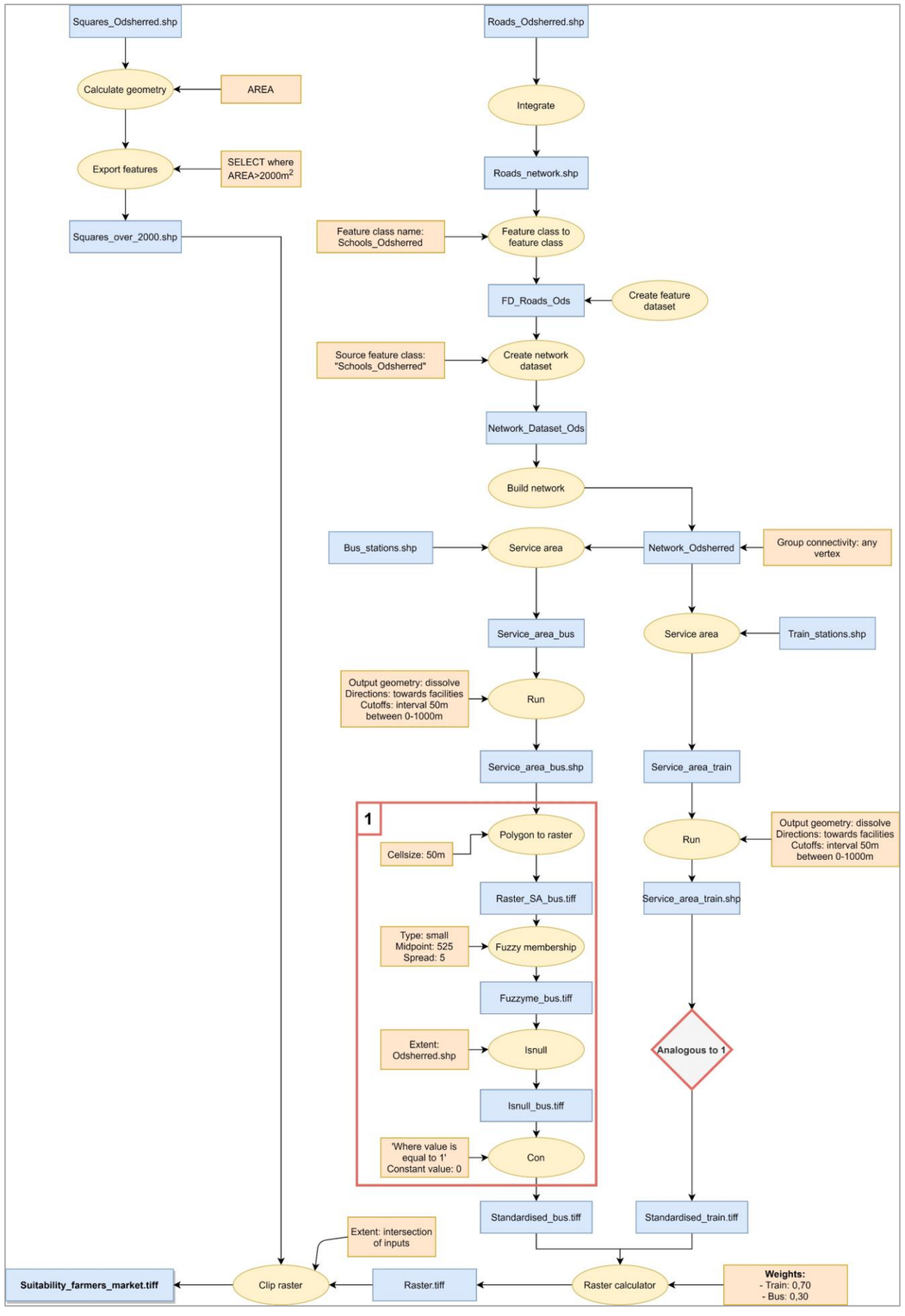
Annex 8: Cartographic models MCEs




Odsherred.shp
Structural_plan.shp
Union
Ods_Struct_plan.shp
SELECT where ZONESTATUS is not 'Byzone' OR ZONESTATUS is not 'Sommerhusområde'
Export features
Agriculture_Ods.shp
Valuable_Nature_Ods.shp
Union
Union_Agr_Nature.shp
SELECT where TYPE is not 'Valuable nature'
Export features
Agriculture_without_nature_Ods.shp
Built_area.shp
Union
Union_Agr_built_wo_nature.shp
SELECT where LANDUSE is ''
Export features
Constraints_part1
Roads_Odsherred.shp
Integrate
Roads_network.shp
Feature class name: Roadregister_Ods
Feature class to feature class
Create feature dataset
FD_Roads_Ods
Source feature class: "Roadregister_Ods"
Create network dataset
Network_Dataset_Ods
Build network
Group connectivity: any vertex
Network_Odsherred
Roads_Odsherred.Shp
Export features
REF is equal to 225
Road_225.shp
self-designation of exit points Rute 21
Road_21_exit.shp
Distance: 100m
Buffer
Buffer
Buffer_Road_225.shp
Buffer_Road_21.shp
Union
Constraints_part2.shp
Intersection
Constraints.shp
Extent: intersection of inputs
Suitability_logistics_centre_Ods.tiff
Clip raster
Raster.tiff
Hospitality_industry.shp
Summary statistics
$x and $y (mean x and y)
Create feature
Hospitality_centroid.shp
Service area
Service_area_hosp
Output geometry: dissolve
Directions: towards facilities
Cutoffs: interval 50m between 0-5000m
Run
Service_area_hosp.shp
Polygon to raster
Cellsize: 50m
Raster_SA_hosp.tiff
Type: small
Midpoint: 2525
Spread: 5
Fuzzy membership
Fuzzyme_hosp.tiff
Extent: Odsherred.shp
Isnull
Isnull_hosp.tiff
'Where value is equal to 1' Constant value: 0
Con
Standardised_hosp.tiff
Weights:
- Hospitality industry: 1
Raster calculator


Nykobing_and_Asnaes.shp
Distance: 500m
Buffer
Buffer_Nykobing_Asnaes.shp
Company_clusters.shp
Buffer
Distance: 250m
Buffer_company_clusters.shp
Intersection
Intersection.shp
Built_area.shp
Union
Union_Built_and_Intersection.shp
SELECT where LANDUSE is ''
Export features
Intersection_without_built.shp
Valuable_Nature_Ods.shp
Union
Union_Int_Built_Nature.shp
SELECT where TYPE is not 'Valuable nature'
Export features
Intersection_without_built_and_nature.shp
Roads_Odsherred.shp
Integrate
Roads_network.shp
Feature class name: Schools_Odsherred
Feature class to feature class
FD_Roads_Ods
Create feature dataset
Source feature class: "Schools_Odsherred"
Create network dataset
Network_Dataset_Ods
Group connectivity: any vertex
Build network
Network_Odsherred
Schools.shp
Service area
Service_area_school
Output geometry: dissolve
Directions: away from facilities
Cutoffs: interval 50m between 0-1000m
Run
Service_area_school.shp
Cellsize: 50m
Polygon to raster
Raster_SA_school.tiff
Type: small
Midpoint: 475
Spread: 5
Fuzzy membership
Fuzzyme_school.tiff
Extent: Odsherred.shp
Isnull
Isnull_school.tiff
'Where value is equal to 1'
Constant value: 0
Con
Standardised_school.tiff
Weights:
- Train: 0,590241
- Bus: 0,188369
- Summerhouses: 0,090842
- School: 0,130548
Extent: intersection of inputs
Suitability_brainport.tiff
Clip raster
Raster.tiff
Raster calculator
Train_stations.shp
Service area
Remark: same parameters for service area 'bus_stations'
Service_area_train
Output geometry: dissolve
Directions: towards facilities
Cutoffs: interval 50m between 0-1000m
Run
Service_area_train.shp
1
Cellsize: 50m
Polygon to raster
Raster_SA_train.tiff
Type: small
Midpoint: 525
Spread: 5
Fuzzy membership
Fuzzyme_train.tiff
Extent: Odsherred.shp
Isnull
Isnull_train.tiff
'Where value is equal to 1'
Constant value: 0
Con
Standardised_train.tiff
Bus_stations.shp
Service area
Service_area_bus
Run
Service_area_bus.shp
Analogous to 1
Standardised_bus.tiff
Built_area.shp
Export features
LANDUSE is equal to 'Sommerhusområde'
Summerhouses.shp
Multiple ring buffer
Distances: interval 50m between 0-1000m
MRB_summerhouses.shp
Cellsize: 50m
Polygon to raster
Raster_summerhouses.tiff
Type: small
Midpoint: 525
Spread: 5
Fuzzy membership
Fuzzyme_summerhouses.tiff
Extent: Odsherred.shp
Isnull
Isnull_summerhouses.tiff
'Where value is equal to 1'
Constant value: 0
Con
Standardised_summerhouses.tiff


Odsherred.shp
Structural_plan.shp
Union
Ods_Struct_plan.shp
SELECT where ZONESTATUS is not 'Byzone' OR ZONESTATUS is not 'Sommerhusområde'
Export features
Agriculture_Ods.shp
Valuable_Nature_Ods.shp
Union
Union_Agr_Nature.shp
SELECT where TYPE is not 'Valuable nature'
Export features
Agriculture_without_nature_Ods.shp
Built_area.shp
Union
Union_Agr_built_wo_nature.shp
SELECT where LANDUSE is ''
Export features
Agriculture_without_nature&built_Ods.shp
Roads_Odsherred.shp
Integrate
Roads_network.shp
Feature class name: Schools_Odsherred
Feature class to feature class
FD_Roads_Ods
Create feature dataset
Source feature class: "Schools_Odsherred"
Create network dataset
Network_Dataset_Ods
Build network
Group connectivity: any vertex
Network_Odsherred
Service area
Bus_stations.shp
Service_area_bus
Output geometry: dissolve
Directions: towards facilities
Cutoffs: interval 50m between 0-1000m
Run
Service_area_bus.shp
Polygon to raster
Cellsize: 50m
Raster_SA_bus.tiff
Type: small
Midpoint: 525
Spread: 5
Fuzzy membership
Fuzzyme_bus.tiff
Extent: Odsherred.shp
Isnull
Isnull_bus.tiff
'Where value is equal to 1' Constant value: 0
Con
Standardised_buss.tiff
Weights:
- Bus: 0,08
- Summerhouses: 0,46
- Village: 0,46
Odsherred.shp
Structural_plan.shp
Union
Ods_Struct_plan.shp
SELECT where ZONESTATUS is 'Byzone'
Export features
Building_zones.shp
Distances: interval 50m between 0-1000m
Multiple ring buffer
MRB_Building_zones.shp
Cellsize: 50m
Polygon to raster
Raster_Building_zones.tiff
Type: small
Midpoint: 525
Spread: 5
Fuzzy membership
Fuzzyme_building_zones.tiff
Extent: Odsherred.shp
Isnull
Isnull_building_zones.tiff
'Where value is equal to 1' Constant value: 0
Con
Standardised_MRB_building.tiff
Built_area.shp
Export features
LANDUSE is equal to 'Sommerhusområde'
Summerhouses.shp
Multiple ring buffer
Distances: interval 50m between 0-1000m
MRB_summerhouses.shp
Cellsize: 50m
Polygon to raster
Raster_summerhouses.tiff
Type: small
Midpoint: 525
Spread: 5
Fuzzy membership
Fuzzyme_summerhouses.tiff
Extent: Odsherred.shp
Isnull
Isnull_summerhouses.tiff
'Where value is equal to 1' Constant value: 0
Con
Standardised_summerhouses.tiff
Raster calculator
Raster.tiff
Extent: intersection of inputs
Clip raster
Suitability_youth_centre.tiff


Squares_Odsherred.shp
Calculate geometry
AREA
Export features
SELECT where AREA>2000m²
Squares_over_2000.shp
Roads_Odsherred.shp
Integrate
Roads_network.shp
Feature class name: Schools_Odsherred
Feature class to feature class
FD_Roads_Ods
Create feature dataset
Source feature class: "Schools_Odsherred"
Create network dataset
Network_Dataset_Ods
Build network
Bus_stations.shp
Service area
Network_Odsherred
Group connectivity: any vertex
Service_area_bus
Service area
Train_stations.shp
Output geometry: dissolve Directions: towards facilities Cutoffs: interval 50m between 0-1000m
Run
Service_area_bus.shp
Service_area_train
1
Polygon to raster
Cellsize: 50m
Raster_SA_bus.tiff
Type: small Midpoint: 525 Spread: 5
Fuzzy membership
Fuzzyme_bus.tiff
Extent: Odsherred.shp
Isnull
Isnull_bus.tiff
'Where value is equal to 1' Constant value: 0
Con
Run
Output geometry: dissolve Directions: towards facilities Cutoffs: interval 50m between 0-1000m
Service_area_train.shp
Analogous to 1
Standardised_bus.tiff
Standardised_train.tiff
Extent: intersection of inputs
Suitability_farmers_market.tiff
Clip raster
Raster.tiff
Raster calculator
Weights:
- Train: 0,70
- Bus: 0,30