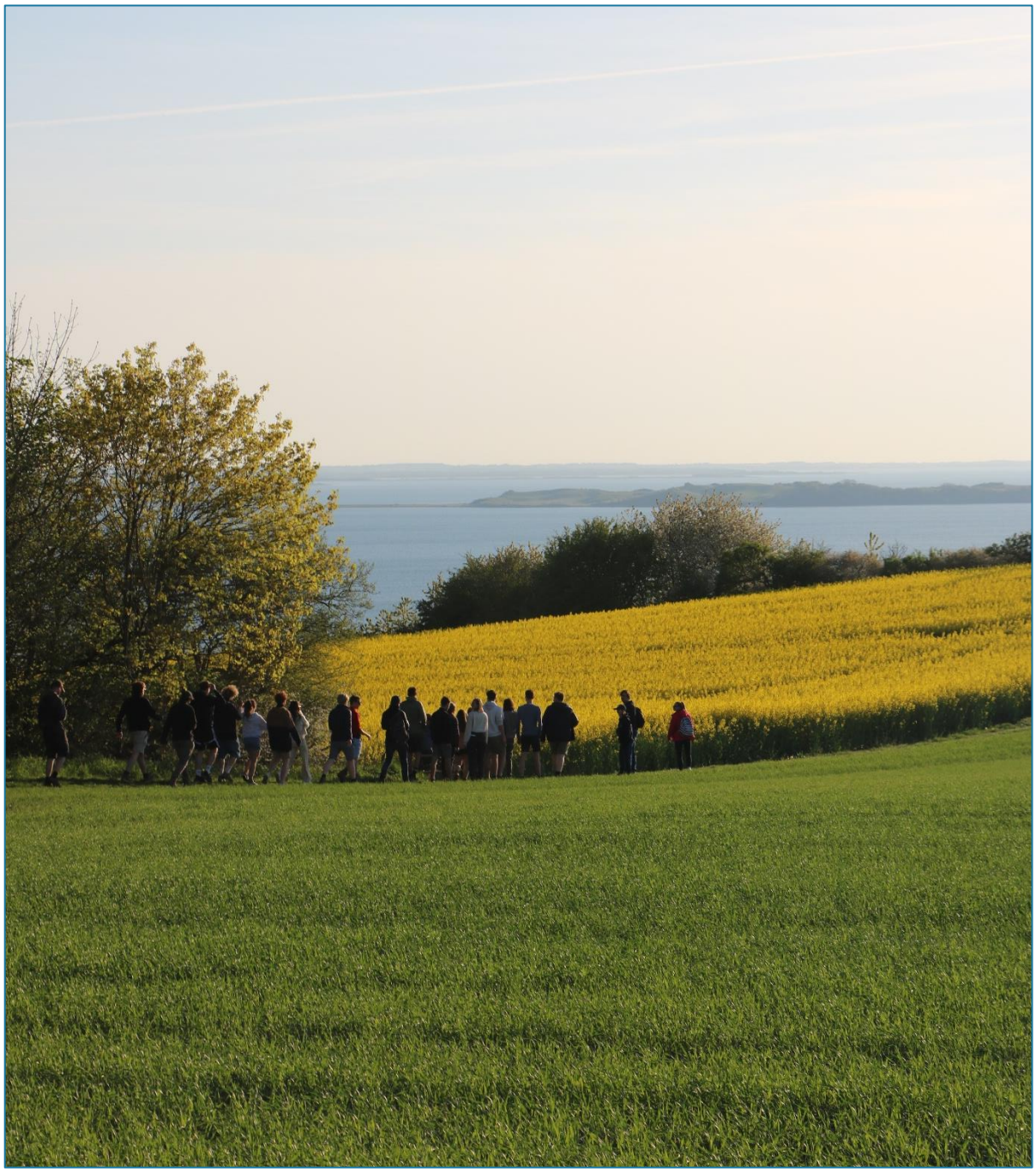

# Odsherred Insights

2nd Edition

*Urban and Environmental Patterns in Odsherred*

7 May – 15 May 2022

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 second edition took place from the 7th to the 15th of May 2022 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. Urban development

*- Lennert Devriendt, Mauk Hillewaert, Emile Roels, Juliet Steffen, Sven Vercauteren, and Ward Van Cauwenberge -*

Analysis of the urban development in Odsherred over the past 30 years.

2. Land use/land cover

*- Lennert De Corte, Seppe Knockaert, Maxim Pauwels, Maarten Podevyn, and Viktor Vangansbeke -*

Relations between land use and land cover and the biophysical variables in Odsherred, Denmark.

3. Recreation patterns in summer house areas

*- Loes Breekelmans, Rune Burggraeve, Zita Demarest, and Paulien Van Haute -*

Existing and preferred recreation patterns in summer house areas in Odsherred, Denmark.

4. Spatial patterns in summer house areas

*- Rune Borremans, Jietse Corneillie, Martha Doffemont, Sarah Strickx, and Axel Vandevannet -*

Looking for spatial patterns in summer house areas in Odsherred, Denmark.

5. Coastal vulnerability

*- Evert Van Bever, Jens Sweerts, Jona Vangansbeke, Klaas Broekaert, Lucas de Oude, Lynn Patyn, Mees Vereeken, and Pieter Plaizier -*

Assessing coastal vulnerability by erosion and risk perception in Sjælland Odde.

The 2nd Edition of the Odsherred Insights was made possible by the collaboration of many people from several organisations.

**Organisers**:

Veerle Van Eetvelde (Ghent University)
Lars De Sloover (Ghent University)
Annelies Van Caenegem (Ghent University)
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**With collaboration of:**

Andreas Aagaard Christensen (University of Copenhagen)
Henrik Vejre (University of Copenhagen)

**Stakeholders that were involved:**

The Municipality of Odsherred
Geopark Odsherred
All interviewed locals
Local organisations

**Special thanks to:**

Per & Katia from Udsigten

# Analysis of the urban development in Odsherred over the past 30 years

Lennert Devriendt, Mauk Hillewaert, Emile Roels, Juliet Steffen, Sven Vercauteren & Ward Van Cauwenberge

Odsherred Insights – 2nd Edition – 2021-2022
Denmark

GHENT UNIVERSITY

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ODSHERRED KOMMUNE

Geopark Odsherred
- UNESCO Global Geopark

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# 1. INTRODUCTION

Urban development has always been a 'hot' topic in the field of urban geography. Thus, there are many ways to analyse the complex dimensions of urban social, economic, cultural, and political processes, patterns, and structures that shape urban development. In this research, a newly developed method, called an Attribute Trajectory Analysis (ATA), has been used to analyse the evolution of different factors that define urbanisation. Before going deeper into this method, it is necessary to frame the study area, which is Odsherred, a municipality located in the Danish region of Sjælland (Figure 1). Since 2015, Odsherred has been defined as a geopark by UNESCO due to the closely intertwinement of the cultural history, arts, and the local products with the landscape and geology in the municipality (https://en.unesco.org/global-geoparks, 2/06/2022). This fact makes this region a remarkably interesting field of study for geographical research that can be approached from many different angles. Odsherred is further subdivided into twelve parishes (Figure 1). These parishes form the spatial entities of the ATA. For each parish, the evolution of a factor defining urbanisation can be represented as a curve or a so-called attribute trajectory. The time scale used goes from 1990 to 2020 with an interval of five years. Subsequently, by comparing the (dis)similarity between the different attribute trajectories of each parish, a clustering algorithm will be applied to visualize parishes with a similar evolution of a factor that defines the urbanisation. In total, six urbanisation factors will be studied. Through fieldwork, interviews and a literature study, the cluster outcomes will be interpreted thoroughly.

The following research questions were used in this study: 'How does the urban environment change over time?', 'What socio-economic and demographic factors influence on the evolution of urban areas?', 'What patterns can be seen in the development of the different parishes?' and 'What are the causes and effects of the found patterns?'. The subsequent objectives are firstly to get insight into the urban development of Odsherred over the past 30 years. By aggregating the six urbanisation factors and thus the different ATA cluster outcomes, a general clustering can be made to see which parishes have a similar urban development. Secondly, by the insight of the past, the future urban development of Odsherred can also be predicted, which is particularly important for spatial planners. Lastly, the potential of an ATA will be validated, as this method has only recently been developed and has not been widely applied in other research in the international literature. This also forms one of the research gaps as well as an urban development study on a scale such as Odsherred, where the urban centres are relatively 'small'.

The structure of this report is as follows. First, a theoretical framework will be set out to briefly describe the used theoretical concepts. Next, the used methods and sources will be discussed in the form of different steps of a general workflow. The results will be described and reported in a structured and clear way. To formulate a short reflection on the project, a discussion will be drawn up. A brief and precise conclusion closes the 'written part' of the report. An appendix is added to the end of the report to include necessary and additional information supporting the main part of the report.

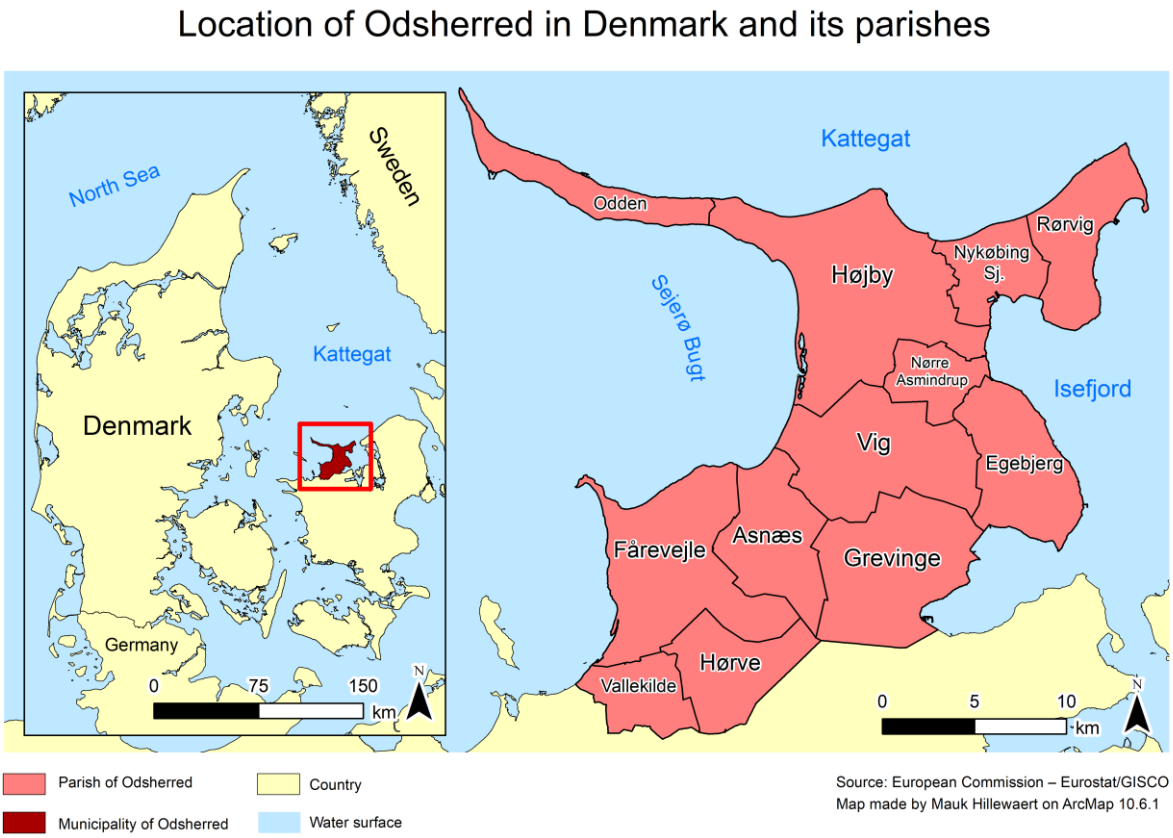


*Figure 1: Map of the location of Odsherred in Denmark with a close-up on its parishes*

Since the year 2010, Odsherred consists of thirteen parishes. Højby was then divided into the parishes Lumsås and Højby. Since the data used in this research dates back to the year 1990, we worked with the pre-2010 subdivision, representing twelve parishes in Odsherred. For the data acquired after the year 2010, we summed the data of the parishes Lumsås and Højby, so the data corresponds to the spatial scale before the year 2010 (Figure 1).

## 2. THEORETICAL FRAMEWORK

### 2.1 Attribute Trajectory Analysis

For this research, an Attribute Trajectory Analysis (ATA) was performed. The term "trajectory" in geography traditionally refers to the path of a moving object. This path is represented by a curve in space and time. This type of data is increasingly used, analysed, and interpreted in combination with the recent data explosion. There is also Attribute Trajectory, another type of trajectory. The difference between this and a traditional route lies in the coordinates of the route. The geographic coordinates have been replaced by object attributes of the different points in a path (Zhang & Van de Weghe, 2018). In an Attribute Trajectory Analysis, one tries to compare the evolution of a certain attribute for m different objects.

Pathway analysis tools and algorithms have been developed to find interesting behaviours and patterns from the original data records and to measure trajectory similarities (Zhang & Van de Weghe, 2018). In this research, clustering was used. During a cluster analysis, without having any information of the data structure gathered beforehand, data is segmented into a set of 'equal' groups. The overall goal can be described as maximising intra-cluster similarity within the cluster and minimising inter-cluster similarity between clusters. This is not based on the spatial attributes dimension, but on their relative multidimensional proximity in time, space, and time-space (Miller & Han, 2009).

The structure of the ATA in this research is according to the idea of the Knowledge Discovery from Databases (KDD). Because of this, the analysis is iterative and interactive. Today, there are many methods and approaches for KDD. This is used to reveal previously unknown patterns. Examples include discovering subgroups, classification, and association rules, as well as clustering. The current trend is to join forces through so-called orchestration via a mediator framework. Orchestration will form a pipeline for knowledge discovery by combining different learning algorithms and analysis methods for data mining. Declarative logic programming techniques can be very useful for transformation and selection (data pre-processing), presentation and evaluation (post-processing of patterns), and data analysis. Exploratory data analysis is an important approach to knowledge discovery to gain the first insights into the data. Typically, the methods are used not only as a useful model but also as a human-interpretable set of patterns. This guides the incremental knowledge discovery process. Declarative approaches are used in such contexts to formalise constraints and interesting criteria, as well as data analysis patterns and model common processes (Seipel & Atzmueller, 2021).

Data mining systems are generally applied for a range of potentially useful, new, and ultimately interesting patterns from large data sets. The resulting patterns are normally interpretable, but the user's assessment of the large result sets of the potentially interesting patterns requires further interpretation techniques and exploration (Miller & Han, 2009). For the implementation of such approaches, orchestration, declarative approaches, and meta-learning are suitable options (Seipel & Atzmueller, 2021).

Next, the different steps within an ATA will be discussed. First of all, the data must be selected. The data consists of a timeseries (CSV-format) and an accompanying geometry file (GeoJSON). After the selection, the data is visualised for the first time, namely the visualisation of the timeseries that represent the data. This visualisation (curves) gives the first insights into the data. We are mainly interested in similarities of the shape of the curves, but the curves of certain objects may be similar in shape but not in absolute numbers. To solve this, a normalisation of the data is necessary and therefore will form the next step in the ATA process. In this way, the data will get a scale going from 0 to 1. The (dis)similarity (i.e., the distance) of the curve of each object with the curve of every other object is calculated. This results in a (m x m) pairwise similarity matrix. Because this similarity matrix has a higher dimension (m x m), it may not be easy to visually extract all the

interesting patterns from it, let alone find meaningful segmentations or clusters. Therefore, the next step is embedding this higher-dimensional matrix in a lower (comprehensible) 2-dimensional representation. For this, a multiple machine learning algorithm called multidimensional scaling (MDS) is applied. MDS is an ordination method that calculates the Euclidean distance between the objects in higher-dimensional space and displays them in a 2-dimensional scatter plot, somewhat similar to Principal Component Analysis. The MDS will represent the gradients of relatedness between entities in a multivariate space based on a distance matrix (Letten, 2022) (Stupariu et al, 2021). The MDS analysis is an iterative process and will attempt to change the position of the objects in a user-defined k-dimensional space in order to minimise the overall stress of the configuration (Stupariu et al, 2021). The last step is data mining. The 2-dimensional scatterplot is used to estimate the number of clusters we want to obtain. Then, based on the similarities between those trajectories or curves, the parishes are clustered and eventually visualised on a map.

## 2.2 Urbanisation

Because of the increase in the total population of the human population, people tended to come together. This way, several settlements formed and grew into what we now call cities. The shift of the organisation of labour from one to another corresponds often with these kinds of growths (National Geographic). An example of this is the industrialization of the economy. Apart from industrialization, cities also attract people because of the big number of jobs available, but also by increased opportunities for entertainment and education (Dyson, 2011). Expansion of the modern urban sector (services and manufacturing) draws the surplus labour from the backward rural economy (agriculture) to cities and towns attracted by higher wages. Urbanisation is fundamentally driven by the wage gap, but several studies have shown the opposite (Dyson, 2011; Fox, 2012). There are also some non-economic motives for urbanisation. Examples are the escape of women from gender discrimination, the taken advantage of the ‘thick’ spouses’ market in urban areas, the desire to escape the control of older generations by the youth, the pursuit of their aspirations in the ‘bright lights’ of the city or to acquire the social prestige associated with urban life. Possible ‘push’ factors can also play an important role in urbanisation. An example of a ‘push’ factor is the fact that population growth in rural areas, stimulated by the decline of mortality, puts the natural resources under pressure. This results in bad living standards, which is why people will be pushed to the ‘better’ cities. Another potential role of urbanisation is the population dynamics. Some research demonstrated a strong correlation (one-to-one) between urban growth and global growth (Fox, 2012).

Urbanisation is characterised by a process of population concentration. It continues in two ways: making more points of concentration and growing the individual points of concentration. The process “[…] may occasionally stop or actually recede, but the tendency is inherent in society for it to proceed until it is inhibited by adverse condition” (Tisdale, 1942, p. 311). Urbanisation also refers to the change in density, size, and heterogeneity of cities (Vlahov & Galea, 2002). Urbanisation is the term for the growth of urban areas as a result of migration from the countryside to the city. The opposite of urbanisation is suburbanisation, in which

the population exchanges the urban area for the countryside (ensie.nl; 3/5/2022). The arrival of factories (18th century) in the city led to a decline in interest in the countryside, causing cities to grow in size. Before that time, more than 75 percent of the population lived outside the city, in 2010 this is still less than half. This trend will continue well into the 21st century. Arguments for moving to the city include greater job prospects, shorter distances to amenities and low dependence on the weather, a factor affecting rural areas (ensie.nl; 3/5/2022). Neil Brenner and Christian Schmid (2013) explain that the traditional definition of urbanisation is changed: "First, the geographies of urbanisation, which have long been understood concerning the densely concentrated populations and build environments of cities, are assuming new, increasingly large-scale morphologies that perforate, crosscut, and ultimately explode the erstwhile urban/rural divide". Suburbanisation is focused on the expansion of the city away from the city centre (Pagliocco, 2020).

Urbanisation, as means of the development of cities with high densities, but also the expansion of exurban areas at the edge of the cities, is the biggest driver of land use change across the globe (Grimm et al., 2000). Understanding differences between urban and rural areas is important to address environmental problems and the management of resources in cities and suburbs, conservation efforts and planning (Grimm et al., 2000; McKinney, 2002). Between different studies, there is low consistency to quantify urbanisation gradients, and in methods to define urban, suburban, and rural areas (Theobald, 2004; Raciti et al., 2012). Studies about urban ecology often rely on vague definitions that define urban or rural-ness in comparison to other categories or just assume the definition of urban and/or subjective classification schemes (Theobald, 2004; McDonnel & Hahs, 2008). In studies where urbanisation is quantified, common measures of urbanisation include population density and other demographic measurements (e.g., Mendley et al., 1995; McDonnell et al., 1997), the closest distance to a major city (e.g., Mendley et al., 1995), and physical measures as the percentage of impenetrable surfaces or road density (e.g., Mendley et al., 1995; Raciti et al., 2012). Metrics for urbanisation are often criticized because they rely on arbitrary cut-offs and/or over-simplify urban structure (McDonnell & Hahs, 2008). Demographic measures like income and population density have often been used to appraise urbanisation, but more abstract cultural and political characteristics have been hard to integrate (Short Gianotti et al., 2016). The study of McIntyre et al. (2000) recommends using characteristics like residents' perceptions of their environment, because "perceptions are integral to people's motivations and actions". Short Gianotti et al. (2016) used a mail survey that probes landowners' perceptions of urban, suburban, and rural along their study area.

At the moment, there is no universal definition of what an urban area is. The United Nations (UN) publishes figures based on nationally defined urban shares. But the problem is that countries have different definitions of urbanisation. The types of metrics differ, but also the threshold of urban versus rural varies. Sweden and Denmark set the definition of an urban area, as at least 200 inhabitants and Japan sets it at 50000 (Ritchie & Roser, 2018).

Economic and demographic growth are the main drivers that make traditional European cities extend their boundaries into adjacent rural areas (Bruegmann, 2006). The pace of this process has been variable over time, between 1940 and 1975 there was a lot of pressure on urban development (Cupers, 2011). After this period there was a period of slowing down (Martinez-Fernandez et al., 2012), these processes resulted in Europe, in a variety of urban expansion patterns around compact cities (Kasanko et al., 2006). The variety of patterns and shapes in land use is the result of actions done by multiple agents. There need to be new tools for representing and analyzing these complex land uses (Antrop, 2013).

Cities are crucial to economic recovery processes in which the logic of capital accumulation is continuously reinvented. But they are also often behind economic downturns, because of their real estate markets that are overheated. In the last ten years, in the aftermath of the global economic crisis of 2008, the interest in building contemporary cities has risen, mainly in relation to the rise of socially interactive digital technologies (Rossi, 2017).

The term peri-urban still has a controversial definition (Kurtz & Eicher, 1958), “traditional spaces” is unclearly defined, in conceptual and geographic terms. Peri-urban areas in general have a high population density compared to rural areas and generate a higher share of GDP (Van Eupen et al., 2012).

## 3. METHODS AND SOURCES

### 3.1 Workflow

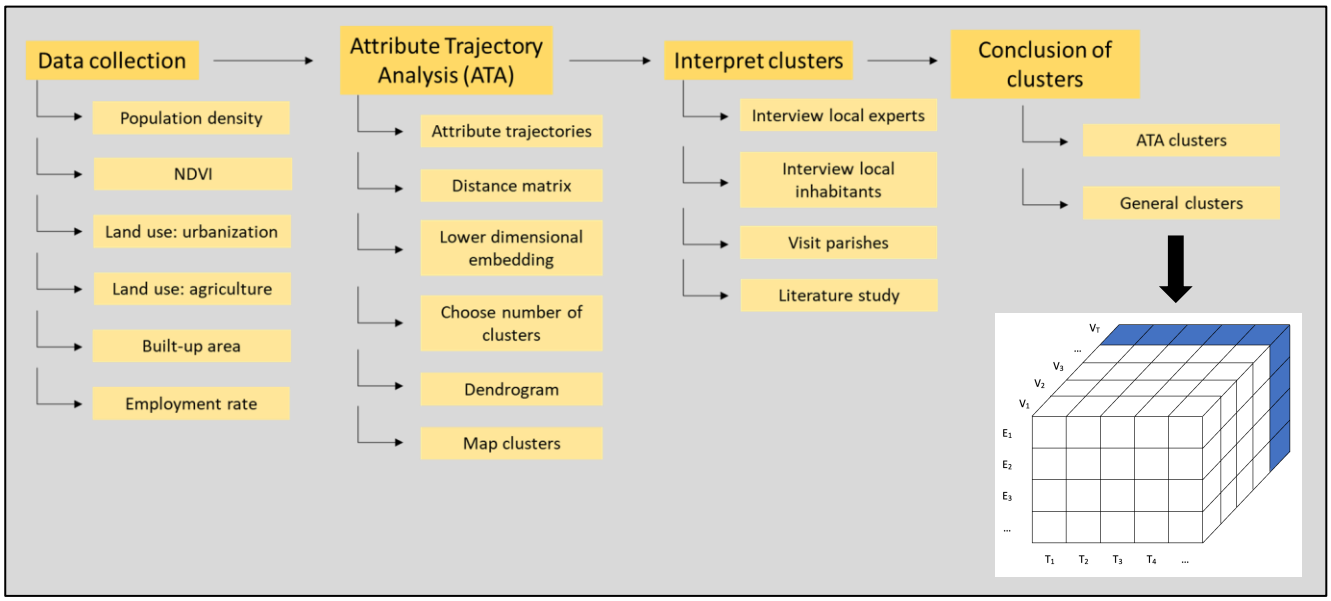


*Figure 2: Methodological workflow (M. Hillewaert, 2022)*

The workflow of this project can be seen in Figure 2. Four general steps can be derived from this flow: the Data collection, an Attribute Trajectory Analysis, an Interpretation of the clusters and the formulation of a Conclusion of the clusters. These four steps will now be discussed separately in more detail.

## 3.2 Preparation

### 3.2.1 Data collection

Before the actual fieldwork, several steps (desktop analysis) had to be completed in order to have good preparation. The first step includes the collection of multiple data factors that define urbanisation. The choice of these factors was mainly based on the availability of the data because we experienced that there was not much data on the scale of parishes in Odsherred, going back to 1990. Besides that, the use of international research and our insight led us to six different data factors: population density, *Normalized Difference Vegetation Index* (NDVI), urbanisation land use, agricultural land use, built-up area, and employment rate. To use this data in the next step, namely the Attribute Trajectory Analysis (ATA), data cleaning was necessary. The data must be continuous and must not contain any NULL values in order to end up in a comma-separated values (CSV) file. An example of a usable CSV file as input data for the ATA is shown in Figure 3.

| id | naam | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|---|
| 1 | Rorvig | 85.058 | 85.382 | 94.114 | 99.483 | 101.1 | 100.129 | 100.97 |
| 2 | Nykobing | 524.035 | 531.122 | 529.214 | 551.749 | 557.02 | 563.38 | 556.383 |
| 3 | Hojby | 77.548 | 83.532 | 86.957 | 88.367 | 91.51 | 91.944 | 92.984 |
| 4 | Odden | 126.55 | 129.994 | 132.749 | 135.702 | 134.816 | 127.928 | 127.928 |
| 5 | Egebjerg | 56.355 | 55.789 | 55.223 | 56.037 | 55.719 | 52.358 | 52.464 |
| 6 | Norre Asm | 97.467 | 94.012 | 96.726 | 96.644 | 94.999 | 88.666 | 90.064 |
| 7 | Vig | 73.806 | 76.672 | 80.823 | 82.885 | 84.492 | 83.34 | 85.616 |
| 8 | Asnaes | 143.01 | 145.85 | 153.257 | 158.36 | 165.604 | 161.941 | 166.056 |
| 9 | Grevinge | 57.859 | 59.627 | 65.008 | 64.854 | 63.342 | 62.471 | 64.111 |
| 10 | Farevejle | 89.664 | 96.623 | 98.934 | 97.468 | 97.418 | 96.126 | 96.747 |
| 11 | Vallekilde | 61.41 | 63.301 | 65.121 | 68.833 | 64.141 | 61.55 | 59.31 |
| 12 | Horve | 106.2 | 107.694 | 110.729 | 114.85 | 114.306 | 116.843 | 118.835 |

```
id;naam;1990;1995;2000;2005;2010;2015;2020
1;Rorvig;85.058;85.382;94.114;99.483;101.1;100.129;100.97
2;Nykobing;524.035;531.122;529.214;551.749;557.02;563.38;556.383
3;Hojby;77.548;83.532;86.957;88.367;91.51;91.944;92.984
4;Odden;126.55;129.994;132.749;135.702;134.816;127.928;127.928
5;Egebjerg;56.355;55.789;55.223;56.037;55.719;52.358;52.464
6;Norre Asmindrup;97.467;94.012;96.726;96.644;94.999;88.666;90.064
7;Vig;73.806;76.672;80.823;82.885;84.492;83.34;85.616
8;Asnaes;143.01;145.85;153.257;158.36;165.604;161.941;166.056
9;Grevinge;57.859;59.627;65.008;64.854;63.342;62.471;64.111
10;Farevejle;89.664;96.623;98.934;97.468;97.418;96.126;96.747
11;Vallekilde;61.41;63.301;65.121;68.833;64.141;61.55;59.31
12;Horve;106.2;107.694;110.729;114.85;114.306;116.843;118.835
```

*Figure 3: An example of a useable CSV file as input for the ATA, here using the factor population density. On the left, the Excel visualization is seen, and on the right, the raw CSV file can be seen.*

It is important to note that every parish has a fixed id-number. This number is used in the ATA's algorithm, so this column must be added to every CSV file. To provide a brief conclusion; each CSV file thus contains data of a factor defining urbanisation for each parish in Odsherred over the past 30 years, with an interval of 5 years. The sources and the data cleaning process of each urbanisation factor will be explained in the next following parts. Important sidenotes: the cartographic models of the data cleaning of each factor can be seen in the appendix, at the end of this report and the data cleaning for each factor was done with the help of the GIS software QGIS 3.16. As a general example, the cartographic model of the data cleaning of the population density factor is fully complete, meaning that the data from each year is included in the model. The cartographic models of the other factors take a more generic approach where the year is stated as a variable such as 'XXXX'. This simplifies the models for better understanding.

#### 3.2.1.1 Population density

To calculate population density (persons / km²), timeseries data of the population figures of each parish were first retrieved from Denmark's National Statistics Database (www.statbank.dk/SOGN10, 2022). Next, the population figures were divided by the total area of each parish to get the population density. It is important to note that the area of the parishes excluding the summer houses was used, so the population density where only the permanent inhabitants were taken into account could be calculated. The shapefiles of the parishes and the summerhouses in Odsherred were retrieved from the digital register for spatial planning in Denmark (www.Plandata.dk). The shapefile of the parishes excluding the summerhouses was also used in the data cleaning processes of all the other factors, except the employment rate.

#### 3.2.1.2 NDVI

The *Normalized Difference Vegetation Index*, or NDVI, is a graphical indicator used to analyse remote sensing imagery and more specifically to analyse if a surface has healthy green vegetation or not. Near-infrared light gets strongly reflected by healthy vegetation when looking at its spectral signature (Figure 4). By using the formula below (formula 1), a value of 0 to 1 can be calculated where a value starting from 0.2 indicates the presence of healthy vegetation in a satellite image. By applying reverse logic, the degree of urbanisation can be determined based on the percentage of healthy vegetation. A simple example: the less vegetation, the more human activities such as the emergence of new buildings occur.

$$NDVI = \frac{(NIR - R)}{(NIR + R)}$$

*NIR = Near-infrared light*
*R = Red light*

*Formula 1: Calculation of the NDVI*

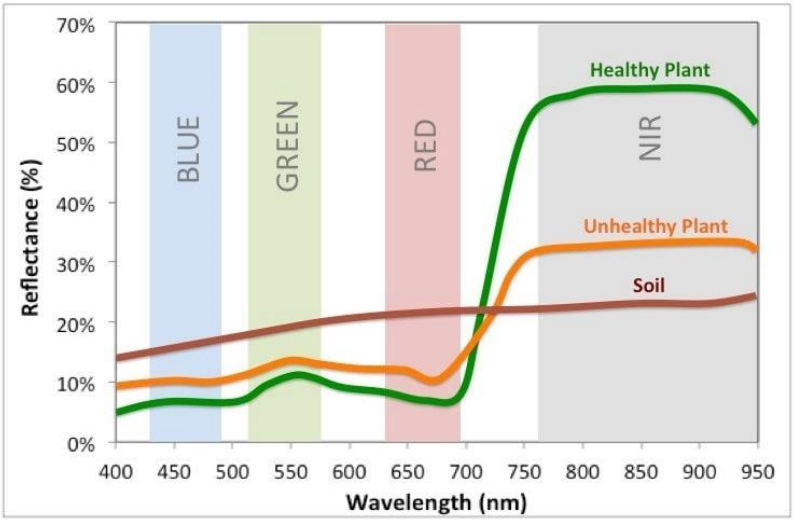


*Figure 4: Spectral signature of healthy vegetation, unhealthy vegetation, and soils (source: https://www.planetwatchers.com/whats-the-matter-with-ndvi-you-are/)*

The satellite images were obtained from the USGS Earth Explorer data portal using images from Landsat 5 and Landsat 8. By using some tools in QGIS, we calculated the ratio of the number of pixels with a value higher than 0.25 and the total number of the pixels, both on a spatial scale of one parish. This gave us a percentage of the amount of healthy vegetation per parish.

But there was a problem with this method. Once the filtered pixels with a value higher than 0.25 were analysed for the first time, we concluded that other land cover types, such as water and fallow ground, also don't reflect much of the near-infrared light just like buildings in urban centres. This will influence the urbanisation grade we are trying to find with the NDVI. The solution we applied for this problem, exists in the spatial relation between the filtered pixels (< 0.25) and the underlying land cover, retrieved from the Department of Environmental Science at the University of Aarhus (Levin et al., 2017). This resulted in the actual pixels defining urbanisation (so less than 0.25) using the NDVI. In the ATA itself, the proportion of healthy vegetation per parish was used, calculated by 1 – (percentage of pixels less than 0.25 in the parish).

#### *3.2.1.3 Land use: Urbanisation*

The factor of land use defining urbanisation consists of the proportion of area that describes urbanisation in relation to the total area of a parish. The data used for this calculation was obtained from the CORINE land cover map (CLC) of Europe. Since the CLC map was only updated and produced in the years 1990, 2000, 2006, 2012 and 2018, some timestamps were missing to complete the full timeseries of a parish. This was solved by predicting the missing values based on existing values along a linear trend, using Microsoft Excel.

#### *3.2.1.4 Land use: Agriculture*

The land use factor defining agricultural land was calculated in the same way as the preceding urbanisation factor for land use. Of course, the area that described agricultural land was used to calculate the proportion in a parish.

#### *3.2.1.5 Built-up area*

The built-up area defines the mean built-up area value of all pixels in a parish. The source for this comes from the Socioeconomic Data and Applications Center from the University of Columbia in the city of New York. This data is somewhat similar to the CLC data, but here the built-up area map describes the percent built-up area for each 30 arc-second grid cell (approximately 1 km at the equator) based on Landsat imagery from respectively 1975, 1990, 2000 and 2014. Multiple satellite images were used for the creation of the CLC map, such as Landsat, SPOT and Sentinel-2. Again, multiple timestamps are missing, so they were predicted using a linear trend as seen before. By calculating the mean value, we can estimate the proportion of building footprint per parish.

#### *3.2.1.6 Employment rate*

The employment rate of each parish was calculated by dividing the number of people who are employed by the total number of people in a parish. The number of employed people per parish from 1990 until 2020 was found by combining two datasets of the National Statistics Database of Denmark which both contain the socio-economic status of the people in a parish (1990 – 2010: www.statbank.dk/INDKF41, 2015 – 2020: www.statbank.dk/KMSTA005). The total number of people per parish was found by using the same dataset as used with the population density factor.

### 3.2.2 Attribute Trajectory Analysis

As already discussed in the theoretical framework, an Attribute Trajectory Analysis (ATA) was performed to analyse the evolution of the urbanisation factors per parish in Odsherred. This methodological framework allowed us to cluster parishes with similar evolutions in terms of urbanisation. The different steps of the ATA have already been discussed in the theoretical framework. Now, the steps will be applied to the collected data and more specifically to the population density factor. This will show the workflow of the ATA tool. The tool is developed by Lars De Sloover, an assistant academic staff member and PhD student at the CartoGIS research group of the Department of Geography at the University of Ghent. Lars was also one of the teaching assistants during the project work in Odsherred and we would like to thank him for developing this tool for our research. The ATA tool is available through a Jupyter Notebook project on Google Colab. The Python code of the tool is available in the appendix of this report.

#### *3.2.2.1 Selection and visualization of the data*

The first step consists of the selection of the data. The timeseries data, obtained as a CSV file in the previous section applying data cleaning, needs to be imported, as well as an accompanying geometry file with GeoJSON as data type. The CSV file in this example is the table of the population density as seen in Figure 3. The GeoJSON contains the different parishes in Odsherred with an id-number and the name of the parish as attributes. The parish ID numbers in the GeoJSON file must match the parish ID numbers in the CSV file, in order to join these two files later in the algorithm.

Next, the timeseries or curves that represent the data were visualized as attribute trajectories. This forms the core of the ATA and helps us in gaining some preliminary insights into the data. Figure 5 shows the attribute trajectory of the population density of each parish in Odsherred.

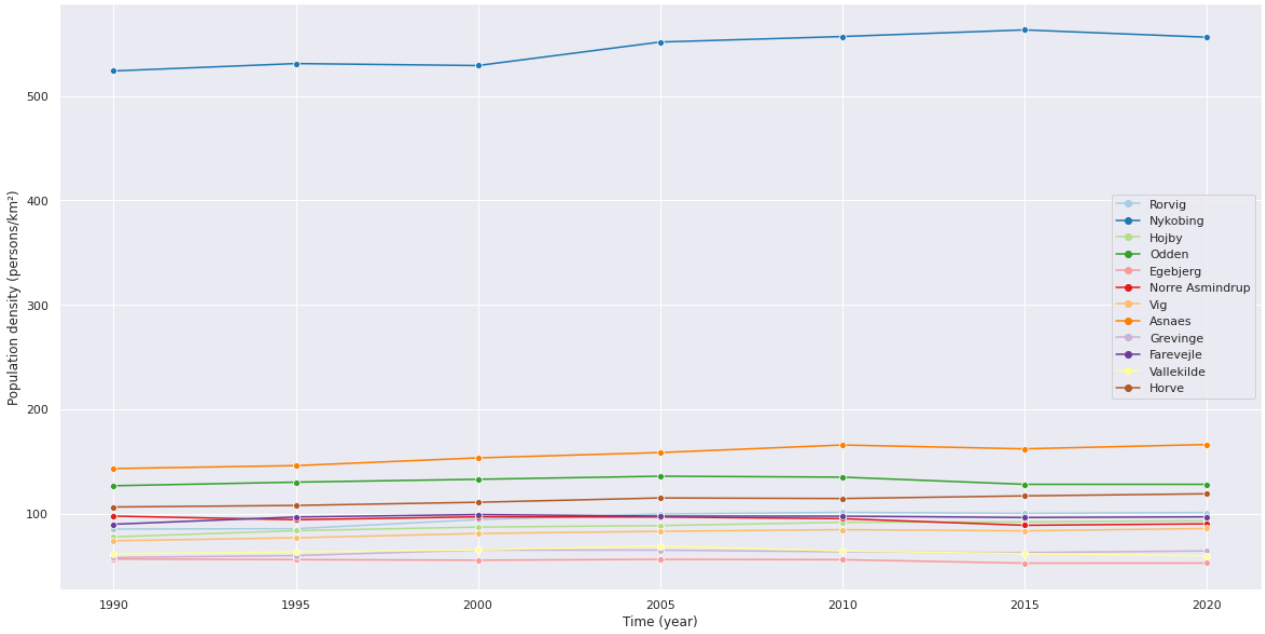


*Figure 5: Attribute trajectories of the population density (persons / km²) of all parishes in Odsherred*

### 3.2.2.2 Data pre-processing

As already discussed in the theoretical framework the data needs to be pre-processed. By normalizing the data to a scale from zero to one, the similarities between the curves can be analysed.

### 3.2.2.3 Data transformation

Next, the (dis)similarity (i.e., the distance) of the curve of each parish to the curve of each other parish is calculated. This results in an (m x m) pairwise similarity matrix (distance matrix) as shown in Figure 6.

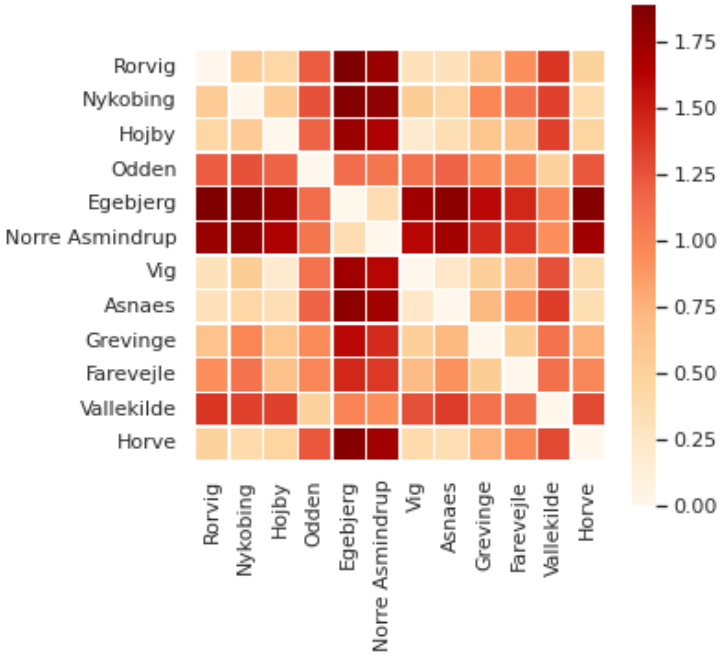


*Figure 6: Distance matrix of the population density attribute trajectories*

By embedding this higher-dimensional matrix into a lower (understandable) 2-dimensional representation using the machine learning algorithm multidimensional scaling (MDS), the number of clusters can be estimated. Figure 7 on the left shows the 2-dimensional representation of the previous distance matrix. The clusters that we could derive from this, by using our interpretation, are indicated in yellow on the right.

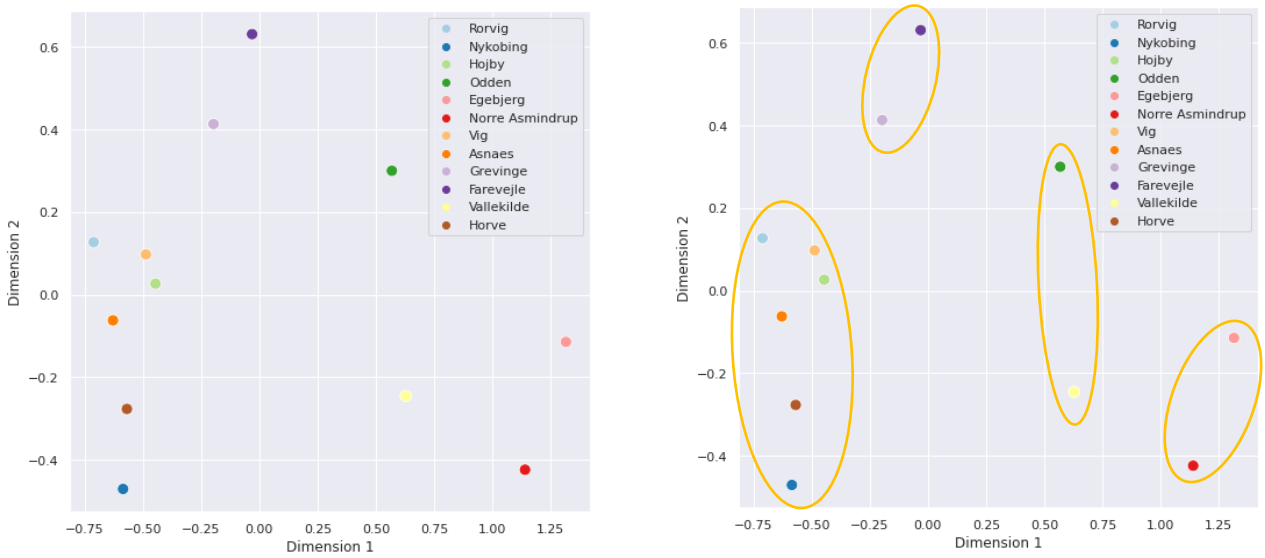


*Figure 7: 2-dimensional representation of the distance between the population density attribute trajectories*

### *3.2.2.4 Data mining*

Once the number of clusters is determined, the clustering algorithm can be run in the ATA tool. We used the hierarchical agglomerative clustering method with the linkage method of Ward. This formed the dendrogram as seen in Figure 8.

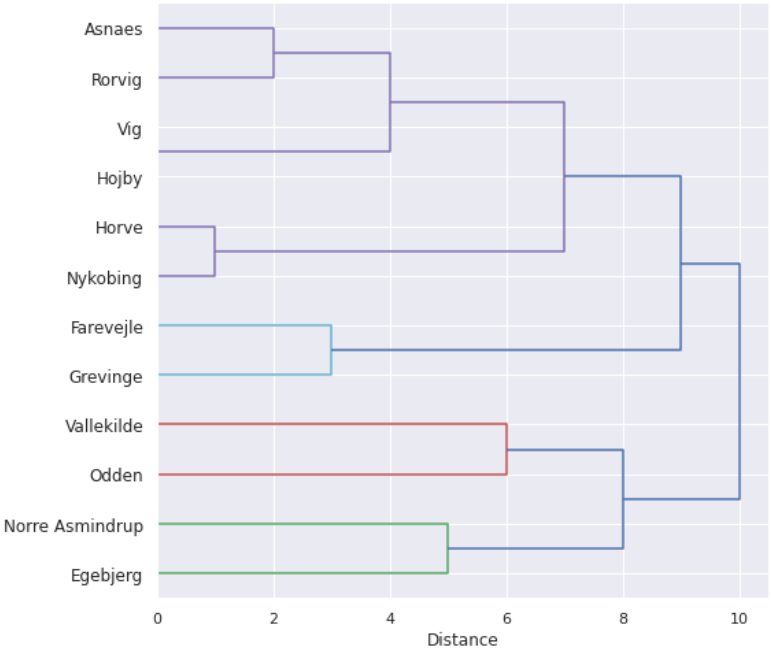


*Figure 8: Dendrogram of the clustering of the population density attribute trajectories*

Finally, the clustering of the parishes is visualized by adding an attribute column to the GeoJSON file (imported in the first step of the ATA) which contains the unique number of a cluster. This means that each parish has a number that represents the cluster. Next, this GeoJSON file is exported to use it in GIS software. Using ArcMap 10.6.1, categorical colours are assigned to the different clusters. The final realized map can be seen in Figure 9.

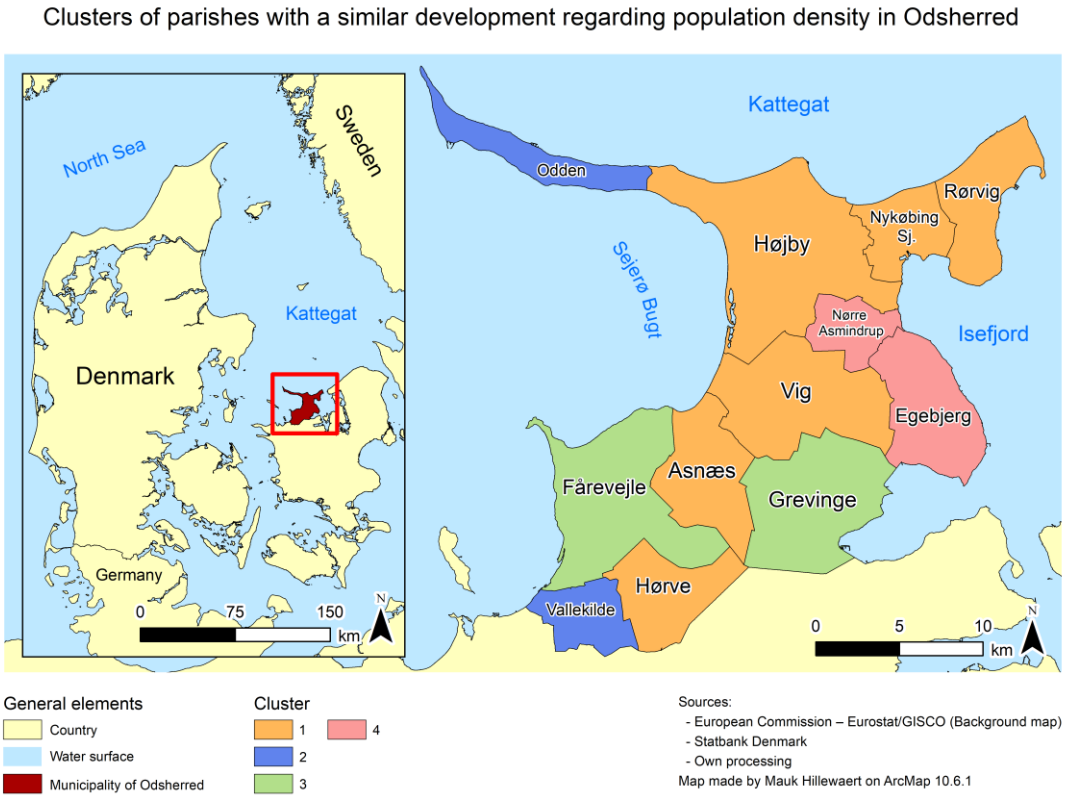


*Figure 9: Map of clusters of similar development regarding population density in Odsherred*

### 3.2.3 Visual interpretation of topographic maps

To properly prepare ourselves for the fieldwork, topographic maps from each examined year (1990-2020) were visually compared. This allowed us to discover specific places and locations in each parish where urban development took place. The focus was on the urban centres of each parish as these were the places we were going to visit during the fieldwork. The discovered locations were indicated as polygons on Google Maps on our smartphones so that we could easily reach these places during the fieldwork. Each polygon belongs to a category that indicates when the urban development took place. This formed the guideline of which places were interesting to visit for our research and helped us in carrying out the fieldwork. The discovered polygons are shown in Figure 10. It is important to note that polygons have not been found for every parish, because urban development is not always possible to observe by comparing topographic maps.

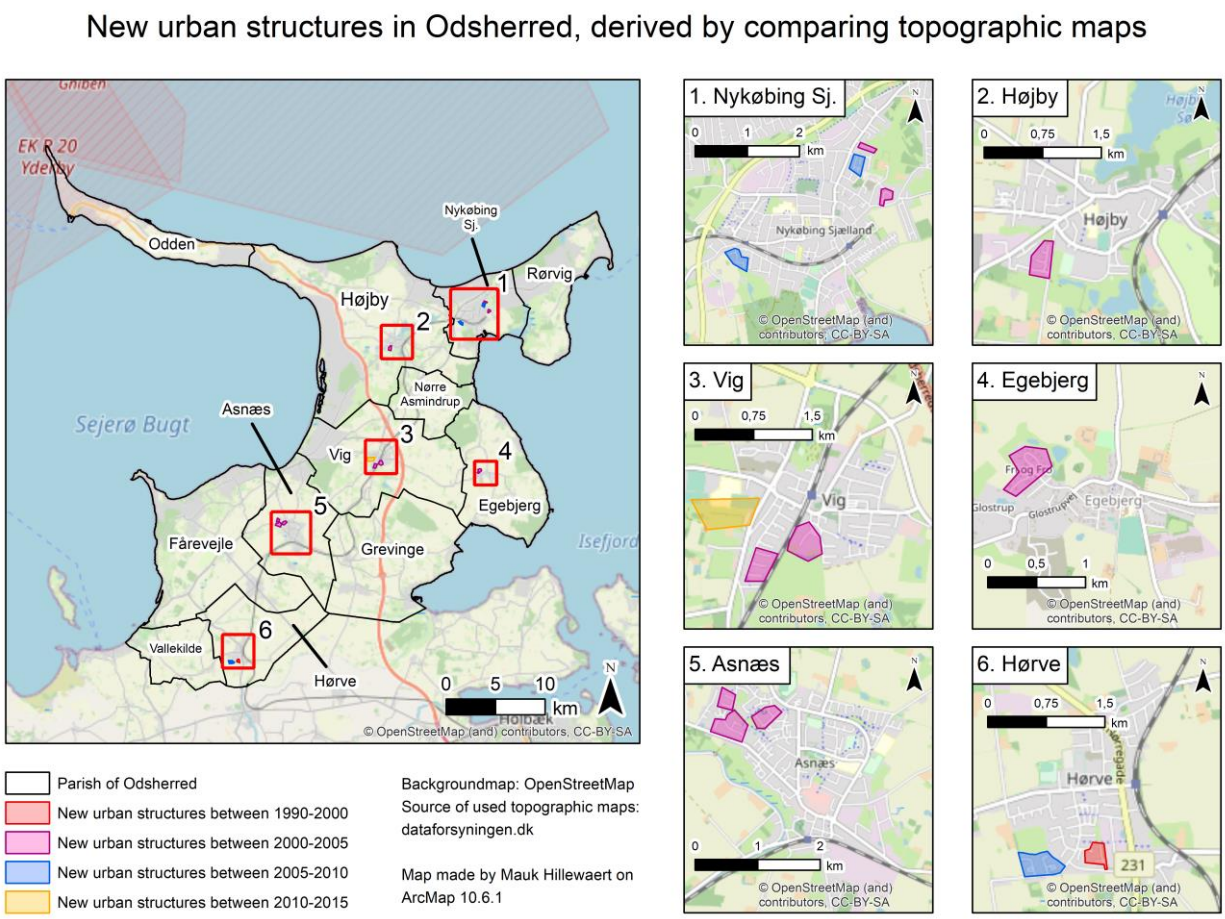


*Figure 10: Map of new urban structures in Odsherred, derived by comparing topographic maps. This map was made as a guideline for the fieldwork.*

## 3.3 Fieldwork

### 3.3.1 Interpretation of the clusters

To interpret the found clusters of each factor that defines urbanisation, fieldwork was necessary. We visited each parish of Odsherred to actually see the urban development and current structure of each parish in real life.

By interviewing local experts and inhabitants in the different parishes, better insights could be formed into the past and current urbanisation processes. The local experts we interviewed were prof. dr. Andreas Aagaard Christensen, professor at the University of Copenhagen at the Section for Landscape Architecture and Planning and Jesper Paludan, a local architect who now works as an employee in the Business, Planning and Construction department at the Odsherred *Kommune* (sort of town hall) in Højby. Apart from the interviews and the visits to the Parishes, a literature study was also necessary to gain more information about the history of the region to understand certain patterns in the clusters.

## 3.4 Reporting

### 3.4.1 Formulate conclusion of the ATA clusters

The final general step of the workflow consists of the reporting of the results and the formulation of conclusions. This formulation is done in two ways. First, the outcomes of the ATA were reported separately. So, for each factor that defines urbanisation, a formulation of the found clusters was made. This can be represented by Figure 11. On the x-axis, the timeseries is shown (T). These are timestamps going from 1990 until 2020 with an interval of 5 years. On the y-axis, the spatial entities are shown (E). These are the twelve analysed parishes in Odsherred. The z-axis represents the different variables used (V). These are the collected factors that define urbanisation. To conclude, each 'slice' of the cube represents one ATA clustering outcome. Except for the last blue slice ($V_T$), which is explained further in the next part.

### 3.4.2 General clusters

To get a general overview of the different ATA clusters of each variable, an aggregation of all the variables was necessary. By creating a pairwise similarity matrix, where each cell represents the number of times each parish is in the same cluster of another parish, the ATA cool could be used to generate general clusters of the parishes in Odsherred. In other words, a clustering of the different ATA clusters was performed. The blue slice ($V_T$) at the end of the cube in Figure 11 represents this aggregation. This general clustering allowed us to find explanations for parishes with a similar urban development and to formulate one general conclusion.

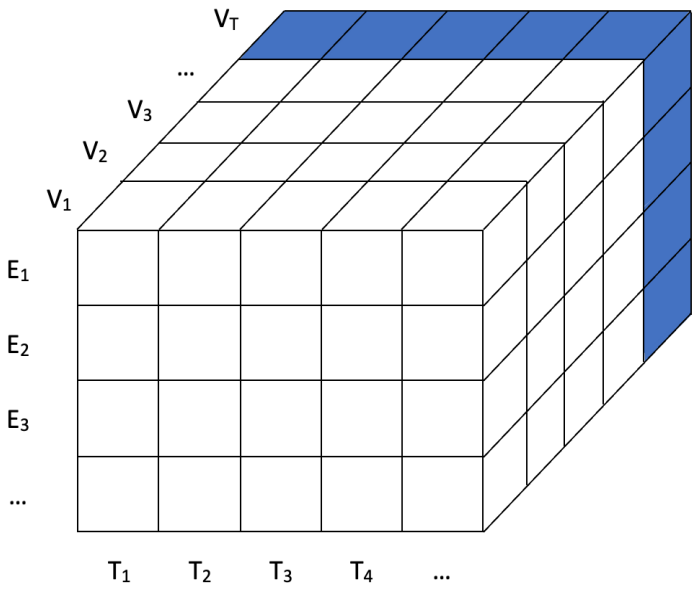


*Figure 11: Theoretical cube representing the different ATA cluster outcomes. At the end, the blue 'slice' represents the aggregation of the different variables to generate a general clustering outcome.*

## 3.5 Sources

An overview of the different sources we used can be found in multiple tables in the appendix at the end of this report. Sources used for the creation of the maps can be viewed there, as well as more information about the people we interviewed in Odsherred.

# 4. RESULTS

## 4.1 Overview of the clusters

*Table 1: Overview of the different ATA clusters*

| | Rorvig | Nykobing | Hojby | Odden | Egebjerg | Norre Asmindrup | Vig | Asnaes | Grevinge | Farevejle | Vallekilde | Horve |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Population Density | | | | | | | | | | | | |
| NDVI | | | | | | | | | | | | |
| Land use: Urbanisation | | | | | | | | | | | | |
| Land use: Agriculture | | | | | | | | | | | | |
| Built-up area | | | | | | | | | | | | |
| Employment rate | | | | | | | | | | | | |

In table 1, the overview of the different clusters is represented. For each attribute, the different parishes with similar development according to that attribute are indicated with the same colour. Starting from this table, a matrix was made that points out how many times a parish is in a cluster with another parish. The matrix is shown in Figure 12 This gives an insight into parishes with very similar development. For example, Højby and Asnæs are for four attributes in the same cluster whereas Højby and Nørre Asmindrup never occurs in the same cluster.

| | Rorvig | Nykobing | Hojby | Odden | Egebjerg | Norre Asmindrup | Vig | Asnaes | Grevinge | Farevejle | Vallekilde | Horve |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rorvig | | 1 | 1 | 1 | 3 | 2 | 2 | 1 | 1 | 0 | 0 | 1 |
| Nykobing | 1 | | 3 | 0 | 1 | 0 | 2 | 2 | 0 | 3 | 0 | 2 |
| Hojby | 1 | 3 | | 3 | 1 | 0 | 2 | 4 | 1 | 3 | 1 | 2 |
| Odden | 1 | 0 | 3 | | 0 | 1 | 0 | 2 | 1 | 1 | 2 | 1 |
| Egebjerg | 3 | 1 | 1 | 0 | | 3 | 2 | 1 | 2 | 1 | 1 | 0 |
| Norre Asmindrup | 2 | 0 | 0 | 1 | 3 | | 3 | 1 | 2 | 0 | 2 | 1 |
| Vig | 2 | 2 | 2 | 0 | 2 | 3 | | 4 | 1 | 1 | 1 | 3 |
| Asnaes | 1 | 2 | 4 | 2 | 1 | 1 | 4 | | 1 | 1 | 2 | 4 |
| Grevinge | 1 | 0 | 1 | 1 | 2 | 2 | 1 | 1 | | 1 | 2 | 1 |
| Farevejle | 0 | 3 | 3 | 1 | 1 | 0 | 1 | 1 | 1 | | 0 | 1 |
| Vallekilde | 0 | 0 | 1 | 2 | 1 | 2 | 1 | 2 | 2 | 0 | | 3 |
| Horve | 1 | 2 | 2 | 1 | 0 | 1 | 3 | 4 | 1 | 1 | 3 | |

*Figure 12: Pairwise matrix of the different cluster outcomes of each parish using an ATA*

As shown in the overview of the clusters, some parishes experienced a similar development according to a certain combination of attributes during the last 30 years. In this part, the most prominent clusters of parishes will be discussed. This will be carried out by searching for the socio-economic and demographic factors that have influenced the urban development in the parishes throughout the last 30 years. But first, three exceptions in the data, which were found by executing the ATA, will be highlighted, and explained.

### 4.2.1 Importance of Nykøbing Sjælland

By performing the cluster analysis for every attribute, it became clear that Nykøbing Sj. is significantly different from the other parishes. It has a much higher population density, built environment and percentage of urban land use than all the other parishes. On top of this, the NDVI is also clearly the lowest. The corresponding attributes are shown in the appendix (Section 8.5). These images indicate that Nykøbing Sj. is a parish where people are concentrated in a higher degree of urban development than in other parishes. But why is Nykøbing Sj. so different?

In the Middle Ages, the town was known for its flourishing harbour. And as professor Vejere said in the city tour, the town received an official trading licence in 1443, after which trade and commerce replaced fishing as the main function of the city. In this way, Nykøbing Sj. became a place where an income could be obtained that was not based on agriculture or the servicing of agriculture. In Nykøbing Sj. money could be earned by trading any type of goods and also by servicing the traders with services, such as banking. Later during the industrial revolution, the industry started to develop around Nykøbing Sj. because industry usually develops along transport vectors or in the trading hubs. All this led to Nykøbing Sj. becoming a big industrial transport hub and developing the biggest economy in the region, while agriculture declined. This attracted a lot of inhabitants who found employment in Nykøbing Sj.. It is also important to note that in the last forty years the more physical type of industry has developed into a more knowledge-based, servicing type of industry and the inhabitants of Nykøbing Sj. developed along with it. In more recent times, according to an inhabitant, the economy isn't doing well during the entire year. Except during summer, the town is then flooded with tourists who stay at the summer houses. The amount of summer houses have a big influence on the economy of the village. At the moment there is a lot of development in the Nykøbing Sj. area to accommodate the tourists.

In 1915, a hospital for mentally ill people opened, named Anneberparken. During the booming years, the nurses and doctors needed homes. It was not possible to extend in Annebergparken, so there was an extension in the village, near the train station. It gradually started to close in 1990, which now leads to only one operational building. Annebergparken is now being transformed into a cultural place with lots of new functions such as housing, art, culture, landscape, and food. The person who is responsible for this transformation to Anneberg Kulturpark is Gitte Klausen. Her overall goal is to place the Anneberg Kulturpark into a larger context within a more tourist-orientated plan, but also to develop Anneberg as a centre for local entrepreneurs in art, food, and gastronomy.

In conclusion, Nykøbing Sj. was chosen to be the centre of development during the Middle Ages by obtaining the only trading licence in the region. They managed to keep this prominent position by developing industrially during the industrial revolution and later transformed into a more knowledge-based economy. The Anneberg psychiatric hospital also created an expansion of housing in Nykøbing Sj. throughout the 20th century.

### 4.2.2 Rise in employment rate (2010-2015)

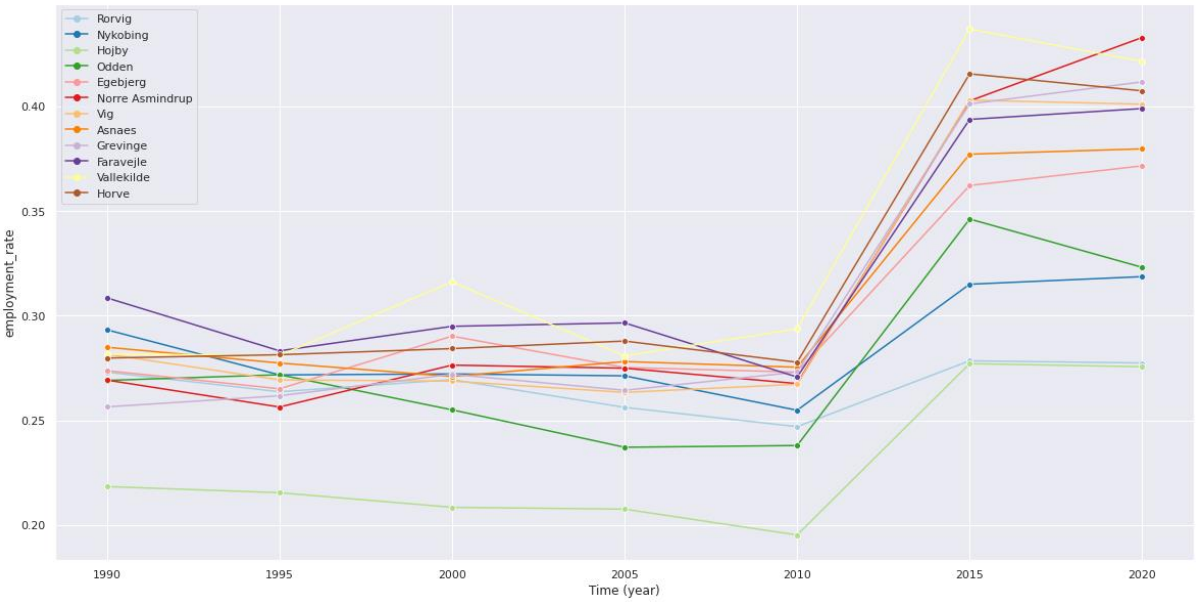


*Figure 13: Attribute trajectories regarding the employment rate for all parishes*

In the figure above, it is remarkable that all parishes experienced a high rise in employment rate between 2010 and 2015. During the interviews with local experts, we tried to get a better insight into this phenomenon. Professor Christensen from the University of Copenhagen thought it might be due to the aftermath of the financial crisis in 2008. The housing prices crashed, and this could have positively influenced the internal migration from other regions in Denmark to Odsherred. Yet, after checking this theory with statistical data from StatBank Denmark, it became clear that the net internal migration of working people into Odsherred is actually decreasing (see Table 2).

*Table 2: Net migration for working and not-working people from 2005 until 2020*

| Netto-migration | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|
| Working people | -159 | -187 | -201 | -203 |
| Not working people | 20 | -81 | 19 | 13 |

Another theory was given by a local architect Jesper Paludan who works at the Department of Urban Planning in Odsherred. He mentioned that there is a relatively large group of low-educated people living in the region, but their knowledge of craftsmanship is increasing. In recent years, it became a sort of new booming specialisation and they are highly respected in the whole Sjaelland region for their qualitative work. Yet, this upcoming trend is not enough to be responsible for the high rise in the employment rate between 2010 and 2015.

The last explanation could also be that there was just a change in the way of data gathering since 2015. No documentation can be found on this matter, but it is the most plausible explanation for the extreme rise in the employment rate between 2010 and 2015.

### 4.2.3 Højby as an administrative centre

Something else that stood out during the research is the fact that the administrative centre of the municipality is located in Højby although Nykøbing Sj. has many more inhabitants and looks more important. This is because in 2007 the government forced to fuse three municipalities into one, what we know today as Odsherred. The city hall was placed in Højby because of its central placement in the region and as a compromise so that every former municipality had a new city hall. It was also placed here to not let Asnæs or Nykøbing Sj. have a competitive advantage over each other as they are two competing towns. The administrative buildings were also already present in Højby. At the moment there is a lot of development in Højby to make it a more attractive place to live.

### 4.2.4 Vallekillde and Hørve

According to NDVI, land use of urban land and agricultural land in Vallekilde and Hørve appears to have a similar development. This can be explained by their locations next to the Lammefjord. The main villages of both parishes are bordered in the east by a dam next to the Lammefjord. This used to be an important part of a route for sailing timber from Copenhagen to Hørve. At the beginning of the 19th century, the fjord was embanked resulting in a very fertile area. This soil with a relatively high percentage of clay makes the area favourable for intense agriculture. This can result in a similar development of both parishes with little urban development and a lot of agricultural activities which was confirmed by the fieldwork. In Figure 14, the situation in 1768 is laid over the current situation of the parishes which shows that the Lammefjord bordered both parishes before being embanked.

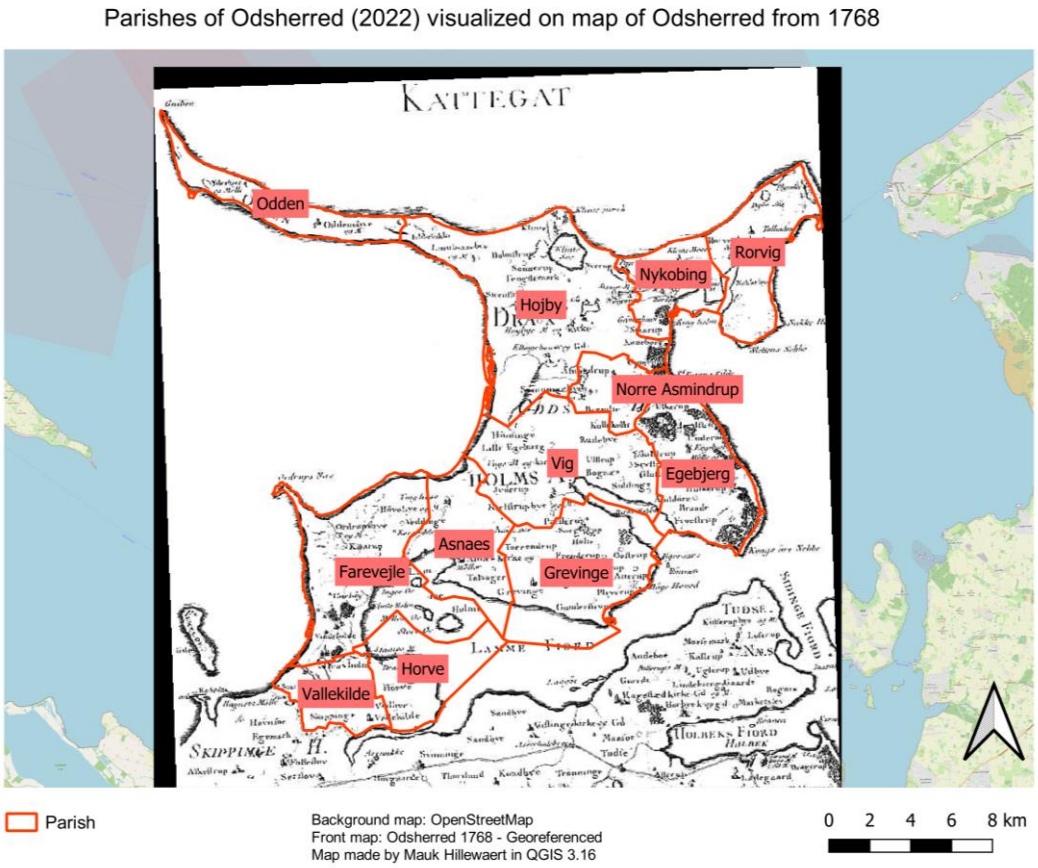


*Figure 14: Map of parishes in Odsherred (2022) visualized on a map of Odsherred from 1768*

### 4.2.5 Nørre Asmindrup, Grevinge and Egebjerg

The parishes Nørre Asmindrup, Egebjerg and Grevinge appear to have a similar development regarding population density, employment rate and the built-up area. These parishes are located on the eastern side of the municipality while most summer houses are located on the northern and western sides of the municipality. This results in “boring” parishes where few activities take place. In addition, the schools in the area are having tough times keeping the students in the area because parents are afraid of small classes where they have one teacher for three levels. The fieldwork also indicated that there are a lot of empty and abandoned buildings as the inhabitants of the parishes get older and older. In Figure 15 the rise in elderly people is given, which is a similar trend in the three parishes.

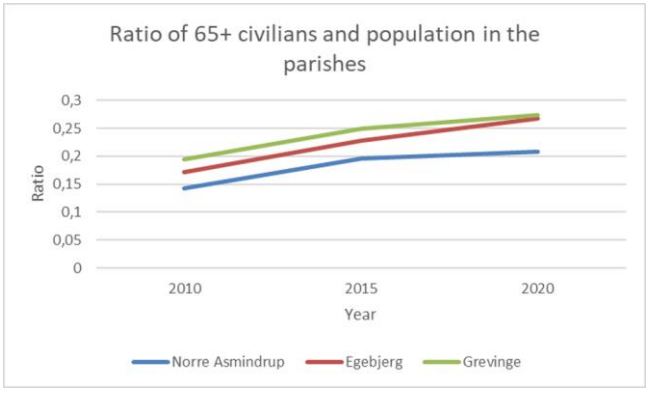


*Figure 15: Ratio of 65+ civilians and population in the parishes of Odsherred (2010 – 2015 – 2020)*

*Figure 16: Abandoned buildings in the parish of Grevinge (M. Hillewaert, 2022)*

But there are some positive prospects for these parishes. For example, *Fri og Fro* (translation: Under the sky) is a collection of houses in Egebjerg that was constructed using sustainable materials like recycled wood, straw, clay, and shells. It was established in 2005. The owners built their houses themself, so it was way cheaper to build their houses and they live in permaculture. A few of the owners are teachers in the school nearby, but the other owners are either retired, artists or work elsewhere. There is an architecture recommendation to inspire people to get better architecture in that region. People want to live in that region and in bigger houses that are not restricted in certain ways. The shops in this region change their products for the new inhabitants, who demand more organic products. There even was a law regulation to make these types of communities possible. The municipality of Odsherred also wants to implement this kind of development in Nørre Asmindrup and Grevinge too to revive these “boring” parishes.


*Figure 17: Collection of pictures from housing project Fri & Fro, located in the parish of Egebjerg (M. Hillewaert, 2022)*

### 4.2.6 Vig, Asnæs and Hørve

These three parishes have experienced a similar development regarding the population density, employment rate and the amount of healthy vegetation (NDVI). In the last 30 years, these villages have been developing the most around the main transport vectors and especially around the railway. The railway passes the three villages in the centre and is the most important transport facility to the northern part of Odsherred (Figure 18). By conducting some fieldwork in all three parishes, it became clear that Vig and Asnæs are setting up new housing projects to attract new people to the villages with the expectation to grow the settlements. Recently, according to an interview with architect Jesper Paludan, the Gymnasium in Asnæs has become a centre of different schooling degrees and this will attract a lot of parents to go live there. Yet, Jesper Paludan also remarks that the summerhouses in the region will keep growing and it will be hard for these villages to attract more people. But, as clearly seen in Figures 19 and 20 the villages expect people to start living in these areas.

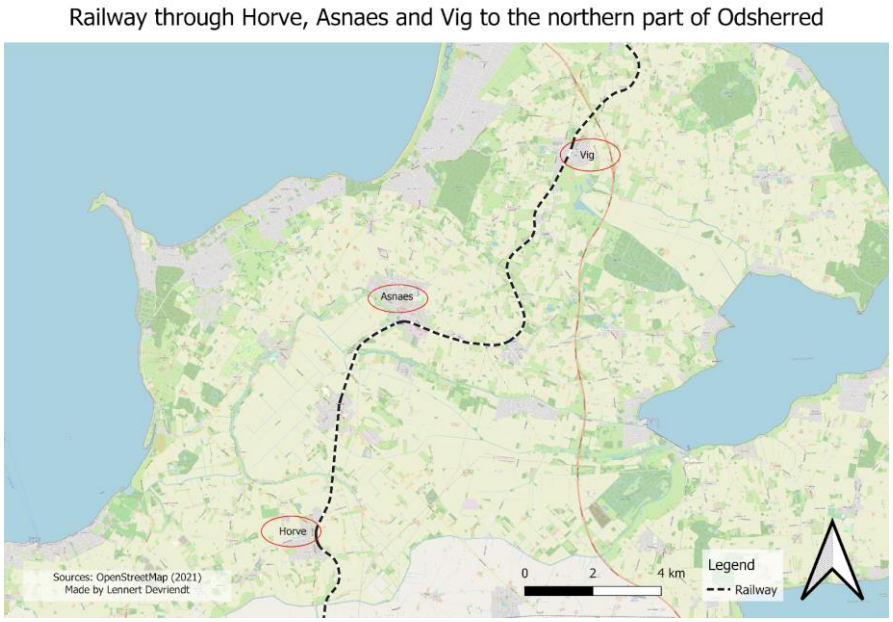


*Figure 18: Map of the railway transport vector going through Hørve, Asnæs and Vig towards the northern part of Odsherred*

*Figure 19: A new urban neighbourhood being built in Vig (M. Hillewaert, 2022)*

*Figure 20: Recent built neighbourhood in Asnæs (M. Hillewaert, 2022)*

### 4.2.7 Højby and Asnæs

Højby and Asnæs have the same urban structure because they are both situated on a hill which gave rise to a sort of star structure. Historically, agricultural land was divided into sort of cake pieces which were limited by the transport lines into the village centre. In this way, three zones were created where the first one is the original centre, the second the infields and the last one the outfields. The few farms/houses in the third zone are some sort of footprints of these outfield areas from the past. Nowadays, the transport lines are still important in urban development as new urban developments happen along these lines. This urban structure, shown in Figures 21 and 22, is quite typical in Denmark but Højby and Asnæs are different. They managed to win the urban development race against the other villages and became a supportive service centre for other settlements in the parish. This historical context explains why the percentage of urbanisation, the built-up area and the percentage of agricultural land are remarkably similar in both parishes.


*Figure 21: Urban development according to the historical structure of Asnæs (Background: Google Maps satellite image, structures made by L. Devriendt, 2022)*


*Figure 22: Urban development according to the historical structure of Højby (Background: Google Maps satellite image, structures made by L. Devriendt, 2022)*

### 4.2.8 Højby and Odden

Højby and Odden have a similar development regarding the built-up area, employment rate and land use of agricultural land. This can be explained by the fact that Højby was in a downward spiral for a little while but has recently been undergoing a revival. The land was cheap in and around Højby, while the land itself was reasonably well connected, this has attracted diverse types of activities to settle in and around the area (e.g., new administrative buildings and a new sports/culture centre). Odden is nowadays an international environment. It is growing fast, but the people are very protective of the area. In the past, it was possible to buy a 'second' house and use it as a summer house. So, the people who wanted summer houses bought the good houses and the local people were stuck with the bad houses. Later on, there were more new buildings because they wanted to attract young families with children from Copenhagen and Denmark. It is becoming a new kind of neighbourhood, very international (always in English), with a new food culture (Michelin star chefs). The development makes the parish more attractive so the built environment and the employment rate will increase. Which is the same for Højby.

### 4.2.9 Nykøbing Sj., Højby and Fårevejle

Given the different clusters, Nykøbing Sj., Højby and Fårevejle seem to have a similar development. As mentioned above, Højby has attracted several types of activities because of the cheap land and the good connection (e.g., new administrative buildings and a new sports/culture centre). In Nykøbing Sj. the interest in the summer houses increases. More and more people want to have a summer house in this region. The region becomes posher and posher and is called little Skagen, named after the posh summer house area Skagen in the North of Denmark. Here there is a lot of development and new houses are being built. In Fårevejle sports is important and are used as an attractive force to receive people. Apart from this, the village is easily accessible using the train, an extra attractive force. Because of this, the link between Nykøbing Sj. and Højby can be explained. All three attract new people. Højby because of the administrative buildings and new sports/culture centre. Nykøbing Sj. because of the significant role, but also of Annebergparken as a culture park that will attract people to come and live here. And lastly, Fårevejle attracts new people because it can be seen as a hotspot for sports.

*Figure 23: A New sports/cultural centre (left) and a new administrative building (right), both located in Højby (M. Hillewaert, 2022)*

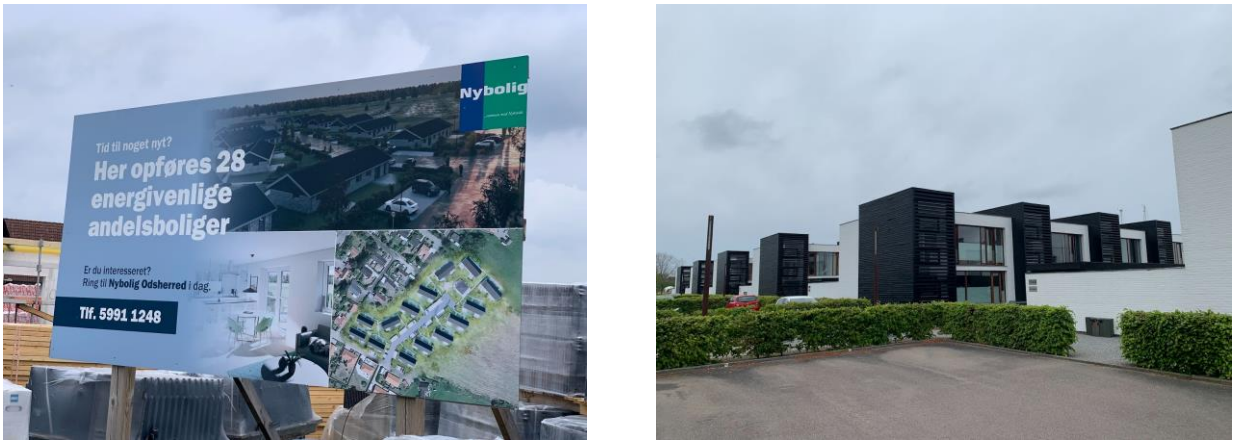


*Figure 24: New development in Nykøbing Sj. (M. Hillewaert, 2022)*


*Figure 25: Accessibility by train in Fårevejle (M. Hillewaert, 2022)*

## 4.3 General clusters

After finding an explanation for certain similar developments between parishes, it is possible to create some general clusters. As explained in chapter 3.5.2 this is done by advancing the ATA tool to generate aggregated clusters out of the original clusters. Due to these new insights, it was possible to divide Odsherred into different regions which are characterised by a similar urban development. The corresponding map with the general clusters is shown in Figure 26.

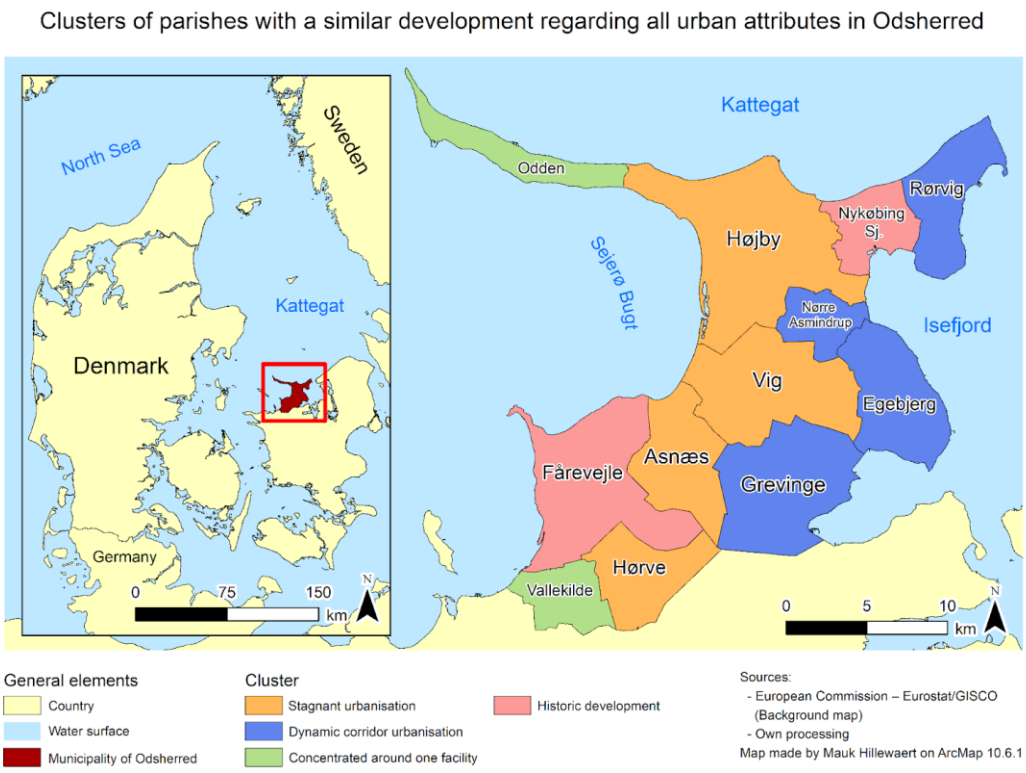


*Figure 26: Map of general clusters of parishes with a similar development regarding all urban attributes in Odsherred*

### 4.3.1 Stagnant urbanisation

The parishes on the East side of Odsherred are quite stagnant areas with very little development. People tend to move more to the summerhouse areas in the northern and western part of Odsherred which are the most beautiful areas. Yet, these villages try to attract people with some new neighbourhoods but people are not that eager to live over there because there are no real important functions or facilities such as big schools, supermarkets, …

### 4.3.2 Dynamic urbanisation

As shown in Figure 18, the railway stations have a considerable influence on the urban development in these parishes. Development is also created around main facilities such as the administrative centre in Højby and a huge supermarket and gymnasium in Asnæs. Both the stations, which increase the accessibility of the inhabitants to other areas, and the main facilities attract people to these parishes. This dynamic urbanisation is also remarkable through the housing projects that were built during the last 30 years.

### 4.3.3 Concentrated around one facility

The third class contains Vallekilde and Odden. According to a teacher of the Vallekilde Folk High School we have interviewed, the urban development in Vallekilde mainly evolves around the boarding school Folk High School. There is not much to do and most of the housing and facilities serve the school. Sports facilities are being used by the students and houses are mainly inhabited by the teachers at the school.

Apart from the summerhouse areas, the harbour is the main driver for the urban development in Odden. It is an old fishing harbour, which is still functional. Odden is mainly used as a summerhouse area because there is a beautiful coast on both sides of the peninsula. Furthermore, there is also a ferry at the western point of Odden to connect Sjaelland with Midtjylland through Aarhus and Ebletoft. So, Odden is mainly destined for summerhouse keepers or used as a passageway to the ferry. Yet, summerhouse areas are not included in our research which means that the harbour is the singular driver for urban development.

### 4.3.4 Historic development

The last class involves two parishes where history is important in their urban development today. Nykøbing Sj. was previously a flourishing trading community which has now changed into a service centre with diminishing importance. Fårevejle only exists for about 150 years and is located in the Lammefjord. The draining of this area has strongly influenced the development of the parish with two quite opposite villages. The first village is concentrated around the church while the second is concentrated around a prominent level of education and the station.

## 5. DISCUSSION

The results of this research give insight into how urban spaces have evolved throughout Odsherred over the past thirty years and even the period before. It is handy to look at these results and interpret them in a way where future research can be developed and underlying questions that have not been answered yet in this research can be answered in the future.

The distances between trajectories of the different variables are computed using the Euclidean distance method in this research. A subject of further research could be the use of other methods to compute these distances. A variety of different methods to calculate distances are available. Some well-known methods that could be used in further research are correlation distance, Manhattan distance or dynamic time warping.

The attribute trajectory analysis was used in this research as a method to examine the evolution of urbanisation in Odsherred. But this tool of analysis could have a multitude of uses in other fields of research. The ATA-tool is a very flexible tool, therefore it can process all sorts of data in the shape of different variables

that are given to the tool. Further research could make use of this tool for multiple types of applications if the right amount of attributes with a large value is available for the tool to process.

If further research is more focused on the research that is presented in this paper, multiple possibilities can be examined. The spatial scale of this research was the municipality of Odsherred. This municipality consists of multiple parishes which formed the granularity of this research. Both a change in spatial scale and granularity can open the door toward different results in the spatio-temporal clustering of urban development.

The spatial scale can be increased or diminished and this will automatically result in a change of granularity. The spatial scale could be increased to encompass the entirety of the country of Denmark. Then, the granularity will be made up of the different municipalities in the country, which previously formed the spatial scale. The same method can be carried out to diminish the spatial scale and to carry out research on a very specific part of the region, leading to very detailed results.

Notable similarities that were found between the urban development of the different parishes were the presence of large traffic connections and educational facilities. In parishes where a significantly larger amount of urban development took place, a traffic node or school was always present. The exact cause for this relationship between the present facilities and the grade of urbanisation was not examined further in this research. Further studies could explore this subject more.

## 6. CONCLUSION

The main conclusion that can be made after the presented research is: all parishes in the municipality of Odsherred have experienced a gradual and stable rise in urbanisation. Fieldwork in the region validated this statement. In every visited parish, an example of urban expansion could be found and was described in this research. For example, urban expansion projects were found in Vig and Nykøbing Sj. and the sustainable community that has been developing in Egebjerg can also be seen as a form of urban expansion. Urbanisation takes on many forms throughout all the parishes but it is ever-present in all of them.

All parishes experience a rise in urbanisation but that does not mean this urbanisation has known the same evolution for all parishes. Some urbanisation factors in these parishes have evolved similarly, others have experienced a different evolution. There is no main urbanisation trend these parishes have followed over the past thirty years. Therefore, each parish was analysed separately in this research, to make it possible to detect even the smallest changes in their evolution. There are similarities though in the urbanisation of these parishes. It could be concluded that the presence of a traffic node, such as a train station, and/or a school or other educational facility, led to an increased grade of urbanisation. As stated before, the exact cause of this relationship is out of the scope of this particular research but could be the subject of further research.

Lastly, it is important to conclude that interviews with local experts and inhabitants are a vital part of this kind of research. It is very hard to interpret the generated clusters without any background knowledge of the municipality or a parish. This information gives more insight into the history of each parish and why its history evolved in that way. This history can then be coupled to the current state of urbanisation and explanations are more easily found.

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# 8. APPENDIX

## 8.1 Sources of the data used for the creation of the different maps

*Table 3: Sources of the data used for the creation of the different maps*

| Name | Type | Source | Used for | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Population density ATA | NDVI ATA | Land use: Urbanization ATA | Land use: Agriculture ATA | Built-up area ATA | Employment rate ATA | Maps in the report |
| Odsherred.shp | Shapefile (vector layer) | Plandata.dk (https://kort.plandata.dk/spatialmap) | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Parishes.shp | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Summerhouses.shp | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Railway.shp | | www.geofabrik.de | | | | | | | ■ |
| NUTS0.shp (countries of Europe) | | Eurostat (www.ec.europa.eu/eurostat) | | | | | | | ■ |
| Population.xlsx (by parish) | Spreadsheet file | Statistics Denmark (www.statbank.dk/SOGN10) | ■ | | | | | ■ | ■ |
| Population_age.xlsx (by parish, sex and age) | | Statistics Denmark (www.statbank.dk/SOGN1) | | | | | | | ■ |
| Employement.xlsx | | Statistics Denmark (www.statbank.dk/INDKF41 & www.statbank.dk/KMSTA005) | | | | | | ■ | ■ |
| Landsat5_image.tiff (1990, 1995, 2000, 2005, 2010) | Tiff-file (raster layer) | USGS EarthExplorer (https://earthexplorer.usgs.gov/) | | ■ | | | | | |
| Landsat8_image.tiff (2015, 2020) | | | | ■ | | | | | |
| CORINE_land_cover.tiff | | Copernicus (https://land.copernicus.eu/) | | | ■ | ■ | | | |
| Denmark_land_cover.tiff | | University of Aarhus (www.envs.au.dk) | | ■ | | | | | |
| Built-up-estimates.tiff | | University of Columbia (https://sedac.ciesin.columbia.edu/) | | | | | ■ | | |
| OpenStreetMap | XYZ-tile | http://a.tile.openstreetmap.org/{z}/{x}/{y}.png | | | | | | | ■ |
| Topographic_map_DK (1980-2001, 2005, 2010, 2015, 2020) | WMS | Dataforsyningen.dk (https://api.dataforsyningen.dk/) | | | | | | | ■ |
| Odsherred_1768.png | PNG-file (georeferenced in QGIS) | www.wikipedia.org | | | | | | | ■ |

## 8.2 Overview of the satellite images used to calculate the NDVI

*Table 4: Overview of the satellite images used to calculate the NDVI*

| Date the satellite image is acquired | Satellite | Used spectral bands | Exact link to satellite image |
|---|---|---|---|
| 18/03/1990 | Landsat 5 | Band 3 - R (Red)<br>Band 4 - NIR (Near infrared) | https://earthexplorer.usgs.gov/scene/metadata/full/5e83d1193824e4fc/LT51950211990077KIS00/ |
| 22/07/1995 | | | https://earthexplorer.usgs.gov/scene/metadata/full/5e83d1193824e4fc/LT51950211995203KIS00/ |
| 27/08/2000 | | | https://earthexplorer.usgs.gov/scene/metadata/full/5e83d1193824e4fc/LT51960212000240FUI00/ |
| 3/09/2005 | | | https://earthexplorer.usgs.gov/scene/metadata/full/5e83d1193824e4fc/LT51950212005246KIS00/ |
| 4/06/2010 | | | https://earthexplorer.usgs.gov/scene/metadata/full/5e83d1193824e4fc/LT51960212010155MOR01/ |
| 21/08/2015 | Landsat 8 | Band 4 - R (Red)<br>Band 5 - NIR (Near infrared) | https://earthexplorer.usgs.gov/scene/metadata/full/5e83d14f2fc39685/LC81960212015233LGN01/ |
| 27/03/2020 | | | https://earthexplorer.usgs.gov/scene/metadata/full/5e83d14f2fc39685/LC81960212020087LGN00/ |

## 8.3 Cartographic models of the data cleaning of each parameter used in the ATA

### 8.3.1 Data cleaning of the population density data

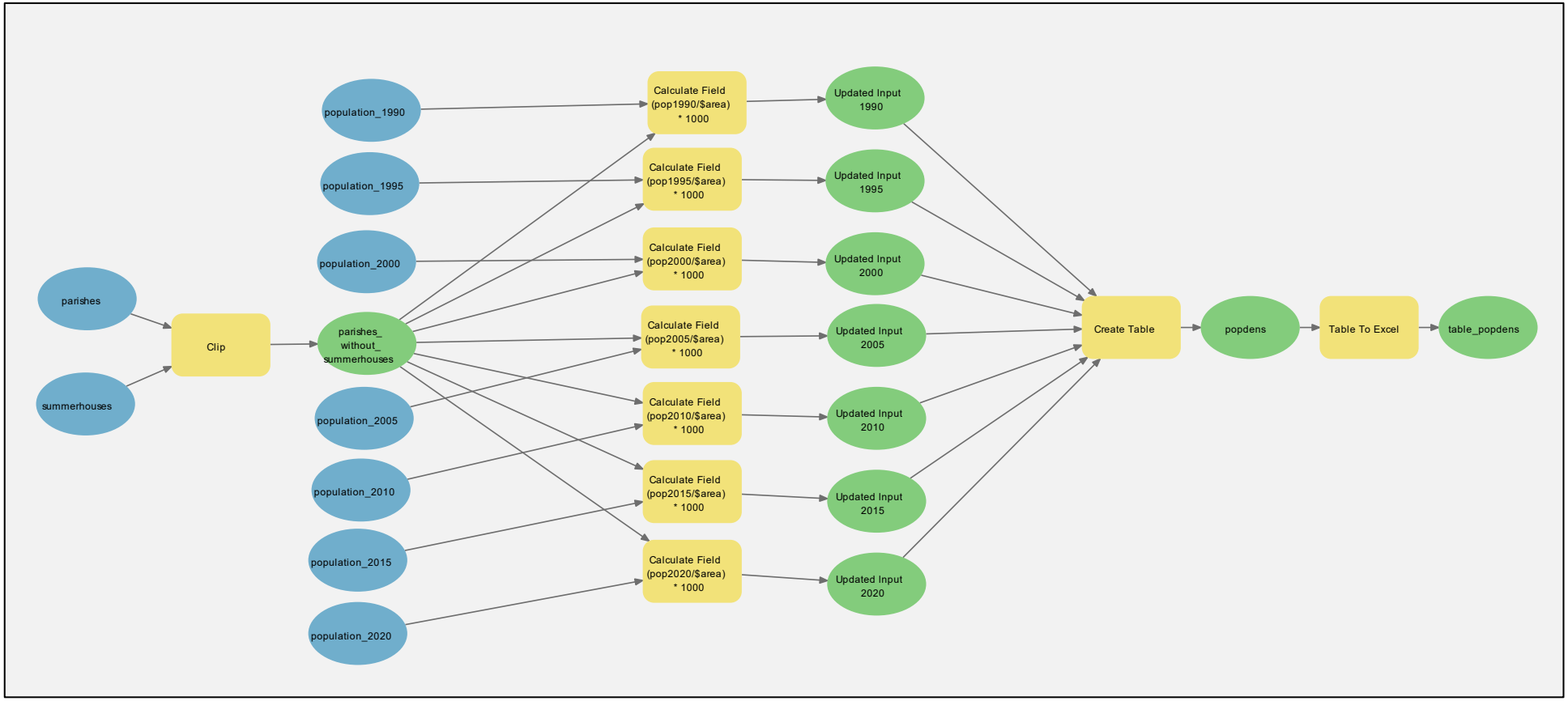


*Figure 27: Cartographic model of the data cleaning process of the population density data*

### 8.3.2 Data cleaning of the NDVI data

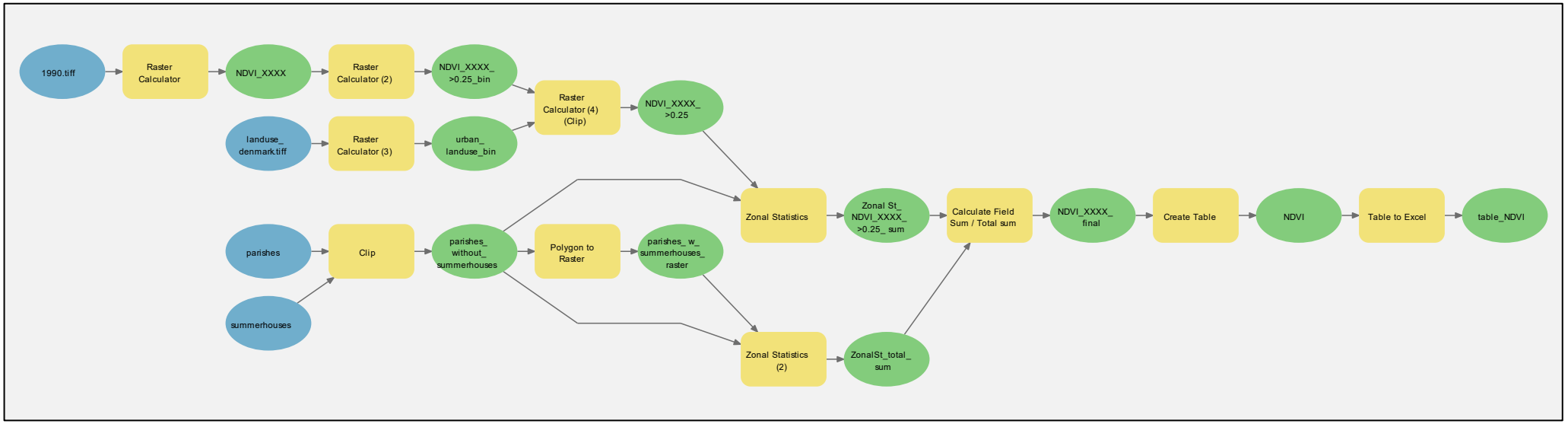


*Figure 28: Cartographic model of the data cleaning process of the NDVI data*

### 8.3.3 Data cleaning of the land use urbanisation data

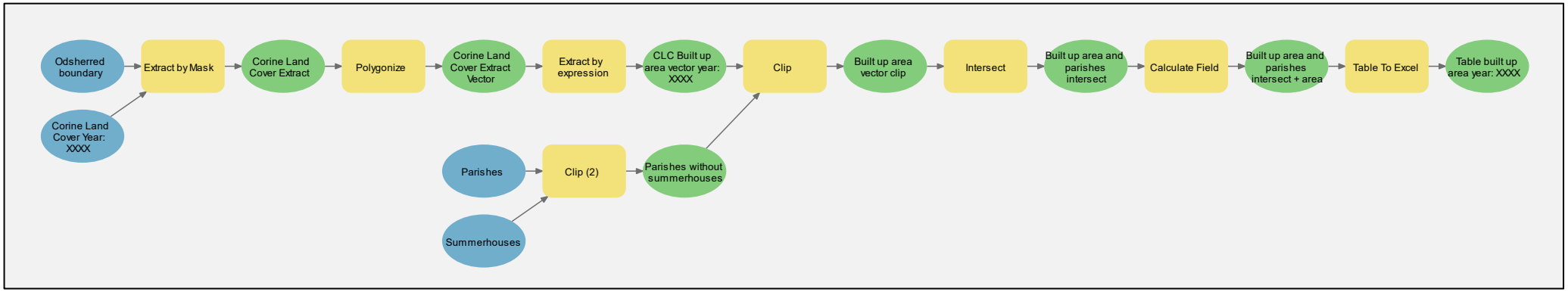


*Figure 29: Cartographic model of the data cleaning process of the land use urbanisation data*

### 8.3.4 Data cleaning of the land use agricultural data

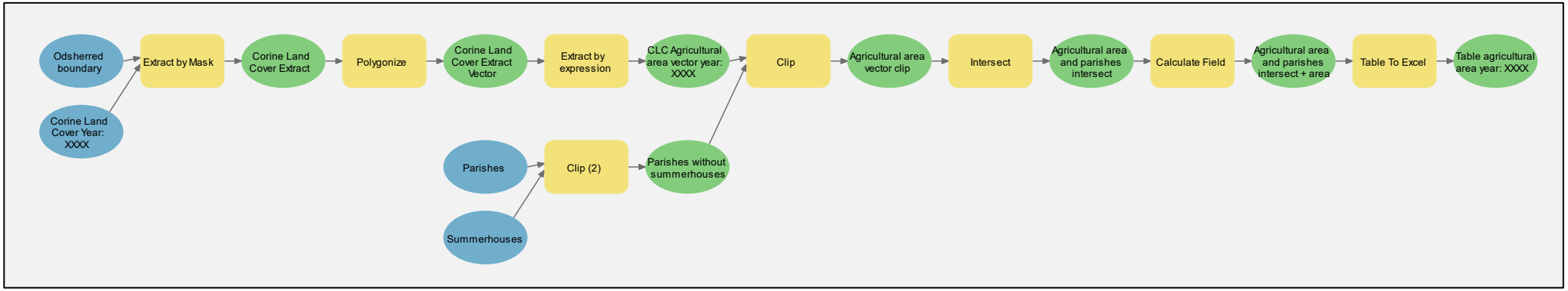


*Figure 30: Cartographic model of the data cleaning process of the land use agricultural data*

### 8.3.5 Data cleaning of the built-up area data

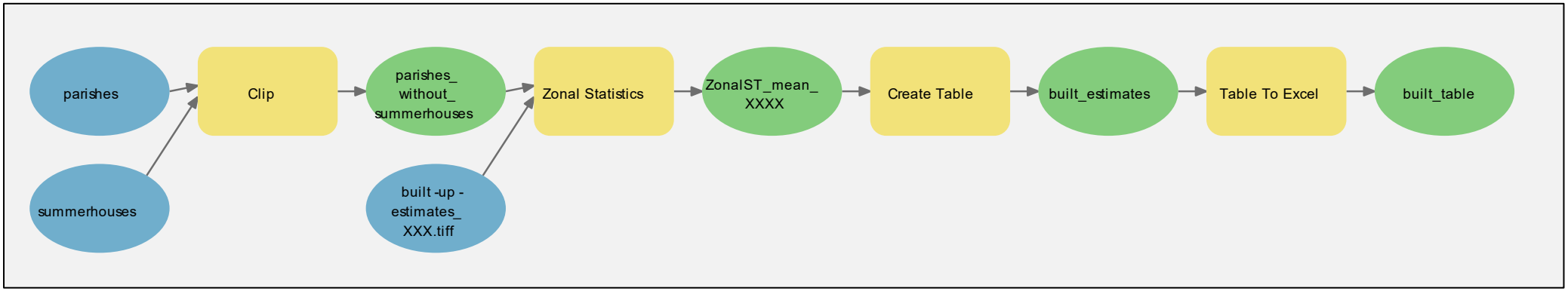


*Figure 31: Cartographic model of the data cleaning process of the built-up area data*

### 8.3.6 Data cleaning of the employment rate data

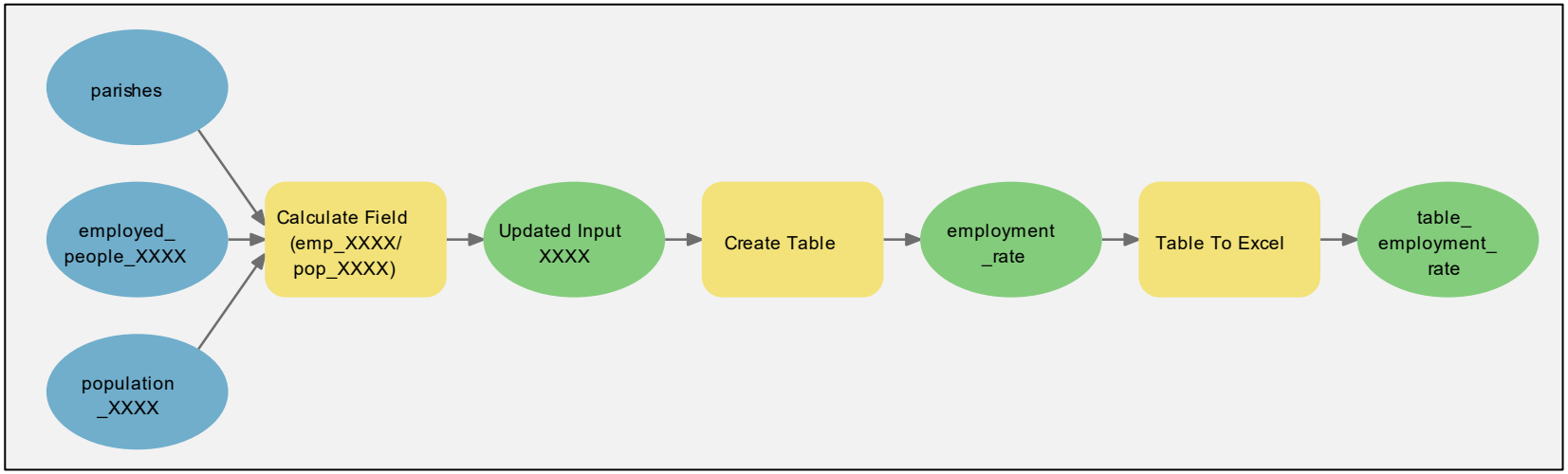


*Figure 32: Cartographic model of the data cleaning process of the employment rate data*

## 8.4 ATA outcome products

### 8.4.1 NDVI ATA outcome products

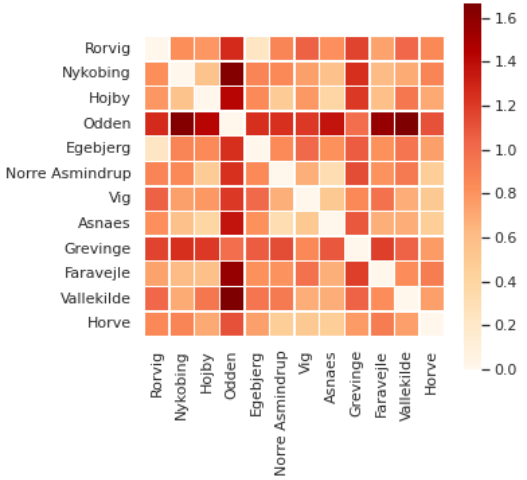


*Figure 33: Distance matrix of the NDVI attribute trajectories*

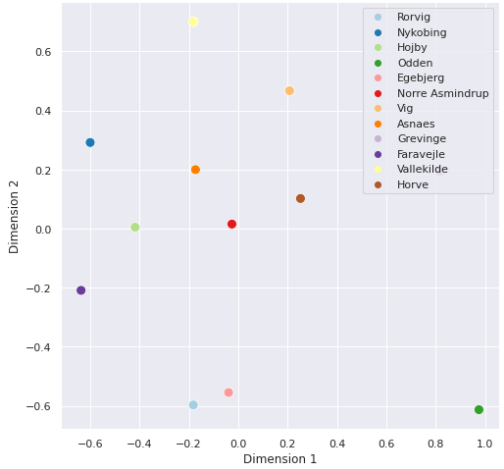


*Figure 34: 2-dimensional representation of the distance between the NDVI attribute trajectories*

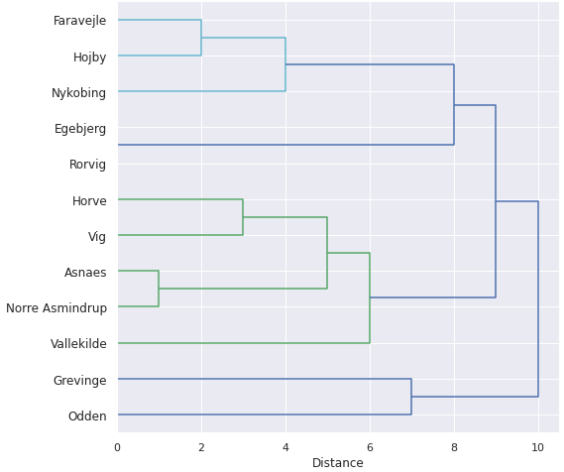


*Figure 35: Dendrogram of the clustering of the NDVI attribute trajectories (5 clusters)*

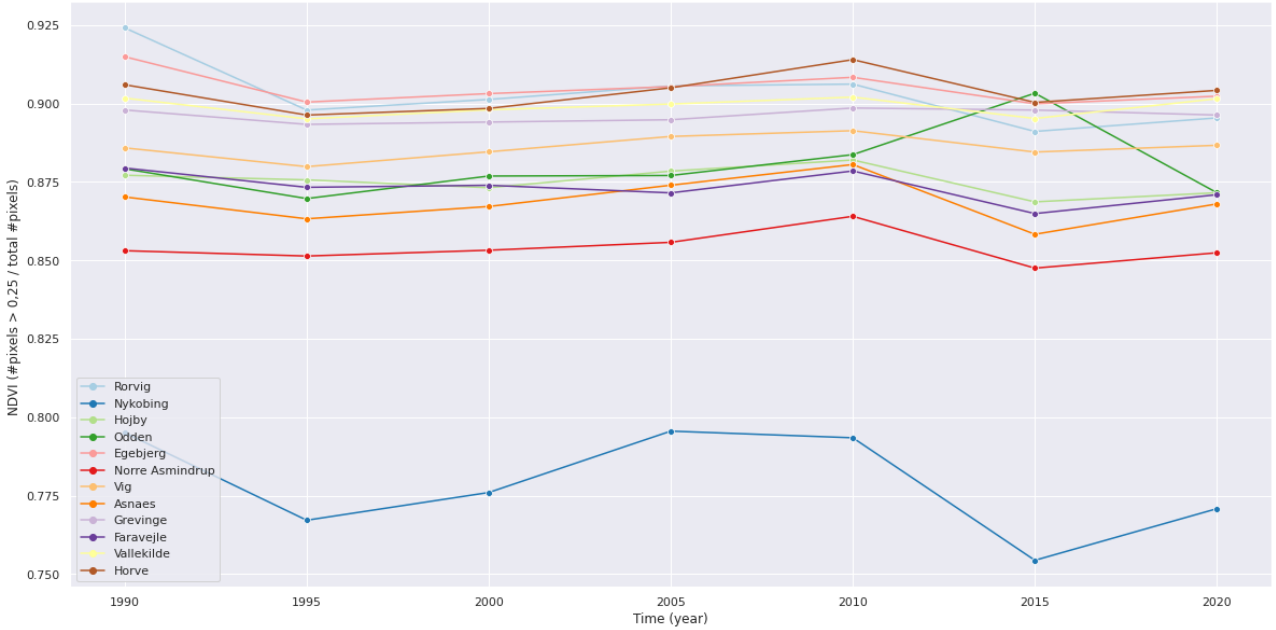


*Figure 36: Attribute trajectories of the NDVI (#pixels > 0.25 / total #pixels) of all parishes in Odsherred*

### 8.4.2 Land use urbanisation ATA outcome products

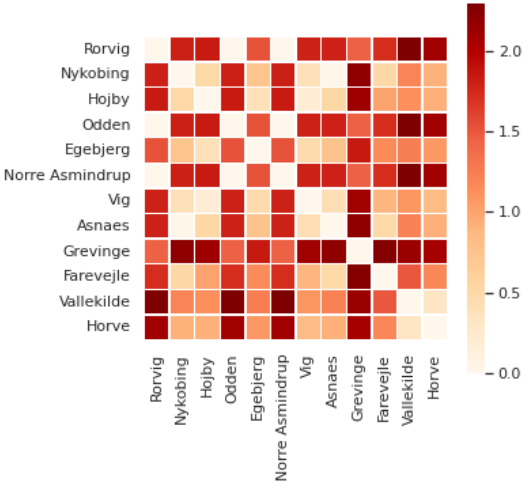


*Figure 37: Distance matrix of the urban land use attribute trajectories*

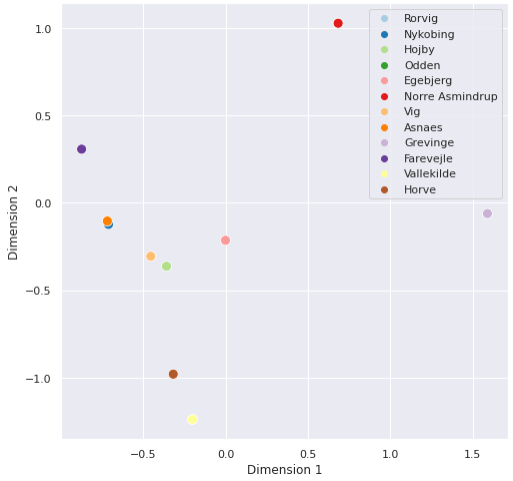


*Figure 38: 2-dimensional representation of the distance between the urban land use attribute trajectories*

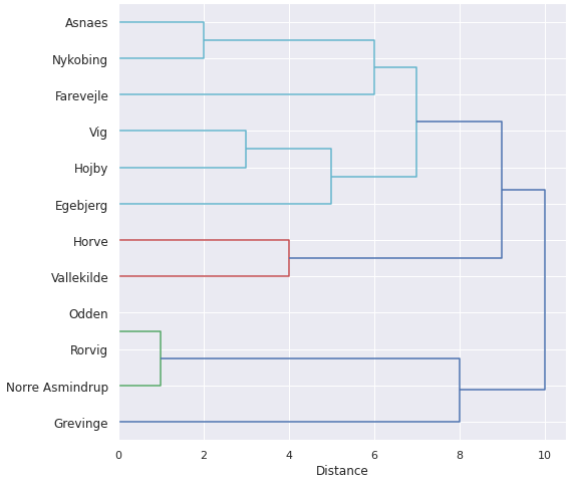


*Figure 39: Dendrogram of the clustering of the urban land use attribute trajectories (4 clusters)*

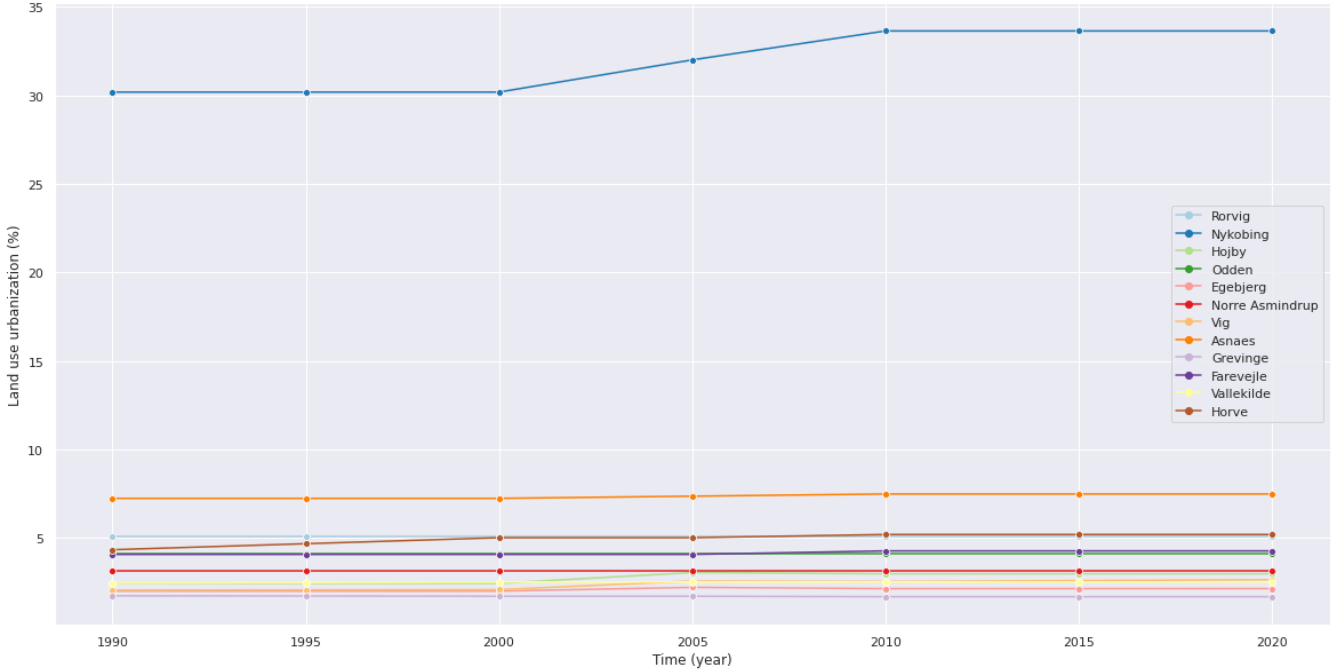


*Figure 40: Attribute trajectories of the urban land use (%) of all parishes in Odsherred*

### 8.4.3 Land use agriculture ATA outcome products

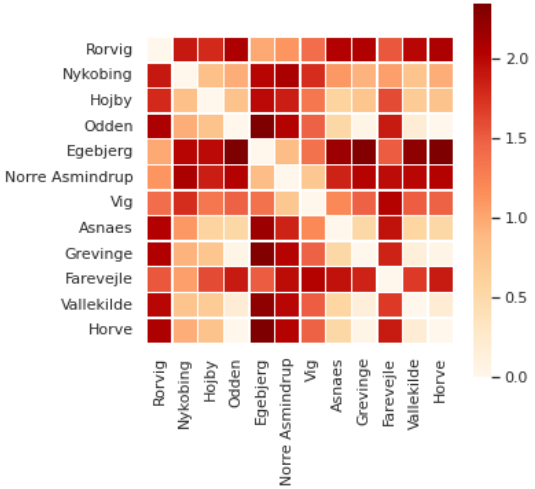


*Figure 41: Distance matrix of the agricultural land use attribute trajectories*

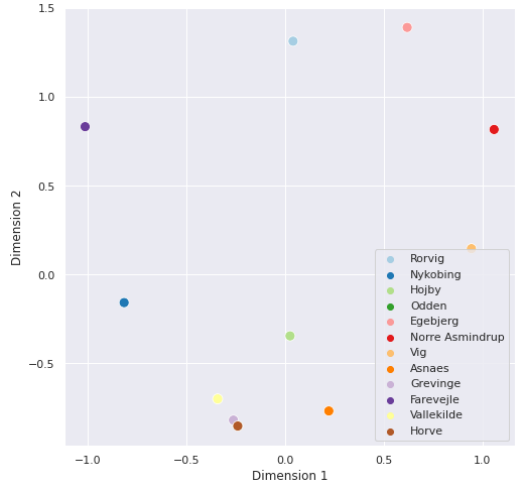


*Figure 42: 2-dimensional representation of the distance between agricultural land use attribute trajectories*

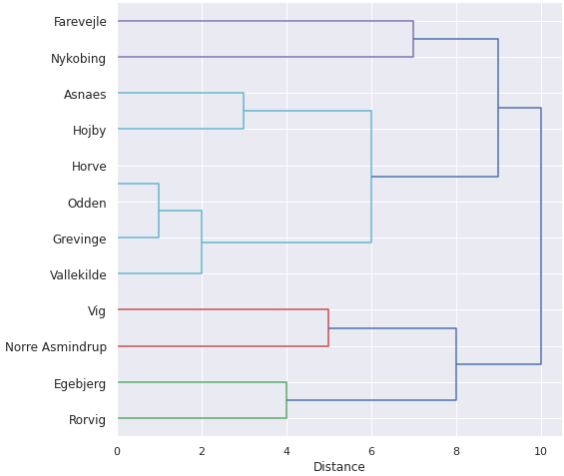


*Figure 43: Dendrogram of the clustering of the agricultural land use attribute trajectories (4 clusters)*

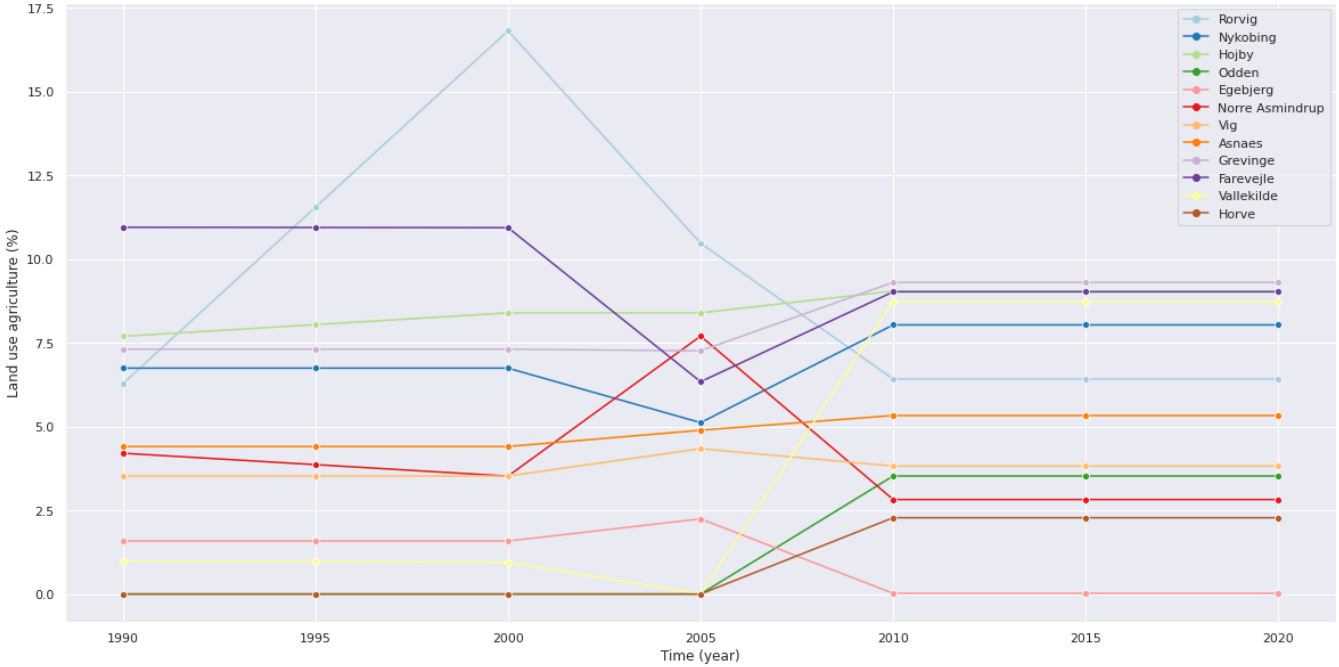


*Figure 44: Attribute trajectories of the agricultural land use (%) of all parishes in Odsherred*

### 8.4.4 Built-up area ATA outcome products

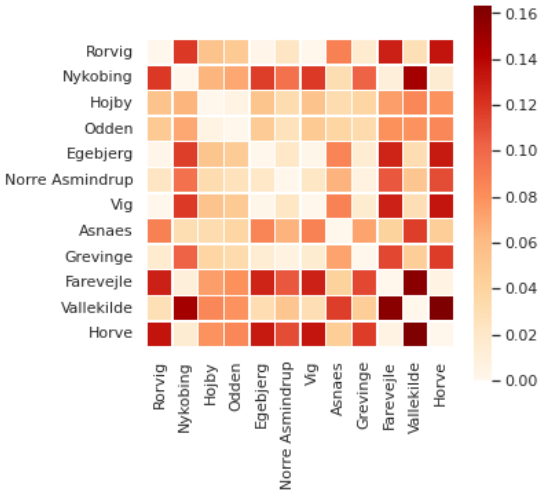


*Figure 45: Distance matrix of the built-up area attribute trajectories*

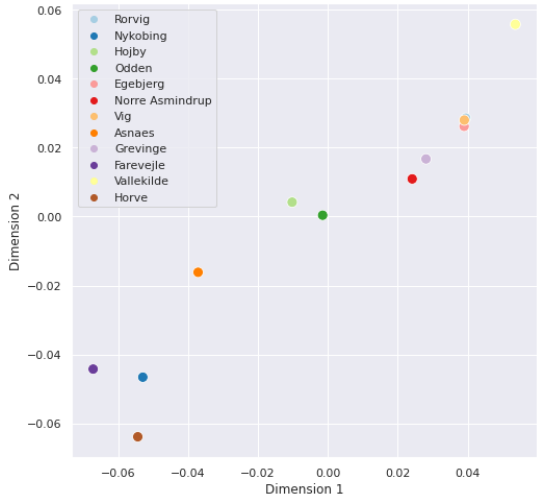


*Figure 46: 2-dimensional representation of the built-up area attribute trajectories*

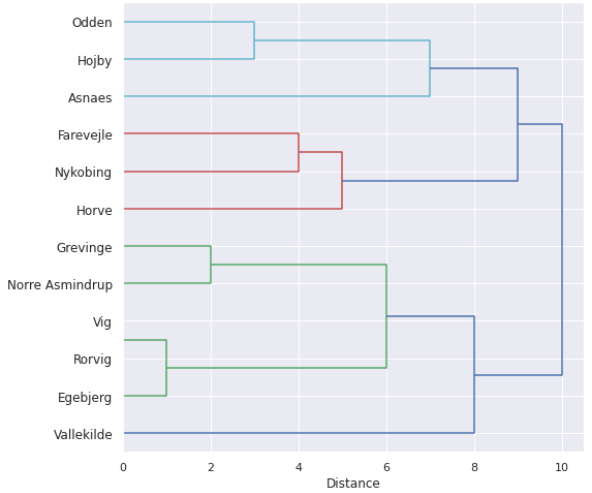


*Figure 47: Dendrogram of the clustering of the built-up area attribute trajectories (4 clusters)*

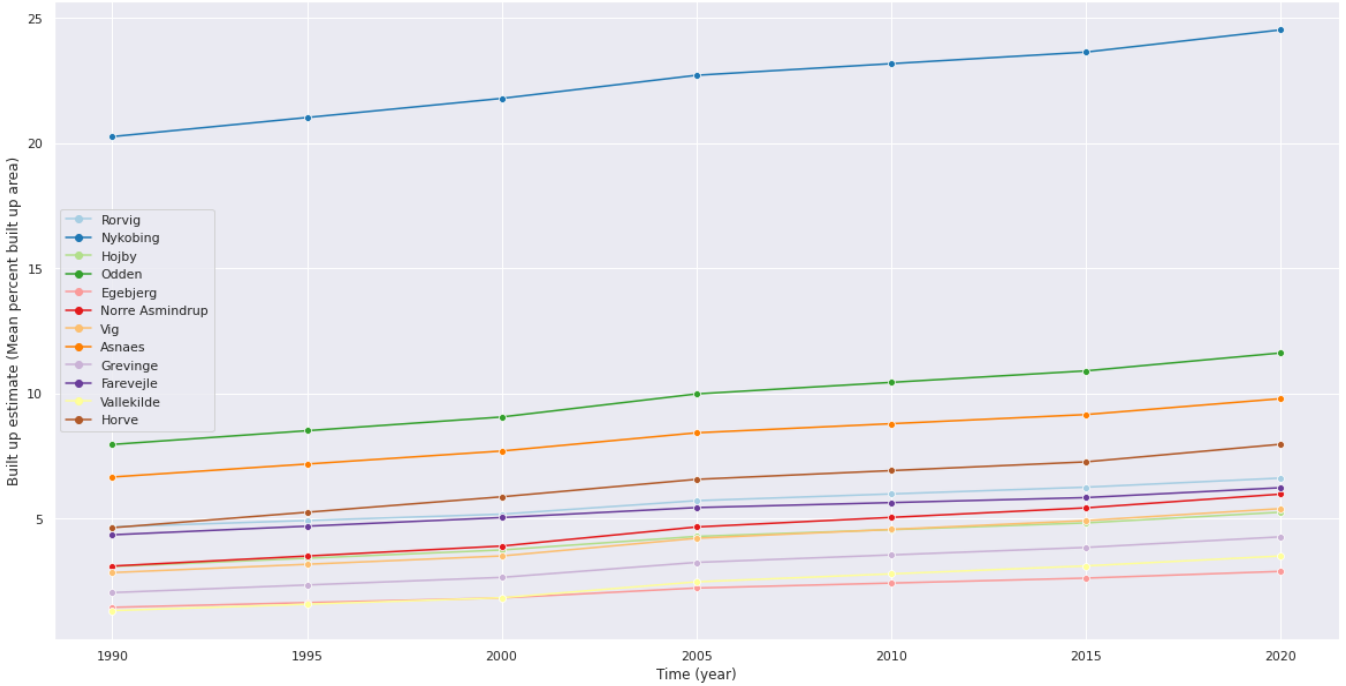


*Figure 48: Attribute trajectories of the built-up area (mean percentage built-up area) of all parishes in Odsherred*

### 8.4.5 Employment rate ATA outcome products

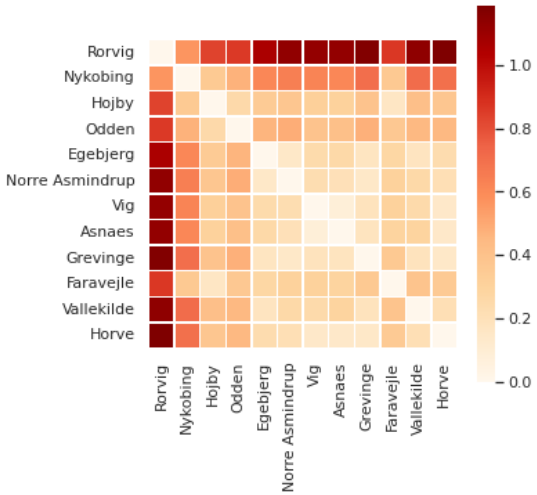


*Figure 49: Distance matrix of the employment rate attribute trajectories*

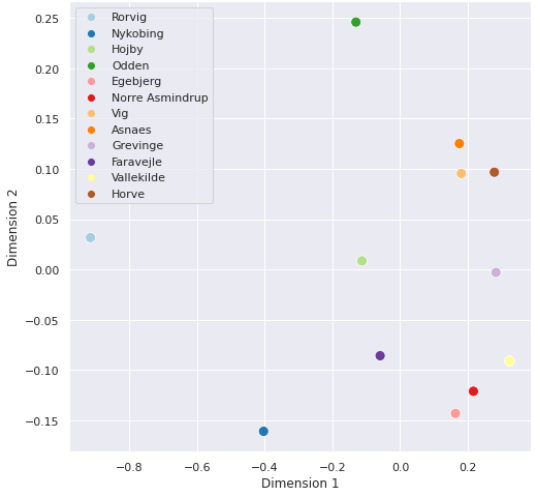


*Figure 50: 2-dimensional representation of the employment rate attribute trajectories*

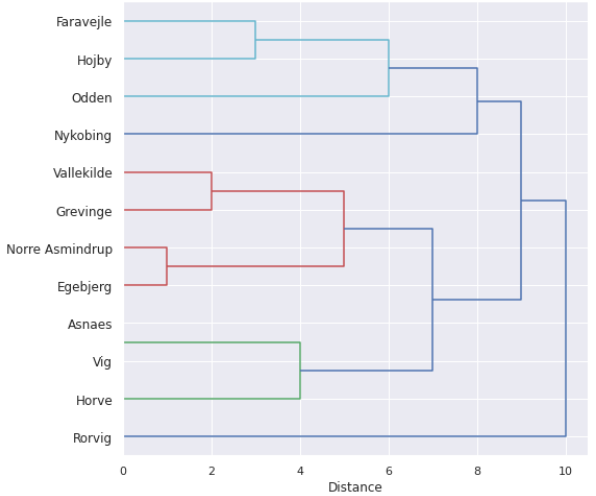


*Figure 51: Dendrogram of the clustering of the employment rate attribute trajectories (4 clusters)*

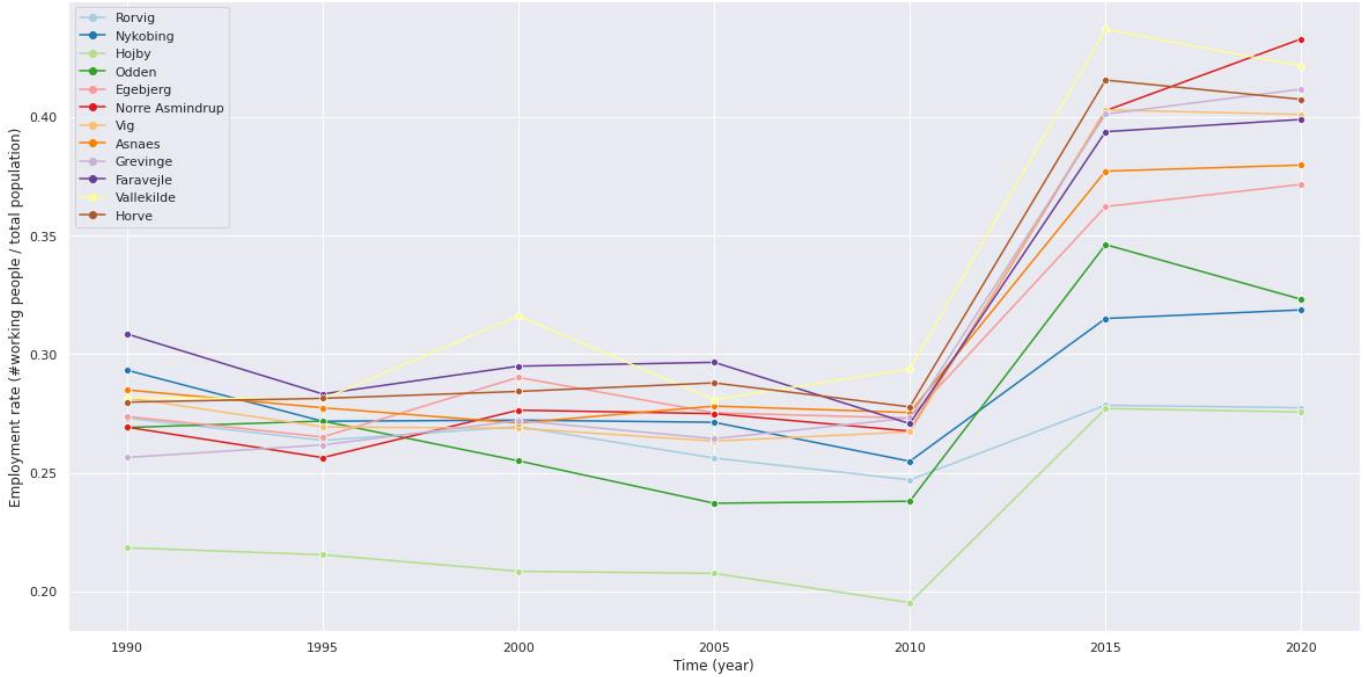


*Figure 52: Attribute trajectories of the employment rate (#working people / total population) of all parishes in Odsherred*

## 8.5 Maps of clusters of each urbanisation factor

### 8.5.1 Clusters of similar development regarding NDVI

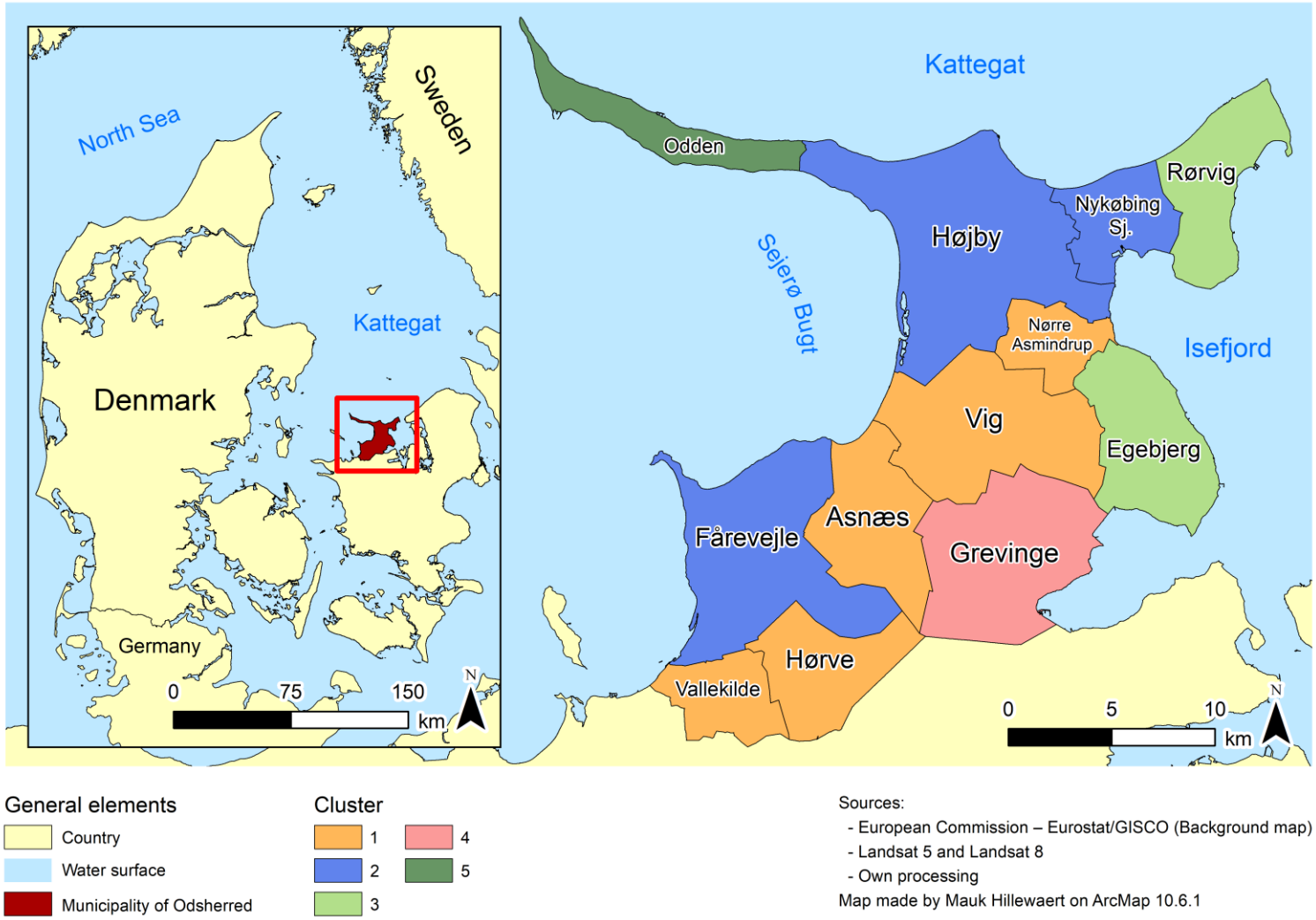


*Figure 53: Map of clusters of similar development regarding NDVI (#pixels > 0.25 / total #pixels) in Odsherred*

### 8.5.2 Clusters of similar development regarding urban land use

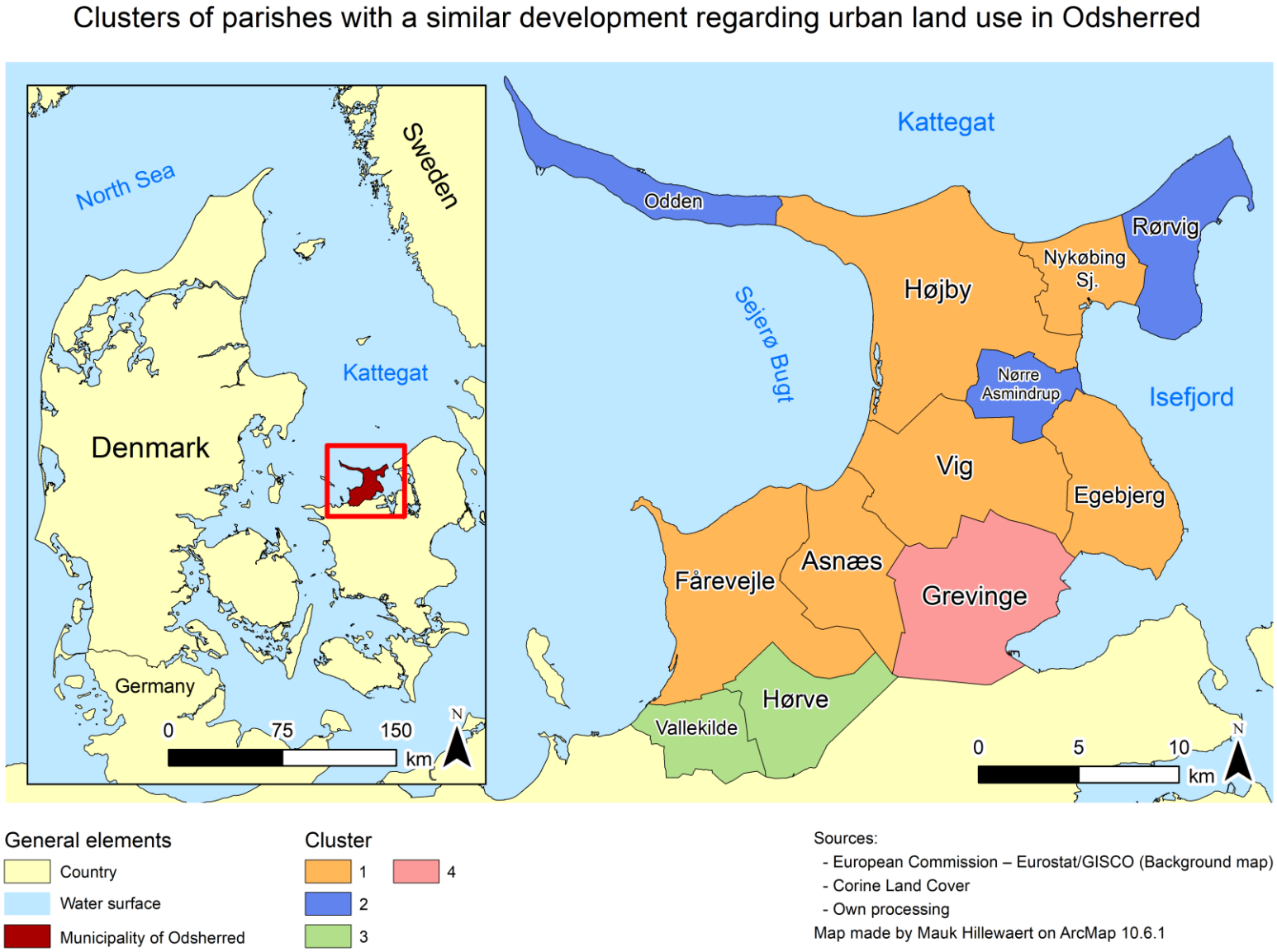


*Figure 54: Map of clusters of similar development regarding urban land use (%) in Odsherred*

### 8.5.3 Clusters of similar development regarding agricultural land use

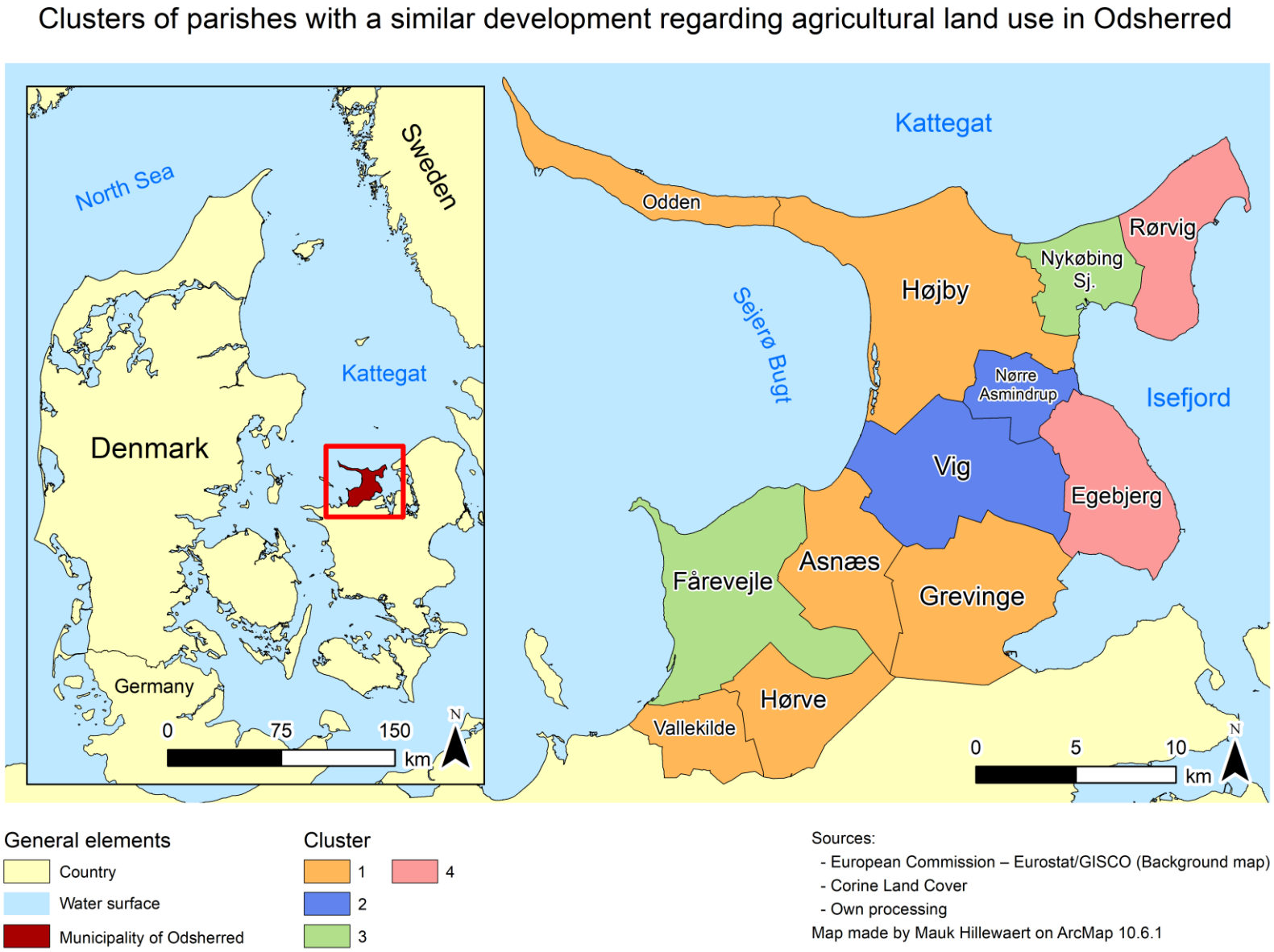


*Figure 55: Map of clusters of similar development regarding agricultural land use (%) in Odsherred*

### 8.5.4 Clusters of similar development regarding built-up area

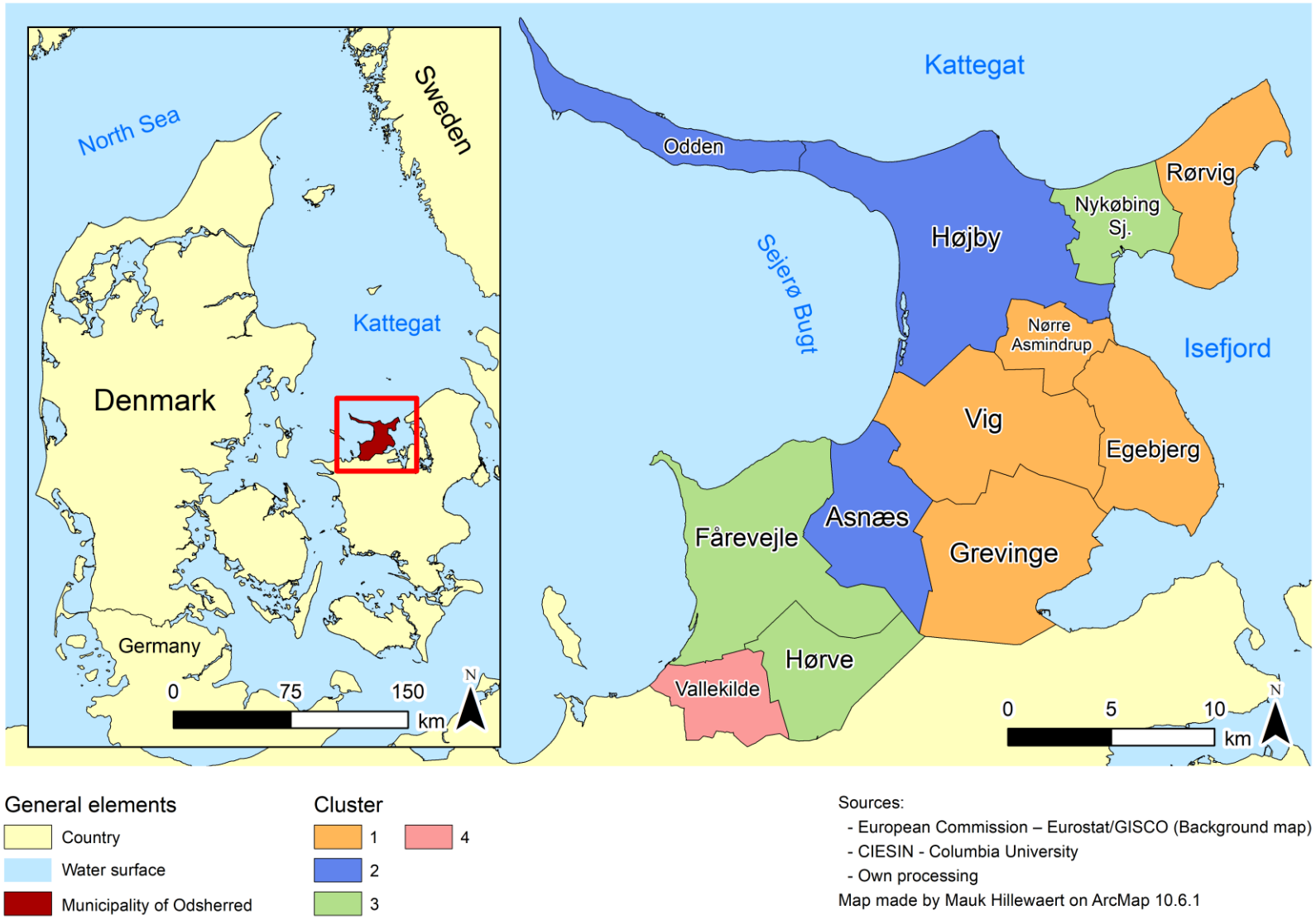


*Figure 56: Map of clusters of similar development regarding built-up area (mean percentage built up area) in Odsherred*

### 8.5.5 Clusters of similar development regarding employment rate

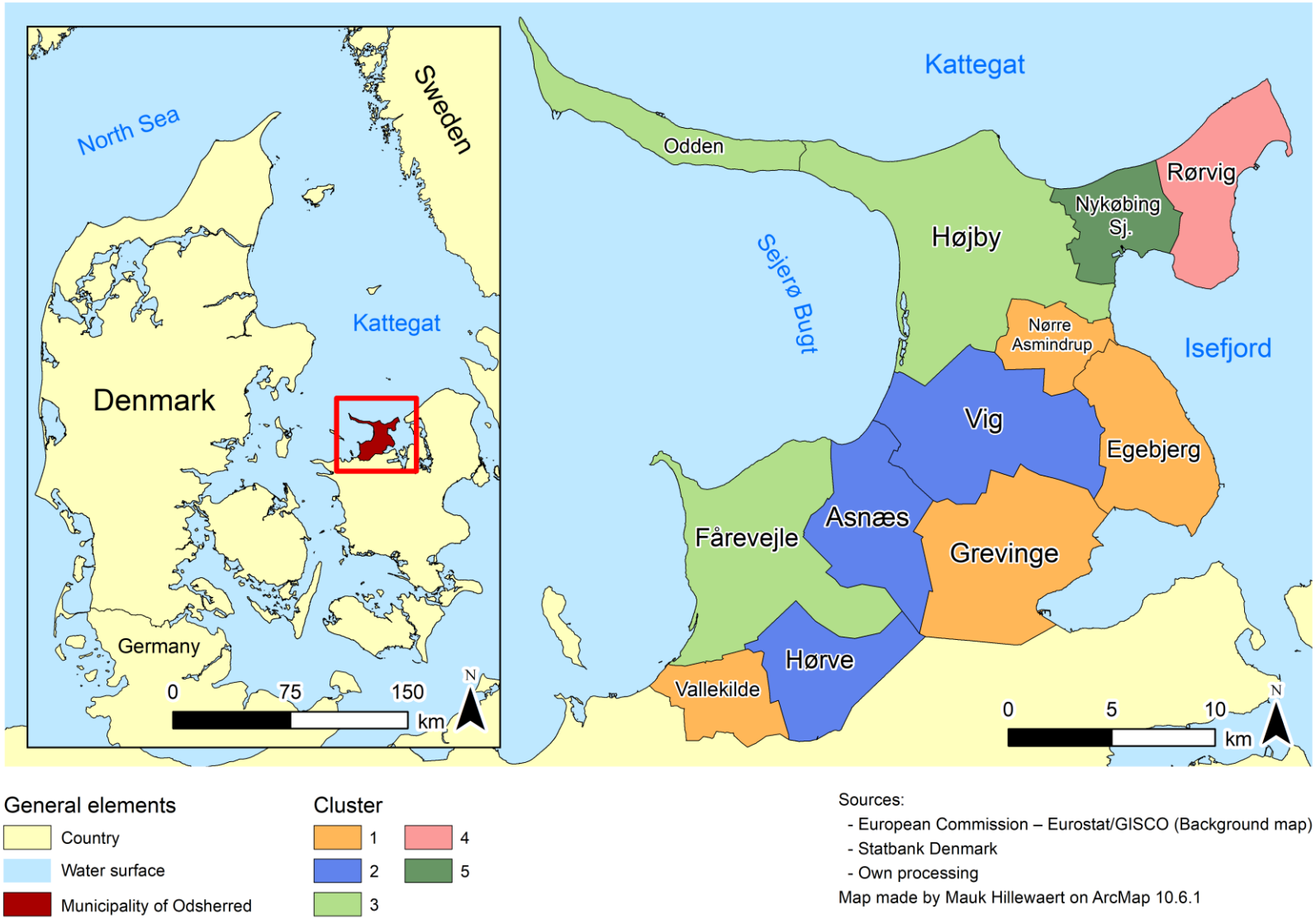


*Figure 57: Map of clusters of similar development regarding employment rate (#working people / total population) in Odsherred*

## 8.6 Interviews

### 8.6.1 Overview of the persons we interviewed

*Table 5: Overview of the persons we interviewed (Inhabitants and local experts)*

| Brief description of the person | Place of interview | Job description | Marked as 'local expert' by us? (If yes, some more information is given) |
|---|---|---|---|
| An adult man of Danish nationality who is not living in Egebjerg. | Egebjerg | Works as employee in the Egebjerg Recycling ApS, a waste disposal service factory located in Egebjerg. It is also known as T20 Egebjerg ApS. | No |
| A retired man of Danish nationality who lives in Egebjerg. | | The interviewed man is retired but he has his own wood exhibition/gallery and shop in his house. Thus, he still keeps himself busy with sculpting out of wood. | No |
| An adult man of Danish nationality who lives in Rørvig | Rørvig | Works as a dock worker in the port of Rørvig. | No |
| An adult man of Danish nationality who lives in Rørvig | | Works as an employee in a real estate office in Rørvig | No |
| An adult man of Danish nationality who lives in Nykøbing Sj. | Nykøbing Sj. | Works as an employee in a real estate office in Nykøbing Sj. | No |
| A retired woman of Danish nationality who lives in Nykøbing Sj. | | The interviewed woman is retired. | No |
| An adult woman of Danish nationality who is not living in Højby. | Højby | Works as an employee in the main building of the Odsherred Kommune in Højby. This is the town hall and the administrative centre of the municipality of Odsherred. | No |
| An adult man of Danish nationality who lives in Odden. | | First worked as an architect. Now, works as employee in the Business, Planning and Construction department at the Odsherred Kommune in Højby. This is the town hall and the administrative centre of the municipality of Odsherred. | Yes<br>Name: Jesper Paludan<br>E-mail: jokra@odsherred.dk<br>(This is the e-mail adress of the head of department of Building, Planning and Construction) |
| An adult man of Danish nationality who lives in Vallekilde. | Vallekilde | Works as a teacher in the Vallekilde Folk High School. | No |
| A group of retired men of Danish nationality who live in Hørve. | Hørve | The interviewed men are retired. | No |
| An adult man of Norwegian nationality who lives in Hørve. | | Moved just recently to Hørve, and is currently a job seeker. | No |
| An adult woman of Danish nationality who is not living in Farevelje. | Fårevejle | Works as a teacher in the Farevelje Efterskole (boarding school). | No |
| An adult men of Danish nationality. | Asnæs | Works as assistant professor at the University of Copenhagen at the departement of Geosciences and Natural Resource Management. The section the professor is associated with, is the section of Landscape Architecture and Planning. | Yes<br>Name: Andreas Aagaard Christensen<br>E-mail: anaach@ign.ku.dk |
| An adult men of Danish nationality. | n/a | Works as professor at the University of Copenhagen at the departement of Geosciences and Natural Resource Management. The section the professor is associated with, is the section of Landscape Architecture and Planning. | Yes<br>Name: Henrik Vejre<br>E-mail: hv@ign.ku.dk |

### 8.6.2 Interview with Andreas Christensen (written out)

The following interview was conducted with the professor of landscape architecture and planning at the University of Copenhagen: Andreas Aagaard Christensen. The goal of this interview was to find answers to questions that had arisen during the analysis of the data used for the ATA. Professor Christensen could provide much insight into why these different variables evolved differently in every parish through time.

**Question 1: Why is Nykøbing Sj. so important in the area of Odsherred (highest population density and percentage of urbanisation)?**

Nykøbing Sj. was traditionally a trading town because of the presence of the harbour. In the Middle Ages, large amounts of trading could only take place in an official trading town, which was rewarded with an official trading licence by the king. In this way, Nykøbing Sj. became a place where an income could be obtained that was not based on agriculture or the servicing of agriculture. In Nykøbing Sj. money could be earned by trading any type of goods and also by servicing the traders such as banking. Later during the industrial revolution, the industry started to develop around Nykøbing Sj. because industry usually develops along transport vectors or in the trading hubs. All this led to Nykøbing Sj. becoming a big industrial transport hub and developing the biggest economy in the region, while agriculture declined. This attracted a lot of inhabitants who found employment in Nykøbing Sj.. It is also important to note that in the last forty years the more physical type of industry has developed into a more knowledge-based, servicing type of industry and the inhabitants of Nykøbing Sj. developed along with it.

**Question 2: Why has Højby been chosen as the administrative capital of Odsherred although Nykøbing Sj. is bigger?**

Around 2007 three municipalities fused to form Odsherred. They didn't do this because they wanted to but the government forced them to. The city hall was placed in Højby because of its central placement in the region and as a compromise so that every former municipality had a new city hall. The administrative buildings were also already present in Højby.

**Question 3: Why have Vig, Asnæs and Hørve a similar development in terms of population density, employment rate and NDVI?**

The landscape conditions are remarkably similar. They are also connected by the same transport vector. Until the 19$^{th}$ century, that road was the only way to reach the North, so the road was frequently used. Essentially these three places are located in the same landscape where the same landscape patterns have taken place. This could explain the similar development of these three parishes.

**Question 4: Why have Nørre Asmindrup and Grevinge a similar urban development for 4 of the 5 researched parameters (Exception is population density)?**

There is something about vitality. If you look at an area with attractive physical attributes such as a lot of vegetation, the attractiveness of that area also increases and vice versa. If for some reason there is a financial regression and people start to earn less, people could leave their homes because it becomes too expensive. The prices of houses will drop but nobody wants to move in because all functions in the area will have disappeared as well as the functions that were present in the area. This starts a vicious cycle that will have to be broken to start the revitalization of that area. This process also happened in Egebjerg, but the cycle was broken and Egebjerg is now a very wealthy town with an industrial neighbourhood.

**Question 5: Why does the employment rate increase drastically generally after 2010 and stagnate from that point on?**

It could be attributed to a different way of counting data from that point on. It could also be related to the period after the financial crisis of 2009. During the financial crisis house prices dropped drastically and a lot of new people came into the parishes. Migration data of the parishes could be analysed to determine if the difference in employment rates is related to the financial crisis or not.

**Question 6: Why are Rørvig's and Nykøbing Sj.'s employment percentages so different from the other parishes? (Low rise of employment in 2015)**

Rørvig and Nykøbing Sj. are highly correlated parishes because of their closeness to each other. The type of employment in Nykøbing Sj. is also very different to the type of employment of the other parishes because of the knowledge-based industry that is present there. Because the employment type is different, its employment rate will also be affected by varied factors and therefore possibly differ from other parishes.

**Question 7: What is the explanation for the low urbanisation grade in Grevinge?**

Grevinge has experienced a revival in recent years, but this doesn't always coincide with an expansion in urbanisation. If there is a revival it can mostly be attributed to the attractiveness of the buildings and functions that are already in place, as previously mentioned. Quality over quantity is in place, if you have too much of something it can become less attractive. This can be verified by inspecting the current state of houses in the parish and determining if Grevinge is an attractive parish to live in or not.

**Question 8: Why is the employment rate of Højby very low from 1990 until 2020?**

It could be attributed to the large number of children living in the parish, which is likely not the case. Also, a lot of older people could be living in the parish, which is more likely. There could be a lot of people living in the parish who are dealing with financial problems, which could also be the case. Højby was in a downwards spiral for a little while but has recently been undergoing a revival. The land was cheap in and around Højby, while the land itself was reasonably well connected, this has attracted different types of activities to settle in

and around the area. Nevertheless, Højby has known a large amount of outflux of younger people towards different places, this could also be seen as an attributing factor towards the low employment rate.

**Question 9: What is the explanation for the constant line in the percentage of agricultural area from 2010 until 2020?**

It can probably be attributed to the fact that the CORINE Land Cover Map doesn't make a clear distinction between agricultural areas, extensive grasslands, and permanent grasslands where flooding occurs regularly. These types of land uses pop up around Odsherred and the whole of Denmark frequently.

### 8.6.3 Interview with Jesper Paludan (written out)

**Biography:**

A 42-year-old Danish man, who lived in Hawaii for 12 years, now lives in the Odden (1.5 years) region. His parents had a summer house in the Nykøbing Sj. area, but he grew up in Copenhagen. First worked as an architect. Now, works as an employee in the Business, Planning and Construction department at the Odsherred Kommune in Højby. This is the town hall and the administrative centre of the municipality of Odsherred.

**Question 1: Why is Nykøbing Sj. so important in the area of Odsherred? (Highest population density and percentage of urbanisation)**

We have 120 Ukrainians in the Nykøbing Sj. area in Annebjerg, so there are going on some interesting things in that area. They moved into some older buildings in that area. The region of Nykøbing Sj. used to consist of smaller municipalities. The region is in the Northwest of Denmark and is very known for its geography (old ice age area). In the '50s and '60s, the whole summerhouse culture started. Wealthy people lived in the North part, over time it became more mainstream. At the moment there are living 30 000 inhabitants in this area but there are also 30 000 summer houses. During the summer it is a completely different place. Nykøbing Sj. has more of a town culture than the other parts, not like a big city but just more. At the moment there is a lot of development because of the summer houses. Summerhouses become more and more expensive in this area because Copenhagen people (wealthy) don't want to go to the most expensive parts. Only Copenhagen people live there. Population wise Nykøbing Sj. will still go down, I guess. But it is not a real city, it has only boring/low-quality shops for tourists. Businesses are inspired by the US and want to make big shopping malls, but this will destroy Nykøbing Sj.. It is not enough to make people stay, there are jobs to accommodate the tourists.

**Question 2: Why has Højby been chosen as the administrative capital of Odsherred although Nykøbing Sj. is bigger?**

It is a political case: it is to not prefer Asnæs over Nykøbing Sj., so one of these towns doesn't have more power because the administrative centre is located in one of them. It Is more of a compromise, to let them compete fairly. Højby has lots of new buildings, a sports arena, a commune building, …

**Question 3: Why have Vig, Asnæs and Hørve a similar development in terms of population density, employment rate and NDVI?**

It is hard for people to want to live here. In Denmark, people are used to not needing to drive longer than 30 minutes. In the future, a lot of people will move to Odsherred, but it will be hard to let them move to these towns because there is not much to do and the coastal areas (beautiful areas) are already built fully with summer houses.

I live in Odden: everyone thinks all people here are 'rednecks', but actually it is an international environment. It is growing, houses in this area are sold within a week, for double the price. Interesting people live here who are very protective of this area. Political decision: Before now, you would have to have your address here, flex permit: summer house, for recreational purposes. Empty houses would be bought more. The summer houses in other regions were much more expensive, but at the moment people want to buy houses in the Odden region. Copenhagen people (wealthy) only wanted the nice houses to be used as summer houses. The cheap houses were only for the local people or were not used. But a group of people want to change this, so the schools stay. When flex permit goes away, more and more people want to live there.

Alternative neighbourhood: no specific development, new ways of building, progressive people live here already. A lot of like minds, local shops get organic section: more alternative people. They try to implement architecture policy to inspire people to get better architecture in that region. They have already started to develop a new region. In Summerhouses, you can't live or stay permanent, they want to change this idea. People want to live there and build bigger houses that aren't restricted in certain ways. It is a political question.

**Question 4: Why are the employment rates so low in Højby?**

There is very little work here, people start to notice the region because the municipality administrative centre is located here, and they are building also new infrastructure. There are also new side jobs, but almost no one does these, people are low educated. It is going to be hard to attract new people here. We 've had a region with a couple of lakes. They wanted to build a development region, but they've found a little frog and don't want to build there anymore, but there were already made investments. It is all about getting people to the schools but people are afraid of small schools because this education is less good. They'd rather move to places with better education probabilities.

**Question 5: Why does the employment rate increase drastically generally after 2010 and stagnate from that point on?**

The financial crisis, why does it go up so constantly, 2010-2015. There are lots of uneducated people, but there are a lot of craftsmen, who can make a very good living. Lots of people work for the people of Copenhagen, they are like little kings. They are in charge and charging more money. The corona situation changed a lot in that area, a lot of houses are being sold… 100 percent of building application corona year and that has even doubled the year after. Because people lived more in their summer house during corona. It is completely impossible for the municipality, hard beating, and more hands are needed.

**Question 6: What is the explanation for the urbanisation grade in Grevinge?**

It is a very small town, schools are closing, and people abandon the town. Kids don't have the best chances if they stay there. But I think it will change.

On the other hand, in Nykøbing Sj., things are changing, there is more development, there are cooler buildings, etc. Small outskirt places won't grow very fast, often with an old population. Very posh area, more and more people want to live out there, for the ferry to the other side.

## 8.7 Python code of the ATA

*Python code of the Attribute Trajectory Analysis tool, developed by MSc. Lars De Sloover*

```
# -*- coding: utf-8 -*-
"""ATA.ipynb

Automatically generated by Colaboratory.

Original file is located at
    https://colab.research.google.com/drive/14Jj4AvT1rCFkTjVIIrNMxcAxje8DUhop

# Attribute Trajectory Analyser
```
Created, maintained and owned by Lars De Sloover (UGent, CartoGIS Research
Unit)
Citation: (De Sloover, Huang & Van de Weghe, 2022)
Questions/issues/suggestions: lars.desloover@ugent.be
Latest version (28/04/2022): 0.1.0
```
This Jupyter Notebook allows you to do **in-depth attribute trajectory
analysis**. The analysis is structured according to the Knowledge Discovery
from Databases (**KDD**) idea: it is therefore **interactive** and
**iterative**. Each phase of the KDD cycle is organised under a header with one
or more code cells. Because of its iterative nature, each previous cell can be
re-run with modified parameters if deemed necessary by the user.
"""

from google.colab import drive
drive.mount('/content/drive')

"""## Run Me First
First of all, run the following cell at the beginning of every session to
import all necessary libraries/packages. If you have not installed them yet,
please do so by ````!pip install````.


"""

!pip install geopandas

import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
import geopandas as gpd
from sklearn.metrics import pairwise_distances
from sklearn.preprocessing import MinMaxScaler
from sklearn.manifold import MDS
from sklearn.cluster import AgglomerativeClustering
from scipy.cluster.hierarchy import dendrogram

"""## Data Selection
The cell below comprises the selection of the data. Please pass your timeseries
data (.csv) and an accompanying geometry file (.geojson) to the respective
```

```
```timeseries``` and ```geometry``` variables.



"""

variable = 'landuse_urbanisation'
timeseries = '/content/drive/MyDrive/ATA/Timeseries/table_landuse_beb.csv'
geometry = '/content/drive/MyDrive/ATA/Geometry/Parishes_orig.geojson'
df = pd.read_csv(timeseries,delimiter=';',parse_dates=True)
entities_gdf = gpd.read_file(geometry)
entities = df['naam'] #hard coded
[str(e) for e in entities]
entities = entities.rename(None)
df = df.drop(['id','naam'],1) #hard coded
df = df.T
df.columns = entities

"""Now, let's start with the core of the attribute trajectory analysis:
visualizing the timeseries or curves that represent our data. This helps us in
gaining some preliminary insights into the data."""

#@title Visualize the attribute trajectory data
sns.set_theme('notebook')
sns.set_style('darkgrid')
markers = ["o"]*len(entities)
plt.figure(figsize=(20, 10));
curves =
sns.lineplot(data=df,palette="Paired",dashes=False,markers=markers,legend="brie
f");
curves.set_xlabel("Time (year)");
curves.set_ylabel(variable);

"""## Data Preprocessing
What we are trying to do in attribute trajectory analysis is to compare the
evolution of a certain attribute for *m* different objects. Then, based on the
similarities between those trajectories or curves, we will try to segment our
objects into similars clusters. Since we are mainly interested in similarity in
the shape of the curves and since the curves of certain objects can be similar
in shape but not in absolute numbers, we first perform a normalisation of our
data. This way, we obtain our data on a scale from zero to one.
"""

def Normalize(dataframe):
    norm_arr = MinMaxScaler().fit_transform(dataframe).T
    return norm_arr

"""## Data Transformation
Next, we calculate the (dis)similarity (i.e., the distance) of the curve of
each object to the curve of each other object. This gives us an *(m x m)*
pairwise similarity matrix. Visualise this matrix by running the cell below.
"""

#@title Visualize the distance matrix
dist_mx = pairwise_distances(X=Normalize(df),metric='euclidean')
```
```

```
#generate distance matrix from general clusters
#dist_mx = np.genfromtxt('/content/drive/MyDrive/csv-
clusters2.csv',delimiter=';')
#make first item 4 because it showed 'nan'
#dist_mx[np.isnan(dist_mx)] = 4

plt.figure(figsize=(5,5));
sns.heatmap(data=dist_mx,robust=False,linewidths=.5,cmap="OrRd",
            xticklabels=entities,yticklabels=entities,square=True)

"""Since our similarity matrix is of a higher dimension *(m x m)*, it may not
be straightforward to visually extract all interesting patterns from it, let
alone find meaningful clusters or segmentations. Therefore, we will start by
embedding this higher-dimensional matrix into a lower (understandable) 2-
dimensional representation. For this we u\\se a manifold machine learning
algorithm called multidimensional scaling (MDS). MDS calculates the Euclidean
distance between our objects in the higher-dimensional space and represents
them here in a 2-dimensional scatter plot, a little similar to Principal
Component Analysis. Use this 2D embedding to estimate the number of clusters
you would like to obtain later on."""

#@title Calculate the lower dimensional embedding { display-mode: "form" }
def Transform(dist_mx):
  manifold =
MDS(metric=True,n_components=2,dissimilarity='precomputed',random_state=1).fit_
transform(dist_mx)
  manifold = pd.DataFrame(manifold,columns=['Dimension 1','Dimension 2'])
  return manifold

embedding = Transform(dist_mx)
sns.set_theme('notebook');
sns.set_style('darkgrid');
plt.figure(figsize=(8,8));
sns.scatterplot(data=embedding,x='Dimension 1',y='Dimension
2',palette="Paired",
                hue=entities,markers=True,legend="brief",s=100);

"""## Data Mining
Based on the 2D embedding above, set the number of clusters you would like to
find in the data, using the slider below.
"""

#@title Choose the number of desired clusters
import ipywidgets as widgets
max_clusters = ((len(entities)-1)/2)+1
slider = widgets.IntSlider(value=2, min=2, max=max_clusters)
display(slider)

#@title Run the clustering
def plot_dendrogram(model, **kwargs):
    children = model.children_
    distance = np.arange(children.shape[0])
    no_of_observations = np.arange(2, children.shape[0]+2)
    linkage_matrix = np.column_stack([children, distance,
no_of_observations]).astype(float)
```

```
    dendrogram(linkage_matrix, **kwargs)
def Cluster(n_clusters,reduced_data):
    algorithm =
AgglomerativeClustering(n_clusters=n_clusters,linkage='ward',affinity='euclidea
n')
    model = algorithm.fit(reduced_data)
    labels = pd.Series(model.labels_)
    labelled_enteties = pd.concat([entities,labels],
axis=1,keys=['parish','cluster']) #hard coded
    labelled_enteties['id'] = labelled_enteties.index + 1 #hard coded, add 1 to
match index
    return (model, labelled_enteties)

n_c = slider.value
M, L = Cluster(n_clusters=n_c,reduced_data=embedding)
plt.figure(figsize=(8,8));
plt.xlabel('Distance');
plot_dendrogram(model=M,get_leaves=True,labels=entities.to_numpy(),

truncate_mode=None,orientation='right',color_threshold=len(entities)-n_c);
result_gdf = entities_gdf.merge(L,on='id',how='inner',suffixes=('', '_d'));
#hard coded
result_gdf.plot(column="cluster",categorical=True,legend=True,figsize=(8,8));
#hard coded
with open(f'{variable}.geojson' , 'w') as file:
    file.write(result_gdf.to_json())
```

# RELATIONS BETWEEN LAND USE/LAND COVER AND THE BIOPHYSICAL VARIABLES IN ODSHERRED, DENMARK

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Denmark

Prof. dr. Veerle Van Eetvelde
MSc. Lars De Sloover
Msc. Annelies Van Caenegem

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ODSHERRED KOMMUNE
Geopark Odsherred
- UNESCO Global Geopark

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# 1 INTRODUCTION

Traditionally, landscapes had clear relations between land qualities and the way how people organized the landscape. During the 19th century, however, there was a shift from the more traditional landscapes to modern landscapes. The organisation of such landscapes could be defined as Land Use and Land Cover (LULC) which is being influenced by various factors such as the biophysical variables. These relationships are often referred to as vertical and horizontal relationships (Antrop & Van Eetvelde, 2017). Such relationships however have yet to be studied in Odsherred, a peninsula in Denmark. In that respect, the aim of this research is to investigate the vertical and horizontal relationships between the current LULC and the biophysical variables. Additionally, this research also tries to find any recurrent patterns that exist in the landscape with the aim, the understanding and explaining of the current LULC in Odsherred.

First, a correlation analysis is made between the LULC and the biophysical variables. From those results, fieldwork has been performed to test the outcome against reality so that more foundation can be given to the statements made from the desktop analysis. Finally, a cluster analysis has been performed to look for any recurrent patterns that could exist in the study and are of interest.

# 2 THEORETICAL FRAMEWORK

## 2.1 Study area

The municipality of Odsherred in situated in north-western Zealand, Denmark which covers an area of 355 km². The area is mainly known by his geopark status which has been granted since 2014 by UNESCO and is till date the only geopark in Denmark. This means that the region contains a geological heritage of international significance (Werther, 2022). Constituted mainly by glacial structures formed during the latter part of the Weichselian approximately 17 000 years ago. From then onwards, the landscape of Odsherred has been formed by postglacial and coastal processes and is still causing a constant change today (https://en.unesco.org, 29 June 2022). From a bird's eye view the landscape can be seen like figure 1. At first sight it is already clear that there is a variety of landscapes.

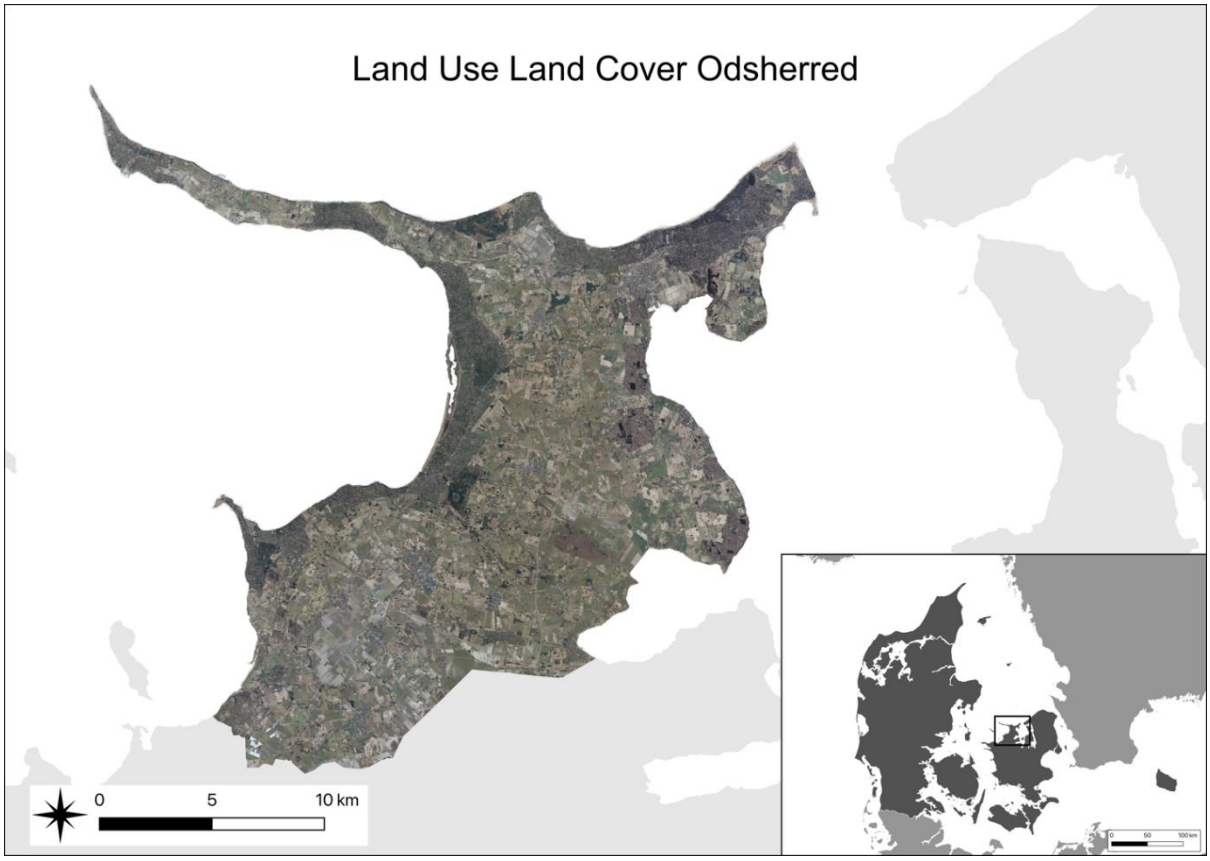



*Figure 1: Land Use and Land Cover map of Odsherred, Danmark (Google maps).*

### 2.2 Relations in the landscape

Before going deeper in the LULC and their relations in Odsherred, it is important to give an explanation about the relations in the landscape in general. First of all, LULC is the term that is widely being referred to as Land Use and Land Cover but what does it mean? “Land Use” is the term used to describe the human use of land. It represents the economic and cultural activities (e.g., agricultural, residential, industrial, mining, and recreational uses) that are practiced at a given place (https://www.epa.gov, 31 March 2022). While “Land Cover” is the term used to describe the surface components of land that are physically present and visible which provides a means to examine landscape patterns and characteristics (https://www.epa.gov, 31 March 2022). From this it is clear that coherence exists between two or more factors (e.g., LULC and biophysical factors). Which is being described to as the concept of ‘relations’. This relation can, according to Antrop and Van Eetvelde (2017), be formed by cause-effect (vertical relations) or by the spatial connection without a causal relation (horizontal relations). This almost immediately should ring a bell in every geographers mind, because this is closely related to Toblers Law of geography: “everything is related to everything else, but near things are more related than distant things” (Tobler, 1970).

When consulting literature, the main factors that make up these relations can be divided into five types (Verburg *et al*., 2004):

1. Biophysical constraints and potentials
2. Economic factors
3. Social factors
4. Spatial policies
5. Spatial interaction and neighbourhood characteristics

The first four types are the most common in land use studies (Dendoncker *et al*., 2007) and mainly related to land use changes (Verburg *et al*., 1999; Mitsuda & Ito, 2011; Marcos-Martinez *et al*., 2017) or predictions (Verburg & Chen, 2000). The fifth type however, makes an essential contribution to analysing spatial patterns of land use and should also be taken into account (Dendoncker *et al*., 2007). For the purpose of this work, only the first type (e.g., biophysical constraints and potentials) will be considered. Therefore, further elaboration of the vertical and horizontal relations is done in the case of this type of factors.

### *2.2.1 Vertical relations*

Vertical relations could exist for numerous amounts of reasons, see also the red arrows in figure 2. For example, certain crops need specific conditions to grow and could be constraint by some locations meaning that they are not an option for that location or will have lower potential yields or require additional inputs such as irrigation, land preparation, etc. at other locations (Verburg *et al*., 2004). Other than agriculture, biophysical factors could also be important for residential constructions. Whereby soil, geology, and drainage conditions determine its suitability (Verburg *et al*., 2004).

These relations are important to understand certain land allocation practices including the use of land as a resource which could be facilitated more efficiently and targeted land policy (Marcos-Martinez *et al*., 2017). Therefore, research investigating these vertical relations are commonly done related to land use changes. They could provide insights into the extent and location of land use changes and its effects (Verburg *et al*., 1999). Furthermore, the relation can be used to predict land use based on those factors. Such understanding can be important for development of comprehensive models of land-use dynamics (Verburg & Chen, 2000).

### *2.2.2 Horizontal relations*

Land use does not develop independently at each individual location; each development affects the conditions of neighbouring and distant locations (Verburg *et al*., 2004). Studies have shown the influence of horizontal relations and demonstrate that decisions of land use can result from contact between individuals within their personal neighbourhood (Dendoncker *et al*., 2007). See also the blue arrows in figure 2.

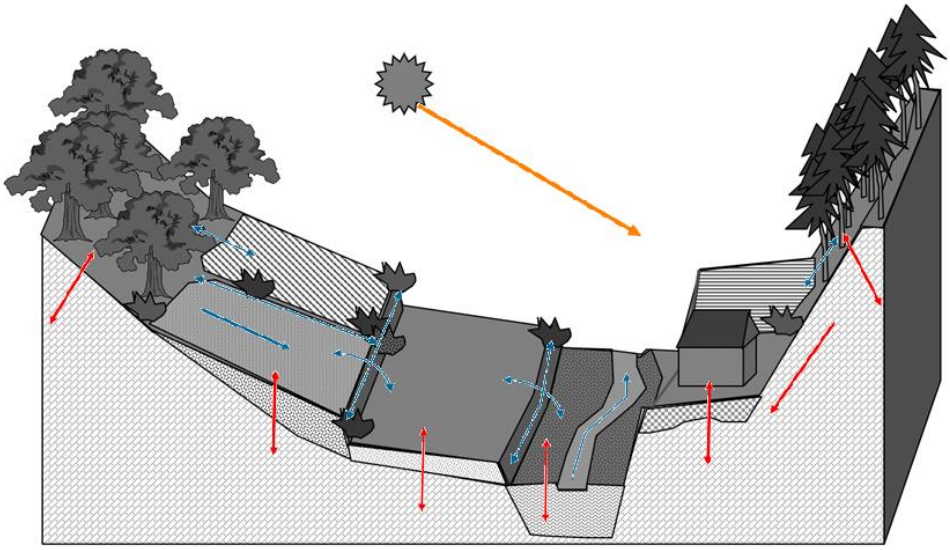


*Figure 2: Vertical and horizontal relations in the landscape. The hypothetical landscape gives an observation of the soil type and land use at regular intervals. Red arrows show a strong vertical (ecological) relation between both resulting in a spatial co-variation. The blue arrows show no relation between both components. However, the landscape is not showing a chaotic pattern but possesses a repeating spatial zonation formed by a horizontal relationship between land cover types (Antrop & Van Eetvelde, 2017).*

### 2.3 Issues of spatial scale

Many properties of the landscape such as, diversity, heterogeneity and the correlation between the components are scale-dependent which have important consequences (Antrop & Van Eetvelde, 2017). There are phenomena occurring at any level which are affected by mechanisms occurring at levels below and above. Therefore, attention must be paid to the scale-related limitations when considering research on land use (Verburg & Chen, 2000). This is because they become a variable that determines the observation of the landscape and consist of two parameters, grain size and extent (Antrop & Van Eetvelde, 2017). For example, using coarser grain size obscure variability whereas fine grain sizes obscure general trends. Furthermore, at coarser grain size, different factors can fall within the same unit of analysis while they could be observed separate at a finer grain size leading to a different correlation structure and thus interpretation (Figure 3; Verburg & Chen, 2000). The extent of the analysis will also have implications on the analysis. A smaller extent offers better insight into the specific situation of the region whereas a larger extent allows for identification of general patterns (Verburg & Chen, 2000). This study is considered to have a smaller extent. Because of this, it will be difficult to generate general patterns and therefore landscape typologies.

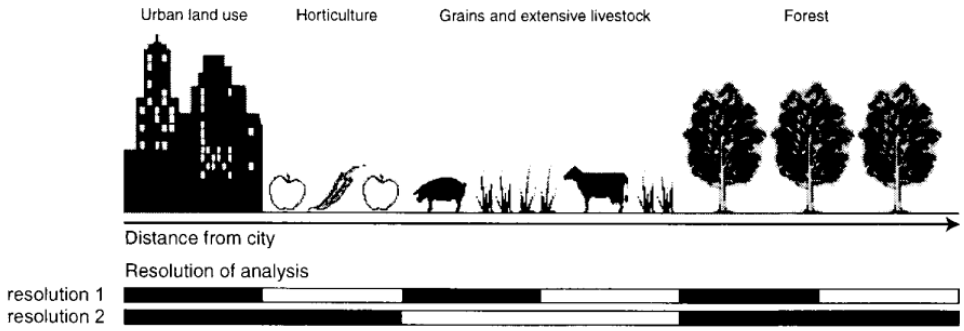



*Figure 3: schematic representation of grain size at two different resolutions (Verburg & Chen, 2000).*

## 3 METHODS AND SOURCES

First, the methods will be explained in order to achieve the desired results of the vertical/horizontal relations, clustering and field work. Subsequently, the data that is being used will be elaborated.

### 3.1 Methods

*Table 1: Steps that are taken to achieve results for the vertical relations*

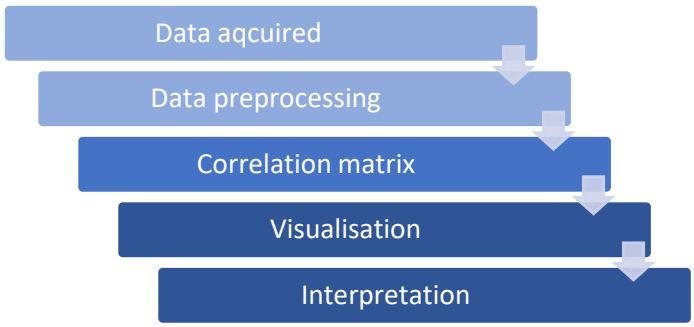



*Table 2: Steps that are taken to achieve results for the horizontal relations*

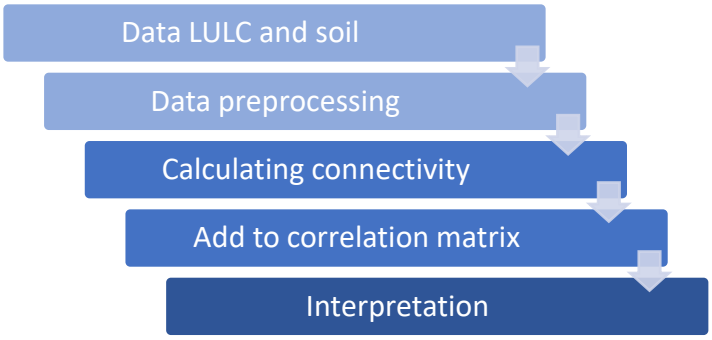



Table 1 and 2 give a short overview in how the vertical and horizontal relations were established. Next, the following paragraphs will explain the different steps in more detail.

### *3.1.1 Data preprocessing*

First, the data needs to be prepocessed (light blue in table 1 and 2) by getting first all the variables in the same resolution and predefined grid, to achieve one general database which has stored all the useful data in an efficient way. This predefined grid uses the coarsest resolution. Note that this database is the same for both the vertical and horizontal relations.

Some of the data needs to be adjusted in a way that an analysis can be performed in a meaningful way in QGIS. The resolution of all data files is resampled to the variable that has the biggest resolution. In this case it is land use with a resolution of 30.4 meters that is used as the basis for all used data. In addition, it is important that all variables are transposed in continuous attributes. Specifically for land use and soil which are originally nominal variables, these will be expressed in percentages of all the types of land use (soil) in the specific grid cell. The raster cells are used as spatial units, whereby each grid cell is firstly expressed as a polygon (with an area of 30.4m x 30.4m) and secondly as a centroid of that polygon, which makes the processing in the future more streamlined (Van Eetvelde & Antrop, 2009). By running through this, all the variables achieve the same resolution similar as the used grid cells.

### *3.1.2 Data processing: correlation matrix*

Next, in the processing phase (blue in table 1, 2 and 3) the realized database in QGIS allows to start searching for correlating relations between land use and the biophysical variables. The processing starts with exporting the JSON file with grid points containing all variables that are made continuous into a CSV file. Python code was then written to convert the CSV file into pandas, a built-in program in Python, for the relevant layers. From this, a correlation matrix is calculated through Python. This is done to examine which variables are more or less related to land use, both positively or negatively (for example, higher elevations that correlate positively with a higher percentage of a certain land use or negatively with lower elevations). This analysis is done with a Pearson Correlation Test, with the result being a correlation matrix, with all variables (both land use and the biophysical variables) on both the x- and y-axis. Each cell in this matrix describing the correlation value between two variables ranging from –1 to +1:

- -1 meaning a perfect negative correlation
- 0 meaning that there is no correlation found between both variables
- +1 meaning a perfect positive correlation

Eventually, each pair of variables will be appointed a correlation value. The question however is which values are considered to be significant? A cut-off point is determined to keep all correlation values that are significant. When setting the p-value at 0.05, correlations are considered significant when these exceed 0.2 or -0.2 which is the equivalent of the R squared value of 0.04. Which is rather low but because of the large dataset it could be already significant at a low correlation value.

For the horizontal relations, calculation of the horizontal connectivity has also been performed (table 2). Doing this by using the average connectivity plugin in QGIS for both the LULC and soil types. This plugin returns a visualisation of the spatial autocorrelation in the study area, defined by certain weights and characteristics of the average connectivity tool, which are:

- Neighbouring cells: this determines how many and which immediate surrounding cells are relevant enough to consider. In other words, which neighbouring grid cells are relevant? Because LULC and soil are the independent variables, it is important to take all of the neighbouring grid cells into account. Doing this by using the queen's pattern/adjacency (figure 4).
- Inverted weighted distance parameter: For each specific cell, the closest neighbouring cells are more important than more distant cells. This is done by allocating higher and lower weights to those cells respectively. The mathematical measure used in this research, is the inverted exponential weight, with each order of adjacency weighing exponentially less than the order before that.

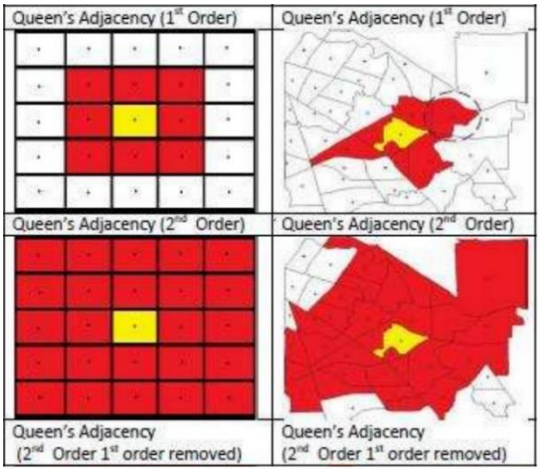
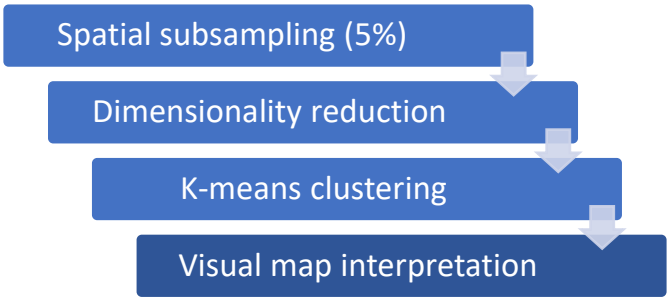



*Figure 4: Queen's case adjacency and order of adjacency for a particular region (Rura et al., 2010).*

### *3.1.3 Data processing: cluster analysis*

Other than the correlation matrix, cluster analysis can be used for investigating horizontal relations more in depth. Cluster analysis is a term used to describe a family of statistical procedures specifically designed to discover classifications within complex data sets. The objective of cluster analysis is to group objects into clusters such that objects within one cluster share more in common with one another than they do with the objects of other clusters. Thus, the purpose of the analysis is to arrange objects into relatively homogeneous groups based on multivariate observations. Furthermore, the chapter discusses the uses for cluster analysis. Clustering methods are useful whenever the researcher is interested in grouping together objects based on multivariate similarity. Cluster analysis can be employed as a data exploration tool as well as a hypothesis testing and confirmation tool (Tinsley & Brown, 2000). Table 3 gives an overview of the steps that are taken to perform the cluster analysis.

*Table 3: Steps taken to perform the cluster analysis*




First of all, a spatial subsampling is taken of 5%. Because of computational runtime and the lack of time to perform the entire dataset in the cluster analysis only a subset of 5% is taken. This means that from the 400 000 grid point approximately 20 000 grid point are considered in the analysis. There was opted to use a spatial subsampling instead of a random subsampling. This choice ensures that the sample points are equally distributed over the entire study area and that there is no loss of information in certain parts of the study area where there might be an inadequate amount of sample points to identify clusters in. Every twentieth point is therefore used in a uniform way. In the second step, a dimensionality reduction is performed. Thus, only the variables that were considered significant ($R^2 > 0,04$) are kept. Subsequently, the cluster analysis is being performed through using the K-means clustering method. In short, K-means makes the data points of inter clusters as similar as possible and also tries to keep the clusters as far as possible. For this analysis, this is based on the similarity of correlation between clusters. This whole process has been performed through Python.

### *3.1.4 Data postprocessing: visualisation*

The final phase is the postprocessing phase (darker blue in table 1, 2 and 3). The main goal here is to visualise the output in such a way, that an interpretation can be made together with the analytical output. From the output of the processing phase, maps could be made in QGIS.

## 3.2 Data

### *3.2.1 Land Use and Land Cover*

Data about Land use and land cover for the municipality of Odsherred was collected from the Department of Environmental Science Aarhus University based on input data for the year 2018 (Basemap03). This is the most up to date national map of land use and land cover, which has a total of thirty-one types for the study area provided as a raster layer with a spatial resolution of 30.4 x 30.4 meter (https://envs.au.dk, 31 March 2022). These were compressed into fifteen types according to similarities in the land use land cover. An overview of the different LULC types used in this research is given in table 4.

*Table 4: Different types of Land Use and Land Cover types used.*

| Land Use Land Cover type | Description |
|---|---|
| Summerhouses | Building area containing only the summerhouse areas |
| Building | Building, low built up; building, high built up; building, other build up; building |
| Industry | Industry/business, airport/runway; building |
| Recreation | Recreation area/sports ground; building |
| Transportation | Road, paved and not paved, railway; building |
| Gravel pits | Resource extraction |
| Agriculture, intensive, temporary crops | Agriculture, intensive, temporary crops |
| Agriculture, intensive, permanent crops | Agriculture, intensive, permanent crops |
| Agriculture, extensive | Agriculture, extensive |
| Agriculture, not classified | Agriculture, not classified |
| Forest | Forest (wet) |
| Nature dry | Nature dry (agriculture, extensive) |
| Nature wet | Nature wet (agriculture , extensive) |
| Water | Lake, stream |
| Unmapped | Areas too small to be classified |

### *3.2.2 Biophysical variables*

The biophysical variables that are being used to perform the analysis are given in table 5 adapted from the study of Dendoncker *et al*. (2007). This study based their selection on a literature review and expert judgement dividing the variables in three categories. Firstly, the 'biophysical variables' such as slope, aspect, elevation and soil. Elevation data is gathered from the European Digital Elevation Model (EU-DEM), version 1.1 from Copernicus which has a spatial resolution of 25 x 25 meter. Slope and aspect were then derived from this data by using QGIS, combining these two layers into one new slope-aspect layer (see description table 2). Slope categories were allocated according to an equal amount of values over the study area. The soil map is a digital geological map showing the surface geology from the Geological Survey of Denmark and Greenland (GEUS). It has a total of 82 different sediment types having only 22 types in the study area of interest.

A second group contains 'climate variables' like temperature and precipitation. However, it was decided that such variables were not useful because climate variables are negligible considering the size of the study area of interest. The last group contains 'accessibility variables' such as distance to the sea, based here on the minimum (Euclidean) distance to the sea. This factor however can not only be described as a physical variable but also as a spatial interaction variable (Verburg *et al*, 2004).

One more variable that will be considered is the topographic wetness index (TWI). It is a variable that was decided to add to the list because it can act as a proxy for soil moisture. The topographical wetness index describes the tendency of water to accumulate in certain areas and to flow to lower areas. Therefore, such a variable can be a good indicator for phenomena such as rivers or wet areas. The index is a function of both the slope and the upstream contributing area per unit width orthogonal to the flow direction and thus can be calculated by a built-in function in QGIS, needing only the digital elevation model.

*Table 5: Biophysical variables used for the analysis*

| Variable | Type | Description | Source |
|---|---|---|---|
| Elevation | Continuous | Raster, spatial resolution of 25 x 25 meter | https://land.copernicus.eu/imagery-in-situ/eu-dem/eu-dem-v1.1?tab=mapview |
| Slope-Aspect | Categorical | Raster, spatial resolution 25 x 25 meter. Slope devided into three categories, 0 – 2°, 2 – 8° and > 8° Aspect devided into four categories, north-facing (315° - 45°), east-facing (45° - 135°), south-facing (135° - 225°) and west-facing (225° - 315°) slopes | ESRI data |
| Topographic Wetness Index (TWI) | Continuous | Calculated from Saga in QGIS at a resolution of 25 x 25 meter | ESRI data |
| Soil (geological) | Nominal | Vector layer from sediment samples at one meter depth and a sample spacing of 100-200 meters | https://frisbee.geus.dk/geuswebshop/ |
| Distance to sea | Continuous | Minimum distance to the coast | ESRI data |

Despite the large differences in land use between the different studied countries, similar key factors were identified for the distribution of land use (Verburg & Chen, 2000). This shows that the variables that will be used could have a more universal explanation and therefore be robust. However, conclusions will be drawn after the actual analysis.

### 3.3 Field work

In the final stages of this research, field work has been performed. An observation sheet was taken and adapted from preliminary research that is preserved for landscape ecology studies, created by professor Van Eetvelde (Ghent University). This sheet can be accessed in the appendix of this paper. First of all, locations were needed to fill out the observation sheets. They were selected according to the output of the correlation matrix. Thus, locations where the LULC types has the most or highest correlations with the biophysical variables were selected together with picking points that were as uniformly as possible across the study area with a diversity of LULC types. Eventually nine places were visited across the study area.

The observation sheets were mainly used to write down the visible and observational aspects of the biophysical variables which were considered in the analysis. Therefore, determining the real, actual values, such as the LULC type, height, topography, slope-aspect, soil and vegetation and some additional information.

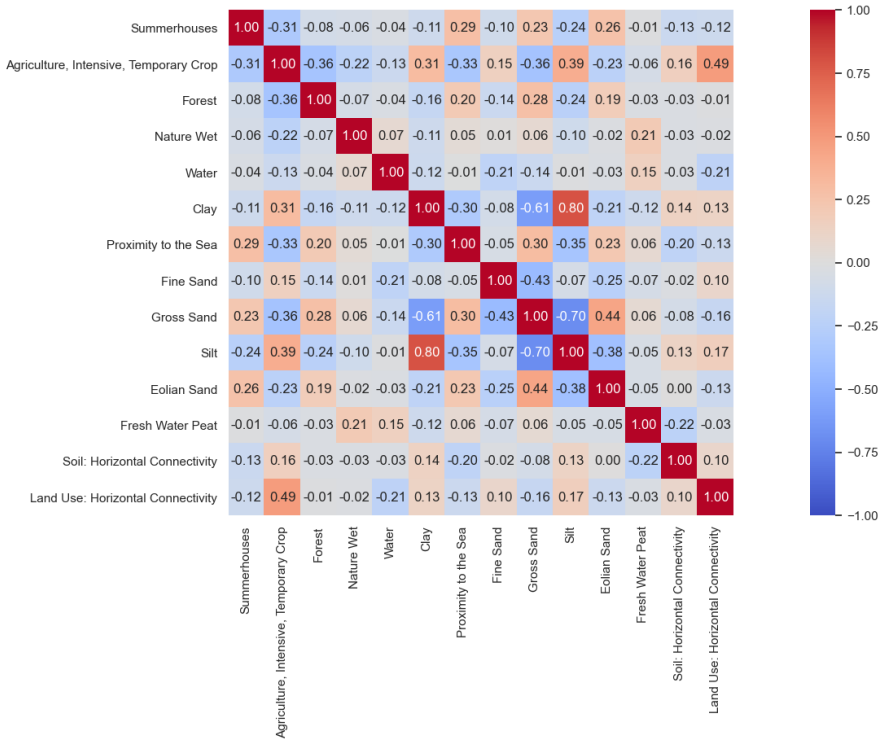
The aim of the field work is to verify to what extent the output of the obtained correlation matrix matches with the actual values found during the field work. This will indicate how reliable and useable the correlation matrix is. If the field work does not match adequately with the results of the correlation matrix, it is up to the researchers to explain this and preferably make certain adjustments where possible to improve the quality of the obtained correlation matrix (e.g., checking if the GIS database doesn't have any flaws).

# 4 RESULTS

## 4.1 Relations in the landscape

### *4.1.1 Vertical relations*

*Table 6: Correlation matrix. Red values show the most positive correlations between variables, blue values show the most negative correlations between variables.*




After visual control and mathematical statistics, there were several correlations higher than the cut-off value of 0.20 between LULC and other variables that were taken into account. These values can be seen in table 6. There are significant correlations between summerhouses and the variables eolian sand (+0.26), gross sand (+0.23), proximity to sea (+0.29) and silt (-0.24); between forest and the variables gross sand (+0.28), proximity to sea (+0.20) and silt (-0.24); between nature wet and the variable fresh water peat (+0.21); between water and the variable fine sand (-0.21); between agriculture intensive temporary crops and the variables clay (+0.31),silt (+0.39), gross sand (-0.36), eolian sand (-0.23) and proximity to sea (-0.33).

Important to note is that, as can be seen in the table, land use and land cover types can correlate with each other. In practice this is not possible because the dataset contains only one layer and thus different types cannot overlap. This is however due to the used method. Where different nominal values are assigned to a grid cell in percentage terms, as stated in the method. Therefore, those correlation values are meaningless and should be ignored which is also true for correlations between soil types.

### *4.1.2 Horizontal relations*

Next to the vertical relations stated above, there are also some horizontal relations that are significant in Odsherred. The significant horizontal correlations are between soil: the variables fresh water peat (0.22) and proximity to sea (-0.21) and between land use: agriculture intensive temporary crops (0.49) and the variable water (-0.21). These numbers are the result of the high amount of presence of these classes in the study area.

## 4.2 Field work

After finding out the significant correlations between the considered land use types and biophysical variables, the team went into the field to see how such landscape does look like and if the correlations are (clearly) visible in the landscape. Nine different places were selected because of their location, e.g., the border between two different LULC-types. The findings (as seen in table 7) were corresponding between agriculture intensive temporary crops (point 1, 6, 7 and 8) and silt, sandy loam, but not always with proximity to sea (point 1 vs. point 7); between forest (point 4) and sand humus and proximity to sea; between nature wet (point 3) and humus; between summerhouses (point 2) and gross sand and between water and clay. Point 9 is a vineyard, marked as agriculture intensive, permanent crops. According to the local winegrower, such crops need to be close to the sea (for temperature) to get successive crops. But a relationship between this type and variable is not significant. In this case it should not be a surprise because the share of such crops is small in the study area and it will have little impact on the significance.

*Table 7: Field work: verification of the correlation matrix with the reality. The red and blue values for the decimal values are corresponding with those of the correlation matrix. In the two most right columns, a green value indicates a match between the results and the reality.*

| | Correlations GIS 30,4x30,4 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | clay | Distance to sea | Eolian sand | Fine sand | Fresh water peat | Gross sand | Silt | soil | Seasight / close to sea |
| Agr_int_temp_crop | 0,31065 | -0,33053 | -0,22809 | | | -0,36188 | 0,39316 | sandy loam, with help | 1 |
| | | | | | | | | silt | 0 |
| | | | | | | | | sandy loam | 0 |
| | | | | | | | | sandy loam | 0 |
| Forest | | 0,20381 | | | | 0,27557 | -0,24045 | sand humus | 1 |
| Nature_wet | | | | | 0,20692 | | | humus | 1 |
| Summerhouse | | 0,28529 | 0,25843 | | | 0,23429 | -0,24356 | gross sand | 1 |
| Water | | | | -0,20626 | | | | clay | 0 |
| Agr_int_perm_crop | | | | | | | | clay | 1 |

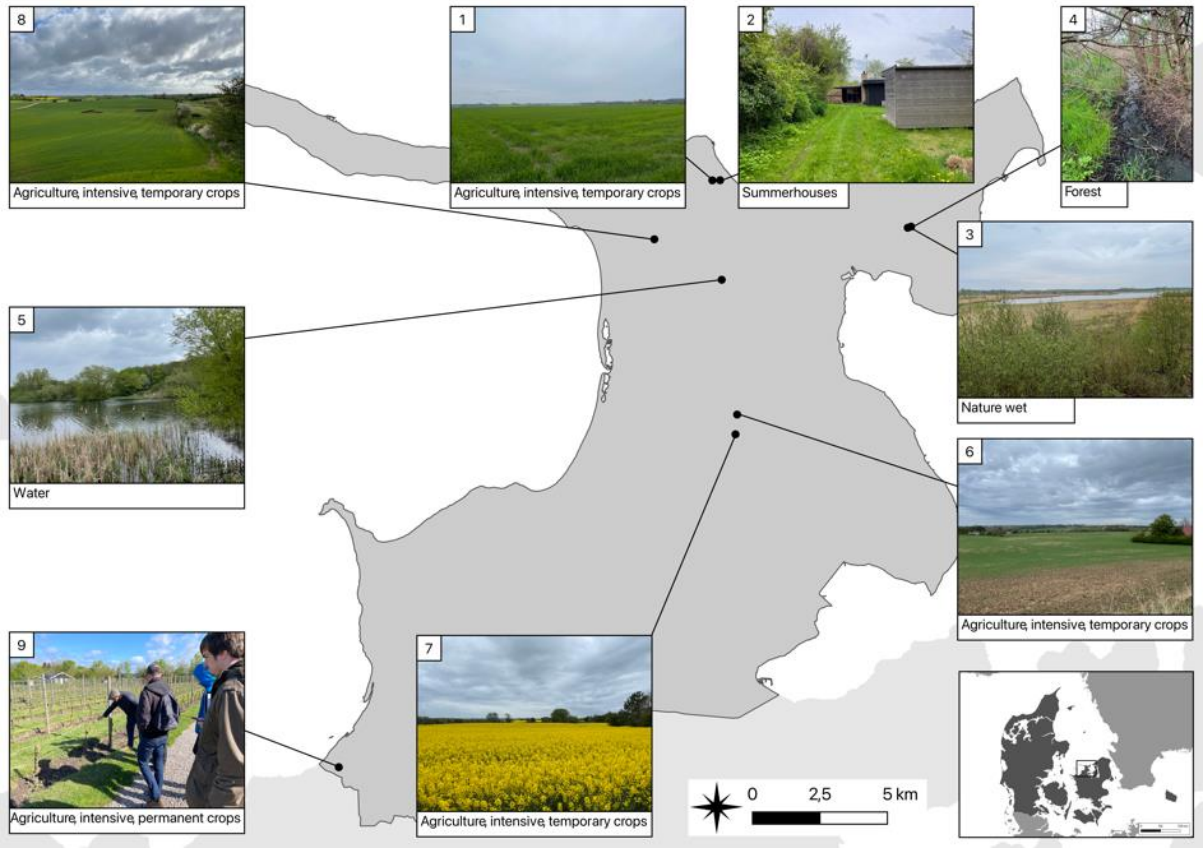



*Figure 5: Pictures from the points of the field work in Odsherred, Denmark.*

### 4.3 Clustering the land of Odsherred

As the result of the correlations between the different variables and the land uses - land covers; a map was created of five categories which can be seen in figure 5. This specific figure also contain maps of the cluster output when considering four, six or seven clusters. The choice for five classes was made by the possibility to visually find the most logical clusters. There are several patches of forest on sandy soils and wetlands on wet soils, whereas agricultural land on clay soils dominates the municipality. The summerhouses on sandy soils and urban zones on infertile zones mark their spots near the water or as chunks in the agricultural lands.

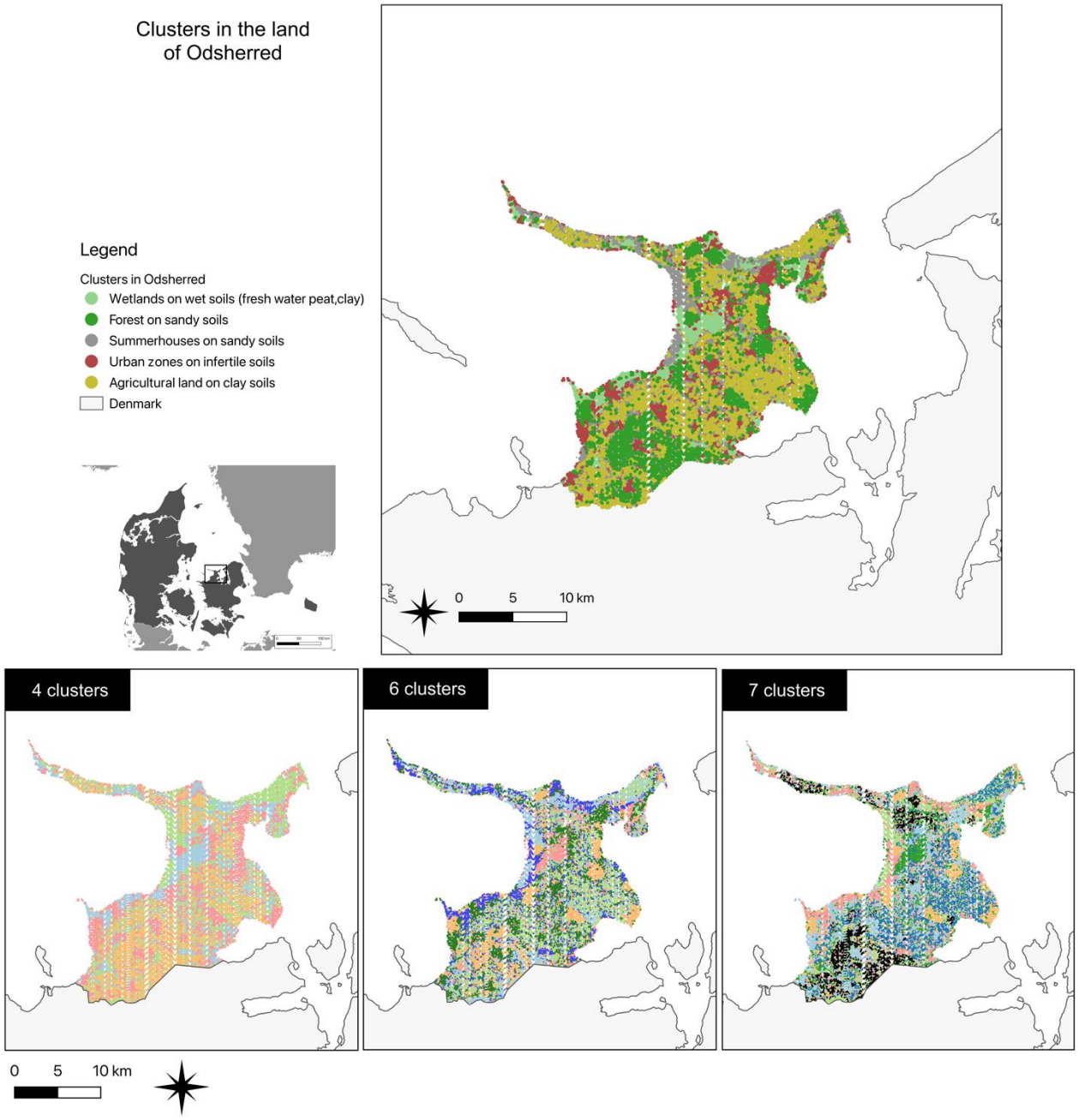



*Figure 6: Four maps showing the cluster output of five (main map), four, six and seven (smaller maps) clusters.*

# 5 DISCUSSION

This project focused on finding the relations between biophysical variables and Land Use and Land Cover (LULC). As it is clear from the results, where only five of the fifteen LULC types have significant correlations with the factors considered, a lot of explanatory power is yet to be found. This is however somewhat to be expected. In the past, traditional landscapes were more common meaning that the people were more dependent on the quality of land to allocate their land use practices. Nowadays, modern landscapes dislocate this dependency of land quality on land use (Antrop & Van Eetvelde, 2017).

Apart from the historical explanation, ignoring other types of possible explanatory variables is another probable cause of the lack of relationship. In literature, economic, social and spatial policies are often taken into account as well as was mentioned in the theoretical framework. Economically, land is devoted to the use that generates the highest potential profitability while social factors are concerned about the locational choices of households based on individuals' cultural values, norms, and preferences (lifestyles), and their financial, temporal, and transport means but also policies at national or subnational level that has a bearing on land use (Verburg *et al*., 2004).

## 5.1 Limitations

A first limitation of this work is the fact that multicollinearity was not taken into account, a statistical problem that can affect the results. To avoid it, we should have examined the correlation of each pair of candidate variables and then carefully select ones for use as explanatory variables in the regression model. Something that can be avoided relatively easily and has been done by most studies (Mitsuda & Ito, 2011). The reason however this has not been done is the small amount of factors considered. By considering multicollinearity, the already few relationships found would have been even less and the subsequent interpretation could have been more difficult. An example of multicollinearity on first sight is the correlation between the factors eolian and gross sand ($R^2 = 0,19$). Because of this, both factors are correlated with summerhouses and agriculture intensive temporary crops.

But there are even more limitations about the cluster analysis performed. Only 5% of the point in the grid are used in the analysis of clusters. This is due to computational limitations and the way cluster analysis is performed. In such an analysis, the similarity of correlations between every point must be considered. Therefore, when adding an extra point to our analysis, computational runtime increases exponentially. Thus, about 20 000 grid points out of about 400 000 grid point were taken into account. The output was only visualised without performing statistical analysis. Making statements about the clusters are therefore only limited to what can be seen on the map.

In addition to the theoretical and methodological limitations, there is also the limitation of field work. Field work was established to make the link from desktop output to reality. In this work, locations where the highest correlations were found were visited which gives a good insight in the found output. Visiting

the locations with a lack of relationship or less expected outcomes could have given a better understanding for these outcomes. But also visiting the (limited) clusters could have given a better understanding in why certain clusters exist. It would even give the opportunity to verify the found cluster types to the reality, which would add more value to the results, as they would be determined as either reliable/unreliable and/or usable/unusable cluster analysis results.

### 5.2 Future research

A first explanation given in the lack of explanatory power is the shift from traditional to modern landscapes (Antrop & Van Eetvelde, 2017). Therefore, results from this project can be used in a landscape genetic approach to compare traditional landscapes with current landscapes. This could give a more in-depth reasoning behind the results that has been found in this work.

The second explanation was that biophysical variables are often not the sole variables considered but also economic, social and spatial policies variables. Having only five out of fifteen LULC types that correlate and using only a few variables did us decide not to take multicollinearity into account. Therefore, taking into account not only more biophysical variables but also in combination with the other variables mentioned (e.g., Economic, social, spatial policies) can give a better comprehension between variables considered and LULC types.

The type of research here performed is often done to determine land use/land use-change (LULUC) patterns to achieve better land management for example (Mitsuda & Ito, 2011). Finding relationships between the biophysical variables and LULUC patterns are therefore often a first step in finding these patterns. This in combinations with using more variables as mentioned before could help to make such LULUC pattern analysis of Odsherred in Denmark.

Finally, the cluster analysis could be optimised. On the one hand, more grid points should be considered when performing this analysis instead of 5% of the total as happened in this work. This is of course if future research has the capacity to handle a larger amount of grid points in the analysis, because this would require advanced software and a deeper understanding of programming tools than that was available to the researchers during this research. On the other hand, statistical analysis should be performed. This way, not only visual interpretations, but also statistical explanations are given so that more well-founded statements can be made about the clusters. In addition, what has not been done in this work, fieldwork can also give the clusters a better interpretation in reality and verify the validity of the results.

# 6 CONCLUSION

The main question of this research was about the vertical relations between Land Use and Land Cover (LULC) and the biophysical variables. After performing the correlation analysis, some correlations came out of the analysis. But there are less correlations which are also smaller than expected. From the fifteen LULC types only five LULC types have significant correlations and from the five variables only two variables have significant correlations with LULC. The five significant LULC types have all significant correlations with soil types and some with the distance to the sea. From this, some logical relations are being found. For example, summerhouses are closer to the sea with dominantly sand and less silt which is the same for forests but without the distance to sea significancy. The opposite can be said about the intensive agriculture with temporary crops. It is more distant from the sea having more silt and clay then sand. Another logical correlation is between wet nature landscapes and the presence of freshwater peat. From field work, these statements were confirmed by visiting those places that had high correlations. Eventually it is to some extent still visible in the landscape. It is further quite remarkable that none of the LULC types have a significant correlation with either elevation, slope-aspect or the topographical wetness index which was used as a proxy for soil moisture. Thus, vertical relations are therefore not only determined by biophysical factors.

Concerning the horizontal relations, there are some visible areas with similar biophysical factors and LULC types. This is the most noticeable in the intensive agriculture with temporary crops as can be seen in the correlation matrix with a horizontal connectivity value of 0.49 ($R^2 = 0.24$). Meaning that this type of land use is found in areas close to each other. The only other significant horizontal connectivity is that of water with a value of -0.21 ($R^2 = 0.04$). Meaning there is more a lack of horizontal relation between water bodies.

Other than horizontal connectivity from the correlation matrix, some statements can be made about horizontal relations from the cluster analysis. From the results the best map was made from an analysis of five clusters showing a recurrent pattern with a high resolution. These clusters can be assigned according to their vertical relations. There are clusters with summerhouses and forests containing mostly sand which were significantly correlated. Just like the clusters wetlands with fresh water peat and the clusters with agriculture which contains mainly clay. The last kind of clusters that can be visually interpreted is this of urban zones on infertile zones. While there was no correlation between urban or building areas and any of the variables considered it comes out as a cluster. This is good example of a landscape which has to some extent horizontal relations but no vertical relations.

In conclusion, biophysical variables show, to some extent, clear relations with LULC with some logical relations. However, in the grand scheme of this research more variables should be considered to become more significant and providing even more informative results. This should also be done for cancelling out the noise that is clearly visible in the cluster maps that were made in this research.

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# 8 APPENDIX

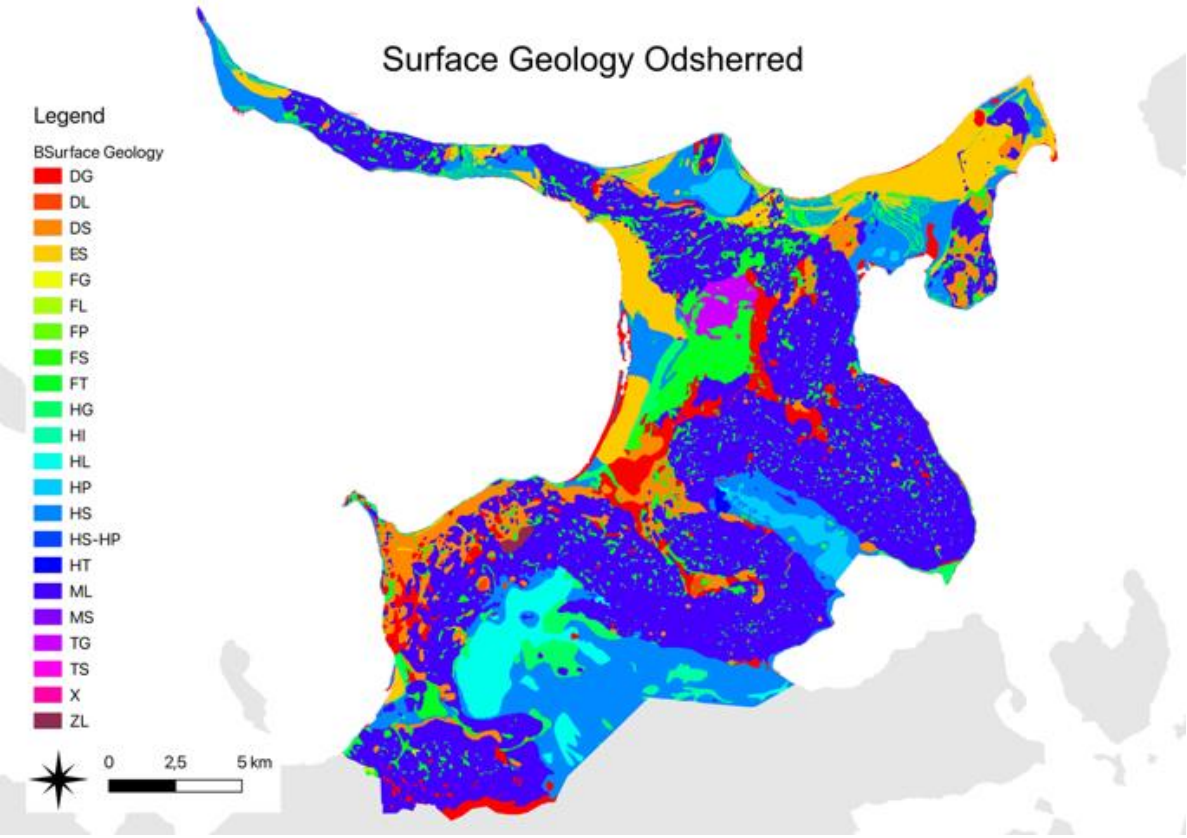



*Figure 7: Map of the surface geology of Odsherred, Denmark*

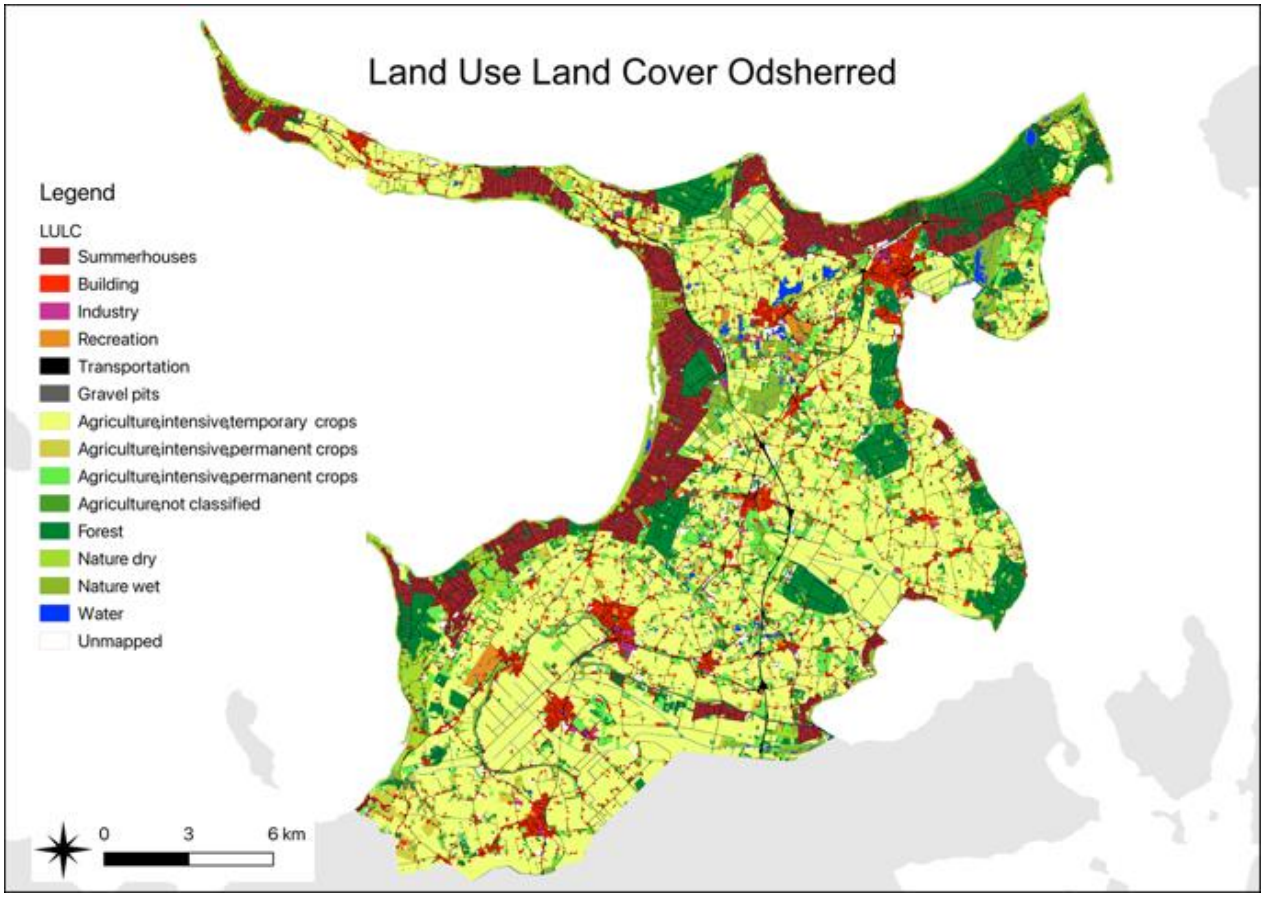



*Figure 8: Map of the LULC in Odsherred, Denmark*

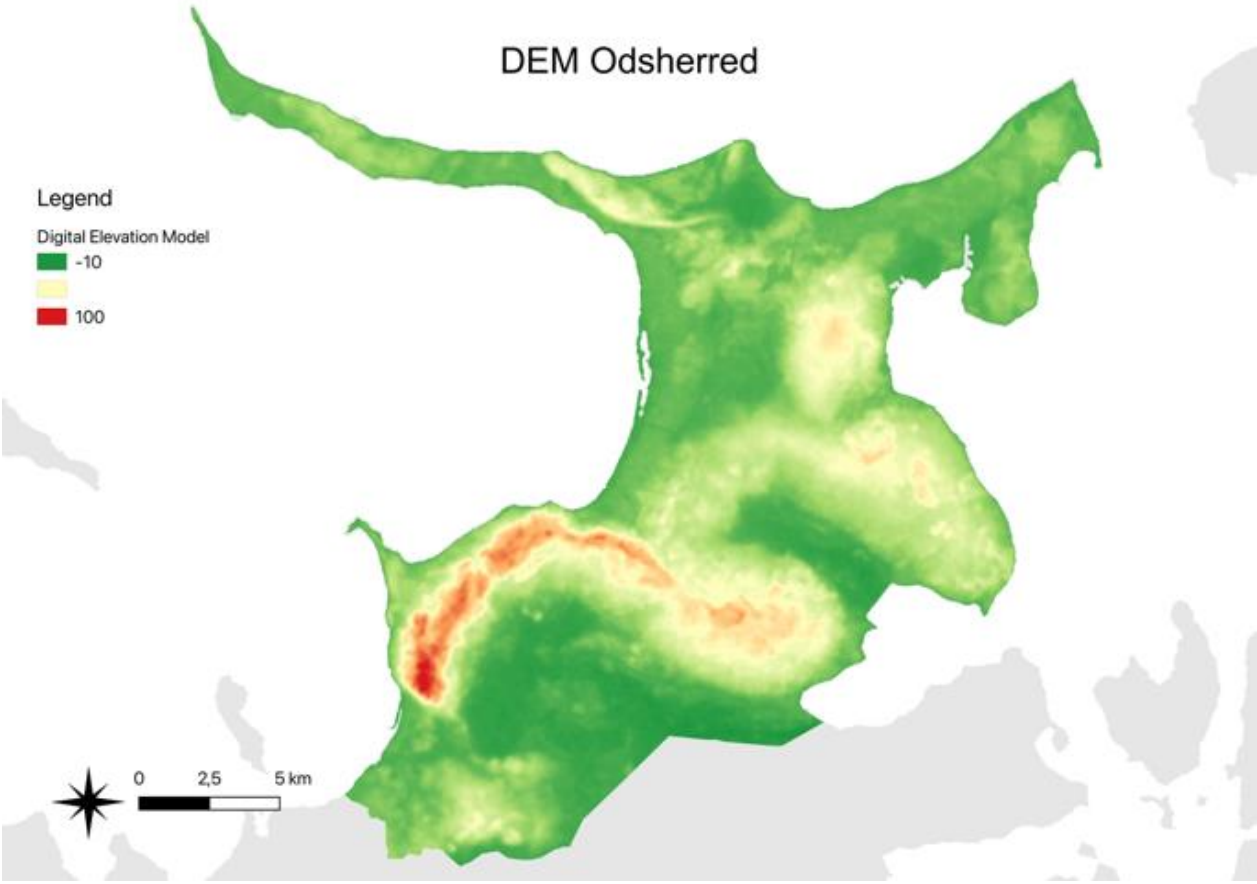



*Figure 9: Map of the digital elevation model in Odsherred, Denmark*

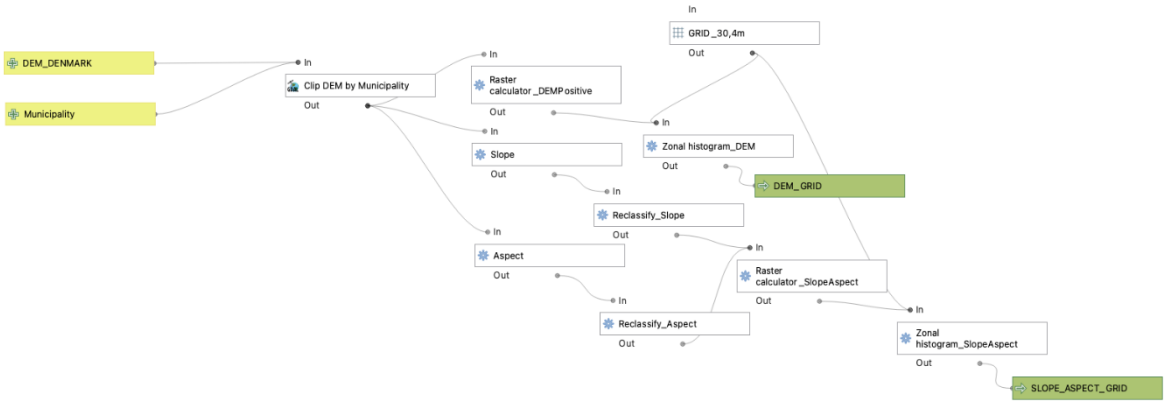



*Figure 10: Cartographic model Slope-Aspect-DEM*

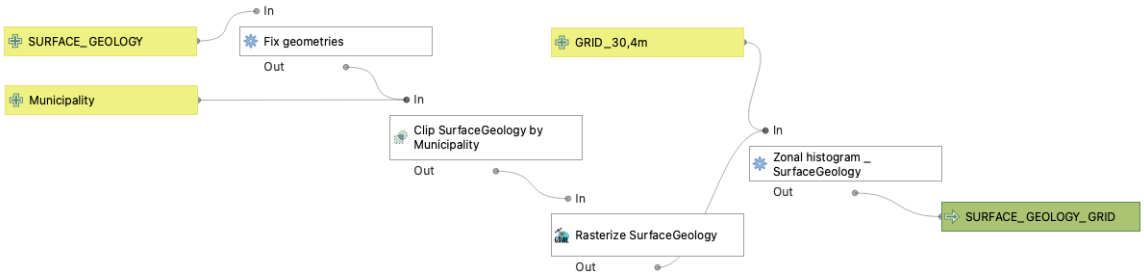



*Figure 11: Cartographic model Surface Geology*

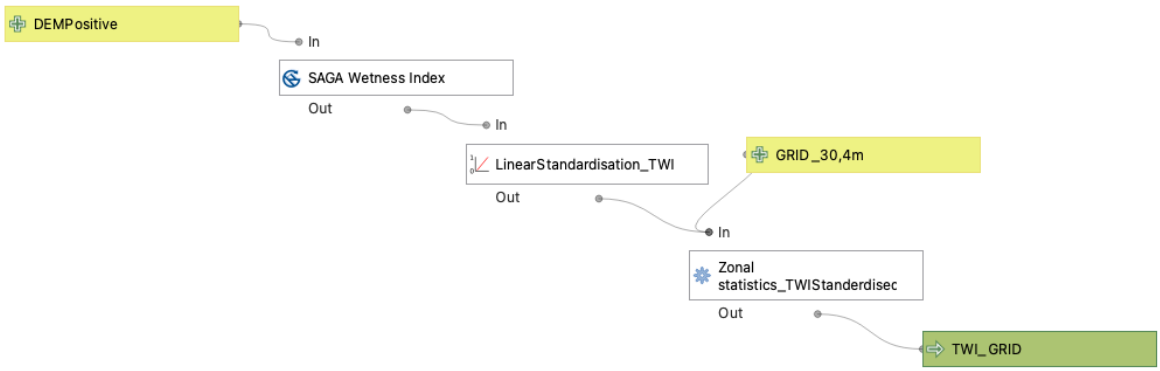



*Figure 12: Cartographic model Topographic Wetness Index (TWI)*

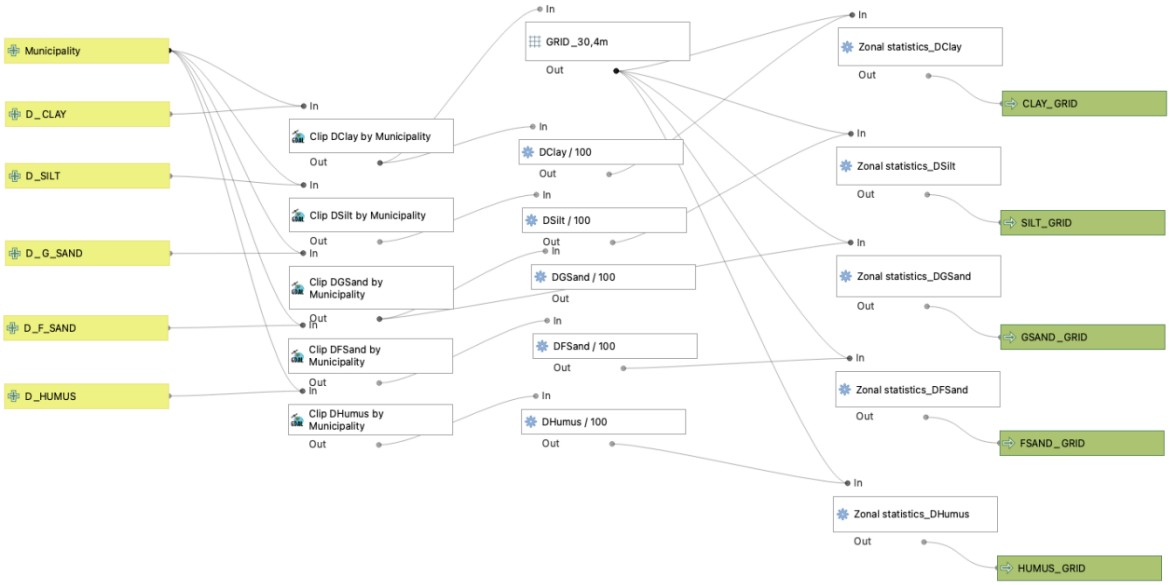



*Figure 13: Cartographic model Soil*

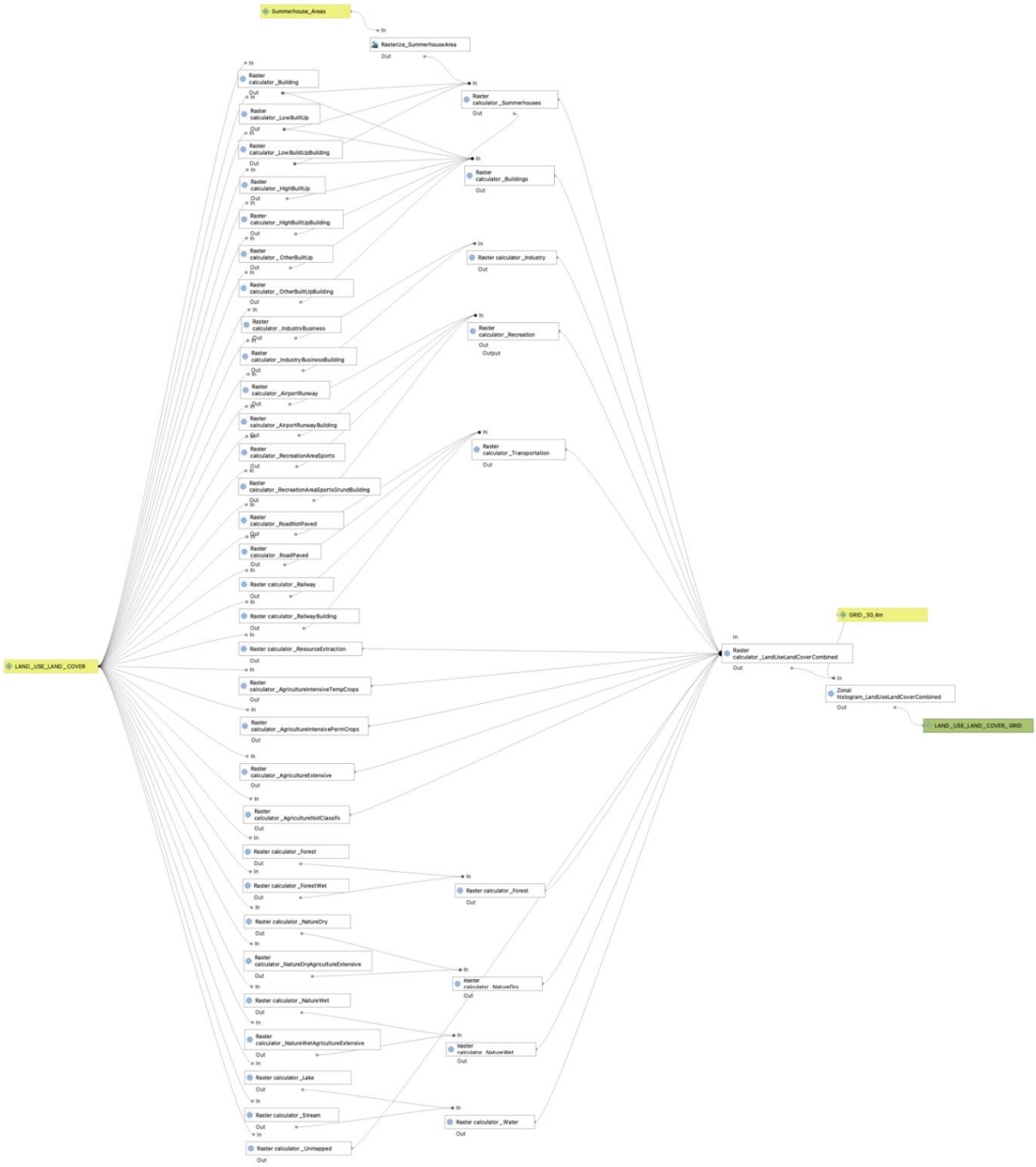



*Figure 14: Cartographic model LULC*

# OBSERVATION SHEET – GEOLAND

| | | |
|---|---|---|
| Date: | | ID observation (letter transect + number sample): |
| Hour: | | Place (village): |
| Observers: | | |
| GPS | X – coordinate: | |
| | Y- coordinate: | |
| | Z-coordinate: | |
| Distance to previous sample point (m) | | |
| Weather conditions: | | |
| Photograph numbers: | | |

**I) Biophysical factors**

1. Land Use:

- ☐ Summerhouses
- ☐ Building
- ☐ Industry
- ☐ Recreation
- ☐ Transportation
- ☐ Agriculture, intensive, temporary crops
- ☐ Agriculture, intensive, permanent crops
- ☐ Agriculture, extensive
- ☐ Agriculture, not classified
- ☐ Gravel pits
- ☐ Forest
- ☐ Nature, dry
- ☐ Nature, wet
- ☐ Water
- ☐ Unmapped

2. Soil:

*Glacial:*
- ☐ Meltwater gravel (DG)
- ☐ Meltwater clay (DL)
- ☐ Meltwater sand (DS)
- ☐ Clayey till (ML)
- ☐ Sandy till (MS)

*Proglacial:*
- ☐ Meltwater gravel (TG)
- ☐ Meltwater sand (TS)

*Postglacial:*
- ☐ Aeolian sand (ES)
- ☐ Freshwater gravel (FG)
- ☐ Freshwater clay (FL)
- ☐ Freshwater gyttja (FP)
- ☐ Freshwater sand (FS)
- ☐ Freshwater peat (FT)
- ☐ Saltwater gravel (HG)
- ☐ Saltwater silt (HI)
- ☐ Saltwater clay (HL)
- ☐ Saltwater gyttja (HP)
- ☐ Saltwater sand (HS)
- ☐ Saltwater sand/gyttja (HS-HP)
- ☐ Saltwater peat (HT)

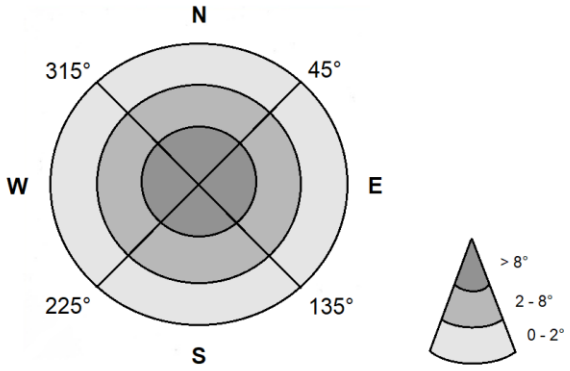
*Marginal glacial:*
- ☐ Glaciolacustrine clay (ZL)

*Other:*
- ☐ Bed unknown, no information (X)

3. Height: ….. meters

4. Topography: ☐ Flat ☐ Slope (N S E W) ☐ Undulating
   ↳ ☐ Convex ☐ Concave

5. Slope-Aspect: Exact percentage or degrees (to be calculated based on XYZ coordinates)




6. Soil

Moisture conditions (Wetness): 0% |----------|----------|----------|----------| 100%
(circle along the gradient) dry wet

| | | | | |
|---|---|---|---|---|
| Top-soil conditions: (circle one or more options) | ☐ bare bedrock (> 75%) | ☐ bedrock, partially bare (50/50%) | ☐ loose soils dominating (>75%): gravel, clay, sand, loam, marl (circle one or more options) | ☐ man-made, anthropogenic |

Other bedrock, soil or topography observations of the site (erosion, weathering, deposition):

7. Vegetation

| | | If yes, specify |
|---|---|---|
| Ground layer coverage: | (1) bare % | |
| | (2) grass % | |
| | (3) herbs % | |
| | (4) cultivated % | |

Number of tree & scrub layers: 0 1 2 3 4 5 more
Layer heights: ☐ < 0,3m ☐ 0,3-0,6m ☐ 0,6-2m ☐ 2-5m ☐ > 5m
Coverage: ☐ open <25% ☐ semi-open 25-50% ☐ semi-closed 50-75% ☐ closed >75%
Spatial distribution: ☐ continuous ☐ uneven ☐ patchy

8. Management

| | |
|---|---|
| What are the current land use activities in this area? | |
| Are there any evidences of past land uses in the site today? | |
| Are there any animals? Which and how much? | |

FACULTEIT WETENSCHAPPEN

# EXISTING AND PREFERRED RECREATION PATTERNS IN SUMMER HOUSE AREAS IN ODSHERRED

Number of words: 9.767

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Course: Integrated international project work

Academic year: 2021 - 2022

UNIVERSITEIT GENT

**TABLE OF CONTENTS**

**KEYWORDS**

- Participatory mapping
- Recreation patterns
- Recreation types
- Summer house owners
- Summer house tenants
- Spatial
- Temporal

## 1. INTRODUCTION

There is a remarkable seasonality in visits to summer houses in Odsherred, a municipality in Sjælland, Denmark. During less busy periods, shops, restaurants and other facilities are forced to close because of too little tourism. This has a big impact on the local community in Odsherred, who still want to do their groceries in Winter for example. A rising idea is if recreation could be a possible pull factor to the region. Therefore, it is relevant to investigate when and where the hotspots of recreation are located in the region and when, where and what types of recreation are still missing for summer house visitors. Also, differences in recreation patterns between sociodemographic subgroups of summer house visitors will be investigated.

The structure of the study is as follows: Section 2 contains the theoretical framework with some important concepts related to recreation, the Geopark and summer houses in Odsherred. In Sections 3, 4 and 5, the problem definition, goals and research questions are written down. The method is described in Section 6 where a desktop study, fieldwork and data analysis are carried out. The fieldwork is divided into two parts: a survey filled in by summer house visitors and interviews taken with two experts of the tourist office in Nykøbing and the Geopark. Sections 7 and 8 contain the results and discussion with all the information and findings from the executed research. The report ends with a conclusion in Section 9.

# 2. THEORETICAL FRAMEWORK

## 2.1 RECREATION

Recreation and leisure have multiple meanings based on individual perception according to Kraus (1971). In his book "Kraus' Recreation and Leisure in Modern Society" rewritten by Hurd, Anderson and Mainieri (2021), he discusses the history of recreation and leisure, important concepts of recreation and leisure in the social and behavioural sciences, and the aim and the problems of organising recreation. He describes the values and functions of recreation for the individual end of the community. Recreation is a vague concept and can, from an individual perspective, involve e.g. watching television, visiting a museum, going on a walk, listening to music, moaning the lawn, etc. Theorists struggle to agree on what to call these types of experiences. "Is it recreation, leisure, free time, available time, creativity, selfishness, or hedonism?" (Hurd *et al.*, 2021, p.2). One's perceptions are so important in the definition of recreation, that researchers plea for in-depth surveys and interviews to gain some insight into the matter. The book of Kraus shows the importance of recreation, parks, and leisure services as part of governmental operations and a vital program element of non-profit, commercial, private membership therapeutic, and other types of agencies. Recreation constitutes a major force in national and local economies and is responsible for millions of jobs in varied fields such as government, travel and tourism, popular entertainment and the arts, health and fitness programs, hobbies and participatory and spectator events. Beyond its value as a form of sociability, recreation also provides major personal benefits in terms of meeting the physical, emotional, philosophical, and other important health-related needs of participants (Hurd *et al*., 2021). According to Kraus, the leisure life of a country reflects its fundamental values and character. Later we will go into depth on this for Denmark and the municipality of Odsherred. The recreation that people enjoy in their leisure help to shape their character and well-being. And even more, also shapes the character and well-being of families, communities, and society at large (Hurd *et al.*, 2021). A very important criterium in the definition of recreation is the voluntary participation of the participant(s). People tend to be influenced by others. For example, a child can be pushed by the parents to go take gymnastics or tennis lessons. Once you're engaged in an activity, you must accept a set of obligations towards the other members of the team or group. Thus, recreation can maybe not be entirely free and spontaneous, since it assumes some of the characteristics of work in the sense of having schedules, commitments, and responsibilities (Hurd *et al.*, 2021).

Kraus (1971) discusses the various meanings of the word recreation. The most common views on recreation are:

- The network of public agencies that provide such facilities as parks, playgrounds, aquatic centres, sports fields and community centres in cities, towns, and countries

- Activities with adventure, risk, excitement and fulfilment, through combining technology and recreation. The activities are mostly carried out by youngsters. They enjoy recreation as an active activity or as an activity including any physical movement
- Outdoor forms of traditional and emerging play in our natural surroundings. These environmentalists have a growing awareness and global perspective (Hurd *et al.*, 2021).

Kraus also focuses on the diversity in the participation in recreation. Recreation may be enjoyed together with thousands of other participants or spectators or may be an intensely solitary experience (Hurd *et al.*, 2021). The diversity and depth of participation can be visualised as a three-dimensional box as depicted in figure 1. The diversity represented by the different kinds of activities and experiences people might engage in as part of recreation is depicted on the vertical plane. Along the horizontal plane, the depth or intensity of participation can be seen. On the third plane, which represents the box dimension, the aspect becomes more complex because it must be considered why people participate as well as with whom they participate, the time spent in the activity, and the costs associated with the involvement or away from other activities (Hurd *et al.*, 2021). The psychological, social and economic aspects all come together in the third plane.

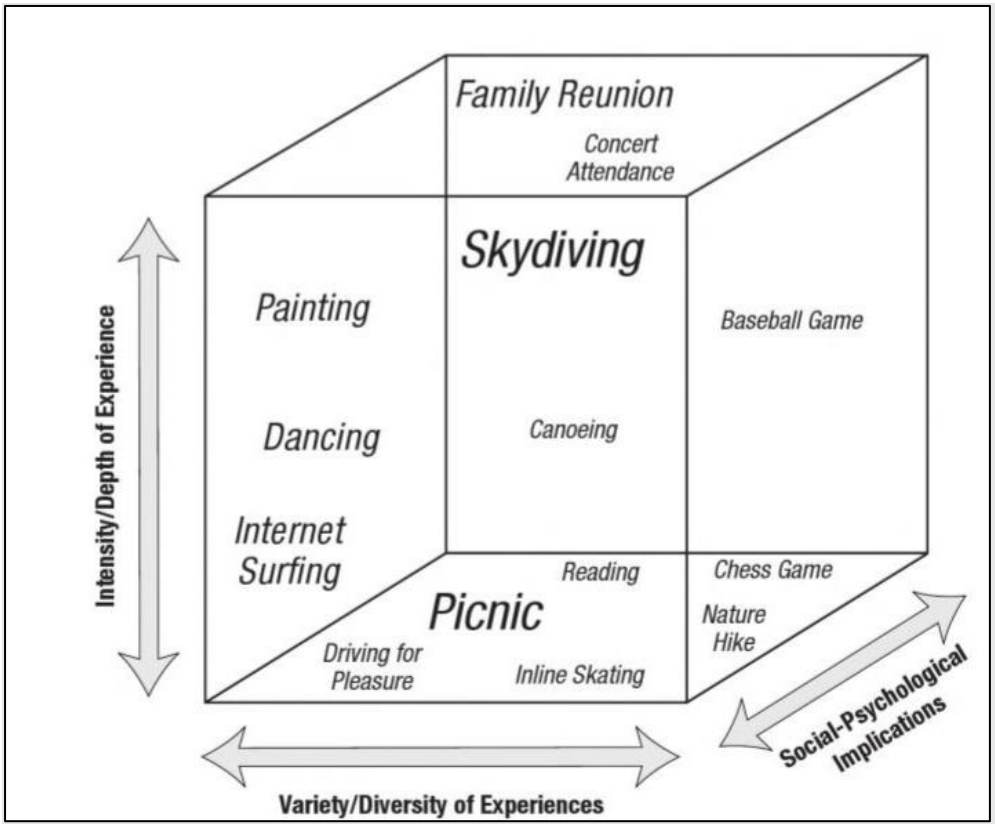
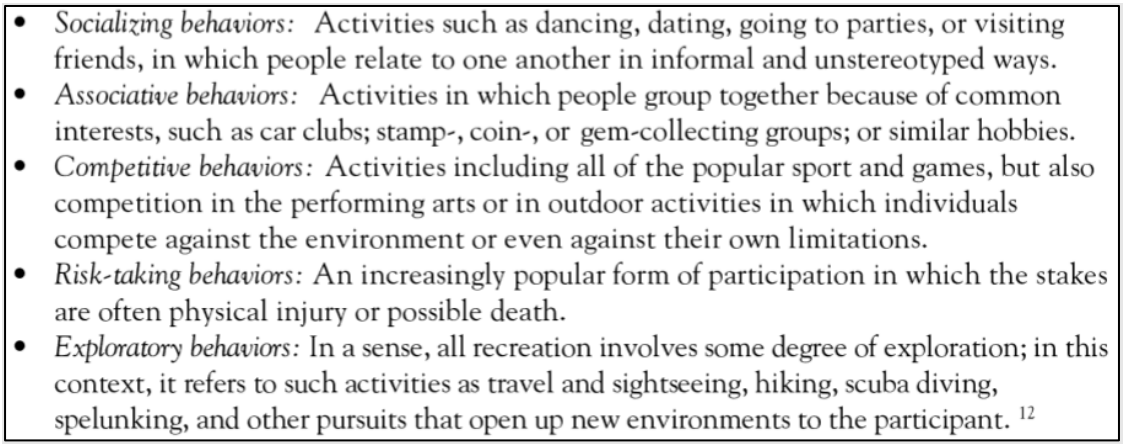



**Figure 1: Simplistic representation of the complexity of recreation experiences (Hurd *et al.*, 2021)**

In addition to the wide range of activities that make up recreation, it also meets a wide range of individual needs and interests. Kraus describes some of the motivations for recreational participation. Many participants take part in recreation as a form of relaxation and release from work pressure or other tension. Others feel the need to express creativity, develop talents, enhance physical skills, or pursue excellence in varied forms of personal expression. For some people, active, competitive recreation may offer a channel for releasing frustration and aggression or for competing against others or the environment in adventurous, high-risk pursuits. Other enjoy recreation that is highly social and provides opportunities for making new friends or cooperating with others in group settings. Furthermore, some are deeply involved in forms of culture or community service. Lastly, and hypothetically most important for our own research in Odsherred, is the motivation of people to explore new environments through travel and tourism or seeking self-discovery or personal enrichment through continuing education or various educational activities (Hurd *et al.*, 2021). In his book, Kraus also enlightens the view of James Murphey and his co-authors on the motives for participation in recreation. These motives are listed in figure 2.



- *Socializing behaviors:* Activities such as dancing, dating, going to parties, or visiting friends, in which people relate to one another in informal and unstereotyped ways.
- *Associative behaviors:* Activities in which people group together because of common interests, such as car clubs; stamp-, coin-, or gem-collecting groups; or similar hobbies.
- *Competitive behaviors:* Activities including all of the popular sport and games, but also competition in the performing arts or in outdoor activities in which individuals compete against the environment or even against their own limitations.
- *Risk-taking behaviors:* An increasingly popular form of participation in which the stakes are often physical injury or possible death.
- *Exploratory behaviors:* In a sense, all recreation involves some degree of exploration; in this context, it refers to such activities as travel and sightseeing, hiking, scuba diving, spelunking, and other pursuits that open up new environments to the participant. [12]

**Figure 2: Motives for participation in recreation by James Murphy and co. (Hurd *et al.*, 2021).**

In the past few decades, increasing attention has been paid to rural tourism as a specific form of tourism development (Hjalager, 2004). When combining leisure usage of rural resources and other types of economic activity, positive side effects such as economic benefits result from this. Most policies in the field of rural tourism have relied on the existence of these positive side effects (Hjalager, 2004). Studies from Getz and Carlsen (2000) suggest that tourism has the potential to enhance the viability of rural communities, and other studies suggest that depopulation and other negative socio-economic effects may be prevented or postponed through tourism development. In the research of Hjalager (2004), it is suggested to adopt a more holistic perspective on the analysis of tourists and local people's interests within a rural context. She worked on the hypothesis that the life modes of the tourists may influence those of the local communities and vice versa, and that, subsequently, the gradual convergence of life

modes is considered crucial to future development opportunities. Through interviews with tourists, including guests in summer houses, users of the marinas, people on the camping site and visitors to the local attractions, she tries to answer the research questions.

### 2.2 GEOPARK ODSHERRED

Odsherred UNESCO Global Geopark is located 100 km from Copenhagen, the capital of Denmark, and covers an area of 355 km². The supreme geological heritage of Denmark's first UNESCO Global Geopark is constituted mainly by glacial structures formed during the latter part of the Weichselian approximately 17 000 years ago. The most dominant landscape feature is the presence of three very distinct end moraines called the Odsherred Arches, which form the core of the UNESCO Global Geopark's landscape (UNESCO, 2021). Postglacial and coastal processes have also shown their importance in forming the landscape, which is still changing today. The Geopark Odsherred attracts a lot of people from everywhere since the 18th century. Today the area is an attractive holiday destination with more than 26 000 summer residences, thus having a summer population arising to more than 100 000 inhabitants (UNESCO, 2021). As a part of the strong and wide community involvement in Odsherred Geopark, local stakeholders, businesses, the tourism agency, the national nature agency and associations help to support the socio-economic development. Odsherred UNESCO Global Geopark wishes to catalyse this, through partnership agreements and the promotion of local products (UNESCO, 2021). Agreements between Geopark Odsherred and partners contribute to a broad local base and a common starting point for where the quality level lies in connection with the development of new products and branding (Geopark Odsherred, 2013). This form of place branding may have social objectives as well as economic ones and contribute to building the community, supporting local awareness and shaping local identities (Olivera, 2015).

Establishing the Geopark was intended to foster rural district development in connection with commerce and tourism and securing tourism as a possible economic livelihood (Geopark Odsherred 2013). Odsherred's municipal council, the tourist agency and the business council all believe that the best way to achieve sustainable development in Odsherred is to become a member of the European Geoparks Network, with all the advantages that go with it (Werther, 2022). In addition, place brands may help maximise positive place experiences among residents, visitors and possible investors (Sebastian *et al.*, 2017). Further recognition by the European Geoparks Network will engender pride and identity among the inhabitants of Odsherred and help to increase knowledge and understanding of the local cultural heritage (Werther, 2022). Ashworth *et al.* (2015) suggest that place brand management is often seen as merely promotional activities to attract place users or, in a slightly wider perspective, as image or reputation management to re-image a place to "correct" a negative impression or to increase awareness of the place. This suggests a top-down approach and is related to a critical view of place management

as a power exercise serving elite interests (Werther, 2022). A contrasting view is that place brand management has at least the potential to be a bottom-up exercise in community-building, focused on internal audiences and aimed at identifying directions for the future and at increasing place attachment (Werther, 2022). It rests on the argument that, in contrast to consumer brands, place brands cannot be owned and that 'asking who owns the place brand is the wrong question'. The right question possibly is 'who has a stake in the place brand', which means that those responsible for place brand development and management should be open to the widest possible stakeholder participation in terms of brand development (Werther, 2022).

Today, the Geopark is managed by the Foundation and Secretariat in close cooperation with the municipality, and it is used for image management, such as promoting Odsherred as an attractive place to live, visit, set up business and work. The present municipal settlement strategy focuses on attracting active empty nesters, young families with children and entrepreneurs (Werther, 2022). Given that tourism makes such a major contribution to Odsherred's economy, providing one-third of private jobs and adding approximately 100.000 residents and visitors to a population of 33.000 during the summer season, the Geopark also features prominently in promoting activities for potential visitors and tourists (Geopark Odsherred, 2013). While the Geopark Foundation's strategy for 2019 to 2024 lists many achievements and projects that have been realized during the first four years, it also acknowledges that there is still some way to go to realize 'the potential the UNESCO designation entails' (Geopark Odsherred, 2013). There are still some challenges like the communication of the concept of Geoparks and the knowledge about the Geopark and its ownership, especially among local residents (Geopark Odsherred, 2013). The Geopark contributes to the re-invention of Odsherred, providing us with a clear profile of Odsherred as a municipality and place. This may increase the number of new residents and visitors to provide the basis for boosting incomes and job creation, and in close cooperation with the municipality and other local partners, 'to facilitate sustainable business development and jobs that are not threatened by relocation and social dumping' (Geopark Odsherred, 2013).

### 2.3 SUMMER HOUSES

Summer houses or second homes are predominant all over Denmark. Second-home tourism is the predominant branch of the tourism industry in Denmark, according to Tress (2002). Second homes are privately owned cottages and houses that are used for recreational purposes. They are often called summer houses since they are mostly used during the summer. In the paper of Tress (2002), an overview of the tradition of second-home use is given. More specific, its origins in Denmark in the nineteenth century and its subsequent development up to the present day (Tress, 2002). Second-home tourism developed in the late nineteenth century when artists and citizens of Copenhagen discovered the recreational value of the countryside, mainly in the small villages on the coast. Odsherred is a great

example of a coastal, rural area of land, not too far away from Copenhagen where the small villages are quiet and perfect to find peace. Small cabins for weekend use supplemented the early homes of the richer people in the early 1920s and 1930s. From 1950 to 1970 second-home development increased enormously. The character of non-commercial tourism changed in the 1960s and 1970s when Danish second homes became vacation homes for domestic and foreign tourists. Since the 1970s, second-home development has been restricted to certain recreational areas on the coast. In the 1980s, primarily German vacationers began to make commercial use of second homes. In the mid-1990s, the peak of commercial second-home overnight stays was reached with about 17 million overnight stays per year. Since then, commercial second-home tourism has slowly decreased. In 2002, more than 218 000 second homes existed (Tress, 2002). There are a lot of rules to who can buy second homes and how many days a year u can live in the house. For the tenants of the houses, there is a limited set of rules. The motivation of Danish people to stay at a summer house is broader than simply being away from the big cities and enjoying some quiet time in the countryside. The phenomenon of spending time in a second home—a *sommerhus, sumarhús, mökki, hytta* or *fritidshus*—is an expression of the high quality of life in the Nordic countries (Slätmo *et al.*, 2020). It's a symbol of well-being and it strengthens the social status of the people that stay over at the summer houses.

## 3. PROBLEM DEFINITION

The region of Odsherred is home to ca. 26 000 summer houses, of which 1 000 are available for tenants. The region is a Geopark and is visited by Danes as well as foreign tourists, mostly Germans, who can stay at those summer houses. The Geopark offers the history of its geological origin in an accessible way for all ages and all backgrounds and is a place that many people use for recreation during vacations, on a day trip or as local residents. There is an observable difference in the frequency of people visiting the region of Odsherred. This difference can be seen between seasons, weekdays and weekends, and holidays and workweeks (holidays in Denmark itself and other countries). Not only the frequency of the visits but also the kind of recreation is different throughout the year. Some activities such as water sports are more carried out during the summer months, and other activities such as walking and cycling will hypothetically be popular throughout the entire year. For the owners of the summer houses, this fluctuation in visits to the region is sensible since, during school weeks and weekdays, their summer houses are less rented than during holidays and weekends. The local community feels the absence of visitors throughout the year. In quieter months, they are often forced to close shops or restaurants, since there aren't enough visitors to profit from their sales. The conclusion can be made that the fluctuation in visits to the area is strongly determinant for the local community of Odsherred. A more continuous visit rate throughout the year could positively influence tourism and consequently also the economy in the region. Therefore, the question rises if recreation could be a possible pull factor for the region.

## 4. GOALS

Investigating these recreational activities could provide valuable insights to help the area's sustainable development, both in terms of socio-economic developments and in enhancing ecological development (e.g. through synergies). Recreational activities have a spatial and a temporal component. The goal is to map when, where and what type of recreation is carried out through desk study and fieldwork using surveys. Hotspots of recreation can then be visualised from the gathered data networks. As result, it should be possible to identify the spatial and temporal differences between various types of recreation throughout the year and thus find recreation patterns in Odsherred. Further on, a distinction can be made between recreation carried out by tourists staying in summer houses (tenants) and summer house owners. There could be a correlation between these types of people (tenants and owners) and their recreation patterns, which will again be identified using the spatial and temporal factors, and types of recreation. According to the detected recreation patterns, it should be possible to address the shortage of recreation and the preferred recreation patterns of summer house tourists. If there is evidence of a shortage in recreation, ideas and opportunities should be drawn up to meet the preferred recreation patterns. Which recreation could attract tourists to stay longer and visit the area more often? Where should these recreation opportunities best be provided? And during which periods? Finding and addressing these missing recreation types, places, and times of activity is one of this research's main goals. Later on, these ideas can certainly be shared with the tourist office of Odsherred.

## 5. RESEARCH QUESTIONS

Based on the problem definition and objectives, the research questions below can be formulated. The temporal, spatial and categorical factors in these research questions are most important to our research.

- When, where and what types of recreation are carried out by summer house owners and tenants in the region of Odsherred?
    - Which differences in recreation are there between different sociodemographic subgroups of summer house visitors?
- When, where and what types of recreation are missing according to the summer house owners and tenants in the region of Odsherred?
    - What opportunities can be set up to meet the missing or preferred recreation patterns?

# 6. METHOD

## 6.1 OVERVIEW

At the start of the study, a literature review is conducted to clarify some concepts that are important to the research. This step in the desk study is described in more detail above (in Section 2. *Theoretical framework*). Second, a primitive inventory is made for ourselves to know which kind of recreation could be expected in the region of Odsherred. After the desk study, we were able to start the fieldwork. To answer the above-mentioned research questions (in Section 5. *Research questions*), surveys with summer house visitors and interviews with experts are carried out in the summer house areas in Odsherred. Lastly, the data analysis takes place in different ways, mostly qualitative oriented.

In figure 3, the workflow of our research can be found with a graphic overview of all the different steps. The steps described below are slightly different than in the workflow but eventually, all components correspond with each other.

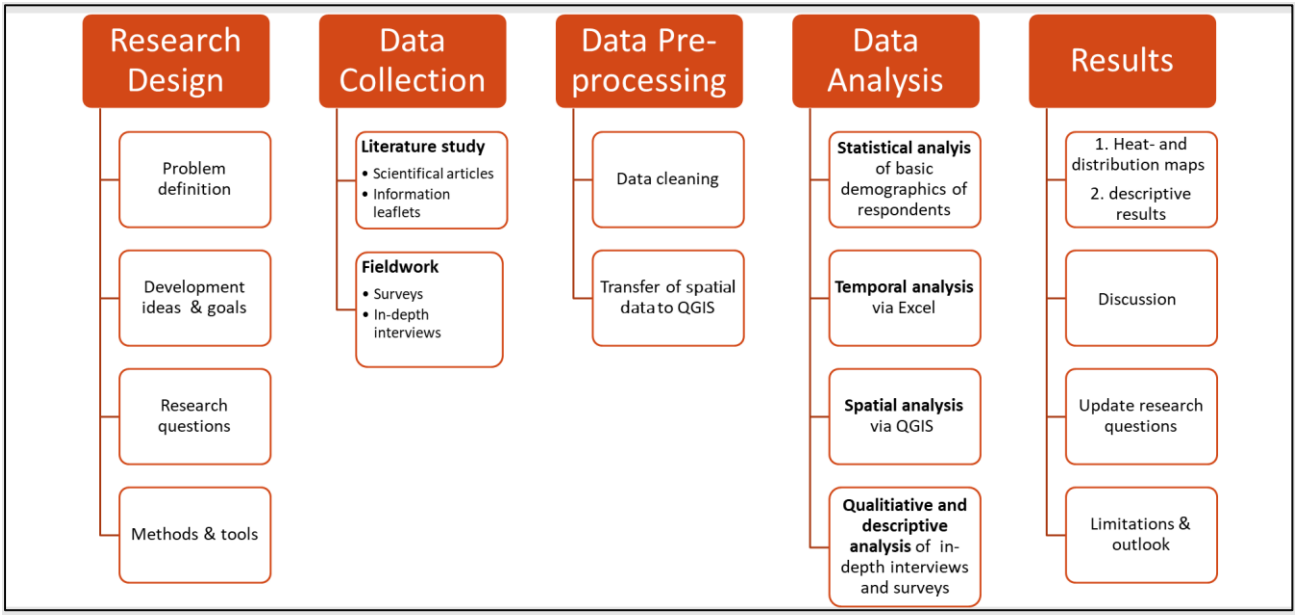



**Figure 3: Workflow**

### 6.2 DESKTOP STUDY

For the desktop study, there is a literature review on the following three subjects; recreation, Geopark Odsherred, and summer houses (described in Section 2. *Theoretical framework).* The literature consists of scientific papers and books, selected from Google Scholar. The goal of the literature study is to get a clear understanding of the terminology used in this study field: recreation. Recreation is a vague term and is broader than first imagined. Brochures about the Geopark and the activities that tourists and locals can enjoy in the region are found at the VisitOdsherreds tourist office in Nykøbing Sjælland. These give a broader insight into the recreation in the area. Since these were collected during the trip to Odsherred, this step can rather be seen as fieldwork instead of part of the desktop study. It is also important to be aware of all recreation (types) already present in the area before starting our fieldwork there. Therefore a small recreation inventory was already made beforehand. Besides that, the survey questions were set up, before the field trip, to ask summer house visitors in Odsherred. In doing so, it is important to get the link between what type of recreation, where and when it is carried out, likewise for the missing recreation. The survey is then also centred around these main questions about current and future research. Also worth mentioning is that the survey is executed in cooperation with group *3A Social and cultural dimension of summer house areas*, so the questions linked to their research were also included. These questions are mainly about demography and summer house (area) information.

Odsherred contains a lot of summer house areas: these are the pink areas in figure 4. From this map, the study area was selected, consisting of four summer house areas which are shown in figure 4 with a red border. The selection is made based on a potential difference in the types of tenants and owners of the summer houses there. They could probably have different temporal and spatial patterns in recreation. By studying multiple summer house areas in the Odsherred Geopark, the best insight into these recreation patterns will be gathered.

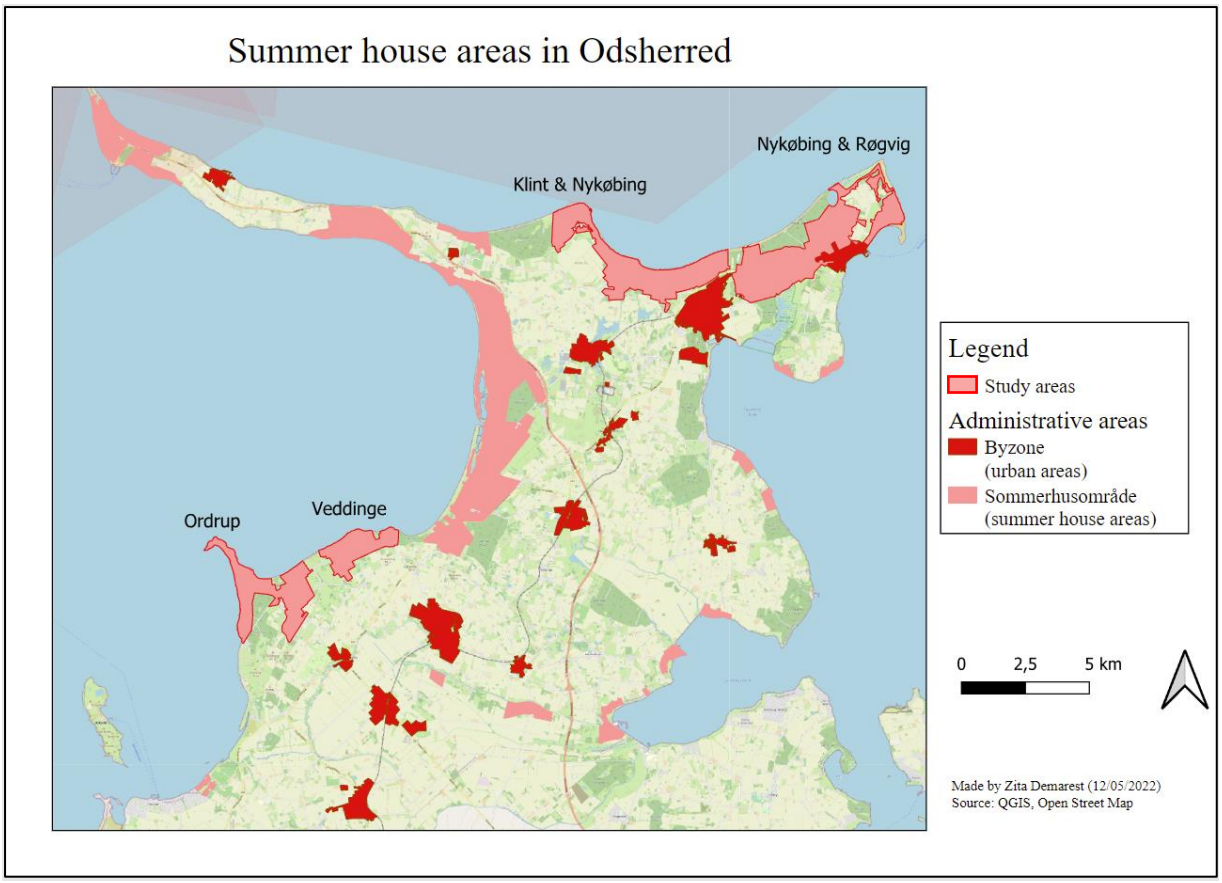



**Figure 4: Summer house areas of interest in Odsherred (Source: Open Street Map, own processing)**

Starting from the literature study and the already collected information in the desktop study, there is an expected difference in Odsherred's recreation between various periods (holidays, school weeks, weekends, weekdays, seasons, …). There is also the expectation that some recreation types will be missed, mostly during less busy periods like Winter.

### 6.3 FIELDWORK

To answer the above-mentioned research questions, surveys are carried out in the chosen summer house areas in Odsherred (see figure 4). The survey is conducted among tenants and owners of summer houses. Respondents are approached in the street or mostly by ringing the doorbell of their houses. The medium used to take the survey is Participatory GIS (PGIS) and Survey123 with a tablet. PGIS is used to indicate on maps where the recreation of summer house visitors is taking place and where they miss certain recreation, so for the spatial component. This programme is described in greater detail in Section 6.3.1 *ArcGIS Survey 123 and PGIS*. Besides the surveys, interviews are taken with some experts, namely with a staff member of the tourist office in Nykøbing and with Morten

Egeskov, the director of the Geopark. In this way, the research contains a combination of quantitative and qualitative data.

### 6.3.1 ARCGIS Survey123 and PGIS

For the fieldwork, we worked with questionnaires drawn up using the Participatory GIS (PGIS) principle. This is a participatory approach for spatial planning and spatial information and communications management. PGIS combines a range of geospatial information management tools and methods to represent peoples' spatial knowledge in the form of two-dimensional maps. These are used as interactive vehicles for spatial learning, discussion, information exchange, analysis, decision making and advocacy. More specifically, the fieldwork is executed with ArcGIS Survey123 on a tablet, which is a possibility for creating surveys where the input would be a map (Esri, 2022). In this way, the respondents themselves can indicate on a map what locations they use for recreation and where they miss recreation.

### 6.3.2 Respondents composition

It is important to mention that the respondent group of our survey, which contains 61 respondents, is rather homogeneous. There are only seventeen people that are not retired and more extremely, only two tenants in the whole group. The rest are all owners of summer houses. Only six people are born outside Denmark and only fifteen respondents earn less than 20 000 DKK or € 2700 per month. As a consequence, our research is rather biased which means that all results and answers should be seen in this context, for this specific group of people: mostly a wealthy, Danish and older group of summer house tenants. This respondent's composition is mostly due to the time frame of the data collection which was a school- and workweek during Spring. It is possible that during Summer on a weekend, for example, the group would be much more diverse.

## 6.4 DATA ANALYSIS

While processing the data, possible patterns could be seen. These patterns are then further examined and an explanation is sought in the remaining data from the surveys. This analysis will mostly contain qualitatively descriptions, where results and answers are interpreted in a more personal way, due to a lack of diversification in the respondent group (see Section 6.3.2 *Respondents composition*). A more specific description of how the analysis and processing of the data are done for each component of the research is given below.

- Temporal component: when is recreation performed by the summer house visitors?

Mostly basic statistical analysis is executed here. More specific, calculating the percentages of the chosen temporal options. The focus lies on the seasons since most people come randomly during school breaks or school weeks and also on weekdays or weekends. So it wouldn't be very interesting to include these last two in the analysis while in seasons, there are relatively more patterns or differences to find. A pie chart showing the proportions of the seasons in which a particular recreation type is carried out is created and added to the heatmaps (described below). This would also be created for periods when recreation would be missed.

- Spatial component: where is recreation performed by the summer house visitors?

The received data type from the survey is a text file. The text points and polygons need to be translated to geometric points and polygons so that they can be linked to a map. The result for each overarching recreation type (the subtypes combined) is an individual heatmap, besides a general distribution map with all recreation types. In this way, the heatmaps will indicate how attractive an area is to recreate for summer house visitors by performing a specific type of recreation. The more the polygons overlap or the more the points are concentrated, the more attractive this area will be because more people indicated that they go to that area to recreate. One disadvantage is that the polygon and point data are visualized in different maps since the model to create the heatmaps is different for these two spatial entities. After the heatmaps are created, a possible link between the recreation type and the time indicators in a certain area will be verified. Here, the pie charts with the seasons are added to the heatmaps. Noticeable patterns in the heatmap will be discussed in Section *8.1 Hotspots for recreation in Odsherred*. After that, maps with missing recreation can be drawn up. For this, the specific subtypes of recreation (like walking, inviting friends, playing board games …) are used. This is because it is important to know specifically what is missing and what would attract more visitors to Odsherred. The temporal component (pie chart) will again be taken along to see where, when and what type of recreation is being missed, all together.

- Current recreation: what types of recreation are performed by summer house visitors? And how important are these recreation types for summer house visitors?

This data is mainly explored by simple statistical analysis: calculating percentages of which recreation types are most popular, or in other words, which recreation types are indicated the most by summer house visitors. Furthermore, the mean importance will be calculated for each recreation type. This is indicated by people on a Likert scale from zero to five. So, the most important recreation types, according to summer house visitors, will appear.

- Missing recreation: what types of recreation are being missed by summer house visitors?

Missing recreation is again investigated by seeing which recreation types are missed the most by summer house visitors with a simple calculation of how many times this is indicated during the fieldwork. The spatial and temporal component related to this is already discussed above.

- Social component: which differences are there between different sociodemographic subgroups of summer house visitors?

The goal of this component is to search for correlations between certain recreation patterns and different subgroups (age, income, owners versus tenants, employment status …) among the respondents. For example, are there more tenants in Summer and do they participate more in active recreation than owners of summer houses? So, normally a correlation analysis would be carried out to answer this social question. However, since the respondents' composition is so homogeneous, it is almost impossible to find significant correlations and patterns between different subgroups. Therefore, it is probably already clear that the differences will be discussed more qualitatively again. A distinction is made between owners and tenants, people born outside and inside Denmark and people of different age groups: 65+ and -65 years old.

- Opportunities setup: what opportunities can be set up to meet the missing or preferred recreation patterns of summer house visitors?

This component is mainly approached by a qualitative analysis of the information gained by the interviews with the expert from the Tourist office in Nykobing and Morten Egeskov. The goal is to draw up ideas to attract visitors all year round with extra recreation to reduce the seasonality of visits to the region.

# 7. RESULTS

## 7.1 EXISTING RECREATION PATTERNS

### 7.1.1 Inventory Tourist Office Nykobing

The tourist office, where a lot of people go for information, has already a good inventory of diverse activities you can do in the region of the Geopark. The most important activities in the region of the Geopark are nature related, mostly walking and cycling. Therefore, a lot of walking and cycling routes are indicated. The Tour de France passes this year in July in Odsherred, about which a lot of publications can be found. Another popular cycling route is the Ice Age route of 390 kilometres which takes you through the history of Odsherred in the Ice Age, so for example how the landscape has formed at different places during this glacial period. Walking, hiking and mountain biking routes are also plentiful. In addition, there are different brochures in the tourist office about various forests, the geological heritage and plants and animals that can be found during a walk or cycle tour in the region. Fishing is a popular activity to do in the area of the Geopark as well. On the other side, there are numerous cultural activities in the region: a surprising number of art galleries, festivals and art days can be found. A specific cultural phenomenon is the Annebergparken, also called The Yellow Village, which is a former psychiatric hospital. Nowadays this place is reformed into a cultural centre with different social activities like (folk) festivals. Some of the houses of former employees are even transformed into coveted appartements. Inside the Geopark, a local art project, called Geokids, can be seen. These are clay masks made by children from the region to give the popularity of the Geopark a great boost. In the third place, information about social activities is available in the office centre. An eye-catcher in this category is the amusement park Sommerland, which is especially a great activity to do with kids. Besides that, there are some theatres, golf clubs, swimming pools, sports complexes and even an event park with paintball and other games. Finally, the tourist office likes to switch from publications on paper - the brochures for example - to mostly electronic publications, mainly because of rising prices on paper in Norway.

### 7.1.2 Interview Morten Egeskov

Most people coming to Odsherred favour nature and quietness the most. The nature in this area is often the main reason that people are visiting this place. In the summer this area is very crowdy, in contrast to the winter that's much calmer (Egeskov, 2022). Morten Egeskov also said that due to corona, many people came to the summer houses in the Geopark and stayed there the whole year. The movement

to the summer houses existed already before the covid-pandemic, but the pandemic accelerated this movement. The number of tourists expanded by more than 20% since this pandemic started (Egeskov, 2022). Further Egeskov told us that during the summer, mostly families with kids are coming to the Geopark, while in the winter the elder people who own the houses stay in this area. Younger, middle-aged people are more and more buying summer houses (Egeskov, 2022).

Further, Morten says the summer house area is very different from other summer house areas in Denmark. There are 25.000 owners of summer houses and only 1.000 tenants of summer houses. It's a place where people own and use their own houses, this gives the people bigger attention to the area. The prices of the summer house area above Copenhagen are much higher than in Odsherred. If you buy a summer house in northern SeaLand it's to be seen, in Odsherred that's not the case. Nevertheless, many of the summer house owners in the Geopark are wealthy. They come to relax and not be seen (Egeskov, 2022).

### 7.1.3 Interview Tourist Office Nykobing

The custom groups of the Geopark are 50% German and 50% Danish (Tourist Office Nykobing, 2022). There is also an agency for renting out summer houses in Germany. Mostly people elder than 50 or families with kids in the summer are visiting Odsherred. The tourist office told us that the art galleries are all over the area in Odsherred. Nature is the biggest asset of Odsherred. Walking and biking are very famous, and the Tour de France that's coming to Odsherred makes this region even more popular for biking tourists. The tourist office in Nykobing had also a busy time during the covid19-pandemic because a lot of people from Copenhagen were coming to the summer houses in Odsherred. This was stimulating the restaurants and shops in the area.

Further, the tourist office said that there are some activities outside the summer season. An example is the 'Odsherred Grand Cru', which is an annual food and harvest festival in Audebo Pumping Station where the best carrot of the year gets chosen (Tourist Office Nykobing, 2022). The festival takes place in week 42 with market days and activities for both children and adults. You can get close to the food producers, go on a bike safari on 'Lammefjord', visit the open farm shops, harvest crops at The Visitor's Field or enjoy one of the many unique Grand Cru menus at the special Grand Cru dining venues. During the summer this area provides some festivals, for example, the 'Vig' festival (Tourist Office Nykobing, 2022). Also, alternative festivals such as rock and jazz festivals take place in Odsherred. So even for younger people, there are different activities to do. Much of these activities are organised by this tourist centre.

### 7.1.4 Summer house visitors

In the survey, owners and tenants of the summer houses were asked to name their three most favourite activities to do while staying at their summer house in Odsherred. They were then asked to indicate on a map where and when they perform those activities. Furthermore, they were asked how important they find a particular recreation type for the region of Odsherred. The aim was to indicate the importance of that recreation type for them while staying at their summer house in the region of Odsherred. As already mentioned, they could indicate the importance on a Likert scale from 0 (not important) to 5 (very important). Figures 4 and 5 show that walking as an activity is very popular throughout the whole year, but especially during summer. This can be explained by the age distribution and employment status of the respondents. Many are of age and retired and come to the region to relax and enjoy the beautiful nature. Another explanation could be that the respondents are in some way obliged to go for walks with their dog for instance. While taking the surveys, there was a significant amount of people letting their dog go for a walk or respondents telling us they owned a dog, as motivation for choosing walking as an activity. Besides walking, resting indoors was mentioned a lot. Here again, can the age of the respondents be the explaining factor. Furthermore, working in the garden and the house was very popular. Respondents explained to us the importance of keeping the house in good shape since the weather can be harsh and the salty air makes the houses more fragile. The respondents often work around their house in spring and summer. Gardening is also popular in spring and summer, and respondents who live permanently in cities such as Copenhagen (figure 7), love gardening in Odsherred. They often don't have the space and time to do so in the cities. The activity of working in the garden and the house got the highest score for importance. Respondents who chose this recreation type as one of their favourites also gave it a high score of importance on the Likert scale. This can be seen in figure 6. Two other types of active recreation were popular amongst the respondents. Both swimming and cycling were mentioned a lot. Swimming is popular since many of the summer house areas are close to the sea. Swimming is logically more popular in the summer, although some respondents love to take a plunge the whole year through. Cycling is becoming more and more popular in the region, according to the tourist office centre. With the Tour de France just around the corner, the region tends to be very popular for cyclists during the weekend.

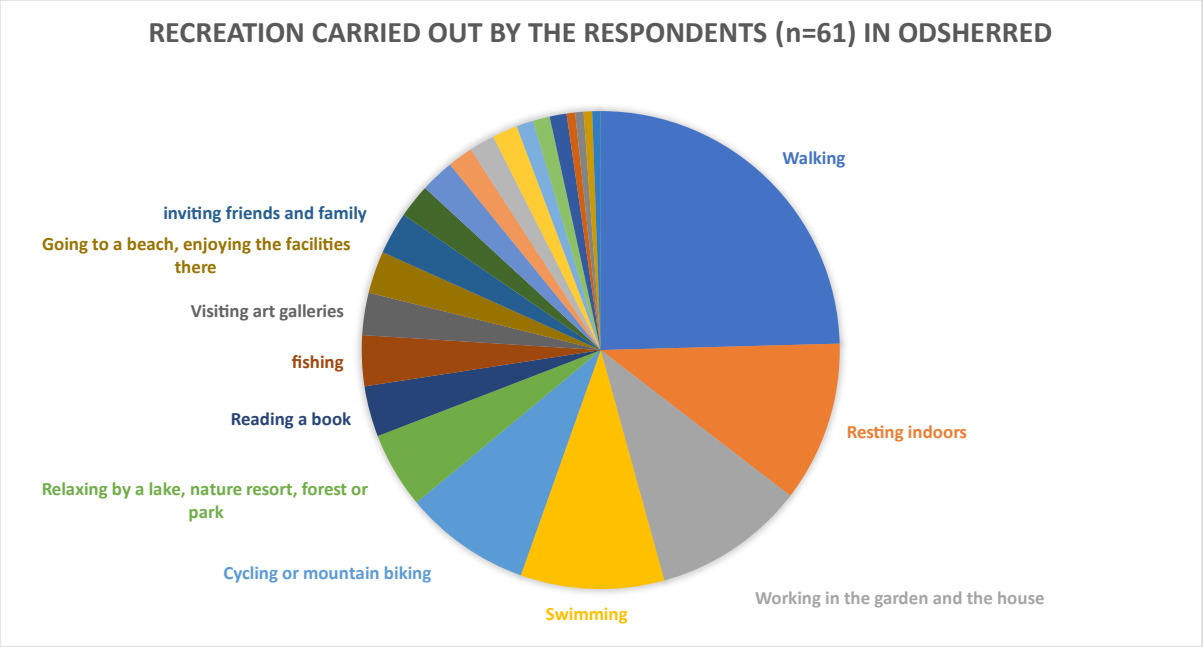



**Figure 5: Popularity of recreation types according to summer house owners and tenants in Odsherred (in absolute value)**

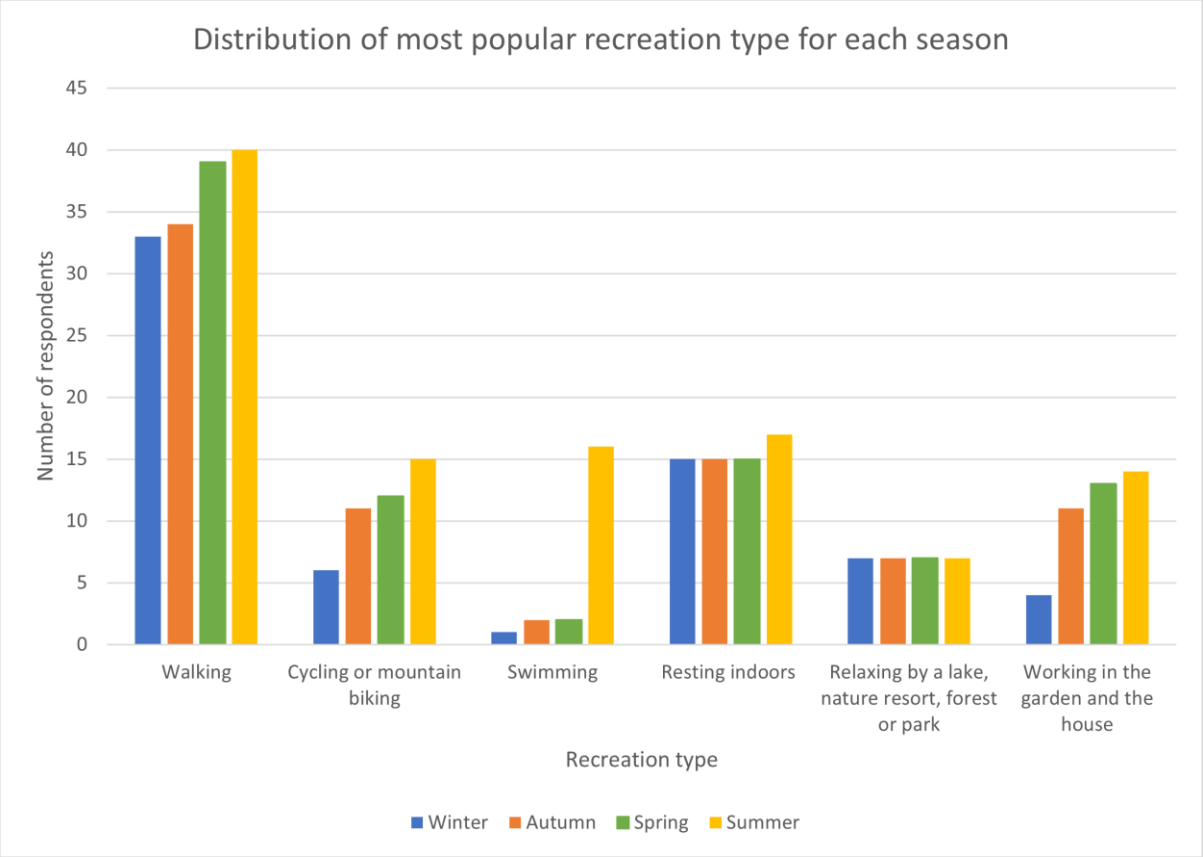



**Figure 6: Distribution over the seasons of the six most popular recreation types in Odsherred**

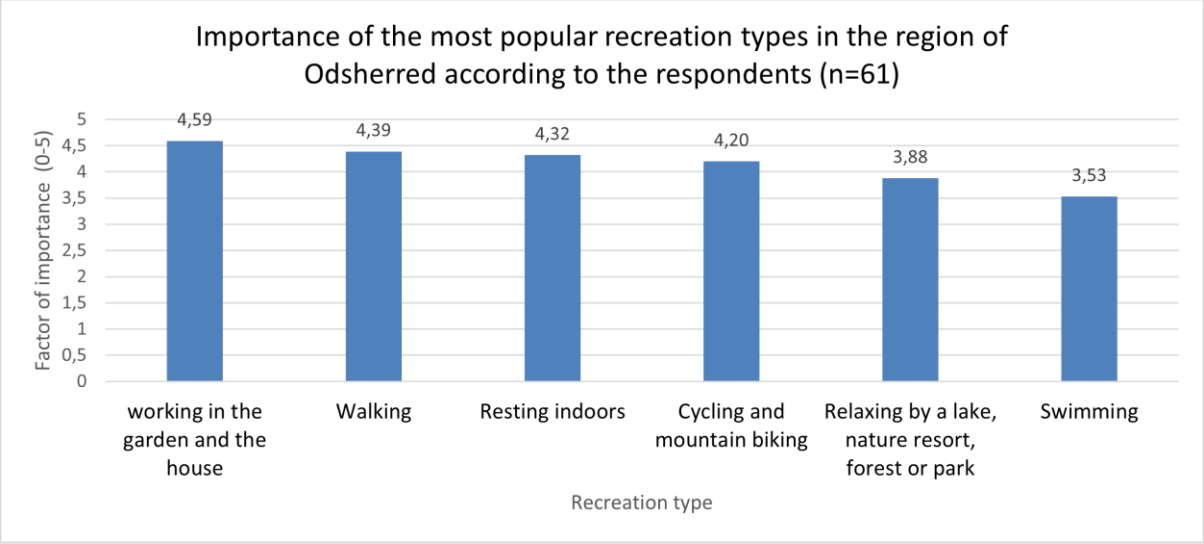



**Figure 7: Mean importance of the most popular recreation types in the region of Odsherred**

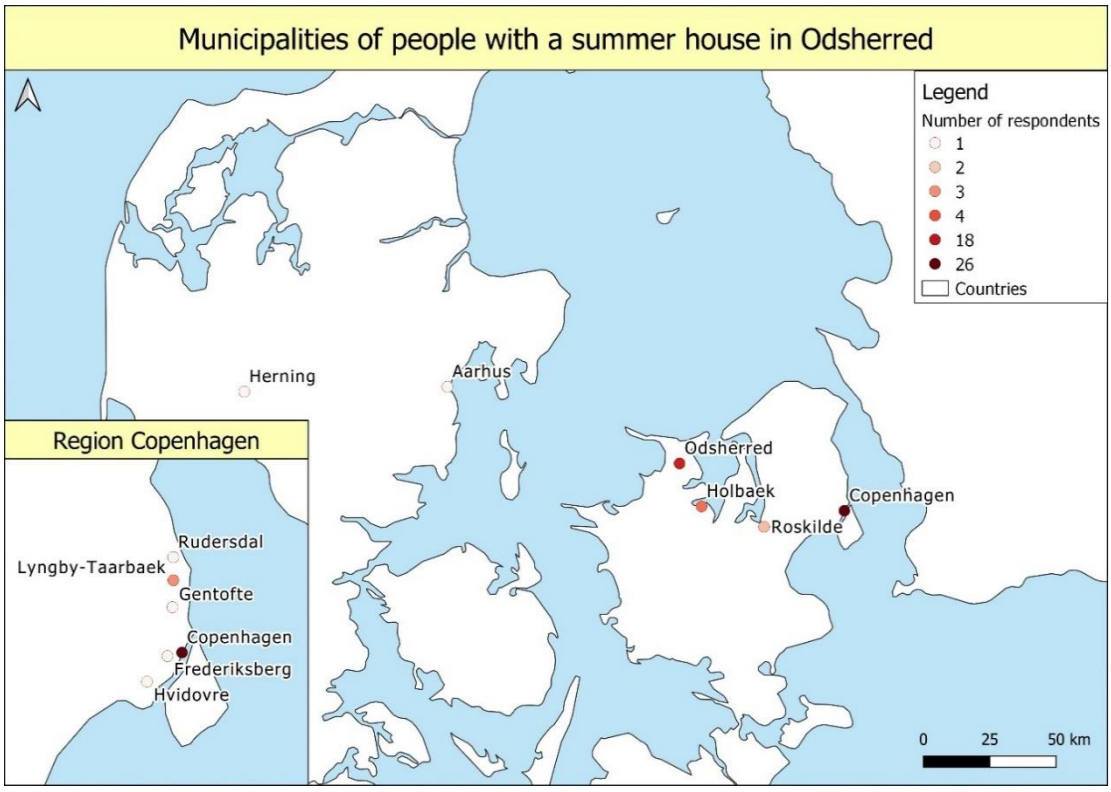



**Figure 8: Municipalities in Denmark where non-permanent summer house owners or tenants live (Borremans, 2022)**

#### *7.1.4.1 Differences between owners and tenants*

Since there are only two respondents' tenants of a summer house and the rest owners, a difference in recreation patterns is difficult to see and cannot be statistically analysed at all. The ratio of two tenants out of 61 respondents is approximately in line with the total number of summer houses in Odsherred and the number that can be rented out: respectively 26 000 and 1 000.

#### *7.1.4.2 Differences between people born in Denmark and other countries*

Six respondents aren't born in Denmark but in Norway (2 people), the United Kingdom, Sweden, Germany and Poland. For foreigners, there are some conditions for buying a summer house in Denmark. People need to have some sort of connection with Denmark, for example, previous stays in summer houses or specific family, business, cultural or financial relations with the region (https://www.hjulmandkaptain.dk/, 12 May 2022).

Walking is the most popular activity. After that, cycling, working in the garden and visiting art galleries are the most important recreation types for people who are born outside Denmark. A striking result is that these people visit relatively more art galleries than people that are born in Denmark. There are only five people in total that regularly visit an art gallery, of which three are born in another country. Working in the garden is also relatively more popular for this group. Of the twelve people in total that indicated this as a frequently performed activity, three are born outside Denmark. For the remainder, the recreation patterns for both groups are similar.

#### *7.1.4.3 Differences between people of different ages: 65+ and - 65*

The group of respondents is divided into two parts based on their age: 65+ and -65 years old. There are some differences and similarities to find for the subgroups in their most performed recreation types. Walking is the most liked activity for both groups with approximately 70% of people performing this. Fishing is an activity that both groups perform similarly often as well, namely about 10% of the respondents. On the other side, there are also some differences to find. The age group of 65+ clearly engage more in working in the garden and the summer house, reading a book, visiting art galleries and visiting markets than the age group of -65. About 15% more respondents in the older group work more in the garden and the house than the younger age group. The last three mentioned recreation types are not carried out by the age group of -65 at all. By contrast, the people of -65 years old do other activities more often. They rest and relax (both indoor and outdoor), and swim and cycle more than the

older group. Besides that, there are even some recreation types that aren't performed by the people of 65+ years at all: playing board games, running, kayaking and going to the beach.

Somewhere it is logical that younger people carry out more active and outdoor recreation types, like swimming, cycling, running, kayaking etc. than older people. Many board games are not known for people at a certain age, which also explains why only the younger group indicated this as a frequently performed activity. On the other hand, older people visit more cultural places like art galleries and markets and perform more often calm activities like reading a book. Many young people are no longer interested in these kinds of recreation. Working in the garden and the house can also be seen as relaxing activities for older people. They enjoy this a lot.

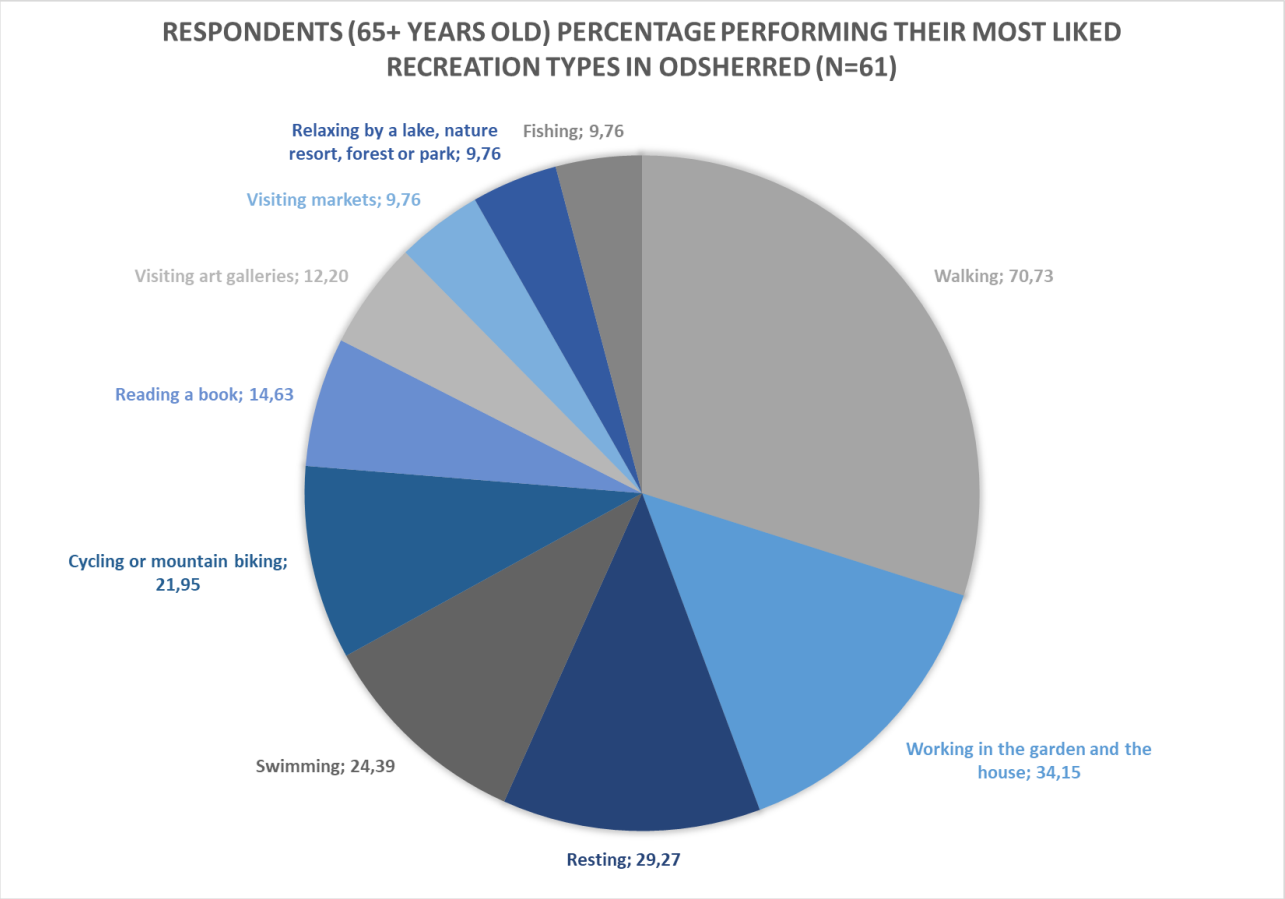



**Figure 9: 65+ respondents performing their favourite recreation types in Odsherred (in percentage)**

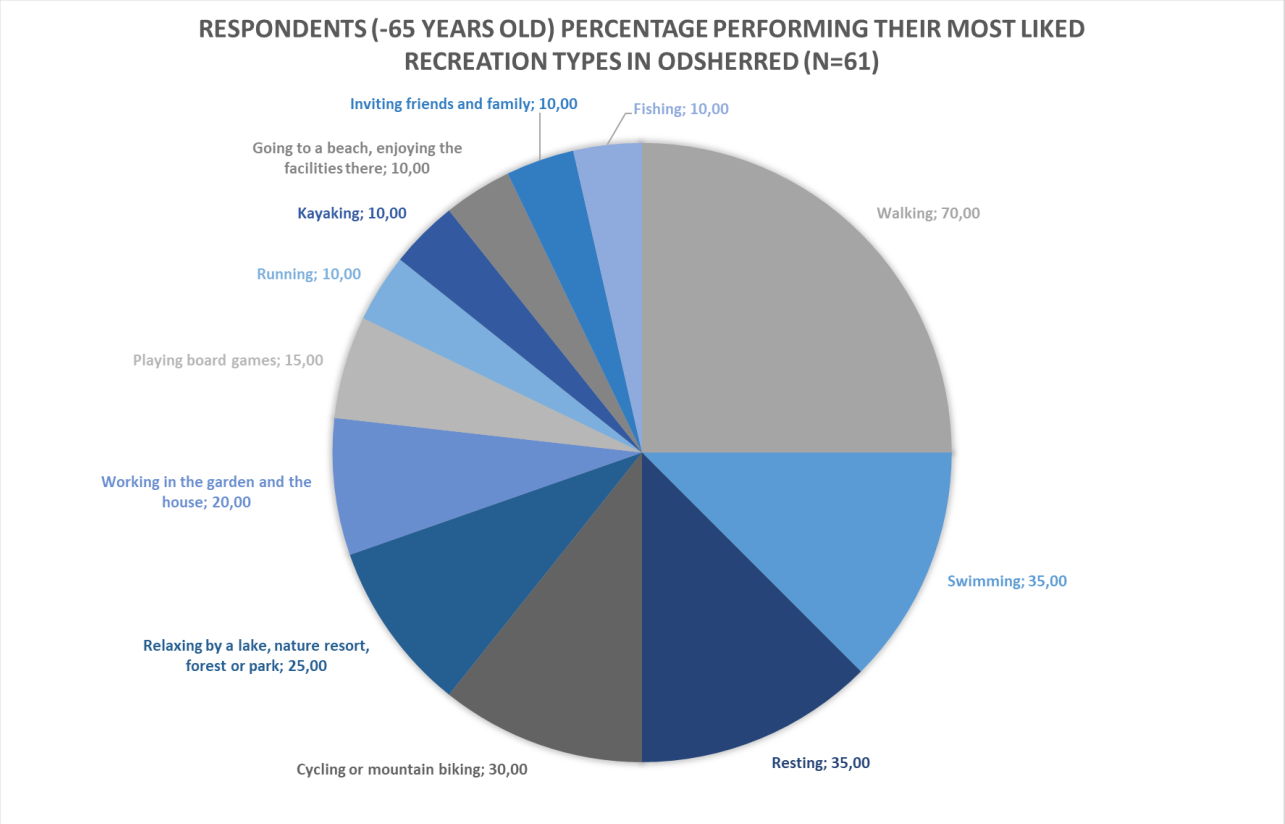



**Figure 10: -65 respondents performing their favourite recreation types in Odsherred (in percentage)**

### 7.2 PREFERRED AND MISSING RECREATION PLACEMENT

As earlier mentioned, there is no need for placing recreation in Odsherred according to the summer house owners and tenants who participated in this research. Since this is their subjective meaning, there needs to be room for some nuance.

#### 7.2.1 Interview Morten Egeskov

The Geopark doesn't think that there is recreation missing (Egeskov, 2022). The focus is more on stretching the high season, because in the summer there are a lot of activities and a lot of people, and the restaurants and shops are open (Egeskov, 2022). On the other hand, the area has more potential to attract tourists, but in the summer, there is not enough space for all those people. Especially in the outer seasons, there is a higher potential for the area to attract more visitors (Egeskov, 2022). Further Morten Egeskov thinks you can make amusement parks in the Geopark, but not in the landscapes why people come to this region. Amusement parks are not the main reason why people are visiting Odsherred. He also told us that as an organization, the Geopark of course promotes its activities in the

region. What people are looking for is, and where the big growth potential of the area is, is high-quality ofference. So, therefore they concentrate on cooking local food and preserving the landscape and its cultural history (Egeskov, 2022).

#### 7.2.2 Interview Tourist Office Nykobing

The tourist centre in Nykobing is planning to make more publications of the region Odsherred in Copenhagen. They also told us that the Geopark is serving to represent Odsherred on the map. Further, the main future goal for recreation is also to extend the high season (Tourist Office Nykobing, 2022). For example, let restaurants open for a longer period, because a lot of restaurants close after August. Also reducing the seasonality is on the list of this tourist office (Tourist Office Nykobing, 2022). In other words, also attracting tourists in the winter is something the tourist office is deploying.

## 8. DISCUSSION

### 8.1 HOTSPOTS FOR RECREATION IN ODSHERRED

The hotspots of recreation in Odsherred, based on our research, are indicated in two different categories, points and polygons. Both categories of recreation hotspots are represented with heatmaps.

#### 8.1.1 Hotspots for recreation in Odsherred – the polygons

The heatmaps of the polygons are divided into three categories: walking, cycling and water sports combined with going to the beach. With water sports, we more specifically mean kayaking and sailing. The heatmaps are presented in the appendix, figures eleven, twelve and thirteen.

When looking at the heatmap of walking in Odsherred (figure 11), there can be concluded that the biggest concentration of walking areas is close to the areas where the surveys were conducted. This means that most of the respondents are walking close to their summer house. This conclusion fits when looking at the age of the respondents because most of the people that were interrogated were 65+ and often don't have the physical possibilities to walk far away. Further, it's clear that the respondents mostly walk nearby the beach, which was often the reason they bought a summer house in this region. When looking at the heatmap of cycling in Odsherred (figure 12), we see that this activity takes place over the whole region. People who are biking in this region cycle bigger distances. They cycle at the coast, but

also inland. However, the biggest concentration of cycling in Odsherred can be found in the northeast. This is probably because a lot of surveys were generated at that place. The water sports (figure 13), in this case, sailing and kayaking, can mostly be found along the Sejero Bugt and the Nyrup Bugt. This is because there is a specific flow needed for these activities that can be found in these bay areas. Further are these also famous places for going to the beach, according to our research.

### 8.1.2 Hotspots for recreation in Odsherred – the points

The analysis of the point and how they are distributed through the area brings up a clear pattern. On the map (figure 14) in the appendix, the overall recreation is visible in Odsherred. The first map shows the distribution of all kinds of (point) recreation in the area, so the activities that are done in one place. The second map is a heatmap (figure 15), this is a map where the colour red is an indication of how popular that place is for all types of recreation. If the heatmap is compared with the map of the summer houses which we visited, there is a clear pattern. People who stay in the summer houses recreate in the area around their homes. They don't go to the other side of the island but stay ratter close to their summer houses to recreate.

The two biggest areas that come forward as recreation hotspots are Ordrup and Rørvig, again those are the summer house areas.

After this general overview of the recreation in the area, six specific maps were drawn under the division of the big recreation categories. These categories were based on the categories that were in the survey. The first map (figure 16 in the appendix) contains the active recreation in the water; it contains fishing, sailing and swimming. The hotspots are Ordrup and the area of Rørvig. And as we could assume this kind of recreation is mostly performed in summer.

The next one was active recreation on land (figure 17 in the appendix), containing golfing and tennis. This was only indicated by a couple of people, so the importance is significantly low. The only thing that could be noticed here, was that the golf and tennis areas aren't placed directly in the area of the summer houses.

The next category is the relaxing outdoor (figure 18 in the appendix), this was clearly something that a lot of people did. Taking care of the house and working in the garden is important to do in almost all seasons. Here it is concentrated in Ordrup and the area of Klint.

The map containing the visiting and connecting with nature and the fun recreation (figure 19 in the appendix) is a map with a few points. Only one person indicated that they go to Rørvig for eating out. On the other hand, two people indicated that they specifically go and visit nature, but we can assume that the people who walk and cycle in this area also visit nature, but on a smaller scale of importance.

When taking the interviews there was something that caught our attention, a lot of people visited art galleries or were interested in art. The hotspot for these art galleries was Nykøbing (figure 20 in the appendix). The cultural recreation is done mostly in the summer.

The people who were staying in the summer houses often indicated relaxing indoors as an activity they find important, and it's this that is visible on the map (figure 21 in the appendix). The high number of points on this map indicates that a lot of people indicated it as an activity they do. Here the area of Ordrup is a clear hotspot. Relaxing indoors is evenly distributed throughout all seasons.

### 8.2 RECOMMENDATIONS FOR PLACING RECREATION

As earlier mentioned, there is no need for placing recreation in Odsherred according to the summer house owners and tenants who participated in this research. Since this is their subjective meaning, there needs to be room for some nuance. The biggest asset of this region is nature in Odsherred (Egeskov, 2022).

### 8.3 MISSING DATA, PROBLEMS FACED DURING THIS RESEARCH

The greatest limitation we faced during this research was the period of our data collection. It was a workweek during which we took the surveys and that for a period of three days. The surveys took place between ten am and five pm. For this research that was a limited timeframe with a limited audience to participate. The season also had a great impact, we went to do research in spring. In spring most people in the summer houses are the permanent residents or the people who stay there a lot. This had a great influence on the dataset and the results. Because of this, the variation in the respondents wasn't that big, so the dataset was rather homogeneous.

Besides that, we also experienced some problems with the Survey123 tool. In the online survey, there was only one option to add a map to our questions. On that map it was only possible to indicate one point or one polygon. So, for example, if people wanted to indicate were they go swimming, they could only indicate one point, even if they did that activity in more than one place. We often had to ask to indicate the point or area they go the most, but because of that we lost a lot of data. Or we had to load a new map and all the previous questions about that activity had to be retaken. For further research we can advise to search for an ther tool to take the surveys, where it is possible to indicate more than one point or area on the same map.

### 8.4 GAPS IN RESEARCH AND OUTLOOK FOR FUTURE RESEARCH

Since the data collection only took three days, the sample was rather homogeneous. To make the research more representable, data should be collected throughout the whole year, at weekends and weekdays, during school weeks and school breaks. More surveys should be taken from a more diverse group of summer house owners and tenants. Not only the temporal factor was restricted, but also the spatial area where the surveys were taken was too small. The surveys were only taken in four summer house areas. It is suggested that further research would also gather data in other areas. Based on the demographic characteristics of the respondents there could be made a cluster analysis, for which then the recreation patterns can be clustered. It would be interesting to see whether there is a clear spatial and temporal difference in recreation types for these groups of summer house owners and tenants. Lastly, further research should take more in-depth interviews with experts on this subject. The interviews we conducted were very educational and made us more aware of the aim of the community of Odsherred regarding the recreation in the area.

## 9. CONCLUSION

When reflecting on the research questions, the following conclusions can be made based on the desk study and fieldwork. There is no clear seasonality in the types of recreation performed by summer house owners and tenants in the region of Odsherred. Most of the activities are carried out throughout the whole year, each season, on weekdays as well as weekends and during school breaks as well as school weeks. Recreation on water, such as swimming and kayaking, are performed more frequently during spring and summer, as temperatures are higher then. The areas around the residence of the summer house owners and tenants are the hotspots for their recreation. The respondents declare that everything they desire in terms of recreation is nearby. The respondents come to enjoy nature, have some off time and rest. Only for golfing, tennis or sailing, some respondents move further away from their house. The most popular recreation according to the respondents were working in the garden and around the house, walking and cycling as active recreation and resting indoors and relaxing outdoors as passive recreation. When looking at the missing recreation according to the respondents, the conclusion was made that there is no need for extra recreation. This needs to be nuanced since our sample was rather homogeneous and the respondents mostly came to their summer houses, on the one hand, to escape the city life and on the other hand to enjoy the beautiful nature, hills, seaside and quietness. Many respondents felt a deep connection with the region of Odsherred, as a place of rest and rejuvenation, and we, as researchers, could definitely sense how much these people love to be there.

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## APPENDIX

MAPS

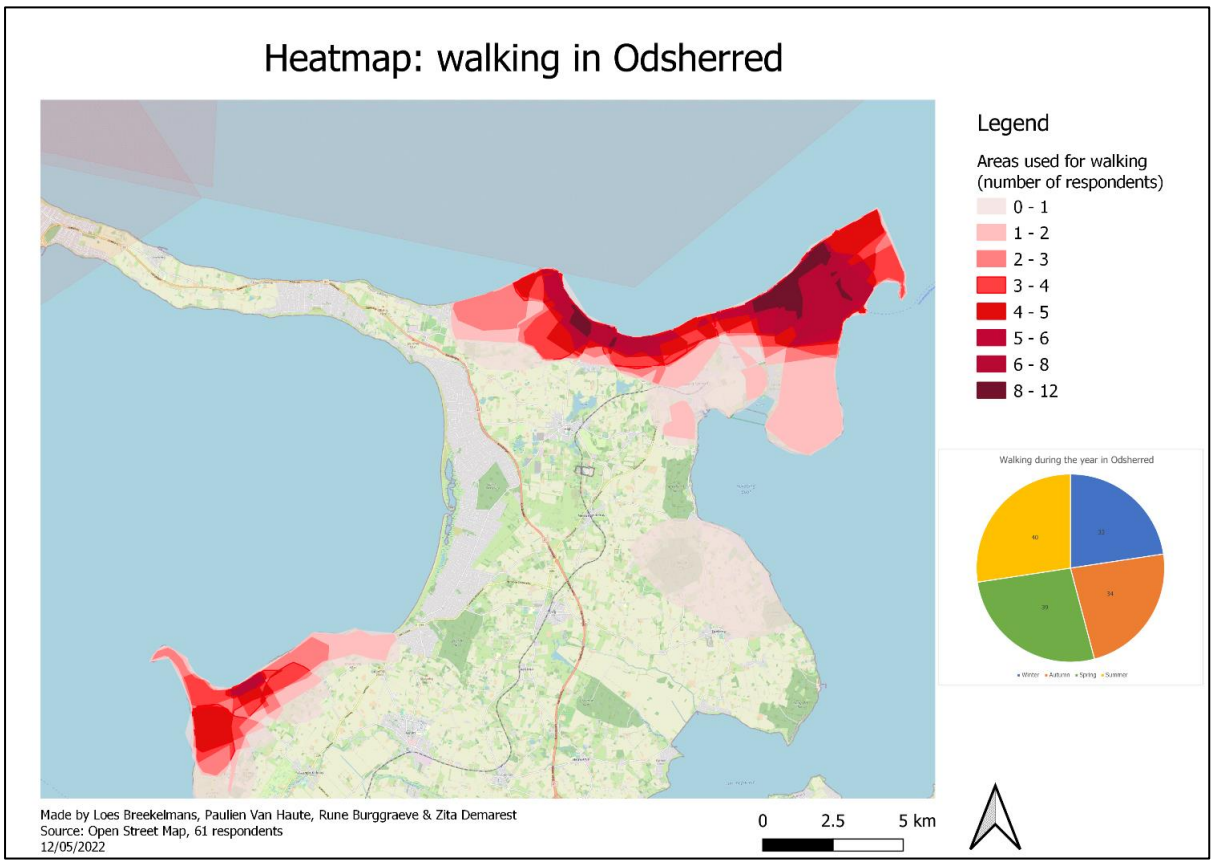


**Figure 11: Heatmap of walking in Odsherred**

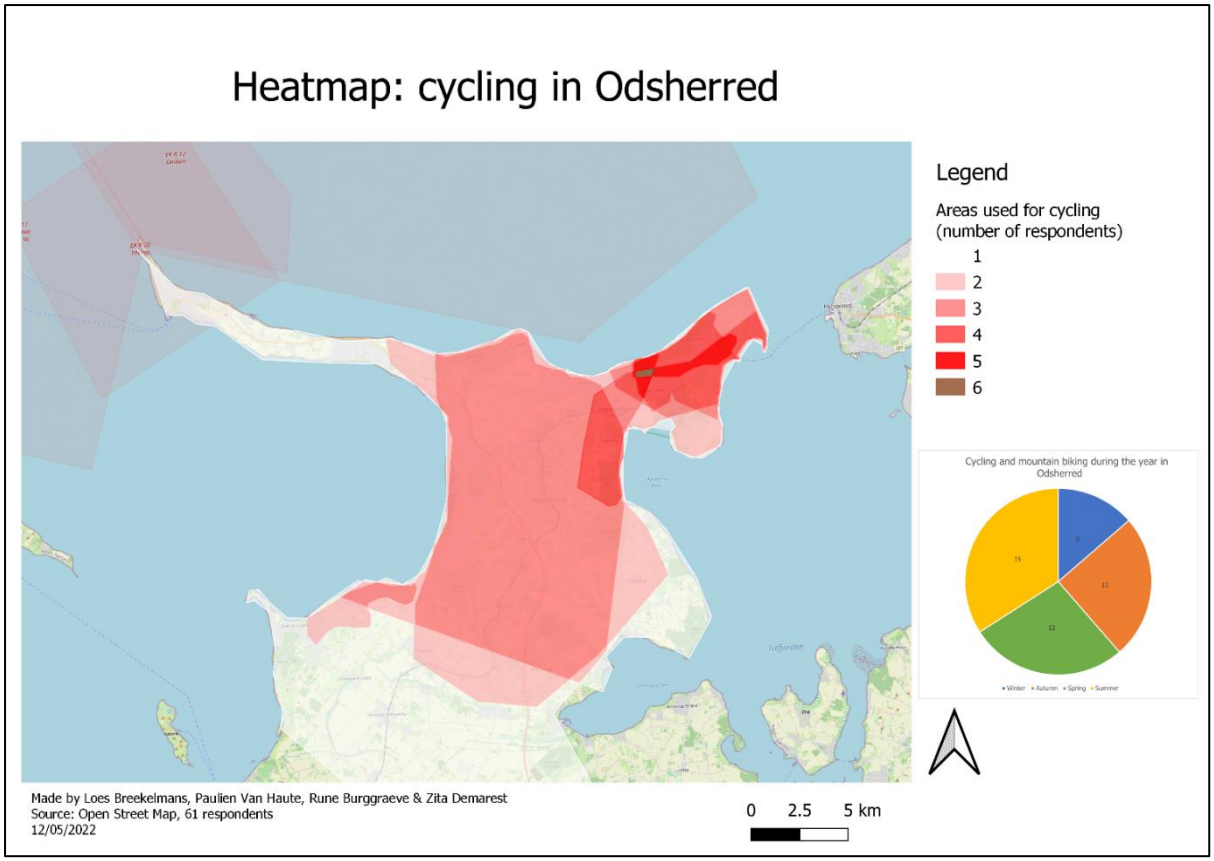


**Figure 12: Heatmap of cycling in Odsherred**

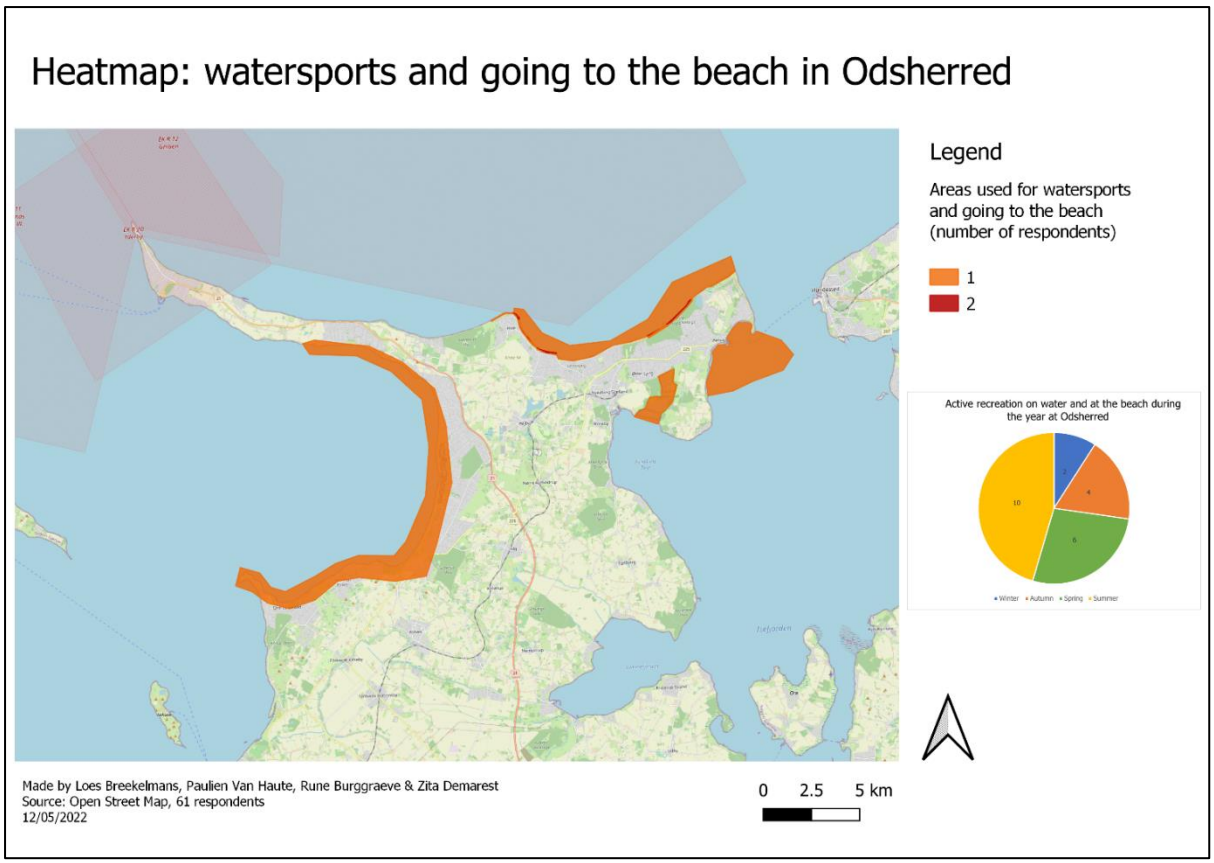


**Figure 13: Heatmap of watersports and going to the beach in Odsherred**

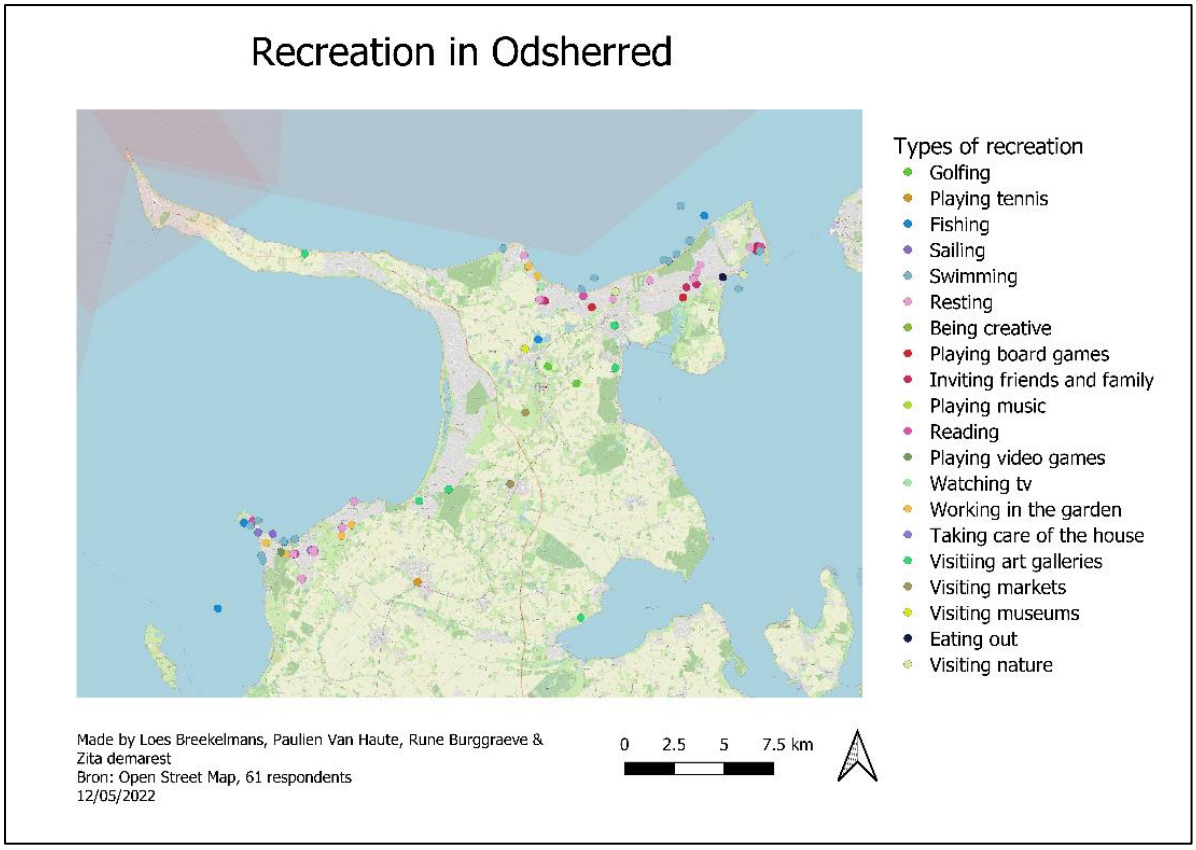


**Figure 14: Recreation in Odsherred (points)**

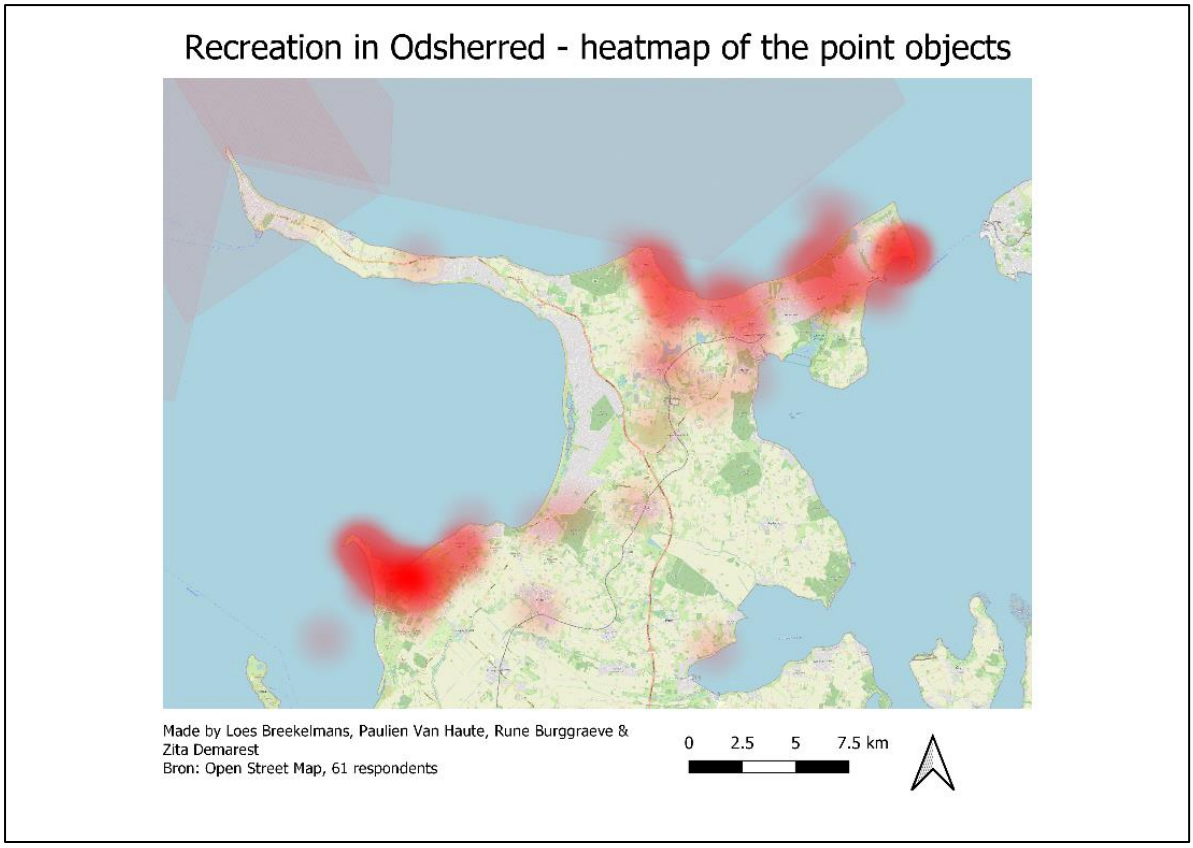


**Figure 15: Heatmap of the recreation in Odsherred (points)**

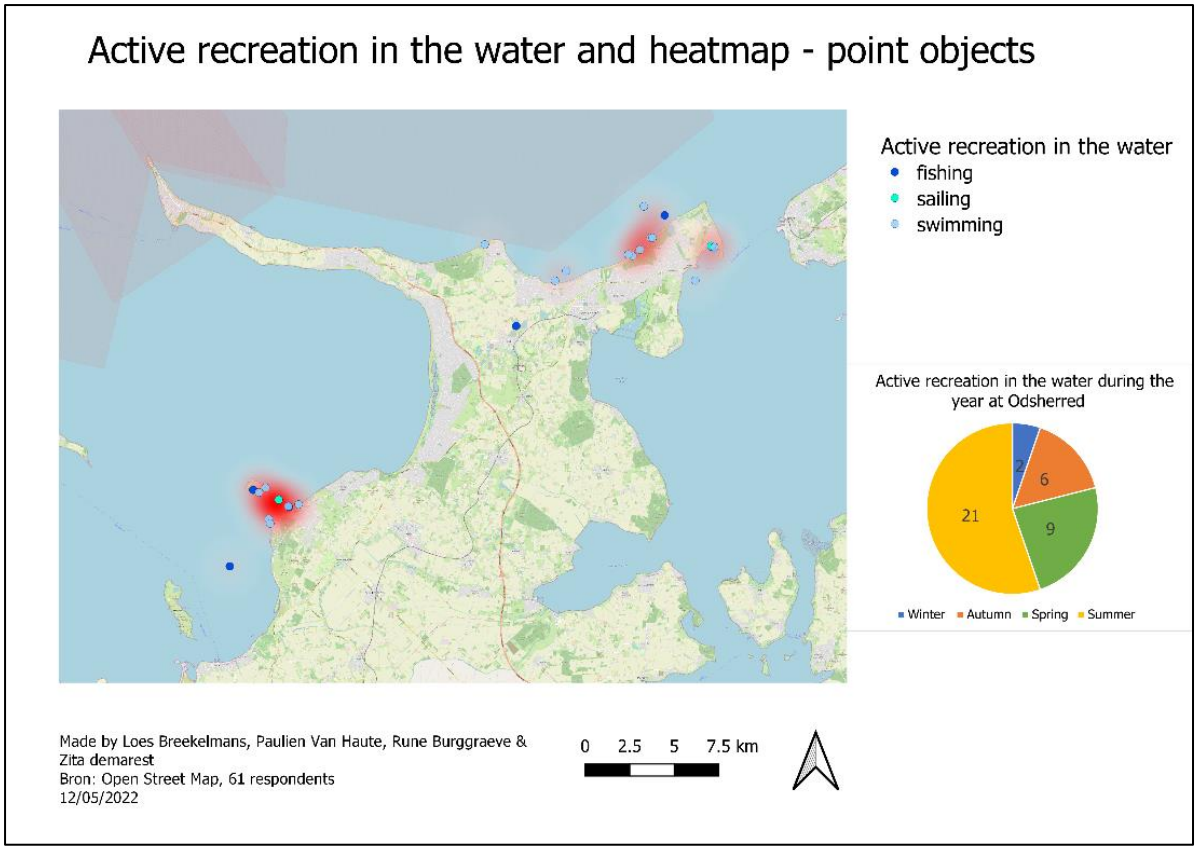


**Figure 16: Active recreation in the water and heatmap (points)**

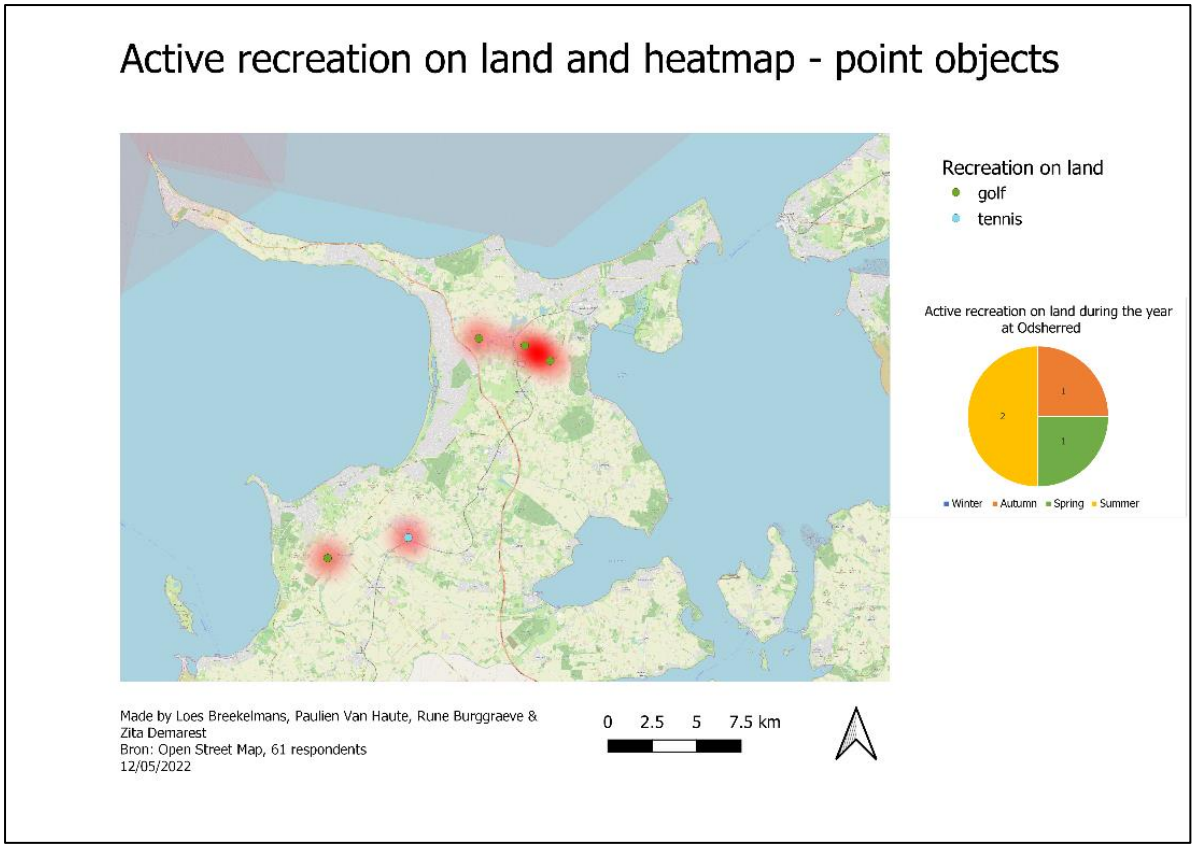


**Figure 17: Active recreation on land and heatmap (points)**

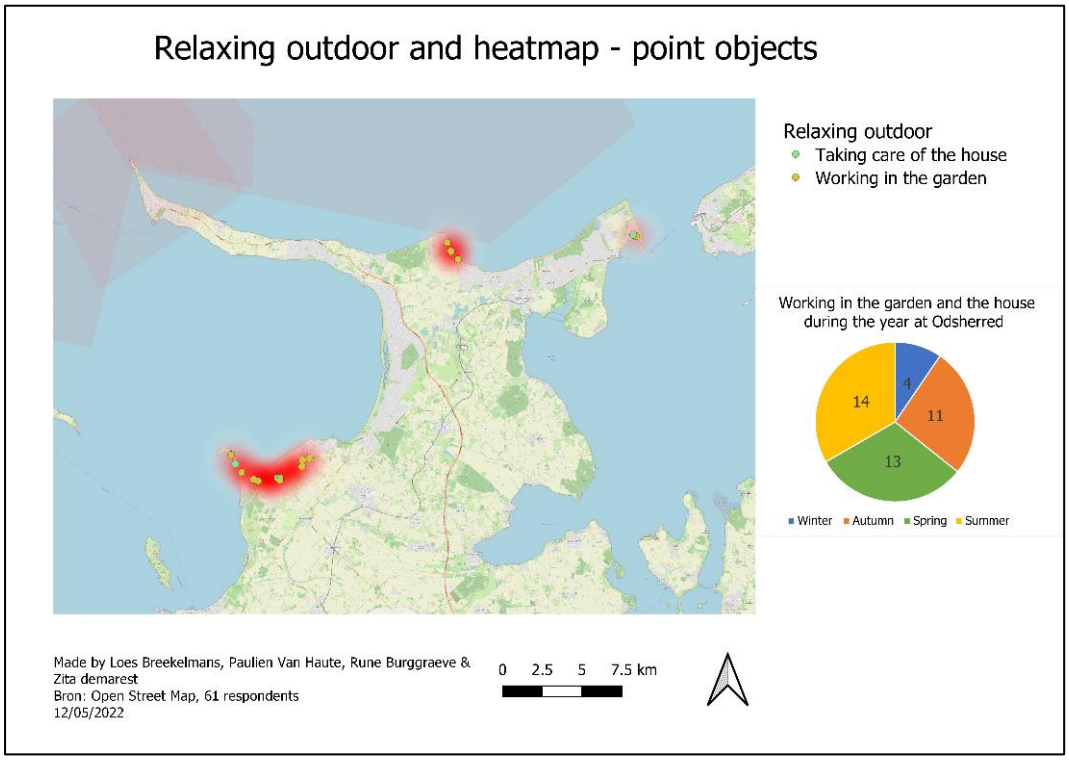


**Figure 18: Relaxing outdoor and heatmap (points)**

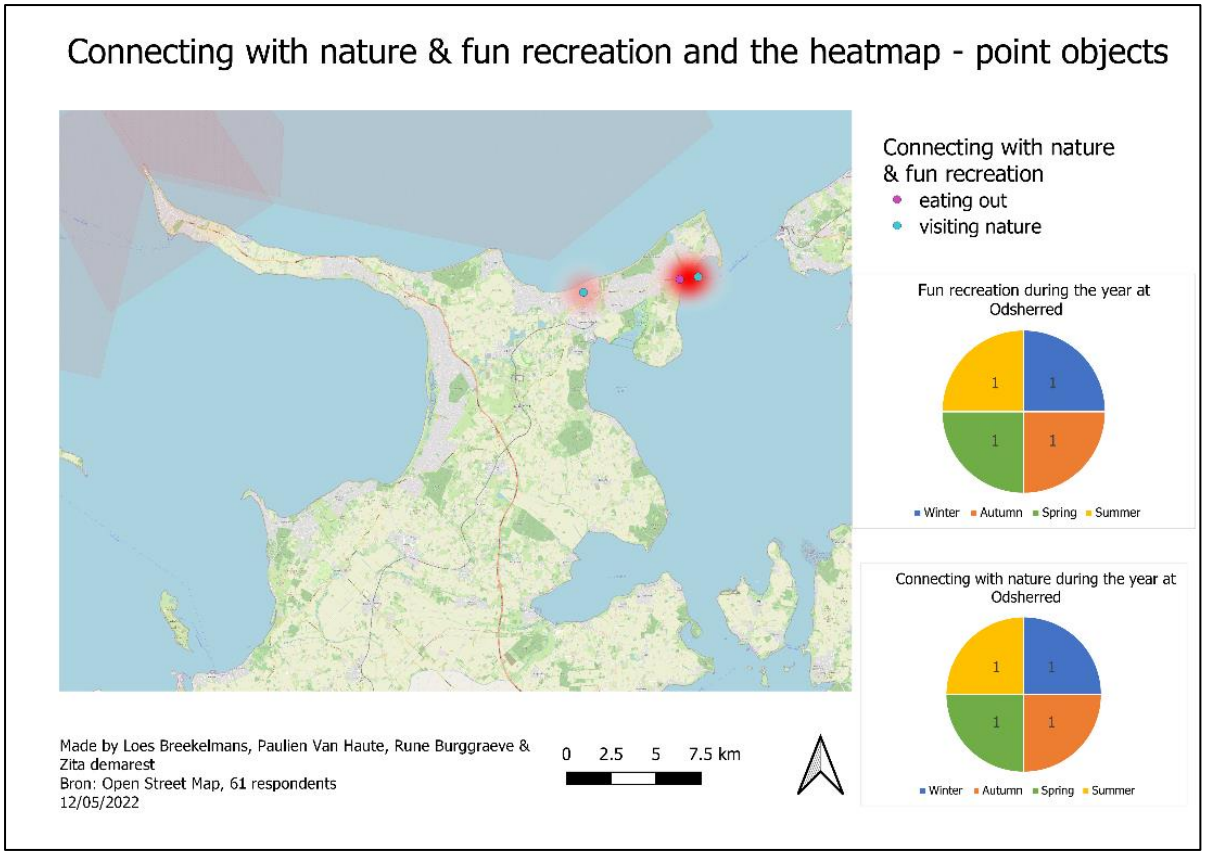


**Figure 19: Connection with nature & fun recreation and the heatmap (points)**

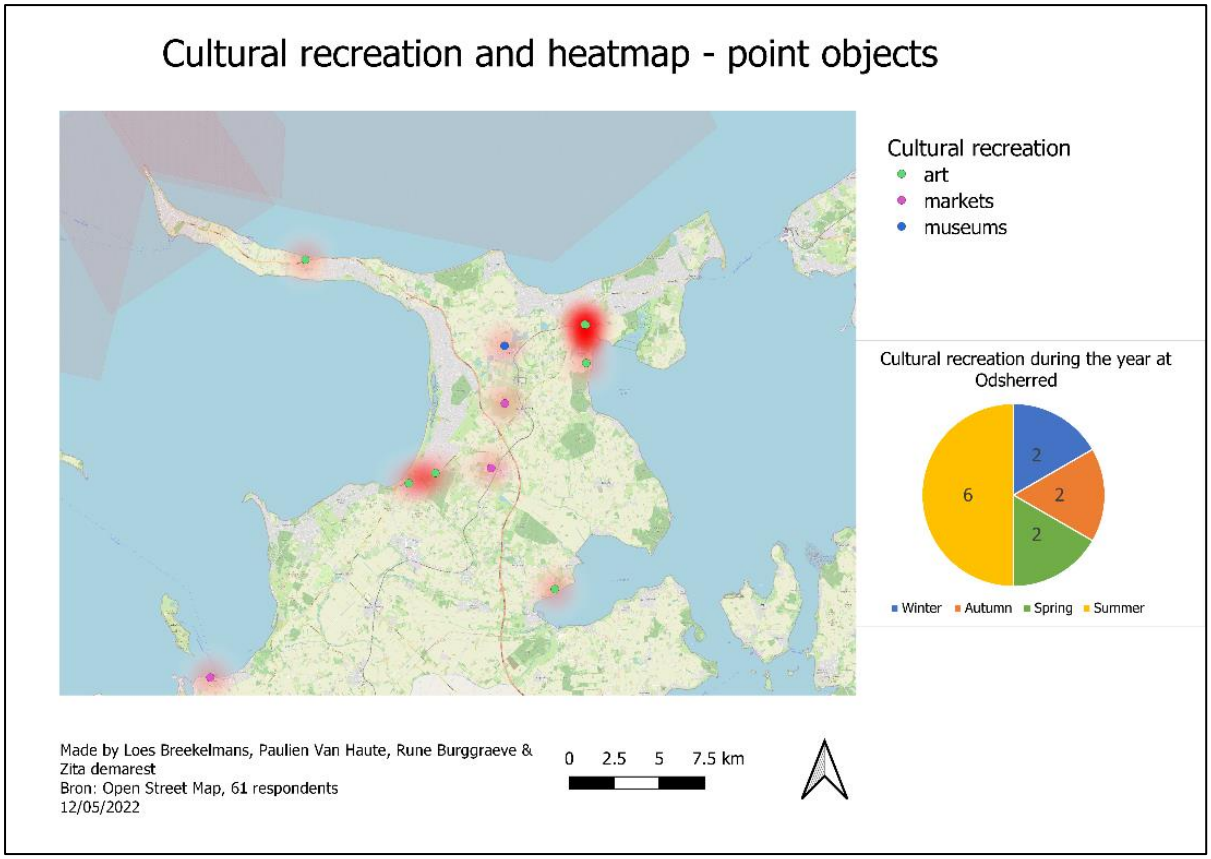


**Figure 20: Cultural recreation and heatmap (points)**

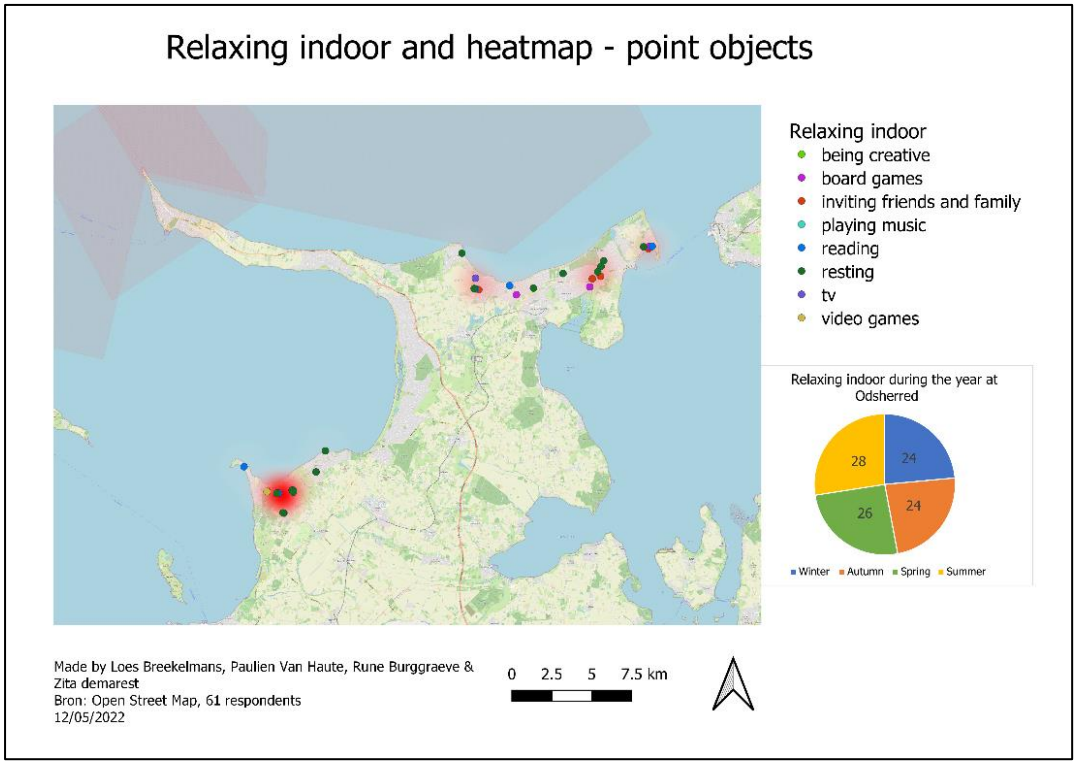


**Figure 21: Relaxing indoor and heatmap (points)**

SURVEY

The survey is added in another document in this folder.

# LOOKING FOR SPATIAL PATTERNS IN SUMMER HOUSE AREAS IN ODSHERRED, DENMARK

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Odsherred Insights – 2nd Edition – 2021-2022

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- UNESCO Global Geopark

# 1 INTRODUCTION

With a total of approximately 24,000 summer houses, Odsherred is the municipality with the most summer houses in Denmark. 1/8 of the total number of summer houses in Denmark are located in Odsherred. This means that 20 % of the municipality is summer house area, and these areas play an important role in the urban development and demographics of Odsherred (Odsherred Kommune, 2021). The municipality of Odsherred is aware of the importance of summer houses for the area. Because of that, they spent a lot of time on the future and development of the summer houses. Overall, the municipality wants to attract more visitors and wants visitors to come more often and stay for longer periods of time (Dansk Bygningsarv, 2014; Odsherred Kommune, 2021).

The community of Odsherred wants to develop and regulate the summer house areas and the surrounding areas. However, the question can be asked if the focus should be the same in the whole municipality. Different groups of people have different interests and therefore different factors that could attract them to stay at a summer house in Odsherred. Therefore, research on a possible spatial divide of groups of people who stay at the summer houses could be useful.

As a result, the research questions for this research are whether there are spatial patterns in the characteristics of the houses in the different summer house areas, and the people who reside in these houses. Answering these questions will give insight in the possible spatial division of people and interests in the summer house areas of Odsherred, which can be used by the community to further develop and attract more visitors.

In this report, you will first find a theoretical framework explaining some theoretical concepts that are used throughout the research. After that, the used methods and resources will be described. Then the results will be discussed, after which a discussion of the results and research follows. Finally, there is a brief conclusion formulated.

# 2 THEORETICAL FRAMEWORK

Odsherred is a municipality in the northwest of the island of Sealand in Denmark. It is located on a peninsula with the same name. The peninsula is surrounded by water in the east (Ise Fjord), in the north (Kattegat) and in the west (Sejerø bay). The municipalities of Kalundborg and Holbæk border in the south. In 2007, the three municipalities of Dragsholm, Nykøbing-Rørgvig, and Trundholm merged to form the municipality of Odsherred.

The landscape of Odsherred is diverse and is protected by UNESCO as a Global Geopark. The three end moraines dominating the elevation were formed during the latter part of the Weichselian (17,000 years ago) (https://en.unesco.org/, consulted on June 28, 2022). There is also a flat polder plain in the south, where the Isefjord used to be. Furthermore, coastal processes in are still active, resulting in erosion and sedimentation in different areas.

There are many summer houses in Odsherred. Summer houses are a unique concept in Denmark. Going to a small wooden cottage in the countryside during the summer is a phenomenon that started in the 19th century among the people living in Copenhagen. This trend spread all over the country during the 1960s and 1970s due to the active policy of rural municipalities. For them luring tourists was a method to create more job opportunities. The first regulations of these summer houses were made in 1977 to protect the coastline. This included that new summer houses could only be built at least three km away from the coastline. During the 1980s the cottages slowly became bigger, creating more comfort by adding pool and spa facilities, big kitchens with dishwashers and large bathrooms. The summer houses are often real mansions (https://www.yourdanishlife.dk/, 2022).

Summer houses are nowadays heavily regulated. Houses can only be built in a specific summer house area. There are limits on the number of summer houses you can own, and it is difficult to buy a summer house if you are not a Danish citizen. Foreigners need to apply for an exemption at the Ministry of Justice. Approximately 50 % of the dispersions granted are to Norwegian citizens. The summer houses are also popular among Germans, but they usually rent the houses instead of buying them (https://www.yourdanishlife.dk/, 2022).

## 3 METHODS AND RESOURCES

The study consists of four different parts. Firstly, different literature was consulted to have a better understanding of the summer house areas in the municipality of Odsherred. Secondly, data on the characteristics of summer houses was extracted through web scraping of rental websites. This data was then analysed by using a linear regression model and a spatial cluster statistic. After the desktop study, the field work was conducted by collecting data through the surveying of residents of the summer houses. This data was analysed as well, this time using a cluster analysis. Finally, the results from the desk study and field work were combined. Every step will now be discussed in more detail.

## Desktop study

*General literature overview*

The first step into the research was to gain insight into the culture and policy of the summer houses in Odsherred as well as to determine what information already exists about the residents and visitors of summer houses in Odsherred. In order to do this, a literature review was performed. There are two documents out of which the most information was gathered, namely Odsherred's vision- and development plan for 2025 and the proposal for the municipal plan of 2021 for Odsherred. The information gathered from these documents was combined with additional information found on websites about the summer houses in Odsherred.

*Web scraping and analysis*

The characteristics of a house can usually tell something about its owner. The data was scraped from different summer house rental sites. Rental sites were chosen over selling websites, because those often only mention the asking price of a house. The price that will eventually be paid for the house could be higher or lower, depending on the interest and number of bids. Therefore, this price is not considered as reliable. The data that seemed interesting to scrape from the rental websites were the price, the building material, the construction or renovation year, the availability of Wi-Fi, the capacity of the house (how many people the house can accommodate) and the location of the house. In the end, only the rental price, availability of Wi-Fi, the capacity of the house and the house location were gathered. To scrape the sites, the Chrome extension Web Scraper was used (https://www.webscraper.io, consulted on April 9, 2022).

Besides the data of the web scraping, there was also a shapefile containing the administrative plots available from the Danish Business Authority (https://kort.plandata.dk, consulted on March 22, 2022). This could be used to determine the area of the plots. The area of the house was measured using OpenStreetMap data (https://www.openstreetmap.org, consulted on April 19, 2022). The distances from the summer houses to the sea, a village and supermarket were measured in a similar manner in a GIS program.

After the data was gathered, a spatial analysis was conducted. Clusters were visualised by using Moran's I's significance (Moran, 1950). Moran's I is a method to detect spatial autocorrelation. There are four types of spatial patterns. The first one is that there is no spatial autocorrelation. This would mean that the characteristics of the houses are randomly distributed over Odsherred. A high-high

correlation is a hotspot. This means that houses with a high value for a certain attribute are surrounded by other houses with a high value for that attribute. The opposite is a low-low correlation, also called a coldspot. Low values attract more low values. Lastly, there is the high-low correlation. A house with a high value for a certain characteristic is surrounded by houses with a low value for that characteristic. This is often described as a doughnut shape.

To see if the rental price is correlated with characteristics of the house and geographical features, a linear regression was performed. These were the dependents intended to use:

- The capacity;
- The availability of Wi-Fi;
- The area of the house;
- The area of the plot;
- The distance to the sea;
- The distance to a village;
- The distance to a supermarket.

To perform a linear regression, there must be no correlation between the dependents.

**Field work: surveying residents**

As stated before, data was collected through surveys. For this, Survey 123 was used. This is an app that can be installed on mobile devices. It is especially suited for geographical research because it allows both normal questions and questions with answers drawn on a map. The app was installed on four tablets to go into the field. Surveys were conducted for three days, from Monday, May 9 through Wednesday, May 11, 2022, which delivered a total of 61 filled-in surveys. The surveys were conducted by asking passers-by and residents of selected summer house areas if they were willing to participate. The selection of the visited summer house areas is based on two factors. Firstly, the areas where other surveys were conducted last year, and this year were not visited as to not bother the residents too much. Secondly, no surveys have been conducted in the small summer house areas due to limited numbers of residents. This could result in hotspots in these areas, just because only a small number of people were interviewed. The surveyed areas were the summer house areas of Ordrup, Ordrup Strand, Veddinge, Veddinge Bakker, Klinten, Klint, Klintehuse, Nykøbing, Nordstrand, Øster Lyng, Rørvig Strand, Rørvig, Nørrevang, Korshage, and Skanserne. The surveys were made and conducted in cooperation with another research group. The large group was divided into groups of two or three people to be able to cover a large area and to survey as many people as possible. The questions delivering

useful data for this research are summed up in the appendix. Summer house residents were questioned about their socio-demographic/economic characteristics such as age, nationality, where they usually live, education level, and income. They were also asked if they are owners or renters of the house, how often they visit, with how many people they visit and how they are related and during which periods of the year they usually visit.

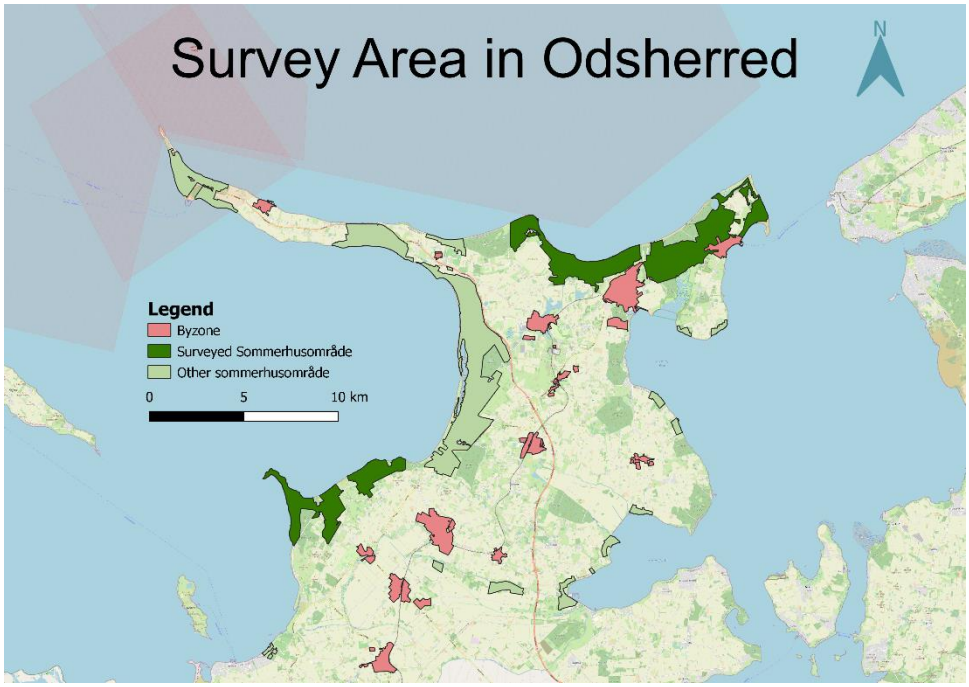


**Figure 1: Map of the surveyed summer house areas.**

**Combining field work and desktop study results**

The data collected through the surveys was used to perform a cluster analysis. Using the method of Wishart, first a hierarchical clustering method was used to determine the number of clusters. Then a partition method was used to determine the clusters. The hierarchical clustering method used was Ward's method. This is an agglomerative method, which means that it starts with as many clusters as there are observations and then it adds these clusters together. In this process, the variance of the clusters is minimised. After running the clustering algorithm, it is possible to determine which number of clusters is meaningful for the data.

The partition method used was K-Means. Based on the number of clusters, K-Means estimates an equal number of start points. The observations from the surveys are added to the start point they are closest to, and this way clusters are formed. After assigning all the data to a cluster, the mean of each cluster

is calculated and used as the new start point. Observations that are now closer to the mean of another cluster are relocated. This process repeats until the division of the clusters is satisfactory. The found clusters were then used in a spatial analysis, similar to the one performed on the characteristics of the summer houses.

# 4 RESULTS

## Desktop study

*General literature overview*

According to the vision and development plan of Odsherred, a part of the summer houses is the property of people living and working in Copenhagen or Aarhus. They use the house in the weekend, as an escape from the busy workweek (Dansk Bygningsary, 2014). In the proposal for the municipal plan of Odsherred, it is stated that an increasing number of summer houses is permanently inhabited (Odsherred Kommune, 2021). These people that reside in their summer house permanently are usually older, retired citizens (Dansk Bygningsary, 2014). It is also mentioned in the vision and development plan that the inhabitants or visitors of summer houses are important for local businesses, cultural events and all types of recreation (Dansk Bygningsary, 2014).

Summer houses are often in one family for generations (Dansk Bygningsarv, 2014). A division between younger and older residents has been noticed, mainly in how they experience their summer house. Younger residents enjoy the privacy, as well as cultivating a social life. They see the lack of a stabile Wi-Fi connection as a loss. They use the summer house as a gathering place for friends and family and they visit more on weekends. On the other hand, older residents often reside permanently in their summer house. They love exploring the cultural activities but find the choice of recreational activities lacking (Dansk Bygningsary, 2014).

Considering the characteristics of the summer houses, Odsherred Kommune (2021) states that there is no spatial pattern in the location of the large houses. There is, however, a diversity between the different summer house areas.

*Web scraping and analysis*

Three sites were found useful to scrape from: feriepartner.dk (313 houses), sommerhus-siden.dk (386 houses), and sologstrand.dk (74 houses). In total these are 773 houses, distributed all over Odsherred.

Due to the limits of web scraping, only a limited number of attributes were extracted: the price, the capacity, the availability of Wi-Fi and the location. The other attributes mentioned earlier, building material and building year of the houses, could not reliably be extracted. Due to inconsistencies in the shapefiles of the plots and the buildings (e.g., multiple houses were located on one plot, a lot of houses had outbuildings that were not linked in the shapefiles), these were not further used.

Three high price hotspots were found. The largest one is in the southwest of Odsherred and stretches from West Veddinge Bakker to Ordrup Strand with a 99 % confidence interval. A hotspot with 90 % confidence is located at smaller summer house areas near Bøsserup and Unnerud in the east of Odsherred. Another hotspot with 90 % confidence interval is located near Skansehage. A hotspot for low prices was found over Hønsinge Lyng, Ellinge Lyng, and Gudmindrup Lyng with a confidence interval of 99 % (Figure 1).

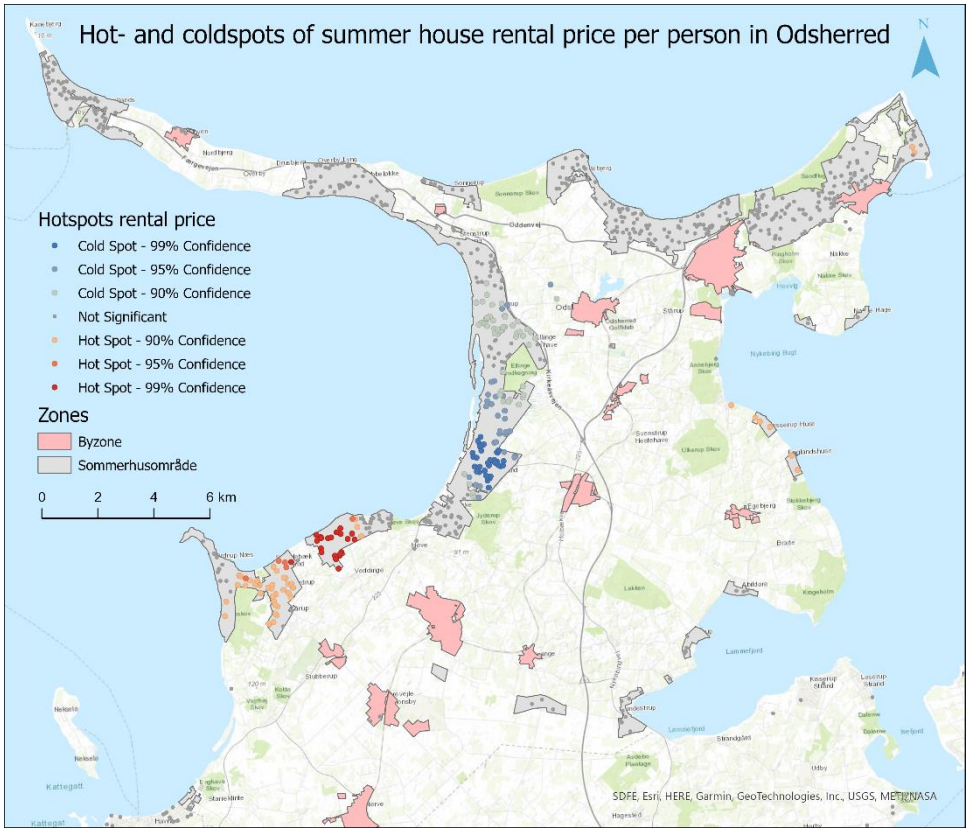


**Figure 1: Map of the hot- and coldspots of summer house rental price per person in Odsherred**

The availability of Wi-Fi has a hotspot at the summer house area north of Nykøbing (90 % confidence interval). There is also a coldspot, a place where there is a lack of Wi-Fi, that stretches from Ellinge Lyng

over Hønsinge Lyng to East Veddinge Bakker (Figure 2). This seems to correlate with the coldspot for prices.

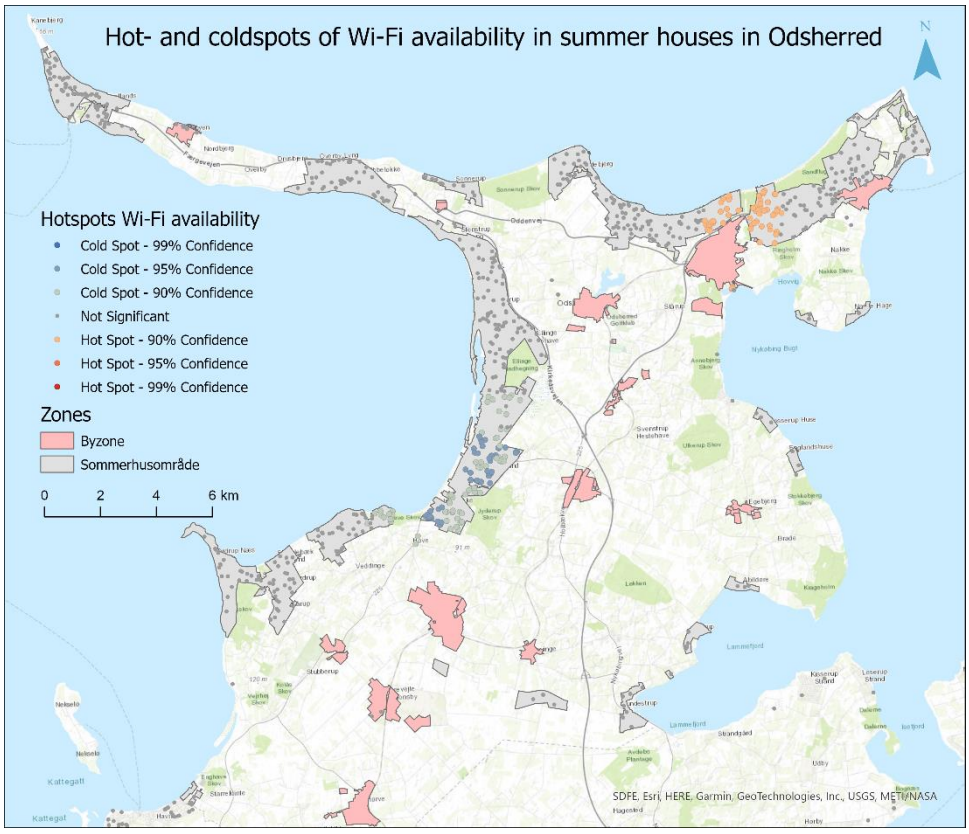


**Figure 2: Map of the hot- and coldspots of Wi-Fi availability in summer houses in Odsherred**

To check for correlations between the dependent variables, a Pearson Correlation matrix (Table 1) was made. There is a correlation between the distance to a village and to a supermarket. A factor analysis was performed with these two variables. The new factor will be called “distance to services”.

**Table 1: Pearson Correlation matrix**

**Correlations**

| | | capacity | Wi-Fi | distance to the sea | distance to a village | distance to a super-market |
|---|---|---|---|---|---|---|
| capacity | Pearson Correlation | 1 | -,010 | -,032 | -,024 | -,018 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Sig. (2-tailed) | | ,779 | ,370 | ,509 | ,623 |
| | N | 772 | 772 | 772 | 772 | 772 |
| Wi-Fi | Pearson Correlation | -,010 | 1 | ,016 | ,022 | ,038 |
| | Sig. (2-tailed) | ,779 | | ,663 | ,546 | ,297 |
| | N | 772 | 772 | 772 | 772 | 772 |
| distance to the sea | Pearson Correlation | -,032 | ,016 | 1 | ,024 | ,058 |
| | Sig. (2-tailed) | ,370 | ,663 | | ,506 | ,104 |
| | N | 772 | 772 | 772 | 772 | 772 |
| distance to a village | Pearson Correlation | -,024 | ,022 | ,024 | 1 | ,855** |
| | Sig. (2-tailed) | ,509 | ,546 | ,506 | | ,000 |
| | N | 772 | 772 | 772 | 772 | 772 |
| distance to a supermarket | Pearson Correlation | -,018 | ,038 | ,058 | ,855** | 1 |
| | Sig. (2-tailed) | ,623 | ,297 | ,104 | ,000 | |
| | N | 772 | 772 | 772 | 772 | 772 |

**. Correlation is significant at the 0.01 level (2-tailed).

However, the linear regression shows that the newly made factor “distance to services” has no significant correlation with the rental price. The capacity is positively correlated, the Wi-Fi availability and the distance to the sea are negatively correlated. The negative correlation of the Wi-Fi availability is surprising because the hot- and coldspot analysis indicates the opposite.

**Table 2: Coefficients of the linear regression**

**Coefficients[a]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | | |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | t | Sig. |
| 1 | (Constant) | 262,171 | 43,561 | | 6,018 | ,000 |
| | Wi-Fi | -121,392 | 29,742 | -,123 | -4,082 | ,000 |
| | capacity | 87,416 | 5,100 | ,517 | 17,141 | ,000 |
| | distance to the sea | -,057 | ,014 | -,126 | -4,176 | ,000 |
| | distance to services | 4,903 | 11,009 | ,013 | ,445 | ,656 |

a. Dependent Variable: rental price/night

**Field work: surveying residents**

The survey included some sociodemographic and economic parameters. Most interviewed people were older than 60 years and were retired. This pattern does not seem to reflect reality and can be caused by the dates the survey was conducted: during a normal school week in May. These numbers would be more representative for the residents if the survey was conducted during a holiday or during summer.

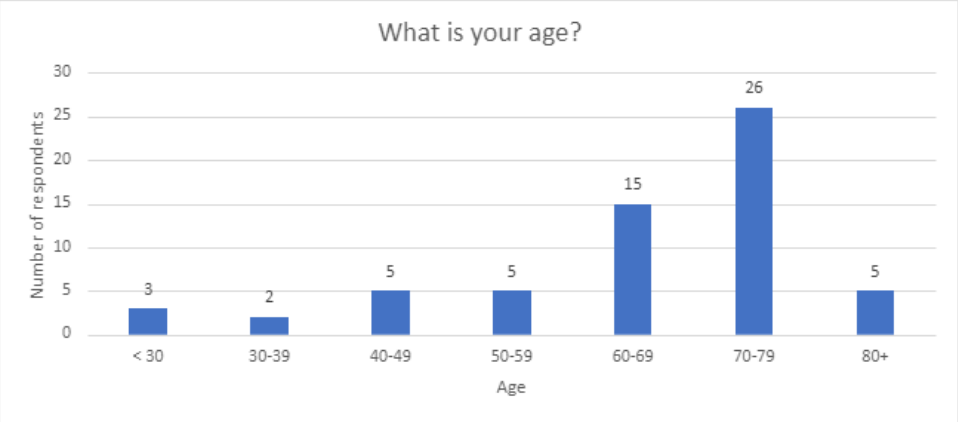

**Figure 3: Age distribution of the respondents**


**Figure 4: Employment status distribution of the respondents**

A majority of the interviewed people are highly educated. The net income is also rather high.

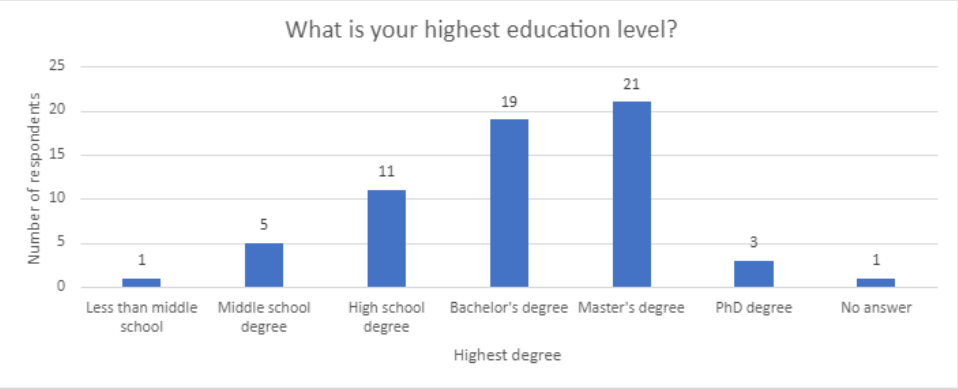


**Figure 5: Distribution of the highest education of the respondents**

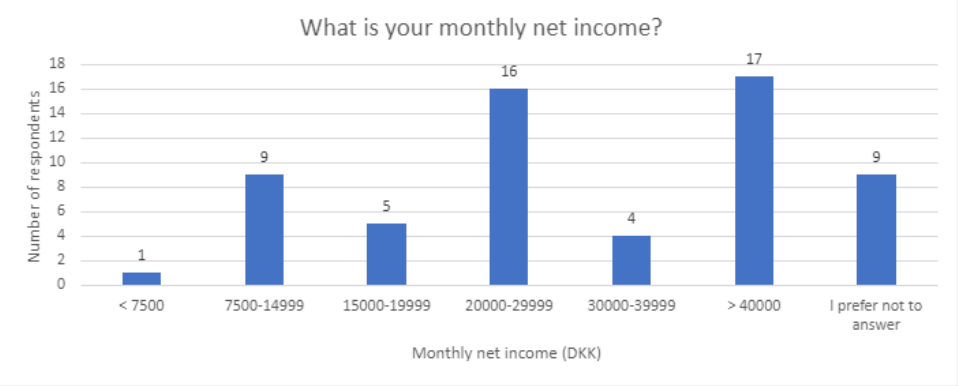

**Figure 6: Distribution of the net income of the respondents**

There is also the spatial distribution of where people are coming from. Most interviewed people were Danish. Only 5 % had another nationality, namely Swedish and Norwegian. However, only 90 % is born in Denmark (whereof one individual in Greenland). Other birth places are Germany, Norway, Poland, Sweden and the United Kingdom. 3 % of the respondents live currently abroad in Germany or in Sweden. People's permanent address is most often in the Copenhagen region or in the neighbourhood of Odsherred. Only two respondents live currently in Jutland.

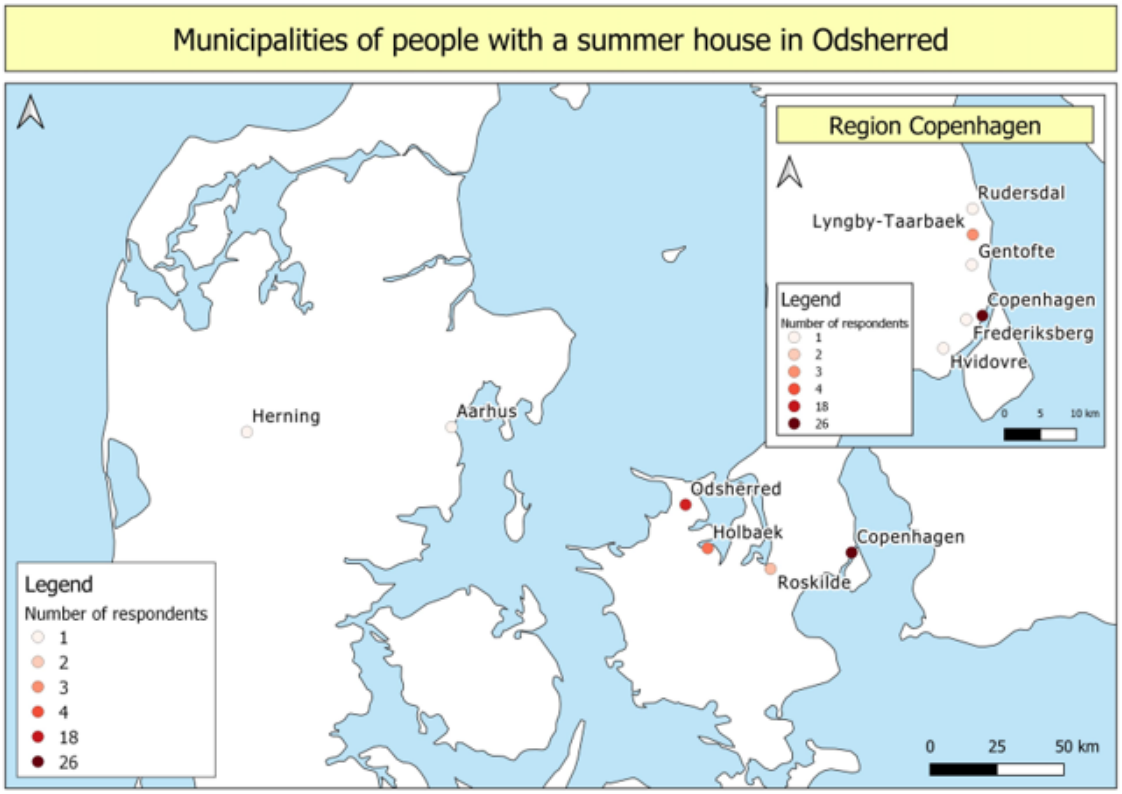


**Figure 7: Map with the municipalities of people with a summer house in Odsherred**

Most people know Odsherred via family and friends or by searching around (in newspapers or on the web). The landscape, nature, sea and beaches are the most contributing factors to choose for a summer house in the region. The price and the properties of the house are mentioned as well.

The hierarchical cluster analysis indicates that using two or four clusters can be meaningful. The only significant variables are:

- The frequency of visits to a summer house
- The age of the respondent
- The highest degree of the respondent
- The monthly net income of the respondent

When using the partition method K-Means to make four clusters, the clusters found can be described as “rich elderly”, “middle class elderly”, “middle-aged”, and “young”. The class “rich elderly” contains the residents older than 72. The question of the highest degree gives different answers. They have the highest net income and usually live permanently in their summer house. The “middle class elderly” are a bit younger, between 53 and 71, and earn a bit less but do not have the lowest salaries. This group also contains different types of education levels. They usually live permanently in their summer house as well. The “middle aged” cluster consists of the participants between 40 and 53 years old. They are usually highly educated and earn high salaries. Their frequency of visiting is variable. The last cluster contains the youngest participants, those who are younger than 40. They are usually highly educated, but their salaries are variable. Also, their frequency of visiting is varied.

The same analysis is performed again, but with only two clusters. The found clusters were “elderly”, which is the clusters “rich elderly” and “middle class elderly” combined, and “younger”, containing “middle-aged” and “young”.

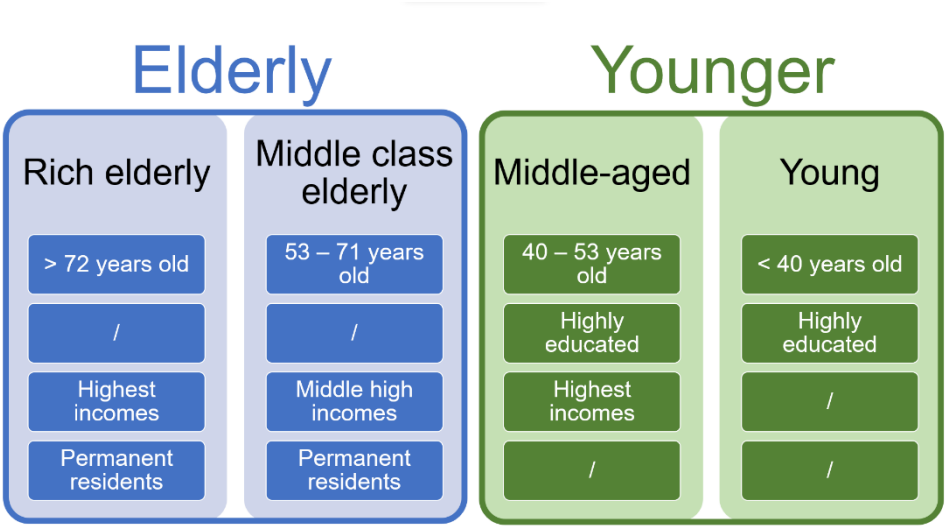


**Figure 8: Scheme of the cluster profiles**

### Combining field work and desktop study results

Unfortunately, there were no hotspots, nor coldspots found in the spatial distribution of the clusters. The spatial analysis was also performed for the parameters separately. No spatial clustering was discovered via this way either. Based on the results of this survey, it seems that the people are equally distributed over the municipality.

## 5 DISCUSSION

To get an answer to the problem statement, different methods were used to collect and analyse data. As a result of the web scraping, three price hotspots were found. These hotspots in rental price match with the visual observations that were made while walking and driving through the summer house areas and conducting fieldwork. More luxurious summer houses (larger in area, larger garden, newer houses…) were seen on site in the hotspot areas identified on the map. However, there is a mismatch between the regression analysis and the cluster analysis for Wi-Fi availability and rental price, which is against expectations. Visually, there seems to be a positive correlation between the coldspot in the prices and the coldspot in the Wi-Fi availability (Figure 1 and Figure 2). This should result in a positive correlation in a linear regression. However, a negative correlation between the rental price and the Wi-Fi availability is found in the linear regression. Intuitively the visual positive correlation makes sense, because rental houses without Wi-Fi would be expected to have a lower rental price than if they did have Wi-Fi available. The reason behind the actual negative correlation found in the linear regression is not known. It is very hard to give meaning to this relation without additional data.

The data gathered from the surveys could be more representative if they were conducted over a bigger area. Because of time restraints, the surveys in this study were only gathered in the southwest and northeast of Odsherred. These regions were chosen because of interesting results in the cluster analysis, namely the hotspot for rental prices (Figure 1). The limited study area may be a reason of why no spatial correlation is found for the people that live in the summer houses. For further research, it would be interesting to conduct the same survey around the same time in the other summer house areas of Odsherred. The data of both surveys can be combined and compared, and perhaps a spatial correlation can be found when these other regions are also taken into account.

Even though it would be interesting to conduct additional surveys in a similar period, future research should also note that this period is not optimal. The surveys in this study were conducted during three days of a school week in May. As a result, the data reflects the people that were present at that certain moment in time. Every conclusion that can be made should be seen from that certain perspective. Most

of the respondents are elderly people who are retired, live (almost) permanently in their summer house and mostly have quite a high income. The high income can be attributed to the areas we visited, which were in general areas with more expensive summer houses. The other two characteristics however are a result of the time period. Because older and retired people are overrepresented in the survey, it was not possible to find a spatial correlation of the people living in the summer house areas. It would be interesting to perform a follow-up study in the summer period, when a lot of young families come to the summer houses to enjoy their vacation. This could lead to different insights and a bigger differentiation in the respondents of the survey. Such a study would be interesting in itself, as well as a comparison between the results in summertime and the results in this study.

Most of the respondents were retired, which gives them the possibility to stay at the summer house permanently. This explains the relatively high number of people that also have their domicile in Odsherred. However, the majority of the interviewed people come from Copenhagen, or the region near Copenhagen. If this survey were repeated during summer, the expectation is that a significant number of summer house residents will still have their domicile in the region of Copenhagen, but also that other regions will be more represented. The share of people having a domicile in Odsherred will probably be lower in summertime, because more non-permanent residents will be visiting during that time.

The survey itself could also be improved. It was made before the travel to Denmark and was conducted without further adjustments. A better idea is to conduct some surveys as a test and then make changes to the survey based on the answers that were received for the questions. For example, some questions seemed to need more options for the answer or options were missing. For other questions only one answer was possible, but it would have been better if people could answer multiple things.

The application used for the survey, Survey 123, caused some problems as well. It was initially chosen because no Wi-Fi is needed to use the application. However, without Wi-Fi the map backgrounds would not load. Every map in the survey only allowed one feature to be drawn on it, and the type of feature (point, line, polygon) had to be pre-determined. If a respondent had multiple answers to a question, a new map needed to be loaded for every answer. This was a problem because loading a new map could take up to one minute. Lastly, the application only allows one answer to be recorded as geometry. This was solved by saving the other answers as text, but unexpectedly the text turned out to be the area and circumference of the polygons. In the end, the missing geometry had to be converted manually.

To validate the accuracy of the survey, answers to some questions are compared to the survey conducted by Epinion (2021) in cooperation with the municipalities of Kalundborg, Holbæk, Odsherred, and Slagelse, Destination Sjælland, Denmark Business Promotion Board, and Danish Coast and Nature

Tourism. This survey contains the answer of 852 participants with a summer house in the municipality of Odsherred and 2,367 participants with a summer house in one of the other three municipalities mentioned before. Most results of this survey line up with the survey conducted by Epinion. However, the percentage of people visiting their summer house with friends is much lower than found in the survey by Epinion. This is probably due to the ability to give multiple answers on the survey by Epinion, while this survey required one answer. Less participants of this survey visit their summer houses during the autumn compared to Epinion's survey.

**Table 3: Comparison between this study's survey and the survey conducted by Epinion**

| | This study's survey | Survey by Epinion (2021) |
|---|---|---|
| Percentage of tenants / houses for renting | 3 % | 4 % |
| Percentage of people visiting their summer house during winter | 67 % | 62 %* |
| Percentage of people visiting their summer house during spring | 89 % | 88 %* |
| Percentage of people visiting their summer house during summer | 95 % | 94 %* |
| Percentage of people visiting their summer house during autumn | 79 % | 90 %* |
| Percentage of people visiting their summer house during school holidays | 77 % | 72 – 95 %* |
| Percentage of people visiting their summer house during weekends (and national holidays) | 94 % | 81 – 96 %* |
| Percentage of people coming with family (including spouse or partner) | 75 % | ≥ 86 %* |
| Percentage of people coming alone | 23 % | 17 %* |
| Percentage of people coming with friends | 2 % | 35 %* |

* This data includes the four municipalities: Odsherred, Kalundborg, Slagelse, and Holbæk.

## 6 CONCLUSION

With over 20,000 summer houses, Odsherred is the municipality in Denmark with the highest amount of summer houses. With approximately 20 % of its surface covered by summer house areas, these areas play a very important role in the urban development and demographics of Odsherred (Odsherred Kommune, 2021). The municipality wants to attract as many visitors as possible to the municipality and the summer houses play an important role in their strategy. However, the question could be asked if this strategy should be the same over the entire municipality, or if other strategies could be more useful in different parts of the municipality. Therefore, an analysis was performed to verify if any spatial divide can be seen across the municipality. This spatial divide is twofold, the first spatial divide that is studied

is for the characteristics of the houses, which was done with a desktop study. The second spatial divide that was studied is about the people that live in the summer houses, which was done by analysing data resulting from conducting surveys. The houses themselves seem to show a spatial division based on different characteristics of the houses. Hot- and coldspots were identified for the rental prices and some coldspots were found for the availability of Wi-Fi as well. Although these two seemed to correlate positively visually, a negative correlation was found in a linear regression. The people that live or stay in the summer houses were divided in two and four clusters with similar profiles. However, these profiles did not show any sign of spatial clustering. Because of this no link could be found between the spatial division of the summer houses and the people staying in the summer houses.

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# 8 APPENDIX

## Factor Analysis

**Communalities**

| | Initial | Extraction |
|---|---|---|
| Distance to a supermarket | 1,000 | ,927 |
| Distance to a town | 1,000 | ,927 |

Extraction Method: Principal Component Analysis.

**Total Variance Explained**

| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 1,855 | 92,735 | 92,735 | 1,855 | 92,735 | 92,735 |
| 2 | ,145 | 7,265 | 100,000 | | | |

Extraction Method: Principal Component Analysis.

**Component Matrix[a]**

| | Component 1 |
|---|---|
| Distance to a supermarket | ,963 |
| Distance to a town | ,963 |

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

**Linear regression with all variables**

**Model Summary**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | ,551[a] | ,304 | ,300 | 305,206042602331540 |

a. Predictors: (Constant), distance to services, capacity, Wi-Fi, distance to the sea

**ANOVA[a]**

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 31170652,326 | 4 | 7792663,082 | 83,656 | ,000[b] |
| | Residual | 71446608,714 | 767 | 93150,728 | | |
| | Total | 102617261,041 | 771 | | | |

a. Dependent Variable: price/night

b. Predictors: (Constant), distance to services, capacity, Wi-Fi, distance to the sea

**Linear regression with only significant variables**

**Model Summary**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | ,551[a] | ,304 | ,301 | 305,046712250775800 |

a. Predictors: (Constant), capacity, Wi-Fi, distance to the sea

**ANOVA[a]**

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 31152175,610 | 3 | 10384058,537 | 111,592 | ,000[b] |
| | Residual | 71465085,431 | 768 | 93053,497 | | |
| | Total | 102617261,041 | 771 | | | |

a. Dependent Variable: price/night

b. Predictors: (Constant), capacity, Wi-Fi, distance to the sea

**Coefficients[a]**

| Model | | Unstandardized Coefficients B | Unstandardized Coefficients Std. Error | Standardized Coefficients Beta | t | Sig. |
|---|---|---|---|---|---|---|
| 1 | (Constant) | 261,912 | 43,535 | | 6,016 | ,000 |
| | Wi-Fi | -120,995 | 29,713 | -,123 | -4,072 | ,000 |
| | capacity | 87,371 | 5,096 | ,517 | 17,145 | ,000 |
| | Distance to the sea | -,056 | ,014 | -,125 | -4,163 | ,000 |

a. Dependent Variable: price/night

## Clusteranalysis

**Final Cluster Centers**

| | Cluster | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| What's the frequency of your visit to a summer house in Odsherred? | 2 | 1 | 2 | 4 |
| How old are you? | 66 | 78 | 49 | 28 |
| What is the highest degree or level of education you have completed? | 3 | 3 | 4 | 3 |
| What is your current employment status? | 4 | 5 | 1 | 1 |
| What is your monthly net income? | 3 | 4 | 5 | 3 |
| During which period do you visit a summer house in Odsherred the most? | 0 | 0 | 1 | 0 |

**ANOVA**

| | Cluster | | Error | | | |
|---|---|---|---|---|---|---|
| | Mean Square | df | Mean Square | df | F | Sig. |
| What's the frequency of your visit to a summer house in Odsherred? | 8,503 | 3 | 2,887 | 57 | 2,945 | ,040 |
| How old are you? | 4386,050 | 3 | 16,906 | 57 | 259,434 | <,001 |
| What is the highest degree or level of education you have completed? | 3,454 | 3 | 1,257 | 57 | 2,749 | ,051 |
| What is your current employment status? | 52,310 | 3 | 2,058 | 57 | 25,412 | <,001 |
| What is your monthly net income? | 8,195 | 3 | 2,693 | 57 | 3,044 | ,036 |

| | | | | | | |
|---|---|---|---|---|---|---|
| During which period do you visit a summer house in Odsherred the most? | ,644 | 3 | ,088 | 57 | 7,317 | <,001 |

**Number of Cases in each Cluster**

| | | |
|---|---|---|
| Cluster | 1 | 22,000 |
| | 2 | 26,000 |
| | 3 | 8,000 |
| | 4 | 5,000 |
| Valid | | 61,000 |
| Missing | | ,000 |

**What's the frequency of your visit to a summer house in Odsherred? * Ward Method Crosstabulation**

| | | | Ward Method | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | Total |
| What's the frequency of your visit to a summer house in Odsherred? | 0 | Count | 11 | 11 | 1 | 1 | 24 |
| | | % of Total | 18,0% | 18,0% | 1,6% | 1,6% | 39,3% |
| | 1 | Count | 6 | 3 | 1 | 0 | 10 |
| | | % of Total | 9,8% | 4,9% | 1,6% | 0,0% | 16,4% |
| | 2 | Count | 4 | 3 | 2 | 0 | 9 |
| | | % of Total | 6,6% | 4,9% | 3,3% | 0,0% | 14,8% |
| | 3 | Count | 3 | 1 | 1 | 1 | 6 |
| | | % of Total | 4,9% | 1,6% | 1,6% | 1,6% | 9,8% |
| | 4 | Count | 3 | 2 | 2 | 2 | 9 |
| | | % of Total | 4,9% | 3,3% | 3,3% | 3,3% | 14,8% |
| | 5 | Count | 0 | 1 | 0 | 0 | 1 |
| | | % of Total | 0,0% | 1,6% | 0,0% | 0,0% | 1,6% |
| | 6 | Count | 0 | 1 | 0 | 0 | 1 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | % of Total | 0,0% | 1,6% | 0,0% | 0,0% | 1,6% |
| | 7 | Count | 0 | 0 | 0 | 1 | 1 |
| | | % of Total | 0,0% | 0,0% | 0,0% | 1,6% | 1,6% |
| Total | | Count | 27 | 22 | 7 | 5 | 61 |
| | | % of Total | 44,3% | 36,1% | 11,5% | 8,2% | 100,0% |

**What's the frequency of your visit to a summer house in Odsherred? * Ward Method Crosstabulation**

| | | | Ward Method | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | Total |
| What's the frequency of your visit to a summer house in Odsherred? | 0 | Count | 11 | 11 | 1 | 1 | 24 |
| | | % of Total | 18,0% | 18,0% | 1,6% | 1,6% | 39,3% |
| | 1 | Count | 6 | 3 | 1 | 0 | 10 |
| | | % of Total | 9,8% | 4,9% | 1,6% | 0,0% | 16,4% |
| | 2 | Count | 4 | 3 | 2 | 0 | 9 |
| | | % of Total | 6,6% | 4,9% | 3,3% | 0,0% | 14,8% |
| | 3 | Count | 3 | 1 | 1 | 1 | 6 |
| | | % of Total | 4,9% | 1,6% | 1,6% | 1,6% | 9,8% |
| | 4 | Count | 3 | 2 | 2 | 2 | 9 |
| | | % of Total | 4,9% | 3,3% | 3,3% | 3,3% | 14,8% |
| | 5 | Count | 0 | 1 | 0 | 0 | 1 |
| | | % of Total | 0,0% | 1,6% | 0,0% | 0,0% | 1,6% |
| | 6 | Count | 0 | 1 | 0 | 0 | 1 |
| | | % of Total | 0,0% | 1,6% | 0,0% | 0,0% | 1,6% |
| | 7 | Count | 0 | 0 | 0 | 1 | 1 |
| | | % of Total | 0,0% | 0,0% | 0,0% | 1,6% | 1,6% |

| | | | | | | |
|---|---|---|---|---|---|---|
| Total | Count | 27 | 22 | 7 | 5 | 61 |
| | % of Total | 44,3% | 36,1% | 11,5% | 8,2% | 100,0% |

**What is the highest degree or level of education you have completed? * Ward Method Crosstabulation**

| | | | Ward Method | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | Total |
| What is the highest degree or level of education you have completed? | 0 | Count | 2 | 0 | 0 | 0 | 2 |
| | | % of Total | 3,3% | 0,0% | 0,0% | 0,0% | 3,3% |
| | 1 | Count | 3 | 2 | 0 | 0 | 5 |
| | | % of Total | 4,9% | 3,3% | 0,0% | 0,0% | 8,2% |
| | 2 | Count | 9 | 2 | 0 | 0 | 11 |
| | | % of Total | 14,8% | 3,3% | 0,0% | 0,0% | 18,0% |
| | 3 | Count | 3 | 11 | 2 | 3 | 19 |
| | | % of Total | 4,9% | 18,0% | 3,3% | 4,9% | 31,1% |
| | 4 | Count | 9 | 6 | 4 | 2 | 21 |
| | | % of Total | 14,8% | 9,8% | 6,6% | 3,3% | 34,4% |
| | 5 | Count | 1 | 1 | 1 | 0 | 3 |
| | | % of Total | 1,6% | 1,6% | 1,6% | 0,0% | 4,9% |
| Total | | Count | 27 | 22 | 7 | 5 | 61 |
| | | % of Total | 44,3% | 36,1% | 11,5% | 8,2% | 100,0% |

**What is your current employment status? * Ward Method Crosstabulation**

| | | | Ward Method | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | Total |
| What is your current employment status? | 0 | Count | 0 | 2 | 7 | 4 | 13 |
| | | % of Total | 0,0% | 3,3% | 11,5% | 6,6% | 21,3% |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | Count | 1 | 2 | 0 | 0 | 3 |
| | | % of Total | 1,6% | 3,3% | 0,0% | 0,0% | 4,9% |
| | 4 | Count | 0 | 0 | 0 | 1 | 1 |
| | | % of Total | 0,0% | 0,0% | 0,0% | 1,6% | 1,6% |
| | 5 | Count | 26 | 18 | 0 | 0 | 44 |
| | | % of Total | 42,6% | 29,5% | 0,0% | 0,0% | 72,1% |
| Total | | Count | 27 | 22 | 7 | 5 | 61 |
| | | % of Total | 44,3% | 36,1% | 11,5% | 8,2% | 100,0% |

**What is your monthly net income? * Ward Method Crosstabulation**

| | | | Ward Method | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | Total |
| What is your monthly net income? | 0 | Count | 0 | 0 | 0 | 1 | 1 |
| | | % of Total | 0,0% | 0,0% | 0,0% | 1,6% | 1,6% |
| | 1 | Count | 5 | 3 | 0 | 1 | 9 |
| | | % of Total | 8,2% | 4,9% | 0,0% | 1,6% | 14,8% |
| | 2 | Count | 2 | 2 | 0 | 1 | 5 |
| | | % of Total | 3,3% | 3,3% | 0,0% | 1,6% | 8,2% |
| | 3 | Count | 5 | 11 | 0 | 0 | 16 |
| | | % of Total | 8,2% | 18,0% | 0,0% | 0,0% | 26,2% |
| | 4 | Count | 3 | 1 | 0 | 0 | 4 |
| | | % of Total | 4,9% | 1,6% | 0,0% | 0,0% | 6,6% |
| | 5 | Count | 4 | 4 | 7 | 2 | 17 |
| | | % of Total | 6,6% | 6,6% | 11,5% | 3,3% | 27,9% |
| | 6 | Count | 8 | 1 | 0 | 0 | 9 |
| | | % of Total | 13,1% | 1,6% | 0,0% | 0,0% | 14,8% |

| | | | | | | |
|---|---|---|---|---|---|---|
| Total | | Count | 27 | 22 | 7 | 5 | 61 |
| | | % of Total | 44,3% | 36,1% | 11,5% | 8,2% | 100,0% |

**During which period do you visit a summer house in Odsherred the most? * Ward Method Crosstabulation**

| | | | Ward Method | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | Total |
| During which period do you visit a summer house in Odsherred the most? | 0 | Count | 27 | 20 | 3 | 3 | 53 |
| | | % of Total | 44,3% | 32,8% | 4,9% | 4,9% | 86,9% |
| | 1 | Count | 0 | 2 | 4 | 2 | 8 |
| | | % of Total | 0,0% | 3,3% | 6,6% | 3,3% | 13,1% |
| Total | | Count | 27 | 22 | 7 | 5 | 61 |
| | | % of Total | 44,3% | 36,1% | 11,5% | 8,2% | 100,0% |

**Survey**

Are you an owner or a tenant of a summer house in Odsherred?

- Owner
    - How many summer houses do you own in Odsherred?
    - Location of the summer houses
- Tenant
    - How many different summer houses have you already rented in Odsherred?
    - Location of the summer houses

Do you own a summer house that's not located in Odsherred?

- No
- Yes

What's the frequency of your visit to a summer house in Odsherred?

- Permantly living in Odsherred
- Weekly
- 2 – 3 times a month
- Monthly
- Several times a year
- Yearly
- Less than once a year
- First time visiting

During which seasons do you visit a summer house in Odsherred the most?

- Winter
- Autumn
- Spring
- Summer

During which period do you visit a summer house in Odsherred the most?

- During school breaks
- During school weeks

During which period do you visit a summer house in Odsherred the most?

- On weekdays
- During weekends

How did you get to know the summer house area(s) or the broader region of Odsherred?

Why did you choose to rent or to buy a house in that place?

For which type of recreation do you mostly come to a summer house in Odsherred? Which types of recreation will you perform the most during your visit?

- Walking
- Cycling or mountain biking
- Horse riding
- Running
- Playing tennis
- Swimming
- Kayaking
- (Wind) surfing
- Canoeing
- Standup paddleboarding (SUP)
- Resting
- Reading a book
- Watching television
- Playing board games
- Playing video games
- Visiting villages
- Visiting museums
- Visiting art galleries
- Visiting statues
- Visiting markets
- Relaxing by a lake, nature resort, forest or park

- Going to a beach, enjoying the facilities there
- Enjoying a panoramic view
- Visiting amusement parks
- Eating out
- Going to a bar, café or pub
- Going out to a club
- Visiting historical landmarks
- Visiting museums about the history of Odsherred
- Learning how the landscape of Odsherred has formed through time
- Other

Where do you usually do this activity?

How important is this activity to you?

Not important 0 – 1 – 2 – 3 – 4 – 5 very important

In which season do you usually do this activity?

- Winter
- Autumn
- Spring
- Summer

During which period do you usually do this activity?

- During school breaks
- During school weeks

During which period do you usually do this activity?

- On weekdays
- During weekends

Do you feel like there is enough recreation in Odsherred throughout the entire year for summer house visitors?

Not enough 0 – 1 – 2 – 3 – 4 – 5 enough

What type of recreation is missing the most?

- Walking
- Cycling or mountain biking
- Horse riding
- Running
- Playing tennis
- Swimming
- Kayaking
- (Wind) surfing
- Canoeing
- Standup paddleboarding (SUP)
- Resting
- Reading a book
- Watching television
- Playing board games
- Playing video games
- Visiting villages
- Visiting museums
- Visiting art galleries
- Visiting statues
- Visiting markets
- Relaxing by a lake, nature resort, forest or park
- Going to a beach, enjoying the facilities there
- Enjoying a panoramic view
- Visiting amusement parks
- Eating out
- Going to a bar, café or pub
- Going out to a club
- Visiting historical landmarks
- Visiting museums about the history of Odsherred
- Learning how the landscape of Odsherred has formed through time
- Other

Where do you miss the facilities do this activity?

Do you think Odsherred will attrack more visitors if there were facilities to do this activity?

Not really 0 – 1 – 2 – 3 – 4 – 5 much more visitors

In which season do you miss the facilities to do this activity?

- Winter
- Autumn
- Spring
- Summer

During which period do you miss the facilities to do this activity?

- During school breaks
- During school weeks

During which period do you miss the facilities to do this activity?

- On weekdays
- During weekends

In which country are you born?

What's your nationality?

In which country do you live at the moment?

In which municipality do you live at the moment?

How old are you?

What is the highest degree or level of education you have completed?

- Less than middle school or lower secondary education (less than folkeskole)

- Middle school degree or equivalent (folkeskole)
- High school degree or equivalent (ungdomsuddannelse)
- Bachelor’s degree or equivalent
- Master’s degree or equivalent
- PhD degree

What’s your current employment status?

- Employed full-time
- Employed part-time
- Seeking opportunities
- Currently at home
- Student
- Retired

What is your monthly net income?

- Less than 7500 DKK (€ 1000)
- 7500 to 14 999 DKK (€ 1000 to 1999)
- 15 000 to 19 999 DKK (€ 2000 to 2699)
- 20 000 to 29 999 DKK (€ 2700 to 3999)
- 30 000 to 39 999 DKK (€ 4000 to 5399)
- 40 000 DKK (€ 5400) or more
- I prefer not to answer

How large is the group with whom you’re visiting Odsherred?

How are you related to each other?

- Family
- Friends
- Alone
- Organisation (business, school, summer camp...)
- Other

# Assessing coastal vulnerability by erosion and risk perception in Sjælland Odde

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# 1 INTRODUCTION

Erosion is a natural process that has shaped the surface of the earth since its beginning. Coastlines can be especially vulnerable to erosion because of the coincidence of different factors contributing to erosion, such as increased wind speeds, proximity to ocean currents, tidal currents, and ocean waves. This implies that countries with large coastlines are more prone to erosion. Coastal erosion can have a personal impact on residents living near the coasts as well as a broader, larger-scale impact on the socio-economic reality within a country. Coastlines that are vulnerable to erosion can for example recede inland, threatening local residences as well as economic activities taking place in the vulnerable area. Climate change can influence the rate of erosion and thus coastal vulnerability, making the study of coastal vulnerability an important field of study in the context of global warming.

The importance or usefulness of protecting coastlines however isn't merely determined by the vulnerability of the coast but also by other, human-related factors. The importance that is given to protecting the coastline can vary based on individual, socio-economic, cultural, and geographical factors. Knowledge of these factors can be important for deciding on which policy measures can be implemented in order to protect the coast in a way that minimizes costs and maximizes benefits considering the local context.

The risk perception of the local population can be such an important factor in determining the support for protective measures and their funding. By linking the risk perception of people to their socio-economic characteristics and spatial distribution, governments can be more aware of the risk perceptions of both spatially and demographically different populations. This information can be used to assess the importance the local people give to the protection of their coastline as well as to assess the amount of action needed to raise awareness as well as the most efficient action that can be taken to raise awareness if this is considered important by respective governments.

This paper discusses research conducted in the Sjaellands Odde peninsula in the Sjaelland province, Denmark. Denmark consists of multiple islands, has a large coastline, and is low in elevation making it a good study area for coastal erosion. Sjaellands Odde has a large number of summerhouses but also hosts regular residences. The spatial variation in coastal vulnerability of the peninsula was assessed by calculating a coastal vulnerability index using GIS analysis. The risk perception of local people was assessed using surveys. The surveys also included questions assessing the respondent's socioeconomic and spatial characteristics. The variation in the coastal vulnerability index and the socio-economic and spatial characteristics was then analysed in terms of their explanatory ability for predicting risk perception using linear regression.

The remainder of this paper is as follows; part 2 elaborates on the theoretical framework that was used to calculate the coastal vulnerability index as well as to measure the risk perception, part 3 explains the research objectives in further detail and , part 4 further explains the used methodology, part 5 discusses

the results and the final parts provide a discussion and conclusion based on the results. An appendix was also included with extra information.

# 2 THEORETICAL FRAMEWORK

## 2.1 Assessing the Coastal Vulnerability

### *2.1.1 Historical development of Sjællands Odde*

In short, the current landscape of Sjællands Odde mainly took shape by Weichselian glacial processes, later sea level rise, and isostatic uplift. When the Nordøstisen advanced, from 23.000 years ago and onwards, flakes of clay from the Elster Glaciation and the subsequent Holstein interglacial were accumulated by the glacier. As the Nordøstisen retreated, a dead-ice moraine formed where the present-day central area of Sjællands Odde is. Later, 18.000 years ago, the Bælthavisen advanced, and formed the Odsherred Arches, southeast of the present-day Sjællands Odde.

When the Littorina Sea reached its greatest extent 7.000 years ago, Weichselian meltwater plains and areas eroded by the glaciers during the ice age were covered by the sea, with only the highest areas remaining above sea level. Later, the isostatic rebound lifted the landscape up, with the former seabed and its sediments becoming dry land as a result (Roll Jakobsen et al., 2015).

An overview of the islands geological changes can be seen in figure 2, the time periods it happened in is also situated in a geological time scale in figure 1.

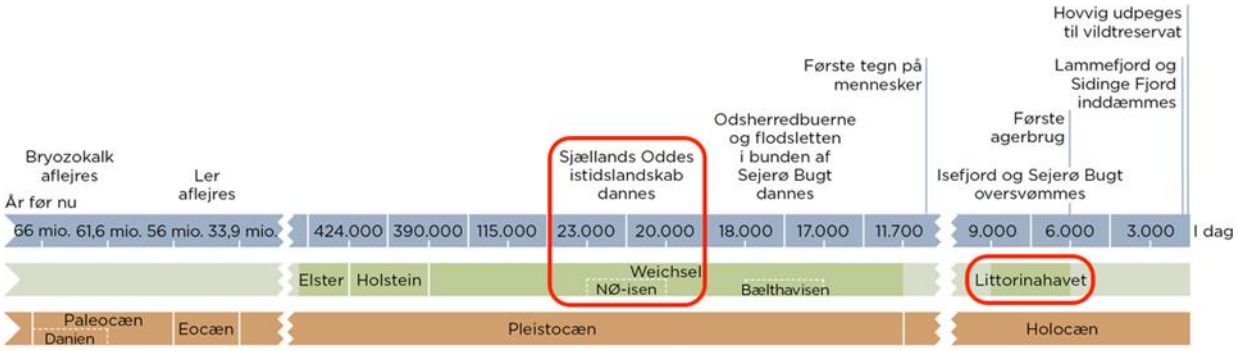



*Figure 1: Annotated geological time scale (Gravesen, 2021)*

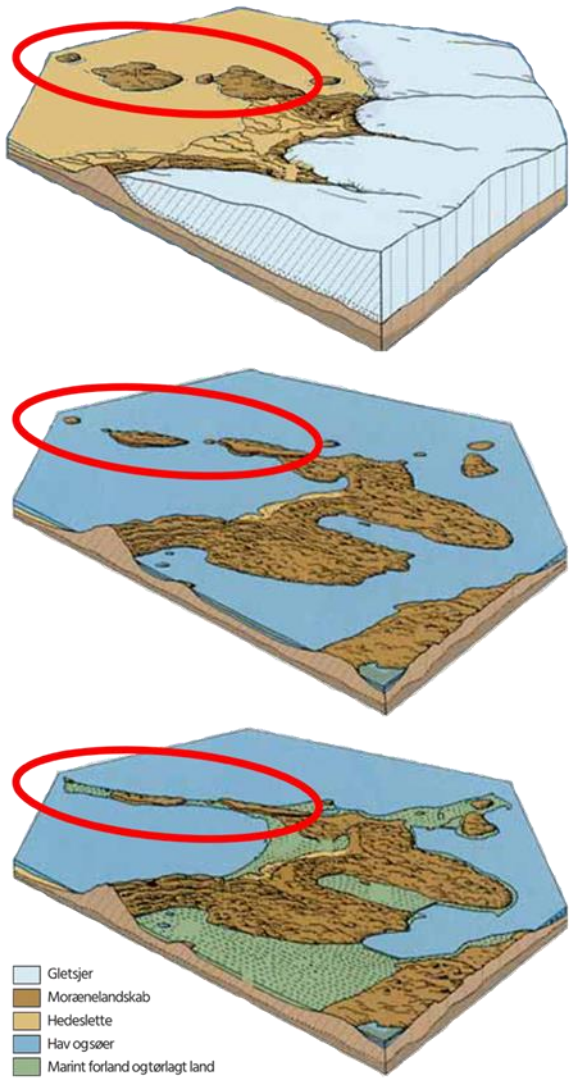



*Figure 2: Formation of the Odsherred landscape, Sjællands Odde encircled in red. The first illustration shows the Bælthavisen, which came after the Nordøstisen, which formed the Sjællands Odde moraines. The second illustration shows the Littorina Sea level. The third illustration shows the landscape after isostatic rebound. (Roll Jakobsen et al., 2015, p. 7)*

### *2.1.2 Erosion*

Soil erosion, often shortened as erosion, is a geomorphological process where soil particles, rock fragments, soil aggregates, and organic matterares loosened at one location and transported to another location. Different processes can cause erosion, they can be classed as natural, human-induced or biological, processes. There are different environmental factors that have an impact on erosion: soil type, topography, land use etc. (Poesen, 2018).

The focus of this research lies on coastal erosion caused by water, a natural process from the island being surrounded by sea.

### *2.1.3 Erosion caused by ferry waves*

Naturally waves are formed by the wind, but in some cases, they are formed due to the movement of ships. At the end of the peninsula, the ferry between Sjælland and Jylland can be found. The impact of the waves around the port has been studied in the past (Piazza, 2014). The areas closest to the port of the ferry are under influence of the waves caused by the ships leaving and entering. The study found that the area just north of the port accumulates more sediment due to the current. The port blocks the current from passing the sediments more east along the coast. The recessed southern edge of the port is protected against the strong west winds. The summer house area on the tip of the peninsula, facing the wind and current coming from the west, is showing significant signs of erosion and flooding.

## 2.2 Measuring Risk Perception

Risk perception is a reflection of the interpretations of risk. It reflects the subjective judgments of a person about the likelihood of negative occurrences (Paek & Hove, 2017). In the research paper of Slovic et al. (1980) risk is defined as a possibility, where its parameters are defined by the perception of risk by the individual. Therefore, it is important to identify the hazard.

Objective risk is commonly defined by experts as the probability of negative outcomes weighted by their severity (Wolf et al, 2019). Almost the same holds true for the definition of subjective or perceived risk in expected utility theories in economics and psychology. Both definitions assume that people assess severity and probability of possible outcomes perceived risk doing so subjectively and with error. Within expected utility theory it is assumed that people integrate this information into an estimate of perceived risk (Wolf et al, 2019). People's risk perception can be measured by using indicators that provide information about the way people perceive risks. Different indicators can be used and there is no clear consensus within the scientific literature on which indicators should be used to measure risk perception (Wolf et al., 2019). Kellens et al. (2012) analyzed 57 papers related to flood risk perception and summarized based on these papers five frequently used variables to measure risk perception. The most used are impact, likelihood, awareness, affect (of worry, fear, concern), and causation or origin.

Following the study of Liu et al. (2018) and the study of Ridha et al. (2022) perceived likelihood, worry/fear, perceived impact/severity and the willingness to pay were chosen to measure the risk perception in this study. Perceived likelihood refers to people's perceived probability of an event happening, while worry refers to a feeling related to anxiety about the risk. Perceived impact/severity refers to the perceived impact that an event will have on the object of study while willingness to pay refers to a respondent's willingness to take personal action to lower the risk which can be considered as an indirect indicator of their perception of the risk.

The indicators "perceived likelihood" and "perceived impact" were included in the survey to best reflect the way in which both objective and subjective risk are defined within expected utility theory as used

within the fields of psychology and economics. These two indicators mostly refer to cognitive evaluations of risk which can be highly influenced by a person's affect, but which don't measure their underlying feelings directly (Wolf et al., 2019). The link between a person's affect, feelings of worry and anxiety can be related to their cognitive evaluation of the risk, but feelings of worry and the cognitive evaluation of risk aren't necessarily connected (Wolf et al., 2019). People can experience worry and anxiety despite perceiving the risk as low, and they can experience no worry and anxiety despite perceiving the risk as high (Wolf et al., 2019). This makes an indicator of worry a less reliable indicator for measuring perceived risk; however, feelings of worry can still affect people's cognitive evaluation of risk unknowingly as well as highly influence their behavior and attitudes (Wolf et al., 2019). For this reason, a worry indicator was also included in the survey. Additionally, willingness to pay was also included because it can be considered an indirect indicator of risk perception as well as a valuable assessment of the willingness of people to support the reduction of the risk.

A survey was made to include at least one question related to the aforementioned indicators.

### 2.3 Linking Risk Perception to Socio-Economic and Spatial Variables

Socioeconomic and spatial variables are important in the sense that they can provide more information about why the risk perception scores are the way they are. These so-called explanatory variables are statistically significant, based on the used dataset retrieved from the survey's answers, when ran through a linear regression. These findings can be used for example in policy's awareness strategies.

Socioeconomic and spatial variables that were observed as important in other studies regarding flood risk perception were incorporated in the survey. Knowing that flood risk perception differs from the risk perception that is defined in this study, it is seen as subsequent and thereby useful, mainly because of the lack of existing literature because of a very specific type of risk perception that is studied. Adelekan and Asiyanbi (2016) found that age has an important impact on the risk perception of floods. S. Qasim, Khan, Shrestha and M. Qasim (2015) found that ownership of the house, education level and distance from the waterbody had an influence on people's risk perception. Gender was also identified as a major influence on how an individual perceives the risk (Kellens, Terpstra & De Maeyer, 2013). Income is also frequently used in these type of studies (Liu et al., 2018).

Next to these specific socioeconomic and spatial variables, other related variables were incorporated in the survey which were thought to have a significant impact in the explanation of risk perception or are in line with the above variables. The survey is consultable in appendix 1.

# 3 RESEARCH OBJECTIVES

In this research, the main objective is to see if there is a relation between the risk perception of the inhabitants of Sjællands Odde and their socioeconomic factors and if a spatial relationship exists between risk perception and the place of residence of the inhabitants on the peninsula.

Socioeconomic factors can influence risk perception. For example, older people can be more aware of erosion itself because they have experienced it, but they might be less worried about something that will, according to them, never happen in their lifetime. Another example is that less educated people may be less aware of the risk and thus feel less worried about risks they should be aware of.
The place of residence can affect the perception of the risk of erosion because not all places on the peninsula are equally vulnerable to coastal erosion. It is expected that inhabitants closer to a more vulnerable coastline will perceive the risk higher than inhabitants further away from more vulnerable coasts. A relation between the vulnerability to erosion and the risk perception will be examined. Therefore, the vulnerability to erosion along the coastline must be determined. This will be done by a GIS analysis.

Not only the proximity to erosion vulnerability can influence the risk perception, but also the distance to the coastline in general can influence the risk perception. Residents closer to the shore may experience more of the effects of erosion and thus may feel more worried. There could be a difference between permanent and non-permanent residents or a difference between owners and tenants. Permanent residents or residents who own property on the peninsula may feel more worried than non-permanent residents or tenants.

The goal of this research is not to determine the risk of erosion but to see if there are correlations between how the inhabitants of the peninsula perceive or feel threatened by the risk to erosion and the socioeconomic factors and if a spatial relationship exists.

The result of this research can be used for governments to see where and on which socioeconomic groups and which residents they need to raise awareness about the risks of coastal erosion and if there is support by the local residents if the government decides to take protective measures.

# 4 METHODOLOGY

## 4.1 GIS Analysis

The goal of the GIS-analysis is to better understand the erosion or accretion that takes place on the coastline in Sjaellands Odde (Vasilis Kotinas et al., 2016). This is knowledge is very important towards coastal planning. Over the years different models or indicators have been used to estimate coastal erosion. All these different models start however from the same principle: they take each parameter into account in relation with future climate chance and how this will affect the sea level rise. In this paper

the ‘coastal vulnerability index’ was used from Gornits et al. (1994). This index takes physical elements and give each element a numerical value so it can be quantified. A higher value means a higher vulnerability. In the end the target is to create a map where the relative vulnerability of Sjaellands Odde is displayed.

### *4.1.1 Model*

In the model different factors are used to determine the vulnerability: relief, geology, geomorphology, vertical movement, shoreline displacement, tidal range and wave height (Kotinas et al., 2016). Not all factors were however used in this research. Sjaellands Odde is a relatively small region (circa 23km²). Some factors are therefore the same across the whole peninsula and therefore not included in this research, because there is no difference between different parts of the shoreline. The factors that were not included are: geology, tidal range, and wave height. There are also other factors that could be taken into account when calculating the coastal vulnerability index such as annual tropical storms and hurricane probability, but these don’t occur in Denmark. Extratropical storms do occur in Denmark, but this factor was not taken into consideration. It can be expected that the impact of those storms would be significantly lower than tropical storms, however leaving this factor out still provides a limitation to our research that is important to note. For the geology there are only the sedimentary rocks that are laying alongside the coast. So, there are no differences alongside the coast.

Tidal range is important because of the inundation of the coastal area. This can be divided into two categories: permanent and episodic inundation events (Kotinas et al., 2016). Areas with a high tide range are more susceptible to permanent flooding following sea level rise. This effect can be reinforced with the combination of storms. On Sjaellands Odde there is a microtidal tide present. This means that the tidal range is very small (less than 0,5m) (Alve & W.Murray, 1999). This can be explained by the small passage towards the North Sea, northwest of our study area. Furthermore, there is no difference between the north and south coast. This variable would therefore make no difference in this research. Also, the wave height indicates the number of materials that have permanently been transported from one beach to another (Vasilis Kotinas et al., 2016) and is dependent on the maximum significant height of the waves. Because of the same reason as the small tidal range there aren’t heigh waves alongside the coast. The small passage to the North Sea protects Sjaelland from big swell waves, who originate from the ocean. The only waves that are present are the wind waves. These waves have much less energy than the swell waves and therefore have a much smaller impact on the coast. Because the wind is the only factor that the waves influence the wave height is the same on both sides and therefore, we can ignore the height of the waves. Because there is no relative difference between the north and south coast. Each factor that was used was divided into five different categories based on the characteristics of the coast and given a score from 1 to 5, with 5 being the most vulnerable.

The following formula was used:

$$CVI = \sqrt{\frac{a * b * c * d}{4}}$$

With a, b, c and d being the factors.

All factors have the same importance in this formula, but this isn't the correct representation of the influences each factor has on the coast. Some elements have a much higher impact on the vulnerability of the coast than others. By using a SAATY analysis each factor can be weighed, which influences the importance (see further). At the end, the values were standardized to make everything more comprehensive.

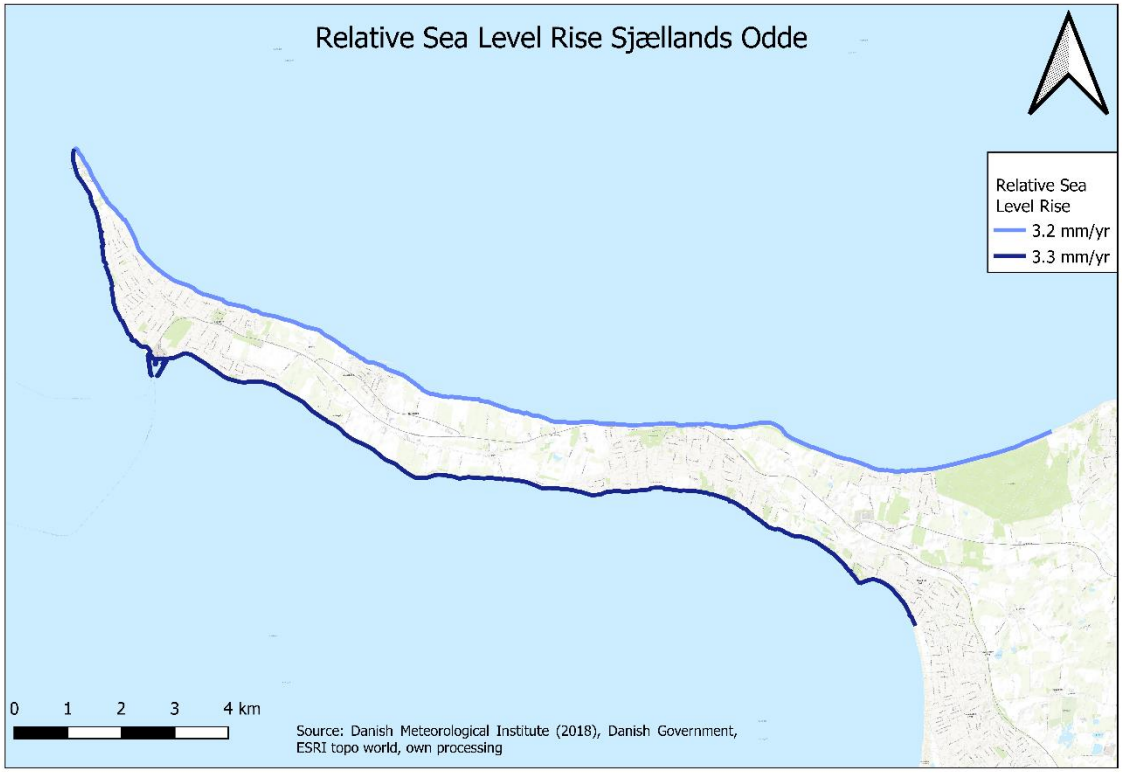
### *4.1.2 Factors*

#### 4.1.2.1 Sea level rise

The first factor taken into account is the expected sea-level rise in the coming decennia. The sea-level rise is partly compensated because of the uplift of the land. There is however still a difference between the north and south coast of Sjællands Odde. On the south coast, the uplift is weaker than on the north, therefore the south coast will be more affected.

Relative sea-level rise values are taken from the Danish climate adaptation portal (n.d.) which predicts the sea-level rise under different climate change scenarios and different extreme events. Here the values are taken for the stabilization scenario (RCP 4.5).

Different values are available for the two parts of the peninsula. The northern part of the Sjælland coast and Sejero Bay were analysed separately so different values for sea-level rise are available for the northern and southern part. The relative sea-level rise in the Sejero bay is 3.2 mm/year which results in the value 4, the sea-level rise on the northern part of the peninsula is 3.3 mm/year which results in the value 5. These values can be seen on map 1.




*Map 1: Relative sea level rise Sjællands Odde*

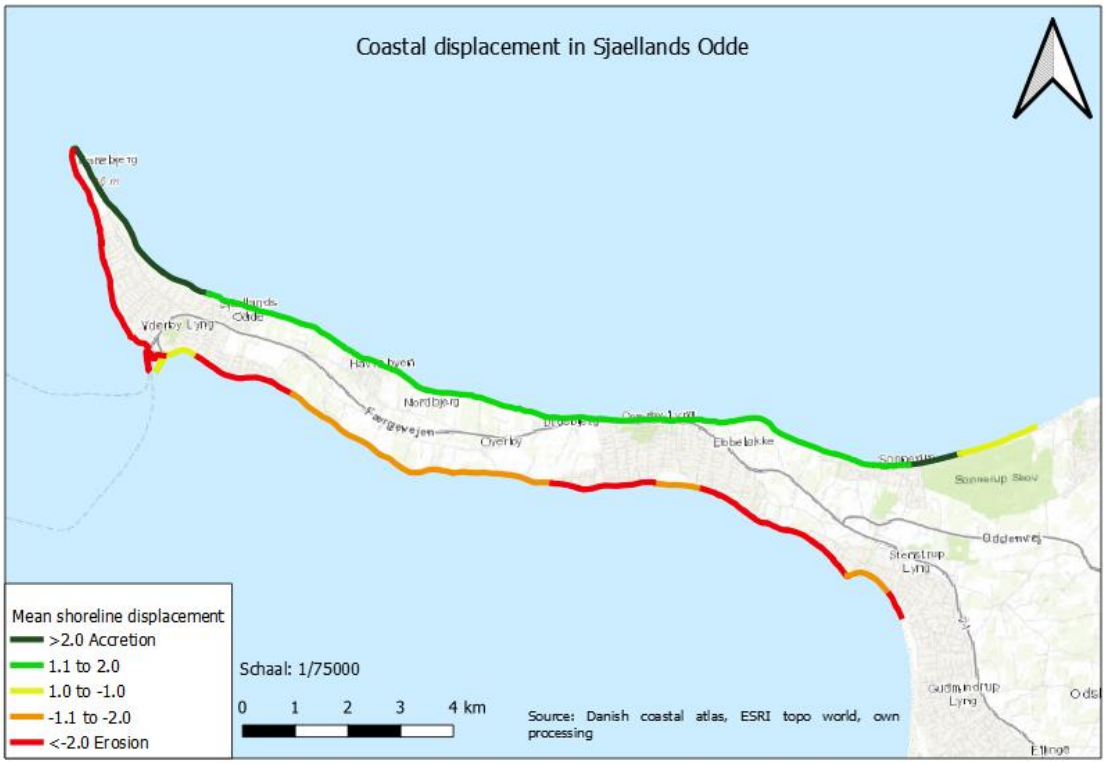
#### 4.1.2.2 Mean shoreline displacement

The best way to research shoreline displacement is by looking at historical data. The data used in this research is from the European Atlas of seas (European commission, 2019). They measured the yearly chance rate of the coast based on satellite data over a period of ten years. In this category places were divided into different groups based on the amount of accretion or erosion that took place. These groups are displayed in Table 1.

*Table 1: Erosion groups based on Kotinas et al. (2016)*

| CVI | Very low | Low | Moderate | High | Very High |
|---|---|---|---|---|---|
| Variables | 1 | 2 | 3 | 4 | 5 |
| Mean shoreline displacement (m/year) | >2.0 accretion | 1.1 to 2.0 | 1.0 to -1.0 | -1.1 tot -2.0 | <-2.0 erosion |

This data was then used to create a map based on these values (see map 2). On the map it is visible that almost on the complete north coast accretion took place, while on the south coast erosion was present.



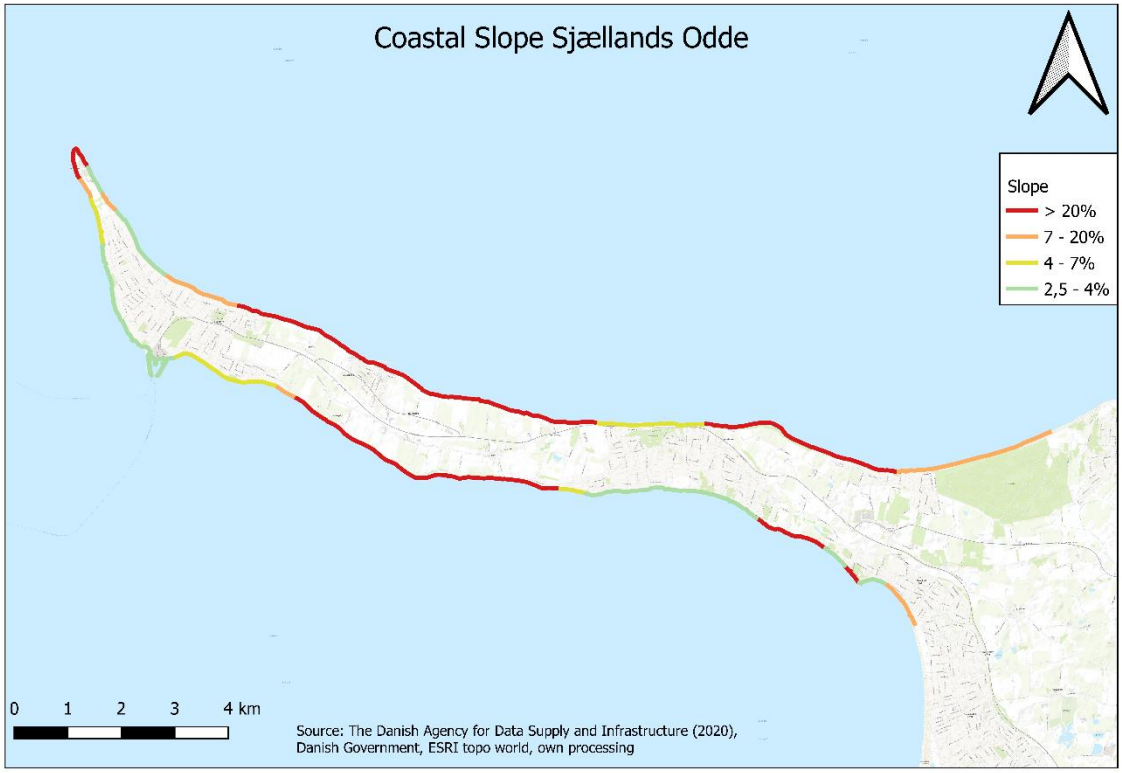

*Map 2: Coastal displacement in Sjællands Odde, European Commission (2019)*

#### 4.1.2.3 Slope

The slope of the shoreline is based on the digital elevation model of the study area. A buffer of the shoreline of 4 meters was created. From this buffer, the DEM was clipped to get an elevation model of only the shore. Based on this elevation model the slope of the coastline was calculated. This is visualised on map 3. The slope values were reclassified from 1 to 5 to get the right values for the CVI calculation. A high slope gets a low value. The slope values are reclassed according to classes in table 2. A slope of less than 2.5% isn't present. The erosion groups used are based on Kotinas et al. (2016), the data for the peninsula has been calculated using the digital elevation model of Denmark (Christensen, 2020).

*Table 2: Groups of coastal slopes based on Kotings et al. (2016)*

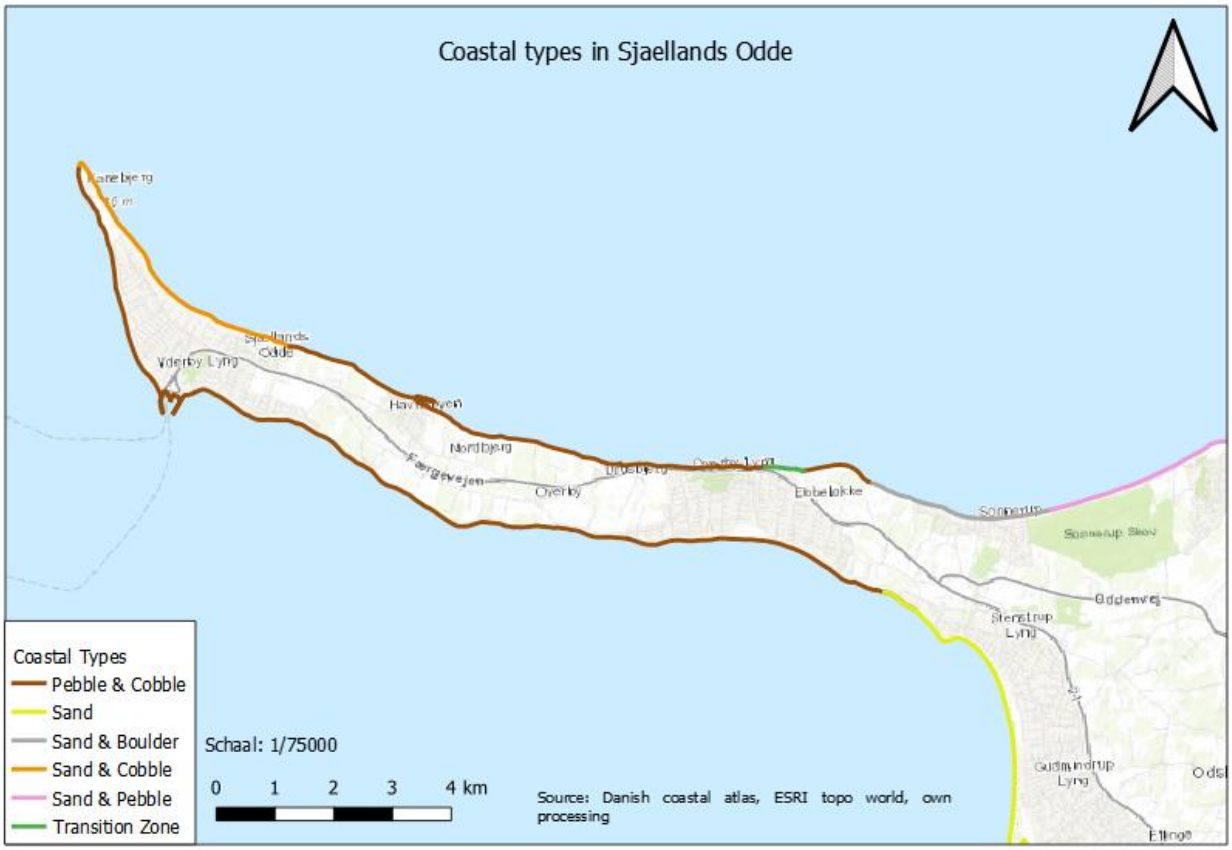
| CVI | Very low | Low | Moderate | High | Very High |
|---|---|---|---|---|---|
| Variables | 1 | 2 | 3 | 4 | 5 |
| Coastal slope (%) | > 20 | 7 – 20 | 4 - 7 | 2.5 - 4 | > 4 |




*Map 3: Coastal slope in Sjællands Odde*

#### 4.1.2.4 Geomorphology

The erosion on the coast is very dependent on the geomorphology. Sand beaches for example will erode much faster than rocky beaches (Kotinas et al., 2016). In Sjællands Odde there are five different types of coasts: sand and boulder, pebble and cobble, sand cobble, sand and transition zone. These types are displayed on the map below (map 4).




*Map 4: Coastal types in Sjællands Odde*

These types were grouped into different categories depending on how resistant each type is against erosion. Pebble and cobble, sand and pebble or boulder beaches are the most resistant. The least resistant type of coast is a sand shore and a transition zone. Again, each type of coast has been assigned a value from 1 to 5. This was done according to the table used in Kotinas et al. (2019) which you can find below (table 3).

*Table 3: Group of coastal geomorphologies, Kotinas et al. (2019)*

| CVI | Very low | Low | Moderate | High | Very High |
|---|---|---|---|---|---|
| Variables | 1 | 2 | 3 | 4 | 5 |
| Geomorphology | Rocky, cliffed coasts, fiords, fiards | Medium cliffs, idented coast | Low cliffs, glacial drift, alluvial planes | Cobble beaches, Estuary, Lagoon | Barrier beaches, sand beaches, salt marsh, mud flats, deltas, mangrove, coral reefs |

### *4.1.3 AHP analysis*

Since not all factors contribute the same to erosion vulnerability, weights must be assigned to the factors and their values. This will be done by using the analytic hierarchy process (Saaty, 2013). This method is based on assumptions made for the different effect of the factors on the erosive processes. First al

the factors will be rated relative to each other, which will result in the ranking matrix. From this the sum values of each factor can be calculated. This value is needed for the weight-matrix where the weights will be extracted from. The weights are a result of the average of the of the values of the factors in the ranking matrix divided by the sum of the values of the factors. The sum of the weights will be one. The ranking matrix and the weight-matrix are seen in respectively table 4 and 5.

*Table 4: Ranking matrix*

| | F1 | F2 | F3 | F4 | ∑ |
|---|---|---|---|---|---|
| F1 | 1.00 | 3.00 | 0.20 | 3.00 | 7.2 |
| F2 | 0.33 | 1.00 | 0.33 | 2.00 | 3.666666667 |
| F3 | 5.00 | 3.00 | 1.00 | 3.00 | 12 |
| F4 | 0.33 | 0.50 | 0.33 | 1.00 | 2.166666667 |
| ∑ | 6.666667 | 7.5 | 1.866667 | 9 | |

*Table 5: Weight-matrix*

| | | | | | Average |
|---|---|---|---|---|---|
| F1 | 0.15 | 0.4 | 0.107143 | 0.333333 | 0.247619048 |
| F2 | 0.05 | 0.133333 | 0.178571 | 0.222222 | 0.146031746 |
| F3 | 0.75 | 0.4 | 0.535714 | 0.333333 | 0.504761905 |
| F4 | 0.05 | 0.066667 | 0.178571 | 0.111111 | 0.101587302 |
| | | | | | 1 |

### 4.2 Survey

To compare the risk perception regarding the coastal vulnerability of the inhabitants of the study area, a questionnaire was made (see appendix 1). The amount of risk perception is gauged by four questions measured on a 5-point Likert scale ranging from strongly disagree/ very unlikely (score: 1) to strongly agree/ very likely (score: 5) with neither agree nor disagree in between (score: 3). The used questions are based on the worry, impact and aware approach of Li and Liu (2016) and Rhida et. Al. (2022).

*Table 6: Distribution of the risk perception questions*

| Question | Indicator | Knowledge (awareness in general) | Focus of the question |
|---|---|---|---|
| How likely do you think that this type of erosion will happen to your area | Perceived likelihood | Awareness of probability Cause-knowledge | Probability |
| When I think about erosion, I feel worried for the coastline closest to where I'm staying/living | worry | Awareness of consequences/impact emotion/feeling | Worry/fear/feeling |
| When I think about erosion, I feel worried for the area surrounding the house where I'm staying/living | worry | Awareness of consequences/impact, emotion/feeling | Worry/fear/feeling |

| | | | |
|---|---|---|---|
| To what extent would the property where you stay/live be affected by the erosion processes | Perceived impact/ severity | Question implies awareness about the severity of possible negative consequences | Impact/ severity |

The social economical and spatial characteristics are assessed as followed. The survey starts with some spatial questions which ask where they live, where they stay in Sjaellands Odde, if they are owner of tenant of that property and how often they visit it. All these questions are categorical questions who give some information for a quantitative analysis. It is followed by a numerical scale on ten where the respondent needs to say how important Sjaellands Odde for him is. This question is also quantitative but has also a qualitative side because it is followed by an open question about what that makes it that important for the respondent. After the spatial part of the survey some pictures about erosion on the island are shown so that some questions about the risk perception and willingness to pay could be asked. The survey ended with the socioeconomical questions which were mainly categorical questions about age, family, average income and educational background and some open questions so that the influence of the respondents on risk perception could be analysed. The structure of the survey was made this order to make the respondents comfortable talking about their personal financial situation.

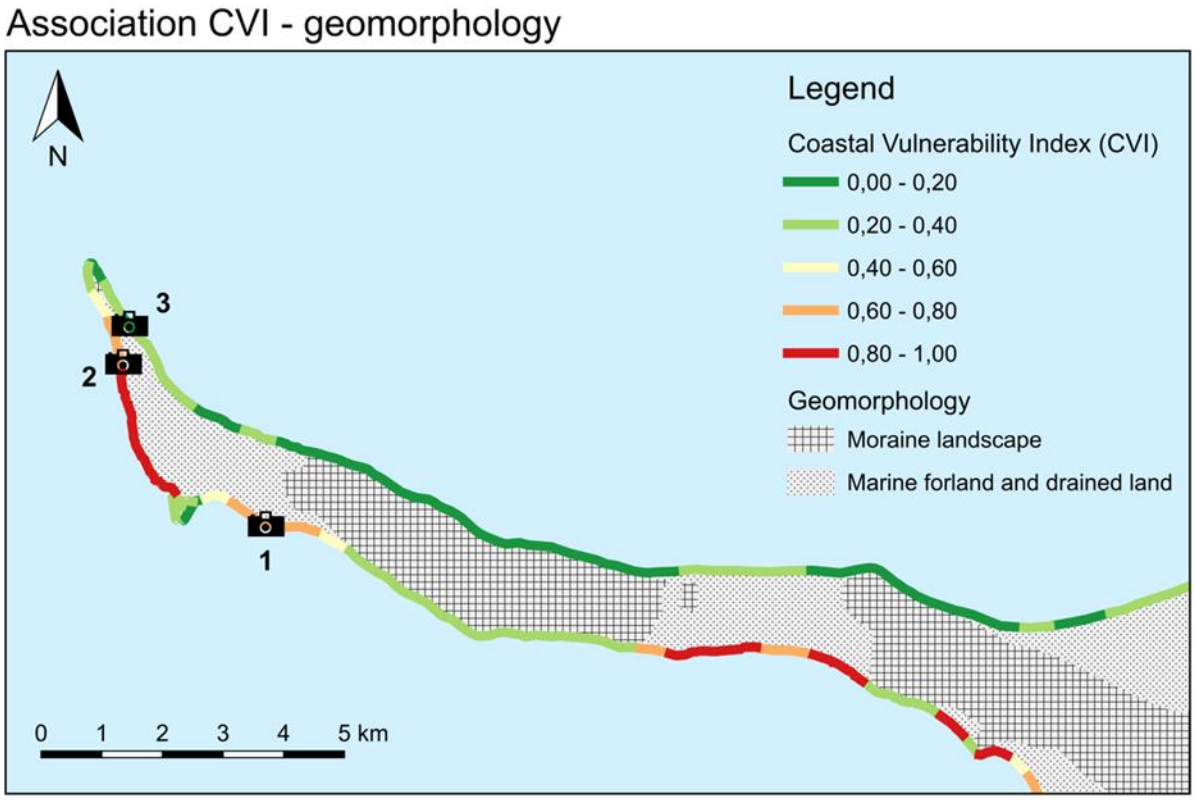
# 5 RESULTS

## 5.1 Coastal Vulnerability

When looking at the spatial pattern of the calculated coastal vulnerability index (map 5), we notice that in general, the northern coastline of Sjællands Odde is less vulnerable than the southern coastline. The plausible assumption that the northern coastline is more vulnerable due to its exposure to Kattegat, appears to be untrue.

On the southern coastline, there appear to be three main areas were a high CVI has been calculated. In the west, from the point of the peninsula to the eastern extent of the western summer house area, high CVI's have been calculated, with exception for the harbor. The second stretch with a high CVI is located along the second summer house area. The third along the eastern part of Sejerø Bugt.

With the historical geomorphological development of Sjællands Odde and the consequent present-day landscape in mind, a link between the calculated coastal vulnerability index and geomorphology is assumed. The geomorphological map from *De Nationale Geologiske Undersøgelser for Danmark og Grønland* (GEUS, n.d.) for Sjællands Odde was aggregated into 'moraine landscape' and 'marine foreland and drained land'. A clear association was observed and is displayed on the map below. The two determining factors for coastal vulnerability appear to be geomorphology (moraine or marine) and orientation (northern or southern coastline).




*Map 5: Association CVI - geomorphology*

Observations in the field confirm the vulnerability of the sections of coastline with a high CVI. Significant coastal erosion can be observed at site 1 (figure 3), local summer house owners speak of five to ten meters coastal recession in a decade. At site 2 (figure 4) a double dike was constructed after multiple storms flooded the area. At site 3 (figure 5), on the northern coastline, a high CVI was calculated. In the field, we observe that dunes protect the coastline.

*Figure 3: Significant coastal erosion at site 1 (see map 5), high CVI*

*Figure 4: Double dikes constructed at site 2 (see map 5), very high CVI*

*Figure 5: Dunes protect the coastline at site 3 (see map 5), low CVI*

## 5.2 Risk Perception

### *5.2.1 Sample characteristics*

The total number of participants is 66. Most of the questionnaires are carried out from door to door, this within a distance of 150 meters from the coastline along the whole coastline. Another part of the surveys is taken at local shops or in the harbour. The questionnaires were only executed in English, what makes a bias towards English speaking respondents. Table 3 gives an overview of the frequencies of the personal and residence characteristics. One third of the participants its residence is in Sjaellands Odde itself. More than 85% of the respondents is owner of the property where they are staying in Sjaellands Odde and 40% of the respondents lives there permanently. From more than eighty percent of the forty

people that don't stay permanently in Sjaellands Odde the average duration of the stay is up to a week or longer. The gender distribution is more or less equally divided, and the bigger part of the respondents are older than 65 years what could be explained by the period where the surveys were conducted. It was during a workweek out of the vacation period of Denmark. A summer or vacation period would give more variety in the dataset.

*Table 7: Overview of the sample characteristics*

| Variable | Number | Percentage | Variable | Number | Percentage |
|---|---|---|---|---|---|
| Residence | | | Gender | | |
| Danmark | 13 | 19,70% | Female | 33 | 50,00% |
| Odsherred | 7 | 10,61% | Male | 32 | 48,48% |
| Out of Denmark | 3 | 4,55% | X | 1 | 1,52% |
| Sjaelland | 23 | 34,85% | Total | 66 | 100,00% |
| Sjaellands Odde | 20 | 30,30% | | | |
| Total | 66 | 100,00% | Age | | |
| | | | 18 -24 years old | 3 | 4,55% |
| Owner or tenant | | | 25-39 years old | 8 | 12,12% |
| Owner | 57 | 86,36% | 40-64 years old | 14 | 21,21% |
| Tenant | 9 | 13,64% | 65 years old < | 40 | 60,61% |
| Total | 66 | 100,00% | No answer | 1 | 1,52% |
| | | | Total | 66 | 100,00% |
| Here permanent? | | | | | |
| No | 40 | 60,61% | Educational level | | |
| Yes | 26 | 39,39% | Academic bachelor/master | 24 | 36,36% |
| Total | 66 | 100,00% | Grund skulle | 15 | 22,73% |
| | | | Gymnasium | 8 | 12,12% |
| Visitation frequency | | | Professional Highschool | 19 | 28,79% |
| Every 2 weeks | 35 | 53,03% | Total | 66 | 100,00% |
| Every month | 12 | 18,18% | | | |
| Every week | 14 | 21,21% | Marital status | | |
| Every year | 3 | 4,54% | Divorced | 2 | 3,03% |
| Less than once a year | 2 | 3,03% | Legally living together | 8 | 12,12% |
| Total | 66 | 100,00% | Married | 45 | 68,18% |
| | | | Single | 8 | 12,12% |
| Visitation duration | | | Widow | 3 | 4,55% |
| < 3 days | 5 | 12,50% | Total | 66 | 100,00% |
| > two weeks | 9 | 22,50% | | | |
| Up to a week | 21 | 52,50% | Children | | |
| Up to two weeks | 5 | 12,50% | no | 10 | 15,15% |
| Total | 40 | 100,00% | yes | 56 | 84,85% |
| | | | Total | 66 | 100,00% |
| Importance score island | | | | | |
| 4 | 2 | 5,13% | Total annual income | | |
| 5 | 1 | 1,52% | < 180 000 DKK | 5 | 7,58% |

| | | | | | |
|---|---|---|---|---|---|
| 6 | 1 | 1,52% | > 350000 DKK | 36 | 54,55% |
| 7 | 3 | 4,55% | 180 000 DKK - 350 000 DKK | 18 | 27,27% |
| 8 | 17 | 25,76% | Empty | 7 | 10,61% |
| 9 | 9 | 13,64% | Total | 66 | 100,00% |
| 10 | 33 | 50,00% | | | |
| Total | 66 | 100,00% | | | |

### *5.2.2 Statistical analysis*

A statistical analysis is necessary in order to find potential relations in the surveys data between socioeconomic and spatial variables and the indicators that explain risk perception. First, surveys that have at least one question that hasn't been answered are deleted from the dataset. Next an exploration of the data took place through descriptive statistics by looking at the frequencies of the given answers. Then correlation between the indicators is checked and found, which resulted in the execution of a factor analysis. At last, hypotheses were tested in trying to find significant relations between the variables and the new produced factors. This is done via linear regressions.

#### 5.2.2.1 Factor analysis

The used survey was made by assuming dimensionality of the data in 4 indicators: perceived likelihood, perceived impact/severity, worry and willingness to pay. These indicators can however be correlated, and the "true" dimensionality of the survey can differ from the assumed dimensionality based on the used literature. Therefore, a correlation matrix was generated as well as a Kaiser-Meyer-Olkin Measure of Sampling Adequacy Test (KMO). Values in the correlation matrix above 0,5 means that there is a correlation between the two indicators in question. The results (appendix 2) showed that multiple bivariate correlation values were just not 0,5 and one was even 0,658. The KMO value of the indicators amounts to 0,751. This is higher than the 0,5 threshold. Adding the fact that the correlation for each pair of indicators is statistically significant, the execution of a factor analysis is useful. The Bartlett's Test of Sphericity (BTS) is smaller than 0.001, which means it's a significant statistical test and thereby implies that a factor analysis might be needed.

The output of the factor analysis shows a clear pattern between two groups, in particular 'high probability and high impact' and 'high probability and low impact'. The total percentage of declaration of these two factors is 78,007%. The high probability and high impact loads high on all the measured indicators while the high impact and low probability only loads high on the question about the perceived likelihood. The resulted factors will be used to find correlations between the socio-demographic variables of the interviewed respondents further in this research.

#### 5.2.2.2 Hypothesis testing

Hypothesis testing is a way of testing certain assumptions (or hypothesises) that have been made based on survey data or an experiment and to check if there are meaningful results (Glen, 2022). With other words hypothesis testing is a way of testing whether your results happened by chance and if the same result would be achieved when repeating the survey. This is done by stating a null hypothesis. This hypothesis always consists out of two variables: an independent and a dependent variable. The independent variable isn't affected by anything, while the dependent variable will change. The null hypothesis will then be accepted or rejected based on adjusted R-squared or the ANOVA-test and the accompanying F- and sigma value.

The adjusted R-squared (adjusted $R^2$) is a value that explains the linear correlation between different inputs (IBM, 2022). The adjusted $R^2$ is an improved version of $R^2$ because $R^2$ tends to optimistically overestimate the fit of the linear regression. $R^2$ can have a value from 0 to 1. Where that 1 means a perfect linear correlation and 0 means no correlation at all.

Another way to test hypothesis is to use the ANOVA-test. This test compares the means of two independent groups using the F-distribution (Glen, 2022). Before any conclusion can be drawn from the hypothesis, first there needs to be checked if the hypothesis is significant and doesn't happen by chance. This needs to be done by looking at the calculated significance and F-value. In this research a significance level of 95% or 90% was used. The critical F-value is in this research equal to 4,034 for the hypothesis with two independent variables and 3,183 for hypothesis with three independent variables combined with the 95% confidence interval. The first thing that needs to be checked, is that the significance level is smaller than 0,05. If this condition is fulfilled the F-value needs to be compared to the critical value. When the calculated value is larger than the critical value the null hypothesis can be rejected and means that there is a significance difference. The same reasoning can be made with the 90% confidence interval except values change: the critical F-value is equal to 2,82 for one degree of freedom and 2,40 for two degrees of freedom. The significance level also changes to 0,1.

In this research the following ten hypothesis are tested:

- H1: Women have a higher risk perception than men.

This hypothesis is based on the idea that men and women have different risk perception as mentioned in 2.3

- H2: The higher the property and the further away from the sea, the lower the perceived impact is.

The idea behind this hypothesis is that when you are closer located to the risk, you will be more prompted to see it as a threat.

- H3: Older people have a high awareness of probability of erosion but think the impact will be low.

Older people are expected to have lived or visited this place for longer. They might be more aware of the erosion happening, due to the fact that they have seen erosion throughout the years they have been to Sjællands Odde. The lower impact refers to the idea they have of the consequences. They can see the erosion as a natural process that always has taken place and that people will adapt to the situation.

- H4: Places where there is a perception that the probability of erosion happening and erosion having a high impact is high, people are more willing to pay for protection measures.

When people think erosion will happen again and think the probability of impact will be high, it can be that they are keener to pay, to protect the island or themselves.

- H5: People with a high income and high education level have a higher risk perception.

It is possible that educated people have more knowledge about the risk of erosion.

- H6: People who own their property have a higher risk perception.

When you own a house, you paid for it and it could be that you look differently at a situation. If you own the place, it could also be possible that you are more often in Sjællands Odde. Therefore, this hypothesis will look is it could be true that house owners have a higher risk perception.

- H7: The more important Sjællands Odde is for the respondent, the higher the probability they think erosion may occur and the lower they think the impact will be.

People who find Sjaeallands Odde more important and think that the probability of erosion will be higher, think that the impact of the erosion will be lower. Because there will be a bigger chance that the government will take protective measures to protect Sjaellands Odde if it is perceived as more important.

- H8: Areas where the risk is high, people will have a high risk perception.

People that live closer to places where erosion takes place will be more aware of the risk that comes with erosion.

- H9: People who have children are more willing to pay for erosion protection measures.

When people have children, they might be more protective about their property because their descendants risk losing a property.

- H10: Women are more willing to pay for protection measures.

Building on the idea of hypothesis 1, if women have a higher risk perception, they could also be more prone to invest in protection measures.

For almost every hypothesis a statistical analysis was performed described above. The hypothesis which are accepted are discussed in more details, including the model summary table and ANOVA table, than those who are rejected. But in appendix 2, the two tables can be found for every hypothesis, including the rejected hypothesises. Only for hypothesis eight a visual interpretation was used.

For hypothesis one gender was used as the predictor in the statistical analysis. And the dependent variable is the combined factor of high probability and high impact. The results can be viewed in table 8 and table 9.

*Table 8: Model summary H1*

| Model summary | | | | |
|---|---|---|---|---|
| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
| 1 | 0,251 | 0,63 | 0,045 | 0,99574592 |

*Table 9: ANOVA test results H1*

| ANOVA | | | | | | |
|---|---|---|---|---|---|---|
| Model | | Sum of Squares | df | Mean Square | F | Sig. |
| | Regression | 3,414 | 1 | 3,414 | 3,443 | 0,069 |
| | Residual | 50,567 | 51 | 0,992 | | |
| | Total | 53,981 | 52 | | | |

The adjusted R square value is 0,045 which is very low. This meaning that there is a very low, to none, linear correlation. The significance of the ANOVA test is larger than 0.05 with a value of 0,069 which means that there is no significance level of 95%. But the value of 0.069 is smaller than 0,1 which is the maximum value for 90% significance, which is still a good level of significance. The F-values is bigger than the critical F-value (2,82) which means that the null hypothesis can be rejected. The hypothesis can therefore be accepted as true. From the hypothesis there can be concluded that men have a smaller risk perception as women.

The second hypothesis uses elevation & distance to coastline as the predictor and high probability and lower impact as the dependent variable.

*Table 10: Model summary H2*

| Model summary | | | | |
|---|---|---|---|---|
| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
| 1 | 0,460 | 0,211 | 0,180 | 0,92951728 |

*Table 11: ANOVA test results H2*

| ANOVA | | | | | | |
|---|---|---|---|---|---|---|
| Model | | Sum of Squares | df | Mean Square | F | Sig. |
| | Regression | 11,564 | 2 | 5,782 | 6,692 | 0,003 |
| | Residual | 43,200 | 50 | 0,864 | | |
| | Total | 54,765 | 52 | | | |

With a value of 0.180 the adjusted R square is low indicating a low, to non-linear correlation. The significance level in table X on the other hand is on low, indicating a high significance level. The F-value is bigger than the critical F-value of 3,183 and the null hypothesis can therefore be rejected. The stated hypothesis is with other words true. The conclusion here is that people who live higher and further away from the sea, perceive a lower impact of erosion.

Hypothesis three used the factor high probability and high impact as depend variable. The predictors that were used in the statistical analysis was the age category. With a significance level of 0.127 hypothesis three is rejected.

The fourth hypothesis was split in two statistical tests. The first one using willingness to pay to protect participants their property as predictor. The second one also used willingness to pay for the predictor, but this time not to protect the participants their own property but the coastline closest to them. High probability and high impact were used as dependent variable for both. With test one and two respectively having a significance level of 0,0273 and 0,380 and an adjusted R square value of 0,004 and -0,004, hypothesis for is also rejected.

Two statistical tests were also used in the testing for hypothesis number 5. High probability and high impact were used as dependent variable in the first test and the second test used the factor high probability and low impact as dependent variable. For both tests educational level and household approximate annual income is used as predictor. Both tests had a negative adjusted R square (-0,024 and -0,038) and the significance from the ANOVA test was 0.680 for the first test and 0,948 for the second one. All of this combined results in a rejection of hypothesis 5.

Hypothesis six use home ownership (owner or tenant) as predictor and the factor high probability and high impact as dependent factor. The results of the statistical test showed also rejection of the hypothesis as the adjusted R square was 0,015 and the significance of the ANOVA test had a value of 0,189.

The importance of Sjællands Odde was used as predictor for hypothesis seven. The depended variable used was the factor high probability and lower impact. With a value of 0,013 for the adjusted R square and a significance of 0,201 for the ANOVA test, the seventh hypothesis was also rejected.

The ninth hypothesis uses willingness to pay to protect the participants property as dependent variable. As predictor having children is used. In table 12 and 13 the important results can be found.

*Table 12: Model summary H9*

| Model summary | | | | |
|---|---|---|---|---|
| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
| 1 | 0,294 | 0,086 | 0,068 | 0,953 |

*Table 13: ANOVA test results H9*

| ANOVA | | | | | | |
|---|---|---|---|---|---|---|
| Model | | Sum of Squares | df | Mean Square | F | Sig. |
| | Regression | 4,283 | 1 | 4,283 | 4,716 | 0,035 |
| | Residual | 45,409 | 50 | 0,908 | | |
| | Total | 49,692 | 51 | | | |

The adjusted R square has a value of 0.068, very low. A linear correlation might thus be not applicable. The significance of the ANOVA test on the other hand is 0,035 which is smaller than 0,05 so a significance level of 95% is there for hypothesis 9. The critical F-value is smaller than the calculated F-value and therefore the null hypothesis can be rejected. The hypothesis is with other words true. People with children are more willing to pay for coast protection than people without children.

The last hypothesis (number ten) used gender as a predictor and willingness to pay to protect the participants property as dependent variable. And the results are in table 14 and 15.

*Table 14: Model summary H10*

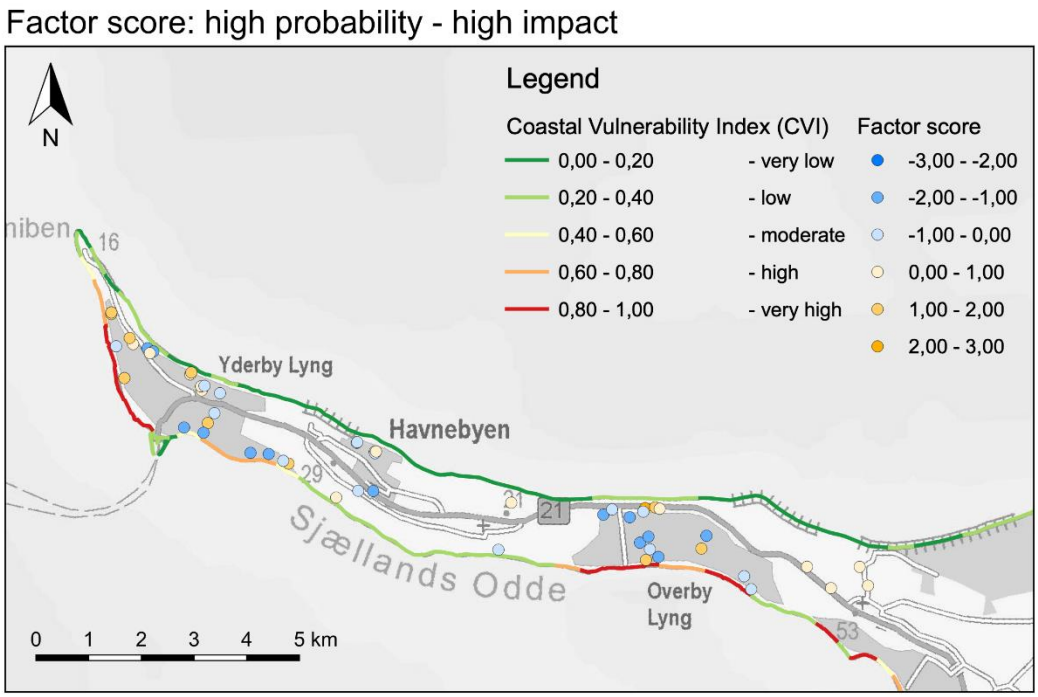
| Model summary | | | | |
|---|---|---|---|---|
| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
| 1 | 0,312 | 0,097 | 0,079 | 0,947 |

*Table 15: ANOVA test results H10*

| ANOVA | | | | | | |
|---|---|---|---|---|---|---|
| Model | | Sum of Squares | df | Mean Square | F | Sig. |
| | Regression | 4,836 | 1 | 4,836 | 5,391 | 0,024 |
| | Residual | 44,856 | 50 | 0,897 | | |
| | Total | 49,692 | 51 | | | |

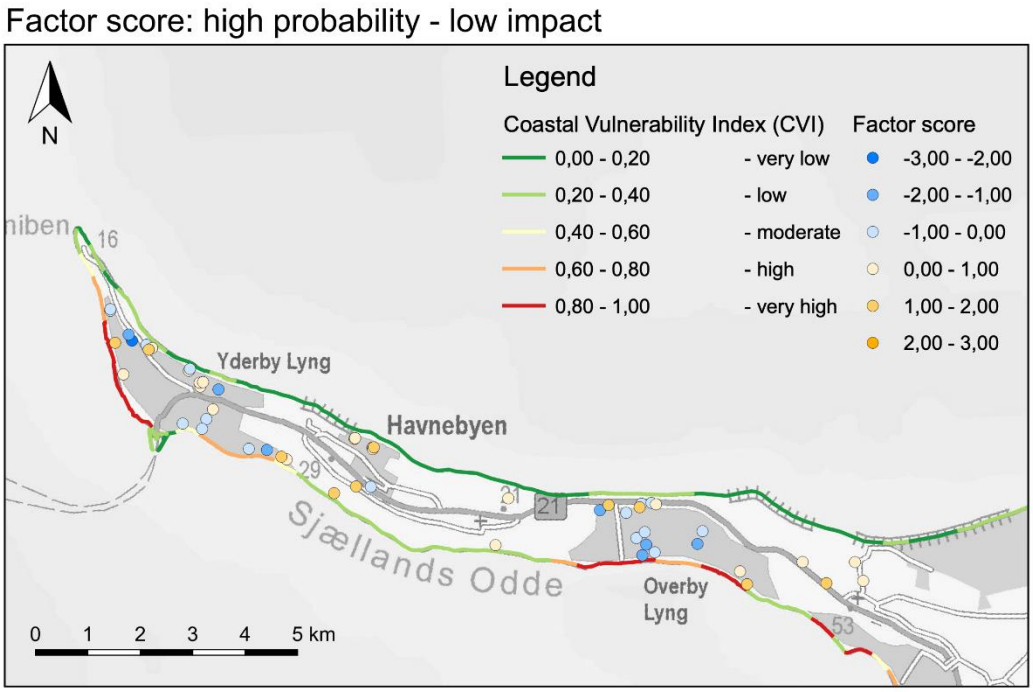
This hypothesis is also accepted, even though the adjusted R square is only 0,079, the significance of the ANOVA test is with its 0,024 within the 95% significance level. The critical F-value is also smaller than the calculated F-value, so the null hypothesis can be rejected. When applying other statistical approaches (e.g. box-plot) it appears that men are more willing to pay (higher amount) than women.

Hypothesis eight was, for the available time, to advance to calculate with (GIS) statistics. Therefore, a visual interpretation was done.




*Map 6: CVI and factor score for high probability & high impact*

In the north-west where the CVI is high, the factor score was high. This indicates that the people living here feel that there is a high probability with high impact of erosion, which seems right as the coast there is very vulnerable. The other locations of the factor scores don't seem to have a significant relation.




*Map 7: CVI and factor score for high probability & low impact*

In general, higher factor scores are found when the impact is low.

## 6 DISCUSSION

The coastal vulnerability index shows that some parts of Sjællands Odde are more sensitive to erosion than others. When combining the CVI and the historical development of Sjællands Odde, it can be seen that the parts of the coast that are less prone to erode have a different geomorphological base of land. Even though only coastal types are considered when calculating the CVI, the effect of the difference between the moraine landscape and marine foreland & drained land can be seen in the index values. It is possible that the historical coastal displacement and coastal types are correlated to the geomorphology and that that is one of the reasons a link can be seen. New research could go further and look at the connection between geomorphology and erosion and look if it would be a contribution to the CVI calculation. Looking at an area, and not just a coastline, for calculating the CVI is also a possibility for future research. The result could be a vulnerability index for the whole island, not only for the current coastline.

The fact that the two factors, the output from the factor analysis, are ‘high probability & high impact’ and ‘high probability & lower impact’ shows that a high probability is one of the things people seem to agreeing on. The difference of high impact – lower impact can be related to different locations of the participants. But as hypothesis eight does not statistically research location and impact, only visual, this

cannot be said for sure. The reason for not doing statistical tests for hypothesis eight was the limited amount of time. Future research could analyze this with statistics and GIS.

A lot of hypotheses where not accepted. There can be multiple reasons for this. It could be possible that the hypotheses are not right for the limited group of participants, and that a broader group of participants could change our results. Another possibility is that the proposed hypotheses are just not right.

Hypothesis one showed differences in gender, something which as mentioned before, has been shown to have an influence on individuals risk perception. Hypothesis ten went further than just looking at the risk perception but built on the idea that when people see something as a risk, they might be keener to pay for protection. On the other hand, hypothesis four, which is also about the willingness to pay, is reject. Even though this hypothesis tests willingness to pay in connection to the occurrence and impact of erosion. The ninth hypothesis, which looked at willingness to pay when having or not having children, was also confirmed with statistics. This is also personal characteristic that has an effect on how people would deal with the risk of erosion. The last hypothesis that was accepted, number two, showed a relation between the distance & elevation of the property to the sea in relation to the expected impact.

The visual interpretation for the eight hypotheses showed a higher factor score for high probability and low impact. This shows that even though people do not necessarily live near a vulnerable coast, they think the probability of erosion happening is there. The north-western part of the island looks to have a high score factor score for both low and high impact. A reason for this can be that there is a dike built there. Some people may view this as a good protection, a reason for thinking the impact of erosion would be low. Others might see the dike as a sign of that their impact could have a high impact of erosion.

When taking the surveys most participants gave the impression that they knew erosion was happening. Some of them were where not worried about it, as it is a natural process. Others felt that the government did not do enough to protect the coast. The dike in the north-west for example is financed with private funding, not government funding. People from the south also gave the impression that the north part of the researched area was more effected by erosion, and it was also the other way around. Some participants also mention that they think erosion is far more a problem in Jutland than in Sjaelland. In general people were also far more concerned about sea level rise than erosion.

When doing this research there where some limitations. The time of data collection was on rainy weekdays when most people who live in holiday homes on the islands where not there. Analysis did not take existing protective measures into account and storms were also not included. Therefore, new research could try to extend this one with more variables to calculate the CVI and analysis of the data could also go further.

# 7 CONCLUSION

Risk perception is the interpretation of risk, it reflects the subjective judgement of a person about the likelihood and severity of negative occurrences. Risk perception in this study was measured using questions in a survey that attempted to reflect the following indicators: perceived likelihood, worry/fear, perceived impact/severity and willingness to pay. Statistical analysis however showed that a factor analysis was appropriate, reducing the assumed dimensionality of four indicators to two factors where a high score on the first factor corresponds to a high perception of both likelihood and impact of the risk while a high score on the second factor also corresponds to a high perception of likelihood but not of the impact of the risk. Socio-economical and spatial variables were used to explain why people perceive a certain level of risk. The field experience illustrated that when taking a survey of a phenomenon like erosion it is useful to use pictures to show what natural process is referred to.

A lot of the hypotheses ended up not finding a relation between the explanatory variables and the two risk perception factors. Having a lot of the hypotheses rejected is not pleasant but can still be considered a usable result. One conclusion that can be taken, with 90% certainty, from our hypothesis is that men are less aware of the erosion that takes place along the coast. Another hypotheses conclusion, that can be taken with 95% certainty, is that people who live higher and further away from the coast, think that they will be less impacted by the consequences of erosion. Contradictory women are not more willing to pay for protective measures than the men. As well as people who have children. All the other hypotheses weren't statistically significant and therefore no conclusion can be made about those. Further research might be needed to statistically analyze whether a connection between the measured risk perception and the calculated vulnerability index exists.

Future research could extend the coastal vulnerability index by adding more parameters, storms for example. Another period for doing field work- surveys could also lead to new insights in risk perception, preferable a holiday or weekend when more holiday house owners are present. And lastly, this research could also be performed in other parts of Denmark, from the surveys some people said erosion is a bigger problem in Jutland.

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# 9 APPENDIX

## 9.1 Appendix 1: Survey

Hi! We are students from the University of Ghent in Belgium. We are here in Denmark to study the vulnerability of coastal areas. In particulary how the people perceive the vulnerability (think/feel about) their own coastal area. Would you be so kind to help us with our research by participating in a quick anonymous survey?

Great, the survey contains three small parts. First we will ask a few spatial questions.

1. Where do you live?

| Sjaellands Odde | Out of Denmark | Other |
|---|---|---|
| o | o | ..... . |

2. Where do you stay in Sjaellands Odde?

3. Are you residing permanently here?

| Yes | No |
|---|---|
| o | o |

4. Are you staying in a summerhouse on Sjaellands Odde?

| Yes | No |
|---|---|
| o | 0 |

5. Are you owner of the property or tenant?

| Owner | Tenant |
|---|---|
| o | 0 |

6. How frequently do you visit Sjaellands Odde

| Every year | Every month | Every 2 weeks | Every week |
|---|---|---|---|
| o | o | o | o |

7. How long is your average stay?

| < 3days | 3 – 5 days | Up to a week | More than a week |
|---|---|---|---|
| o | o | o | o |

8. How important is Sjaellands Odde for you?

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|

Specify?

Next, we will ask you some questions related to your perception about the coast closest to the property where your stayin. With property we don't only mean only the house but also the garden plot surrounding it. We will show you some pictures, which we will describe and we will ask you some questions related to them.

9. How likely do you think that this type of erosion will happen to your area

| Very unlikely | unlikely | Neither likely neither unlikely | likely | Very likely |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |

10. When I think about erosion, I feel worried for the coastline closest to where I'm staying/living

| Strongly disagree | Disagree | Neither agree nor disagree | Agree | Strongly agree |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |

11. When I think about erosion, I feel worried for the area surrounding the house where I'm staying/living

| Strongly disagree | Disagree | Neither agree nor disagree | Agree | Strongly agree |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |

12. To what extent would the property where you stay/live be affected by the erosion processes

| Deffenitely not affected | Not really affected | General affected | Affected | Strongly affected |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |

13. I would be prepared to pay ..... (in %) of the property value to take measures to reduce the impact of erosion to the property where I'm staying/living.

| 0% | 0 – 5% | 5 – 10% | 10 – 20% | > 20% |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |

14. would be prepared to pay ..... (in %) of the property value to take measures to reduce the impact of erosion to the coastline closest to the property where I'm staying/living.

| 0% | 0 – 5% | 5 – 10% | 10 – 20% | > 20% |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |

To end this survey, we will ask some quick personal questions. Don't worry, like we said these are anonymous and are just necessary to process the results of our research.

15. Gender

| Male | Female | X |
|---|---|---|
| 0 | 0 | 0 |

16. What is your age?

| 18-24 yo | 25-39 yo | 40-64 yo | 65 yo < |
|---|---|---|---|
| o | o | o | o |

17. What is your educational level?

| w | Gymnasium | Profession Higschool | Academic bachelor/master | PHD |
|---|---|---|---|---|
| | o | o | o | o |

18. Do you have children?

| Yes | No |
|---|---|
| o | o |

19. What is your household approximate annueal income, including wages, tips, investment income, public assistance and income from retirement plans? would you say it is....

| < 325 000 DKK | 325 000 DKK - 900 000 DKK | > 900 000 DKK |
|---|---|---|
| o | o | o |

We are very thankful for your participation.

20. Do you still have some information you would like to share with us regarding the coastline of Sjællands Odde that you think is interesting?

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## 9.2 Appendix 2: Results statistical tests

### *9.2.1 Results Factor analysis*

| Correlation Matrix | | | | | |
|---|---|---|---|---|---|
| | | perceived likelihood | worry coastline | worry property | impact |
| Correlation | perceived likelihood | 1,000 | 0,373 | 0,358 | 0,394 |
| | worry coastline | 0,373 | 1,000 | 0,473 | 0,490 |
| | worry property | 0,358 | 0,473 | 1,000 | 0,658 |
| | impact | 0,394 | 0,490 | 0,658 | 1,000 |
| Sig, (1-tailed) | perceived likelihood | | 0,001 | 0,002 | 0,001 |
| | worry coastline | 0,001 | | 0,000 | 0,000 |
| | worry property | 0,002 | 0,000 | | |
| | impact | 0,001 | 0,000 | 0,000 | 0,000 |

### *9.2.2 Results hypothesis testing*

H1:

- Predictors: Gender
- Dependent variable: High probability and high impact

| Model summary | | | | |
|---|---|---|---|---|
| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
| 1 | 0,251 | 0,63 | 0,045 | 0,99574592 |

| ANOVA | | | | | | |
|---|---|---|---|---|---|---|
| Model | | Sum of Squares | df | Mean Square | F | Sig. |
| | Regression | 3,414 | 1 | 3,414 | 3,443 | 0,069 |
| | Residual | 50,567 | 51 | 0,992 | | |
| | Total | 53,981 | 52 | | | |

H2:

- Predictors: elevation, distance to coastline
- Dependent: REGR factor score 2 for analysis 2

| Model summary | | | | |
|---|---|---|---|---|
| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
| 1 | 0,460 | 0,211 | 0,180 | 0,92951728 |

| ANOVA | | | | | | |
|---|---|---|---|---|---|---|
| Model | | Sum of Squares | df | Mean Square | F | Sig. |
| | Regression | 11,564 | 2 | 5,782 | 6,692 | 0,003 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Residual | 43,200 | 50 | 0,864 | | |
| | Total | 54,765 | 52 | | | |

H3:

- Predictors: age category
- Dependent: High probability and high impact

| Model summary | | | | |
|---|---|---|---|---|
| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
| 1 | 0,213 | 0,045 | 0,026 | 1,00530991 |

| ANOVA | | | | | | |
|---|---|---|---|---|---|---|
| Model | | Sum of Squares | df | Mean Square | F | Sig. |
| | Regression | 2,438 | 1 | 2,438 | 2,412 | 0,127 |
| | Residual | 51,543 | 51 | 1,011 | | |
| | Total | 53,981 | 52 | | | |

H4:

Willingness to pay property

- Predictors: willingness to pay property
- Dependent: high probability and high impact

| Model summary | | | | |
|---|---|---|---|---|
| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
| 1 | 0,155 | 0,024 | 0,004 | 1,02491952 |

| ANOVA | | | | | | |
|---|---|---|---|---|---|---|
| Model | | Sum of Squares | df | Mean Square | F | Sig. |
| | Regression | 1,288 | 1 | 1,288 | 1,227 | 0,273 |
| | Residual | 52,523 | 50 | 1,050 | | |
| | Total | 53,811 | 51 | | | |

Willingness to pay – coastline

- Predictors: willingness to pay coastline
- Dependent: high probability and high impact

| Model summary | | | | |
|---|---|---|---|---|
| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
| 1 | 0,124 | 0,015 | -0,004 | 1,02936563 |

| ANOVA | | | | | | |
|---|---|---|---|---|---|---|
| Model | | Sum of Squares | df | Mean Square | F | Sig. |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Regression | 0,832 | 1 | 0,832 | 0,785 | 0,380 |
| | Residual | 52,980 | 50 | 1,060 | | |
| | Total | 53,811 | 51 | | | |

H5:

High probability – high impact

- Predictors: education level, household approximate annual income
- Dependent: high probability and high impact

| Model summary | | | | |
|---|---|---|---|---|
| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
| 1 | 0,124 | 0,015 | -0,024 | 1,03107761 |

| ANOVA | | | | | | |
|---|---|---|---|---|---|---|
| Model | | Sum of Squares | df | Mean Square | F | Sig. |
| | Regression | 0,825 | 2 | 0,412 | 0,388 | 0,680 |
| | Residual | 53,156 | 50 | 1,063 | | |
| | Total | 53,981 | 52 | | | |

High probability – lower impact

- Predictors: educational level, household approximate annual income
- Dependent: high probability and lower impact

| Model summary | | | | |
|---|---|---|---|---|
| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
| 1 | 0,046 | 0,002 | -0,038 | 1,04544180 |

| ANOVA | | | | | | |
|---|---|---|---|---|---|---|
| Model | | Sum of Squares | df | Mean Square | F | Sig. |
| | Regression | 0,117 | 2 | 0,059 | 0,054 | 0,948 |
| | Residual | 54, 647 | 50 | 1,093 | | |
| | Total | 53,765 | 52 | | | |

H6:

- Predictors: owner or tenant
- Dependent: high probability and high impact

| Model summary | | | | |
|---|---|---|---|---|
| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
| 1 | 0,183 | 0,034 | 0,015 | 1,01141354 |

| ANOVA | | | | | | |
|---|---|---|---|---|---|---|
| Model | | Sum of Squares | df | Mean Square | F | Sig. |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Regression | 1,810 | 1 | 1,810 | 1,769 | 0,189 |
| | Residual | 52,171 | 51 | 1,023 | | |
| | Total | 53,981 | 52 | | | |

H7:

- Predictors: importance of Sjællands Odde
- Dependent: high probability and lower impact

| Model summary | | | | |
|---|---|---|---|---|
| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
| 1 | 0,178 | 0,032 | 0,013 | 1,01961299 |

| ANOVA | | | | | | |
|---|---|---|---|---|---|---|
| Model | | Sum of Squares | df | Mean Square | F | Sig. |
| | Regression | 1,744 | 1 | 1,744 | 1,678 | 0,201 |
| | Residual | 53,020 | 51 | 1,040 | | |
| | Total | 54,765 | 52 | | | |

H9:

- Predictors: having children
- Dependent: willingness to pay property

| Model summary | | | | |
|---|---|---|---|---|
| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
| 1 | 0,294 | 0,086 | 0,068 | 0,953 |

| ANOVA | | | | | | |
|---|---|---|---|---|---|---|
| Model | | Sum of Squares | df | Mean Square | F | Sig. |
| | Regression | 4,283 | 1 | 4,283 | 4,716 | 0,035 |
| | Residual | 45,409 | 50 | 0,908 | | |
| | Total | 49,692 | 51 | | | |

H10:

- Predictors: gender
- Dependent: willingness to pay property

| Model summary | | | | |
|---|---|---|---|---|
| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
| 1 | 0,312 | 0,097 | 0,079 | 0,947 |

| ANOVA | | | | | | |
|---|---|---|---|---|---|---|
| Model | | Sum of Squares | df | Mean Square | F | Sig. |
| | Regression | 4,836 | 1 | 4,836 | 5,391 | 0,024 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Residual | 44,856 | 50 | 0,897 | | |
| | Total | 49,692 | 51 | | | |