Urban expansion and population dynamics: exploring the relationship between housing development and population density in the Northern Netherlands

Hylke Ettema

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Version	**Final**
Author	**Hylke Ettema**
Student ID	**S4092821**
Supervisor	**Mark van Duijn**
Assessor	**M. Abbasiharofteh**
E-mail	**h.ettema@student.rug.nl**
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Abstract

This study investigates whether housing developments have increased population density in the Northern Netherlands between 2014 and 2020 to combat housing shortage and further improve liveable conditions for residents. Spatial and statistical analyses are performed using quantitative data from Statistics Netherlands (CBS) and the Dutch national register of addresses and buildings (BAG, Kadaster). The spatial analysis reveals that over half of the new developments occurred within a 10 kilometre radius of the largest cities in each province supporting the central place theory that most housing developments occur near urban centres. Both the linear regression and the scatterplot yielded results showing a linear relationship between new housing developments and population density. The findings indicate that within the Northern Netherlands, new housing developments are predominantly characterized as urban sprawl rather than the smart growth that the Dutch government aims to promote.

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1. Introduction

1.1 Motivation

Many countries worldwide face substantial housing challenges, including housing affordability, shortages, decreasing residential mobility, and the need for sustainable housing solutions. These issues are prominent on political agendas. In response, many policymakers emphasize the construction of new residential housing units. For instance, the Netherlands is facing a significant housing shortage, with a deficit of 279,000 houses reported in 2021. This shortage is projected to increase by 14% to 317,000 houses by 2024 (Ministry of General Affairs, 2023). This growing deficit underscores the urgency for the development of new housing.

However, simply building more houses is not straightforward due to numerous regulations and lengthy procedures for developers, necessitating extensive planning in the Dutch context. The Netherlands also grapples with spatial constraints, characterized by its compact geography and high population density. Additionally, there is a rising preference for smaller and affordable housing, driven by changes in household composition (Ministerie van Algemene Zaken, 2023). These factors highlight the need for innovative approaches to develop a larger quantity of housing within a limited land area to address current housing challenges effectively.

This research investigates whether housing is indeed being developed more densely, which should lead to an increased population density.

1.2 Academic relevance

Within academic literature, the study by Levkovich et al. (2019) examines the impact of highway construction on the population density of core cities and surrounding towns. Their findings challenge the assumption that highways depopulate city centers as people move to suburban areas. In the Netherlands, these assumptions have been proven untrue, likely due to the country's strict planning policies and land development restrictions. Despite this, there has been a lack of recent studies investigating the effects of housing development on population density, particularly in the context of the current housing shortage in the Netherlands. This research seeks to address this gap in the literature on population density and housing development.

Additionally, this study aims to establish a methodological framework for future research. By identifying effective research strategies and deriving lessons from potential challenges, this work seeks to provide a roadmap for broader investigations into urban development dynamics. This framework is intended not only for the Northern Netherlands but also for other regions facing similar housing challenges.

1.3 Research problem statement

The rapid pace of urbanization and population growth in the Northern Netherlands necessitates a closer examination of the relationship between housing development and population density. This research aims to understand how the creation of housing developments is associated with population density in the Northern Netherlands. Therefore, this thesis will address the following research question:

“What is the relationship between housing development and population density in the Northern Netherlands between 2014 and 2020?”

The first sub-question is a theoretical inquiry designed to provide a deeper understanding of the connection between the main variables. This sub-question will be explored in detail in Chapter 2:

“How do urban development theories explain the relationship between housing development and population density?”

To gain a better understanding of the spatial distribution, the second sub-question will focus on housing developments measured at the municipal level. This sub-question will be discussed in detail in Chapter 4:

“How are housing developments geographically distributed across the Northern Netherlands between 2014 and 2020?”

The third sub-question, similar to the second sub-question, will also focus on spatial analysis but will examine the distribution of population density at the municipal level. Together with the second sub-question, it aims to provide a comprehensive overview of changes in housing development and population density. This sub-question will be discussed in detail in Chapter 4:

“What is the distribution of population density within the Northern Netherlands?”

1.4 Reading guide

Chapter two will consist of a theoretical framework which defines the core concepts that will be used during this research. In chapter three, the context, data collection, ethical considerations and methodology will be discussed. The fourth chapter will discuss both the spatial and statistical results obtained throughout the research. Chapter five will conclude this research, discuss the limitations experienced during the research and make recommendations for future research.

2. Theory, literature review and hypothesis

In the Netherlands, there are stringent planning policies and land development restrictions that shape how housing development is executed (Levkovich et al., 2019). These restrictions are designed to promote certain types of development while discouraging others. Within this theoretical framework, two types of development will be highlighted: urban sprawl and smart growth.

Urban Sprawl is a type of development characterized by low-density, automobile-dependent expansion of urban areas. It often leads to inefficient land use and increased infrastructure costs. Dutch planners aim to avoid urban sprawl due to its negative environmental and social impacts (Buitelaar & Leinfelder, 2020).

Smart Growth, on the other hand, represents an innovative approach to urban development. It focuses on creating compact, transit-oriented, walkable, and bicycle-friendly urban environments. Smart growth promotes sustainable cities that are better suited to accommodate future growth without the adverse effects associated with urban sprawl (Litman & Victoria Transport Policy Institute, 2016).

After discussing these two development types, this framework will delve into theories related to these developments and population density, providing a comprehensive understanding of how planning policies can influence urban form and residential patterns

2.1 Urban sprawl

Urban sprawl is generally considered to be more costly and less efficient than a more compact form of urban expansion (Keleş et al., 2022). One key reason for this decreased efficiency is that services must cover a larger area to reach the same number of customers, leading to higher costs (Keleş et al., 2022). Additionally, higher population density provides a competitive advantage for companies, as the agglomeration theory suggests that businesses benefit from being close to complementary enterprises (Mulligan, 1984).

In the Netherlands, numerous laws and policies aim to prevent urban sprawl, a necessity due to the country's limited available land (Halleux et al., 2012). Dutch cities can be described as constrained cities because they cannot expand significantly due to the lack of lower-value land surrounding them. Consequently, population growth in these cities requires increased densities (Litman & Victoria Transport Policy Institute, 2016).

One major concern with urban sprawl is the increased car dependency it fosters in neighborhoods. This reliance on automobiles negatively impacts health and safety by promoting sedentary lifestyles and contributing to traffic-related air quality issues (Geller, 2003). Urban sprawl also has significant environmental repercussions, including the extensive consumption of land, which can lead to habitat loss, wetland destruction, and degradation of air and water quality (Litman & Victoria Transport Policy Institute, 2016).

In contrast, smart growth cities address these concerns by promoting reinvestment in existing communities, utilizing existing infrastructure more effectively, and providing diverse transportation options. Smart growth aims to create sustainable, efficient, and livable urban environments that minimize the negative impacts associated with urban sprawl.

2.2 Smart growth

Smart growth theory envisions communities not just as places to live but as mechanisms that promote health and well-being (Geller, 2003). Smart growth cities emerged as a reaction to urban sprawl, emphasizing sustainable and efficient urban development. In the Netherlands, urban areas already exhibit low car dependency, with public transport and infrastructure for alternative modes of transport being well-developed. Car dependency increases only in more remote and rural areas due to less extensive public transport options.

Smart growth cities often utilize mixed land uses to make alternative modes of transport, such as walking and cycling, viable. These cities design neighborhoods where people can live, work, and play within walking or cycling distance, creating a welcoming environment for those who cannot afford a car and benefit from having essential services nearby (Theart, 2007).

However, smart growth theory also faces criticism. For instance, development restrictions aimed at promoting smart growth can reduce land affordability, contrasting with the idea that compact or densified development makes cities more economically sustainable (Theart, 2007). Moreover, smart growth cities might reduce incentives to expand urban areas, leading to challenges in accommodating growing populations within limited space.

In the Netherlands, these limitations on urban expansion could foster creative solutions to increase urban population densities without excessive land use. This aligns with the country's need to balance population growth with spatial constraints, highlighting the potential of smart growth principles to drive innovative urban planning and development strategies.

2.3 Central place

Central place theory illustrates the influence of a central city or large village on the surrounding smaller settlements (Mulligan, 1984). According to this theory, larger settlements tend to have higher populations and greater population densities compared to their surrounding villages. This is complemented by the theory of rural-urban migration, which suggests that people move from smaller villages to larger settlements due to the economic benefits and the greater number of services available in the latter (Sun, 2019).

However, Ravenstein's law of migration posits that there is always a counter-stream, meaning that despite the popularity of rural-urban migration, urban-rural migration also occurs (Sun, 2019). Both migration flows impact population density and influence the need for new developments or demolitions in certain areas.

A study conducted in Italy presents a nuanced perspective on urban density. It suggests that moving to denser cities does not always yield positive outcomes, as the marginal cost of living in such cities does not decrease proportionally with the income and employment opportunities available (Antoniucci & Marella, 2016). This finding challenges the notion of rural-urban migration and helps explain why some people move to more rural areas. Despite this, the study acknowledges that the higher collective cost of living in denser cities, compared to sprawling cities, can be a rational choice for households and businesses when considering the potential for social and economic improvements (Antoniucci & Marella, 2016).

This theoretical framework underscores the complexity of urban development and migration patterns, highlighting the interplay between economic opportunities, living costs, and population density. Understanding these dynamics is crucial for addressing the challenges of housing development and urban planning in the Netherlands and other regions facing similar issues.

2.4 Conceptual model and Hypothesis

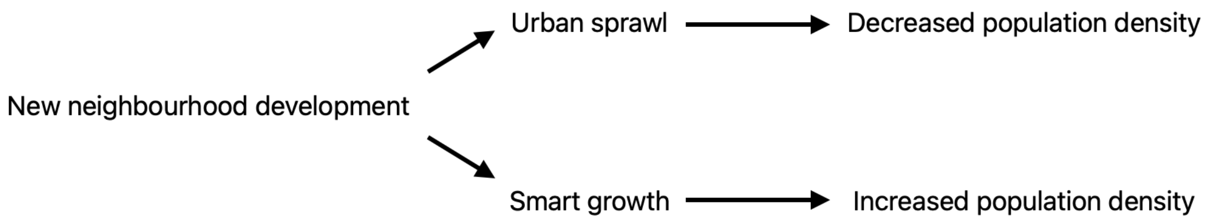

Figure 1 (conceptual model)

Figure 1 shows the conceptual model derived from the theoretical concepts on urban sprawl and smart growth. It assumes that new housing development can follow two directions: i) The path of urban sprawl, which according to the model would lead to a decrease in population density due to its large area use per unit ii) The path of smart growth which according to the model would lead to an increase in population density as it aims to build denser neighbourhoods than urban sprawl.

It is hypothesized that due to the policies against urban sprawl and the need for more housing in The Netherlands, the new housing developments will be build more dense and will therefore likely fall into the category of smart growth.

3. Data and methods

3.1 Context

The study focuses on the Northern Netherlands, encompassing the provinces of Friesland, Groningen, and Drenthe. This region is characterized by its predominantly rural and agricultural landscape, with a population of approximately 1.7 million inhabitants (CBS Statline, 2018).

In the Northern Netherlands the largest population growth can be found in urban areas. There is population decline between 2013 and 2018 in many non-urban municipalities. Between 2018 and 2023 population decline seems to disappear for most non-urban municipalities in the Northern Netherlands except for Noordenveld, Stadskanaal and Delfzijl (CBS, 2023). Demographic shifts in the Northern Netherlands are driven by both internal migration from rural to urban areas within the region, as well as outward migration from the Northern Netherlands to the Randstad region in the west of the Netherlands. The Randstad includes the four largest cities in the Netherlands (Amsterdam, Rotterdam, The Hague, and Utrecht) and accommodates nearly half of the Dutch population (CBS Statline, 2018).

The study will employ quantitative data to examine these demographic changes, housing developments, and their impact on population density within the Northern Netherlands. This approach aims to provide a comprehensive analysis of urbanization trends, housing policies, and their implications for regional development and population dynamics in this rural-agricultural context..

3.2 Data collection

Data used to answer the research question are obtained from Statistics Netherlands (CBS) and the Netherlands’ Cadastre, Land Registry and Mapping Agency (Kadaster).

From CBS the districts and neighbourhood maps of the years 2014 and 2020 have been downloaded which include number of inhabitants and number of houses on the municipal level.

From Kadaster (BAG) a housing project database was obtained. This database shows all the housing development within the Northern Netherlands and shows both build and demolished housing in the area. The BAG data also has shapefiles that can be used within ArcGIS, combined with the CBS data it can be visualized in what municipality the new developments have been build and where most developments take place.

Within ArcGIS, municipal data gathered from Statistics Netherlands (CBS) has been used. Due to changes in municipal borders, mostly municipalities merging, the 2014 municipalities have been merged to match the 2020 municipalities as much as possible. In the appendix 1 and appendix 2 there are two maps showing the municipal borders used for both 2014 and 2020. In these maps there are a few municipalities that differ with their municipal borders. These differences might skew the data a little bit as there are numerous housing projects within the areas that belong in a different municipality in 2014 than in 2020. With more ArcGIS experience this could have been done more precise. As the names of 2014 municipalities cannot be combined as well as the shapefiles, the municipalities have been numbered to keep it easy to compare the 2014 and 2020 data.

The CBS data show the number of houses there are within the municipalities, therefore when detracting the 2014 data of the 2020 data it should show how many houses are build or demolished in this time period. When looking at information about the building plans between 2023 and 2030 on the site from the Central Government of The Netherlands (Rijksoverheid), the Northern Netherlands should gain about 60.000 houses in the upcoming years (Ministerie van Algemene Zaken, 2023).

3.3 Ethical considerations

Within this research, ethical considerations primarily revolve around data management and usage rather than substantial ethical dilemmas. The databases utilized, such as those from CBS (Statistics Netherlands), are publicly accessible and do not contain sensitive or personal information that would necessitate additional protections beyond standard research practices.

Specifically, the BAG (Basisregistratie Adressen en Gebouwen) database was accessed with the understanding and agreement to use the data solely for the purposes of this research project. It was explicitly agreed not to share the database or its contents with others, ensuring compliance with data privacy and confidentiality guidelines. To uphold this agreement, the databases were exclusively accessed and processed on two designated personal devices.

It's important to note that the data extracted from the BAG database does not include personal identifiers or sensitive information. Therefore, the analysis and outputs derived from this data are unlikely to pose ethical concerns related to privacy or confidentiality.

In summary, the ethical considerations in this research primarily involve responsible data management practices, ensuring compliance with agreements and regulations regarding data usage, and safeguarding the confidentiality of information accessed from databases.

3.4 Methodology

This research employs a spatial analysis using ArcGIS to visualize the distribution patterns of housing developments across the study area. The spatial analysis aims to provide insights into how housing development has spatially unfolded within the Northern Netherlands.

For the quantitative data analysis, a linear regression model will be utilized to explore the relationship between housing development and population density. In this model, population density (measured at the municipal level) serves as the dependent variable, while housing development is considered the independent variable. Housing development is operationalized as the difference in the number of houses between 2014 and 2020, derived from authoritative datasets.

Linear regression is chosen for its ability to estimate the linear relationship between variables, helping to ascertain whether increases in housing development are associated with corresponding changes in population density. This statistical approach allows for a systematic examination of how variations in housing development may impact population density trends across municipalities within the Northern Netherlands.

From the linear regression the following calculation follows: ΔPopulation Density=$\beta 0+\beta 1 \times \Delta$ New housing $+\epsilon$

Population density will be the difference in residents per square kilometer between 2014 and 2020.

Housing development data for this research will be sourced either from the CBS (Central Bureau of Statistics) dataset, where the difference in the number of houses between 2014 and 2020 will be calculated, or from the BAG (Basisregistratie Adressen en Gebouwen) dataset. In the case of the BAG dataset, housing development will be determined by aggregating all newly developed houses currently in use and subtracting the number of houses that have been demolished to facilitate this new development.

These datasets provide comprehensive information necessary to analyze and understand the dynamics of housing development within the Northern Netherlands over the specified time period. The choice between datasets will depend on which source offers the most accurate and detailed information suitable for the study's objectives.

$\beta 0$ is the intercept coefficient, representing the estimated baseline population density when the housing development is zero.

$\beta 1$ is the regression coefficient, indicating the estimated change in population density associated with a one-unit increase in new housing development.

ϵ is the error term, accounting for unexplained variability in population density not captured by the regression model.

Next to the linear regression model a scatterplot will be used to further visualize the relationship between population density and new housing.

The findings from both the data analysis and the spatial analysis will be used to show trends, correlations and spatial associations between housing development and population density.

4 Results

4.1 Spatial analysis and results

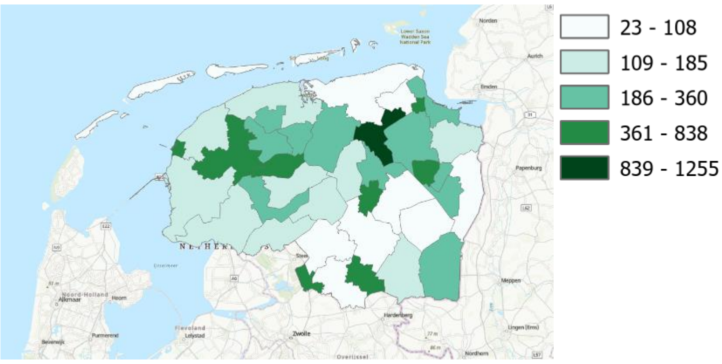

Figure 2 (Population density modified municipalities 2014)

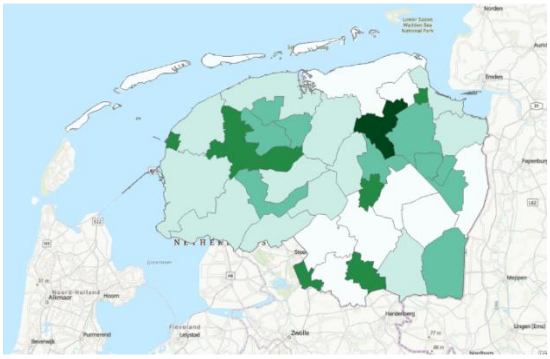

Figure 3 (Population density municipalities 2020)

Figure 2 and 3 depict the population density of municipalities in 2014 and 2020 based on CBS data. It is crucial to note that the municipal borders for 2014 have been adjusted to align as closely as possible with those of 2020. The maps use a gradient from white to dark green, where white represents the lowest population densities (inhabitants per square kilometer) and dark green represents the highest. The color ranges have been standardized for both maps to facilitate comparison.

During the period from 2014 to 2020, there were no municipalities that experienced an increase in population density. Instead, several municipalities showed a decrease in population density, particularly those that were already less densely populated. These findings align with Sun's theory (2019), which posits that individuals tend to migrate from smaller to larger settlements over time.

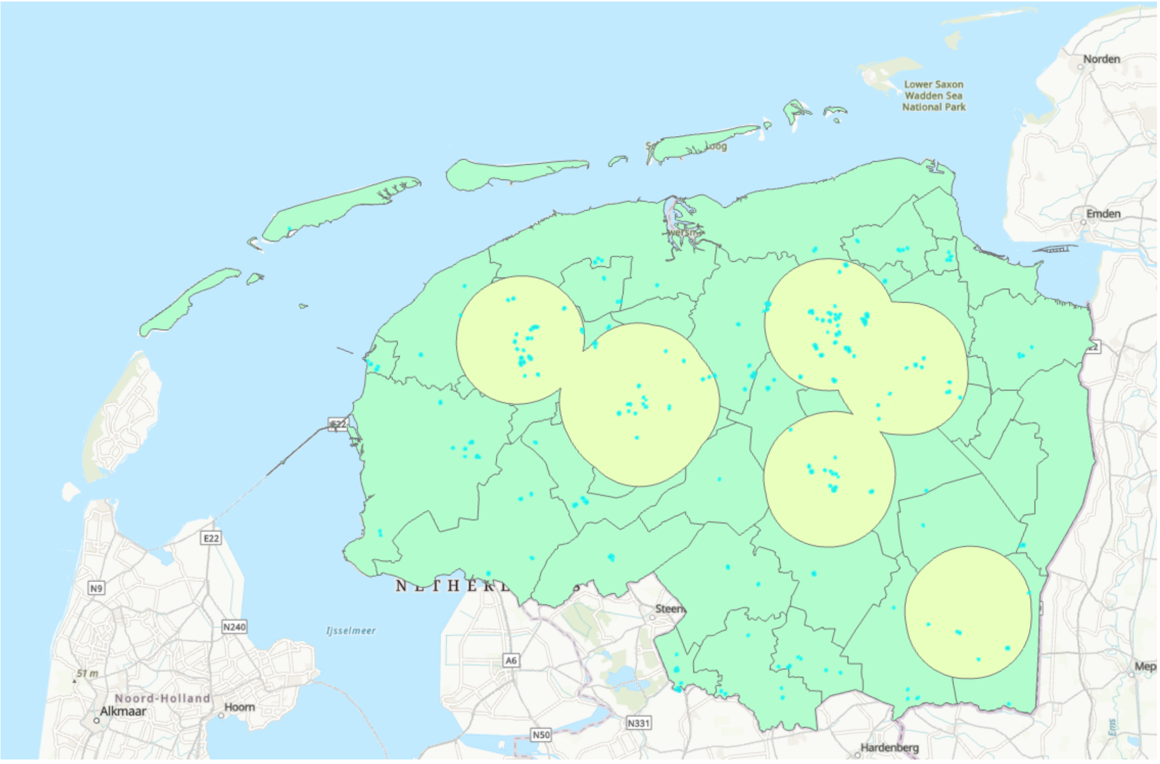

Figure 4 (map with buffer zones)

Figure 4 illustrates the housing developments within a 10-kilometer radius of the two largest cities in each province. The selection of these cities was based on population size rather than population density, resulting in buffer zones that do not align precisely with the most densely populated areas depicted in Figures 2 and 3. In the map, green polygons represent municipalities with 2020 borders, yellow circles denote buffer zones around city centers, and blue polygons highlight housing development projects. This visualization provides insights into the distribution of housing developments.

A total of 213 projects were identified by intersecting the Northern Netherlands area with housing development data, out of which 126 projects fell within the 10-kilometer buffer zones surrounding the two largest cities of each province. This finding supports Sun's theory (2019) that people increasingly gravitate towards urban centers. According to central place theory, these urban centers typically exhibit higher population densities, suggesting that concentrating development around these areas rather than rural zones could potentially increase overall population density (Mulligan, 1984).

It is important to note that the buffer zones may not fully capture the impact of cities on their surrounding areas, as they do not encompass all cities in the region. Including additional cities would lead to map clutter. Moreover, selecting only the two largest cities per province does not encompass all six largest cities in the Northern Netherlands. However, this approach was chosen to balance the map and examine effects across different provinces.

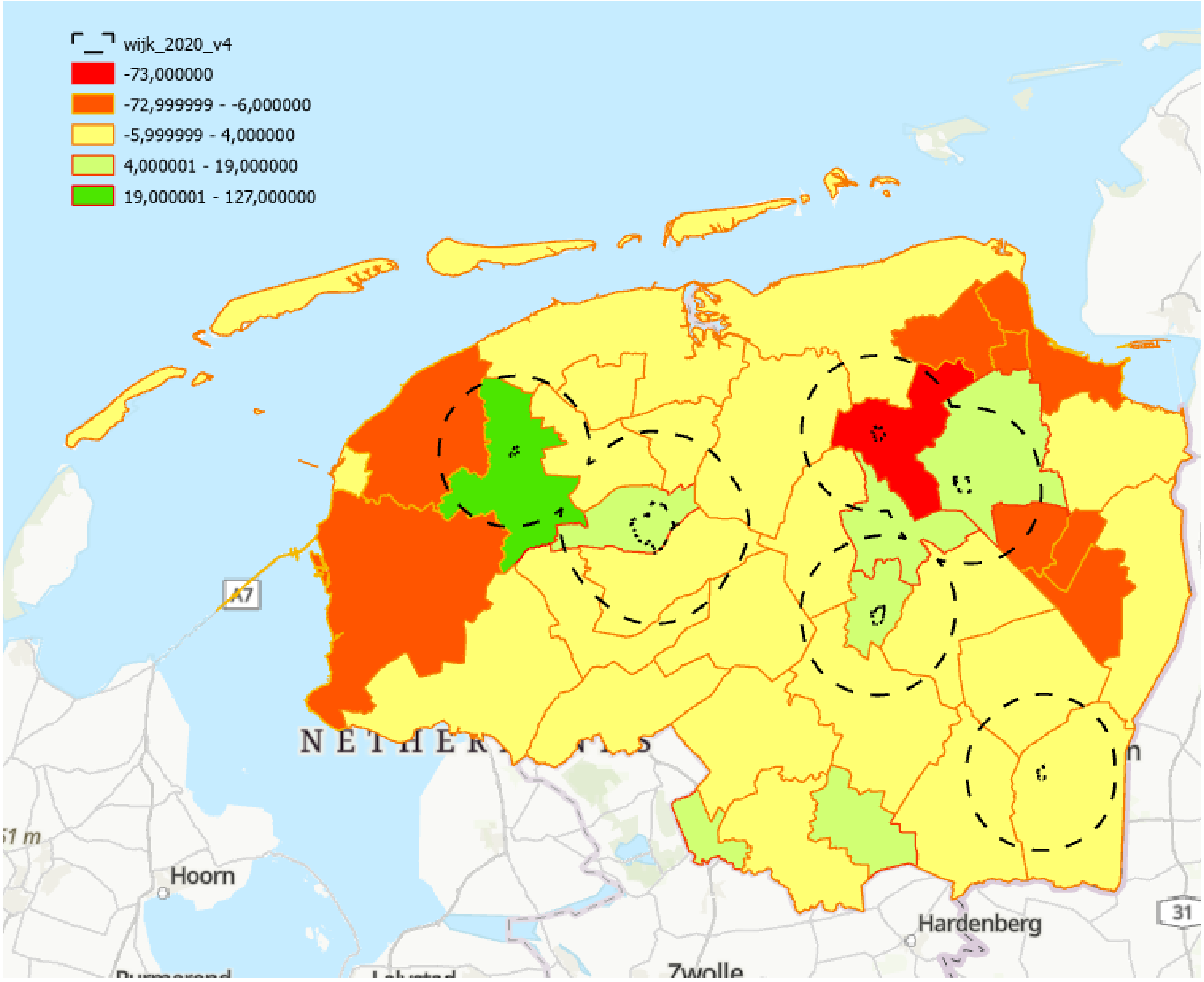

Figure 5 (map with population density difference and buffer zones)

Figure 5 overlays the buffer zones of the two largest cities in each municipality onto the difference in population density between 2014 and 2020. In this map, the yellow buffers have been replaced with a black dotted outline, allowing transparency to visualize the underlying areas with population density. The original municipal borders of the cities around which the buffers were created are also depicted. The legend indicates the difference in population density, where a positive value denotes an increase (e.g., +4 indicates an increase of 4 people per square kilometer), and a negative value indicates a decrease (e.g., -4 indicates a decrease of 4 people per square kilometer).

The map reveals that most municipalities surrounding cities show an increase in population density. This finding aligns with the conclusions drawn by Sun (2019). Notably, Groningen experiences a significant decrease in population density, while Emmen shows a similar population density in 2020 compared to 2014. The decrease in

Groningen's population density may be attributed to the expansion of land area between 2014 and 2020 due to changes in municipal borders.

4.2 Statistical analysis and results

A disadvantage of the spatial analysis above is that visualizing variables do not provide statistical evidence of a possible association between housing development and population density. To do so, a scatterplot is created and a simple linear regression is performed using the change in population density between 2014 and 2020 as the dependent variable and the change in homes between 2014 and 2020 as the independent variable.

Table 1: Descriptive statistics

	Mean	Standard deviation	Min/Max
Change in population density (person/km2)	1.05	23.838	-73 / 127
Difference houses CBS (2014-2020)	632.93	1324.373	-481 / 7769

Note: N=42, change is measured between 2014 and 2020

Table 1 shows the descriptive statistics indicate a general upward trend in population density alongside an increase in the number of houses. The table provides metrics such as the mean, standard deviation, and range (min/max) for both the change in population density from 2014 to 2020 and the difference in the number of houses over the same period, derived from CBS data.

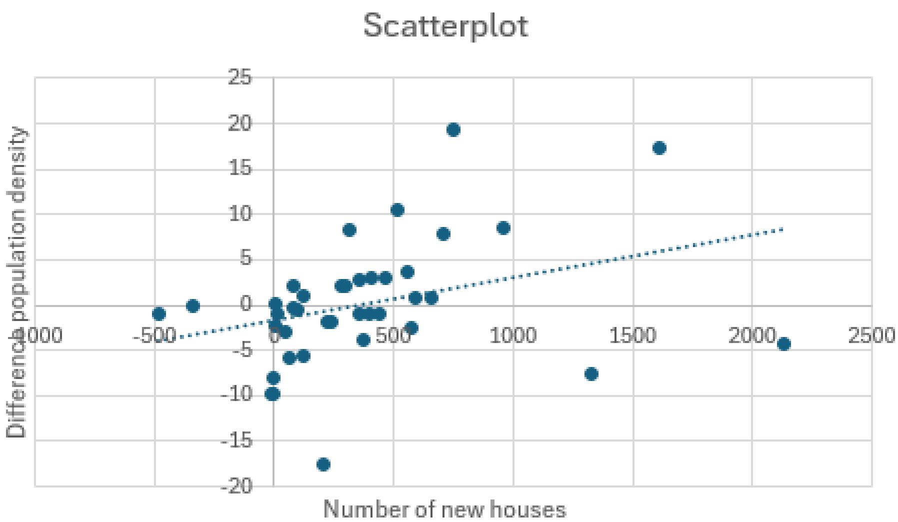

Figure 6 (scatterplot difference population density and number of new houses, without outliers)

A scatterplot was generated from the CBS data, with the Y-axis representing the change in population density between 2014 and 2020 for each municipality, and the X-axis representing WONING_DIFF within the same period. The initial scatterplot, shown in Figure 9 of the appendix, includes several large outliers. Figure 6 presents a refined version of this scatterplot, excluding the three largest outliers, though significant variance remains evident.

The expectation is that an increase in new housing should correlate with an increase in population density. Thus, when the number of new housing projects is above zero, a corresponding positive change in population density should be observed. In Figure 6, the regression line indicates a positive relationship between WONINGEN_DIFF and the change in population density. Despite this, several municipalities with an increase in new housing still exhibit a decrease in population density. Conversely, among the two municipalities with a negative number of new houses, one shows no change in population density, while the other shows a decrease of one person per square kilometer. This observation aligns partially with predictions, yet the decrease in population density among municipalities with positive housing development is disproportionately large.

When utilizing CBS data to analyze the relationship between changes in the number of houses and changes in population density, a linear regression model was employed. In this regression model, the difference in population density serves as the dependent variable, while the difference in the number of houses acts as the independent variable. The results of this regression analysis are summarized in Table 2 below:

Table 2 (Regression table, difference of houses based on CBS database)

Model	**Unstandardized B**	**Coefficients Std. Error**	**t**	**Sig**
(constant)	5.633	3.787	1.487	0.145
WONINGEN_DIFF	-0.007	0.003	-2.781	0.008

Adjusted R-square = 0.141
F-statistic = 7.735
Number of cases = 41

A. Dependent Variable: BEV_DICHT_DIFF

The H0 for the linear regression is that in the population there is no relationship between difference in housing and difference in population density. Table 2 shows a p value of 0.008, this is lower than 0.05 and so the test is significant. We can thus reject H0. This indicates there is a relationship between difference in housing and difference in population density. The test implies that the bigger the difference is in the amount of housing, the smaller the difference in population density will be. This contradicts the outcome shown in Figure 6. Within Figure 6 these outliers have been taken out, but in the regression model the outliers are still in the dataset. Therefore the outliers have most likely caused this change in outcomes.

Looking back at the literature the population density was expected to increase with the growing need for new housing development. As seen from the descriptive statistics there is an overall increase in population density of around 1.05 people per square kilometer. Furthermore, the government plans to build more houses seems to be effective as the CBS descriptives show an increase in the number of houses with an increase of 632.93 houses per municipality on average.

5. Conclusion

This thesis investigates the relationship between the difference in the amount of housing and the difference in population density within the Northern Netherlands. It compares spatial patterns and statistical relationships using GIS and regression analyses with CBS and BAG data. The GIS analysis shows that more than half of the housing development happens near the two largest cities of each province. According to Mulligan (1984), this development near urban areas has a high likelihood of being built more densely. Furthermore, most of the municipalities containing cities show an increase in population density. The only outlier here is Groningen, but this is due to other reasons. Even two cities within Drenthe that just fall outside of the two largest cities of the province show an increase in population density within their municipality. This could indicate that there is a relationship between the presence of a large city in a municipality and an increase in population density as a result of the number of houses built. Although this is not the outcome the research aimed to achieve, it has created a new question for future research.

The regression results show a significant relationship between the difference in the number of houses and the difference in population density. Notably, the regression coefficient for the number of new houses is negative, suggesting that an increase in the number of houses is associated with a decrease in population density. This counterintuitive result could be explained by factors such as the spatial distribution of new housing developments, potential out-migration, or inaccuracies in population data due to changing municipal boundaries. These statistical results contradict the hypothesis that the majority of new housing developments would be categorized as smart growth.

Policy recommendations

The literature indicates that numerous policies have been implemented to mitigate urban sprawl (Halleux et al., 2012). However, the findings of this study reveal that recent housing developments predominantly exhibit characteristics of urban sprawl. Consequently, it is recommended that policies should more robustly promote high-density urban development, thereby advancing the principles of smart growth to [solve which big societal issue?].

Limitations of the study

At the outset of this research, there were challenges with integrating the datasets into ArcGIS. These issues were resolved through consultation with the GEOdienst, which facilitated the preparation of the data for use in ArcGIS. During the ArcGIS analysis, another complication arose: the borders of municipalities, regions, and neighborhoods had undergone changes between the years 2014 and 2020. To address these discrepancies, the 2014 municipalities were consolidated to closely match the 2020 municipal boundaries. As illustrated in Appendix 1 and Appendix 2, these borders still exhibit minor differences. Consequently, some parts of the dataset do not reflect the exact changes over the years but rather the differences resulting from variations in area size. This alteration has affected the number of houses and population density within these areas, potentially influencing the regression outcomes.

Originally, the BAG data was intended for use in the statistical analyses. However, due to misunderstandings of the dataset and errors during its reorganization, it was decided that the linear regression analysis should be conducted using the CBS data. The CBS dataset remained unmodified and was therefore deemed more reliable for this analysis.

Future research

Future research should investigate the impact of large cities on the population density of municipalities over time. As evidenced in this study, most municipalities containing a large city exhibit an increase in population density. To comprehensively understand the impact of cities, further research is necessary on a larger scale.

Additionally, future studies should examine other factors influencing urban densification. It is particularly important to determine the significance of these factors and identify the key determinants affecting urban planning and residential decisions.

Another recommendation for future research is to establish a closer relationship between researchers and data providers. As highlighted throughout this study, there were difficulties working with the BAG dataset, particularly in obtaining realistic results regarding the number of houses built. Improved communication and collaboration between data creators and researchers could facilitate a better understanding of the dataset, resulting in more accurate and useful data. Such an enhanced dataset could then be compared with the official figures from the CBS datasets, allowing for a clearer understanding of the discrepancies between the two sources.

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Appendix

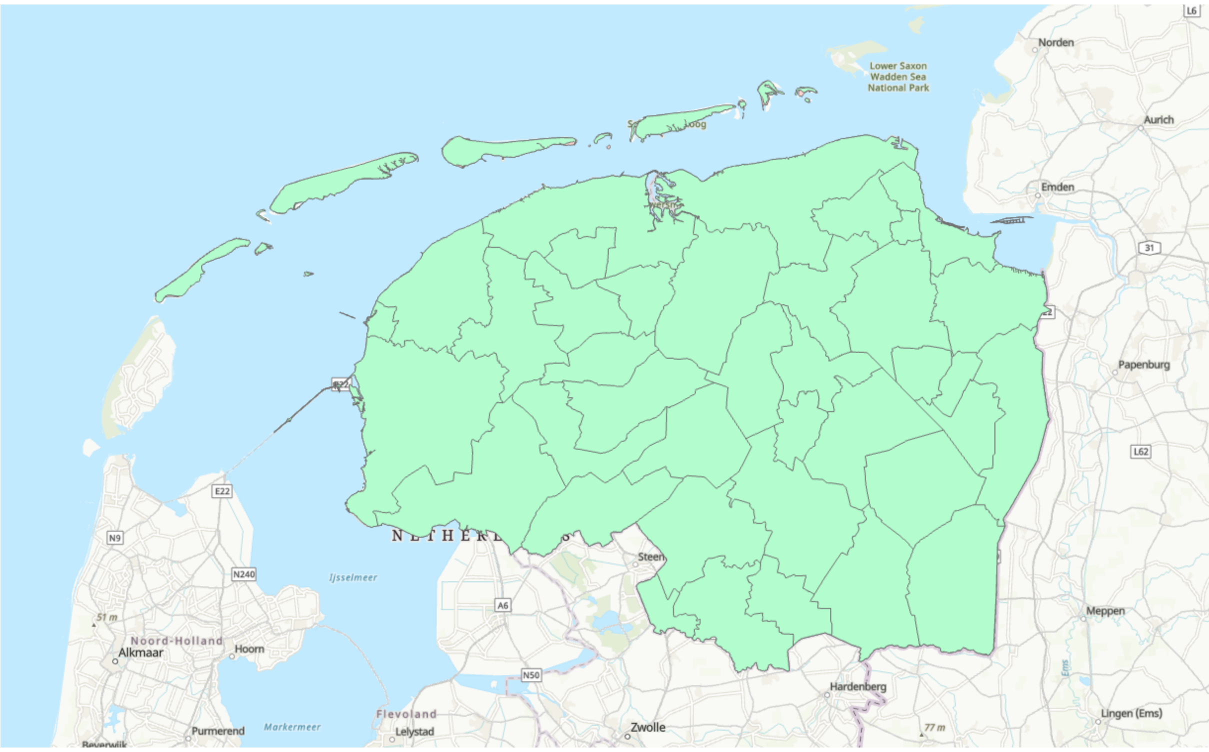

Figure 7 (Municipal map 2020)

Figure 8 (Municipal map 2014)

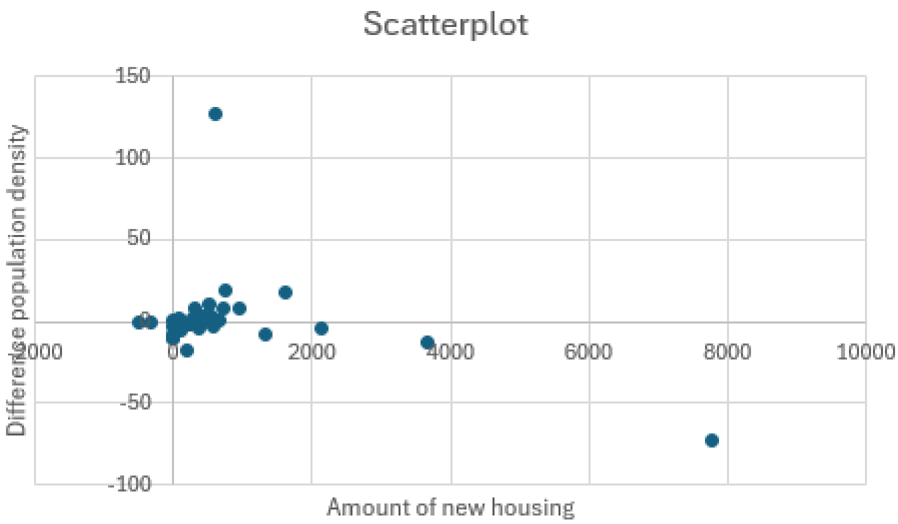

Figure 9 (scatterplot difference population density and number of new houses)

The outliers that were removed from the dataset were the municipalities with codes: GM0014, GM0086 and GM1900. These can be retraced within the 2020 districts and neighbourhoods dataset from the CBS.