The spatial relation between housing growth and nature in the Northern Netherlands between 2000 and 2020

Fig. 1: Housing growth near de Blauwe Stad (Province of Groningen)

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Summary

Housing shortage will be one of the biggest challenges in the Netherlands for the coming years. The solution to this problem is mainly sought in the building of new houses. Another national challenge is the preservation of nature. To fight global warming, (European) climate policies have become more important during the past decades. The construction of new houses within or near nature can have a direct negative impact on nature. Therefore, insight regarding the spatial relation between housing growth and nature is needed. This research investigates the spatial relation between housing growth and protected nature areas in the three northern provinces of the Netherlands (Friesland, Groningen, and Drenthe). The following main research question is central to this thesis:

"How was the spatial relation between housing growth and nature in the Northern Netherlands during the first two decades of the 21st century?"

In order to investigate the spatial relation between housing growth and protected nature areas, various spatial analysis tools in ArcGIS Pro are used. First the location of housing growth is determined and later compared to the location of protected nature areas. Furthermore, clusters of housing growth are mapped with the help of a hotspot analysis. Also, the average distance of housing growth clusters to protected nature areas is calculated. During the first decade, almost 25.000 more houses were built than during the second decade. In both decades, less than 1% of all housing units was built within protected nature areas. However, both during the first and the second decade, approximately one third of the housing growth took place within a 1 km distance of protected nature areas. Results of this research can help policymakers to make decisions regarding housing growth and nature preservation.

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1. Introduction

1.1 Background and societal relevance

In 2021, there was a housing shortage of roughly 263.000 houses in the Netherlands. The urge for new housing is extremely high and there are plans for the construction of 100.000 new residential building per year (Capital Value, 2019). At the same time the Dutch are dealing with a nitrogen crisis resulting from, for example, agricultural land use, car emissions, and the construction of new houses (PBL, 2021). Climate problems like the nitrogen crisis and global warming have led to stricter European climate policies (European Commission, 2019). Within these climate policies, there is substantial emphasis on the preservation of nature areas. Protected nature areas are crucial for the conservation of species threatened by land-use change and habitat reduction. They are crucial for the conservation and improvement of biodiversity (Prendergast et al., 1993). Two examples of European climate policies are the Special Protection Area (SPA) which is defined by the EU Birds Directive (European Council, 2009) and the Site of Community Importance (SCI) which is a designation under the EU Habitats Directive (European Council, 1992). Also on the national level, various policies regarding nature preservation have been developed and implemented in the Netherlands. Several nature sites have received a special protected status. There is the overarching Natuurnetwerk Nederland (NNN) of existing and new nature reserves. Furthermore, there are twenty national parks situated in the Netherlands (Stichting SNP, 2021). Evidently, nature preservation has a high priority in the Netherlands.

The solution for the tight housing market is mainly sought in the construction of new houses. The tendency in Dutch politics is fixated on adding new houses to increase the housing supply (Trouw, 2021). The construction of new houses near or within protected nature areas has direct negative effects on nature. For example, it fragments native habitats and increases predation by pets (Radeloff et al., 2005; Crooks & Soulé, 1999). Additionally, the construction of residential buildings near nature areas can disturb important corridors that connect nature areas (Beier, 1993). The effectiveness of nature reserves can be threatened by housing development.

Figure 1.1 displays a conceptual model that describes the situation. The red arrow in the conceptual model represents the part on which this research is focused. This research investigates where housing growth took place relative to nature. Three consequences of housing growth near or within nature are included. According to the literature, they all result in reduced effectiveness of nature areas.

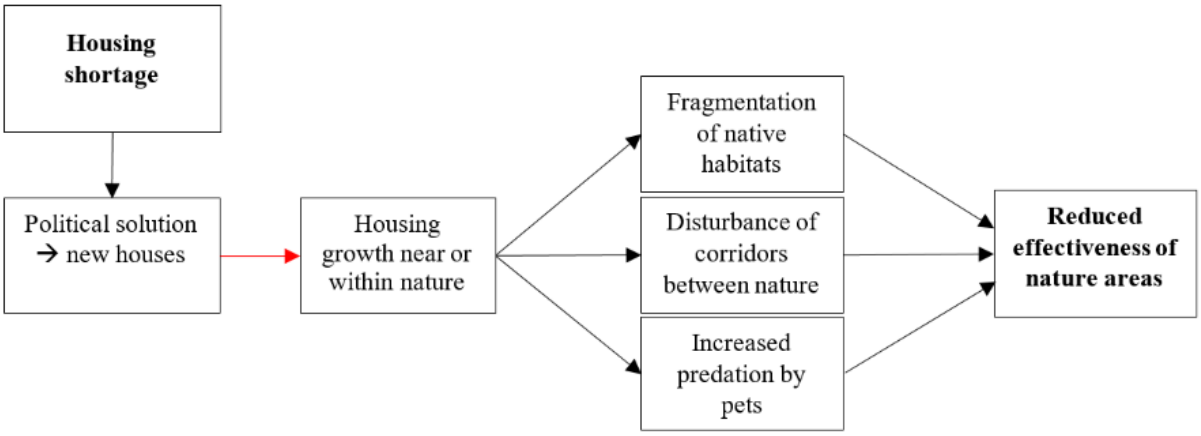


Figure 1.1: Conceptual model

1.2 Theoretical Framework

During the first and second decade of the 21st century, the annual number of new houses grew from 60.000 houses between 2001 and 2003 to 83.000 houses in 2009 (CLO, 2012). As a result of the financial crisis in 2008, this steady growth of the first decade slowed down. In 2010, only 56.000 housing units were built in the Netherlands. After 2011, the total housing stock recovered to a net increase of 86.014 housing units in 2013. During the coming years, housing growth will continue to increase. At the same time, the preservation of nature is crucial. The aim of this research is to map and analyze housing growth relative to nature areas in the Northern Netherlands (Friesland, Groningen, and Drenthe). This is done for the first two decades of the 21st century. The results for both decades are analyzed and compared to each other. This study extends on several studies that investigated the spatial development of housing growth and the impact of housing growth on nature.

Radeloff et al. (2009) performed a large scale research to the impact of housing growth in and near protected nature areas in the United States between 1940 and 2030. In their study, Radeloff and his colleagues measured the number of housing units in and near protected nature areas. The number of houses was quantified for different distances to nature. They looked at houses within nature areas, within a range of 1 km from nature areas, and within a range of 50 km from nature areas. The impact of the different ranges on the conservation value of the protected nature areas was investigated. Furthermore, a clear visualization of where in the United States housing growth had taken place was accomplished. The results of this research showed that housing growth development in or near nature areas had a negative impact on the ability of nature reserves to function as a safe haven for wild species. Moreover, housing growth during the

second half of the 20th century had led to increasing isolation of protected nature areas. Overall, housing growth in this period was a major threat for the conservation value of the nature areas in the United States.

Another relevant research to housing growth trends and their impacts on nature is from Lepczyck et al. (2007). This research also highlights the fact that housing growth is one of the main drivers for present-day landscape change. Due to the ecological impact of housing growth development, the understanding of housing growth patterns in relation to nature becomes of more importance. Lepczyck and his colleagues aimed to quantify hotspots of housing growth in the United States. They looked at a timeframe of 60 years (1940-2000). The first objective was to find where housing growth hotspots were located. Defining hotspots was done with the help of a spatial statistical tool called Getis-Ord Gi*. This method calculates if a specific area significantly deviates from the average of the total area. The results of this research indicated that housing growth was occurring at distinct locations in the study area. Moreover, the study demonstrated that the hotspot analysis Getis-Ord Gi* could be useful for research to housing clusters and housing development trends.

Van Dalen (2013) did a similar kind of research to housing growth development for the Netherlands. His research was based on the method used by Lepczyck and his colleagues. Van Dalen focused on the spatial development of housing growth in the Netherlands between 1950 and 2010. Inspired by Lepzyck's research from 2007, he also determined housing growth clusters with the help of the Getis-Ord Gi* analysis. Van Dalen found that absolute housing growth took place mostly near cities. Large scale hotspots were mainly located in the Dutch metropolitan area the Randstad.

In the literature the negative impact of housing growth on protected nature areas is mentioned often. Therefore, it is useful to look at housing growth patterns relative to nature areas. This bachelor thesis does that by extending and combining the three aforementioned studies. The study area for this thesis is smaller compared to the three other studies. The focus is on the three Northern provinces of the Netherlands.

The main research question for this bachelor thesis is as follows: "*How was the spatial relation between housing growth and nature in the Northern Netherlands during the first two decades of the 21st century?"*

First, housing growth development is mapped and quantified. Individual housing units are counted for several distances from nature and then analyzed similar to the study of Radeloff et al. (2009). Then, clusters of housing growth (500 by 500 meters) are defined and localized with the same hotspot analysis as Lepczyck et al. (2007) and Van Dalen (2013). Thereafter, these housing growth clusters are mapped and analyzed relative to protected nature areas. And finally, the average distance between housing growth clusters and protected nature areas is calculated for both decades.

1.3 Structure of the thesis

This thesis follows a standard structure and consists of four chapters. The background, relevance, and theoretical framework are outlined in the introduction section above. In the methodology, the research methods and data collection process are described. After that, in the results section, the findings are presented and discussed. Finally, in the fourth chapter the conclusions are made and briefly outline the main findings. At the end of the thesis, three appendices with multiple maps, tables and GIS operations are included.

2. Methodology

2.1 Methodological approach and data collection

This study investigates the spatial relation between housing growth and nature in the Northern Netherlands from 2000 to 2010. To measure the spatial relation between housing growth and nature, a quantitative analysis based on secondary datasets is used. A secondary dataset regarding housing growth was retrieved from the Dutch Land Registry (Kadaster). This dataset called Basisregistratie Addressen en Gebouwen (BAG) contains basic municipal data on all buildings and addresses in the Netherlands (BZK, 2021) The BAG dataset was exported to ArcGIS Pro, a Geographical Information Systems (GIS) program that is designed for analysis and offers many options for data visualization. By use of this GIS program, multiple steps were taken to gradually filter the BAG dataset. After this filter process, two separate datasets were created. One containing all residential buildings built between 2000 and 2010, the other one containing residential buildings built between 2010 and 2020. With these two datasets, housing growth between 2000 and 2020 was mapped and analyzed relative to nature. The World Database on Protected Areas (WDPA) was used to map protected nature areas. The WDPA is a comprehensive global database on terrestrial and marine protected areas by the United Nations Environmental Program (UNEP) and the International Union for Conservation of Nature and Natural Resources (IUCN). At this point, three layers were created: housing growth from 2000 to 2010, housing growth from 2010 to 2020, and a nature layer according to the WDPA. Several techniques were used to visualize the spatial relation between housing growth and nature. Housing growth within nature was quantified. Houses built within a 1 km distance of protected nature areas were counted. Additionally, clusters of housing growth were distinguished from scattered housing growth with a hotspot analysis and then compared to nature. Finally, the average distance between housing growth clusters and protected nature areas was calculated for both decades.

2.2 Nature data

For this research, nature was defined according to the protected nature areas of the WDPA (UNEP-WCMC, 2021). This dataset is recognized by the IUCN as the most extensive global database on both terrestrial and marine protected areas (IUCN, 2021). According to the WDPA, there are 463 protected nature areas located in the Netherlands. Only protected nature areas situated in the three Northern provinces of the Netherlands were relevant to this study. Therefore, a selection for the Northern Netherlands was made (Appendix C 1). This selection

was created by a tool in ArcGIS Pro that allows to select features based on their location relative to features in another layer (ESRI, 2021). The result was a WDPA subset for the study area consisting of 108 protected nature areas (Appendix A 1). This map displays the WDPA protected nature areas located (partly) in the Northern Netherlands (now referred to as "nature layer").

There are many laws and regulations related to nature preservation assigned to different institutions. The WDPA is a database that has compiled all the protected nature areas that are designated by one or more of these institutions. The WDPA selection made for this study, consisted of eight different institutional nature preservation acts (Appendix B 1). Many of them are intertwined which explains the overlap in the nature layer (Appendix A 2). This overlap can be observed for many areas in the nature layer. For example, the protected nature area Alde Feanen, a nature area located in the province of Friesland. Alde Feanen is assigned to four different institutional nature preservation acts. The following four FIDs from this table are all assigned to Alde Feanen (Appendix B 2).

FID 11 = Ramsar Site, Wetland of International Importance (Ramsar Convention)

FID 37 = Site of Community Importance (EU Habitats Directive)

FID 65 = Special Protection Area (EU Birds Directive)

FID 69 = Nature Conservation Act (Dutch Government)

The different institutional nature preservation acts cause the overlap in the database. In this research, the overlap has not been removed on purpose since all of the eight institutional acts are from reliable sources. Moreover, they often consider a slightly different geographical location for each protected nature area.

2.3 Housing growth data

The BAG dataset is the basis for the housing growth data in this study. This secondary dataset is available through the official webpage of the Dutch Land Register (Kadaster, 2021). The BAG dataset contains basic information about all buildings and addresses in the Netherlands. The BAG dataset was exported to GIS program ArcGIS Pro. The following data processing steps were executed with tools in this program.

A selection of only residential buildings was necessary for this research. In the BAG dataset residential buildings are called "Verblijfsobjecten". In this research I refer to them as residential buildings. Not every residential building is categorized as a building with only a residential

function. Some of the residential buildings, for example, have a shop function or an office function as well. This research focuses on housing growth with a residential motive. Therefore, only residential buildings with a residential function were selected. Since the BAG dataset operates on a national level, the majority of the residential buildings in both datasets was outside of the study area. In order to remove the residential buildings that were not situated in the study area, a selection of residential buildings located in the Northern Netherlands was made. This was done with the clip tool that extracts the input features (residential buildings) that overlay the clip features (Northern Netherlands) (ESRI, 2021). Appendix C 2 shows the steps for this clip analysis. After creating a selection of residential buildings with a residential function located in the Northern Netherlands, only the residential buildings built during the first two decades of the 21st century were selected. Residential buildings built between 2000 and 2010 were assigned to a subset called RB_2000_2010, mapped in Appendix A 3. Residential buildings built between 2010 and 2020 were assigned to a subset called RB_2010_2020, mapped in Appendix A 4**.** With these two datasets, housing growth within nature was quantified. Also, housing growth near nature was mapped and quantified. The results were used to analyze the spatial relation between housing growth and protected nature areas.

2.4 Housing growth in clusters

Considering the housing data as individual points only lacks clarity. Therefore, this research also aims to map and analyze where clusters of housing growth are situated and how they relate to protected nature areas within the Northern Netherlands. Clusters of housing growth were determined with the help of multiple steps. First, a raster with a grid square size of 500 by 500 meters was laid over the study area. According to Van Dalen (2013), middle sized grids: 1.000, 2.000, and 5.000 meters are mainly used for a national scale in hotspot analysis. Since the study area for this research covers a relatively smaller area, a grid size of 500 by 500 meters was chosen. This raster layer consists of 36.165 grid squares covering the Northern Netherlands.

The next step was to aggregate the housing growth data to the raster file. This was done with a spatial join analysis in ArcGIS Pro (Appendix C 3). This tool joins attributes from one feature to another feature based on the spatial relationship (ESRI, 2021). In other words, for each housing unit was determined to which grid square it belonged. This resulted in an extra column in the attribute table of the raster layer called “joint count”. This column contains the number of residential buildings for each individual grid square (Appendix B 3 & Appendix B 4).

2.5 Getis-Ord Gi* Hotspot analysis

With the number of residential buildings per grid square, a hotspot analysis could be executed. ArcGIS Pro offers an analysis tool that can determine hotspots called Getis-Ord Gi* Hotspot analysis. This analysis calculates a z-score and a p-value (GiP-value) for each feature in the dataset (ESRI, 2021). In this case the dataset used for the analysis is the raster layer with the join count column containing the number of housing units for each grid square (Appendix C 4). The result of this hotspot analysis is a so-called "Gi_Bin distribution" (Appendix B 5 & Appendix B 6) For each grid square, the chance of it being a hotspot is calculated on the basis of confidence intervals. In social sciences, the default confidence level is 95% (Clifford et al., 2010). The confidence interval of 95% was therefore used for this hotspot analysis. Each cluster with a GiP-value of less than 0,05 has a 95% chance of being a hotspot and is therefore defined as a hotspot (i.e. housing growth cluster). Similar to Lepczyck et al. (2007) who defined a hotspot as a grid square with significant housing unit growth. Appendices A 5 and A 6 show the clusters of housing growth for respectively 2000-2010 and 2010-2020.

2.6 Housing growth within nature

First housing growth was analyzed by looking at the increase of individual residential buildings within protected nature areas. Residential buildings built between 2000 and 2010 that were located within a protected nature area were selected with the Select features by location tool. The same was done for the dataset with residential buildings built between 2010 and 2020. Appendix C 5 shows the operation in ArcGIS Pro. The result of this analysis was a new layer for both housing growth subsets containing only residential buildings that were located within nature (Map 3.1 & Map 3.2). To quantify the number of housing clusters within nature, the same technique was used (Appendix C 6). Since housing clusters in this study represent a fixed area containing many houses, it was decided to also include clusters that were only partly situated within nature. This was done because of the intensity of a housing growth cluster as opposed to just a single residential building. Again this analysis resulted in two new layers. One layer representing all housing growth clusters within nature between 2000 and 2010. The other layer showing the housing clusters within nature between 2010 and 2020 (Map 3.5 & Map 3.6).

2.7 Housing growth near nature

Earlier studies to the impact of housing growth on nature, showed that housing growth near nature has a negative impact on several key aspects of the nature areas (Radeloff et al., 2009).

Similar to Radeloff et al. (2009), housing growth within a range of 1 km from protected nature areas was investigated. In ArcGIS Pro, a buffer of 1 km was placed around features in the nature layer. All housing units built within this 1 km range from protected nature area were selected. Houses that were built within nature were excluded since they were already examined in the previous research step. Map 3.7 and Map 3.8 show all residential buildings located within a 1 km distance of a protected nature area for both decades. The Select Features by Location tool was used to select for houses that were built within the buffer (Appendix C 7).
Clusters of housing growth were examined in the same way (Appendix C 8). For both decades separately, all clusters located within the 1 km buffer zone were selected and visualized in a new layer (Map 3.9 & Map 3.10).

2.8 Average distance of clusters to nature

The last analysis that was performed for this research was to calculate the average distance of housing growth clusters to protected nature areas. First the polygon shaped clusters were converted to points with the Feature to Point tool. ArcGIS Pro provides a tool called Near Analysis that calculates the nearest distance between two features of different layers. In this case the distance between a housing growth cluster and its nearest protected nature area (Appendix C 9). The analysis was performed for both decades. A reduced version of the entire table is displayed in Appendices B 7 and B 8.

2.9 Ethical considerations

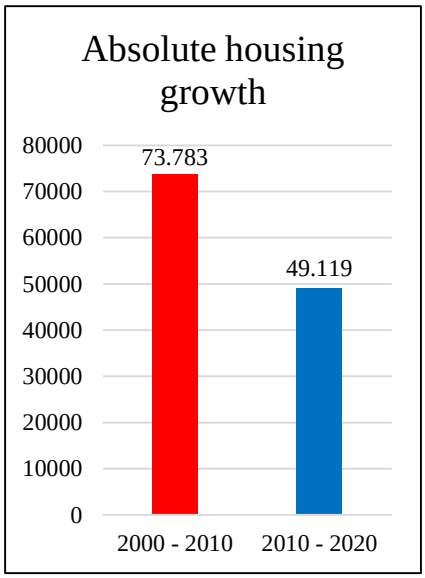
In general, the use of secondary datasets should be done very carefully. Secondary data is collected by external parties or individuals and therefore the integrity of the data should be checked thoroughly. In this research, the housing data was retrieved from the Dutch Land Registry. The nature dataset (WDPA) was also compiled by legitimate institutions. These sorts of datasets are known for their reliability. The way in which the data was processed and analyzed is more sensitive to errors. After exporting both datasets to ArcGIS Pro, many editing tools and analyses concerning the data were used. During the process of data editing, some minor mistakes could have been made. These possible mistakes might have affected the final results.

3. Results

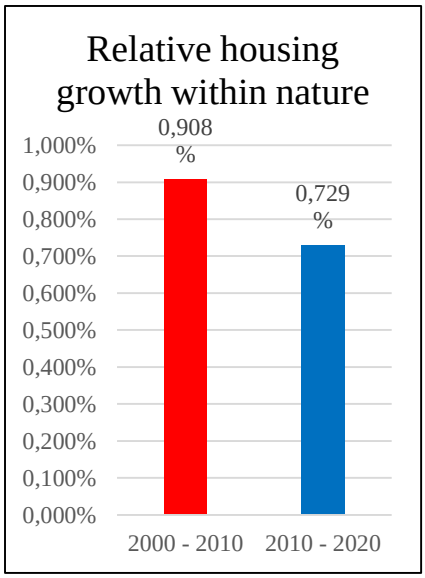
3.1 Housing growth within protected nature areas

The total housing growth during the first decade was 73.783 residential housing units. Between 2010 and 2020, 49.119 residential housing units were built in the Northern Netherlands. Between 2000 and 2010, a total of 670 houses was built within protected nature defined by the WDPA dataset (0,908% of all housing units). In the following decade from 2010 to 2020, a total of 358 housing units was built within protected nature areas (0,729% of all housing units). Interesting to see is the big difference in absolute housing growth between both decades (Graph 3.1). Almost 25.000 more residential housing units were built between 2000 and 2010 compared to the second decade. This difference in absolute housing growth is quite likely the result of the financial crisis that started in 2008 and the following housing policies by the government.

Moreover, we can now examine the relative housing growth within protected nature areas.



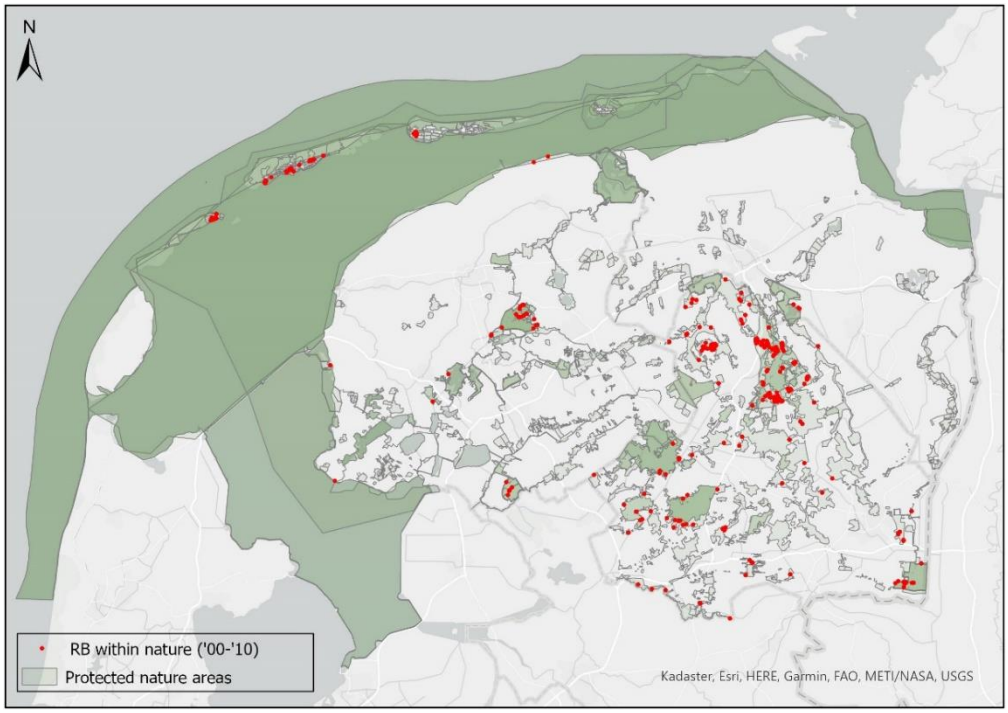
Graph 3.2



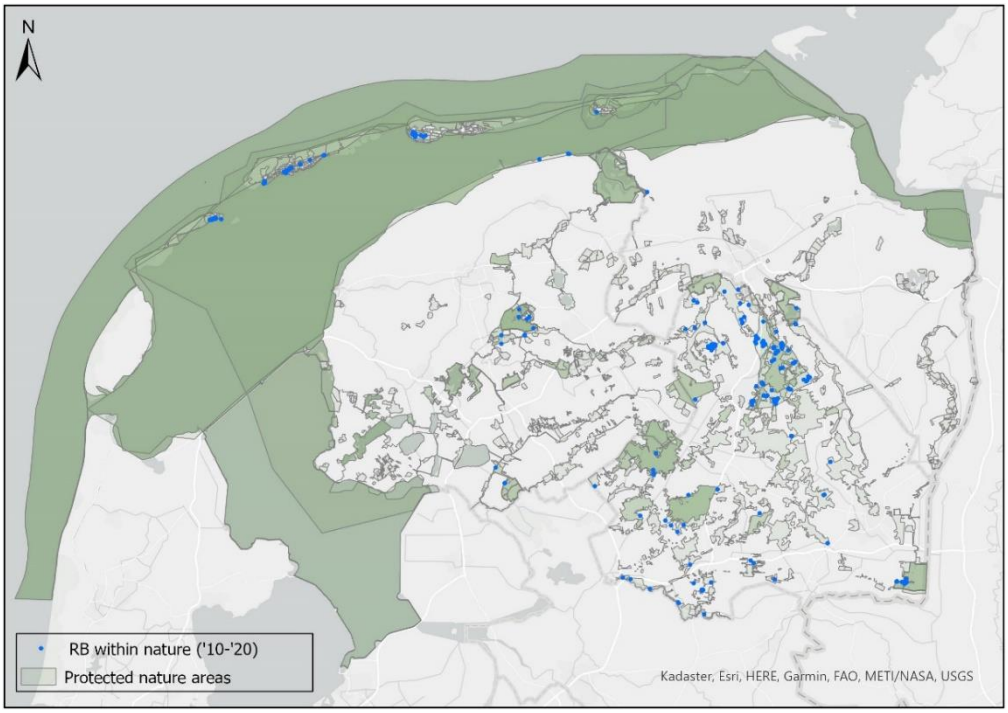
Graph 3.1

For both decades, less than 1,00% of the total housing growth was built within protected nature areas. Not only the total housing growth was lower during the second decade. Also the relative number of houses built within protected nature areas decreased from 0,908% to 0,729% (Graph 3.2). A reason for this decrease could be the reformation and establishment of new nature areas between 2010 and 2020. From 2010 until 2016, 25 protected nature areas were established in the Northern Netherlands (Appendix B 2). In particular the reformation of the Natuurnetwerk Nederland (*Nature Reserves Owned by Professional Nature Management Organization* in the dataset), had resulted in an increase of the total surface area of protected nature areas. The old National Ecological Network had been reformed to the Natuurnetwerk Nederland in 2013. Each province has its own protected nature area that is assigned to the Natuurnetwerk Nederland

(Appendix B 2). Apart from the surface expansion, stricter rules apply for the Natuurnetwerk Nederland established in 2013 (Atlas Leefomgeving, 2018). This makes it more difficult to build within these areas.

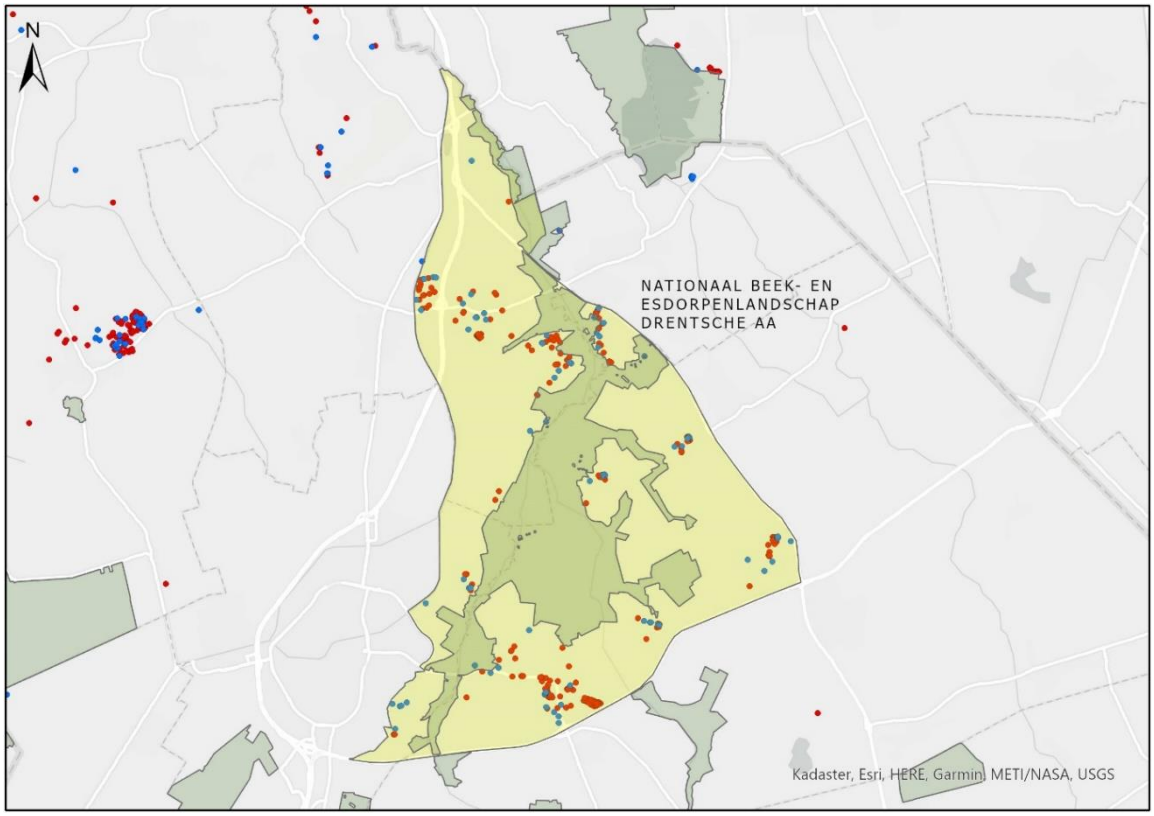


Map 3.1: Residential buildings built within protected nature areas (2000-2010)



Map 3.2: Residential buildings built within protected nature areas (2010-2020)

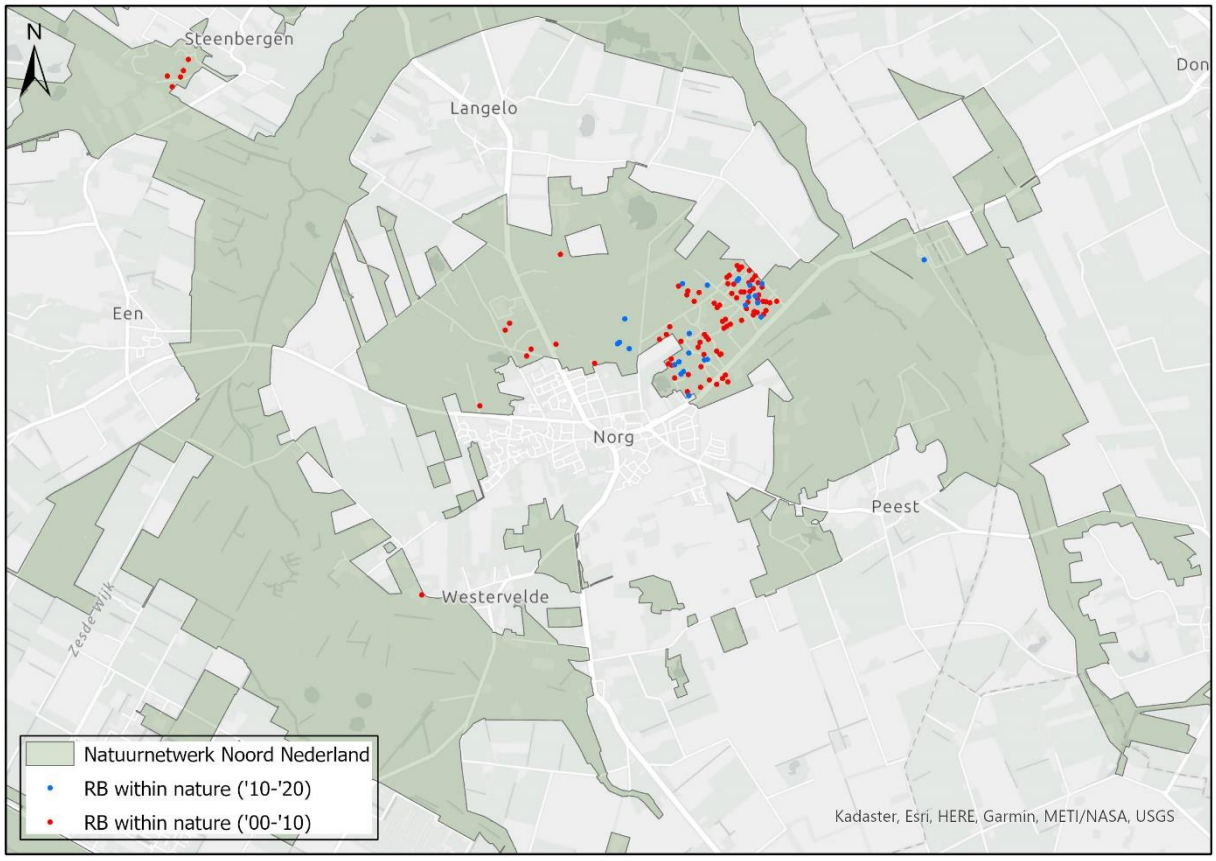
The results of housing growth within protected nature areas demonstrate the difference between the various categories of the nature layer used for this research. For example, there was clearly more housing growth within National Parks compared to Nature Conservation Act areas. An example is the area around the Drentsche AA. Map 3.3 shows that individual housing units were built within the National Park area (yellow). However, almost no housing units were built within the National Conservation Act area (green). The difference between the two could be the institution that sets the rules. The National Conservation Act is based on the European Birds and Habitats Directive (Wettenbank, 2021). Although National Parks also offer protection to nature, protection according to the National Conservation Act seems to be stricter.



Map 3.3: Housing growth relative to National Park (yellow) and Nature Conservation Act (Green) Red dots display RB ’00-’10. Blue dots display RB ’10-’20.

The WDPA category that displays the Natuurnetwerk Nederland areas, covers a substantial part of the total study area (Appendix A 7). Zooming in on Drenthe it can be observed that almost no individual residential buildings were built within these protected nature areas. Except for many residential buildings in the same area near the village of Norg in Drenthe (Map 3.4). This housing growth consist of mainly residential buildings with an additional vacation function. A plausible reason for the location of these houses within nature could also be the result of

changing nature conservation regimes. Next to that, the additional vacation function might have played a role in obtaining a building permit.

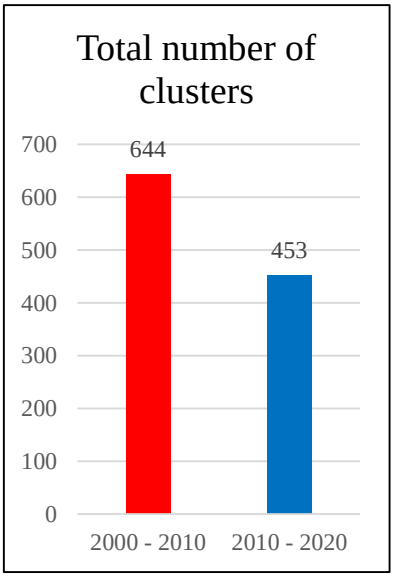


Map 3.4: Housing growth relative to Natuurnetwerk (Norg area)

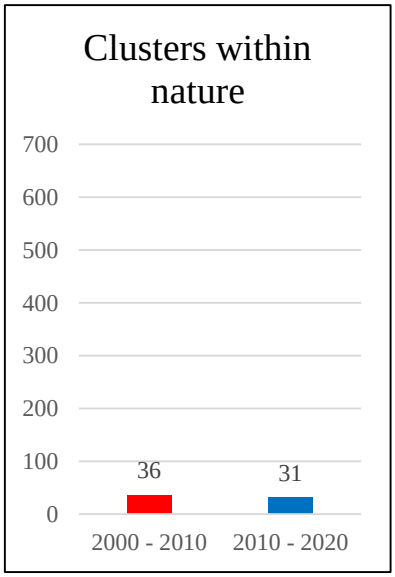
3.2 Clusters of housing growth within protected nature areas

Housing growth clusters were determined by a Getis-Ord Gi* Hotspot Analysis. Each grid square with a GiP-value of less than 0,05 was defined as a cluster. Between 2000 and 2010, there were 644 grid squares with a GiP-value of less than 0,05 (i.e. 644 housing growth clusters). From 2010 to 2020, there was a total of 453 housing growth clusters (Appendix A 5 & Appendix A 6). Looking at Appendix A 8, it is remarkable that most clusters are situated within or near already existing cities and villages for both decades. This corresponds to findings of Van Dalen (2013) who found that cluster of housing growth mainly occur within and near cities and in particular larger cities. In the Northern Netherlands, indeed the majority of the clusters is situated in and around relatively big cities like Leeuwarden, Drachten, Groningen, and Assen.

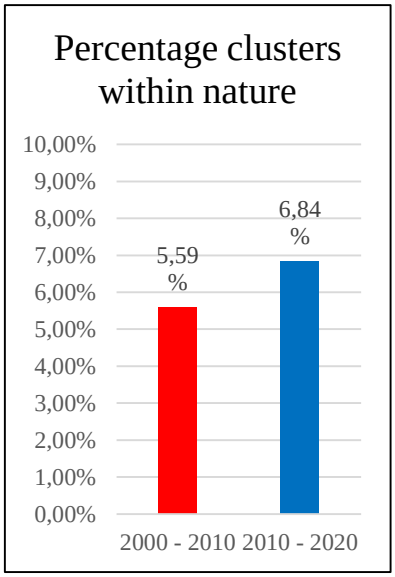
During the first decade, 36 housing growth clusters of a total of 644 were built (partly) within protected nature areas (5,59%). From 2010 until 2020, 31 housing growth clusters of a total of 453 were built (partly) within protected nature areas (6,84%). Although the absolute number of housing growth clusters decreased over time, the percentage clusters within nature had increased during the second decade (Graph 3.3 & Graph 3.5). It is surprising that when looking at individual residential buildings, the relative number of housing growth within nature decreased whereas the percentage of housing growth clusters within nature increased (Graph 3.5). In other words, the number of houses within nature decreased comparing the second to the first decade. However, the relative number of housing growth clusters within nature increased. The reason for this difference could have been caused by the research method. In the analysis. housing growth clusters were polygon shaped. Residential buildings were points in the analysis. The housing growth cluster polygons have a bigger size than the point data and are therefore more likely to be located within nature. Besides that, the research method used to count the number of clusters within nature areas, also selected the clusters that were only partly located within nature. Looking at Map 3.5 and Map 3.6, we can observe that many housing growth clusters are located on the edge of protected nature areas. Even polygons slightly intersecting a nature area, were labeled as a cluster that was located within nature.



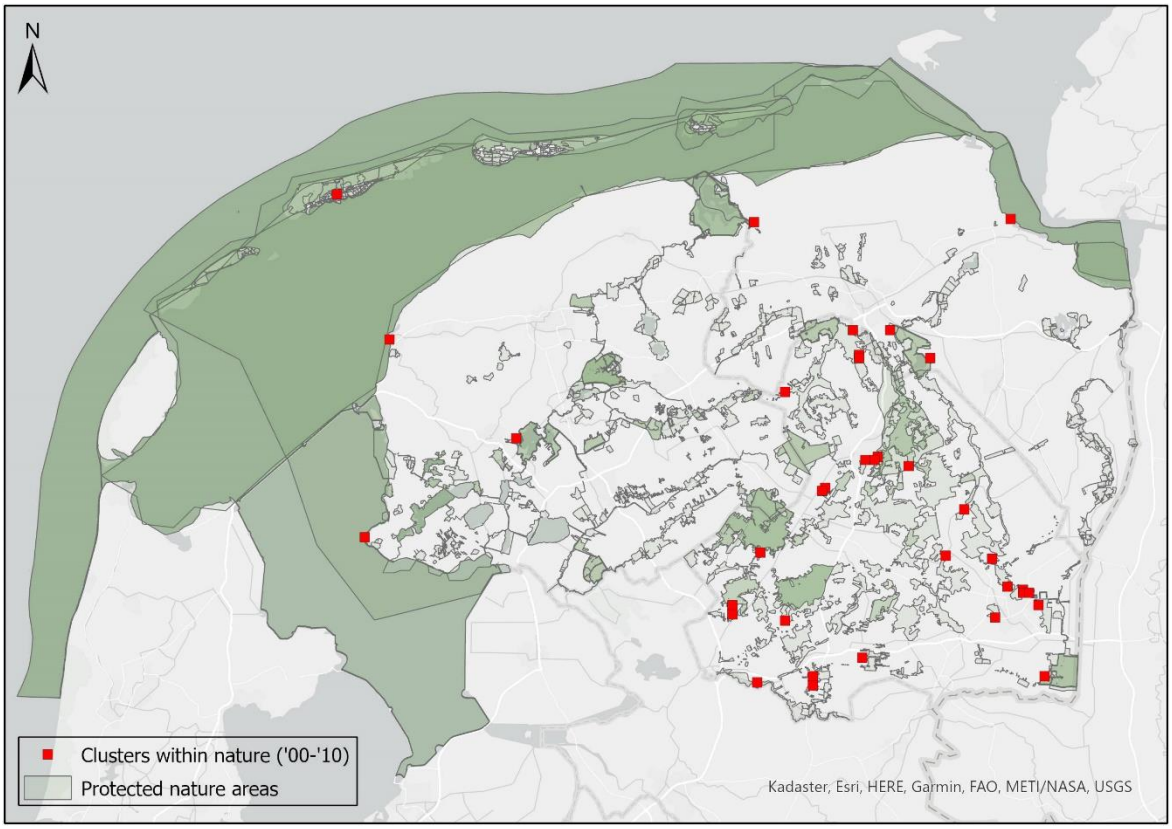
Graph 3.5



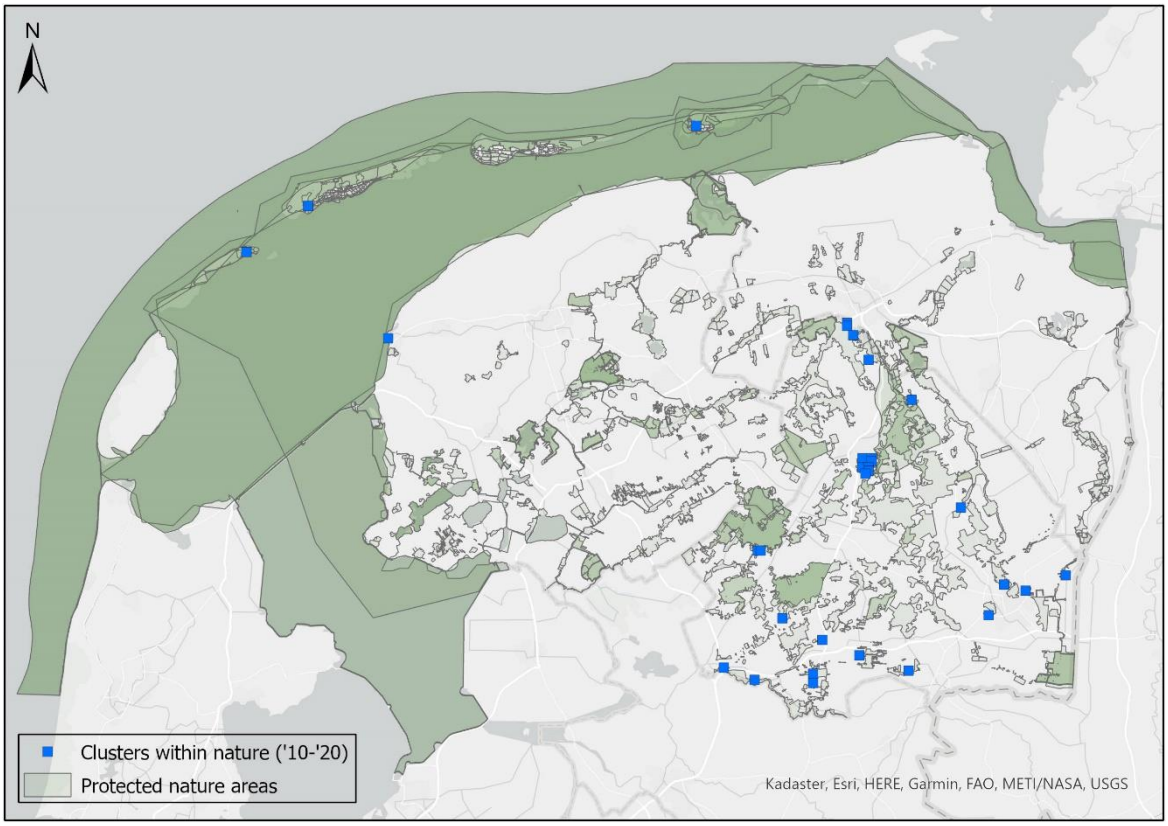
Graph 3.4



Graph 3.3



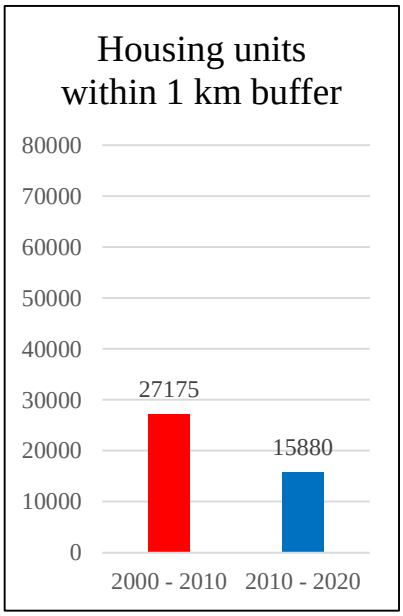
Map 3.5: Housing growth clusters within protected nature areas (2000-2010)



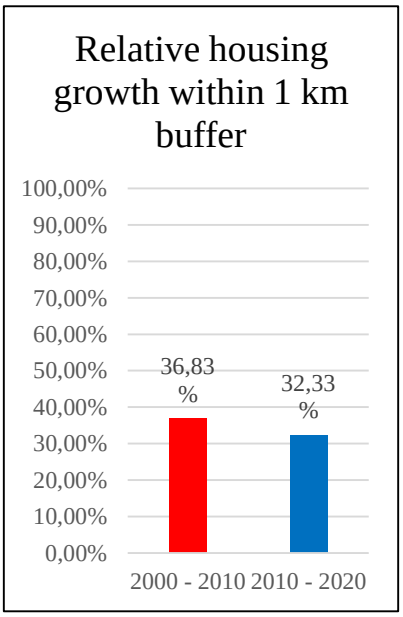
Map 3.6: Housing growth clusters within protected nature areas (2010-2020)

3.3 Housing growth near nature

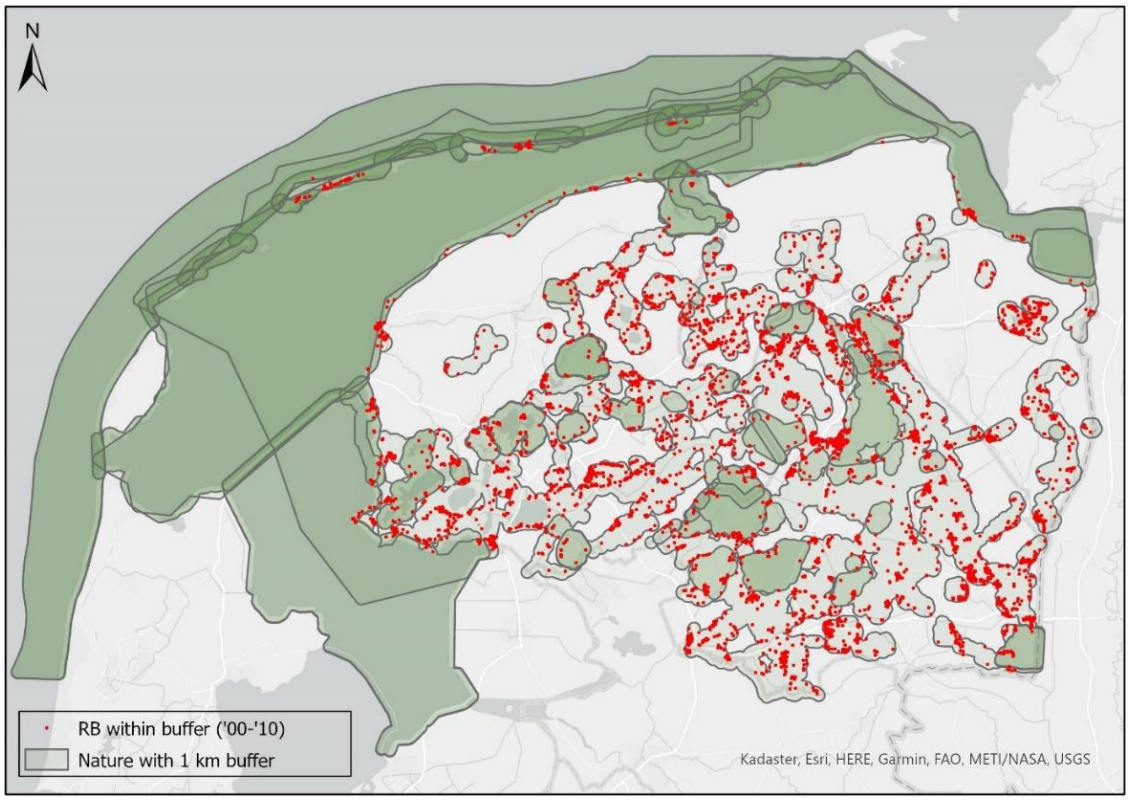
A large percentage of residential buildings was built near protected nature areas during both decades. Houses built within a range of 1 km from nature were counted. Houses built within protected nature areas were excluded for this analysis. During the first decade, 27.175 residential buildings were built within a 1 km distance of protected nature areas. This means that 36,83% of the total housing growth from 2000 to 2010 was situated near protected nature areas (Graph 3.7). Map 3.7 shows the spatial relation between residential buildings and the nature buffer of 1 km for the first decade. Looking at the second decade, another 15.880 residential buildings were built within this 1 km range of protected nature areas. During the second decade, 32,33% of the total housing growth was built within the 1 km buffer of protected nature areas (Graph 3.7). Map 3.8 demonstrates the residential buildings that were built within the 1 km buffer for 2010-2020. The absolute decrease of residential buildings near nature is in line with the overall decline in housing growth when comparing the second decade to the first decade. However, remarkable is that the relative housing growth near protected nature areas decreased with 4,5%. This relative decrease is in compliance with the results of housing growth within nature areas. Not only relatively less residential buildings were built within protected nature areas. Also relatively less residential buildings were built near nature comparing the first to the second decade.



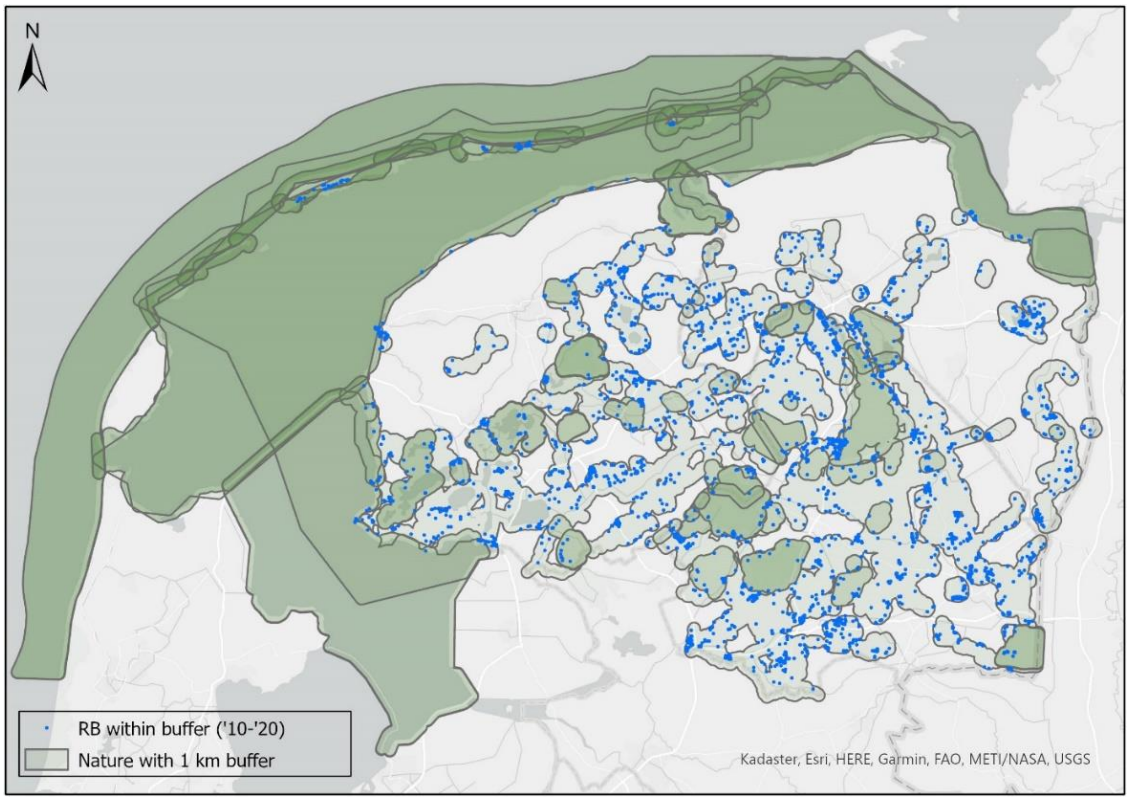
Graph 3.6



Graph 3.7

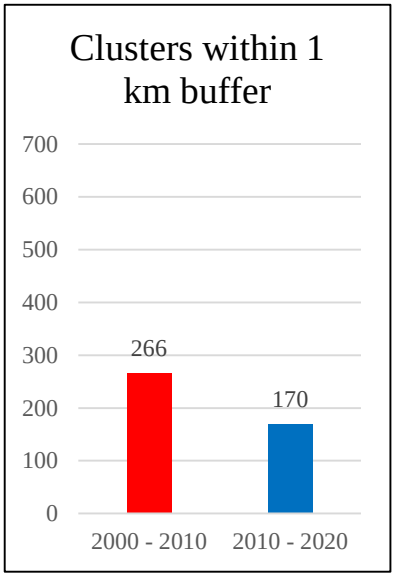


Map 3.7: Residential buildings within nature buffer (2000-2010)

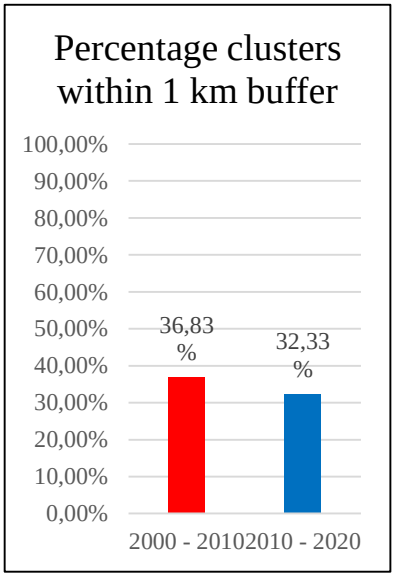


Map 3.8: Residential buildings within nature buffer (2010-2020)

Looking at clusters of housing growth near nature, we also see that a relatively big part of the total number of clusters was built near protected nature areas. From the total of 644 housing growth clusters of the first decade, 266 were built within 1 km distance of a protected nature area (41,30% of the total). During the second decade, 170 of a total of 453 housing growth clusters were built in this buffer (37,53% of the total) (Graphs 3.8 & 3.9). Map 3.9 and Map 3.10 show the spatial relation between housing growth clusters and the 1 km buffer from nature for the two decades. Concluding that during the first 20 years of the 21st century, more than one third of all housing clusters was located near (i.e. within 1 km range) protected nature areas. Although housing growth within protected nature areas is strictly regulated, these numbers show that housing growth close to nature is common. It looks like the strict regulations that apply for housing growth within nature in The Netherlands, do not apply for building near nature. According to Radeloff et al. (2009), housing growth within a range of 1 km from nature, greatly diminishes the conservation value of nature areas. Without policies regarding housing growth near nature areas and with the current plans for new housing, it is plausible that housing growth near nature will increase.



Graph 3.8

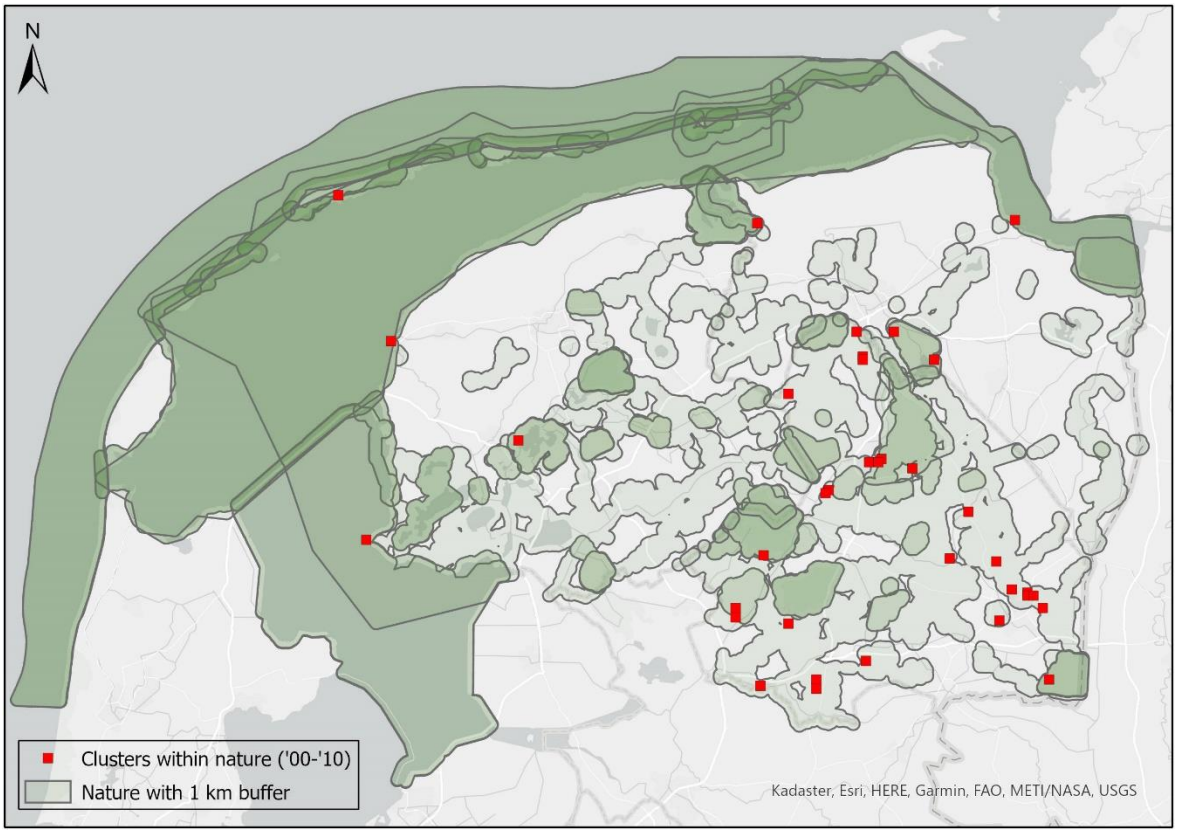


Graph 3.9

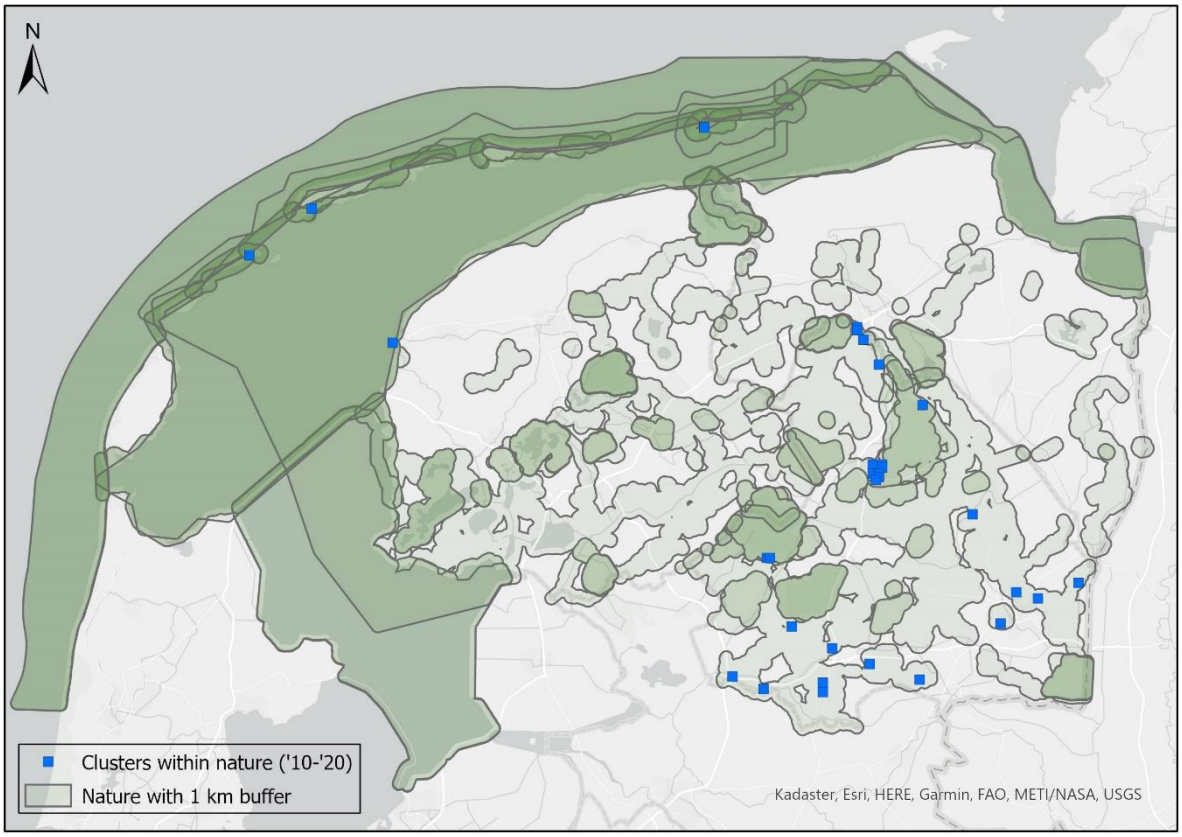
3.4 Average distance from clusters to nature

Finally, the average distance between housing growth clusters and protected nature areas was calculated (Appendix C 9). During the first decade, the average distance of a cluster to its nearest protected nature area was 2.019 meters. The average distance from a cluster to its nearest protected nature area in the second decade was 5.435 meters. In the second decade, the average

distance between nature and clusters was more than 2,4 km bigger than in the first decade. However, attention must be given to the fact that there is a difference in the total number of housing growth clusters for both decades. As demonstrated by Lepczyck et al (2007) and Radeloff et al. (2009), clusters of housing growth near nature can disturb essential aspects of nature. A bigger distance between clusters of housing growth and nature can have a positive effect on the overall effectiveness of nature areas. Therefore, the distance between housing growth clusters and nature is an aspect that policymakers can take into account when making decisions regarding housing growth and land-use planning.



Map 3.9: Housing growth clusters within nature buffer (2000-2010)



Map 3.10: Housing growth clusters within nature buffer (2010-2020)

4. Conclusions

This bachelor thesis investigated the spatial relation between housing growth and nature in the Northern Netherlands during the first two decades of the 21st century. During the first decade of this century, over 73 thousand new residential buildings were built in the Northern Netherlands. Of them, 0,908% was built within protected nature areas. From 2010 to 2020, only a little more than 49 thousand residential buildings were built in the Northern Netherlands. Of this total, 0,729% was built within protected nature areas.

Besides individual housing units, clusters of housing growth were also mapped and analyzed in this research. With the help of Getis-Ord Gi* Hotspot Analysis, 644 housing growth clusters were defined between 2000 and 2010. From the 644 clusters, 5,59% was built (partly) within a protected nature area. The hotspot analysis defined 453 housing growth clusters built between 2010 and 2020. During this decade, 6,84% of the housing growth clusters was built (partly) within nature.

Housing growth near nature was analyzed using a 1 km buffer that was placed around the protected nature areas. For both decades, about one third of the total housing growth was located within a range of 1 km from nature. Relatively more clusters were built near nature compared to single residential buildings. From 2000 to 2010, 41,30% of the clusters was built within the 1 km range and during the second decade 37,53% of the clusters was located near nature.

The low number of residential buildings located within nature is quite likely the consequence of strict housing policies resulting from new (European) laws and regulations. Although prevention of housing growth within nature areas is well organized, more than one third of housing growth took place within a near distance (1 km) of nature areas. As earlier research in the United States showed, housing growth near nature areas has direct negative effects on nature.

Mapping and analyzing the spatial development of housing growth in relation to nature can help policymakers to make substantiated decisions regarding land-use planning. A suggestion for future housing policy could be improved prevention for housing growth near nature. It is a political decision to decide if indeed stricter policies are needed.

This research illustrates that housing growth within protected nature areas barely took place in the first part of this century. However, approximately one third of the total housing growth took place near (i.e. within 1 km) protected nature areas. An implication for future policies could be to reconsider current policies regarding housing growth in relation to nature. More emphasis could be placed on housing growth near protected nature areas. With the strong need for new

houses, the (Northern) Netherlands is facing a difficult task regarding land-use planning for the coming decades. Studies similar to this one that map how housing growth develops relative to nature can be used as a tool for future land use planning. Therefore, future studies to housing growth in relation to nature can be relevant. For the Netherlands, a similar kind of research for other regions or on a national level can be helpful for policies regarding housing growth, land-use planning, and nature preservation.

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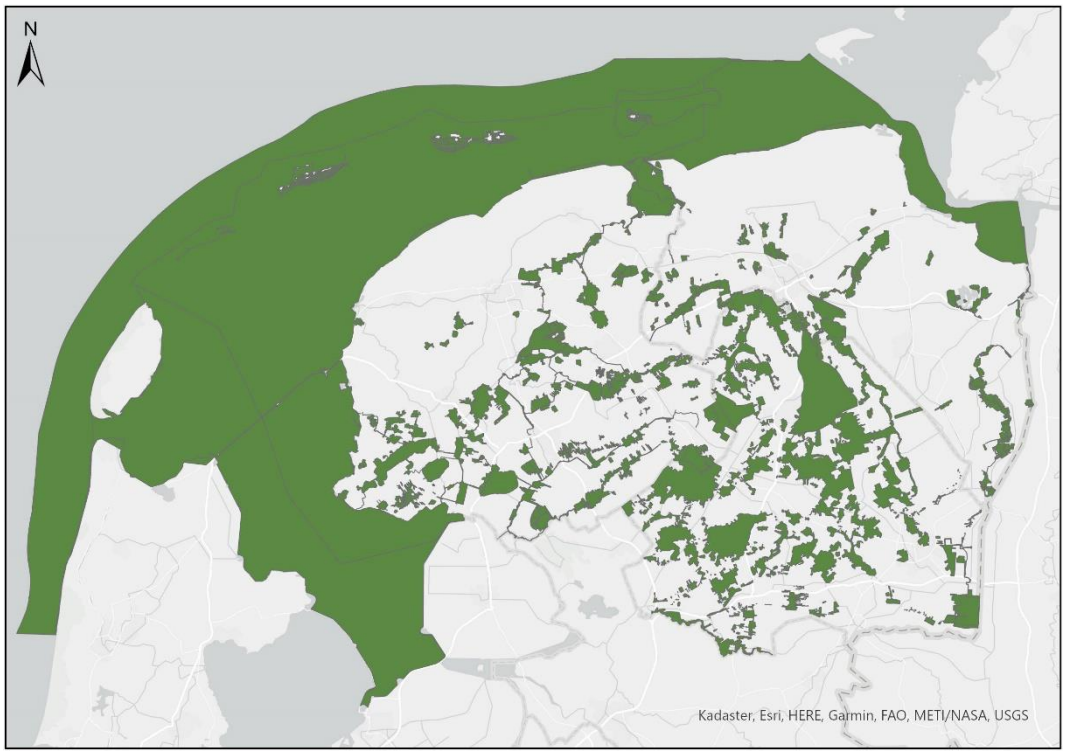
Appendices A: MAPS

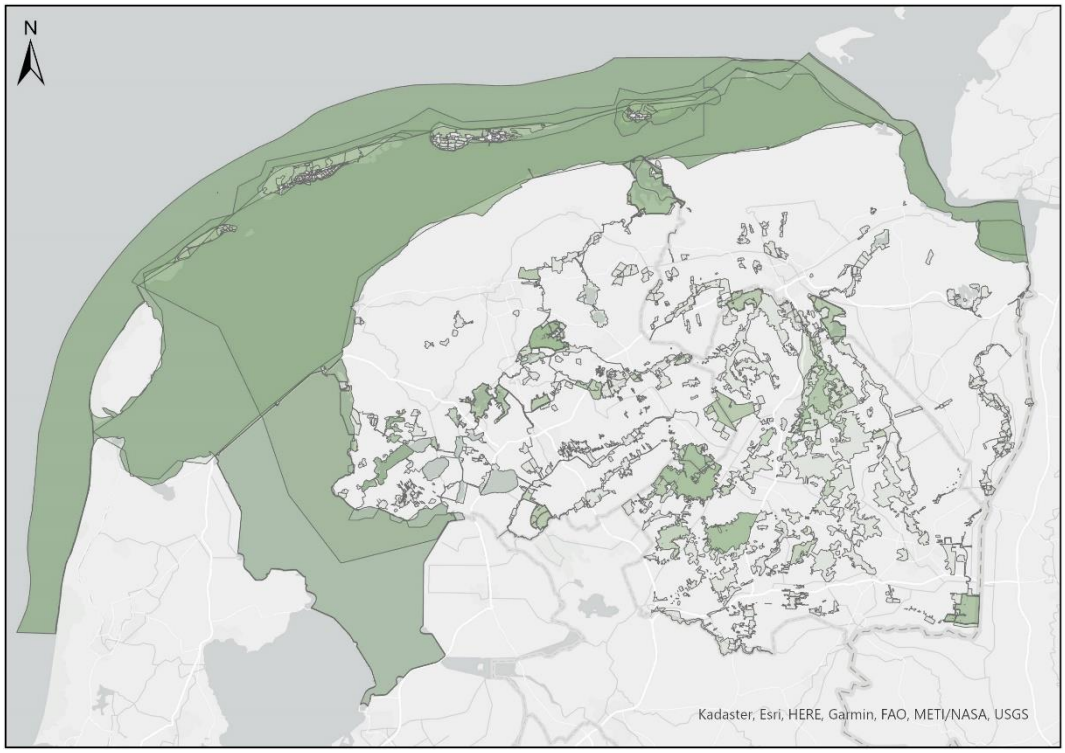
Appendix A 1

WDPA Protected nature areas Northern Netherlands



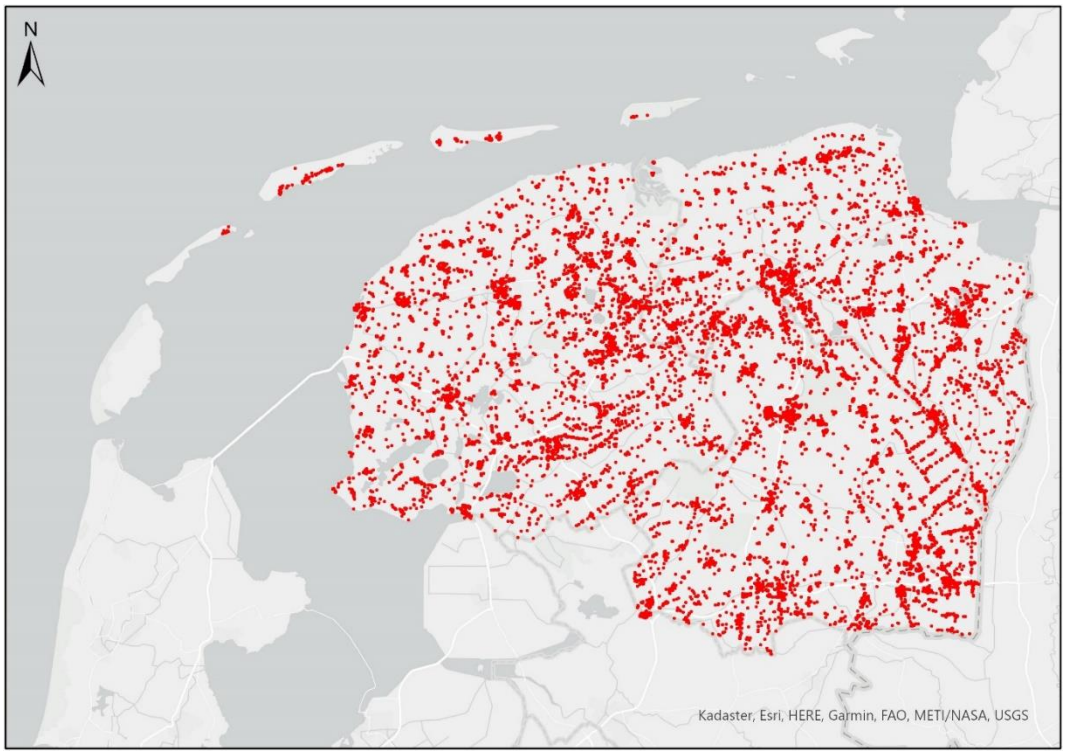
Appendix A 2

WDPA Protected nature areas Northern Netherlands (overlap visible)



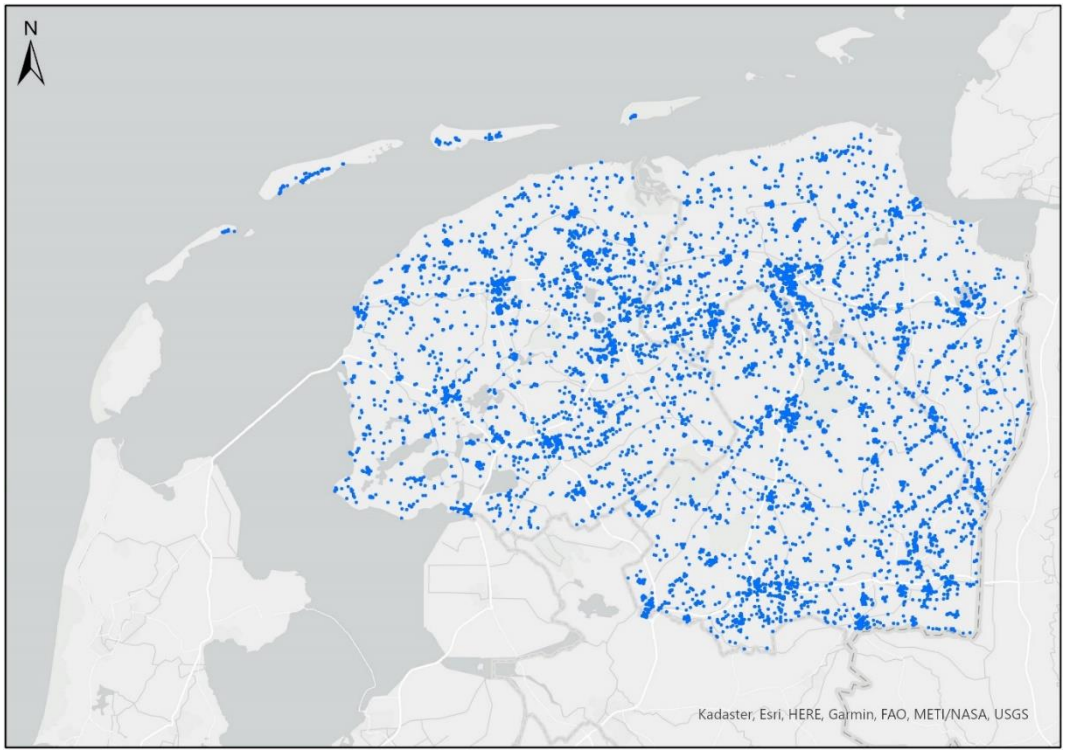
Appendix A 3

Red dots represent total residential buildings built between 2000 and 2010



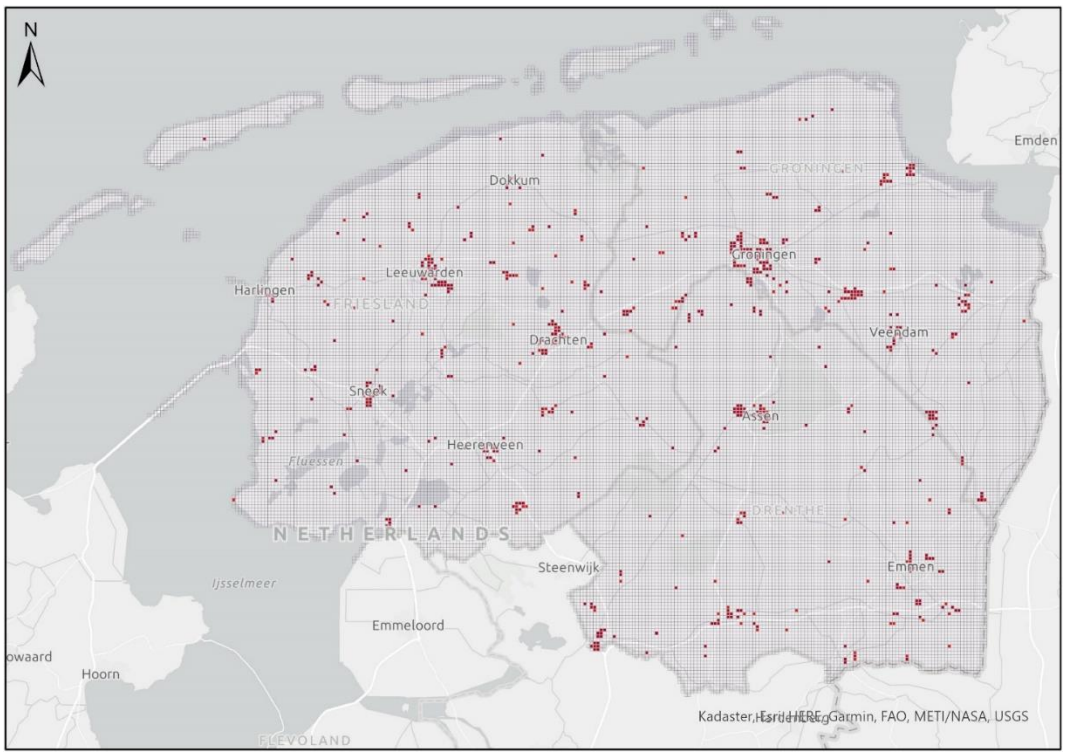
Appendix A 4

Blue dots represent total residential buildings built between 2010 and 2020



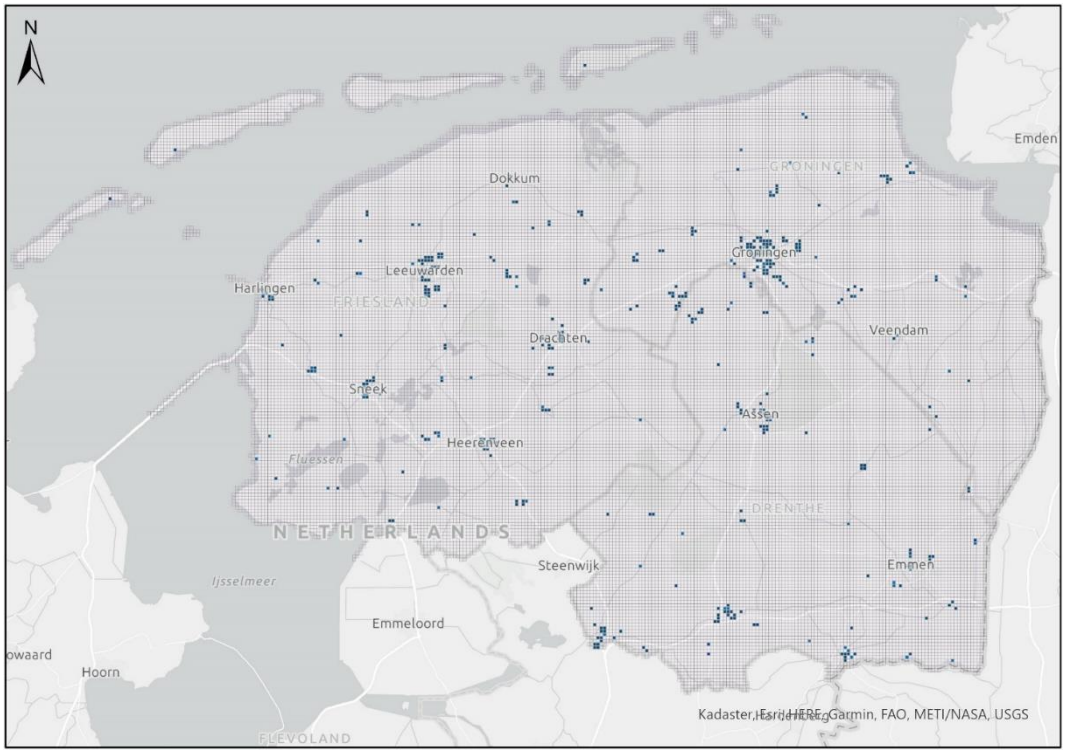
Appendix A 5

Red squares represent housing growth clusters built between 2000 and 2010



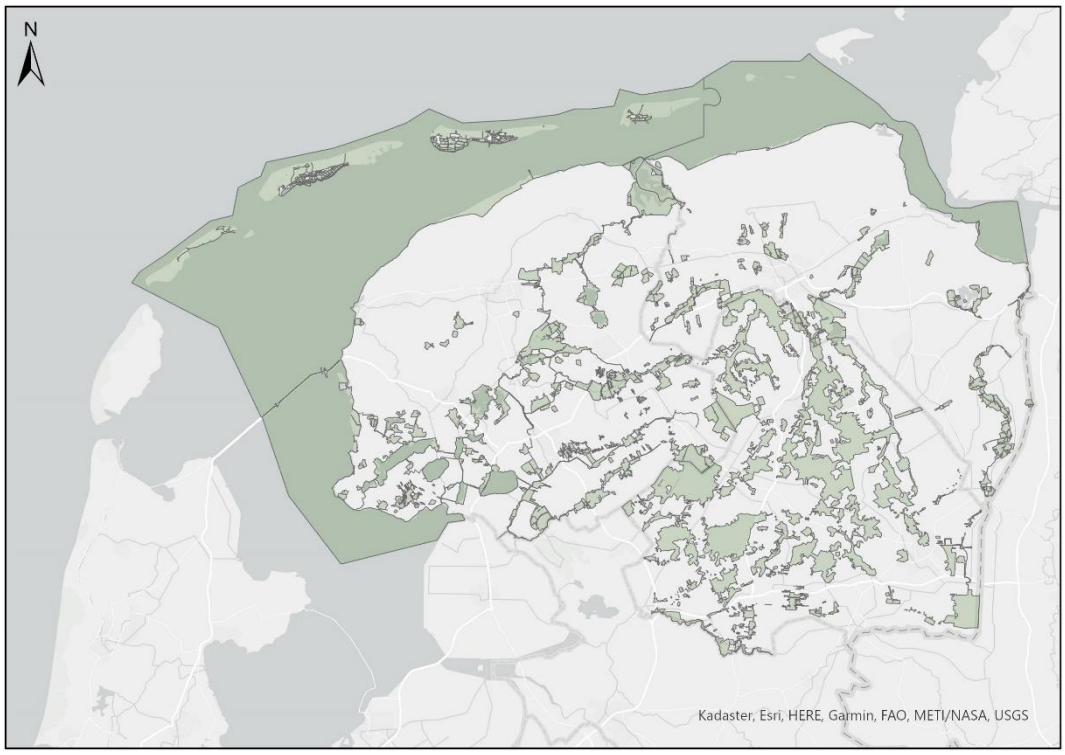
Appendix A 6

Blue squares represent housing growth clusters built between 2010 and 2020



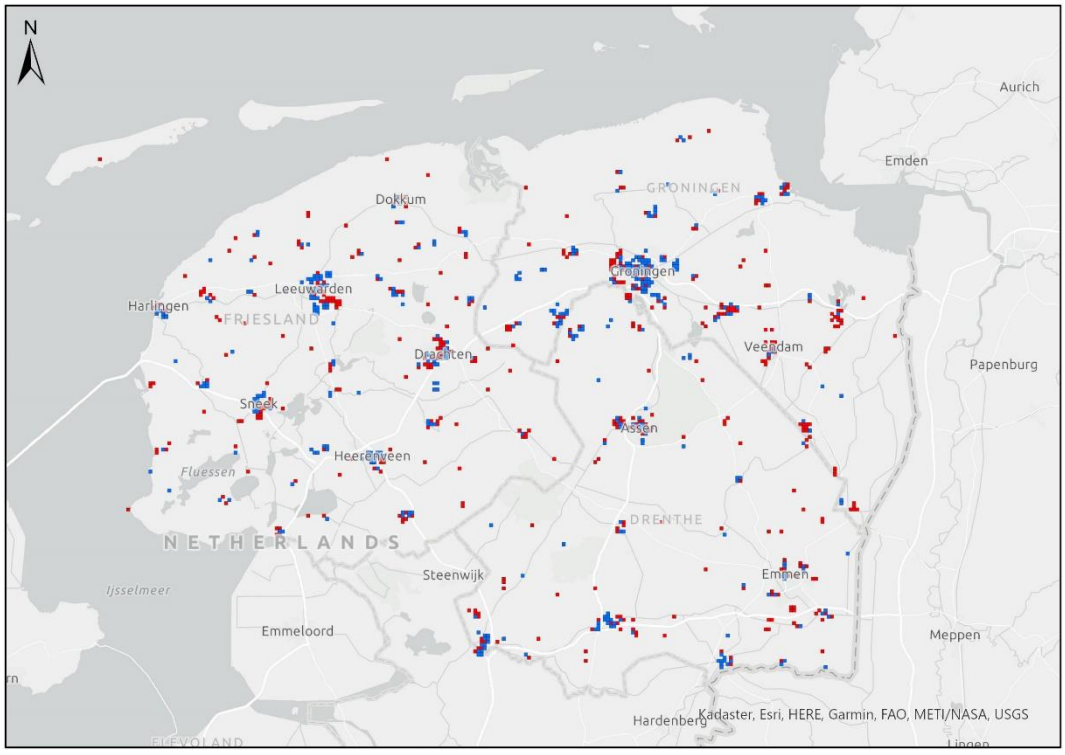
Appendix A 7

Green area represents Natuurnetwerk Nederland (est. 2013)



Appendix A 8

Total housing growth clusters relative to cities (red: ’00-’10), blue (’10-’20)



Appendices B: TABLES

Appendix B 1

Sources and institutions of the World Database on Protected Areas

WDPA SOURCES

Name WDPA Dataset	Institution	Link
UNESCO-MAB Biosphere Reserve	UNESCO	UNESCO-MAB
Special Protection Area (Birds Directive)	European Union	Special Protection Area
Site of Community Importance (Habitats Directive)	European Union	Site of Community Importance
Ramsar Site, Wetland of International Importance	International treaty	RAMSAR Treaty
Nature Reserves Owned by Professional Nature Management Organizations (Natuurnetwerk Nederland)	Dutch Government	Natuurnetwerk Nederland
Nature Conservation Act	Dutch Government	Nature Conservation Act
National Park	Dutch Government	National Parks Netherlands
Marine Protected Area (OSPAR)	OSPAR	OSPAR

Appendix B 2

WDPA Protected nature areas located in the Northern Netherlands. Sorted by Institutional designation

WDPA Protected nature areas (Northern Netherlands)

FID	NAME	DESIG_ENG	IUCN_CAT	STATUS_YR
106	Schiermonnikoog	National Park	II	1989
97	Dwingelderveld	National Park	II	1991
96	Drents-Friese Wold	National Park	II	1999
105	Nationaal Beek- En Esdorpenlandschap Drentsche Aa	National Park	II	2002
101	Lauwersmeer	National Park	II	2003
95	De Alde Feanen	National Park	II	2006
107	Bargerveen	Nature Conservation Act	IV	1992
69	Alde Feanen	Nature Conservation Act	IV	1994
83	Dwingelderveld	Nature Conservation Act	IV	1996
73	Fochteloërveen	Nature Conservation Act	IV	1998
89	Van Oordt'S Mersken	Nature Conservation Act	IV	2000
79	Duinen Ameland	Nature Conservation Act	IV	2009
80	Duinen Schiermonnikoog	Nature Conservation Act	IV	2009

81	Duinen Terschelling	Nature Conservation Act	IV	2009
82	Duinen Vlieland	Nature Conservation Act	IV	2009
66	Waddenzee	Nature Conservation Act	IV	2009
92	Witterveld	Nature Conservation Act	IV	2009
76	Deelen	Nature Conservation Act	IV	2010
77	Drents-Friese Wold & Leggelderveld	Nature Conservation Act	IV	2010
84	Elperstroomgebied	Nature Conservation Act	IV	2010
85	Groote Wielen	Nature Conservation Act	IV	2010
75	Ijsselmeer	Nature Conservation Act	IV	2010
100	Lauwersmeer	Nature Conservation Act	IV	2010
104	Leekstermeergebied	Nature Conservation Act	IV	2010
94	Noordzeekustzone	Nature Conservation Act	IV	2010
86	Norgerholt	Nature Conservation Act	IV	2010
87	Oudegaasterbrekken, Fluessen En Omgeving	Nature Conservation Act	IV	2010
88	Sneekermeergebied	Nature Conservation Act	IV	2010
90	Wijnjeterper Schar	Nature Conservation Act	IV	2010
91	Witte En Zwarte Brekken	Nature Conservation Act	IV	2010
93	Zuidlaardermeergebied	Nature Conservation Act	IV	2010
70	Bakkeveense Duinen	Nature Conservation Act	IV	2013
72	Drentsche Aa-Gebied	Nature Conservation Act	IV	2013
78	Drouwenerzand	Nature Conservation Act	IV	2013
74	Holtingerveld	Nature Conservation Act	IV	2013
67	Lieftinghsbroek	Nature Conservation Act	IV	2013
68	Mantingerbos	Nature Conservation Act	IV	2013
71	Mantingerzand	Nature Conservation Act	IV	2013
99	Rottige Meenthe & Brandemeer	Nature Conservation Act	IV	2013
16	Waddensea Area	UNESCO-MAB Biosphere Reserve	Not Applicable	1986
103	Nnn-Fr	Nature Reserves Owned By Professional Nature Management Organizations	Not Assigned	2014
102	Nnn-Dr	Nature Reserves Owned By Professional Nature Management Organizations	Not Assigned	2015
98	Nnn-Gr	Nature Reserves Owned By Professional Nature Management Organizations	Not Assigned	2016
12	Wadden Sea	Ramsar Site, Wetland of International Importance	Not Reported	1984
47	Waddenzee	Special Protection Area (Birds Directive)	Not Reported	1991
61	Bargerveen	Special Protection Area (Birds Directive)	Not Reported	1992
20	Deelen	Special Protection Area (Birds Directive)	Not Reported	1992
11	Alde Feanen	Ramsar Site, Wetland of International Importance	Not Reported	1993
15	Bargerveen	Ramsar Site, Wetland of International Importance	Not Reported	1993

14	Deelen	Ramsar Site, Wetland of International Importance	Not Reported	1993
65	Alde Feanen	Special Protection Area (Birds Directive)	Not Reported	1994
58	Dwingelderveld	Special Protection Area (Birds Directive)	Not Reported	1996
60	Fochteloërveen	Special Protection Area (Birds Directive)	Not Reported	1998
39	Drents-Friese Wold & Leggelderveld	Special Protection Area (Birds Directive)	Not Reported	2000
7	Duinen Ameland	Ramsar Site, Wetland of International Importance	Not Reported	2000
63	Duinen Ameland	Special Protection Area (Birds Directive)	Not Reported	2000
8	Duinen Schiermonnikoog	Ramsar Site, Wetland of International Importance	Not Reported	2000
64	Duinen Schiermonnikoog	Special Protection Area (Birds Directive)	Not Reported	2000
9	Duinen Terschelling	Ramsar Site, Wetland of International Importance	Not Reported	2000
25	Duinen Terschelling	Special Protection Area (Birds Directive)	Not Reported	2000
10	Duinen Vlieland	Ramsar Site, Wetland of International Importance	Not Reported	2000
26	Duinen Vlieland	Special Protection Area (Birds Directive)	Not Reported	2000
62	Groote Wielen	Special Protection Area (Birds Directive)	Not Reported	2000
0	IJsselmeer	Ramsar Site, Wetland of International Importance	Not Reported	2000
18	IJsselmeer	Special Protection Area (Birds Directive)	Not Reported	2000
1	Lauwersmeer	Ramsar Site, Wetland of International Importance	Not Reported	2000
51	Lauwersmeer	Special Protection Area (Birds Directive)	Not Reported	2000
2	Leekstermeergebied	Ramsar Site, Wetland of International Importance	Not Reported	2000
57	Leekstermeergebied	Special Protection Area (Birds Directive)	Not Reported	2000
59	Noordzeekustzone	Special Protection Area (Birds Directive)	Not Reported	2000
4	North Sea Coastal Area	Ramsar Site, Wetland of International Importance	Not Reported	2000
13	Oudegaasterbrekken, Fluessen en omgeving	Ramsar Site, Wetland of International Importance	Not Reported	2000
36	Oudegaasterbrekken, Fluessen en omgeving	Special Protection Area (Birds Directive)	Not Reported	2000
5	Rottige Meenthe en Brandemeer	Ramsar Site, Wetland of International Importance	Not Reported	2000
3	Sneekermeergebied	Ramsar Site, Wetland of International Importance	Not Reported	2000
34	Sneekermeergebied	Special Protection Area (Birds Directive)	Not Reported	2000
33	Van Oordt's Mersken	Special Protection Area (Birds Directive)	Not Reported	2000

32	Witte en Zwarte Brekken	Special Protection Area (Birds Directive)	Not Reported	2000
6	Zuidlaardermeergebied	Ramsar Site, Wetland of International Importance	Not Reported	2000
28	Zuidlaardermeergebied	Special Protection Area (Birds Directive)	Not Reported	2000
37	Alde Feanen	Site of Community Importance (Habitats Directive)	Not Reported	2004
24	Bakkeveense Duinen	Site of Community Importance (Habitats Directive)	Not Reported	2004
40	Bargerveen	Site of Community Importance (Habitats Directive)	Not Reported	2004
27	Drentsche Aa-gebied	Site of Community Importance (Habitats Directive)	Not Reported	2004
30	Drents-Friese Wold & Leggelderveld	Site of Community Importance (Habitats Directive)	Not Reported	2004
22	Drouwenerzand	Site of Community Importance (Habitats Directive)	Not Reported	2004
45	Duinen Ameland	Site of Community Importance (Habitats Directive)	Not Reported	2004
46	Duinen Schiermonnikoog	Site of Community Importance (Habitats Directive)	Not Reported	2004
56	Duinen Terschelling	Site of Community Importance (Habitats Directive)	Not Reported	2004
21	Duinen Vlieland	Site of Community Importance (Habitats Directive)	Not Reported	2004
48	Dwingelderveld	Site of Community Importance (Habitats Directive)	Not Reported	2004
23	Elperstroomgebied	Site of Community Importance (Habitats Directive)	Not Reported	2004
31	Fochteloërveen	Site of Community Importance (Habitats Directive)	Not Reported	2004
43	Groote Wielen	Site of Community Importance (Habitats Directive)	Not Reported	2004
52	Holtingerveld	Site of Community Importance (Habitats Directive)	Not Reported	2004
35	IJsselmeer	Site of Community Importance (Habitats Directive)	Not Reported	2004
49	Lieftinghsbroek	Site of Community Importance (Habitats Directive)	Not Reported	2004
42	Mantingerbos	Site of Community Importance (Habitats Directive)	Not Reported	2004
50	Mantingerzand	Site of Community Importance (Habitats Directive)	Not Reported	2004
53	Noordzeekustzone	Site of Community Importance (Habitats Directive)	Not Reported	2004
44	Norgerholt	Site of Community Importance (Habitats Directive)	Not Reported	2004
54	Oudegaasterbrekken, Fluessen en omgeving	Site of Community Importance (Habitats Directive)	Not Reported	2004
29	Rottige Meenthe & Brandemeer	Site of Community Importance (Habitats Directive)	Not Reported	2004
38	Van Oordt's Mersken	Site of Community Importance (Habitats Directive)	Not Reported	2004
41	Waddenzee	Site of Community Importance (Habitats Directive)	Not Reported	2004
55	Wijnjeterper Schar	Site of Community Importance (Habitats Directive)	Not Reported	2004

19	Witterveld	Site of Community Importance (Habitats Directive)	Not Reported	2004
17	Noordzeekustzone	Marine Protected Area (OSPAR)	Not Reported	2009

Appendix B 3

Fragment of attribute table after Spatial Join for RB ’00-’10 and Raster Layer. Each OBJECTID represents a raster square. The Join_Count represents the number of residential buildings located on that raster square.
*Only the first five and the last five attributes of the entire table are included in this table due to the size of the entire attribute table.

	OBJECTID *	Join_Count	Shape_Area
1	21979	519	250000
2	34443	464	250000
3	21733	451	250000
4	21980	441	250000
5	21732	382	250000
6	36159	0	250000
7	36160	0	250000
8	36163	0	250000
9	36164	0	250000
10	36165	0	250000

Appendix B 4

Fragment of attribute table after Spatial Join for RB ’10-’20 and Raster Layer. Each OBJECTID represents a raster square. The total Join_Count represents the number of residential buildings located on that raster square.
*Only the first five and the last five attributes of the entire table are included in this table due to the size of the entire attribute table

	OBJECTID *	Join_Count	Shape_Area
1	9703	706	250000
2	9454	644	250000
3	9700	564	250000
4	9459	563	250000
5	10703	473	250000
6	36161	0	250000
7	36162	0	250000
8	36163	0	250000
9	36164	0	250000
10	36165	0	250000

Appendix B 5

Fragment of the attribute table after Getis-Ord Gi* Hotspot analysis for housing growth 2000-2010. All attributes with a GiPValue Fixed 1 between 0 and 0,05 were defined as housing growth clusters.

*Only the first five and last five attributes of the entire table are included in this table due to the size of the entire attribute table

	SOURCE_ID	Join_Count	GiZScore Fixed 1	GiPValue Fixed 1	NNeighbors Fixed 1	Gi_Bin Fixed 1	NEAR_DIST
1	21979	519	36,31967	0	1	3	1108,039115
2	34443	464	32,455557	0	1	3	1087,648591
3	21733	451	31,542221	0	1	3	1382,053738
4	21980	441	30,839655	0	1	3	1083,314904
5	21732	382	26,694515	0	1	3	1036,617779
6	32767	30	1,964191	0,049508	1	2	192,048841
7	33758	30	1,964191	0,049508	1	2	921,407451
8	34068	30	1,964191	0,049508	1	2	505,444398
9	34715	30	1,964191	0,049508	1	2	640,309564
10	35756	30	1,964191	0,049508	1	2	5292,212087

Appendix B 6

Fragment of the attribute table after Getis-Ord Gi* Hotspot analysis for housing growth 2010-2020. All attributes with a GiPValue Fixed 1 between 0 and 0,05 were defined as housing growth clusters.

*Only the first five and last five attributes of the entire table are included in this table due to the size of the entire attribute table

	SOURCE_ID	Join_Count	GiZScore Fixed 1	GiPValue Fixed 1	NNeighbors Fixed 1	Gi_Bin Fixed 1	NEAR_DIST
1	9703	706	55,999888	0	1	3	2183,201872
2	9454	644	51,07257	0	1	3	2006,282011
3	9700	564	44,714741	0	1	3	2501,480903
4	9459	563	44,635268	0	1	3	2029,572791
5	10703	473	37,48271	0	1	3	2927,403659
6	28642	27	2,037813	0,041569	1	2	293,866947
7	32012	27	2,037813	0,041569	1	2	511,268
8	33945	27	2,037813	0,041569	1	2	1049,860279
9	35571	27	2,037813	0,041569	1	2	4440,303821
10	35755	27	2,037813	0,041569	1	2	5314,686898

Appendix B 8

Fragment of the attribute table after Near Analysis for housing growth clusters ’00-’10. The NEAR_DIST represents the distance in meters between a Housing growth cluster (SOURCE_ID) and its nearest protected nature area.
*Only the first five and the last five attributes of the entire table are included in this table due to the size of he entire attribute table

	SOURCE_ID	NEAR_DIST
1	14602	9131,614903
2	14600	8952,294422
3	15567	8889,485553
4	15566	8463,105366
5	16056	8360,379134
6	16681	52,354562
7	24568	12,925839
8	17174	11,125471
9	9205	0
10	23782	0

Appendix B 7

Fragment of the attribute table after Near Analysis for housing growth clusters ’10-’20. The NEAR_DIST represents the distance in meters between a Housing growth cluster (SOURCE_ID) and its nearest protected nature area.
*Only the first five and the last five attributes of the entire table are included in this table due to the size of he entire attribute table

	SOURCE_ID	NEAR_DIST
1	35834	15084,438335
2	35753	15054,253219
3	35666	15040,638287
4	35665	14854,801156
5	35571	14543,770838
6	19186	500,078349
7	4103	483,352247
8	23452	415,535415
9	13210	348,251976
10	12971	347,960898

Appendices C: GIS OPERATIONS

Appendix C 1

ArcGIS 1: Selection of WDPA Nature Areas in Northern Netherlands

Select Features by Location

- Input features: WDPA_WDOECM_poly_Nov2021_NLD
- Relationship: Intersect
- Selecting Features: Provincies Bestuurlijkegrenzen 2020
- Selection type: New selection

Result: WDPA Nature areas located in the Northern Netherlands
Layer name: Protected nature areas

Appendix C 2

ArcGIS 2: Clip of Residential Buildings in Northern Netherlands

Clip

- Input Features or Dataset: Residential buildings Nederland 2021
- Clip Features: Provincies Bestuurlijkegrenzen 2020
- Output Features or Dataset: Residential buildings Noord Nederland

Result: All residential buildings in the Northern Netherlands built between 2000 and 2020.
Two subsets
RB_00_10: All residential buildings in Northern Netherlands built between 2000 and 2010.
RB_10_20: All residential buildings in Northern Netherlands built between 2010 and 2020.

Appendix C 3

ArcGIS (X): Spatial Join RB x Raster

Residential buildings X Raster 2000-2010
Spatial Join

- Target Features: Raster Layer (CBS_vk500_2020_v1)
- Join Features: RB_00_10
- Output Feature Class: Spatial Join RB and Raster 00_10
- Join Operation: one to one
- Match option: Intersect

Result: An extra column called “spatial join” with the join count for each grid square for 2000-2010

Residential buildings X Raster 2010-2020
Spatial Join

- Target Features: Raster Layer (CBS_vk500_2020_v1)
- Join Features: RB_10_20
- Output Feature Class: Spatial Join RB and Raster 10_20
- Join Operation: one to one
- Match option: Intersect

Result: An extra column called “spatial join” with the join count for each grid square for 2010-2020

Appendix C 4

ArcGIS 7: Getis-Ord Gi* Hotspot analysis

Housing growth clusters 2000-2010

Getis-Ord Gi Hotspot Analysis*

- Input Feature Class: Spatial Join RB and Raster ’00-‘10
- Input Field: Join_Count
- Output Feature Class: Getis_00_10
- Conceptualization of Spatial Relationship: Fixed_distance_band
- Distance Method: Euclidian
- Distance Band or Threshold: 1

Result: A new layer with the Getis-Ord Gi* statistics for 2000-2010.

Housing growth clusters 2010-2020

Getis-Ord Gi Hotspot Analysis*

- Input Feature Class: Spatial Join RB and Raster ’10-‘20
- Input Field: Join_Count
- Output Feature Class: Getis_10_20
- Conceptualization of Spatial Relationship: Fixed_distance_band
- Distance Method: Euclidian
- Distance Band or Threshold: 1

Result: A new layer with the Getis-Ord Gi* statistics for 2010-2020.

Appendix C 5

ArcGIS 3: Select features by location Residential buildings within nature

Residential buildings within nature 2000-2010

Select Features by Location

- Input Features: RB_00_10
- Relationship: Intersect
- Selecting Features: Protected nature areas
- Search Distance: -
- Selection Type: New selection

Result: A selection of 670 residential buildings that are intersecting (i.e. located within) a WDPA protected nature area.

From this selection, a new layer was created: RB within nature (’00-’10)

Residential buildings within nature 2010-2020

Select Features by Location

- Input Features: RB_10_20
- Relationship: Intersect
- Selecting Features: Protected nature areas
- Search Distance: -
- Selection Type: New selection

Result: A selection of 358 residential buildings that are intersecting (i.e. located within) a WDPA protected nature area.

From this selection, a new layer was created: RB within nature (’10-’20)

Appendix C 6

ArcGIS 4: Select features by location Housing growth clusters within nature

Housing growth clusters within nature 2000-2010

Select Features by Location

- Input Features: Clusters_00_10
- Relationship: Intersect
- Selecting Features: Protected nature areas
- Search Distance: -
- Selection Type: New selection

Result: A selection of 36 of a total of 644 clusters that are intersecting (i.e. partly situated) in a nature area.

From this selection, a new layer was created: Clusters within nature (’00-’10)

Housing growth clusters within nature 2010-2020

Select Features by Location

- Input Features: Clusters_10_20
- Relationship: Intersect
- Selecting Features: Protected nature areas
- Search Distance: -
- Selection Type: New selection

Result: A selection of 31 of a total of 453 clusters that are intersecting (i.e. partly situated) in a nature area.

From this selection, a new layer was created: Clusters within nature (’10-’20)

Appendix C 7

ArcGIS 5: Select features by location: Housing growth within buffer

Residential buildings within buffer 2000-2010

Select Features by Location

- Input Features: RB_00_10
- Relationship: Interesect
- Selecting Features: Nature with 1 km buffer
- Search Distance: -
- Selection Type: New selection

Result: A selection of 27.175 residential buildings that are intersecting (i.e. located within) a buffer of 1 km from protected nature areas.

From this selection, a new layer was created: RB within buffer (’00-’10)

Residential buildings within buffer 2010-2020

Select Features by Location

- Input Features: RB_10_20
- Relationship: Intersect
- Selecting Features: Nature with 1 km buffer
- Search Distance: -
- Selection Type: New selection

Result: A selection of 15.880 residential buildings that are intersecting (i.e. located within) a buffer of 1 km from protected nature areas.

From this selection, a new layer was created: RB within buffer (’10-’20)

Appendix C 8

ArcGIS 6: Select features by location: Clusters within buffer

Housing growth clusters within buffer 2000-2010

Select Features by Location

- Input Features: Cluster_00_10
- Relationship: Intersect
- Selecting Features: Nature with 1 km buffer
- Search Distance: -
- Selection Type: New selection

Result: A selection of 266 clusters that are intersecting (i.e. partly located) in a 1 km buffer from protected nature areas.

From this selection, a new layer was created: Clusters within buffer (’00-’10)

Housing growth clusters within buffer 2010-2020

Select Features by Location

- Input Features: Cluster_10_20
- Relationship: Intersect
- Selecting Features: Nature with 1 km buffer
- Search Distance: -
- Selection Type: New selection

Result: A selection of 170 clusters that are intersecting (i.e. partly located) in a 1 km buffer from protected nature areas.

From this selection, a new layer was created: Clusters within buffer (’10-’20)

Appendix C 9

ArcGIS 8: Near Analysis

Housing growth clusters 2000-2010

Near analysis

- Input Features: Clusters_points_00_10 (without clusters located in nature)
- Near Features: Protected nature areas
- Method: Plenar

Result: An extra column in the attribute table of Clusters_points_00_10 giving the distance for each cluster to the nearest protected nature area.

Total distance = sum of all clusters = 1.227.686 meters

Average distance = 1.227.686/total number of clusters = 1.227.686/608 = 2019,22 meters

Housing growth clusters 2010-2020

Near analysis

- Input Features: Clusters_points_10_20 (without clusters located in nature)
- Near Features: Protected nature areas
- Method: Plenar

Result: An extra column in the attribute table of Clusters_points_10_20 giving the distance for each cluster to the nearest protected nature area.

Total distance = sum of all hotspots = 2293688 meters

Average distance = 2293688/total hotspots = 2293688/422 = 5435,28 meters