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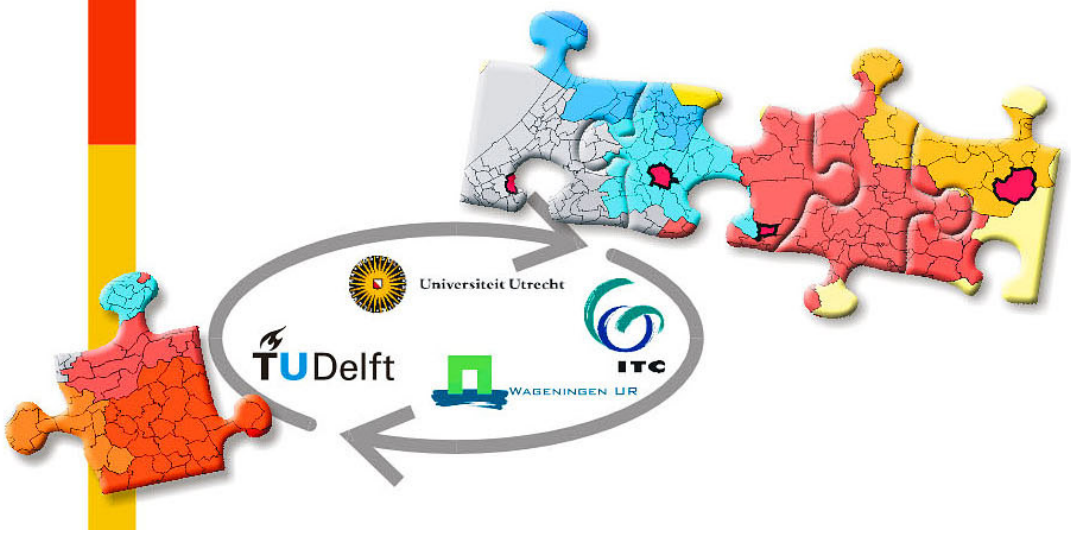
Using GIS in Analyzing Population Development

A case study on the spatial factors behind population decline in the Province of Fryslân 2000-2008

Alex de Jonge



Using GIS in Analyzing Population Development

A case study on the spatial factors behind population decline in the Province of Fryslân 2000-2008

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Geographical Information Management & Applications (GIMA)
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Preface

In the first decade of the twenty-first century population decline has become topic of public debate in the Netherlands. Many demographic prognoses are presented showing a declining population in the peripheral parts of the Netherlands, including the Province of Fryslân. Being a geographer the spatial extent of population decline has my interest. Why do some areas face population decline whilst others are still expanding in population and economic opportunities? In fact, this can be regarded as one of the most fundamental questions in geography. Doing research on this topic by using the possibilities and opportunities learned during the GIMA programme proved to be an interesting task.

Subject of this research is the Province of Fryslân, one of the peripheral provinces of the Netherlands. Although the threat of population decline for this province is not as eminent as it is in for example Limburg and Groningen, local population decline is becoming a topic of interest in the provincial policy making. This thesis is executed with close support of these policy makers and researchers of the Province of Fryslân, for which I would like to thank them. First for giving me the opportunity to execute this research and secondly for their support. In particular I would like to thank all the members of the BGI department for their help on data handling, GIS, cartography and their visions on population decline. From the GIMA programme my thank goes to Jan Jaap Harts, for good to-the-point feedback and overall guidance during this research.

The intention of this research is to generate a conceptual framework and methodology to research local population development in the Province of Fryslân. To achieve this, special focus is put on applying GIS methods and techniques. It has become clear that there is no conceptual framework complete enough to fully explain population development. This research is written as a search to gain better understanding in the concept of population development and it should be interpreted as such. It might be even concluded that this research raises even more questions than it answers. Therefore I hope it leads to an inspiring read!

Abstract

Population development can be regarded as the result of natural increase and migration, both caused by a manifold of explanatory factors. This research focuses on population development in the province of Fryslân over the years 2000-2008 and the use of GIS in analyzing this subject. Two applications of GIS are described: visualization of spatial patterns and spatial analysis. Examples of spatial analysis are distances, area calculations, overlay functions, neighborhood functions and travel time.

The explanatory factors related to population development are divided into three themes: population characteristics, planning & infrastructure and amenities & economy. For a number of factors the correlation with population development can be demonstrated. These explanatory factors include the number of inhabitants, age composition, average household size, planning hierarchy, railway stations, housing stock and amenities. The correlations between straight line distances, travel time by car, employment and population development can not be proven.

Of all explanatory factors the development of the housing stock can be regarded as the most strongly correlated explanatory factor. Also the factors related to population characteristics have a relative strong correlation: population size, age composition and average household size.

Keywords: GIS, Geo, spatial analysis, population development, population decline, Fryslân.

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List of figures, tables, maps and boxes

List of abbreviations and terminology

Abbreviation	Explanation	Dutch original
AE	Amenities & Economy	
ATM	Automated Teller Machine	Bankautomaat
BGI	Unit Policy- and Geo-Information (Province of Fryslan)	Afdeling Beleids- en Geo-Informatie (Provincie Fryslan)
CBS	Statistics Netherlands	Centraal Bureau voor de Statistiek
Decl	Number of declining cores	
DUO-CFI		Dienst Uitvoering Onderwijs – Centrale Financiën Instellingen
ECTS	European Credit Transfer and Accumulation System	
EHS	Ecological main structure	Ecologische Hoofdstructuur
ESRI	Environmental Systems Research Institute	
EU	European Union	
GIMA	Geographical Information Management & Applications	
GI	Geo-Information	
GIS	Geographical Information System(s)	
GP	General Practitioner	Huisarts
Grow	Number of growing cores	
IPO	Inter provincial counsel	Interprovinciaal Overleg
Km	Kilometres	
Km/h	Kilometres an hour	
N	Number of cases	
NWB	National road dataset	Nationaal Wegen Bestand
PC	Population characteristics	
PI	Planning & Infrastructure	
Q	Quantile	
RD	Rijksdriehoeksstelsel	
RIVM	National Institute for Public Health and the Environment	Rijksinstituut voor Volksgezondheid en Milieu
ROS		Regionale Ondersteunings Structuur
SBO		Sectorbestuur Onderwijsmarkt
SD	Standard Deviation	
SE	Standard Error	
SPSS	Statistical Package for the Social Sciences	
WOZ	Real estate value	Waardering Onroerende Zaken
WGR	Employment register	Werkgelegenheidsregister

English	Dutch
Urban concentration zone	Stedelijk bundelingsgebied (Streekplan Fryslan)
Economic core area	Economische kernzone (Streekplan Fryslan)
Regional plan	Streekplan
Main city	Stedelijk centrum (Streekplan Fryslan)
National landscape	Nationaal Landschap
National spatial planning act	Nota Ruimte
Regional centre	Regionaal centrum (Streekplan Fryslan)

1. Introduction

Population growth has been one of the driving factors of the economic growth and spatial planning in the second half of twentieth century Netherlands. The post-war situation has lead to a "population explosion" in the sixties and seventies[1]. Dutch population growth over the last 29 years show a stable increase: from just over 14 million in 1980 up to 16.5 million in 2009 (figure1-1) [2]. National population growth will be prevailing until 2038, reaching a peak of 17.5 million inhabitants[3].

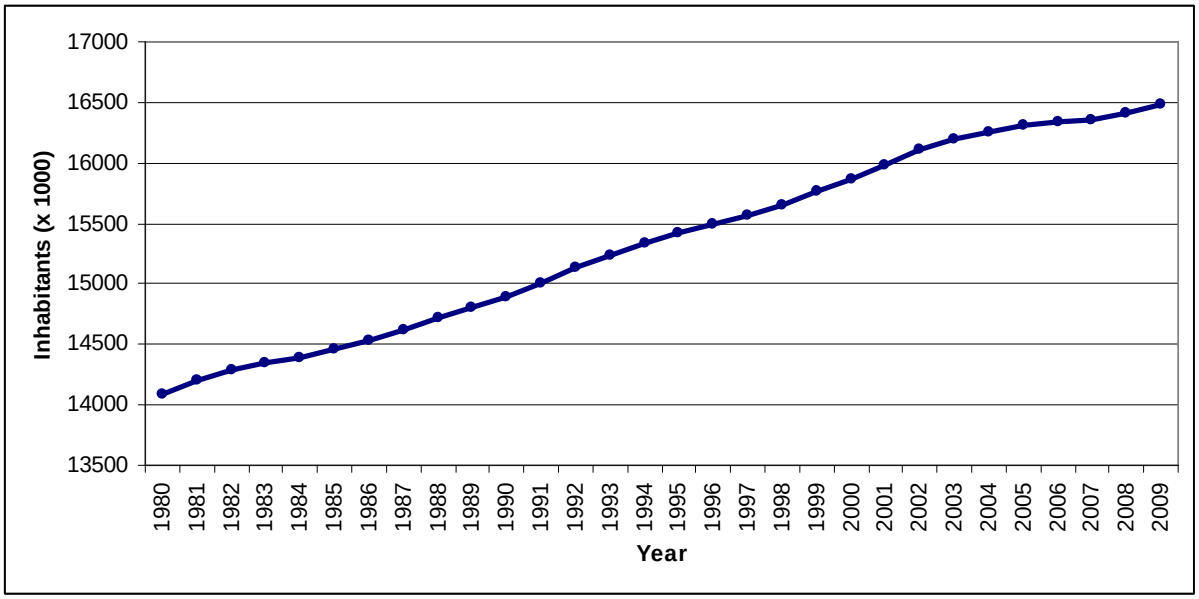
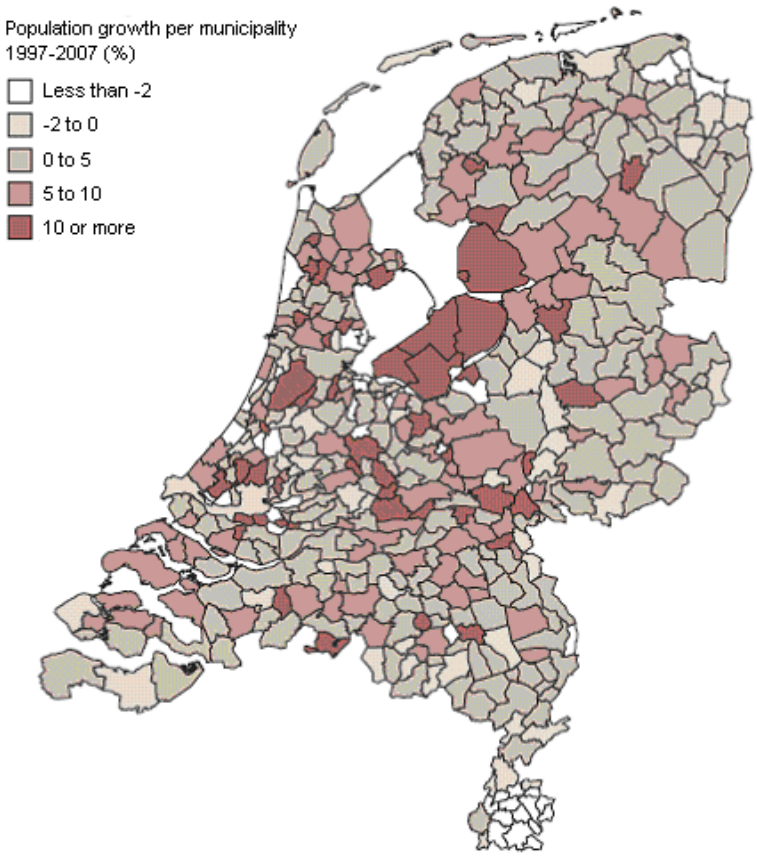


Figure 1-1: Population growth in the Netherlands. Based on: Milieu & Natuurcompendium 2009 & CBS Statline 2010

The depicted growth figures of figure 1-1 are national averages, which mean that there is spatial deviation. Some areas have and will show high growth figures, while other areas already have declining population figures. The municipal population growth in the Netherlands between 1997 and 2007 is depicted in map 1-1. Regions close to economic core areas show high population growth in that decade: more than 10 percent in for example the province of Flevoland. But from this map and literature also two peripheral regions that have a negative population growth can be identified: South-Limburg and North-East Groningen[4].

[1] Van Nimwegen & Heering 2009a
[2] Milieu & Natuurcompendium 2009
[3] Van Nimwegen & Heering 2009a
[4] Van Dam, Verwest & De Groot 2008; Van Nimwegen & Heering 2009b; Warbroek 2009



Map 1-1 Population growth per municipality, 1997-2007 (%) Source: Van Nimwegen & Heering 2009b

1.1. Defining population development

Population decline is the same as a negative population growth. Both sides together, the phenomenon is called population development. If a population is increasing the term population growth is used, if a population decreases the term population decline is used. Population development is determined by four elements[5]:

- Number of births
- Number of deaths
- Number of in-migrants
- Number of out-migrants

The number of births minus the number of deaths makes up natural increase. The number of in-migrants minus the number of out-migrants is the net migration. To calculate the change in population in a year the following formula is used:

$$Population_{end} = population_{begin} + naturalincrease_{year} + netmigration_{year}$$

$$naturalincrease_{year} = births_{year} - deaths_{year}$$

$$netmigration_{year} = inmigrants_{year} - outmigrants_{year}$$

[5] Livi-Bacci 2001; Knox & Marston 2004

Population development is inherently spatial. Scale is a very important element in interpreting population decline. Population growth on a high level can still mean that lower scale levels face population decline, as seen in the comparison between the national population growth figures (figure 1-1) and population growth per municipality (map 1-1).

1.2. Population decline on various scales

Focusing on the scale of the whole world, population decline is not predicted for the nearby future. The prognoses reach to 2050, when the world is foreseen to inhabit 9.2 billion people compared to 6.7 billion in 2006[6].

On the scale of Europe population decline will occur within 30 years. The population of the EU-27 will slowly grow from 496 million in 2008 to a peak of 520 million in 2035. Within the EU a large spatial deviation is present. Central- and Eastern Europe already show a decline in population[7].

As described in the opening paragraph, the Netherlands fit in the general trend of Europe. For the Netherlands the turning point from population growth to population decline is foreseen in 2038, compared with 2035 for the EU-27. Locally in the Netherlands there already is spatial deviation, what can be seen in map 1-1.

The case of population decline in the Province of Fryslân will be examined in detail in the next chapter. The scale of that analysis is explicitly local: the residential core.

1.3. Challenges of population decline on a local level

In the second half of the twentieth century population growth triggered an economic growth, that both have lead to a huge (spatial) impact. The Dutch planning system was focussed on accommodating this growth; population decline destabilizes this planning system[8].

On a local level the challenges of population decline can be classified in four categories[9]:
- **Financial**. Local government will face a decrease of tax income as well as in income out of new constructions. Public housing authorities face a growing number of vacancies and as a result of that a decline in revenue.
- **Built environment**. Buildings and houses become vacant because of population and household decline. House prises drop resulting in a lack of interest of home owners and public housing authorities to invest. This will all lead to an impoverishment of the built environment.
- **Amenities**. Due to the decrease of population as well as societal trends the support base for many amenities is declining. This results in closure and a loss of amenities.
- **Cultural**. A population decline leads to a changed social cohesion in villages. This might even influence the spread and use of the Frisian language.

Aspects of the first three effects are already clearly present in the three Dutch regions facing population decline: South-Limburg and North-east Groningen. But also in Fryslân the decline of amenities and impoverishment of the built environment is already in effect, although this is not merely caused by population decline[10].

[6] UN 2007
[7] Van Nimwegen & Heering 2009c
[8] Warbroek 2009; Bukman 2009; Derks 2006; Van Dam, Verwest & De Groot 2008
[9] Warbroek 2009, Province of Fryslân 2010a
[10] Mik 2009a

Consensus is that the negative effects of population decline outweigh the positive effects, but some researchers and policy makers see population decline as an opportunity. It is envisioned to lead to more (spatial) quality: quietness, openness, nature and an increased focus on local culture.[11]

Population decline is likely to have a negative effect on household development, but this can be tempered by a decline average household size. A decline in the number of households has effects similar to the effects of population decline.

1.4. Problem description

As mentioned above population decline results in many challenges on the local level. Because population decline is of high impact on planning policy, the provincial administration wants to monitor the population decline in order to be able to adjust policy to cope with the challenges of population decline. To create effective policy extensive knowledge about population decline is needed. A lot of knowledge is already present at the provincial administration, but more research about the factors causing population decline is needed[12].

Traditionally research about population development is executed primarily by statistical analyses. This excludes the spatial characteristics of the topic and this is regarded as a current deficit and an opportunity to include in research about population decline.

1.5 Thesis outline

In chapter 2 the population development within the Province of Fryslân and the province itself will be properly introduced. Focus is put on the spatial extent of population development, natural increase and net migration. In chapter 3 explanatory factors of population development will be introduced, based on general theory.

Chapter 4 describes the objectives of the research and the research goals and questions are explained. The following chapter (chapter 5) states the research methodology on how to reach the stated research objectives. Chapter 6 zooms in on specific GIS functionality in relation to this research.

The chapters 7, 8 and 9 are similar chapters, all thee zooming in on the spatial outlay of explanatory factors of population development in the Province of Fryslân from a specified theme. The three chapters cover the themes of population characteristics (chapter 7), planning & infrastructure (chapter 8) and amenities & economy (chapter 9). In chapter 10 these three individual themes will be integrated with the use of a regression analysis.

The integration of the individual themes extents into the chapters 11 and 12. Chapter 11 will draw conclusions about the explanatory factors of population development in Fryslân, whilst chapter 12 will open up discussion on this research and point out possible follow-up studies.

[11] Bukman 2009; Van Dam, Verwest & De Groot 2008
[12] Province of Fryslân 2010a

2. Population development in Fryslân

This chapter introduces the province of Fryslân and its residential cores. The variation in population development will be examined with the use of the population balance.

2.1. The province of Fryslân

Fryslân is one of the twelve provinces of the Netherlands. The provinces form the link between the municipalities and the state: they deal with issues which are too substantial for the municipalities and not substantial enough for the state[1]. A key responsibility is environmental planning. This includes determination of locations where new housing sites, industrial estates or business parks are allowed as well as the accessibility within the province.

Map 2-1: Province of Fryslân (in orange). Source: Wikipedia 2010c

The province of Fryslân is located in the north of the Netherlands, as depicted in map 2-1. In 2009 the province had a population of 645,000 inhabitants, which makes it one of the smallest Dutch provinces based on population[2]. Based on the land and water area it is the largest province of the Netherlands with 5749 square kilometers, including 2407 square kilometers of inland and coastal water[3].

2.1.1. Local levels in Fryslân

The province of Fryslân is divided into 31 municipalities, responsible for local government. The last municipal reorganization dates from 1984: so the municipalities are unchanged for over 25 years now.

In 2008 the province of Fryslân had 419 residential cores. This is two more than the situation in 2000, at that time there were 417 cores. Two hamlets received the status of a residential core in the meanwhile: Nij Altoenae (seperated from St. Annaparochie in 2006) and

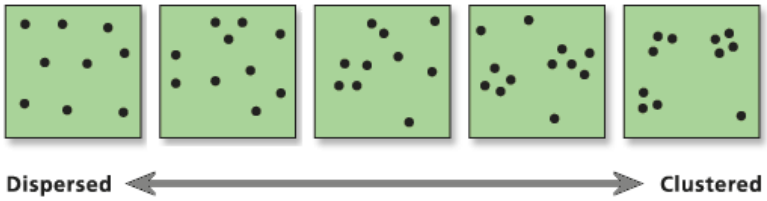
[1] IPO 2009
[2] Province of Fryslân 2010a
[3] CBS Statline 2010

Oostmahorn (separated from Anjum in 2007)[4]. Another complication is the case of Oudeschoot. In the last decades parts of this core were annexated by the municipality of Heerenveen and a residential area was build, called "Heerenveen-Zuid". In 2003 this residential area was transferred to Oudeschoot, resulting in a population change from 148 to 1513 overnight[5]. To cope with these three anomalities these cores are merged with their parent core, leading to 416 cores to apply research on.

The average nearest neighbour ratio (box 2-1) of the spatial distribution of the cores is 0.991, so it can be stated that the distribution of the cores over space is random. Later on in the research the spatial hierarchy of the planning system will be discussed in detail.

Box 2-1: Average nearest neighbour

The average nearest neighbour function can be used to research the distribution of features over space, in order to identify spatial clusters of that feature. A feature can be clustered (distances between features are minimal), dispersed (distances between features are maximal) or random (average distances between features). These are not extremes, but it is a continuum.



This function compares the distribution of the existing features with a hypothetical random distribution with the same number of features and the same extent. For both data sets the distance between each feature and its nearest neighbour is calculated and the average distance is generated. Both average distances are compared with each other in a ratio. This nearest neighbour ratio can have three outcomes:

Nearest neighbour ratio	Description
Ratio = 1	Features are randomly distributed
Ratio < 1	Features are clustered
Ratio > 1	Features are dispersed

The statistical validity is determined by the Z-score.

2.2. Applying the population balance on Fryslân

The population development of Fryslân can be explained with the use of the population balance as described in chapter 1, with the components of natural increase and migration. A conceptual representation is depicted in figure 2-1.

[4] Stichting Dorpshuis Utwyk 2009; Nijsnet.nl 2007
[5] Plaatselijk Belang Oudeschoot 2009

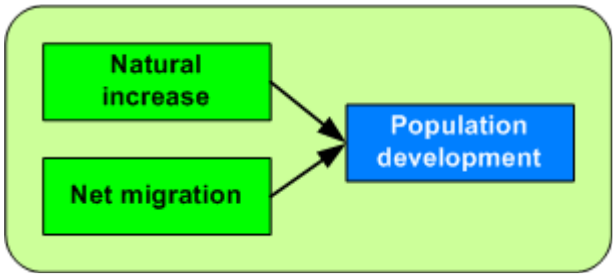


Figure 2-1: Conceptual representation of the population balance. After: Livi-Bacci 2001

The population balance has two research dimensions: time and space. The time dimension gives yearly developments of the elements for the whole of the province and the spatial dimension shows the distribution of the elements within a fixed time over space. Because of the geographical nature of this research the main focus is on the spatial extent: it will be applied on the level of 416 residential cores.

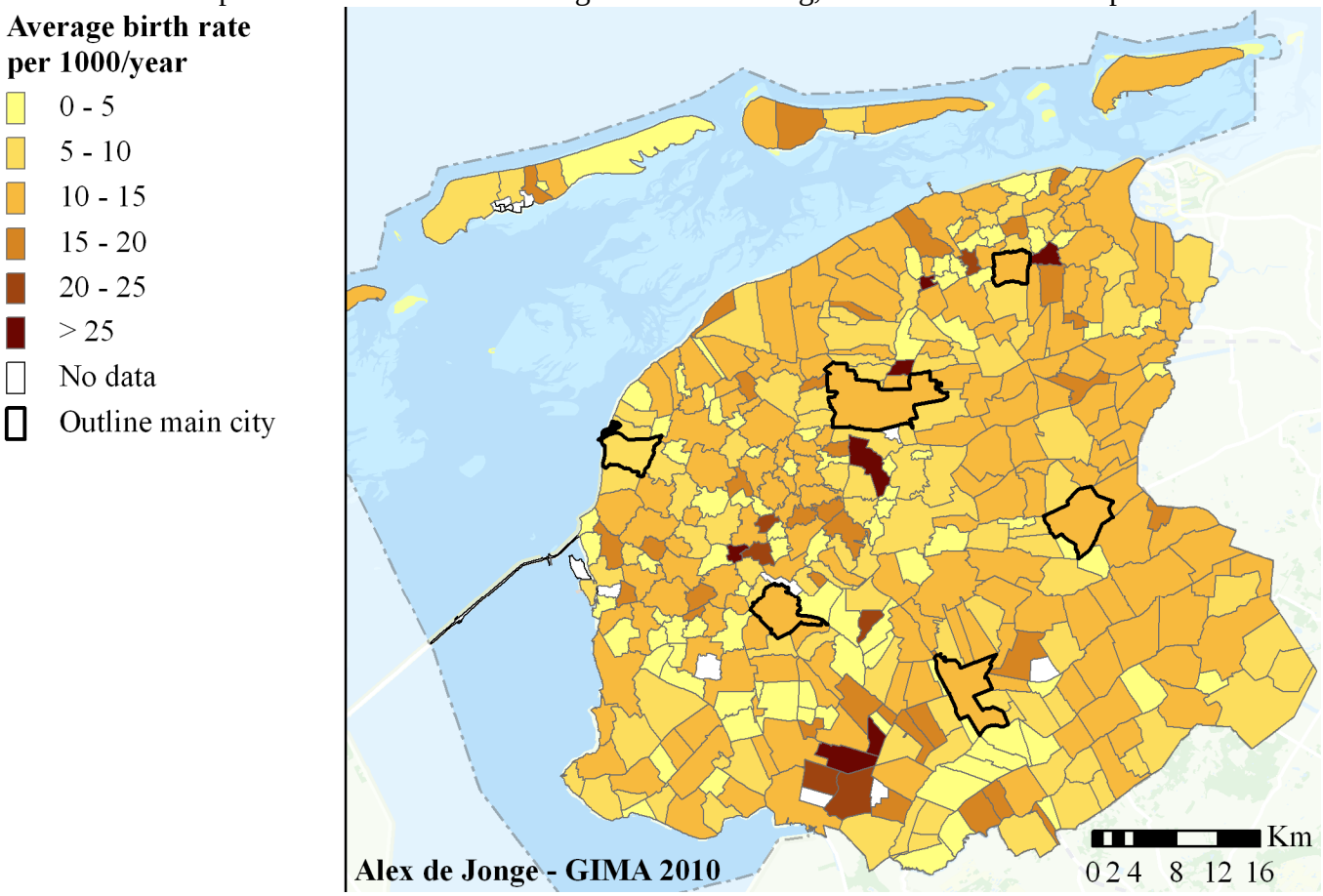
2.3. Natural increase

The natural increase (or decrease when there are more deaths than births) is calculated on a core level. The data about births and deaths that is made available by the CBS concerns the period of 2004-2007[6]. The yearly average over this period is calculated as a birth- and death rate and it is regarded as representative for the timeframe of 2000-2008. The birth- and death rates need to be regarded as indicative for the population composition of a core. The available birth and death numbers are rounded of to five by the CBS, in order to preserve privacy for the small cores. For this reason the data about births and deaths is not reliable for these small cores. It even leads to a rounding off to zero for both events for the smallest cores. For large cores, more than 500 inhabitants, the rounding to five is not a main reliability issue, but the birth and death rates can only be regarded as indicative.

[6] CBS Statline 2010

2.3.1. Births

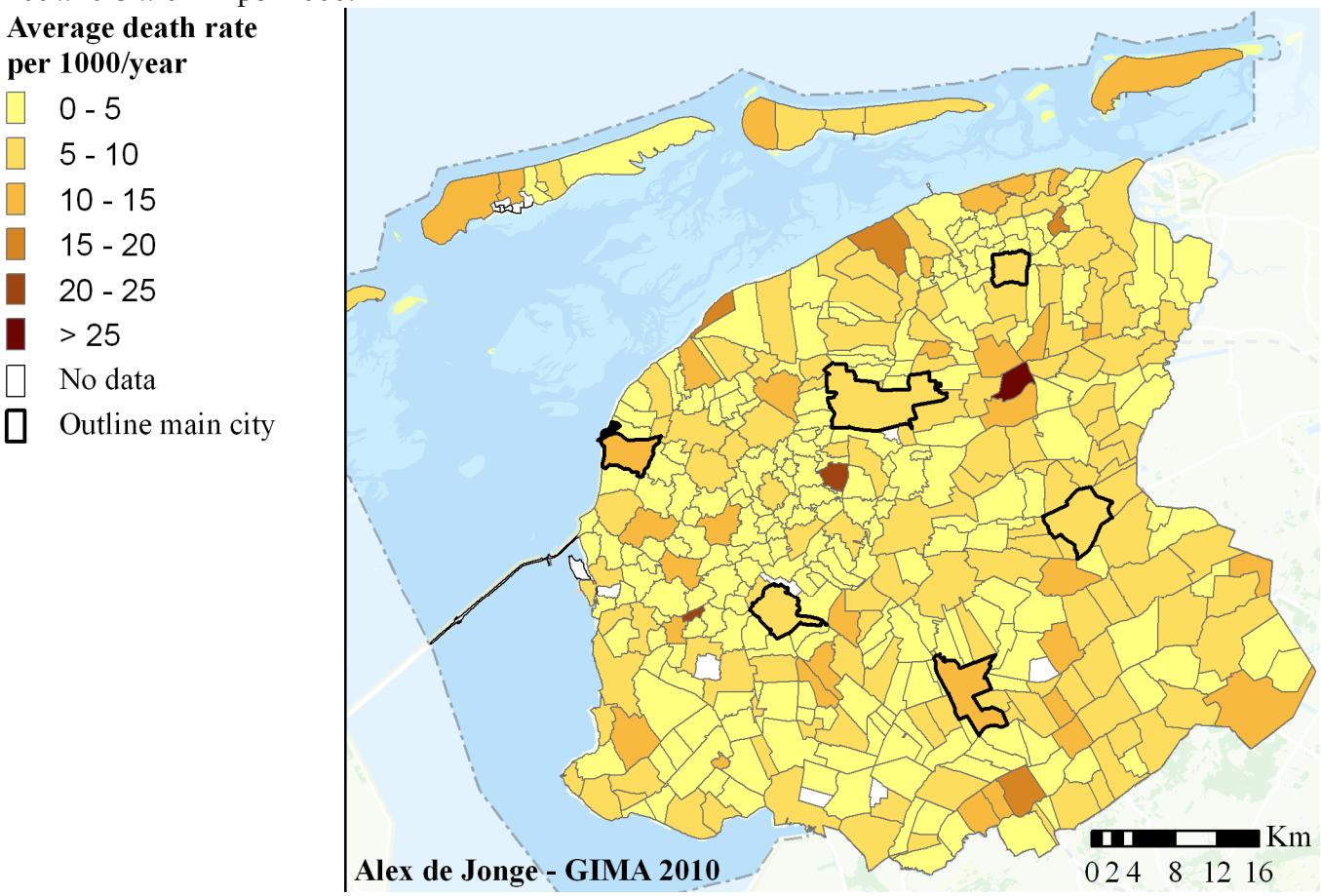
The average yearly birth rate is depicted in map 2-2. The darkest coloured areas are the outliers: small cores with less than 500 residents. The overall image is that the spread is very even. Of all the cores with a population over 500, Oosterzee has the highest birth rate: 21 births per 1000. Second is the village of Echtenerbrug, with a birth rate of 20 per 1000.



Map 2-2: Average yearly birth rate (2004-2007). Based on CBS Statline data

2.3.2. Deaths

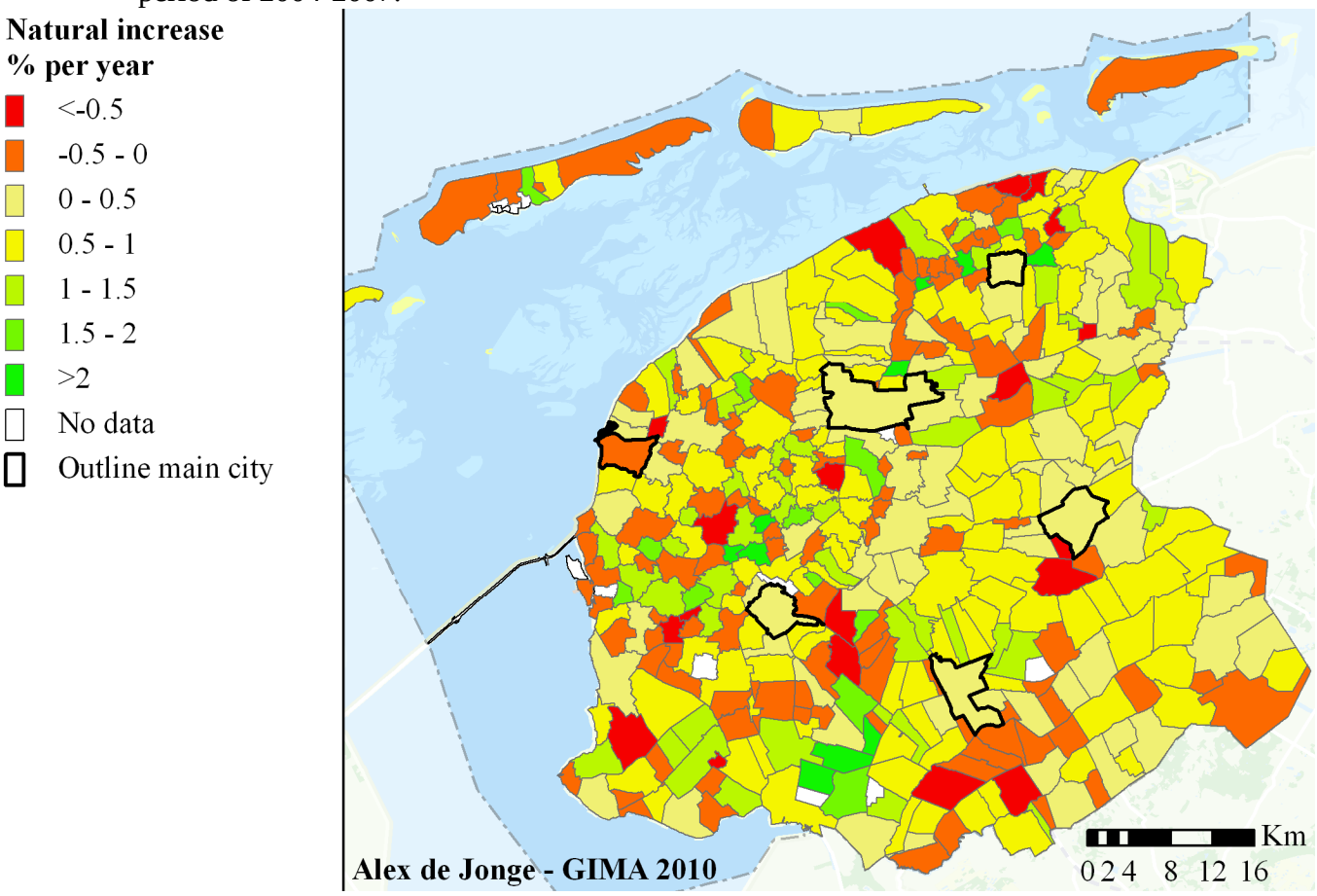
The average yearly death rate is depicted in map 2-3, again showing an evenly spread distribution. The two cores with the highest death rates are Noardburgum, 32 per 1000, and Blauwhuis with 24 per 1000.



Map 2-3: Average yearly death rate (2004-2007). Based on CBS Statline data.

2.3.3. Sum of natural population increase

Subtracting the average yearly death rate from the average yearly birth rate calculates the natural increase or decrease per core (map 2-4). Out of the 416 cores 267 show a natural increase and 38 a natural decrease. The remaining 111 cores show no significant change in the period of 2004-2007.



Map 2-4: Average yearly natural growth or decline (2004-2007). Based on CBS Statline data.

Again, disregarding the cores smaller than 500 inhabitants, the village of Oosterzee shows the largest yearly natural increase with 18 per 1000 inhabitants. Number two is Scharsterbrug with 15 per 1000. Because Oosterzee is also the large core with the highest birth rate it is evident that this large natural increase is caused mainly by a high number of births.

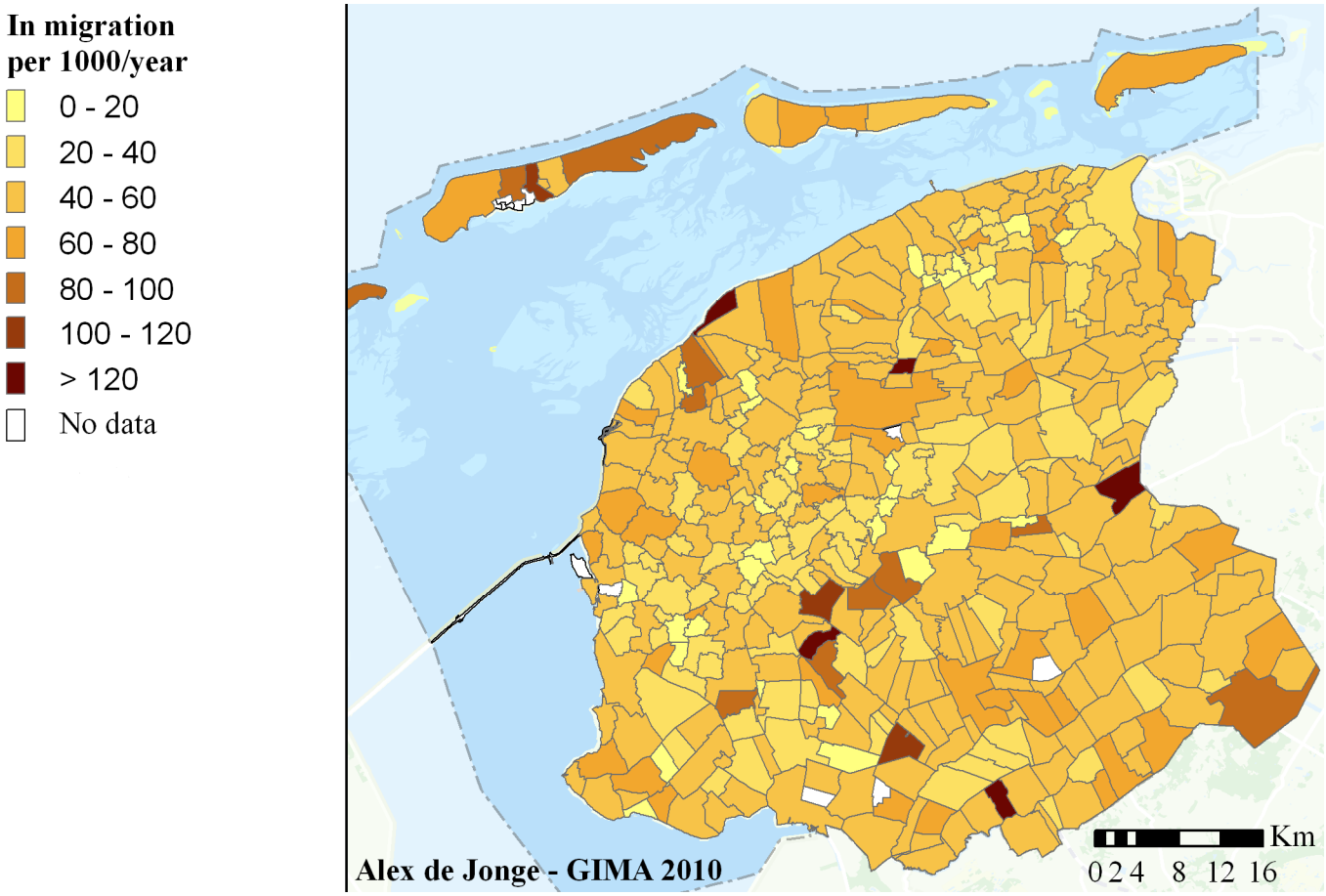
Regarding a negative natural increase the village of Noardburgum is on top, with a natural decrease of 21 per 1000. Runner up is Weidum with a decrease of 16 per 1000. Noardburgum is also the core with the highest death rate, evidently influencing this high natural decrease.

2.4. Migration

The net migration for each core is the in migration minus the out migration. Data about migration between the cores in Fryslân is available over the period of 1998-2008[7].

2.4.1. In migration

An average yearly in migration rate is calculated over the period of 1998-2008 and it is depicted in map 2-5. Once again, it is hard to determine a spatial distribution. Only the islands have a relative high in migration rate. The two cores with a population over 500 inhabitants with the highest in migration rate are Drachtstercompagnie (175 per 1000) and Midsland (99 per 1000).

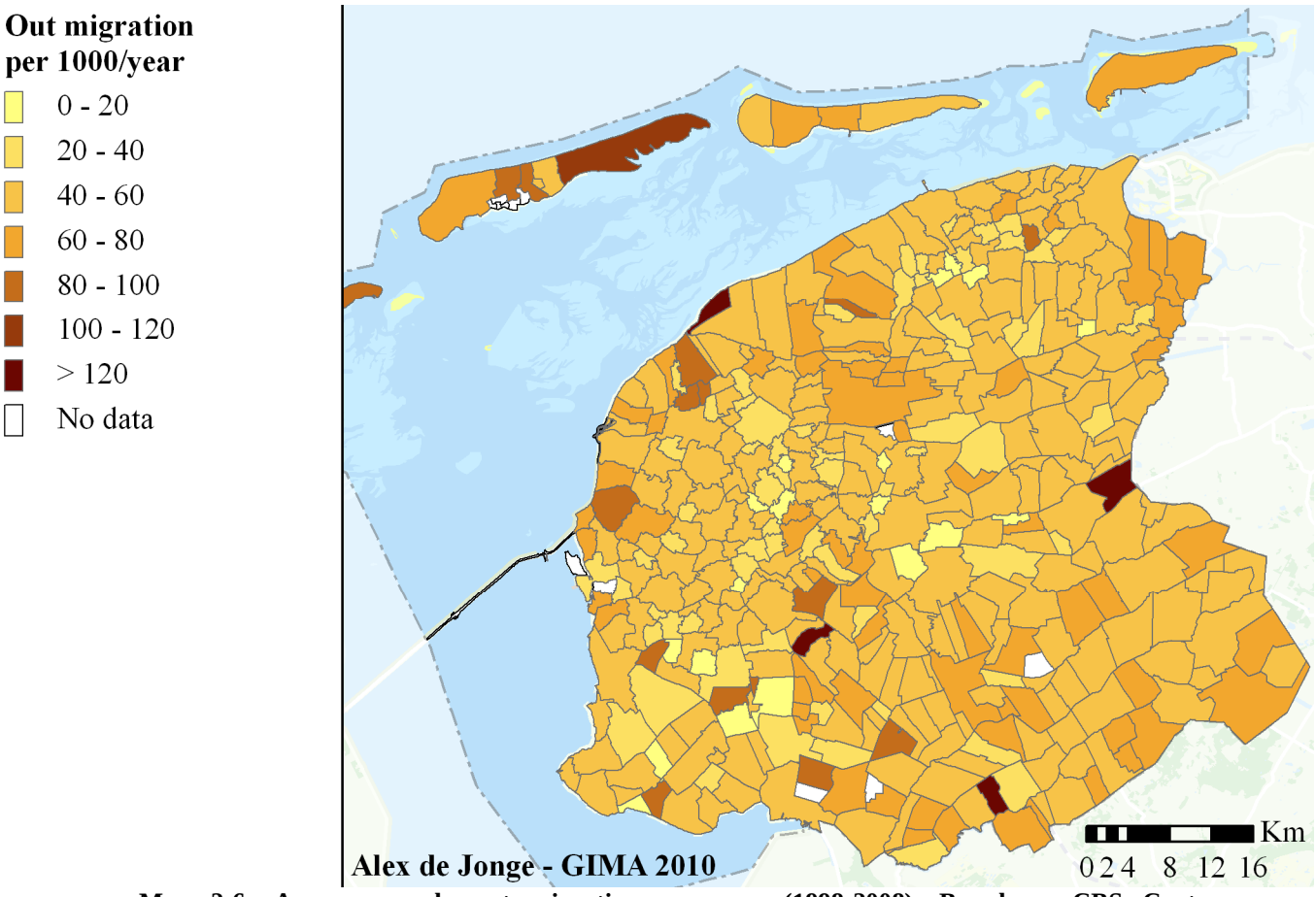


Map 2-5: Average yearly in migration per core (1998-2008). Based on CBS Centrum voor Beleidsstatistiek data.

[7] CBS Centrum voor Beleidsstatistiek 2009

2.4.2. Out migration

Similar to the in migration the average yearly out migration over the period 1998-2008 is mapped in map 2-6. The map image shows a picture similar to the in migration depicted in map 2-5. Again the islands have a relative high out migration rate. Also, the same two cores with a population of over 500 inhabitants that top the in migration are the cores with the highest out migration: Drachtstercompagnie (168 per 1000) and Midsland (96 per 1000).

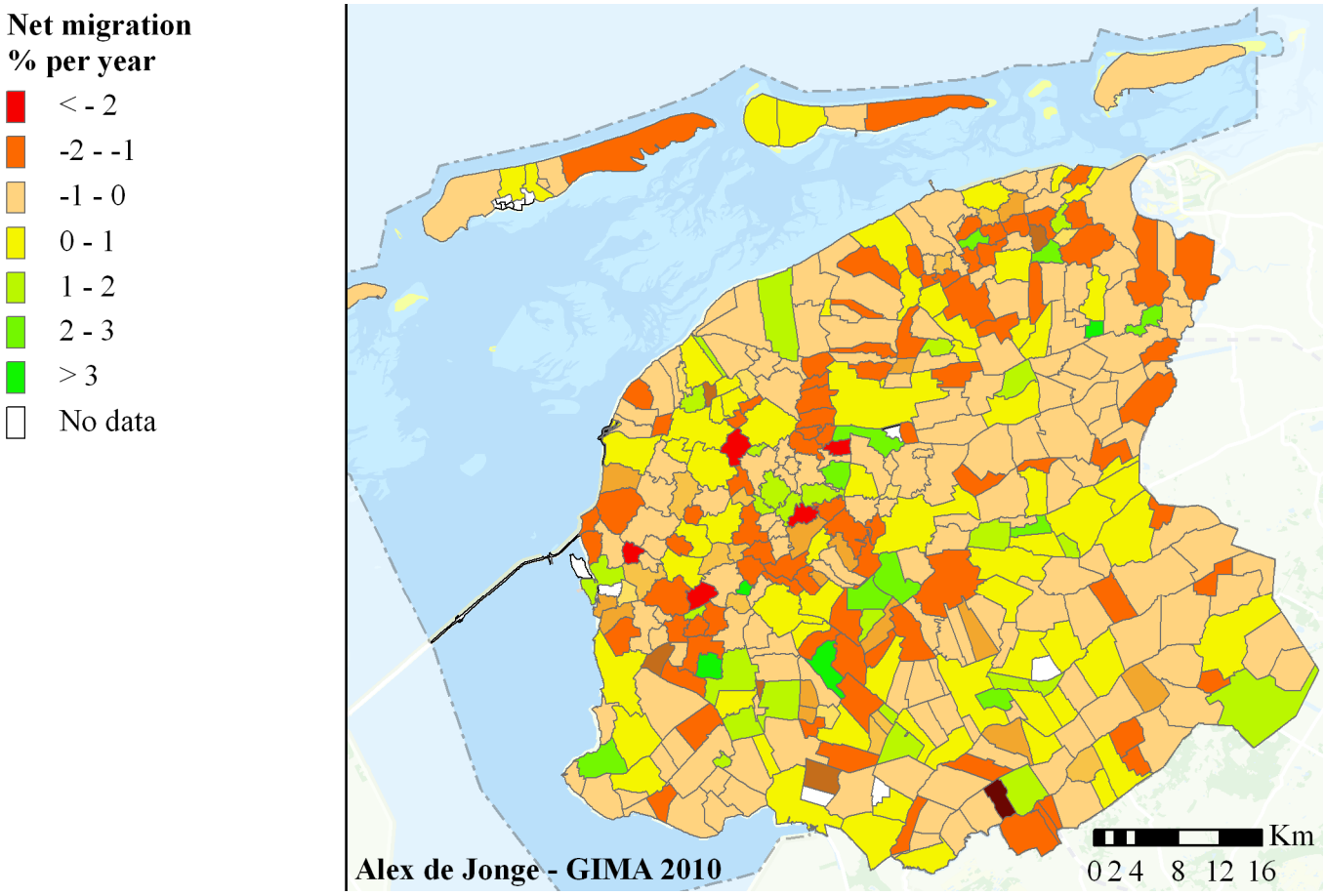


Map 2-6: Average yearly out migration per core (1998-2008). Based on CBS Centrum voor Beleidsstatistiek data.

It has to be noted that there is a strong correlation between high out migration and in migration, expressed in the two villages leading both lists: Drachtstercompagnie and Midsland. This can be explained by the fact that when people move out it leaves room for newcomers to move in.

2.4.3. Net migration

The net migration is mapped as a yearly change percentage in map 2-7. Of all cores larger than 500 inhabitants the cores of De Wilgen and Oranjewoud have the largest migration surplus: 2.9 and 2.5 %. In the same category of cores Tjalleberd and Kimswerd have the highest migration deficits: -2.6 and -2.2 %.



Map 2-7: Average yearly net migration (1998-2008). Based on CBS Centrum voor Beleidsstatistiek data.

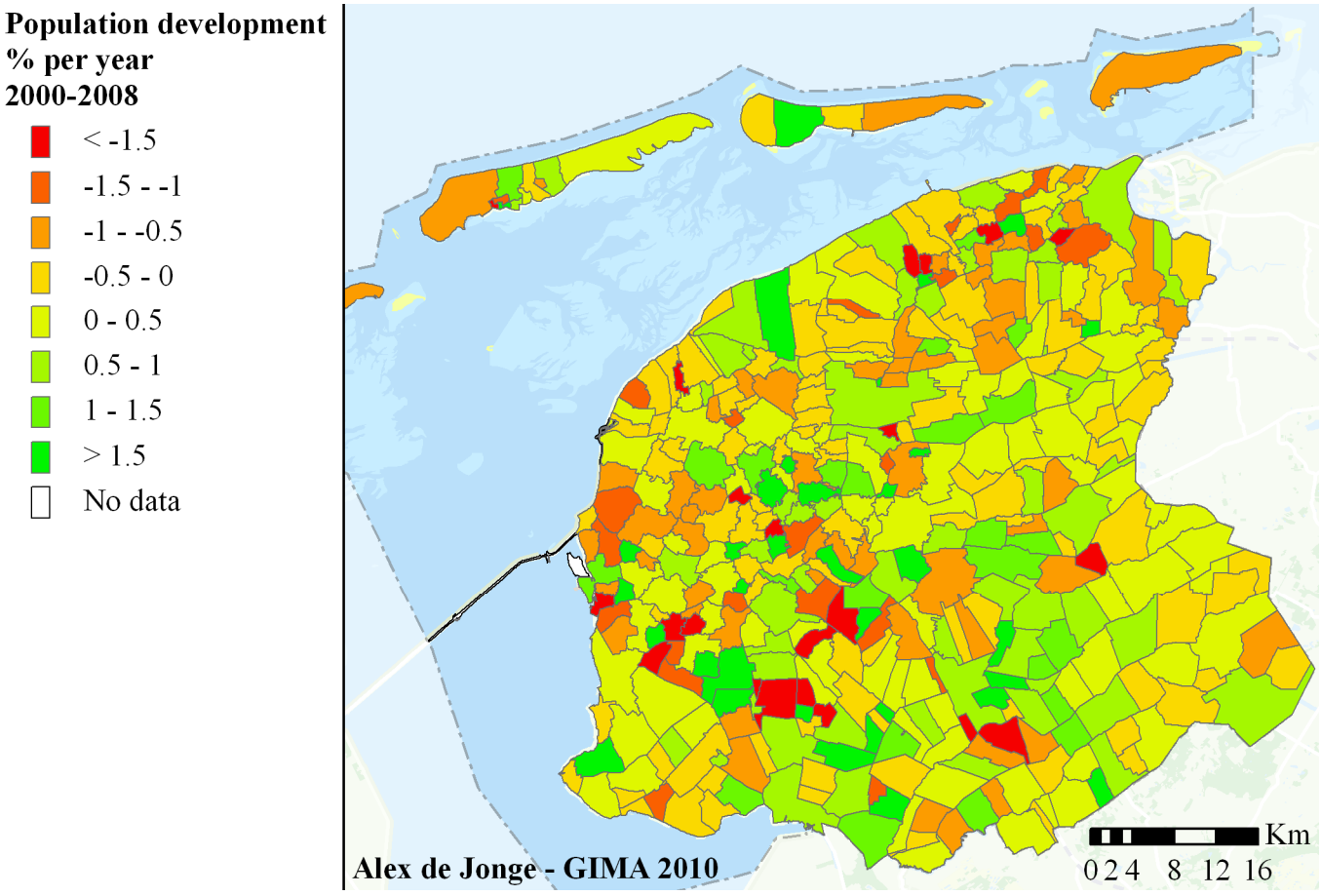
2.5. Population balance

The natural increase together with the net migration makes up the population development. Comparing both elements on their spatial extent, it can be noted that migration shows a higher spatial spread: there are higher extremes and the map image is less even. It needs to be noted that both elements are compiled based on round figures from the CBS, so hard comparisons can not be made. For the same reason the more precise data about the population from the Frisian municipalities is used to calculate the population development[8].

[8] Province of Fryslân 2010c

2.5.1. Population development

The average yearly population balance shows where the absolute growth and decline in population is taking place, but it is hard to analyze it without relating it to the population distribution. Therefore the change in population per core in the period 2000-2008 is calculated as percentage of the population in the year 2000 (map 2-8).



Map 2-8: Population development per core (2000-2008). Based on data from Kerncijfers Fryslân.

The cores that have perished population decline in the last eight years are distributed quite randomly over the province of Fryslân. This can be determined both visually, as well as with the help of the Moran's I test (box 2-2). The results of this test are a Moran's I value of -0.001259 combined with a Z-score of 0.732897: no valid results to define a statistical significant clustered or dispersed distribution.

The population growth champion is the village of Nes (Boarnsterhim). The realized population growth of 26.7 % in eight years can be explained by the recently developed water rich residential area. The other two cores with the highest population growth are Idzega (8.3 %) and Tjalhuizem (6.6 %). Focussing on the negative population growth, the population decline, two villages stand out: Nijhuizum (-4.7 %) and Smallebrugge (-4.2 %).

Box 2-2: Calculating spatial autocorrelation with Moran's I
There are a number of other measures to indicate spatial autocorrelation (Geary's C, Ripley's K and Joint Count Analysis) but the de facto standard is Moran's I. This is an indicator that measures similarity of neighbouring features. This measure is based on both the feature locations as well as its values.

For each feature the function takes into consideration the attribute value of that particular feature, the attribute value of another feature's attribute value, the overall mean of that attribute value and a weight. The weight is often the inversed distance.

The function returns a Moran's I index and a Z-score. The Moran's I index is a value between -1 (perfect dispersion) and 1 (perfect correlation). This value can be converted into a Z-score for testing statistical significance. A Z-score of more than 1.96 or less than -1.96 indicates spatial autocorrelation that is significant at the 5% level.

Source: ESRI 2009b, Lembo 2002

2.5.2. Population development in time

Disregarding the spatial extent, focussing on historical development of population development, natural increase and migration for the whole of Fryslân reveals certain trends (figure 2-2). Population development at this scale is composed out of three elements: natural increase, national migration and international migration[9].

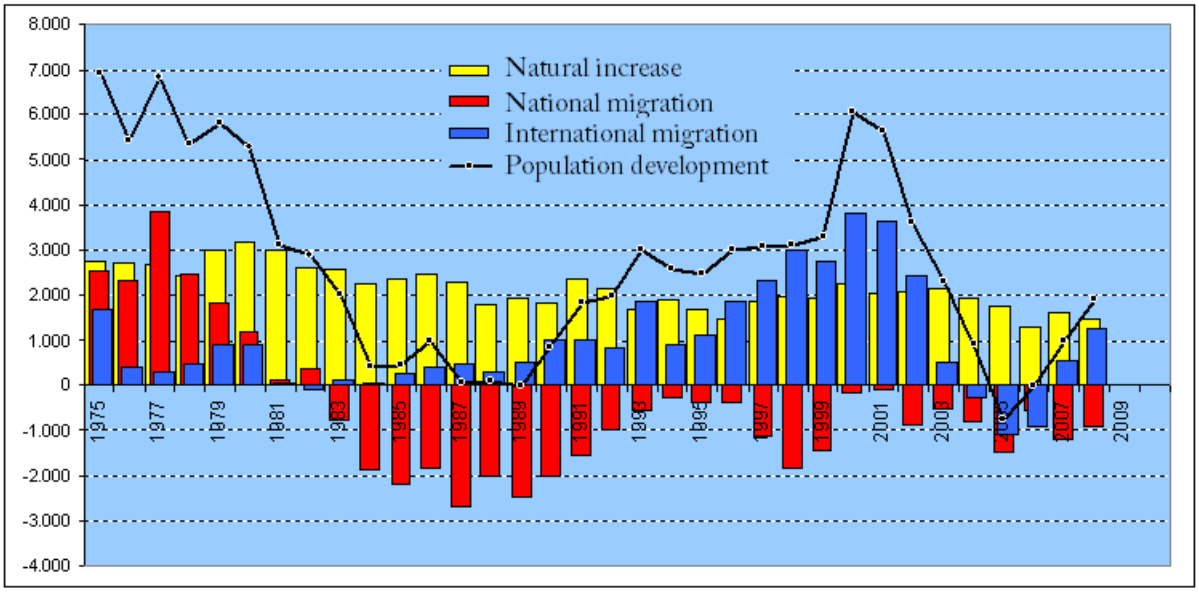


Figure 2-2: Population development in Fryslân (1975-2008). Source Province of Fryslân 2010a

The natural increase between 1975 and 2008 is relatively stable, with around 2,000 more births than deaths per year. The two forms of migration, national and international, show more fluctuation. The national migration shifted from a positive to a negative balance in the early 1980s. The international migration is the most fluctuating; it is largely dependent on the number of refugees which is a result of policy making from the national government. These refugees or asylum seekers cause more deviations in the provincial population balance. Policy in the Netherlands is to spread the number of asylum seekers over the country, resulting in a

[9] Province of Fryslân 2010a

share for the Province of Fryslân. Many of these people migrate later on to the west of the Netherlands, making Fryslân a transit area.

Overall it can be concluded that population development is heavily influenced by migration. The drop of the population increase in the late 1980 is predominantly caused by a negative national migration balance. The high population growth peaks of the late 1990s and early 2000s on the other hand are caused by the international migration.

Similar to the spatial deviations between cores migration is more fluctuating in time than natural increase. Therefore migration is determined to be the dominant element in changes in population development.

3. Spatial factors

In the previous chapter the population development in Fryslân is described, with a focus on the spatial deviations. This chapter will introduce a conceptual model with relevant factors, causing these spatial deviations. These factors can be described as explanatory factors, or as spatial factors: putting emphasis on the spatial extent of these factors.

3.1. Demographic changes

Population development is not a stand alone process. Together with change in household composition (a smaller household size) and population aging, population development is regarded as demographic changes[1]. These elements of demographic changes are interrelated, as shown in figure 3-1.

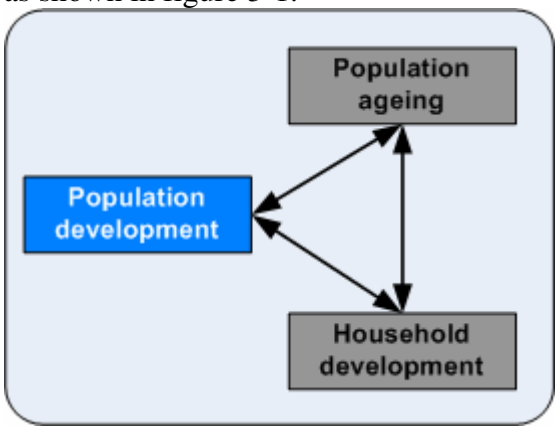


Figure 3-1: Demographic changes

All three elements of demographic changes are closely related and have the same background and even partially share the same causes. The focus of this research is primarily on population development and therefore the other two elements are not the focal point of research, but they will be taken in consideration regarded as explanatory variables.

3.2. Explanatory factors introduced

Demographic change in general and population development in particular is presumed to be caused by a manifold of factors. Intention of this research is to identify those factors related to population development and focus on the spatial characteristics. A factor can be described as: "a circumstance, fact, or influence that contributes to a result"[2].

As shown in map 2-8 population development clearly has spatial deviation: it differs per core. It can be assumed that the causes of population development show spatial deviation as well, what can be of influence on population development. In this research six themes are determined that later on in this chapter will be elaborately introduced:

- Population characteristics
- Planning
- Infrastructure
- Housing
- Amenities
- Economy

[1] Province of Fryslân 2010a
[2] AskOxford 2009

Not all explanatory factors are known; therefore the element of unknown factors is added. This element of unknown factors consists out of types. Factors not yet related to population development, but that may be of influence and factors that are hard to measure, quantify and research.

3.3. Conceptual model

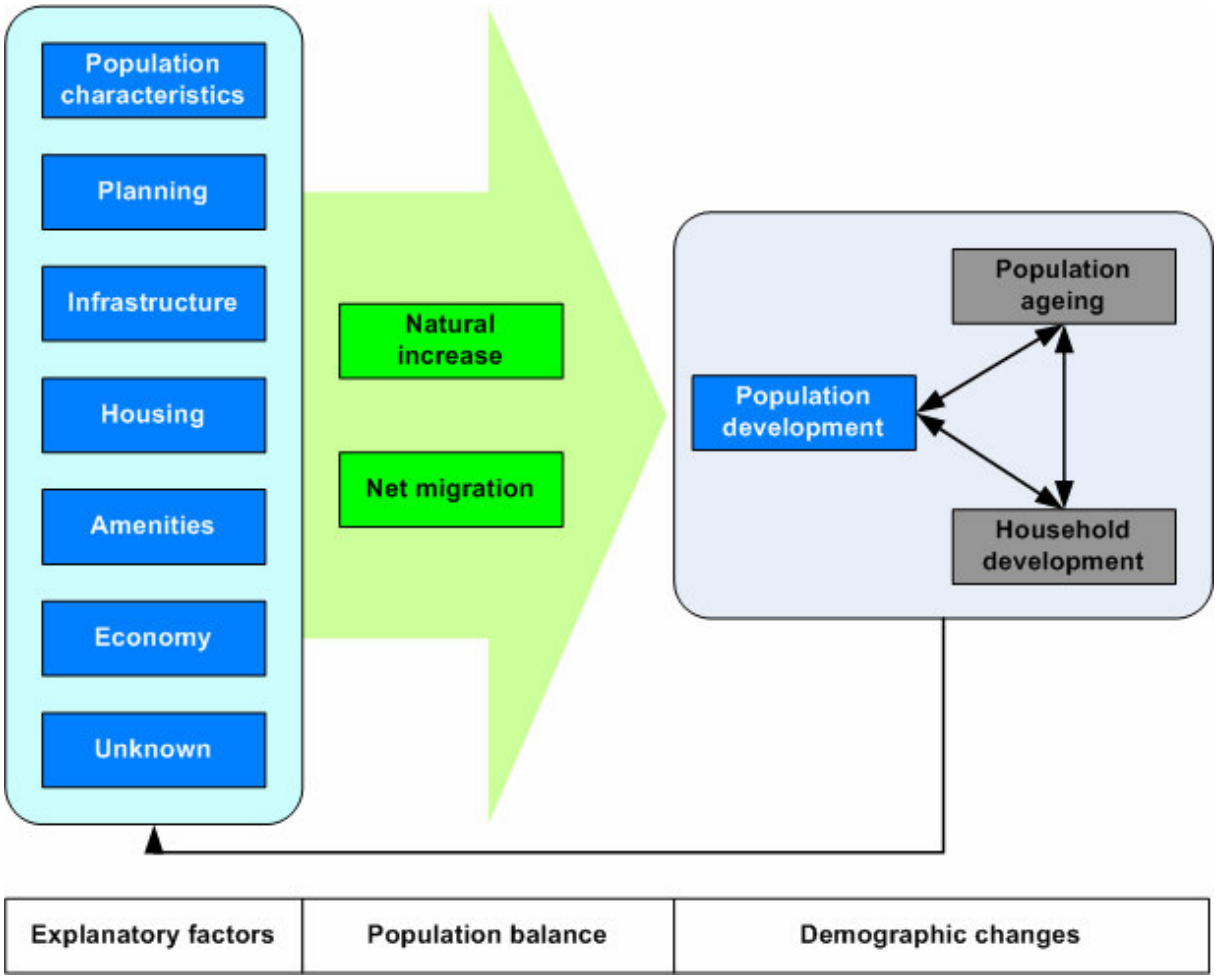


Figure 3-2: Conceptual model

The conceptual model as depicted in figure 3-2 has two main building blocks. The block on the right represents demographic changes. These demographic changes are assumed to be caused by the explanatory factors on the left. For the subject of research, population development, these two blocks are interrelated by the population balance, as introduced in the chapters 1 and 2. The primary direction of the relation is that the explanatory factors influence the demographic changes. But feedback links are also occurring, as represented by the black arrow.

The population balance has two elements: natural increase and migration. The natural increase is mainly influenced by the population characteristics and not so much by the other elements. Migration on the other hand can be regarded as influenced by all elements. In combination with the conclusion that the factor of migration is dominant over the factor of natural increase (see chapter 2) the importance of migration for population development is very high.

3.4. Push- and pull factors

Migration is the movement of occupancy from an origin to a destination. The underlying motivation for these movements can be explained by push- and pull factors. Push factors can be described as "events and conditions that impel an individual to move from a location" and push factors as "forces of attraction that influence migrants to move to a particular location"[3]. This implies that migration is caused by spatial inequality.

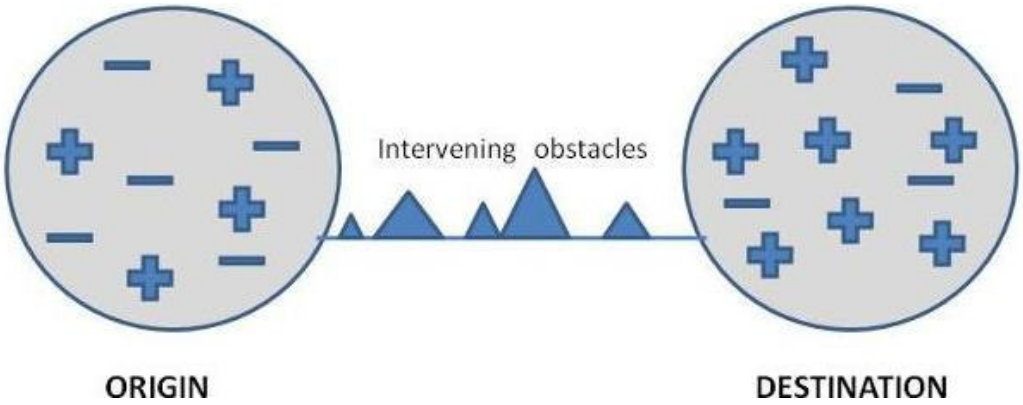


Figure 3-3: Push and pull factors acting in migration. Source: AAG Center for Global Geography Education (2010). After Lee (1966)

The theory is exemplified by figure 3-3, where at the origin the negative push factors dominate. At the destination the positive pull factors outweigh the negative factors. In between are intervening obstacles, which make the actual migration more difficult.

Because migration is determined the dominant element causing population development, the concept of push- and pull factors is also important for population development. The spatial inequalities that cause migration are therefore also of influence on the spatial distribution of population development.

The push- and pull factors can be linked to spatial quality. If a core has relative many strong pull factors and few push factors, the quality of living can be regarded as good and people like to life there. This retains the present inhabitants and attracts new residents. Both lead to a positive population development.

3.5. Themes related to population development

As stated in the conceptual model (figure 3-2) there are six themes that are regarded as influencing population development. In the next section they are shortly introduced. In the chapters 7, 8 and 9 these themes are described in more detail and linked to the Province of Fryslân. Where needed, explicit reference to the push- and pull factors theory is made.

3.5.1. Population characteristics

The field of research that is connected to the theme of population characteristics is called demography[4]. Relevant topics of demography that are related to population development are age composition, average household size and number of inhabitants per core.

[3] Knox & Marston 2004, p. 510
[4] Knox & Marston 2004

The age composition is of influence on natural increase but even more on migration. Some age groups are more willing to move than others. This is linked to the concepts of life cycles and life courses, which imply that certain events influence migration behavior of families and individual. Events include marriage, birth of children, children leaving home, death of a spouse, participation in the labor force and retirement[5]. Research has led to empirical age migration schedules. An example of an age migration schedule is depicted in figure 3-4.

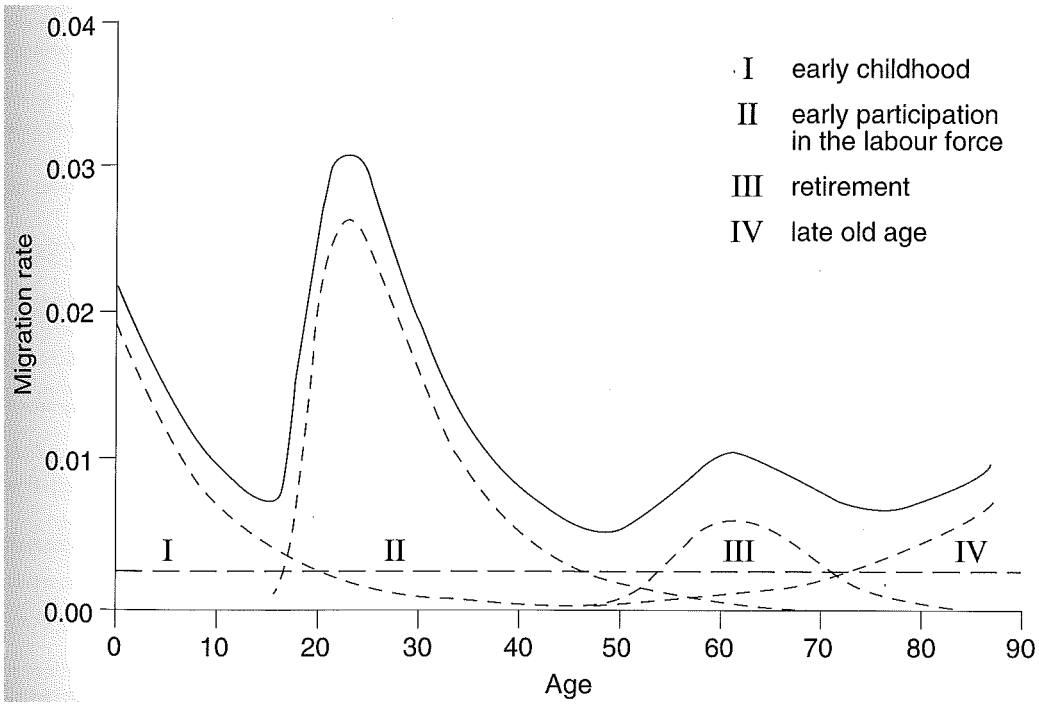


Figure 3-4: A model age migration schedule. Source: Boyle, Halfacree & Robinson 1998, p111.

Four common peaks of migration can be identified: early childhood, early participation in the labour force, retirement and late old age. It can be argued that the peak in the early 20s is not only caused by early participation in the labour force, but also by starting higher education[6].

The average household size together with the population size influences the number of houses needed per core, what influences migration and population development. In chapter 7 this is described in more detail.

Population size of a core is not only the result of population development but a factor as well. Also a high population figure might as well be a pull factor. Population size is often reflected in the planning hierarchy, which will be treated below.

3.5.2. Planning

Planning is a mechanism to order space. Governments can assign a planning hierarchy, in which some cities receive more spatial development opportunities than others. This unequal situation will influence the development of the population as well. Next to planning hierarchy concentration zones are also a widely used tool to steer developments.

[5] Boyle, Halfacree & Robinson 1998
[6] Harts 2008a

Apart from stimulating developments, governments can also guide developments by setting restrictions. They can allow certain activities at some locations, while limiting it in other locations.

3.5.3. Infrastructure

The topic of infrastructure is very closely related to distances and also planning. An important aspect is the topic of centrality.

The core-periphery system is relevant concept regarding centrality. Economic development is never evenly spread over space. Some areas are more developed that others and unequal relations exist[7]. Key of this system is that there is a centre, where the power is located and a remote, peripheral surrounding that is less developed. So being in or close to the centre area is a plus for development possibilities.

The proximity to a core area can be measured in a straight line distance as well as travel distance[8]. This travel distance is affected by the transportation infrastructure like roads and railways. In general a good infrastructure and short travel times are regarded to have positive influence on population development.

3.5.4. Housing

Housing is often stated to be a main reason for migration[9]. So population decline and housing are two related topics[10]. Two linked aspects are important to housing: the quantity and the quality of the housing stock.

Quantity implies the number of houses in an area. In a balanced situation the supply of houses equals the demand of houses. The number of houses needed can be calculated by multiplying the population size with the average household size. The average household size is influenced by changes in society and in lifestyles of individuals. This can be grouped under the theme of population characteristics, as stated in the conceptual model (figure 3-2). If the average household size keeps decreasing, this can lead to the situation of displacement. With a stable population in an area more houses are needed, but if the housing stock is limited (due to planning constraints) this leads to friction. Parental home leaving children may be forced to leave the area, leading to population decline in the area of origin.

In a downward tendency of population decline household decline can often be identified as well. This is of direct influence on the number of houses needed. When there is a decrease in demand for houses and the supply in housing stock remains stable, house prices will drop leading to a number of other negative effects[11]. An extra complication is the position of the public housing agencies. Apart from value loss in real estate they also suffer extra loss in income due to vacancies.

Apart from the number of houses the quality of housing is also of high importance. The current demands on quality are not in line with the houses built in the post war years (1950s-1960s) like for example the Bomenbuurt in Winschoten[12]. As a result of this low overall

[7] Knox & Marston 2004
[8] Knox & Marston 2004
[9] Boyle, Halfacree & Robinson 1998; Harts 2008b
[10] KEI 2009
[11] Bukman 2009; Visser 2009
[12] Haartsen 2009

quality these neighbourhoods are under threat of population decline. Restructuring and revitalisation of these neighbourhoods is often performed, for example in Norg[13].

3.5.5. Amenities

Amenities are a key aspect in the liveability of the countryside. Therefore a decline in available amenities is often linked to population decline[14]. This link is two-sided: a lower number of (potential) users lead to a smaller base to support the amenities but a low coverage of amenities might influence out-migration as well.

A decline in potential users is not the only cause of a decline in the number of amenities. Social-economical factors like change in life style, change in mobility and an increase in scale also influence the persistence of amenities[15]. This decline of amenities can accelerate population decline. This situation can be regarded as a vicious circle[16]. Next to this relation between amenities and population development, the development of the amenities has its own dynamic.

This described situation can be linked with the push- and pull factors theory. Having many amenities in a core is regarded as a pull factor, whilst a lack of amenities is a push factor.

3.5.6. Economy

Just like amenities the economy is two-way linked with population development. People tend to migrate towards areas with good opportunities in the job market and businesses tend to settle at locations where there is a high potential in the population[17].

In general the economies of the origin and destination areas are regarded as one of the key push- and pull factors for migration[18]. Phenomena that are related to this are employment, unemployment rates and average incomes.

Regarding employment the presence of jobs within the core is only of secondary importance. The number of jobs in a larger region is of more importance regarding the job opportunities for inhabitants of a specific core.

[13] De Mik 2009b
[14] Leenes & Noordhoff 2009; Van Nimwegen & Heering 2009a
[15] Vias 2004
[16] Van Nimwegen & Heering 2009a
[17] Boyle, Halfacree & Robinson 1998; Province of Fryslân 2010a
[18] Boyle, Halfacree & Robinson 1998

4. Research objectives

The topic of research combines multiple fields of geography: demography, human geography and spatial planning. Because of the quantitative and spatial characteristics the main method of research is also a field of geography: Geographical Information Systems (GIS).

The focus is put on the spatial distribution of population development and the explanatory factors that are related to this population development on a core level.

4.1. Research goals

This research contains two research goals. The first goal is to gain insight in the spatial factors that are of influence on local population decline in the province of Fryslân. The second goal is related to achieving the first goal and is of methodological nature. The goal is to apply GIS based techniques for research in population decline. For both goals the intention is to fit them in with the needs of the provincial administration.

4.2. Research questions

To comply with the objective of the research and combining the two research goals a main research question is formulated:
Which factors behind local population decline in Fryslân can be revealed by using GIS?

To be able to answer the main research question two sub questions are generated. Together they will answer the main question. First research question:
Which GIS techniques can be used to research spatial factors related to local population decline?

Second research question:
Which factors can be identified to explain local population decline?

4.3. Scope

Because this research combines multiple research fields and the complexity of population decline, limitations have to be set.

4.3.1. Limiting population development

Population development is only one element of a broader term: demographic changes (see figure 3-1). This also includes changes in household composition, life styles and population age structures. These are all important elements in the interrelated demography of the Province of Fryslan[1].

Demographic change that is expressed in population decline and household decline is often related to economic decline. Economic decline itself is regarded out of scope; it will only be used as an explanatory factor.

This research only focuses on the factors behind local population decline, not on the effects of population decline. Therefore demographical discussions such as shortage of employees or the ageing of the population are out of scope. The age composition of the population will be used as explanatory variable.

[1] Province of Fryslân 2010a

4.3.2. Empirical data

The timeframe of research is the period 2000-2008. Empirical data about population decline is available for this timeframe. For reasons of certainty prognosis data about population decline is not used. Otherwise this might lead to insecure and unreliable outcomes.

4.3.3. Scale

The spatial focus of this research is put on the level of the residential core, of which 416 are identified for this research (see chapter 2). Only explanatory factors that are specific per core are used. Large scale aggregate statistics, like for example on a municipal or regional level, are not used as an explanatory factor for population development on a local core level. This is to avoid the ecological fallacy. The ecological fallacy implies that large scale aggregate data (e.g. on a municipal level) is not applicable on individual cores.

4.3.4. Determining relations

Based on the explanatory spatial factors described in chapter 3, relations with population development will be tried to be identified. The size and the direction of these relations will be determined. Only relations are determined, not the causality. Often one direction of causality is expected based on theory, but this can not be proven. Also there is very often a feedback between population development and the explanatory factor. A change in population will lead to a change in the explanatory factor, again leading to a change in population. A vicious circle prevails.

4.3.5. Spatial statistics

This research will primarily be based on “traditional”, non-spatial statistics to determine relations between explanatory factors and population development. For each of the 416 Frisian cores data is processed with the use of GIS, but the statistical relations will be determined with the use of “traditional” statistical methods. The spatial interference between cores will not be used in statistical analysis.

5. Methodology

In this chapter the methodology by which this research is applied is explained. The methodology is created to answer the research questions by means of a pre-structured procedure using software and data.

5.1. Answering the research questions

The structure of this research is that the two sub questions contribute to answering the main research question. The first sub question is related to GIS techniques, the second sub question relates to spatial factors causing population development.

5.1.1. GIS techniques

The first research question is about determining GIS based spatial analysis techniques that are useful to help answering the second research question. These techniques need to be moulded into a structure, so methodologies can emerge. The used techniques serve as a tool of data preparation for the next step.

5.1.2. Determination of factors

The determination of the relevant spatial factors behind local population decline is done by generating hypotheses and statistically analysing them. Therefore it continues on the data processed with the use of GIS technology in the previous step.

5.2. Research methodology

The research is divided into five main steps of which the fourth is the most elaborate step and is divided into six sub steps. Table 5-1 gives an overview of the five research steps with their sub steps.

Table 5-1: Research steps

Step	Name	Description	Chapter
1	Population development in Fryslân	Research on the population development in Fryslân, by applying the population balance with the components of natural increase and migration. Focus is on the spatial extent of population development.	2
2	Theory on local population development	Literature research on possible explanatory factors for local population decline. This leads to the creation of a conceptual model for local population decline	3
3	Research on GIS techniques	Introduction of basic GIS analysis techniques.	6
4a	Determine possible spatial relations	Possible relations between local population development and explanatory factors are moulded into research hypotheses.	7,8&9
4b	Determine (GIS) analysis techniques	Determination of analysis techniques to test the research hypotheses. This includes spatial as well as non-spatial analysis.	7,8&9
4c	Determine data needs & data acquisition	Determination of the data needed to test the research hypotheses.	7,8&9
4d	Non-spatial data processing	The acquired data needs to be pre-processed before it can be used for (GIS) analysis.	7,8&9
4e	GIS data processing & analysis	Spatial analysis will be executed with the use of GIS	7,8&9
4f	Statistical analysis	The data processed in the previous steps is used in order to determine statistical relationships connected to the research hypotheses	7,8,9&10
5	Conclusions	The research questions and the results are discussed	11&12

Step 4 is executed three times, described in three chapters treating the combined themes of the conceptual model (figure 3-2). The whole research process is depicted as a flow chart in figure 5-1.

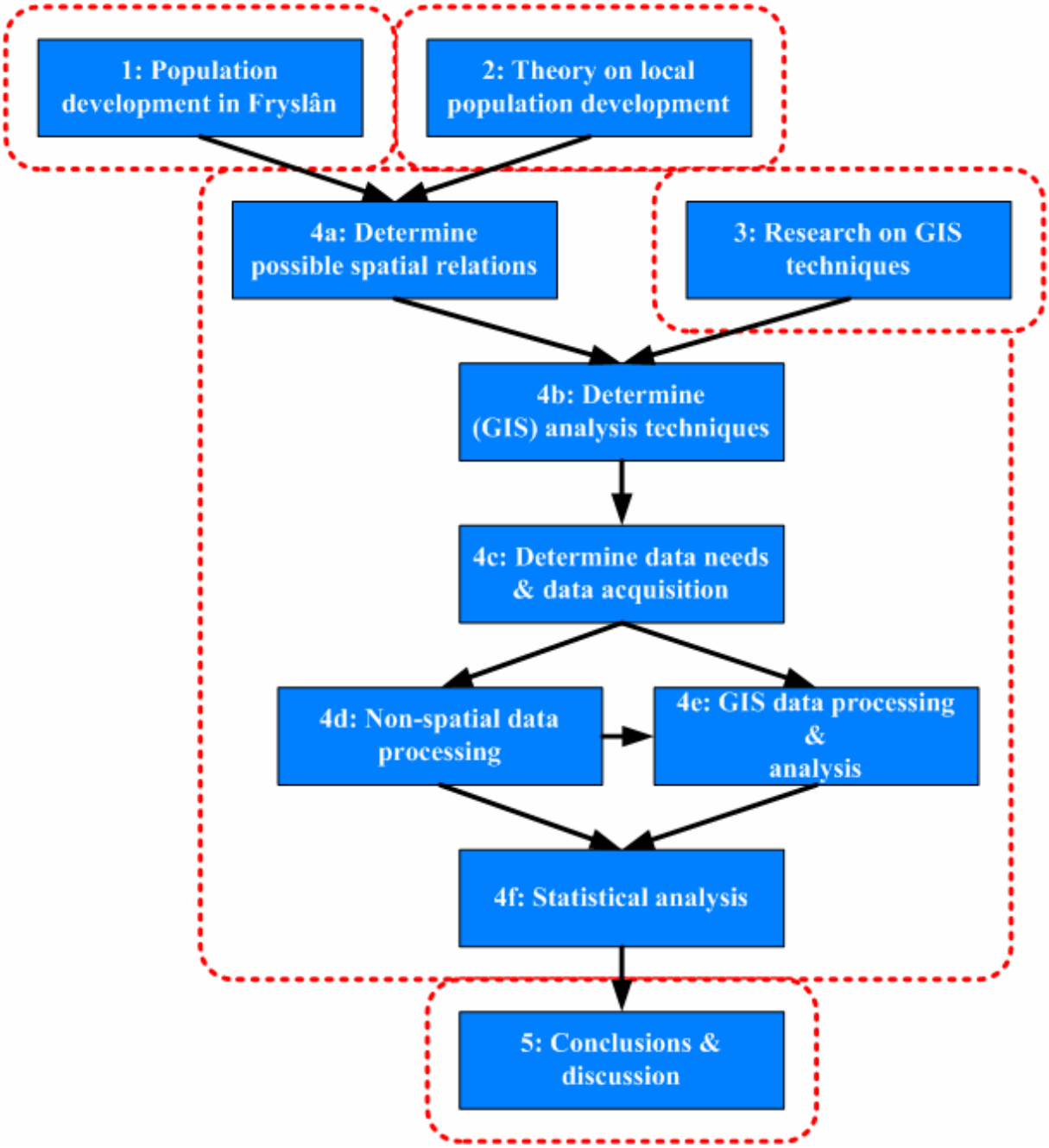


Figure 5-1: Flow chart of the research methodology

5.3. Software

The used specialized software will consist out of two parts: GIS software and statistical software. Microsoft Office is a broadly used software package. Microsoft Word for the report, Microsoft Excel for the creation of graphs and non-spatial, non-statistical calculations and Microsoft Access for managing databases. Microsoft Visio will be used for the creation of figures and flow charts.

5.3.1. GIS software

As main GIS software package ESRI ArcGIS will be used. This includes the ArcMap/ArcCatalog package of which version 9.3 will be used. Licensing is accounted for with the use of the licence pool of the province of Fryslân. This ranks up to the ArcInfo license. In addition to the basis software package additional ArcGIS extensions will be used. This includes Network Analyst and Spatial Analyst.

To gain insight in the spatial extent of the population development as well as the explanatory variables interactive thematic maps will be created on the fly with the use of CommonGIS[1]. This is a GIS application that can be used as a tool to visualisation and exploring of geographically referenced statistical data[2].

For the main spatial analysis processing and the creation of maps ESRI ArcGIS will be the default.

5.3.2. Statistical software

For the statistical analysis the package SPSS will be used, that is available at the provincial administration. The used version is SPSS 16.

5.4. Data

Intention of this research is to explain patterns in population development and relate them to the explanatory factors.

5.4.1. Data needs

For this research data about population development as well as data on the six specified themes of the conceptual model is needed. The data used will be discussed and introduced where needed. A detailed list about the used data can be found in appendix A.

5.4.2. Data acquisition

Basically the used data for this research can be classified into three categories.

- Data that is produced by the Province of Fryslân. This data is available and there are mostly no restrictions regarding the use.
- Data that is produced by external parties, but available at the provincial administration. The data is available and can be used in research but restrictions can be applicable.
- Data that is not produced by or available at the provincial administration. This data needs to be located and arrangements need to be made to obtain the data.

As expressed in the scope the data about population development is based on the period 2000-2008 and the data on explanatory variables is of a suitable timeframe. The numbers about population decline are based on the period 2000-2008.

5.5. Statistical analysis

Goal of this research is to correlate possible explanatory factors of population development to the population development figures per core. As stated in the scope of this research (chapter 4) statistical research will only focus on the relations between the explanatory factors and population development. Spatial interference is not taken into account.

[1] Fraunhofer IAIS 2010
[2] ESDS 2010

These possible explanatory factors can be very divers and have various measurement scales. A division into four measurement scales is used, see table 5-2[3].

Table 5-2: Measurement scales

Measurement scale	Nature of data
Nominal	Data of different nature / identity of things (qualitative)
Ordinal	Data with a clear element of order, though not quantitatively determined (ordered)
Interval	Quantitative information with arbitrary zero
Ratio	Quantitative data with absolute zero

The variable of population development can be represented in two measurement scales. The first one is a nominal scale: cores that have a population growth and cores that have a population decline. The second representation is a ratio scale: an annual percentage.

The fact that the explanatory factors can have many different measurement scales leads to complications in comparison between the different factors. Therefore a method of statistical analysis is created that can be applied on all explanatory factors. This is achieved by reclassifying all interval and ratio variables into a limited number of discrete classes. These classes can be analyses in the same manner as nominal and ordinal variables. These discrete classes can be researched on two facets: the ratio between growing and declining cores and the average annual population development over the years 2000-2008.

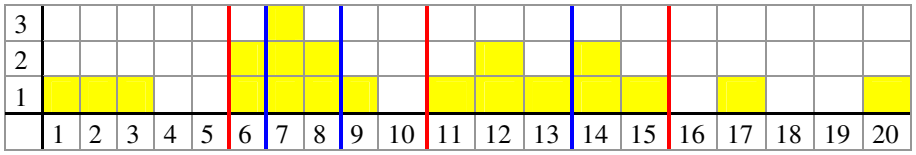
The reclassification of ratio and interval values of the explanatory factors into discrete classes can be subject of discussion. There are basically three methods:

- Equal interval: The whole range of the ratio or interval variable is divided into a fixed number of classes all with an equal-sized sub range. The number of cases in each interval can vary[4].
- Quantiles: The whole range of the ratio, interval or ordinal variable is divided into a number of classes, each with the same number of cases[5].
- Custom: The variable is classified based on a specific classification schedule, preferably based on a publication.

The choice for the classification method differs per topic. A custom classification is preferred if it can be based on relevant classifications made in earlier research or policy. If the values are evenly distributed and the values are meaningful an equal interval classification is chosen, otherwise a quantile classification is applied. An explanation on the difference between an equal interval and a quantile classification is given in box 5-1.

[3] De By 2004
[4] ESRI 2010c
[5] ESRI 2010d

Box 5-1: Difference between equal interval and quantile classification



In this example the values on the x-axis range from 1 to 20 (depicted in the yellow squares). Both the equal interval (red) as well as the quantile (blue) classification split the dataset into four classes. In the equal interval classification the sub range for each class is equal: in this example 5. This leads to break values on the x-axis of 5, 10 and 15.

In the quantile classification the number of cases in each class is of importance: each quantile has 5 cases in this example. This leads to break values on the x-axis of 6, 8 and 13.

	Equal interval	Quantiles
Number of classes	4	4
Size of sub range	5	2-7
Number of cases per class	2-8	5

5.5.1. Statistical interpretation

When the explanatory factor is classified into a discrete number of classes, the individual classes can be compared with each other. That is done for each variable with the same statistical analysis, based on the two facets of population development as described above: the ratio between growing and declining cores and the annual average population development (2000-2008).

The analysis output exists out of three components: class definition, growth/decline ratio and population development. The latter two are determinants to establish the correlation between the explanatory factors and population development.

Based on the statistical outcomes the correlations can be assumed present, not present or unclear. Not every correlation can be clearly identified or discarded, hence the last category. The correlations can be either positive or negative. A positive correlation means that a high value of the explanatory factor results in a high average annual population development. A negative correlation implies the opposite: a high value of the explanatory factor belongs to a low average annual population development.

6. GIS techniques

A Geographic Information System (GIS) can de defined as a tool to capture, store, update, manipulate, analyze, and display geographically referenced information[1]. Because this research on local population development is based on existing and available data, the focus of this research is on the latter three aspects: manipulation, analysis and visualization. This chapter consists of two sections: GIS manipulation techniques and visualisation.

6.1. Spatial representations

A GIS is a representation of real world phenomena[2]. Focussing on two-dimensional representations there is a clear distinction between two spatial data models: raster and vector[3]. A raster representation models real world space into a grid of discrete cells. Each cell is assigned a value corresponding to the real world space. In vector representations two-dimensional Cartesian (x,y) coordinates are the building blocks of the points, lines and polygons used to model real world features[4]. In figure 6-1 the conversion from real world phenomena (1) into a raster representation (2) and a vector representation (3) is depicted.

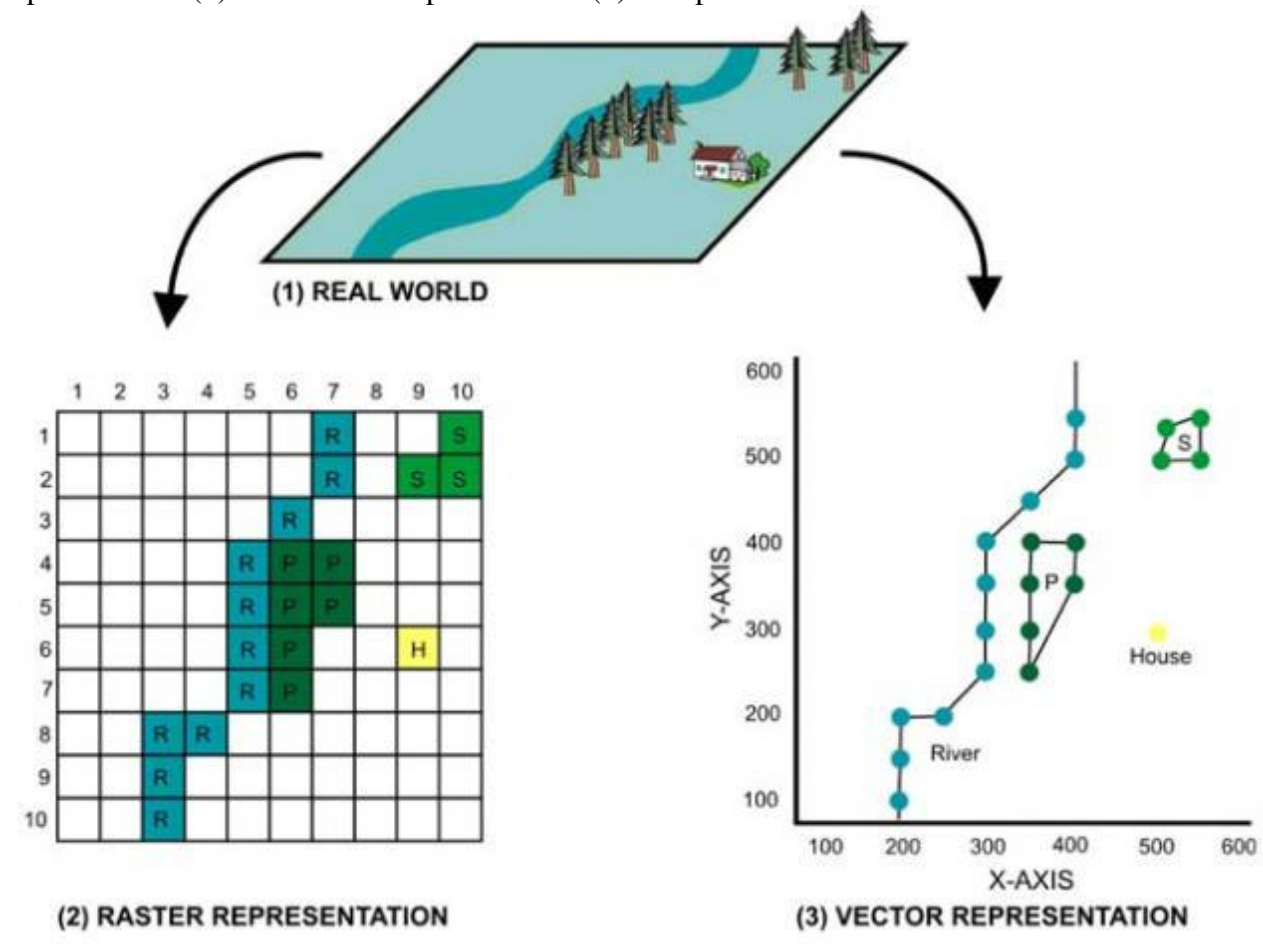


Figure 6-1: Raster and vector representation. Source: Housing and Land Use Regulatory Board (2007)

Both types of data models have their own advantages and disadvantages. Therefore they also have their own use cases. Raster representation is the default for (air) photos, scanned maps

[1] ESRI 2010b
[2] Augustijn 2005
[3] Heywood et al 2006
[4] Heywood et al 2006

and often used in physical soil data and land use classifications. Vector representation is default for road networks and topographical datasets. Administrative data is often linked to vector points or polygons. This research will mainly use administrative data, so this implies that most of the data used in this research is vector data.

6.2. GIS manipulation and analysis

Manipulation and analysis of geodata are two closely coupled aspects that together make up the analytical GIS capabilities. A classification of analytical GIS capabilities into four main groups is proposed by Aronoff[5]:

- Measurement, retrieval and classification functions
- Overlay functions
- Neighbourhood functions
- Connectivity functions

All four categories of GIS manipulation and analysis will be described below, with a focus on the application on vector data.

6.2.1. Measurement, retrieval and classification functions

This category of functions allows the exploration of the data without making fundamental changes. All the functions only apply on one single data layer. Functions of this kind are often used in the beginning of data analysis and data exploration. Three important functions are:

- **Measurement functions**. This includes the computation of distance between features, length of perimeter and area size as well as counting frequencies. A special form of measurement is the determination of autocorrelation and clustering[6].
- **(Spatial) query**. The selection of features based on geometry/location or on attribute data. This includes interactive spatial selection (clicking on a feature to identify and select it) and selecting on specified attribute characteristics[7].
- **Classification**. The (re)assignment of a thematic value to features in a data layer[8].

6.2.2. Overlay functions

The overlay function combines two or more data layers in order to compute a new data layer. This new data layer combines features from multiple layers that occupy the same location[9].

In the vector data model an overlay combines the two associated disciplines of geometry and topology. There are three basic types of vector overlay functions: point-in-polygon, line-in-polygon and polygon-on-polygon. The latter is the most complex and can be divided into three main categories: union, intersect and erase[10]. A graphical explanation of the above mentioned functions is displayed in figure 6-2.

[5] De By 2004
[6] ESRI 2009b
[7] De By 2004
[8] Heywood et al 2006; De By 2004
[9] De By 2004
[10] Heywood et al 2006

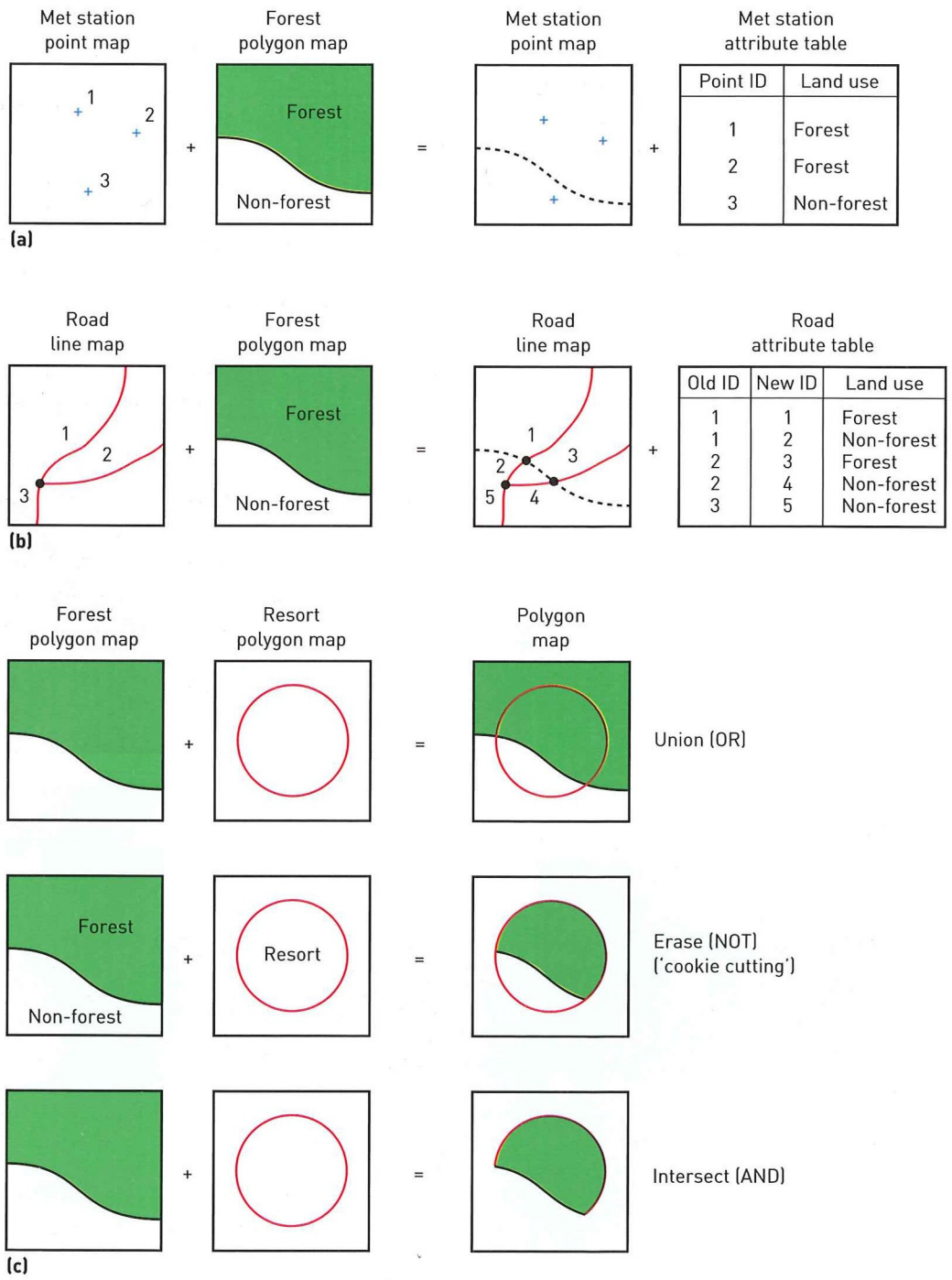


Figure 6-1: Vector overlays: (a) point-in-polygon; (b) line-in-polygon; (c) polygon-on-polygon. Source: Heywood et al 2006, p. 184

Overlay functions know many practical applications. For example which agricultural plots are located inside a nature preservation area can be determined with this technique. Or multiple classified data layers can be combined to become a site suitability model.

6.2.3. Neighbourhood functions

A neighbourhood function calculates a value for an entity in interaction with the area surrounding the feature. A value is generated based on the vicinity of the entity[11]. The most straight forward application of a neighbourhood function is a buffer. This function generates a zone of interest surrounding an entity, based on a geometric distance. A practical application for this can be for example to determine a safety zone of 500 meters surrounding a dangerous factory. A buffer can be applied on raster data as well as on point, line and polygon vector data (figure 6-3).

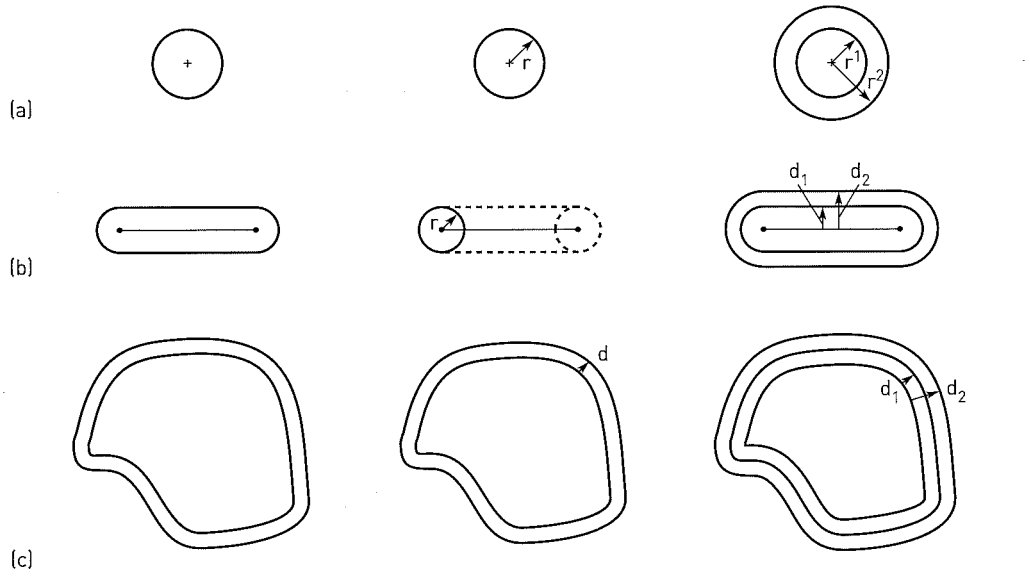


Figure 6-2: Buffer zones around (a) point, (b) line and (c) polygon. Source Heywood et al 2006, p.178

Another form of proximity analysis is the creation of Thiessen polygons: determining service areas on geometric distance[12]. Both buffer zones and Thiessen polygons are based on geometric distance and the assumption that phenomena spread evenly over all directions. This is not the case with phenomena like pollution and ground water. This can only be adequately modelled with spread and seek functions, which require a raster data model. Spread functions assume that phenomena spread in all directions, but not all equally easy, while seek functions assume that only the path of least resistance is chosen[13].

6.2.4. Connectivity functions

Connectivity functions can be defined as a broad term covering network analysis. A network is a set of interconnected features through which resources can flow[14]. A commonly used network dataset is a road network. There are many types of network analysis, but the two most relevant for this research are optimal path finding and network allocation[15].

Optimal path finding - This function calculates the most optimal path between two points on an interconnected network. The term optimal can mean shortest in distance, but also the fastest in travelling time or the cheapest in fuel costs. This optimal path finding functionality is the basis of GPS car navigation systems.

[11] De By 2004
[12] De By 2004
[13] De By 2004
[14] Heywood et al 2006
[15] De By 2004

Network allocation - In network allocation analyses the various network segments are allocated to a number of target locations, or facilities. These facilities can be for example hospitals or schools. The assignment of network segments to a target location is usually done based on the optimal path. The result of this analysis is a determined service area for each facility. Two restrictions are commonly added to this analysis: the capacity of the target location and the demand for the resource among the network segment. The demand for a resource can be, for example, related to the population density of a network segment[16].

6.3. Visualisation

The most designated way of visualising geospatial data is presentation in the form of maps[17]. Maps provide information and reveal spatial patterns that are hard to obtain from a text or a table[18]. Despite of all the developments in computing and analysis techniques, the human eye and brain is still the most efficient mechanism for identifying spatial map patterns[19].

Maps can be divided into two broad categories: topographic maps and thematic maps.[20] Topographic maps display the locations of objects like roads, towns and administrative borders. These maps are the designated map type for orientation purposes. Thematic maps focuses on one particular theme and its spatial pattern[21]. Therefore it is very useful for presenting data on a theme like population development. A thematic map always needs topographic data, to enable the user to locate the thematic info and to help explain spatial distribution patterns[22].

This research on population development deals predominantly with statistical data, which is quantitative ratio data. Classifying statistical data into ordinal classes and visualising it in areas is called chloropleth mapping[23].

6.4. Additional value of GIS

The overall research methodology as introduced in chapter 5 (figure 5-1) describes the steps of data non-spatial and spatial data processing and the analysis that follows on that. In traditional research general data is used that is analysed with non-spatial techniques. The analysis is executed with generating graphs and tables and applying statistical methods. Figure 6-4 explains the main additional values of GIS complementary to traditional research.

[16] De By 2004
[17] Kraak & Ormeling 2003
[18] De By 2004
[19] Layne 2006
[20] Heywood et al 2006
[21] Heywood et al 2006
[22] Blok 2008
[23] Heywood et al 2006

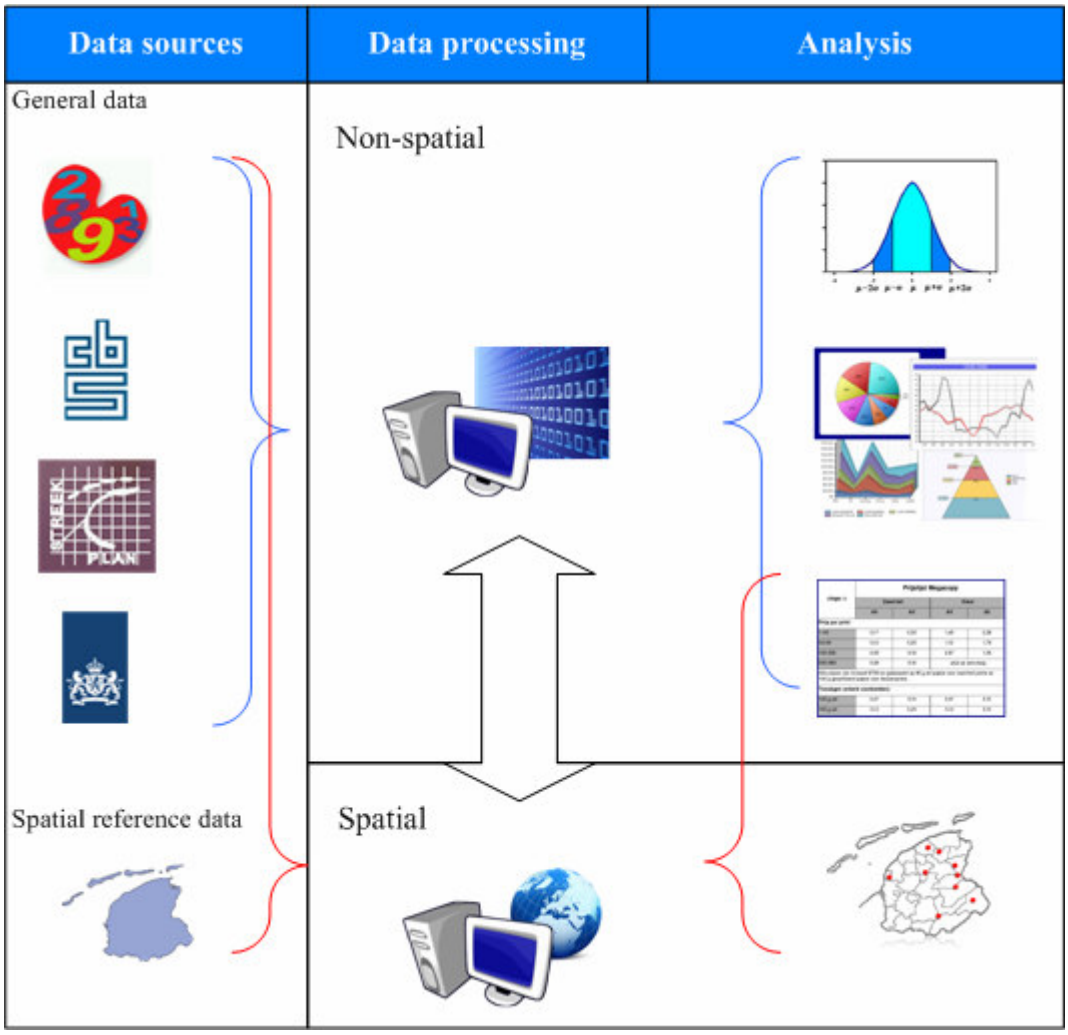


Figure 6-3: Application of GIS in data manipulation and analysis

General data about explanatory values can be linked to spatial reference data, to transform non-spatial data into geo-data. The main advantage of this is that instead of only be presented in text or tables the data can be presented in a map, revealing the spatial characteristics of the data. Additional spatial processing can be applied: the analytical GIS capabilities as described earlier in this chapter.

6.5. Application of GIS in this research

Out of the described possibilities GIS techniques offer, the intention is to use a broad as possible set in the following chapters. For all the research topics visualization will be used in the form of thematic maps. The selection of used analytical GIS capabilities is more specified.

For example distance measures will be used to determine the straight line distance between the Frisian cores and central cities. An area measurement will be used to determine the areal of a core that is designated as EHS. Spatial queries are used to determine of a core is located inside or outside an area of economic or natural importance. The neighbourhood functionality is applied to determine which cores are nearby a highway or the number of jobs within a set radius of the core. Finally the connectivity functionality is used to determine travel time by car from each core to important cities, railway stations and amenities. In the next three chapters the choices and applications of the selected analytical GIS capabilities will be explained in more detail.

7. Population characteristics

As stated in chapter 3 the development of the population is an aspect of demography that is related to many other population characteristics. This chapter will focus on three basic population characteristics: population size, age composition and average household size.

7.1. Population characteristics of the Frisian cores

The three above mentioned aspects will be research on the spatial level of the 416 cores in the province of Fryslân. The selection of these 416 cores is described before in chapter 2.

7.1.1. Population size

In an international context some of the most striking examples of population decline are in large cities, for example in the United States and former East-Germany[1]. In the United States this is largely caused by suburbanization, while in East-Germany migration for economic reasons is common.

Opposed to this de- and suburbanization in for example the United States, urbanization movements are still very common in the developed world. Rural and remote areas in for example Sweden and Finland often face population decline. In those countries one in two rural residents is living in a region threatened by population decline[2].

In the Netherlands population decline in the past decades took place predominantly in the smaller municipalities. Large cities rarely have a declining population[3]. Therefore the Netherlands is tending more towards the Scandinavian situation, albeit with an important deviation due to the relative small size of the Netherlands.

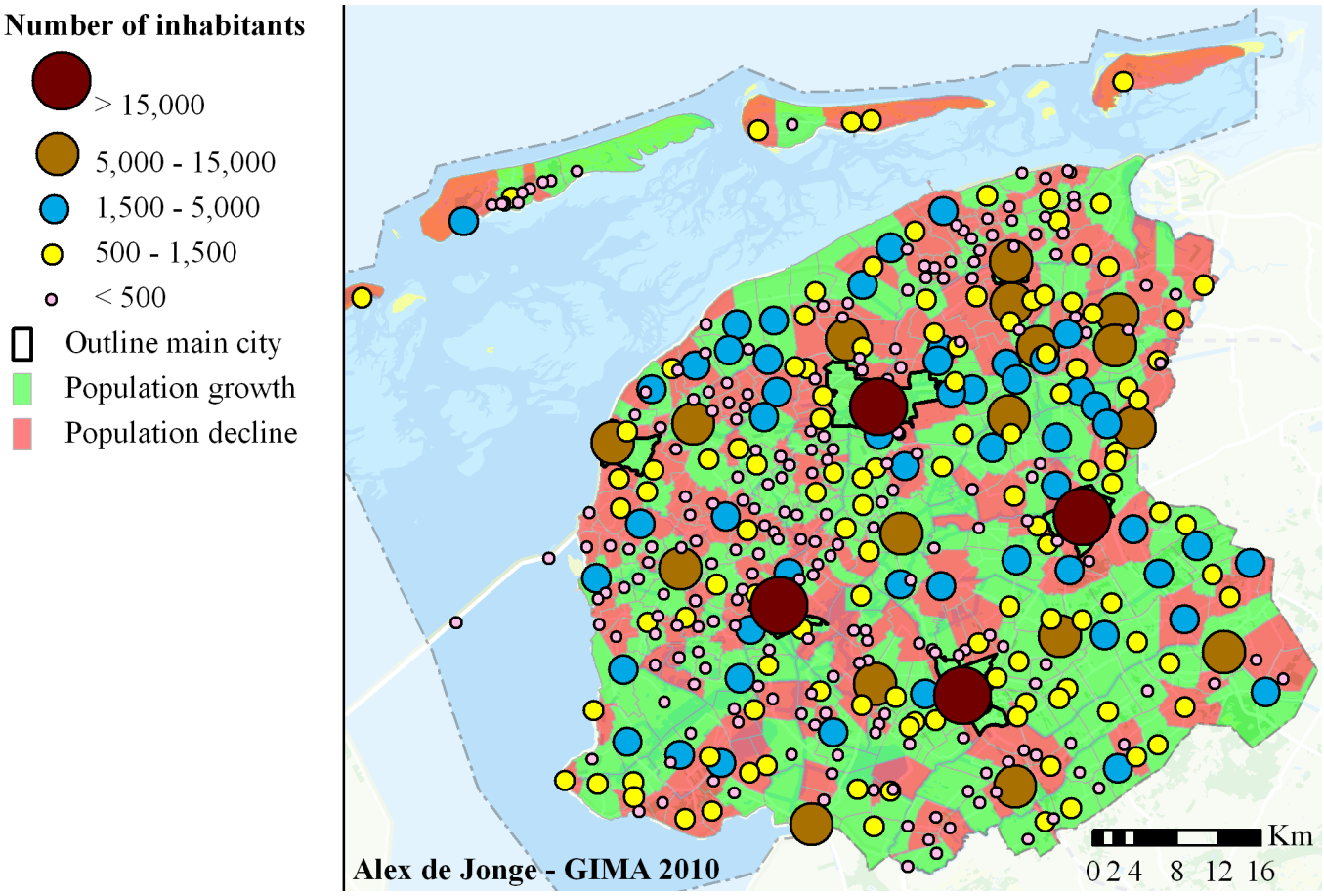
The province of Fryslân includes 416 residential cores varying in size. Population numbers range from only four in Breezanddijk up to over 87 thousand in Leeuwarden[4]. This range in number of inhabitants is classified by the provincial administration into five classes and is depicted in table 7-1[5].

Table 7-1: Classification of size classes

	Number of inhabitants
Class 1	> 15 000
Class 2	5000 - 15 000
Class 3	1500 – 5000
Class 4	500 – 1500
Class 5	< 500

The spatial distribution of the Frisian cores according these population size classes is depicted in map 7-1.

[1] Demographia 2010
[2] European Union 2010
[3] Louter 2009
[4] Province of Fryslân 2010c
[5] Province of Fryslân 2006



Map 7-1: Population size per core (2000). Source: Province of Fryslân 2010c

Two interesting observations can be derived from map 7.1. In the coastal zone and the area west of the centre of Fryslân many small cores can be found. In the eastern part of Fryslân are fewer cores located, but in general they are of a larger size.

7.1.2. Age composition

As introduced in chapter 3, population development is dependent on age composition of the inhabitants. The age composition affects both the net migration as well as the natural increase. The influence of age on migration is depicted in figure 3-4, from where four peaks can be derived[6]:

- **Early childhood migration** (approximately 0-15): This group is almost completely dependent on the migration decision making by their parents. Therefore this age group is a good measure for the migration of households with children. This group often migrates because of reasons related to career opportunities, housing or living environment. The general pattern is a migration away from large cities towards suburban and rural villages[7].
- **Educational migration** (approximately 15-25): After finishing high school it is common to continue education. This more specialized education of choice is often not located in the same city as the high school: the distance between the parental home and the education institution increases significantly (see also the later chapter on amenities & economy: chapter 9). This increased distance and the desire to leave the parental home leads to migration of students towards cities with many education opportunities, and specific higher education[8]. Mi-

[6] Boyle,Halfacree & Robinson 1998
[7] Harts 2008b
[8] Harts 2008a

gration of this age group coincides with migration related to early participation in the labour force, which is generally towards large cities[9].

- **Retirement** (approximately 50-70): Where the large cities are the designated place to follow a good education and pursue a career, it might not be the ideal living environment after the children left home and retirement is in sight. Although the retirement age in the research period is 65, migration of the age group 50-65 anticipating retirement is not uncommon[10]. Migration of this kind is often towards a more beautiful living environment. This living environment is often expressed in a more rural community, whether or not remigrations to the region people originate from[11].
- **Late old age** (approximately starting from 75): Where retirement migrants often move towards the more rural communities, this tranquil living environment also has its downsides. With old age health and mobility decreases, whilst the need for amenities and services increases. Living in a remote, rural location is becoming problematic. Migration towards a city with more amenities close by or to a retirement home is a solution to cope with this situation[12].

The influence on the natural increase on population development is via the size of the population that is in their reproductive phase of life. Figure 7-1 shows the average age of the mother of each live born child. The peak is around the age of 30 with the bulk of the live born children having a mother with an age between 25 and 38[13]. Assuming an average age difference of two years between the mother and the father the gender unspecific reproductive age group ranges from 25 to 40[14]. Families with children are also often migrating for reasons described under “early childhood migration”.

[9] Boyle, Halfacree & Robinson 1998
[10] Harts 2009
[11] Harts 2009
[12] Harts 2009
[13] CBS Statline 2010
[14] CBS 2010

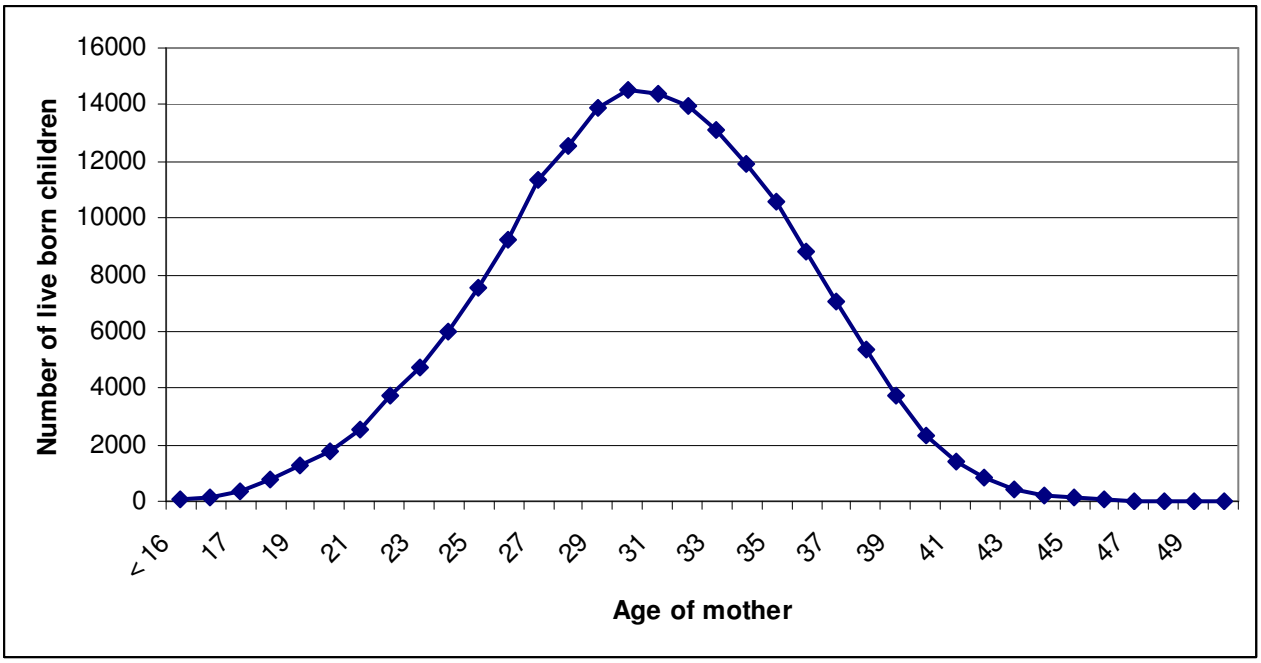


Figure 7-1: Age of mother by birth (2008). Total number of live born children in the Netherlands is 184,634. Source: CBS Statline 2010

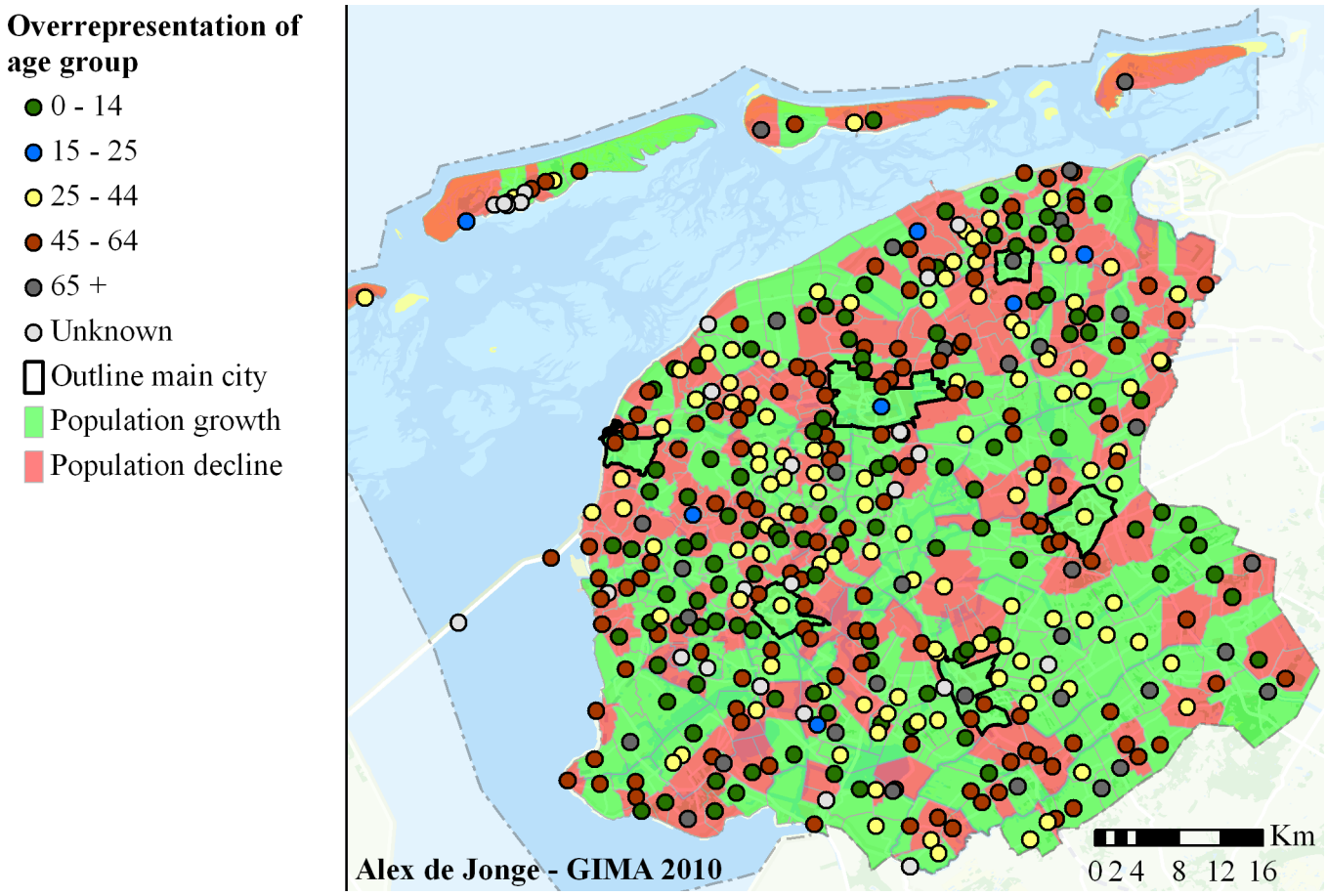
On large spatial units the CBS has very complete and detailed age composition data, specified on age in years and gender[15]. But for smaller sized statistical units this data is not available due to privacy constraints. For small cores and statistical neighbourhoods a classification is made in five age categories[16]. The five categories with their explanatory relevance are stated in table 7-2, together with the proportion of these groups of the total Frisian population.

Table 7-2: Determination of five age groups

Age group	Relevance	Proportional size in Fryslân (2001)[17]
0-14	Early childhood migration.	19,0 %
15-24	Migration induced by early participation in the labour force and study	12,3 %
25-44	Reproductive years	29,1 %
45-64	Migration induced by children leaving the parental home and retirement	25,0 %
65+	Migration due to old age	14,3 %

For each core with a known age group composition the most overrepresented age group per core can be determined. This is done by calculating per age group the difference between the percentage per core and the Frisian percentage. Compensation for the different age group sizes is achieved by multiplying this difference with again the Frisian percentage. This over-representation means that the age group is relative dominant in the residential core. Because the significance of this dominance is hard to compare in between different cores, it is only a measure to describe a particular core. The results are depicted in map 7-2.

[15] CBS Statline 2010
[16] CBS Statline 2010
[17] CBS Statline 2010



Map 7-2: Overrepresentation of age groups (2001). Source: CBS Statline 2010

An overrepresentation of the age group 15-24 is the most uncommon type. The specific overrepresentation in the cities of Leeuwarden and West-Terschelling can be explained by the high number of students connected to the educational facilities there. The most overrepresented age group in the large cities of Heerenveen and Dokkum as well as in some medium sized cities (St. Annaparochie, Kollum, Oosterwolde, Gorredijk, Wolvega, Joure, Balk and Bolsward) is the group of 65 years and over. This might be related to the high level of amenities in these cities and specifically the retirement homes (see chapter 9). The remaining three age groups are often overrepresented in the cores surrounding the large cities in Fryslân.

7.1.3. Average household size

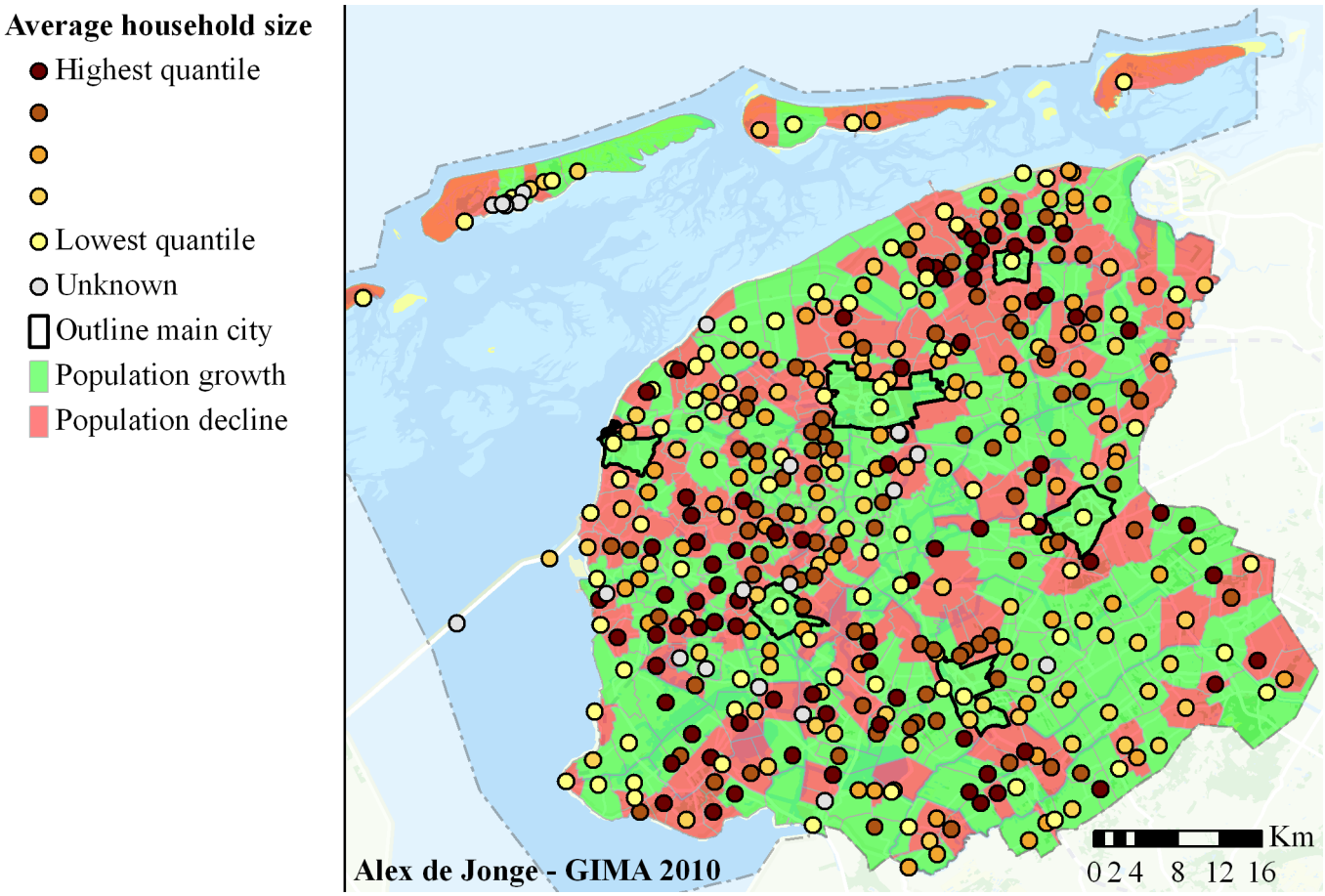
As stated in chapter 3 the average household size is a topic closely linked to the theme of housing and therefore to population development. The vacancy rate of houses asides, the inhabitants, number of houses and average household size per core are interrelated according the following formula:

Number of inhabitants = average household size X number of houses

Of these three factors the number of houses for each core is the most stable factor. Increasing and decreasing the housing stock is slow. The planning and building of new residential homes costs a considerable amount of time and money whilst demolishment of surplus houses is often regarded as important disinvestment. This implies that the change in the number of inhabitants is most directly influenced by a change in average household size.

The current demographic trends in Fryslân show a stable population development, but still a thorough growth in the number of households[18]. This implies a drop in average household size. This will most strongly affect the cores with a high average household size: here a transition form large families into smaller household units will occur most. With the housing market being slow, the newly created households may be forced to leave the core, leading to population decline in the core of origin.

The average household sizes in Fryslân in the year 2001 ranges between 1.85 (Leeuwarden) and 3.80 (Swichum)[19]. The spatial spread of the average household sizes per core is depicted in map 7-3.



Map 7-3: Average household size per core (2001), Source: CBS Statline 2010

A small average household size can be identified in large cities as well as in small villages. The top 25 of smallest average households includes cities like Leeuwarden, Heerenveen, Sneek, Harlingen and Drachten. A large average household size is generally caused by a high number of large families with multiple resident children. Small households are often consisting of young adults or students on one side, or elderly without residing children on the other side. Young adults and students often live in large cities, while elderly people live in the cities as well as on the rural countryside. The rural parts of Fryslân with a relative lack of large families (e.g. the Wadden Islands), have a low average household size.

[18] Province of Fryslân 2010b
[19] Province of Fryslân 2010c

7.2. Hypotheses

Combining the above mentioned three population characteristics with population development leads to the generation of a set of seven research hypotheses.

Based on the fact that population decline in the Netherlands is predominantly occurring in small municipalities without large cities:

PC 1 There is a positive correlation between the number of inhabitants and population development

Based on the age migration schedule (figure 3-4) and underlying explanations combined with the influence of the size of the reproductive age group on natural increase:

PC 2 There is a positive correlation between the relative proportion of the age group 0-14 and population development

PC 3 There is a positive correlation between the relative proportion of the age group 15-24 and population development

PC 4 There is a positive correlation between the relative proportion of the age group 25-44 and population development

PC 5 There is a negative correlation between the relative proportion of the age group 45-64 and population development

PC 6 There is a negative correlation between the relative proportion of the age group 65+ and population development

Because of the anticipated large influence of the average household size on the local housing market:

PC 7 There is a negative correlation between average household size and population development.

7.3. Methodology

To test the research hypotheses for this chapter a specified methodology is needed. This methodology is based on the general methodology described in chapter 5. The used data is briefly introduced in this section, but details can be found in appendix A.

7.3.1. Population size

For the population per core data from the CBS is used, containing the number of inhabitants in the year 2000 for all the 416 Frisian cores[20]. Numbers are absolute and not rounded. The classification for the data is into 5 classes according to the Regional plan of Fryslân as depicted in table 7-1[21].

[20] Province of Fryslân 2010c
[21] Province of Fryslân 2006

7.3.2. Age composition

Age composition data is derived from CBS Statline[22]. The original data offered by CBS Statline is not on the spatial level of the 416 Frisian cores, but it is presented on the scale of the neighbourhood level. Used are the absolute number of inhabitants per neighbourhood in 2001 and the proportional distribution of this population over the five specified age groups in percentages. These proportional age distributions are calculated into age group sizes in absolute numbers per neighbourhood. Individual neighbourhoods are grouped into the structure of 416 Frisian cores, summarizing the absolute figures of each age group. These absolute numbers are converted into proportional percentages per core.

It has to be noted that the proportional group sizes given by the CBS are round of percentages, without decimal precision. This implies a small deviation, propagated in the aggregated age group composition per core. There are 26 cores with no data about age composition; most of them are of a very small size. The 390 cores with a known age composition are divided into five groups with an equal number of cores, by means of a quantile classification. The division into the five quantiles means that class 1 stands for the 78 cores with the lowest percentage of the inhabitations in that age group and class 5 represents the 78 cores with the highest percentage of that age group.

7.3.3. Average household size

The average household size data is generated in a similar fashion as the age composition. Source data from CBS Statline is on neighbourhood level, which is aggregated into average household sizes per core. The 395 cores with a known average household size are divided into 5 quantiles, similar to the quantile classes of the age composition.

7.4. Population characteristics versus population development

The link between population characteristics and population development leads to the outcomes described below.

7.4.1. Population size

For all five of the size classes determined by the province of Fryslân the ratio between growing and declining cores is calculated as well as the mean average population development rate with the associated standard deviation.

Table 7-3: PC 1. Number of inhabitants versus population development

Class	N	Grow	Decl	Ratio	Mean	SD
Class 1: 15000-83704 inhabitants	4	**4**	0	-	0.71	0.16
Class 2: 5000-15000 inhabitants	17	**15**	2	7.50	0.37	0.44
Class 3: 1500-5000 inhabitants	52	**31**	21	1.48	0.18	0.62
Class 4: 500-1500 inhabitants	118	**65**	53	1.23	0.16	0.70
Class 5: 4-500 inhabitants	225	101	**124**	0.81	0.06	2.35
Total	416	**216**	200	1.08	0.12	1.78

[22] CBS Statline 2010

The highest average yearly population growth is occurring in the four largest cities of Fryslân: Leeuwarden, Drachten, Sneek and Heerenveen. Their average growth figure is 0.71 % per year and that is almost double the average provincial growth rate of 0.37 %. Completely in line with the provincial average is the class of cores with a population between 5000 and 15000 inhabitants. The remaining three size classes show below average population growth, but still in the positive range per size class. Only in the class of cores with less then 500 inhabitants more cores are declining than growing. From this classification into five classes a clear correlation between core size and population development can be determined.

It can be stated that the four largest cities, with their high absolute number of inhabitants, are very important factors in the provincial population development. Therefore it is necessary to make a distinction between the average provincial population development of 0.37 % (dominantly influenced by the highly populated main cities) and the average population development per core of 0.12 %, where each residential unit has the same input.

7.4.2. Age composition

The age composition per core is a combination of five age groups, together making up the total population. The assumption is that the proportional size of an age group in 2001 is influencing the population development between 2000 and 2008.

Table 7-4: PC2. Proportion of age group 0-14 versus population development

Class	N	Grow	Decl	Ratio	Mean	SD
Unknown	26	**16**	10	1.60	0.98	2.92
Q1: 7-18.735 %	78	**42**	36	1.17	0.06	1.11
Q2: 18.736-20.151 %	78	**41**	37	1.11	0.05	0.72
Q3: 20.155-22 %	78	**41**	37	1.11	0.13	0.80
Q4: 22-24.381 %	78	39	39	1.00	0.03	0.89
Q5: 24.49-35.644 %	78	37	**41**	0.90	0.07	3.31
Total	416	**216**	200	1.08	0.12	1.78

The most striking observation is that cores with an unknown age group distribution have the highest average population growth. This can be explained by the fact that these often small cores are outliers regarding population development.

Concerning the proportion of the age group of 0-14 no large differences between the classes can be determined. There seems to be no correlation between the proportion of the age group 0-14 in 2001 and population development over the period of 2000-2008. The bulk of this group is expected to continue living with their parents during the research period.

Table 7-5: PC3. Proportion of age group 15-24 versus population development

Class	N	Grow	Decl	Ratio	Mean	SD
Unknown	26	**16**	10	1.60	0.98	2.92
Q1: 1-9.091 %	78	**41**	37	1.11	0.48	3.21
Q2: 9.139-10.891 %	78	**48**	30	1.60	0.25	0.82
Q3: 10.891-11.943 %	78	**44**	34	1.29	0.09	0.81
Q4: 11.962-13.289 %	78	39	39	1.00	-0.04	0.90
Q5: 13.304-22 %	78	28	**50**	0.56	-0.45	1.09
Total	416	**216**	200	1.08	0.12	1.78

The relative size of the age group 15-24 shows more differences. The smaller the proportion of this age group, the higher the average population growth per core. The lowest quantile is with 0.48 percent annual growth well above the provincial average and the average growth figure per core. Population growth numbers decline when the proportion of the age group of 15-25 increases, up to an annual population decline of 0.45 of the highest quantile.

These findings are in contradiction with the theory that cities with a large population of inhabitants in their early twenties usually have a relatively high population growth. This theory implies that these youngsters are students and that the cities are student cities. In Fryslân these are only Leeuwarden and West-Terschelling. Leeuwarden is a student city with three higher education institutions where West-Terschelling is a peculiar exception with a maritime educational institution located in a relative small community. The ratio of student cities against non-student cities is two against 414 in Fryslân, hence explaining the low impact of student cities in the provincial demography.

Also the assumption that all persons in the age group 15-24 are students or young professionals is not true. The range of he age group 15-24 includes many people that were a teenager living with their parents in 2001, but became adult and left the parental home in the years following 2001. So it can be concluded that there is a correlation between the size of the age group 15-24 and population development, but the other way round than initially expected: a relative small size in 2001 leads to the highest average growth.

Table 7-6: PC4. Proportion of age group 25-44 versus population development

Class	N	Grow	Decl	Ratio	Mean	SD
Unknown	26	**16**	10	1.60	0.98	2.92
Q1: 15.842-26.733 %	78	32	**46**	0.70	-0.20	1.42
Q2: 26.765-28.776 %	78	35	**43**	0.81	-0.09	0.90
Q3: 28.779-30.386 %	78	37	**41**	0.90	-0.14	0.67
Q4: 30.414-32.09 %	78	**45**	33	1.36	0.13	0.66
Q5: 32.118-40.594 %	78	**51**	27	1.89	0.63	3.15
Total	416	**216**	200	1.08	0.12	1.78

Regarding the proportional size of the age group 25-44 a somewhat linear correlation can be identified, exemplified best in the highest quantile. A large proportion of the age group 25-44 leads to a higher average yearly population growth. An explanation for this situation is that 25-44 is the age group in their reproductive years, getting children in the years following 2001. This is corresponding with what was expected based on the theory.

Table 7-7: PC5. Proportion age group 45-64 versus population development

Class	N	Grow	Decl	Ratio	Mean	SD
Unknown	26	**16**	10	1.60	0.98	2.92
Q1: 13.861-23.531 %	78	**44**	34	1.29	0.33	3.17
Q2: 23.564-25.056 %	78	**44**	34	1.29	0.14	0.79
Q3: 25.06-27 %	78	**52**	26	2.00	0.18	0.87
Q4: 27-29.613 %	78	36	**42**	0.86	0.00	0.87
Q5: 29.703-57 %	78	24	**54**	0.44	-0.32	1.30
Total	416	**216**	200	1.08	0.12	1.78

The age group 45-64 also depicts differences between the five quantiles. The highest average growth is in the class with the lowest proportion of this age group (0.33 %) and the lowest growth in the class with the largest proportion (-0.32 %). So there is a correlation between the relative size of the age group 45-64 and population growth, albeit not linear. The proposed explanation is that this age group is migrating related to their retirement they want to spend in a different environment.

Table 7-8: PC6. Proportion of age group 65+ versus population development

Class	N	Grow	Decl	Ratio	Mean	SD
Unknown	26	**16**	10	1.60	0.98	2.92
Q1: 0.99-7.805 %	78	33	**45**	0.73	0.00	3.29
Q2: 7.867-10 %	78	**40**	38	1.05	0.07	0.87
Q3: 10-11.824 %	78	39	39	1.00	-0.02	0.90
Q4: 11.881-14.768 %	78	39	39	1.00	0.02	0.86
Q5: 14.782-25.743 %	78	**49**	29	1.69	0.26	0.98
Total	416	**216**	200	1.08	0.12	1.78

A correlation between the relative size of the age group 65+ and population development can not be identified for the four lowest quantiles: all four annual population growth figures show an around stable average. The quantile with the highest proportion of 65+ has with 0.21% an above average annual population growth. This exception is explained by the fact that many elderly people live in large cores with many amenities. That group of cores is showing positive population development figures.

7.4.3. Household size

Table 7-9: PC7. Average household size versus population development

Class	N	Grow	Decl	Ratio	Mean	SD
Unknown	21	**13**	8	1.63	1.12	3.16
Q1: 1.849-2.395 %	79	**49**	30	1.63	0.28	0.92
Q2: 2.4-2.508 %	79	**43**	36	1.19	0.10	0.97
Q3: 2.51-2.66 %	79	**44**	35	1.26	0.18	0.78
Q4: 2.665-2.8 %	79	38	**41**	0.93	-0.02	0.80
Q5: 2.8-3.8 %	79	29	**50**	0.58	-0.19	3.30
Total	416	**216**	200	1.08	0.12	1.78

Similar to the age group composition the highest average population growth can be identified in the cores that have an unknown average household size. Regarding the 395 cores with a known average household size a prudent correlation can be identified: cores with a small average household size show higher average population growth than cores with large households.

This is in line with the expectations regarding the role of average household size regarding demographic transitions and population development. A high average household size most often represents large families. Families that where large in 2001 often face children leaving the parental home in the years after 2001. When they leave the core, population decline occurs.

7.5. Summary

The four largest cities of (Leeuwarden, Heerenveen, Sneek and Drachten) can be regarded as the driving force of population growth in the province of Fryslân. The average annual population growth decreases with each step down in size class and population decline is more common under the smaller cores.

Of the five researched age groups only one has a clear positive influence on population development: the age group of 25-44. This group is responsible for growth through migration, but particularly due to natural increase.

Two age groups have a negative influence on population development: the age groups of 15-24 and 45-64. The latter can be explained by the fact that their children leave home and the migration relate to their retirement. The negative influence of the proportion of the age group 15-24 is in contradiction with theory that suggests that cities with a large community of youngsters are growing. This theory is only applicable on student cities, not on rural villages. Also a large proportion of teenagers in 2001 leads to migration in the following years.

For the age group 0-14 and population development no correlations can be derived. Regarding the age group of 65+ there is only a correlation between the top quantile and population growth. Many elderly people live in relatively large cores with a high level of amenities, which also tends to have above average population growth.

There is a correlation between household size and population development: cores with a low average household size have a higher average annual population development than cores with a higher average household size. This can be explained by the fact that cores with a large average household size have to cope more intensively with the demographical trend towards a smaller average household size.

8. Planning & infrastructure

The second theme of the conceptual model (figure 3-2) is planning and infrastructure. This broad term is used to cover the topics that the (provincial) government has a clear role in. Topics include planning hierarchy, centrality, environmental restrictions, infrastructure and housing.

8.1. Planning & infrastructure in Fryslân

Of the theme of planning and infrastructure four topics are researched: the planning system, centrality in the Frisian and Dutch context, planning restrictions and the infrastructure.

8.1.1. Planning system

The settlement pattern of Fryslân is traditionally much spread (see chapter 2). Not only small villages are spread around the province, the cities as well. This inherited spatial structure is acknowledged and endorsed by the provincial government. The provincial government introduced the planning concepts of spatial planning hierarchy and urban concentration zones in order to allocate, steer and restrict spatial developments[1].

The spatial planning hierarchy consists out of three hierarchical types of settlement cores[2]:

- Main cities
- Regional centres
- Remaining cores

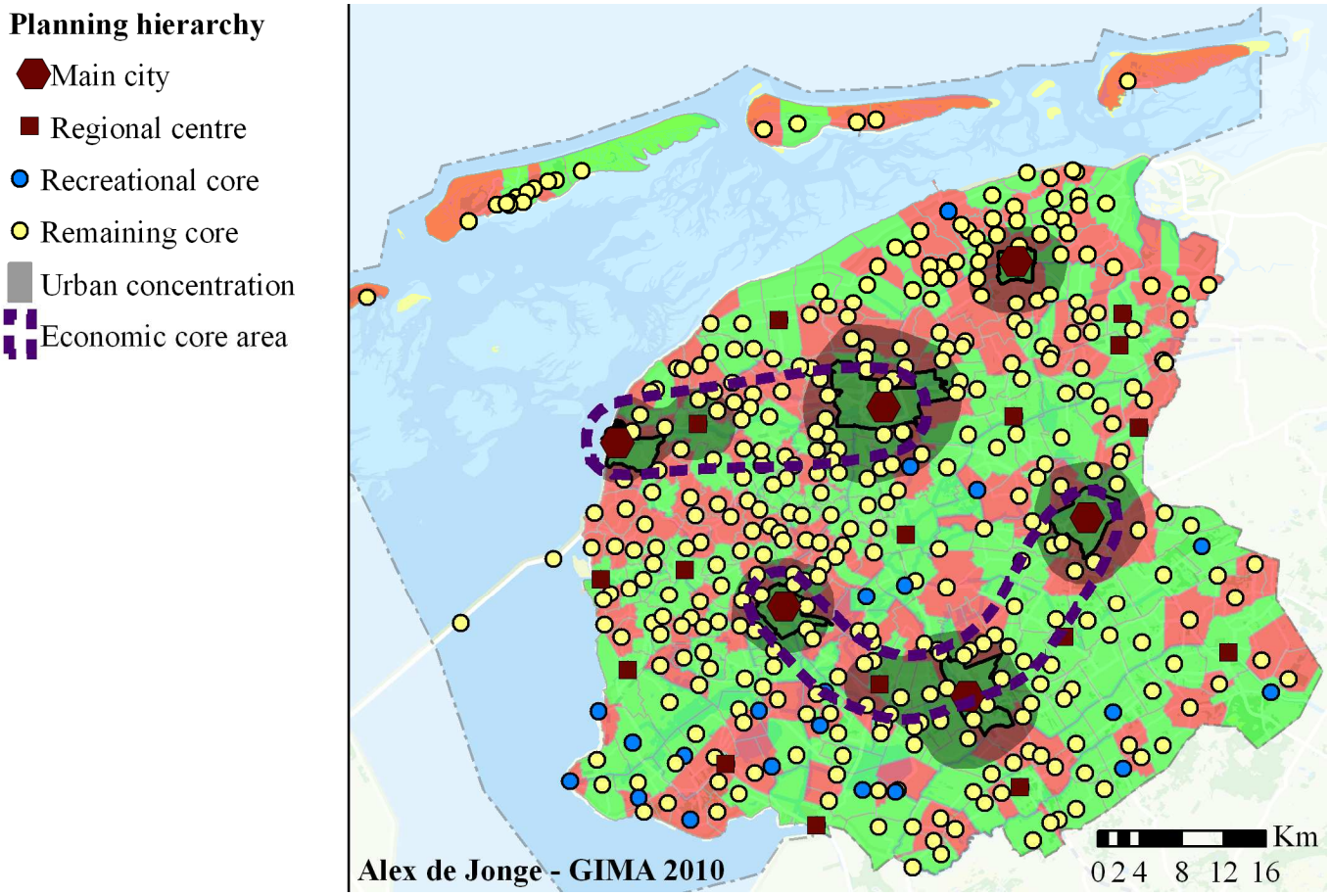
The six main cities of Fryslân are Leeuwarden, Drachten, Heerenveen, Sneek, Harlingen and Dokkum. These cities are regarded to be driving factors in the provincial economy and employment and they have high level amenities. The sixteen regional centres are determined to spread amenities equally over the province. As a result, almost entire Fryslân is within a 10 kilometre range of a regional centre. The third category consists out of the remaining cores. They are not allowed to have large scale housing or business expansions and major amenities are limited. They are foreseen to rely on the urban and regional centres.

The effect of this policy is that cores that are of a high hierarchical class are expected to expand, both economically as well as in population. Small countryside cores on the other hand are limited in their possibilities.

One further pseudo-hierarchical division of the remaining cores category can be made. Based on recreational facilities, the provincial government appointed 21 villages as recreational cores. Together with the main cities and regional centres these recreational cores are allowed to develop large scale and intensive recreational facilities[3].

All types of planning hierarchy as mentioned above are depicted in map 8-1.

[1] Province of Fryslân 2006
[2] Province of Fryslân 2006
[3] Province of Fryslân 2006



Map 8-1: Urban concentration zones and regional centres. Source: Province of Fryslân 2006

Surrounding the six largest cities of Fryslân concentration zones are appointed, as depicted in map8-1. These urban concentration zones are meant to concentrate the allocation of new large scale housing and business areas[4]. This is linked to the concentration versus de-concentration discussion[5]. Urban concentration, or the concept of the compact city, is the norm in Dutch spatial planning. This implies the spatial concentration of population and economical activities. Perceived advantages of spatial concentration can be classified into four fields: geography (e.g. less fragmentation and degradation of open space), economy (e.g. saving on infrastructure), social (e.g. more diversity) and environmental (e.g. less energy consumption)[6].

Next to the urban concentration zones economical core areas are determined in the Frisian Streekplan as well. These are areas following main highways in Fryslân and including main cities[7]. There are two economic core areas: The A-7 zone and Westergo, following the A-31.

In figure 8-1 the annual developments in Dutch population concentration is charted with the use of an “entropy measure”. A negative score means that municipalities with a low population figure grow relatively harder than municipalities of a large size. From figure 8-1 can be derived that de-concentration was growing intensively from the 1950s to a peak in

[4] Fryslân 2006
[5] Louter 2009
[6] Voogd 1999
[7] Province of Fryslan 2006

1973. From the mid 1980s to 2007 a fluctuating trend towards minimal concentration can be identified[8].

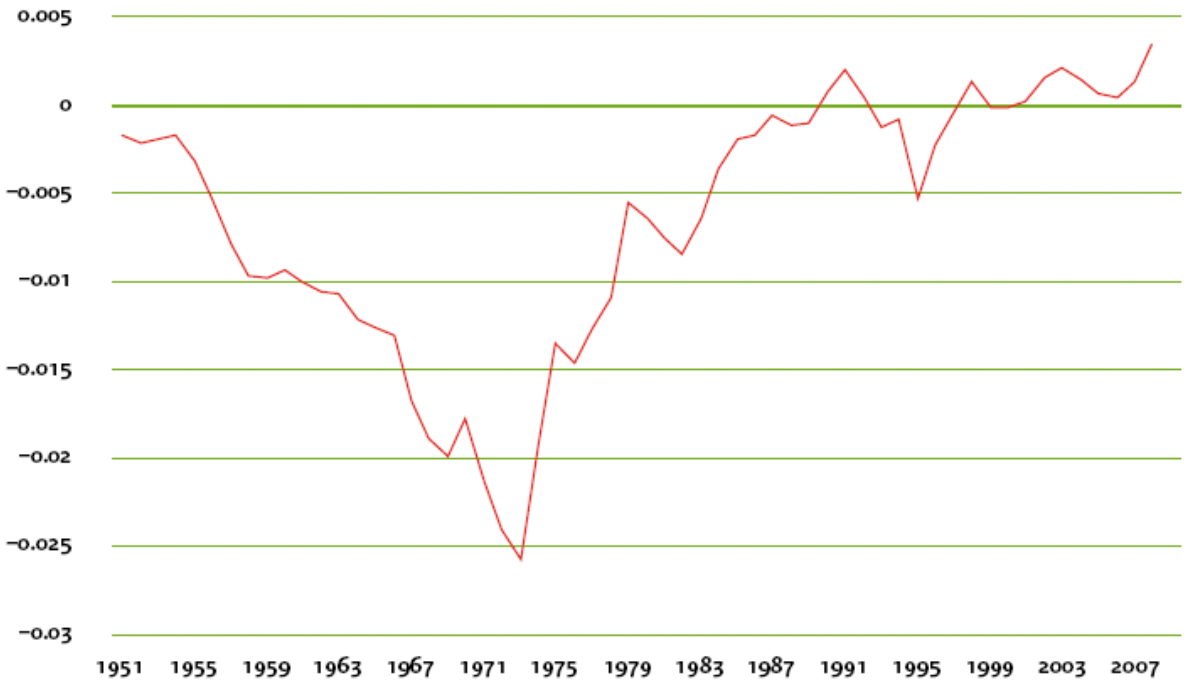


Figure 8-1: Developments in spatial concentration of the Dutch population, 1950-2008. Source: Louter 2009, p32.

Spatial concentration implies cores that are designated as a main city, regional centre or recreational core, or are located in a designated urban concentration area which are foreseen to expand. This in contrast to the remaining cores that have fewer opportunities and more limitations. The relation between spatial concentration and population development is closely linked to the relation between population size and population development, as described in the previous chapter.

8.1.2. Centality

Economic development is never evenly distributed over space. Some areas are more developed than others and unequal relations exist, this is also known as the core-periphery system[9]. This is evident on the scale of the world (developed versus the undeveloped world), the Netherlands (Randstad versus the edge-provinces[10]) or in Fryslân (Leeuwarden versus countryside villages). Key of this system is that there is a centre, where the power is located and a remote, peripheral surrounding that is less developed. So being in the spatial centre is a plus for development possibilities.

This concept is very much related to the hierarchical planning system of the province as shown in map 8-1. In its application the topic of centrality is very straight forward: it is assumed that places located far away from Leeuwarden (determined as the central city of

[8] Louter 2009
[9] Knox & Marston 2004
[10] Louter 2009

Fryslân[11]) or Amersfoort (determined as the central city of Netherlands[12]) have a lower population development.

8.1.3. Environmental planning restrictions

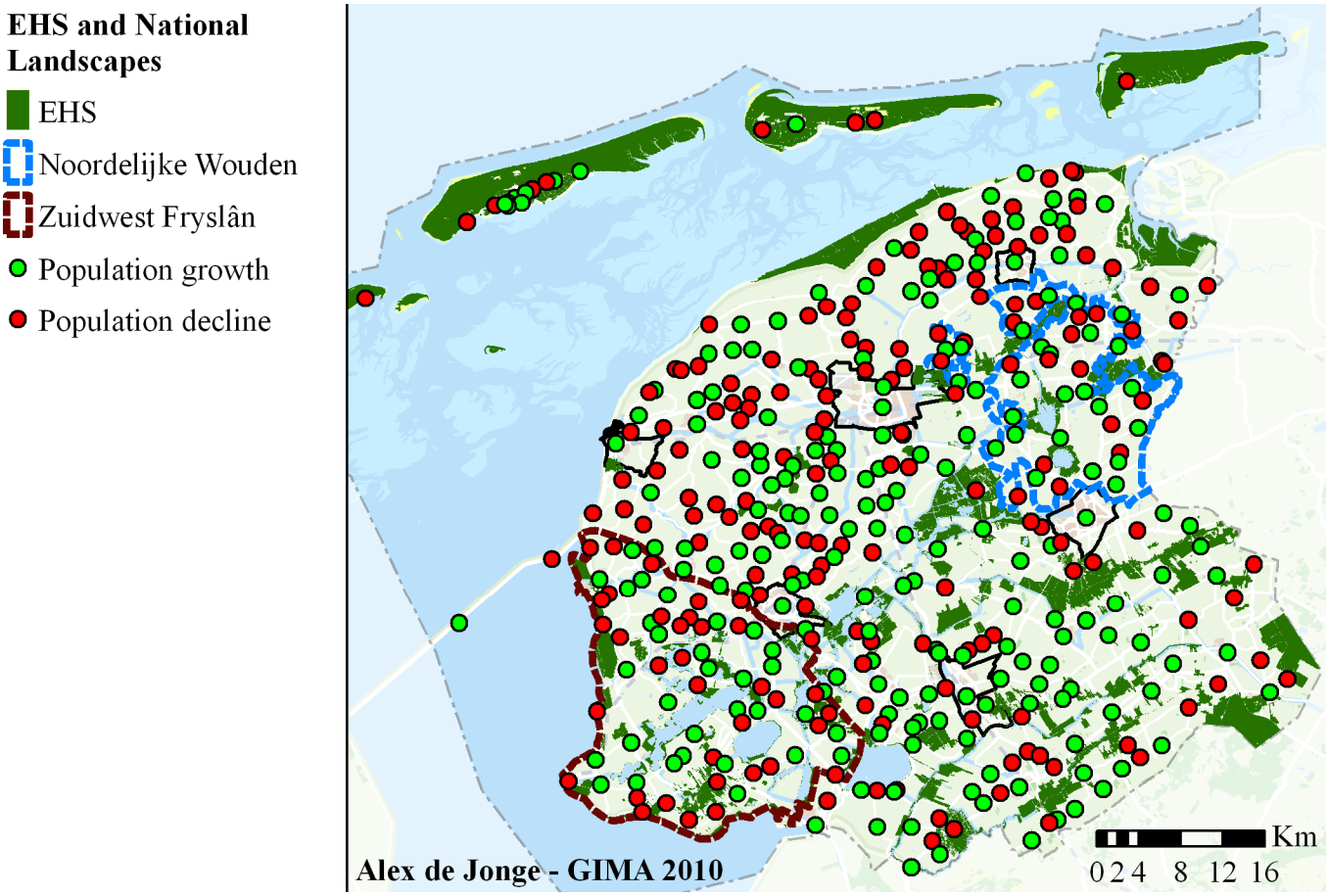
(Spatial) planning is about steering of developments; therefore restrictions are an integral aspect. Some of the most intense spatial restrictions are related to natural and environmental preservation. In the Dutch planning system two concepts regarding this topic are leading: the EHS and the National Landscapes.

The abbreviation EHS stands for “Ecologische Hoofdstrustuur", which means ecological main structure[13]. The EHS is not one single type of nature, but it is an umbrella term for many forms of natural land use that together forms an interrelated network[14]. The provincial administration of Fryslân implements the EHS in the following structure[15]:

- Large existing forest and nature areas, including large bodies of water
- New, enclosing nature areas
- Enclosing demarcated nature control areas
- Realized ecological connection zones, including wet connections

The EHS is intended to strengthen the intrinsic natural qualities and therefore the spatial quality of Fryslân[16]. To ensure these intrinsic natural qualities the EHS areas are limited in land use opportunities. Because of the diversity of the EHS, not all types have the same characteristics and limitations. But in general intensive economic and housing activities are restricted. Therefore EHS is regarded to have a negative impact on population development. The areas that are designated as EHS are depicted in map 8-2.

[11] Province of Fryslân 2006
[12] Wikipedia 2010a
[13] Province of Fryslân 2006
[14] Ministerie van Landbouw, Natuur en Voedselkwaliteit 2010
[15] Province of Fryslân 2006
[16] Province of Fryslân 2006



Map 8-2: EHS and National Landscapes in Fryslân. Source: Province of Fryslân 2006.

National landscapes are areas with national or international rare or unique features of the landscape qualities[17]. The spatial qualities of these areas are both natural as well as cultural-historical. According to the national spatial planning act, the Nota Ruimte, the values of the National Landscapes need to be protected by limiting population growth[18]. In Fryslân this limitation is less strict, there is space to cope with the local housing needs, but in migration has to be limited[19]. Of the twenty Dutch National Landscapes two are located in Fryslân: Zuidwest-Fryslân and Noordelijke Wouden, both depicted in map 8-2.

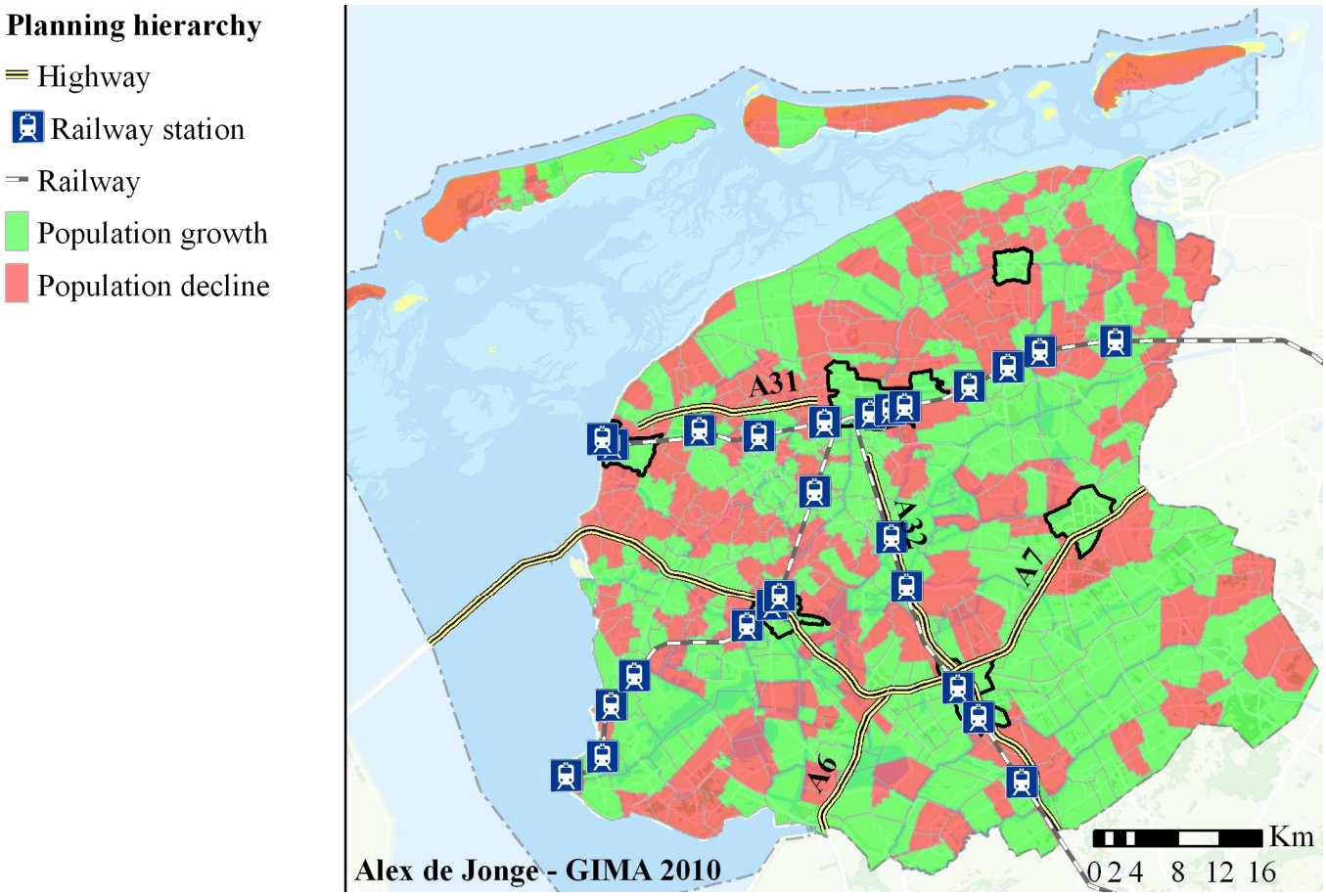
From map 8-2 it can be derived that the EHS and the National Landscapes do not strongly coincide: they are both very different entities. The EHS is more spatially scattered and aimed at ecological preservation and the National Landscapes are more focussed on integral cohesion of nature, culture and history.

The perceived influence of these environmental planning restrictions on the development is negative. All the attached limitations reduce options for the expansion of housing and thereby population development.

[17] Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer 2004
[18] Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer 2004
[19] Province of Fryslan 2006

8.1.4. Infrastructure

A good transportation network is highly important for the mobility of the inhabitants of Fryslân and therefore the social-economical development of the province. Well accessible locations develop more spatial dynamic[20]. Spatial dynamic can be regarded as intensive interactions with social, cultural and economical aspects. Therefore spatial dynamic is an important aspect to attract employment, amenities and population, it is a genuine pull-factor.



Map 8-3: Main infrastructure of Fryslân. Source: Province of Fryslân 2006

Regarding the day-to-day accessibility of the Frisian population two transportation modalities are of importance and depicted in map 3: roads and railways[21], both depicted in map 8-3. Main roads in Fryslân are the A7: North-Holland – Bolsward – Sneek – Joure – Heerenveen – Drachten - Groningen, A32: Leeuwarden – Heerenveen – Wolvega – Overijssel, A6: Joure – Lemmer - Flevoland and the A31: Harlingen – Franeker – Leeuwarden. These roads are major factors in reducing travel time, so increasing accessibility.

The province of Fryslân has two railway linkages to the rest of the Netherlands. The main connection is from Leeuwarden via Heerenveen to Zwolle and the Randstad. The second connection is the line Leeuwarden – Buitenpost – Groningen. Next to these two external connections there are two railway routes within the provincial boundaries: Leeuwarden – Franeker – Harlingen and Leeuwarden – Sneek – Stavoren. A clear hub in the Frisian railway network is the city of Leeuwarden, all four lines connect here.

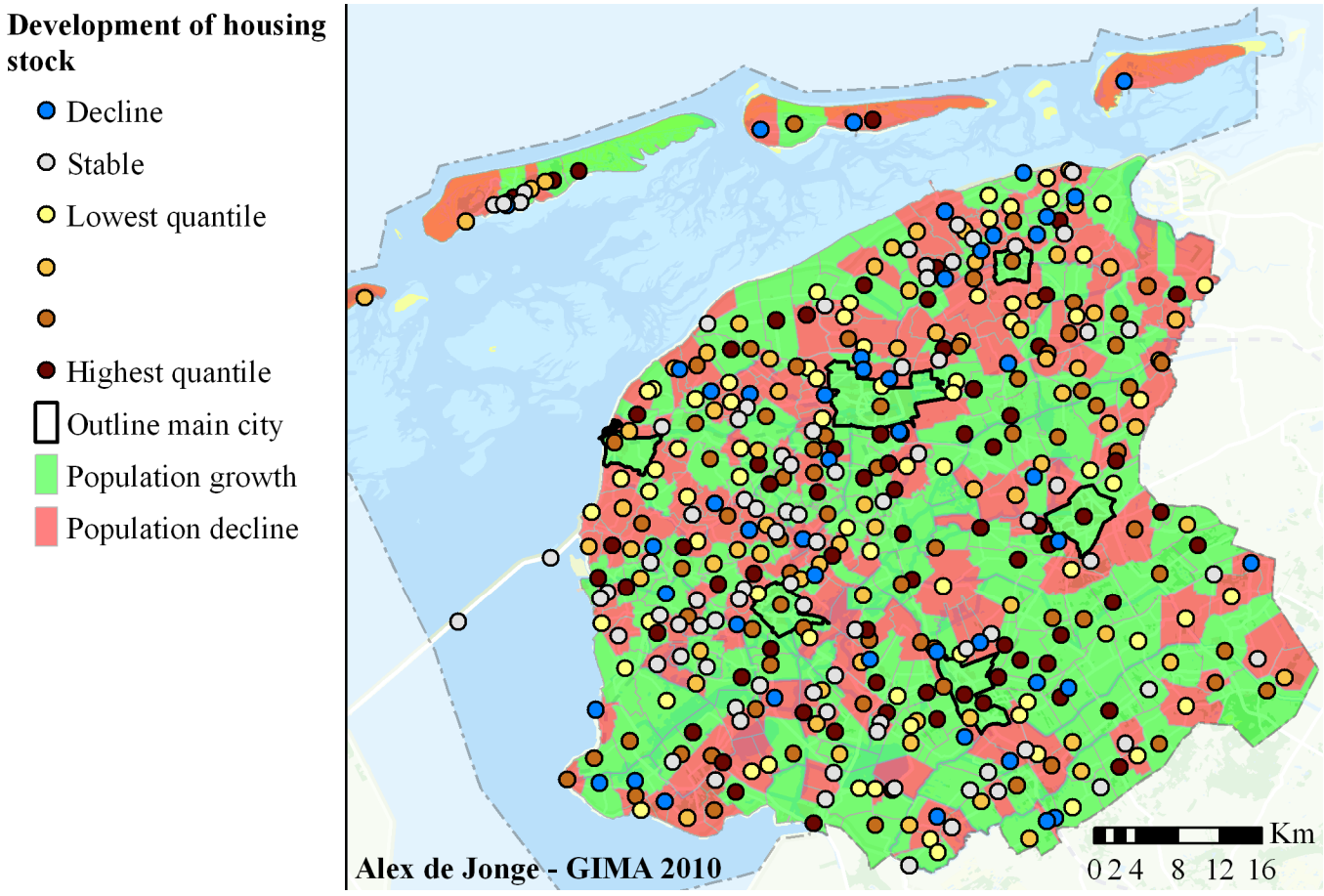
[20] Province of Fryslân 2006
[21] Province of Fryslân 2006

The influence of accessibility can be seen similar to the push- and pull factor analogy. A good accessibility by car and train is assumed to have a positive and a bad accessibility a negative influence on population development.

8.1.5. Housing

As stated in chapter 3 housing has a large influence on migration[22]. The topic of housing has two components: quality and quantity. Quality is basically a subjective term and therefore harder to measure than quantity. But the term quality can also be captured in numbers and figures. Factors related to the quality of a house are for example construction year, floor space, building materials and energy efficiency. Because of this complex combination of factors it is hard to apply and therefore omitted from this research.

The relationship between the quantity of houses and population development can be researched with more reliability. For each Frisian core the growth in housing stock between 2000 and 2008 is known and depicted in map 8-4. The relationship between housing and population development is already described in the previous chapter on population characteristics: the number of inhabitants is a function of the average household size and the number of houses in a core.



Map 8-4: Development of housing stock between 2000 and 2007. Source: Province of Fryslân 2010c

[22] Boyle, Halfacree & Robinson 1998

Map 8-4 on the spatial distribution of housing stock development gives a mixed image. All over the province cores with a growing housing stock and cores with a declining housing stock can be identified. Even on the Wadden Islands some villages have a growth in the housing stock. Schiermonnikoog is the only island and municipality with a decline in housing stock.

8.2. Hypotheses

This chapter consists out of four topics, each with their own set of research hypotheses. These research hypotheses are described below.

Based on the trend of concentration of population, amenities and employment:

PI 1 There is a positive correlation between the rank in the planning hierarchy and population development.

PI 2 There is a positive correlation between being part of an urban concentration area and population development.

PI 3 There is a positive correlation between being part of an economic core area and population development.

Considering centrality an important aspect in the population development of Fryslân:

PI 4 There is a negative correlation between the straight line distance to Leeuwarden and population development

PI 5 There is a negative correlation between the travel time by car to Leeuwarden and population development

PI 6 There is a negative correlation between the straight line distance to Amersfoort and population development

Based on the limiting effects of planning restrictions regarding environmental quality:

PI 7 There is a negative correlation between the areal of a core that is determined as EHS and population development

PI 8 There is a negative correlation between being part of a National Landscape and population development

Considering the importance of adequate infrastructure on population development:

PI 9 There is a negative correlation between the travel time by car to a railway station and population development

PI 10 There is a negative correlation between the travel time by car to a main city and population development

PI 11 There is a negative correlation between the travel time by car to a main city or regional centre and population development

PI 12 There is a positive correlation between being within a 5 kilometre radius of a highway and population development

Based on the relations between housing, average household size and population development:

PI 14 There is a positive correlation between the growth of the housing stock and population development.

8.3. Methodology

To test the hypotheses stated above, for each topic an additional methodology is described. The correlation between the explanatory factors and population development is examined in the same manner as before: each factor is classified in a number of discrete classes that are

compared on average annual population growth and the ratio between growing and declining cores within the class. A detailed description about the used data and classification can be found in appendix A.

8.3.1. Planning hierarchy

Information about the planning hierarchy types of the cores is obtained from the regional plan of the province[23]. This is obtained on the level of 416 cores. To determine which cores are within an urban concentration area or an economic core area a spatial query is used in the form of select by location.

8.3.2. Centrality

The straight distance between Leeuwarden and the remaining 415 cores is calculated using the dataset of the 416 Frisian cores[24]. For the calculation of the straight line distance between the 416 cores and the centre of the Netherlands the coordinates of Amersfoort are added. In the RD coordinate system the coordinates are X: 155000 an Y: 463000[25]. The travel time by car to Leeuwarden is calculated by using a road network dataset of OpenStreetMap[26]. How this is calculated is described in Appendix B.

8.3.3. Environmental planning restrictions

The calculation of the EHS ratio consists out of two elements: the total area of a core and the area of a core that is designated as EHS. Because relevant spatial activities like housing, amenities and businesses are usually land based both area figures are adjusted for open water and wet EHS.

The determination of the cores that are located inside a Nation Landscape is executed with the use of a spatial query.

8.3.4. Infrastructure

The topic of infrastructure consists out of three elements: railway stations, proximity of highways and travel time by car to main cities and regional cores. The latter is done with the same method as the travel time to Leeuwarden, see appendix B.

Regarding the railways stations, they can also be derived from the Streekplan Fryslân[27]. Of the 25 Frisian stations two are not in a fully regular service: Leeuwarden Achter de Hoven and Heerenveen IJsstadion, therefore they are omitted from the analysis. The remaining 23 stations are spread over 20 cores: the cities of Leeuwarden, Sneek and Harlingen have two railway stations. Travel time from cores without a station towards a station is calculated with the use of the generated OpenStreetMap network dataset, like described above.

The determination of the cores that are within a five kilometre range of a highway is executed with the help of a neighbourhood function within a GIS. A buffer of five kilometre is generated surrounding the highways in the NWB road dataset, the cores inside that buffer are selected with a select by location function.[28]

[23] .Province of Fryslân 2006
[24] ESRI 2010a
[25] Alberda & Ebbinge 2006, p.22
[26] OpenStreetMap 2010
[27] Province of Fryslân 2006
[28] SWOV 2010

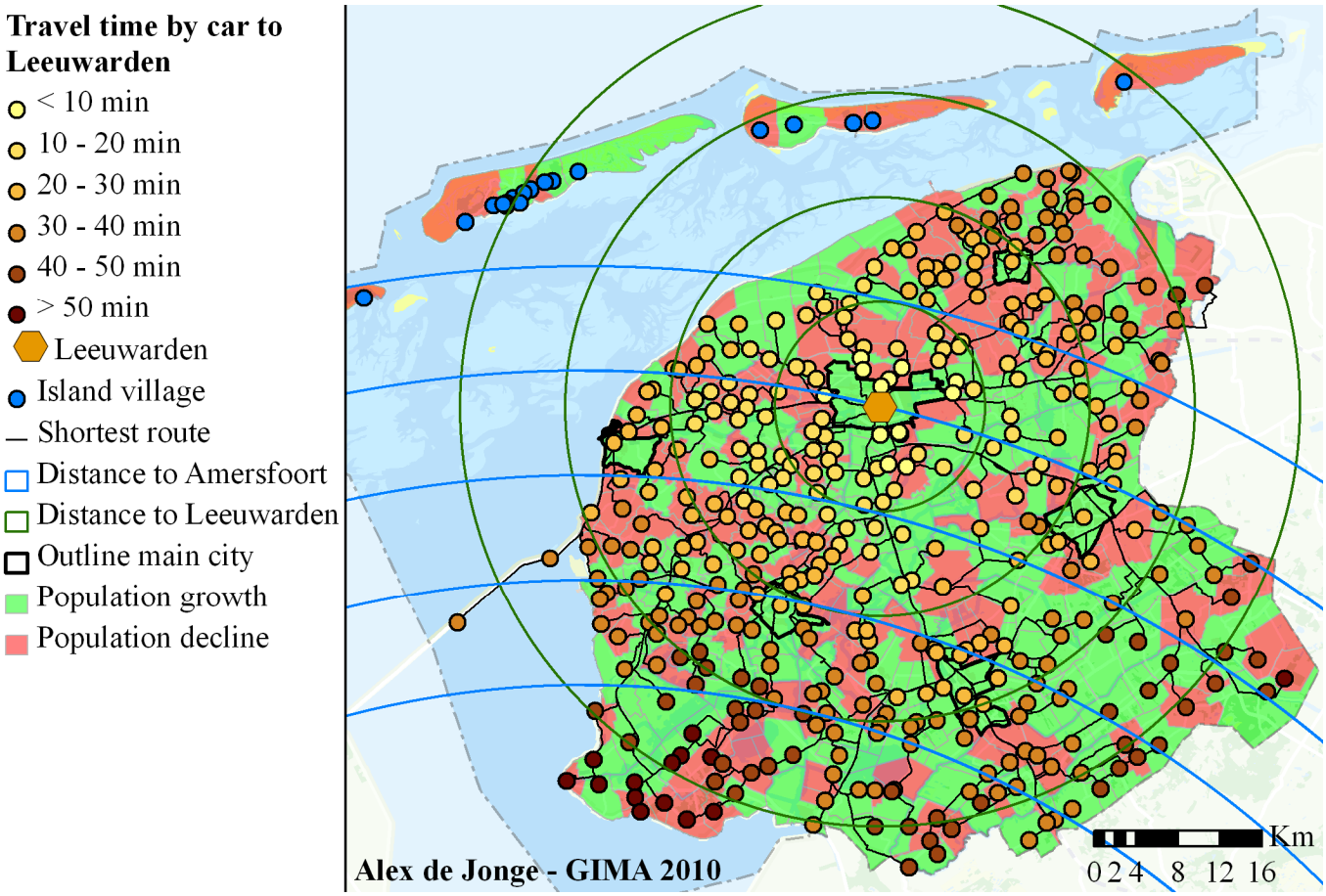
8.3.5. Housing

Data about the development in the housing stock of the 416 Frisian cores is derived from the CBS[29]. The average annual growth rate between the years 2000 and 2007 is calculated and will be used as explanatory factor.

8.4. GIS results

The first topic of this chapter, planning hierarchy, has no specific outcomes out of GIS processing. The spatial layout of the planning hierarchy and urban concentration zones is already depicted in map 8-1. The GIS results for the remaining three topics are described below.

8.4.1. Centrality



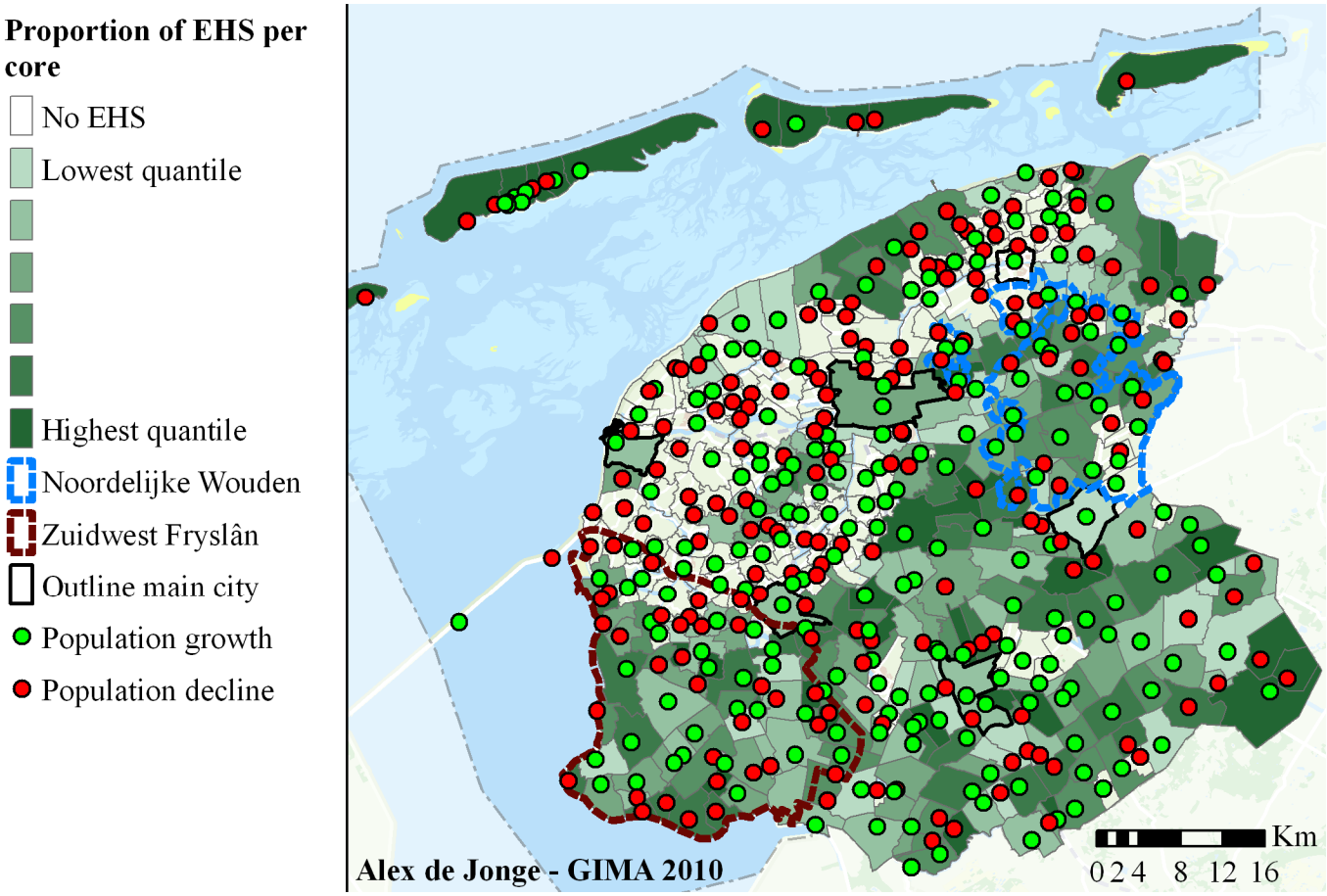
Map 8-5: Travel time to Leeuwarden and distances to Leeuwarden and Amersfoort

Map 8-5 depicts the straight line distance from each core to the cities of Leeuwarden and Amersfoort, as well as the travel time by car to Leeuwarden. First thing that can be noticed is that Leeuwarden is not the spatial centre of Fryslân. The provincial capital is located approximately 13 kilometres north of the exact spatial centre of mainland Fryslân. Regarding the straight line distance to Amersfoort it can be noticed that the north-eastern part of the province is located relatively far away from Amersfoort and the Randstad.

[29] Kerncijfers Fryslan

The travel times by car to Leeuwarden conforms mostly to the straight line distance. But main roads like the A31, A32, N31 and N355 are interfering: cores closely located to these roads show better accessibility than other cores with the same straight line distance.

8.4.2. Environmental planning restrictions

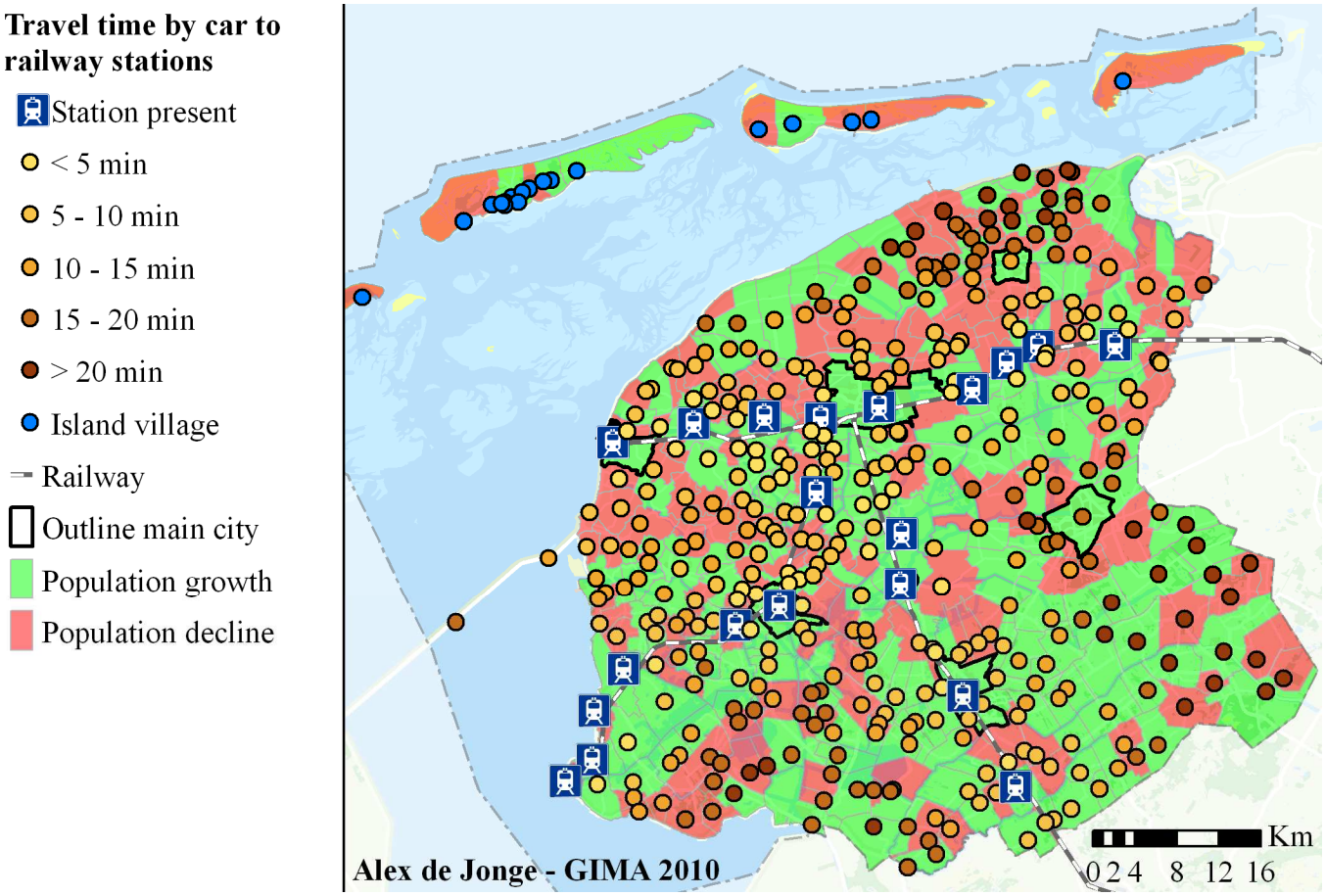


Map 8-6 Proportion of EHS per core

The ratio of the area of each core that is determined as EHS is depicted per core in map 8-6. The highest ratios are found on the Wadden Islands. The core with the highest EHS ratio of mainland Fryslân is Nijetrijne (0.78). Main concentrations of cores with high EHS ratios are the nature rich borders regions of Fryslân (Lauwersmeergebied, Drents-Friese Wold) and the south-western lakes. Once again, the National Landscapes score mediocre on the element of EHS.

8.4.3. Infrastructure

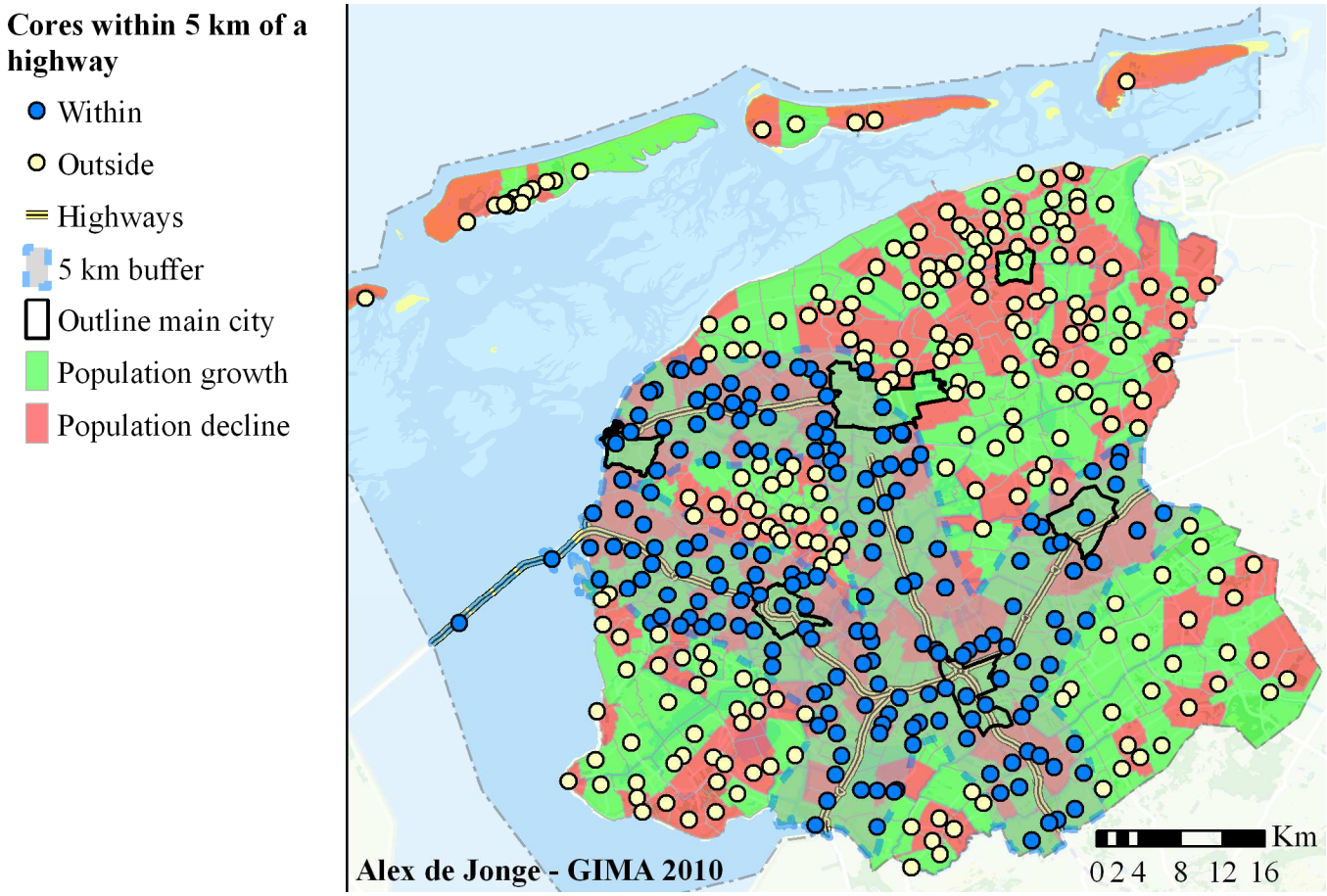
The four Frisian Wadden Islands and their cores have an exceptional position in relation to infrastructure. Being disconnected from the mainland implies that the islands don't have railways and have an exceptional high and irregular travel time to mainland cores.



Map 8-7: Travel time by car to railway stations

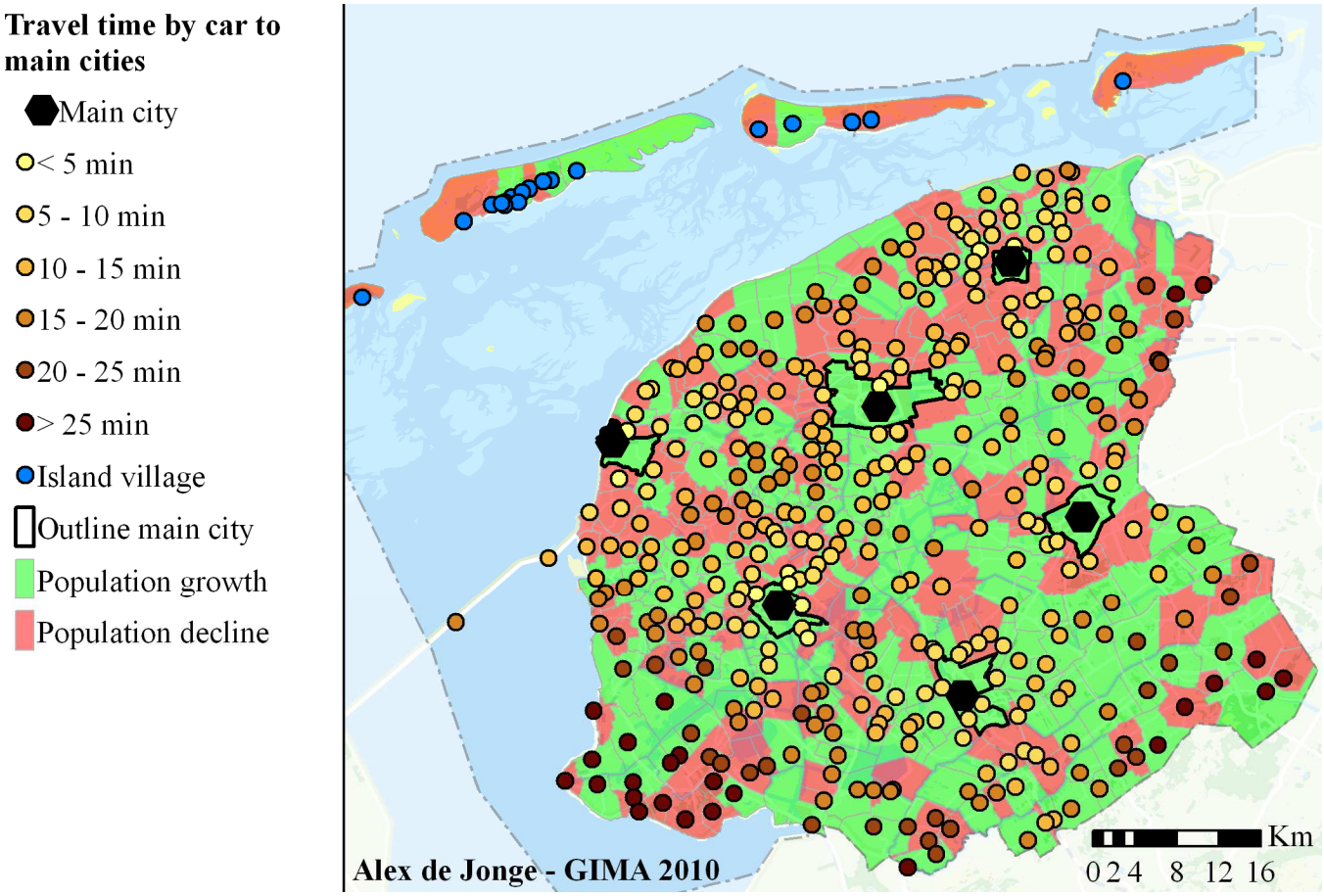
From map 8-7 three areas can be derived that have a relative poor access to railway stations: the northern coastal zone, Lemmer and surroundings and the south east corner of the province. The first two areas are relatively sparsely populated. The lack of a railway connection in the south eastern corner is more eminent. Drachten, being the second largest city of Fryslân, is the largest Dutch city without any form of railway transportation[30]. This is regarded as undesirable and a problem. Therefore the railway connection Heerenveen-Drachten-Groningen is currently being planned[31]. The extreme tip of the south-eastern corner of the province is served by the railway station of Assen, which is less than ten kilometres from the provincial border.

[30] Wikipedia 2010b
[31] Nederlands Dagblad 2008



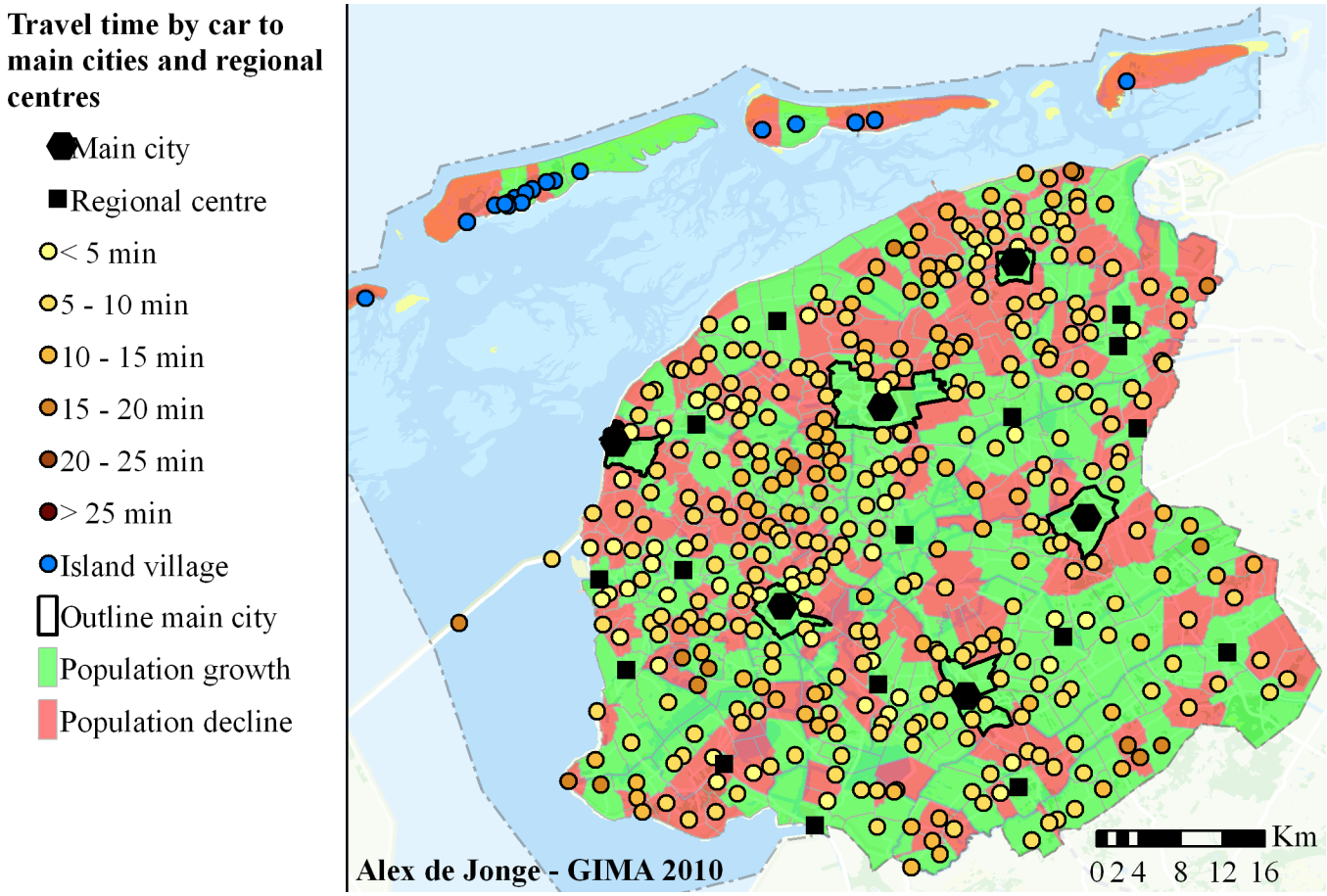
Map 8-8: Cores within a 5 kilometre radius of a highway

Map 8-8 depicts the highways with their corresponding five kilometre corridor. Out of the 416 cores, 187 cores are inside and 229 cores are outside the buffer zone. A large part of the province has excellent access to highways; the area with the most significant lack of highways is the north-eastern part of the province.



Map 8-9: Travel time by car to main cities

From map 8-9 four areas can be derived with poor accessibility to the six major cities of Fryslân: this is expressed in a travel time by car of more than 20 minutes. These areas are south-west Fryslân, Buitenpost and surroundings, Lemmer and surroundings and De Stellingwerven. The latter two areas have high travel times to the main cities of Fryslân, but cities in other provinces are relatively close. These are respectively Steenwijk (Overijssel) and Assen (Drenthe). Across the border from Buitenpost lays the rural countryside of the province of Groningen, South-West Fryslân is bordered by the water of the IJsselmeer.



Map 8-10: Travel time by car to main cities or regional centres.

Focusing on the travel times from the cores towards the major cities or regional centres another pattern emerges (map 8-10). Zero cores have a travel time of more than 20 minutes. Additionally, only a small number of cores have a travel time between 15 and 20 minutes.

8.5. Planning and infrastructure related to population development

Connecting the planning and infrastructural topics with population development leads to the following results. For some explanatory factors the Wadden Islands depict some deviating outcomes. The explanation for this situation is given in box 8-1.

Box 8-1: Population development on the four Frisian Wadden Islands

Out of the 18 cores on the islands of Vlieland, Terschelling, Ameland and Schiermonnikoog ten cores are declining and 8 cores are growing. The unweighted average annual population development is with 0.41 % above average, so that seems contradictory. Regarding the absolute numbers the total population of the Frisian Wadden Islands was 10,407 in 2000 and reduced to 10,219 in 2008. This makes a weighted average population decline of 0.23 %. This deviation between two calculation methods might imply a high impact of some (small) cores with high average annual population development on the unweighted figure. Because of this complex situation and the extraordinary position of the Wadden Islands, they are considered as deviant to mainland Fryslan.

8.5.1. Planning hierarchy

The planning hierarchy of Fryslân consists out of two genuine high hierarchy planning classes (main cities and regional cores), a pseudo planning hierarchy class (recreational core) and the group of remaining cores without a specified planning hierarchy. This is introduced in section 1.1.

Table 8-1: PI 1. Planning hierarchy class versus population development

Class	N	Grow	Decl	Ratio	Mean	SD
Main city	6	**6**	0	-	0.59	0.26
Regional centre	16	**16**	0	-	0.62	0.47
Recreational core	21	**12**	9	1.33	0.33	0.72
Remaining cores	373	182	**191**	0.95	0.08	1.87
Total	416	**216**	200	1.08	0.12	1.78

There is a clear correlation between the planning hierarchy of a core and population development. The main cities and regional centres show very high population growth figures. All 22 cores are growing in population and the average population growth rate is around 0.6 % per year. Recreational cores perform above average and the remaining cores slightly below average. It can be concluded that there is a clear correlation between the rank in the Frisian planning hierarchy and population development.

Table 8-2: PI2. Urban concentration areas versus population development

Class	N	Grow	Decl	Ratio	Mean	SD
Inside urban concentration area	99	47	**52**	0.90	-0.02	1.18
Outside urban concentration area	317	**169**	148	1.14	0.17	1.93
Total	416	**169**	148	1.14	0.12	1.78
Difference					-0.18	

The hypothesis is that cores within an urban concentration area show higher population development figures than cores outside this area, because of the planning system that is aimed at concentration. The result of the analysis is the exact opposite of this hypothesis. Cores inside a concentration area have a slightly below zero population development. The balance

between growing and declining cores inside an urban concentration area gently tilts towards decline. Cores outside an urban concentration area have a slightly above average annual population growth.

This negative unweighted average annual population development figures do not mean that the whole urban concentration zone is facing population decline. In total the six concentration zones grew with 10,496 inhabitants in the period 2000-2008, making an average annual population growth of 0.42 %. The six main cities alone are responsible for an eight year growth of 10,483 inhabitants, almost all of the growth of the urban concentration areas. So these negative figures are caused by population decline in the smaller cores. Splitting the broad category of urban concentration areas into the six urban concentration areas surrounding a specific main city leads to the following results.

Table 8-3: PI 2. Six individual urban concentration areas versus population development

Class	N	Grow	Decl	Ratio	Mean	SD
Dokkum	12	4	**8**	0.50	-0.24	0.80
Drachten	10	4	**6**	0.67	-0.23	1.01
Harlingen	9	4	**5**	0.80	-0.11	0.43
Heerenveen	24	**16**	8	2.00	0.14	1.24
Leeuwarden	29	12	**17**	0.71	-0.10	0.96
Sneek	15	7	**8**	0.88	0.28	1.97
Outside urban concentration areas	317	**169**	148	1.14	0.17	1.93
Total	99	47	**52**	0.90	0.12	1.78

It can be concluded that only two urban concentration areas deviate from the negative trend. The urban concentration area of Heerenveen/Joure has an around average population growth but a strongly positive growth/decline ratio and the urban concentration area of Sneek has a strongly above average annual population growth. An explanation for this overall negative relation between urban concentration areas and population development might be the heavy competition between large cities and the small surrounding villages. The main cities are expanding at the expense of these smaller surrounding cores.

Table 8-4: PI 3. Economic core area versus population development

Class	N	Gro	Dec	Ratio	Mean	SD
A7	35	**21**	14	1.5	0.17	1.006
Westergo	37	16	**21**	0.762	-0.02	0.890
Outside an economic core area	344	**179**	165	1.085	0.14	1.914
Total	416	**216**	200	1.08	0.12	1.784

Just like the previous hypothesis it is expected that cores within a core economic area have an above average population development. The two individual economic core areas differ strongly in between. The A7 zone (Sneek, Heerenveen, Drachten) has an above average population growth, whilst the Westergo zone has a minimal population development. The ratio between growing and declining cores supports this outcome. The remaining cores that are not located inside an economic core area have around average scores. There is a positive relation between being in the A7 zone and population development and a negative correlation between the Westergo zone and population development.

8.5.2. Centrality

The topic of centrality consists out of the absolute and relative distance to Leeuwarden and the absolute distance to Amersfoort.

Table 8-5: PI 4. Straight line distance to Leeuwarden versus population development

Class	N	Grow	Decl	Ratio	Mean	SD
< 10 km	44	21	**23**	0.91	0.00	0.91
10 – 20 km	115	**58**	57	1.02	0.33	2.67
20 – 30 km	132	**67**	65	1.03	-0.01	1.46
30 – 40km	87	**50**	37	1.35	0.06	1.12
> 40 km	38	**20**	18	1.11	0.27	1.47
Total	416	**216**	200	1.08	0.12	1.78

There does not seem to be a clear correlation between the population growth per core and the straight line distance to Leeuwarden. Three classes depict an almost stable average annual population development and two an above average annual population development. The distribution of these groups is unclear.

Table 8-6: PI 5. Travel time by car to Leeuwarden versus population development

Class	N	Grow	Decl	Ratio	Mean	SD
< 10 min	14	5	**9**	0.56	-0.38	1.07
10 - 20 min	76	**42**	34	1.24	0.52	3.17
20 – 30 min	119	**62**	57	1.09	0.09	0.99
30 – 40 min	127	**65**	62	1.05	-0.14	1.31
40 – 50 min	48	**28**	20	1.40	0.35	1.57
> 50 min	14	6	**8**	0.75	0.00	0.72
Island village	18	8	**10**	0.80	0.41	2.04
Total	416	216	200	1.08	0.12	1.78

Focusing on travel time by car to Leeuwarden instead of straight line distance shows an even more unclear pattern. Therefore no correlation between the travel time to Leeuwarden and population development can be determined. Both hypotheses about the central role of Leeuwarden in relation to population development need to be rejected. Leeuwarden cannot be regarded as the one primate city of the province. Because both the absolute and the relative distance to Leeuwarden do not show clear outcomes, it can not be determined which measure is more applicable.

Table 8-7: PI 6. Straight line distance to Amersfoort versus population development

Class	N	Grow	Decl	Ratio	Mean	SD
< 90 km	51	**29**	22	1.32	0.29	0.84
90 – 100 km	79	**43**	36	1.19	-0.15	1.77
100 – 110 km	74	**43**	31	1.39	0.56	3.29
110 – 120 km	79	**41**	38	1.08	0.11	0.95
120 – 130 km	55	27	**28**	0.96	0.00	0.65
> 130 km	78	33	**45**	0.73	-0.02	1.31
Total	416	216	200	1.08	0.12	1.78

Regarding the balance between growing and declining cores over the six classes there seems to be a correlation between the straight line distance to Amersfoort and population development. Looking at the average annual population development a linear correlation can not be identified. Only for the two most outer shells, the area of Northern Fryslân, a clear negative correlation is identified. Overall, the correlation between the straight line distance to Amersfoort and population development can not be fully adopted, but there are leads to assume there is a relation between distance to the Randstad and population development.

8.5.3. Planning restrictions

The influence of planning restrictions on population development is exemplified in the percentage of the areal of each core that is designated as EHS. 158 cores are completely outside the EHS zoning, the remaining 258 cores are divided into six quantiles based on EHS areal.

Table 8-8: PI 7. Percentage of EHS areal versus population development

Class	N	Grow	Decl	Ratio	Mean	SD
No EHS	158	75	**83**	0.90	0.04	1.17
Q1: 0-1.427 %	43	**22**	21	1.05	-0.01	0.98
Q2: 1.484-5.951 %	43	**24**	19	1.26	0.64	4.19
Q3: 6.126-13.208 %	43	**23**	20	1.15	0.03	1.09
Q4: 13.261-21.332 %	43	**28**	15	1.87	0.16	1.10
Q5: 21.447-34.622 %	43	**24**	19	1.26	-0.05	0.87
Q6: 35.402-96.316 %	43	20	**23**	0.87	0.30	2.06
Total	416	216	200	1.08	0.12	1.78

The relation between the EHS areal quantile and population development seems very fluctuating. The quantile with the highest average annual population development has a very high standard deviation: which implies that it is strongly influenced by population growth extremes. Overall, no clear correlation between the percentage of EHS and population development can be identified.

Table 8-9: PI 8. National Landscapes versus population development

Class	N	Grow	Decl	Ratio	Mean	SD
Inside a National Landscape	106	53	53	1.00	-0.04	1.43
Outside a National Landscape	310	**163**	147	1.11	0.18	1.89
Total	416	**216**	200	1.08	0.12	1.78
Difference					-0.22	

It can be derived that the 53 cores that are located inside a National Landscape have a considerable lower average annual population development than the other cores. The main explanation for this situation is the fact that the two national landscapes are located in rural and peripheral parts of the province. The borders are drawn to exclude main cites and regional centres like Bolsward, Sneek, Lemmer, Drachten, Burgum, Buitenpost and Kollum. Those cities are growing cores of Fryslân. The hypothesis that there is a negative correlation between national landscape and population development can be accepted.

Comparing the limiting force of environmental restrictions on population development the National landscapes have a more clear correlation than the EHS.

8.5.4. Infrastructure

The research on infrastructure consists out of three elements: railway stations, travel time by car to main cities and travel time by car to main cities or regional cores. Because of the exceptional position of the Wadden Island in relation to infrastructure as well as population development they treated special (see box 8-1).

Table 8-10: PI 9. Travel time to railway stations versus population development

Class	N	Grow	Decl	Ratio	Mean	SD
Core with station	20	**15**	5	3.00	0.39	0.77
< 5 min	49	**26**	23	1.13	0.61	4.05
5 – 10 min	128	63	**65**	0.97	0.00	1.04
10 – 15 min	93	**51**	42	1.21	0.06	1.21
15 – 20 min	71	34	**37**	0.92	0.00	1.43
> 20 min	37	**19**	18	1.06	0.04	0.70
Island village	18	8	**10**	0.80	0.41	2.04
Total	416	216	200	1.08	0.12	1.78

Out of the analysis results a clear division in average annual population development rates can de derived. Cores that either have their own railway station or are within a five minute car travel time of a station clearly have a higher population growth than cores located further away from railway stations. So a correlation between railway accessibility and population development can be identified.

Table 8-11: PI 10. Travel time by car to main cities versus population development

Class	N	Grow	Decl	Ratio	Mean	SD
Main city	6	**6**	0	-	0.59	0.26
< 5 min	10	2	**8**	0.25	-0.31	1.08
5 – 10 min	97	42	**55**	0.76	-0.15	1.23
10 – 15 min	138	**77**	61	1.26	0.25	2.49
15 – 20 min	92	**55**	37	1.49	0.19	1.13
20 – 25 min	30	14	**16**	0.88	0.15	1.88
> 25 min	25	12	**13**	0.92	0.07	0.66
Island village	18	8	**10**	0.80	0.41	2.04
Total	416	216	200	1.08	0.12	1.78

As concluded from the analysis on planning hierarchy the main cities show an above average population growth. Focusing on the remaining mainland cores a particular curve can be identified in the relation between travel time to main cities and population development. Villages very close to a main city show population decline, whilst core with 10-15 minutes of travel time from main cities show the highest average annual population growth. The population decline figures of the villages closest to the main cities are related to the population decline of cores inside the urban concentration zones. Regarding the research hypothesis a slightly more complex correlation can be identified.

Table 8-12: PI 11. Travel time by car to main cities or regional centres versus population development

Class	N	Grow	Decl	Ratio	Mean	SD
Main city or regional center	22	**22**	0	-	0.61	0.42
< 5 min	45	17	**28**	0.61	-0.22	1.18
5 – 10 min	228	112	**116**	0.97	0.12	2.06
10 – 15 min	89	**50**	39	1.28	0.06	1.21
> 15 min	14	7	7	1.00	0.59	2.39
Island village	18	8	**10**	0.80	0.41	2.04
Total	416	216	200	1.08	0.12	1.78

Again main cities and regional centres top the list of average annual population growth per core. Also the villages nearby these main cities and regional centres again show population decline. This might be related to the population development in the urban concentration zones. Curiously, the 14 cores located the furthest away from the high hierarchical cores show a high average annual population development, but more cores are declining than growing. The correlation between travel time to main cities and regional centres and population development is less clear compared to the correlation between travel time to main cities only and population development.

Table 8-13: PI 12. 5 kilometre zone from highway versus population development

Class	N	Grow	Decl	Ratio	Mean	SD
Within 5 km of a highway	187	**102**	85	1.20	0.21	2.27
Not within 5 km of a highway	229	114	**115**	0.99	0.06	1.25
Total	416	114	**115**	0.99	0.12	1.78
Difference					0.15	

Cores that are within a five kilometre radius of a highway have an average annual population development of 0.21 %. This is 0.15 % higher than cores outside that zone. Concerning the growth/decline ratio the differences are more modest. But overall, it can be concluded that there is a correlation between being within five kilometres of a highway and population development.

8.5.5. Housing

Table 8-14: PI 13. Development of housing stock versus population development

Class	N	Grow	Decl	Ratio	Mean	SD
Decrease	48	17	**31**	0.55	-0.35	1.01
Stable	84	29	**55**	0.53	-0.25	1.98
Q1: 0.044-0.0275	71	25	**46**	0.54	-0.23	0.62
Q2: 0.275-0.53	71	33	**38**	0.87	0.02	0.89
Q3: 0.531-0.85	71	**48**	23	2.09	0.24	0.66
Q4: 0.851-27.262	71	**64**	7	**9.14**	1.23	3.19
Total	416	**216**	200	1.08	0.12	1.78

It can be concluded that there is a very strong correlation between the growth in housing stock in the period 2000-2007 and population development. Both in average annual population development as well as in the ratio between growing and declining cores. The average annual population development of the 71 cores with the highest growth in housing stock is very extreme with 1.23 %, albeit with a high standard deviation too. It has to be noted that this strong correlation has to be interpreted in both directions. An increase in the number of houses is leads to a positive population development and a positive population development leads to a growth in the housing stock.

8.6. Summary

Related to the subject of planning and infrastructure a selection of GIS techniques is used. A spatial query is used to determine the cores inside an urban concentration area. An area measurement function is used to calculate the proportion of the areal of each core that is designated as EHS and distance measurement functions are used to calculate the straight line distance from the cores to Leeuwarden and Amersfoort. Next to the absolute distance the relative distance can also be computed by means of a connectivity function: the travel time by car between the cores and respectively the nearest railway station, main city, regional core and Leeuwarden is calculated.

The highest average annual population growth can be identified at the 22 cores of the main cities and regional centres. They show a population growth figure of almost twice the average annual population growth of the recreational cores. The remaining cores still show an average annual population growth figure, but more of these cores are declining than growing. The

relationship between urban concentration areas and population development is different than expected. It appears that the main cities are growing at the expense of small villages surrounding those main cities.

The factor of centrality related to Leeuwarden and Amersfoort does not correlate with population development. Also a relation between the ratio of EHS in each core and population development can not be identified. Both topics of centrality and planning restrictions can not be determined as influential on population development.

Considering the topic of infrastructure railway stations have a correlation with population development. It can be identified that cores that either have an own railway station, or are within 5 minute travel time from one have a strikingly higher average annual population growth. Travel time by car to main cities and/or regional centres show a little more diffuse correlation with population development. The first shell around the cores with a high planning hierarchy show an annual population decline, similar to the urban concentration areas outcome. For the travel time to the main cities only, a negative linear correlation with population development can be identified. For travel time to main cities or regional centres this correlation is less present.

9. Amenities & economy

The third theme in the conceptual model (figure 3-2) is the combined theme of amenities and economy, both regarded as push – and pull factors. The topic of economy in this research is exemplified by the topic of employment.

9.1. Amenities & economy in Fryslân

As introduced in chapter 3 a link between a decline in amenities and population decline is often assumed in a general context. It is connected by the interlinking topics of liveability and social cohesion[1]. A high level of amenities in an area can be regarded as a pull factor while a relatively low level of amenities can be determined as a push factor.

The term amenities is closely linked with the term services, although a distinction needs to be made. An amenity can be defined as "a useful or desirable feature of a place"[2] and a service as "a system supplying a public need such as transport, or utilities such as water"[3]. The practical distinction is that amenities have a fixed physical location and services are footloose and often brought to the beneficiary. This research puts focus on the influence of the fixed spatial layout of amenities on population development.

Focussing on the situation of the province of Fryslân the broad term amenities can be defined in more detail. The provincial administration determines seven basic types of amenities that are of importance[4]. These seven amenities are listed below with between the parentheses the most explicit examples:

- Education (primary school)
- Health care (general practitioner)
- Social-cultural (community building)
- Retail (supermarket or village shop)
- Business services (bank or postal agency)
- Welfare (nursing home)
- Public transportation (train station or bus stop)

The importance of the locations of these spatially anchored amenities is not the same for each subgroup of the population. For persons that are healthy, mobile and prosperous it is no problem to travel towards amenities. But people that are young, old, less vital or less wealthy travelling is not so self-evident and they are more dependent on locally based amenities[5]. A perceived result of this is the out migration of these population groups, declining the base for the amenities even more. This can be regarded as a vicious circle that is hard to break[6].

[1] Province of Fryslân 2006
[2] AskOxford 2010a
[3] AskOxford 2010b
[4] Province of Fryslân 2010e
[5] Province of Fryslân 2010a
[6] Province of Fryslân 2010a

The relationship between amenities and population development is two-way. Amenities influence population development and population development leads to changes in the structure of amenities. A close relationship between demographics and amenities is not totally uncontested. Van Dam et al sketch a situation of supply and demand, where the changing behaviours of providers and customers are more important for the support of amenities than developments of the population or the households[7]. This is most clearly manifested in the open market of the retail sector, but it also applies for other amenities. Spatial concentration and increase of scale are mainly caused by changing consumer behaviour (a mix of increased mobility, changing lifestyles and changing preferences) and business factors (operation costs, scale advantages). Demographic changes are perceived to only have a stimulating or muting effect on these autonomous developments and vice versa[8].

9.1.1. Education

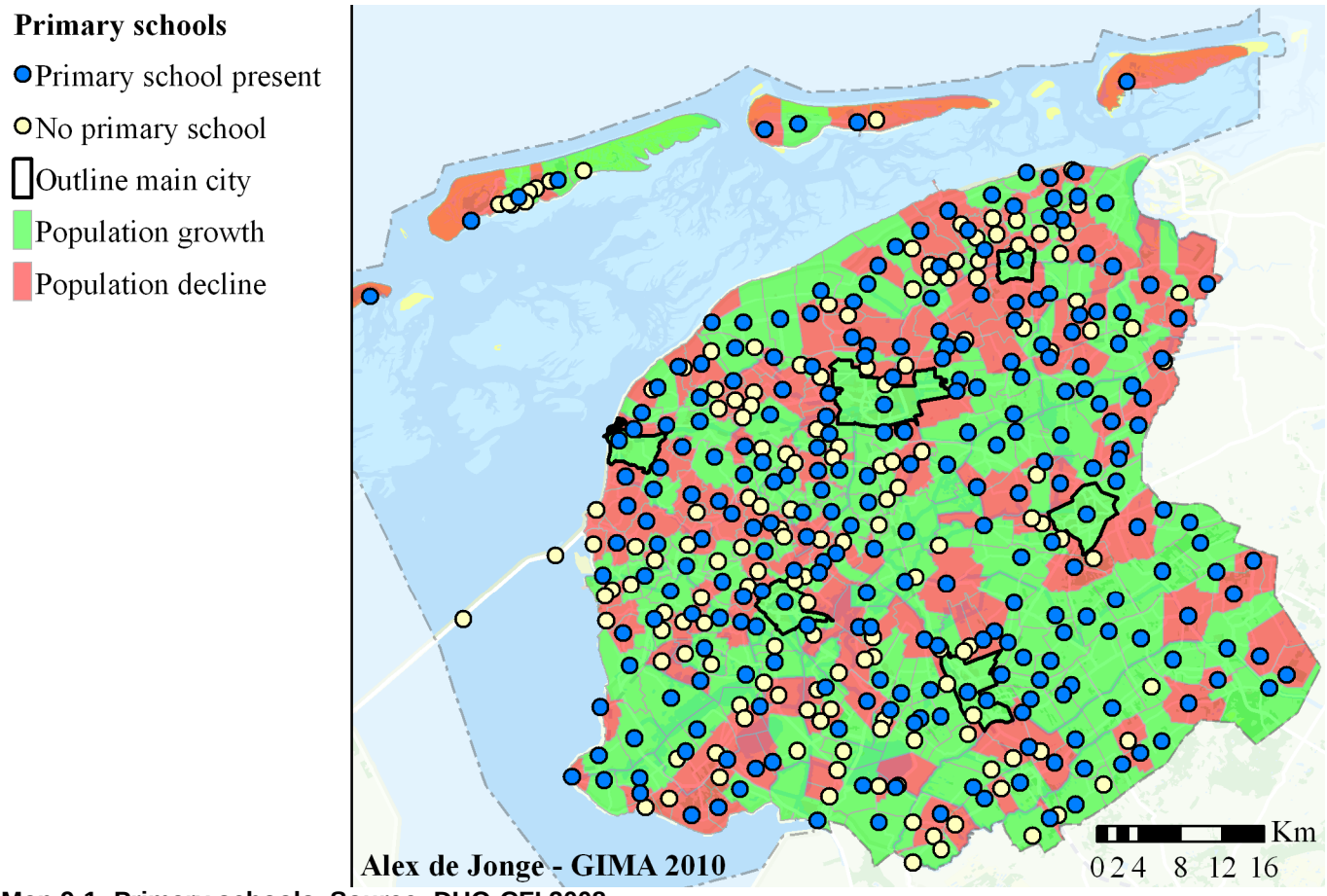
The first amenity that is a subject of research is education. Omitting schools for special education, the Dutch school system can be classed into five types of education[9]: For each type a typical service area size can be determined. The service area size is basically reversed proportional with the number of available facilities. Many of the individual schools are collaborating in or are merged into one large school board. Regarding the secondary schools and vocational education it is often the case that there is one main location and multiple annexes in smaller villages.

Table 9-1: Types of education

Type	Service area	Number in the Netherlands (2008)[10]	Number in Fryslân[11]	Number of cores in Fryslân
Primary school	Neighbourhood or (multiple) villages	6898	505	260
Secondary school	Municipality	647	29	28
Vocational education	Region	60	3	8
Higher education	Province	36	4	2
University	Part of the country	12	0	0

The Dutch school planning system does not know the concept of school districts. Therefore there are no limited service areas for schools. Combined with the various types of denominations, this leads to the situation that schools have overlapping and fuzzy service areas. The most widely spread type of education are the primary schools. Also primary schools are often named as an important factor regarding population development[12].

[7] Van Dam et al 2008
[8] Van Dam et al 2008
[9] Sectorbestuur Onderwijsarbeidsmarkt (SBO) 2010
[10] Sectorbestuur Onderwijsarbeidsmarkt (SBO) 2010
[11] Primary school: DUO-CFI 2008; Secondary school: Province of Fryslân 2010d;Vocational education: Fryslân 2010d; higher education: Opleiding.net 2010; Maritiem Instituut Willem Barentsz Terschelling 2010
[12] Province of Fryslân 2010a



Map 9-1: Primary schools. Source: DUO-CFI 2008.

In the whole of Fryslân there are 505 primary school locations which are distributed over 260 villages, which makes that 62.7 % of the Frisian cores have a primary school[13]. The spread of villages is depicted in map 9-1, from what can be noted that the villages in the south-east of Fryslân very often have a primary school. This can be related to the fact that these villages generally have a relativily large population (see map 7-1). Additionally it can be derived from comparing both maps that the larger cores generally have more primary schools.

The average school size in Fryslân is 134 pupils, compared to the national average of 225[14]. Many small schools are under threat of closure because of their small size. The legally imposed minimum school size differs per municipality, but closure forms a threat for many schools[15].

Another related aspect about primary schools is the fact that they differ a lot. The basic form of primary schools is the public school; independent of religious believe, life stance or educational vision. Primary schools differ from the public schools on one or more of these grounds. Common religious denominations are for example Catholic, Christian Reformed, Jewish and Islamic. Also primary schools can differ on their educational philosophy, like Dalton, Montessori and Jenaplan educational methods[16]. Having choices in school options can be regarded as a pull factor for migrating young parents.

[13] Partoer 2008
[14] Province of Fryslân 2010a
[15] Province of Fryslân 2010a
[16] Sectorbestuur Onderwijsarbeidsmarkt (SBO) 2010

9.1.2. Health care

The Netherlands National Institute for Public Health and the Environment (Rijksinstituut voor Volksgezondheid en Milieu/RIVM) defines seven basic types of health care, divided into first line and second line care. First line health care is open and directly accessible for everyone, whilst second line health care is more specialized and needs referral from a first line health care entity.[17]

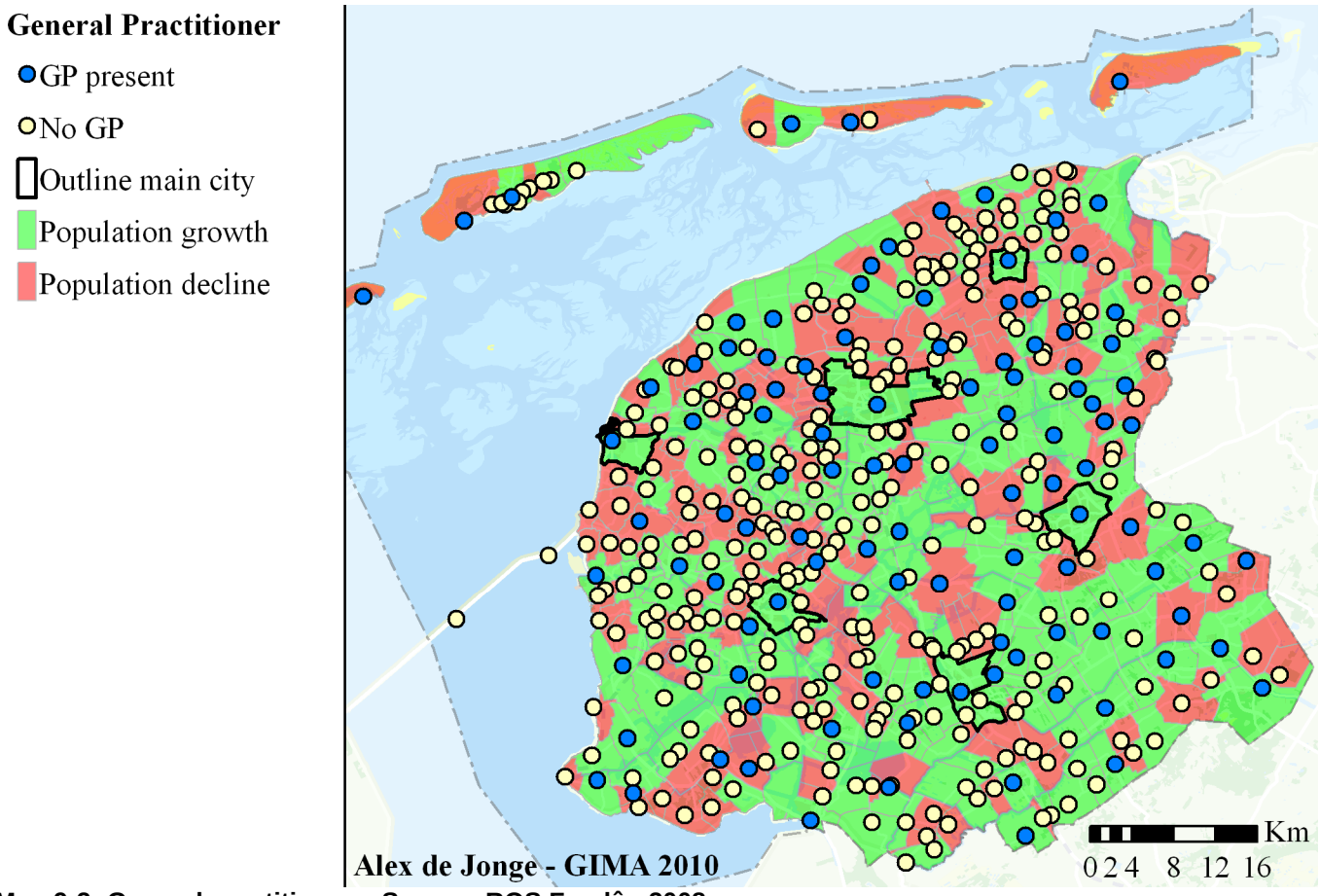
For the whole of the Netherlands two distance measurements are known related to each type of health care: the average distance and the 80 % threshold distance[18]. The latter indicates the distance where 80 % of the Dutch population lives within. Both distance measurements state the distance between the resident's home and the stated facility.

Table 9-2: The Dutch health care system and average- and threshold distances

Type	Average distance (in km)[19]	80% threshold distance (in km)[20]
First-line:		
General practitioners	1,1	1,6
Physiotherapists	2,2	3,1
Pharmacies	1,3	1,7
Obstetrician	3,6	5,5
Children's health care	1,7	2,5
Second-line:		
Hospitals	7	11,7
Nursing homes	3,7	5,2

Of this list general practitioners (GP's) can be determined as the most widely spread type of health care. The general practitioner is often the first contact when facing medical complaints and thereby frequently visited. Overall, a general practitioner is the type of health care most related to liveability and therefore population development.

[17] Ministerie van Volksgezondheid, Welzijn en Sport 2010
[18] RIVM Zorgbalans 2008
[19] RIVM Zorgbalans 2008
[20] RIVM Zorgbalans 2008



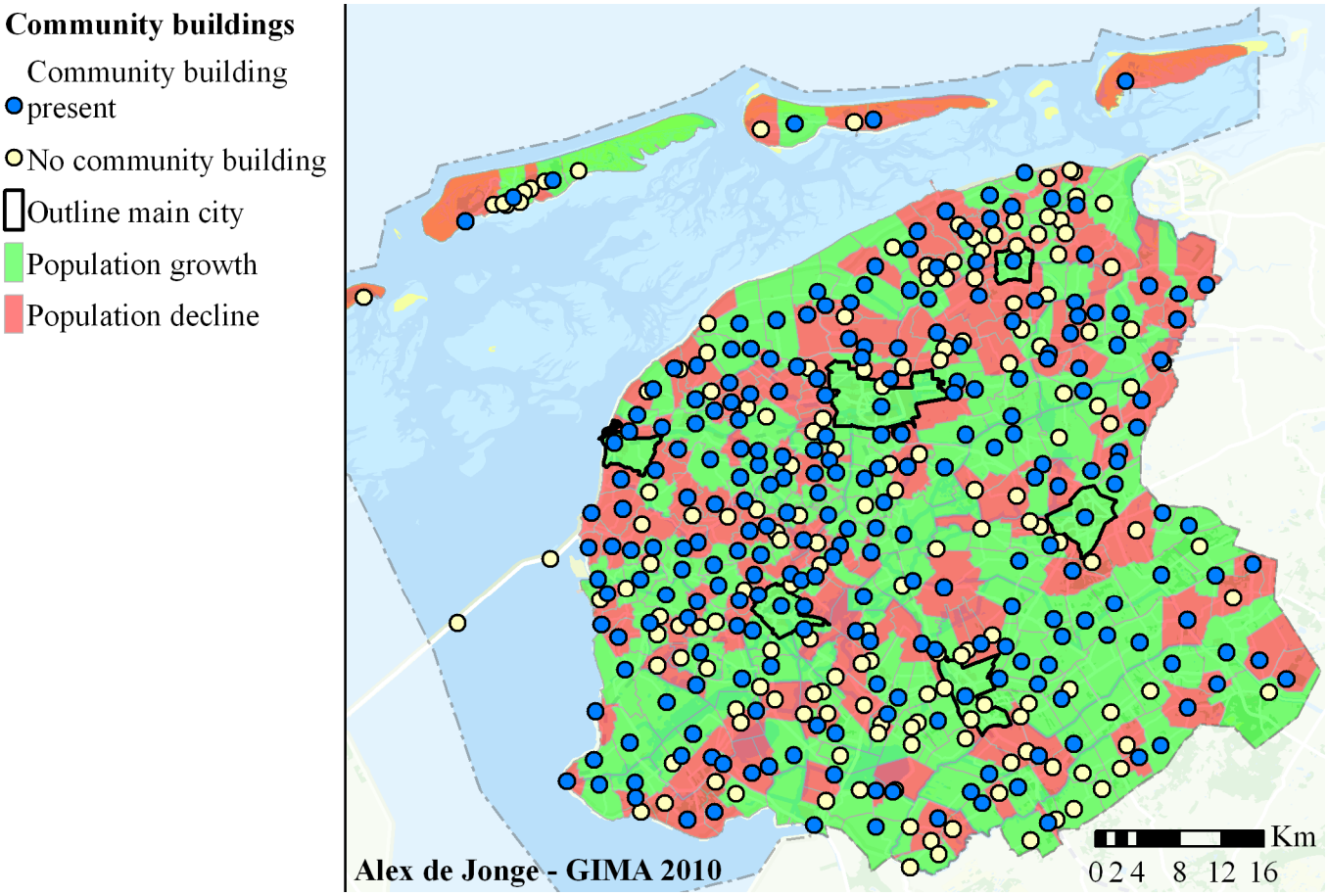
Map 9-2: General practitioners. Source: ROS Fryslân 2008

In the province of Fryslân there are 228 practices spread over 110 cores in 2009[21], as depicted in map 9-2. Again the cores with a high population have more general practitioners. In the south-western half of the province relatively many cores can be detected without a general practitioner. This coincides with the fact that these are often small villages.

[21] Regionale Ondersteunings Structuur (ROS) Friesland 2008

9.1.3. Social-cultural

An important aspect of the liveability in a village is the social-cultural community life[22]. This community life can only flourish when there is a public space to congregate in the village. A community building is therefore regarded as a prerequisite for a successful community life.



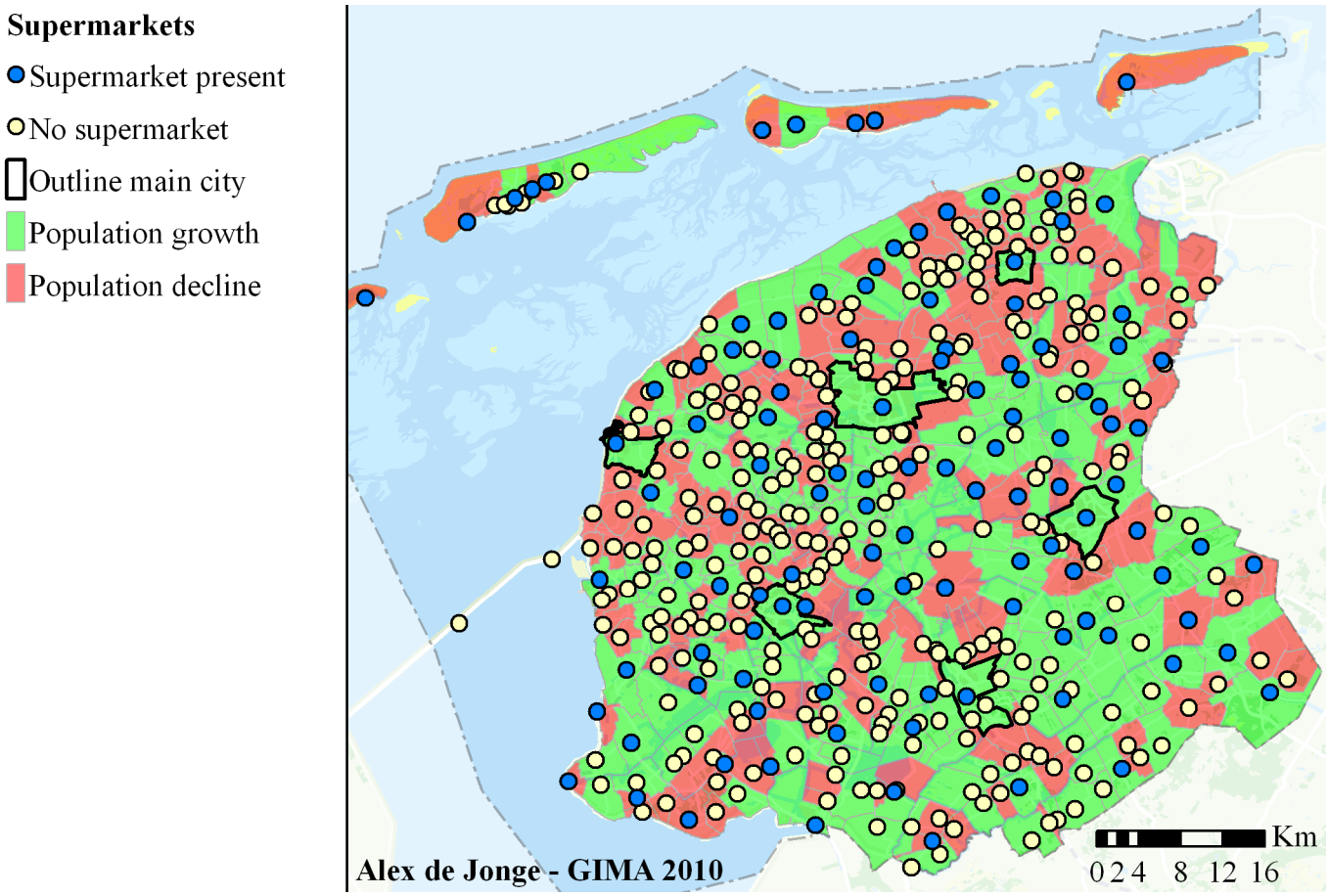
Map 9-3: Community buildings. Source: Doarpswurk 2008

230 out of the 416 cores in Fryslân have a community building, see map 9-3[23]. It has to be noted that many large towns and cities do not have a designated community building. But those cities are foreseen to have sufficient facilities to accommodate social activities. Regarding the designated community buildings the spatial distribution is quite even.

[22] Province of Fryslân 2010a
[23] Doarpswurk 2008

9.1.4. Retail

Changes in the retail business can be linked to many causes. Support for retail amenities is only partially dependent on the total number of inhabitants of an area. More important are changes in shopping behaviour of consumers and location decisions by retailers[24]. The most common and daily type of shopping is shopping for groceries. This includes shops as bakeries, greengrocers and butcheries, but the most predominant form of grocery shopping is the supermarket.



Map 9-4: Supermarkets. Source: Province of Fryslân 2010d

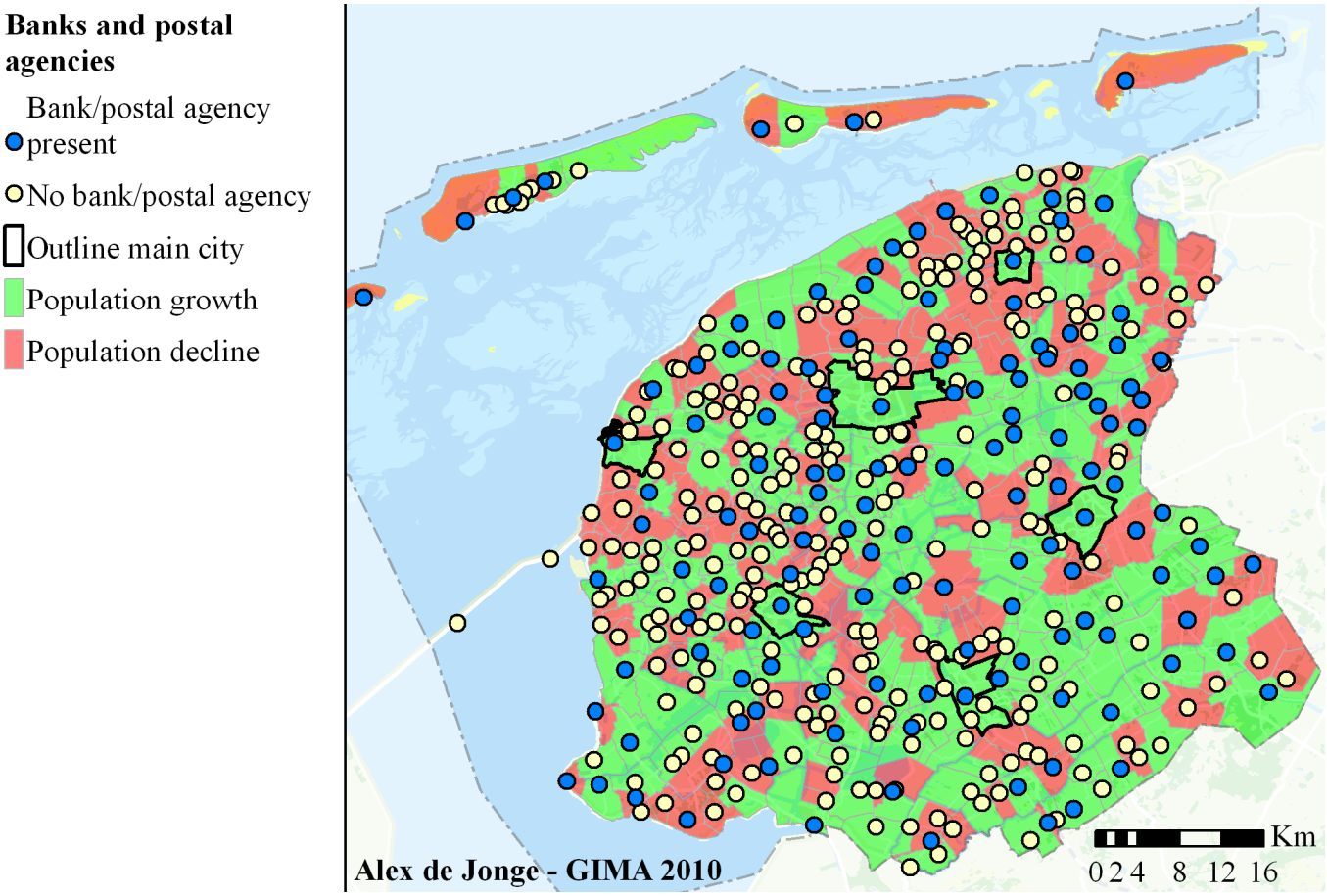
In Fryslân 280 individual supermarkets can be identified, divided over 118 cores[25]. The spatial distribution is depicted in map 9-4. In the western parts of Fryslân relatively fewer villages have a supermarket; this might be related to the relative small size of these villages.

[24] Van Dam et al 2008
[25] Province of Fryslân 2010d

9.1.5. Business services

Next to retail, business services are an important aspect of daily live. Examples of business services are banks, postal agencies and ATM's. People are often in need of these services, so it can be regarded as a basic amenity related to liveability.

Banks and postal agencies are not totally equivalent on their delivered services. Banks are primary front offices for large financial institutions where banking and insurance activities can be arranged. Postal agencies are more focussed on sending and distribution of post and packages. The common denominator is the option to obtain money at both offices.



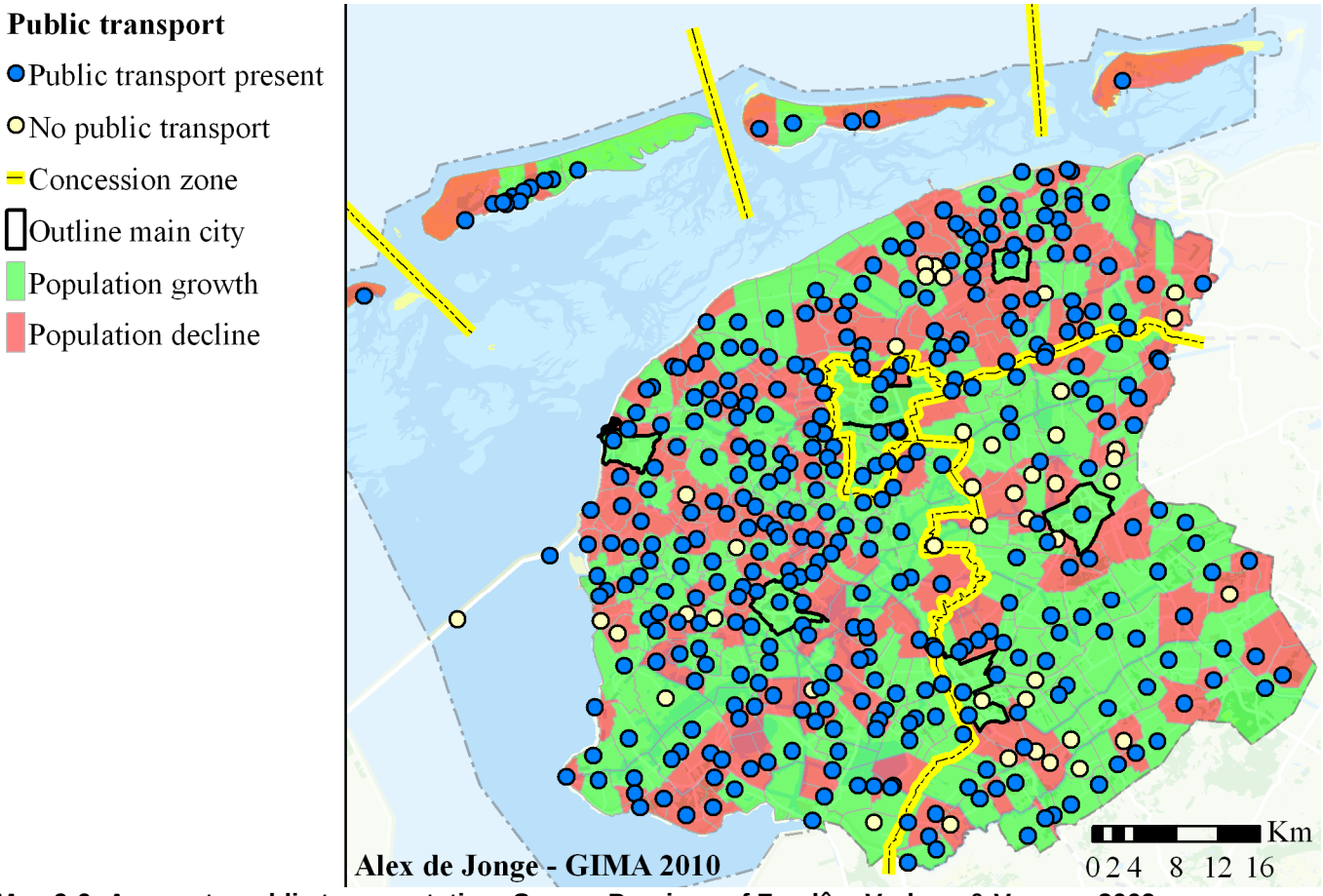
Map 9-5: Banks and postal agencies. Source Province of Fryslân 2010d; TNT Post 2009.

The spatial distribution of cores with a bank office or a postal agency is depicted in map 9-5 and shows an even pattern[26]. Again the cores with a high population have multiple banks and postal agencies.

[26] Province of Fryslân 2010d; TNT Post 2009

9.1.6. Public transport

As stated in the introduction of this chapter: not every person has the same mobility. Healthy, affluent middle aged people often own a car and are therefore highly mobile. Two groups that are not car mobile are the elderly and the youth. Therefore they are dependent on public transport.



Map 9-6: Access to public transportation: Source Province of Fryslân: Verkeer & Vervoer 2009

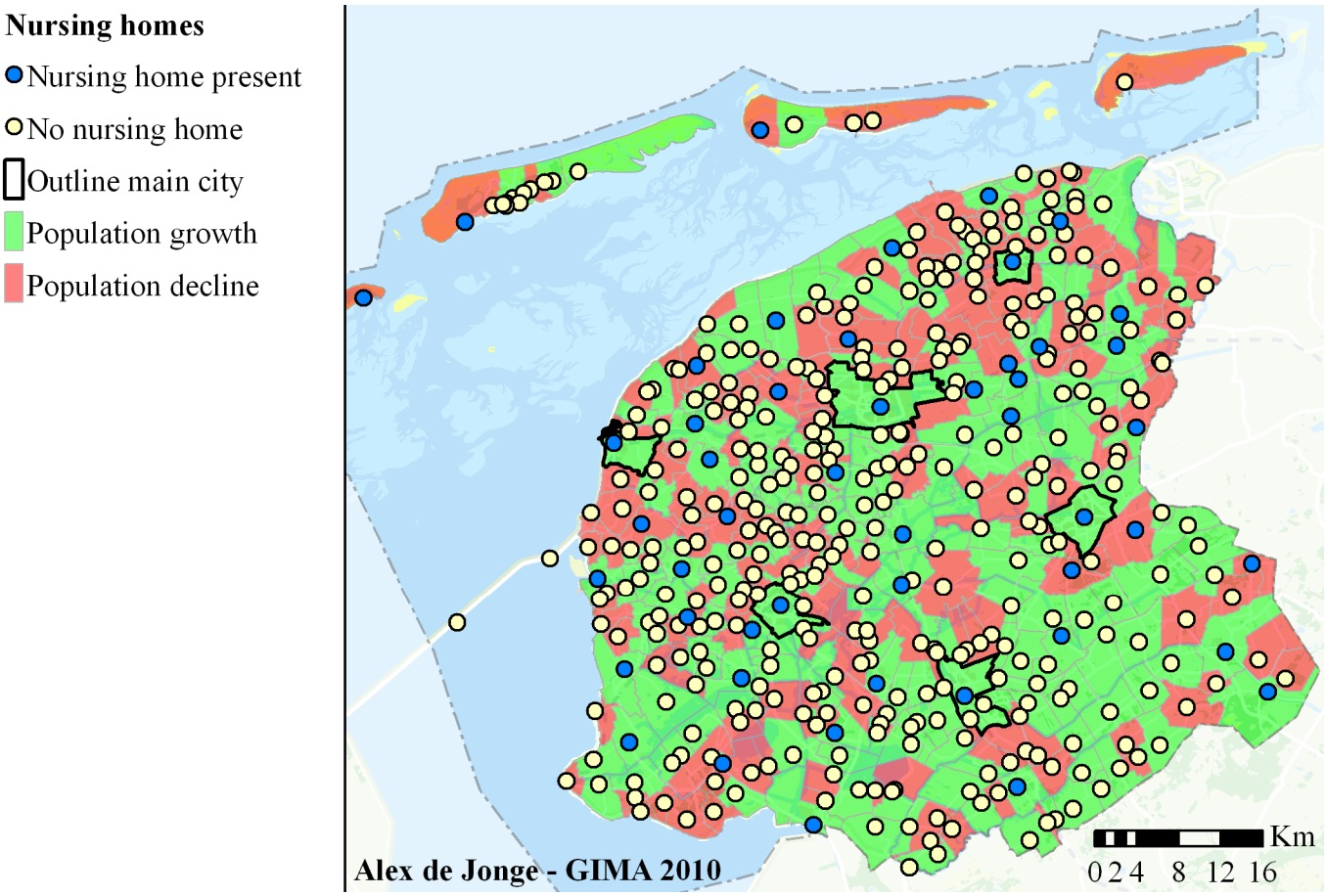
In Fryslân public transportation consist out of train and bus routes. The train connections and the importance of railway stations are described earlier in this chapter. The bus routes are all regular, scheduled routes. Out of the 416 Frisian cores 372 cores are served by some form of public transport[27]. This makes 89.6 % of all the cores. The spatial distribution of the cores with public transportation access is depicted in map 9-6. Most regions have very dense public transportation coverage, only some gaps can be identified in the east and the south of the province. The explanation for the widespread nature public transportation is the recently abolished Provincial policy that each core of over 250 inhabitants needs to have access to public transportation.

Regarding the concession zones the Wadden Island and the city region of Leeuwarden have a full coverage. The two largest public transportation concession zones are North- and South-West Fryslân and South-East Fryslân. Of those two concession zones the North- and South-West definitively has a better coverage.

[27] Province of Fryslân: Verkeer & Vervoer 2009

9.1.7. Welfare

As stated above the elderly and less vital are less mobile and therefore more dependent on local amenities. The most intensive form include internal residency for people that are not able to live independently due to (physical) handicaps or old age. The umbrella term for such kind of entity is nursing home. Because nursing homes have resident clients, it has an influence on population development of a core.



Map 9-7: Cores with a nursing home. Source: Partoer 2008

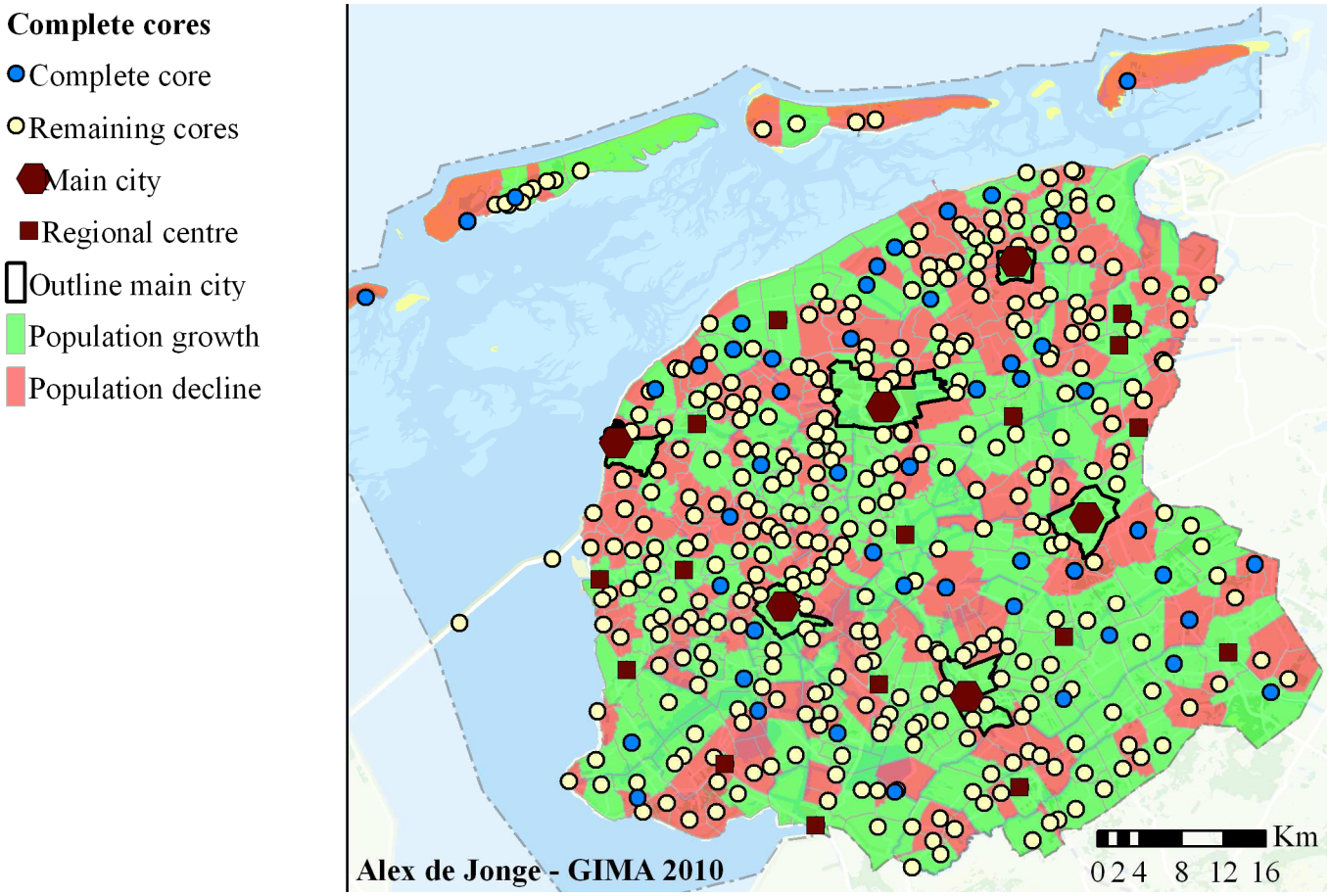
In the province of Fryslân there are 84 nursing homes, spread over 49 cores[28]. The spatial distribution of the cores with nursed living is depicted in map 9-7 and the distribution pattern is quite even. Regarding the number of nursing homes per core the main cities stand out, supplemented with the towns of Bolsward and Wolvega.

9.1.8. Complete cores

Each individual type of amenity is of importance on the liveability, but the mix of available amenities in each core is also relevant to the liveability and population development. Following a holistic motto of “the whole is more than the sum of its parts” might be even more important. Cores that are regarded to have a sufficient mix of basic amenities are determined as complete cores[29]. Although the term complete core is an important concept no strict definition can be given. The best applicable definition is to determine cores that posses six or seven out of the seven basic amenities are regarded as complete cores[30]. Complete cores are regarded to

[28] Partoer 2008
[29] Province of Fryslân 2006
[30] Province of Fryslân 2010e

have sufficient facilities to offer. Inhabitants do not have to leave the village on a regular basis in order to fulfil their needs.

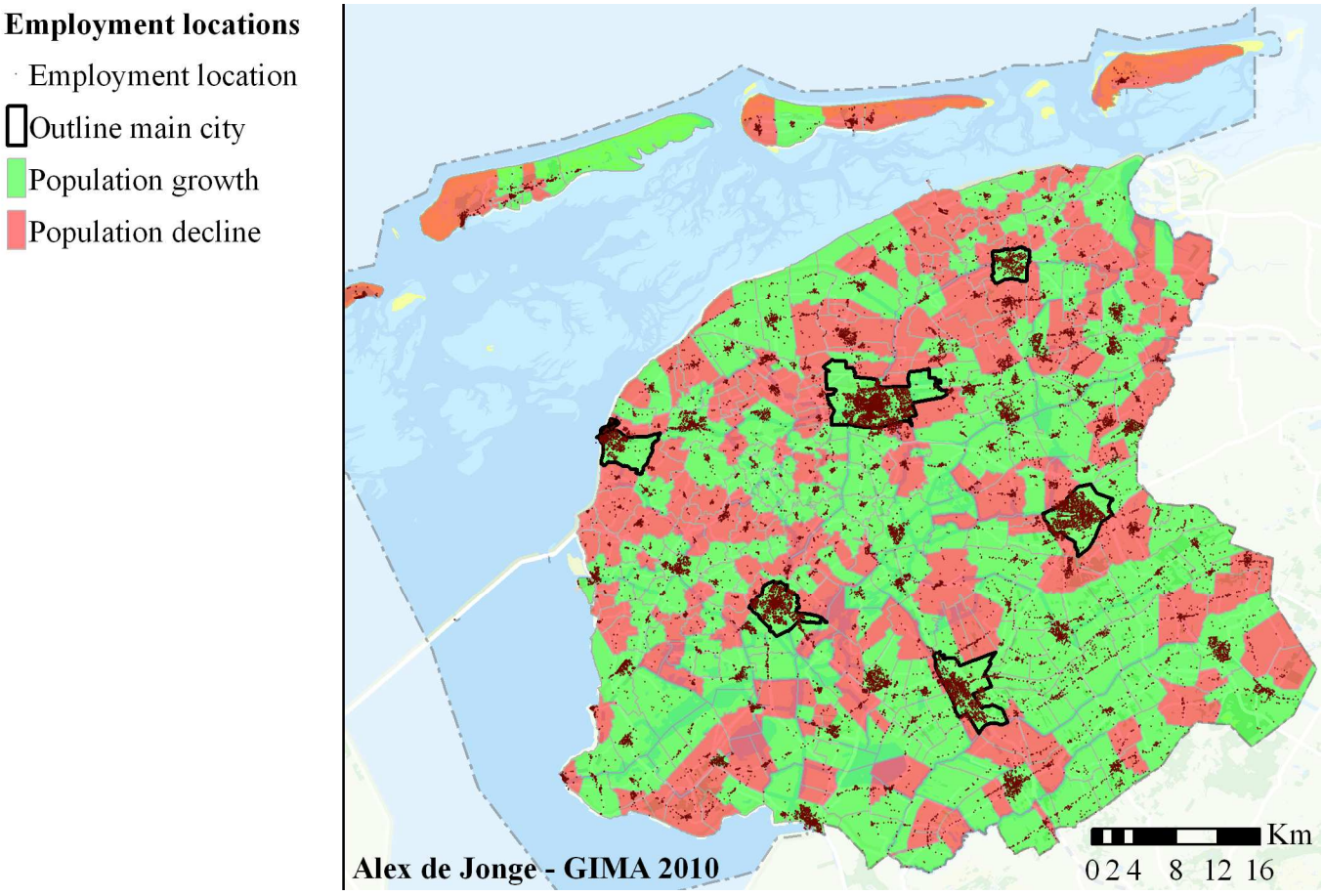


Map 9-8: main cities, regional centres and complete cores. Source: Province of Fryslân 2006.

The complete cores are depicted in map 9-8. All the six main cities and 16 regional centres have at least six of the seven described basic amenities, so they are complete cores as well. The spatial distribution can be described as even.

9.1.9. Employment

In the year 2006 there where in total just over 35,000 employment locations in Fryslân[31]. An employment location is a work location where employees are registered to carry out paid work. These locations can include company and organization's headquarters as well as annexes. The spatial spread of these employment locations is depicted in map 9-9.



Map 9-10: Employment locations 2006. Source: Province of Fryslân 2010d

It can be noted that many employment locations are found in the cities: main cities as well as regional centres. The eastern part of the province also seems to have a high number of employment locations.

Regarding employment there is an important division between site and situation. Each core has its own internal employment, but of course many people are not employed in their residential core. Therefore the measure of the number of jobs within a certain distance from each core is deemed of more importance.

[31] Province of Fryslân 2010d; this dataset does not include employment in the agricultural sector

9.2. Hypotheses

On the theme of amenities and employment the research hypotheses as described below are generated.

Based on the envisioned positive influence of the presence of individual amenities on the liveability and therefore population development:

AE 1 There is a positive correlation between the presence of a primary school and the population development of a core.

AE 2 There is a positive correlation between the presence of general practitioner and the population development of a core.

AE 3 There is a positive correlation between the presence of a supermarket and the population development of a core.

AE 4 There is a positive correlation between the presence of a community building and the population development of a core.

AE 5 There is a positive correlation between the presence of public transportation and the population development of a core.

AE 6 There is a positive correlation between the presence of a bank office and the population development of a core.

AE 7 There is a positive correlation between the presence of nursing home and the population development of a core.

Assuming not only the individual amenities are important, but the combinations of amenities even more:

AE 8 There is a positive correlation between the number of existing amenity types per core and population development

AE 9 There is a positive correlation between being a complete core and population development.

Introducing travel times to the relation between amenities and population development:

AE 10 There is a negative correlation between the average travel time by car to a mix of essential amenities and population development

Regarding the effect of nearby employment on population development:

AE 11 There is a positive correlation between employment within a 10 kilometre radius of the centre of a core and population development

9.3. Methodology

Additional to the general methodology as described in chapter 5 specific GIS methods are used to research the hypotheses stated above.

9.3.1. Individual amenities and complete cores

Regarding the seven individual types of amenities the inventory of 2010 is used[32]. For each of the 416 cores is known which amenities are present inside each core. A core is determined as complete when six or seven of these amenities are present. For this part of the theme of amenities no specific spatial or GIS analysis is applied except geo-visualization. An overview of the data used and classification method is described in Appendix A.

[32] Province of Fryslân 2010e

9.3.2. Average travel times

Next to the presence of amenities the average travel time by car to a mix of amenities can be calculated with the use of a connectivity function. Just like the previous theme of planning and infrastructure this is calculated with the use of the OpenStreetMap road dataset (appendix B). The essential mix of amenities consists out of the following five amenities:

- Primary schools
- General practitioner
- Supermarket
- Bank or postal agency
- Community building

The spatial locations of the first four amenities are derived from the "Werkgelegenheidsregister" (WGR), a dataset about employment[33]. This dataset contains information about employment and type of employer and it is spatial referenced by means of a postal code. For the community buildings the exact spatial location is not known, therefore the spatial centre of the corresponding core is used as input for accessibility calculations.

Two amenity types are omitted from the mix of amenities: nursing homes and public transportation. The first is not an amenity many people visit on a daily basis and the latter is best regarded as a mode of transportation itself, which is also widely distributed over the province.

9.3.3. Employment

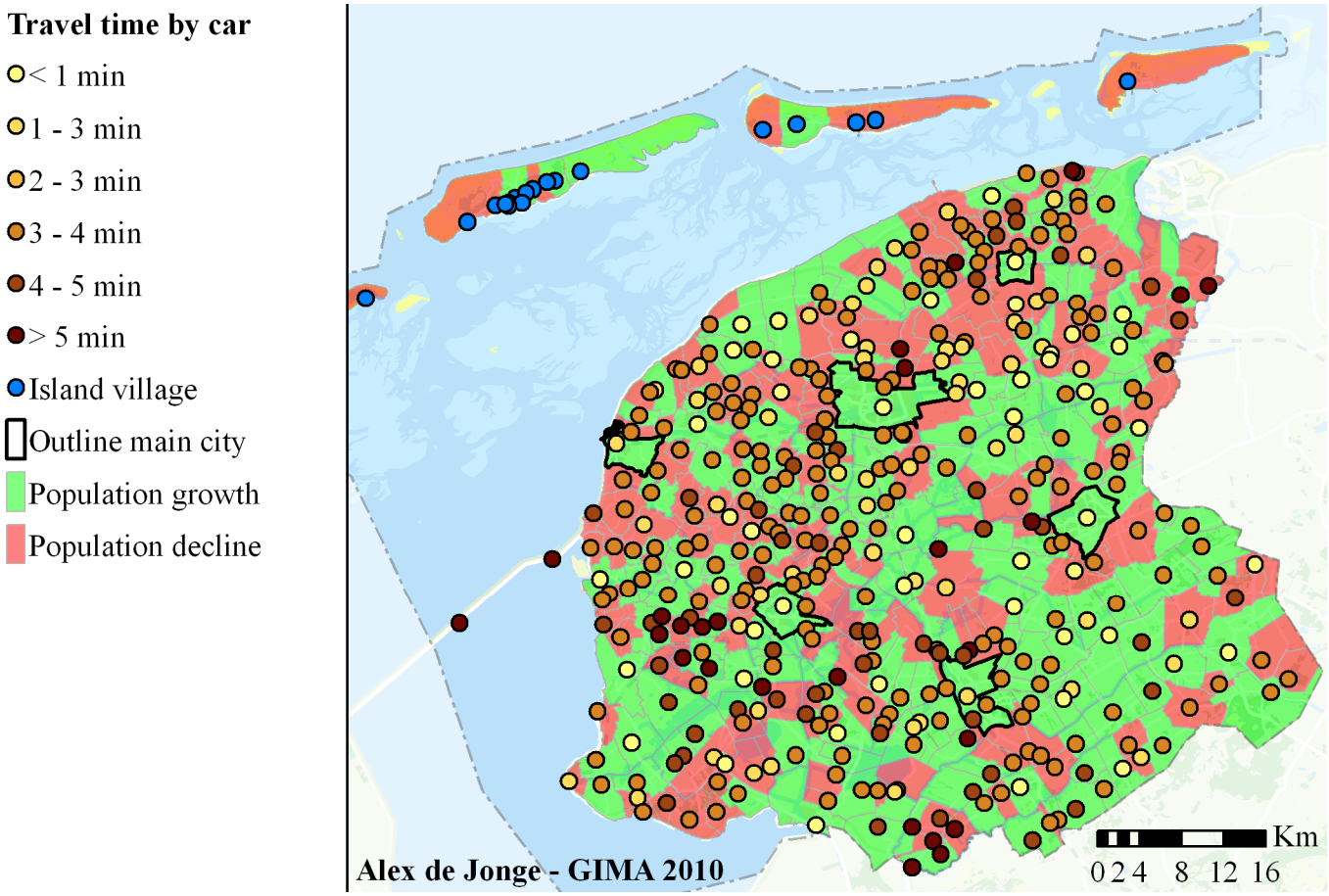
The calculation of employment within a 10 kilometer radius is executed on the provincial employment register of 2006, which is georeferenced[34]. This calculation is an example of a neighbourhood function combined with an overlay function. Around each core a 10 kilometre buffer is created and the employment of all the companies and organizations within that buffer is summarized by an overlay (intersect) and dissolve combination.

9.4. GIS results

Regarding the individual amenities and the complete cores no GIS processing is executed. The average travel time towards the mix of five amenities and the number of jobs within a 10 kilometre radius around a core are new GIS specific outcomes.

[33] Province of Fryslân 2010d
[34] Province of Fryslân 2010d

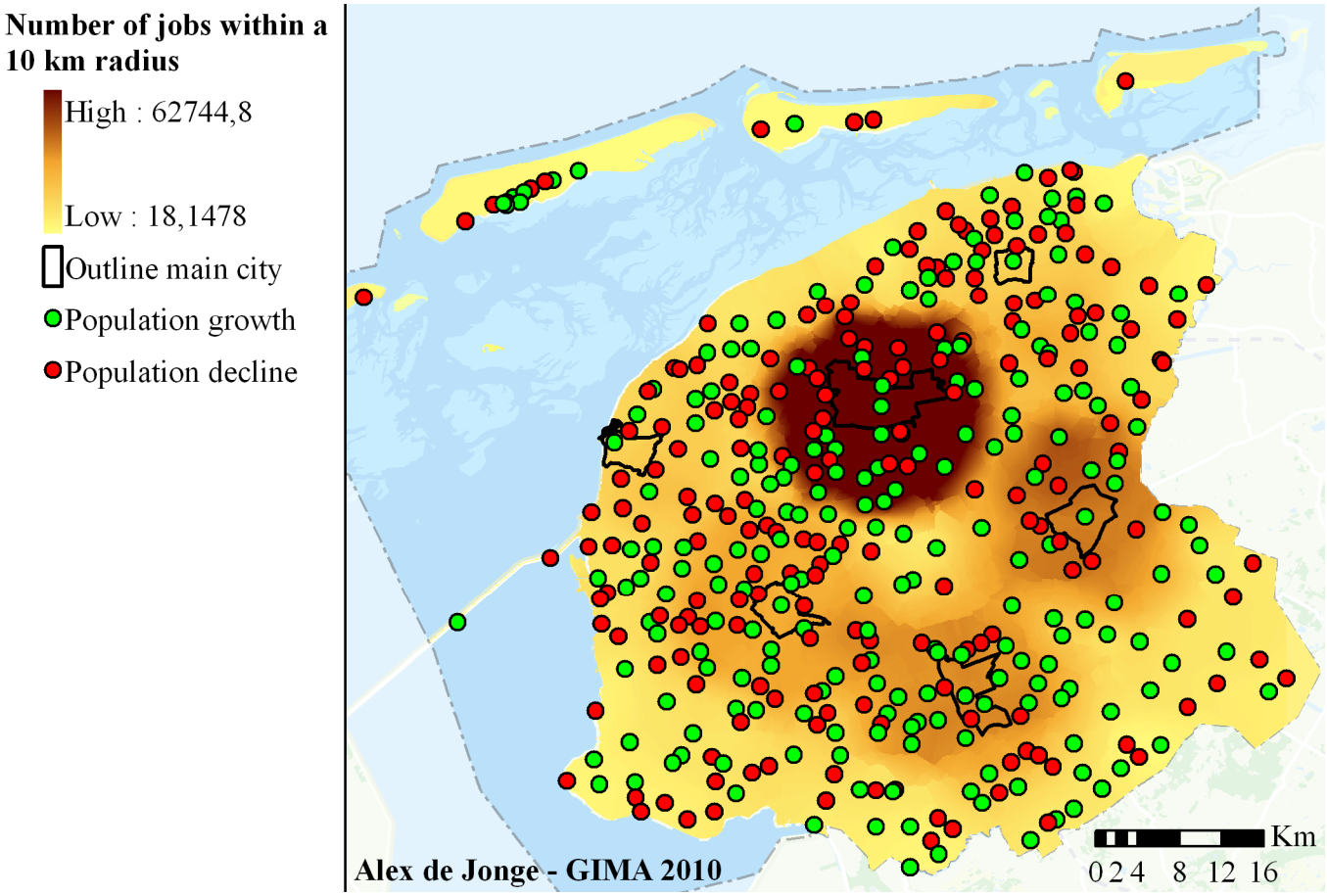
9.4.1. Average travel times



Map 9-11: Travel times by car to the mix of five amenities

The average travel time by car to a mix of five amenities (primary school, general practitioner, supermarket, bank/postal agency and community building) is depicted in map 9-10. Because of the exceptional position of the Wadden Islands their eighteen villages are grouped into one specific class. On the mainland the most remote villages can be identified in the south-western region. It has to be noted that regarding the border regions amenities in the neighbouring provinces are not taken in account. This might lead to slightly lower travel times.

9.4.2. Employment



Map 9-11: Employment within a 10 kilometre distance

The number of employees within a 10 kilometre range of the centre of each core is depicted in map 9-11. Again the large cites can be derived from the map image. Leeuwarden has a strong impact and three other cities have a medium impact: Sneek, Heerenveen and Drachten. Cores in the vicinity of those cities can benefit from the high employment options of the large cities nearby.

Due to data restrictions (only employment data within the Province of Fryslân is used), some areas show values that are lower than in reality. Because the data of actual employment locations of neighbouring provinces is omitted it is not counted as employment within a 10 km radius from the centre of each core. This partially explains the low scores for the border regions. The low scores for the coastal areas and the Wadden Islands represent actual low employment opportunities.

9.5. Amenities & economy and population development

All the research hypotheses are subject of statistical analyses. For the first seven hypotheses the analysis is very simple: cores that have a certain amenity are compared with cores that lack that amenity. The other amenities are compared like the chapters before and as described in chapter 5.

9.5.1. Individual amenities

Table 9-3: AE 1. Presence of primary schools versus population development

Class	N	Grow	Decl	Ratio	Mean	SD
Primary school present	260	**148**	112	1.32	0.15	0.79
No primary school	156	68	**88**	0.77	0.09	2.73
Total	416	**216**	200	1.08	0.12	1.78
Difference					0.06	

The annual population development averages between cores with or without primary schools do not differ much: both classes score around average. Also noteworthy is the fact that in the group of cores that lack a primary school more cores are experiencing population decline than in the group of cores that have a primary school. But overall the differences are small. Therefore it cannot be stated that there is a clear correlation.

Table 9-4: AE 2. Presence of general practitioner versus population development

Class	N	Grow	Decl	Ratio	Mean	SD
General practitioner present	110	**74**	36	2.06	0.27	0.68
No general practitioner	306	142	**164**	0.87	0.07	2.04
Total	416	**216**	200	1.08	0.12	1.78
Difference					0.19	

Regarding the topic of general practitioners the effect of the presence of one on the average annual population development is stronger than the presence of a primary school: 0.19 % against 0.06 %. The most striking observation is in the group of cores with a general practitioner the number of growing cores is more than double the number of declining cores. It can be concluded that there is a correlation between the presence of a general practitioner and population development.

Table 9-5: AE 3. Presence of a community building versus population development

Class	N	Grow	Decl	Ratio	Mean	SD
Community building present	247	**134**	113	1.19	0.20	1.88
No community building	169	82	**87**	0.94	0.01	1.63
Total	416	**216**	200	1.08	0.12	1.78
Difference					0.19	

Just like the general practitioners the difference between the groups of cores that have a community building and the group that has not is 0.19 %. The growth/decline ratio is less pronounced than the previous amenity. It has to be noticed that some major cities do not have a designated community building, possibly leading to a deviant outcome. But overall there is a clear positive correlation between the presence of a community building and population development.

Table 9-6: AE 4. Presence of a supermarket versus population development

Class	N	Grow	Decl	Ratio	Mean	SD
Supermarket present	118	**76**	42	1.81	0.26	0.70
No supermarket	298	140	**158**	0.89	0.07	2.06
Total	416	**216**	200	1.08	0.12	1.78
Difference					0.19	

The difference in average annual population development between the group of cores with and the group without a supermarket is just like the two previous amenities: 0.19 %. The growth/decline ratio is in between both previous treated amenities. Just like the other two, a clear correlation can be determined.

Table 9-7: AE 5. Presence of a bank or postal agency versus population development

Class	N	Grow	Decl	Ratio	Mean	SD
Bank or postal agency present	142	**89**	53	1.68	0.21	0.66
No bank or postal agency	274	127	**147**	0.86	0.08	2.15
Total	416	**216**	200	1.08	0.12	1.78
Difference					0.12	

The difference in average annual population development between cores with a bank or post agency and the cores without is 0.12 %. This can be described as a mediocre positive correlation.

Table 9-8: AE 6. Presence of public transportation versus population development

Class	N	Grow	Decl	Ratio	Mean	SD
Access to public transportation	372	**194**	178	1.09	0.13	1.85
No access to public transportation	44	22	22	1.00	0.07	1.11
Total	416	**216**	200	1.08	0.12	1.78
Difference					0.06	

Public transportation is the most widely spread basic amenity in Fryslân. Only 44 cores lack a regular scheduled stop of public transport. This might explain the small differences in average annual population development between cores that have and cores that do not have access to public transportation. Equal to the hypothesis on primary schools, a clear correlation can not be determined.

Table 9-9: AE 7. Presence of nursing home versus population development

Class	N	Grow	Decl	Ratio	Mean	SD
Nursing home present	49	**36**	13	2.77	0.35	0.65
No nursing home	367	180	**187**	0.96	0.09	1.88
Total	416	**216**	200	1.08	0.12	1.78
Difference					0.25	

The differences between the group of cores with a nursing home and without a nursing home are quite large. The average annual population development differs 0.25 %, the highest score of all seven basic amenities. Also the number of growing cores with a nursing home is almost

three times higher than the number of declining cores. A very strong positive correlation between the presence of a nursing home and population development can be determined.

This relation between nursing homes and population development can be linked to the relation between the age group of 65+ and population development. A relative large proportion of residents of nursing homes are 65+. Both factors show a positive correlation, what also might be related to the size of a core and the planning hierarchy. Nursing homes are more often located in larger towns.

9.5.2. Complete cores

Complete cores posses a minimum mix of basic amenities. The most straightforward method is to count the number of present amenity types per core. Cores with six or seven amenities are regarded as complete.

Table 9-10: AE 8. Number of present amenity types versus population development

Class	N	Grow	Decl	Ratio	Mean	SD
No basic amenities	11	3	**8**	0.38	-0.43	1.54
1 type	105	**54**	51	1.06	0.07	1.95
2 types	73	31	**42**	0.74	0.31	3.26
3 types	83	36	**47**	0.77	-0.08	0.83
4 types	33	**19**	14	1.36	0.04	0.62
5 types	41	**22**	19	1.16	0.18	0.79
6 types	35	**22**	13	1.69	0.26	0.70
7 types	35	**29**	6	4.83	0.45	0.60
Total	416	**216**	200	1.08	0.12	1.78

Two extremes can be identified: cores without any type of amenity have an average annual population decline of 0.43% and cores with seven amenities have an average population growth of 0.45%. The relation is not entirely linear. Cores with 5 or 6 amenities have a somewhat linear score, but a strange deviation is the group of cores with exactly two types of amenities. This group has an average annual population growth of 0.31 %. This figure is linked with a high standard deviation of 3.26, what implies a large influence of outliers. Overall the figures tend towards a correlation between number of unique amenities and population development, but this can not be fully endorsed.

Table 9-11: AE 9. Complete cores versus population development

Class	N	Grow	Decl	Ratio	Mean	SD
Complete	70	**51**	19	2.68	0.35	0.66
Not complete	346	165	**181**	0.91	0.08	1.93
Total	416	**216**	200	1.08	0.12	1.78
Difference					0.28	

Using the definition that a core is complete when six out of seven amenity types are present there is a clear difference between complete cores and non- complete cores[35]. Complete cores have a higher average annual population development and the balance between growing and declining cores is tilting strongly towards growth. Therefore a strong positive correlation between complete cores and population development can be determined.

9.5.3. Average travel time by car

Table 9-12: AE 10. Average travel time by car to mix of amenities versus population development

Class	N	Grow	Decl	Ratio	Mean	SD
<1 min	48	**38**	10	3.80	0.43	0.55
1-2 min	56	28	28	1.00	0.48	3.63
2-3 min	114	56	**58**	0.97	0.05	1.13
3-4 min	102	47	**55**	0.85	0.01	1.12
4-5 min	52	**27**	25	1.08	-0.14	1.48
>5 min	26	12	**14**	0.86	-0.12	2.11
Island village	18	8	**10**	0.80	0.41	2.04
Total	416	**216**	200	1.08	0.12	1.78

The hypothesis is that if an essential mix of amenities (primary school, general practitioner, supermarket, bank/postal agency and community building) is close by and easy to reach this positively correlates with a high population development. The outcomes of the analysis do not support this hypothesis, so it needs to be rejected.

9.5.4. Employment

Table 9-13: AE 11. Employment within a 10 km radius versus population development

Class	N	Grow	Decl	Ratio	Mean	SD
Q1: 10-4902 jobs	52	25	**27**	0.93	0.17	1.32
Q2: 4926-7182 jobs	52	**29**	23	1.26	0.04	0.79
Q3: 7249-10275 jobs	52	25	**27**	0.93	0.45	3.91
Q4: 10284-12883 jobs	52	23	**29**	0.79	-0.10	1.03
Q5: 12949-19506 jobs	52	**28**	24	1.17	0.03	0.95
Q6: 19606-23585 jobs	52	**30**	22	1.36	0.23	1.90
Q7: 23605-31298 jobs	52	**29**	23	1.26	0.07	1.23
Q8: 31609-61504 jobs	52	**27**	25	1.08	0.10	0.98
Total	416	216	200	1.08	0.12	1.78

Focussing on the correlation between the number of employees within a 10 kilometre radius of the centre of the core and population development gives no correlation whatsoever. This is in contradiction with the research hypothesis, implying there is a correlation between nearby employment and population development.

[35] Province of Fryslân 2010e

9.6. Summary

In this chapter on amenities and population development a selection of GIS techniques is applied. For each core the average travel time towards a set of essential amenities is calculated, as well as the number of jobs within a 10 kilometre radius.

The presence of each of the seven individual basic amenities does not correlate with population development in the same extent. The strongest positively correlated amenity is the nursing home, followed by the general practitioner, supermarket and community building. The correlation between the presence of a bank/postal agency and population development is prudent, whilst the relations between respectively primary schools and public transportation with population development are determined not valid.

Beyond the individual amenities the constellation of amenities for each core is also of importance. There is a prudent positive correlation between the number of present amenity types and population development. Defining a core as complete when six out of seven amenities are present leads to a relative strong correlation between complete cores and population development.

The last two hypotheses on the correlation between average travel time towards an essential mix of amenities and population development and the correlation between the number of jobs in a 10 kilometre radius and population development cannot be proven valid.

10. Regression analysis

The chapters 7 till 9 treat three different themes, where the relations of individual explanatory factors with population development are researched. In this chapter the individual elements are integrated into one statistical analysis: a linear regression model.

10.1. Linear regression

The application of a regression model is to determine the influence of individual explanatory factors on a dependent factor, in this research population development. This is cast in a formula with the following structure:

Population development = constant + B1 X factor1 + B2 X factor2 + B3 X factor3 + …

The constant is a mathematical value used to adjust the formula. The B-values are related to each individual factor. This B-value describes the influence of the change of the factor on population development. The B-value is dependent on the related factors and therefore they can not be compared in between. This is resolved by standardizing the B-value in a Beta-value, ranging between -1 and 1.

A positive Beta-value means that the explanatory factor has a positive influence on population development and a negative value implies a negative influence of the explanatory factor on population development. An absolute value close to 1 means a large influence on population development and close to zero means a low influence on population development.

In a multi-factor research like this a number of factors coincide: those factors both show the same correlation with population development. When using a linear regression some of these correlating factors might not show up in favour of another factor that describes the relationship more clearly. This is not a denial of the correlations as described in the chapters 7 to 9.

10.2. Outcomes

The linear regression as applied on the average yearly population development per core. The R-square is 64 %, which means that 64 % of the variance of population development can be explained by the explanatory factors as described in this research. Table 10-1 lists the explanatory factors and their influence on the linear regression formula. The explanatory factors are sorted on absolute value.

Table 10-1: Linear regression

Explanatory factor	B	SE	Beta	t
Constant	2.244	0.892	-	2.514
Development of housing stock	0.933	0.037	0.765	25.340
Age group 25-44	0.043	0.014	0.192	3.163
Age group 15-24	-0.080	0.021	-0.173	-3.736
Average household size	-0.319	0.202	-0.116	-1.580
Distance to Amersfoort	0.000	0.000	-0.085	-1.692
Age group 45-64	-0.018	0.011	-0.077	-1.664
Age group 0-15	-0.020	0.019	-0.073	-1.043
Distance to Leeuwarden	0.000	0.000	-0.065	-1.088

Community building	-0.228	0.243	-0.063	-0.940
Employment within a 10 km radius	0.000	0.000	-0.044	-0.891
Travel time to amenities	0.000	0.000	0.039	0.715
Supermarket	-0.154	0.292	-0.039	-0.527
Within 5 km of a highway	-0.137	0.140	-0.038	-0.975
National Landscape	-0.121	0.137	-0.029	-0.880
Number of amenities	0.024	0.209	0.027	0.117
General practitioner	-0.111	0.286	-0.027	-0.388
Primary school	0.091	0.258	0.025	0.351
Economic core area	0.074	0.112	0.025	0.665
Urban concentration area	0.102	0.166	0.024	0.611
Nursing home	0.082	0.334	0.015	0.245
Main city	0.192	0.788	0.013	0.243
Regional centre	0.110	0.364	0.012	0.303
Public transportation	-0.059	0.275	-0.010	-0.213
Bank or postal agency	0.035	0.300	0.009	0.116
Age group 65+	0.003	0.017	0.007	0.156
EHS	-0.063	0.442	-0.007	-0.144
Railway station	-0.048	0.293	-0.006	-0.162
Recreational core	0.035	0.271	0.004	0.131
Complete core	-0.009	0.298	-0.002	-0.029
Inhabitants in 2000	0.000	0.000	0.000	-0.013

Four explanatory factors are statistically excluded:
- Travel time to Leeuwarden
- Travel time to main cities
- Travel time to main cities and regional cores
- Travel time to railway stations

10.3. Interpretation

The explanatory factor with the highest Beta-value is the development of the housing stock, with a positive Beta-value of 0.765. This means that change in housing stock is strongly related with population development. This is an expected outcome because an increase in housing stock offers opportunities for new inhabitants to settle in the village and vice versa: a growth in population can be absorbed with the construction of new houses.

Four out of the five age groups have a relative high impact on population development, only the impact of the age group of 65+ is negligible. The directions of the influence are consistent with the correlations between the individual age groups and population development. The impact of the age group 25-44 is the highest. It has to be noted that the impact of the age group 25-44 with a Beta-value of 0.192 is much lower than the Beta-value of 0.760 of development in housing stock. The age groups together with the average household size form the core of the population characteristics. It can be concluded that these population characteristics form the strongest correlated topic in this research.

Curiously the number of inhabitants of the year 2000 is of virtually no influence on population development in this regression model, whilst the correlation between inhabitants and population development individually was determined positive (see chapter 7). This situation can be explained by the fact some other factors coincide with the number of inhabitants of 2000, like for example the presence of amenities.

11. Conclusions

This research consists out of two sub questions that together form the main research question, as described in chapter 4. The two sub questions will be treated individually first and later integrated by answering the main research question.

11.1. GIS techniques

The first research question of this research is:
Which GIS techniques can be used to research factors related to local population decline?

It is important to make a distinction between the visualization of spatial data by means of generating maps and more advanced spatial analysis capabilities of GIS.

11.1.1. Visualization

As discussed in chapter 2, population development in Fryslân differs per core; it has a clear spatial extent. These spatial deviations in population development of the 416 Frisian cores are best depicted with the use of a map (map 2-8). Visual analysis with the use of maps is still the most efficient mechanism to identify spatial patterns[1].

The same as with population development the explanatory factors also have spatial differentiation. Again this is best identified with the use of a map, what is done in both the introductory sections as well as the GIS outcomes sections of chapters 7, 8 and 9. It can be concluded that when researching a geographical subject like the differences in population development between cores and their explanatory factors, maps are indispensable. Maps are an essential tool to understand the spatial layout and analyze the spatial spread.

11.1.2. Spatial analysis

On the subject of spatial analysis a classification of analytical GIS capabilities into four main groups is made in chapter 6[2]:

- Measurement, retrieval and classification functions (for example the straight line distance between all the Frisian cores and Leeuwarden)
- Overlay functions
- Neighbourhood functions (for example the determination which cores are within 5 kilometre of a highway)
- Connectivity functions (for example travel time by car towards the main cities of Fryslân)

This classification can be used as a framework to understand and identify various spatial analysis tools and methods. These analytical functions are applied in chapters 7, 8 and 9 as spatial data processing in order to do statistical analysis. An overview of which spatial analysis function is used for each hypothesis is in table 11-1. The hypotheses that do not require spatial analysis are also listed.

[1] Layne 2006
[2] De By 2004

Table 11-1: Research hypotheses and GIS methodology

	Description	Non-spatial only	Distance measurement	Area measurement	Spatial query	Overlay	Neighboorbood	Connectivity
	Population characteristics							
PC 1	Number of inhabitants	■						
PC 2-6	Proportion of age groups	■						
PC 7	Average household size	■						
	Planning & infrastructure							
PI 1	Planning hierarchy	■						
PI 2	Urban concentration area				■			
PI 3	Economic core area				■			
PI 4	Straight line distance to Leeuwarden		■					
PI 5	Travel time by car to Leeuwarden							■
PI 6	Straight line distance to Amersfoort		■					
PI 7	EHS ratio			■				
PI 8	National Landscape				■			
PI 9	Travel time by car to railway stations							■
PI 10	Travel time by car to main cities							■
PI 11	Travel time by car to main cities and regional centres							■
PI 12	Within 5 km of a highway						■	
PI 13	Development of housing stock	■						
	Amenities & economy							
AE 1	Primary schools	■						
AE 2	General practitioner	■						
AE 3	Community building	■						
AE 4	Supermarket	■						
AE 5	Bank or postal agency	■						
AE 6	Public transportation	■						
AE 7	Nursing home	■						
AE 8	Number of unique amenity types	■						
AE 9	Complete cores	■						
AE 10	Travel time by car to mix of amenities							■
AE 11	Employment within a 10 km radius					■	■	

Out of the 27 topics 13 have a spatial analysis methodology and 14 lack a spatial analysis component. But all research hypotheses and explanatory factors have a spatial extent, which can be visualized by means of mapmaking as mentioned above.

A widely used class of spatial analysis is the connectivity functionality or network analysis. This is used in calculating travel times by car from the Frisian cores to Leeuwarden, main cities, regional centres, railway stations and amenities. Neighbourhood functions are used to determine which cores are within five kilometres of a highway, as well as in combination with an overlay to determine the number of primary schools or jobs within a set radius. Solitary use of the overlay function is to determine the number of jobs within the area of a core.

The related spatial query is used to identify which cores are located in a specified zone, like an urban concentration area, economic core area or National Landscape. The function of area measurement is only applied to determine the ratio of EHS of the areal of each core, whilst the distance measurement is used to calculate the straight line distance between the individual cores and Leeuwarden and Amersfoort.

11.2. Determination of factors

The second research question is constructed to identify which explanatory factors correlate with population development:
Which factors can be identified to explain local population decline?

In chapter 3 the three main themes related to population development are stated. These three themes function as umbrella terms to cover multiple explanatory factors, all with a spatial component. The three themes are:

- Population characteristics
- Planning & infrastructure
- Amenities & economy

For each of these themes a set of research hypotheses are generated, proposing a correlation between an individual explanatory factor and population development. Based on the statistical outcomes correlations can be identified, with their directions.

11.2.1. Population characteristics

Based on chapter 7 where the research hypotheses related to population characteristics and population development are stated and treaded table 11-2 is generated.

Table 11-2: Correlations between population characteristics and population development

	Description	Correlation	Direction
PC 1	Number of inhabitants	Yes	Positive
PC 3	Proportion of age group 15-24	Yes	Negative
PC 4	Proportion of age group 25-44	Yes	Positive
PC 5	Proportion of age group 45-64	Yes	Negative
PC 7	Average household size	Yes	Negative
PC 6	Proportion of age group 65+	Unclear	Positive
PC 2	Proportion of age group 0-14	No	-

Many of the population characteristics research hypotheses apply on the province of Fryslân. The largest six cities can be determined as driving force of population development. There is a clear positive correlation between the number of inhabitants and population development.

Regarding the age composition only the proportion of the age group 0-14 does not correlate with population development. The presence of the age group 25-44 has the largest positive correlation with population development: this is assumed to be caused by migration of this age group and natural increase. The average household size is negatively correlated with population development.

11.2.2. Planning & infrastructure

In chapter 8 the research hypotheses concerning planning, infrastructure and housing are researched. The outcomes in brief are stated in table 11-3

Table 11-3: Correlations between planning & infrastructure and population development

	Description	Correlation	Direction
PI 1	Planning hierarchy	Yes	Positive
PI 2a	Urban concentration area	Yes	Negative
PI 2b	Urban concentration area: Dokkum	Yes	Negative
PI 2c	Urban concentration area: Drachten	Yes	Negative
PI 2d	Urban concentration area: Harlingen	Yes	Negative
PI 2f	Urban concentration area: Leeuwarden	Yes	Negative
PI 2g	Urban concentration area: Sneek	Yes	Positive
PI 3b	Economic core area: Westergo	Yes	Negative
PI 8	National Landscape	Yes	Negative
PI 9	Travel time by car to railway stations	Yes	Negative
PI 12	Within 5 km of a highway	Yes	Positive
PI 13	Development of housing stock	Yes	Positive
PI 2e	Urban concentration area: Heerenveen	Unclear	Positive
PI 3a	Economic core area: A7	Unclear	Positive
PI 6	Straight line distance to Amersfoort	Unclear	Negative
PI 10	Travel time by car to main cities	Unclear	Positive
PI 11	Travel time by car to main cities and regional centers	Unclear	Positive
PI 4	Straight line distance to Leeuwarden	No	-
PI 5	Travel time by car to Leeuwarden	No	-
PI 7	EHS ratio	No	-

The planning hierarchy as determined by the provincial administration of Fryslân is clearly reflected in the provincial population development. Main cities and regional centers clearly have an above average population development. Urban concentration areas on the other hand have a negative correlation with population development: villages close to large cities have a below average population development. That is also why the correlation between travel time by car towards main cities and/or regional cores and population development is not clear.

Being within five kilometre of a highway correlates positively with population development, just like being in the economic core area of the A7 zone. The economic core area of the Westergo region on the other hand is negatively correlated with population development. Planning restrictions in the form of EHS and National Landscapes have only a minimal effect on population development in Fryslân.

The clearest correlation between an explanatory factor and population development can be identified between the development in housing stock and population development. This is a clear link: the newly build houses are occupied by new inhabitants, causing population growth.

11.2.3. Amenities & economy

The third main theme of this research, amenities & economy is treated in chapter 9. The outcomes of the research hypotheses are stated in table 11-4.

Table 11-4 Correlations between planning & infrastructure and population development

	Description	Correlation	Direction
AE 2	General practitioner	Yes	Positive
AE 3	Community building	Yes	Positive
AE 4	Supermarket	Yes	Positive
AE 5	Bank or postal agency	Yes	Positive
AE 7	Nursing home	Yes	Positive
AE 9	Complete cores	Yes	Positive
AE 1	Primary schools	Unclear	Positive
AE 6	Public transportation	Unclear	Positive
AE 8	Number of unique amenity types	Unclear	Positive
AE 10	Travel time by car to mix of amenities	No	-
AE 11	Employment within a 10 km radius	No	-

Except the primary schools and public transportation the presence of each individual basic amenity has a positive correlation with population growth. Cores that are determined as complete also show this positive correlation.

The topics concerning travel times to a mix of essential amenities, the number of schools within a five kilometre radius and employment do not clearly correlate with population development.

11.2.4. Regression

From the regression described in chapter 10 can be derived that the growth of the housing stock between 2000 and 2007 is the strongest related explanatory factor. Also factors that score high are the age composition of each core, related to the population characteristics described in chapter 7.

11.3. Main question

The main question of this research is a combination of the two previous sub questions:
Which factors behind local population decline in Fryslân can be revealed by using GIS?

Broadly it can be concluded that answering the two sub questions answers the main question, but one aspect needs some special attention. That is the determination of which spatial analysis technique has lead to the most valuable results. Therefore table 11-1 is combined with the tables 11-2 to 11-4 into one list specifying the research hypotheses of which a correlation can be determined (or is unclear) and required spatial analysis. This list is stated in table 11-5.

Table 11-5: Spatial analyses that lead to correlation with population development

Hypothesis	Description
PI 2	Urban concentration area
PI 3	Economic core area
PI 4	Straight line distance to Amersfoort
PI 8	National Landscape
PI 9	Travel time by car to railway stations
PI 10	Travel time by car to main cities
PI 11	Travel time by car to main cities and regional centres
PI 12	Within 5 km of a highway

Out of this list it can be concluded that two main groups of analytical GIS capabilities can be meaningful applied on population development research: spatial query and travel time by car. In addition a distance measurement and a neighbourhood function can be applied with equal success.

Table 11-5 implies that there are also some results of spatial analysis that did not lead to valuable outcomes. These research hypotheses are stated in table 11-6.

Table 11-6: Spatial analyses that did not lead to correlation with population development

Hypothesis	Description
PI 4	Straight line distance to Leeuwarden
PI 5	Travel time by car to Leeuwarden
PI 7	EHS ratio
AE 10	Travel time by car to mix of amenities
AE 11	Employment within a 10 km radius

Not all distance measurements, neighbourhood functions and travel time by car calculations lead to meaningful results, shows table 11-6. For the area calculations no useful application is determined in this research.

Once again, all the explanatory factors have a spatial extent. Using GIS to visualize the spatial spread of each factor proves a valid form of analysis for each explanatory factor.

12. Discussion

In chapter 11 (Conclusions) is stated which knowledge is gained by this research. But except answering questions, this research on the spatial factors behind population development maybe raises even more. This chapter is aimed to give guidance in the relevance of this research and possible new leads. First some limitations of this research are discussed and later suggestions for further research are made.

12.1. Limitations of the research

As far as not described in the scope of this research (chapter 4) other limitations that came up during the research process are described below.

12.1.1. Correlations versus causality

Goal of this research is to identify the spatial factors behind population development. This is achieved by searching for correlations between these explanatory spatial factors and population development. An important remark is that when a correlation is proven, this does not imply there is causality. A specific spatial pattern in an explanatory factor might not be the cause of changes population development. Population development might be the cause of change of that spatial factor. Or both the spatial factor and population development are caused by a third factor.

12.1.2. Spatial distribution

As depicted in map 2-8 the spatial pattern of growing and declining cores seems very random. No clustering can be identified. Therefore it can not be said that one specific region within the province of Fryslân is a decline region. This is in contrast to for example north-east Groningen or Zeeuws-Vlaanderen in the Province of Zeeland.

The distribution pattern of population development might be related to the spatial distribution of an explanatory factor, which is part of the focus of this research. But because of the mix of explanatory factors there is not one that can be determined as the sole explanation. Therefore the spatial distribution of this one sole explanatory factor can not be linked to the spatial distribution of population development. With the use of the CommonGIS application some spatial relations are interactively investigated, but it was proven hard to use it in order to come up with clear correlations.

12.1.3. Absolute versus relative growth

Population development figures are in the most original form absolute figures. The number of inhabitants is known for the years 2000 and 2008 (1st of January). From this the average annual population development can be derived (see chapter 5).

The main advantage of the relative growth is that the development of different cores can be compared, regardless to the size of the cores. This relative figure implies that each core has an equal impact in the statistical analysis, which has complications. The large impact of absolute numbers in a city like Leeuwarden with 3760 more inhabitants in 2008 instead of 2000 only leads to an average annual population growth of 0.56 %. The growth of this case is statistically balanced by the average annual population decline of 0.56 % in the village of Waaksens (Littenseradeel), although it only means an eight year decline of four inhabitants. This situation explains why the average annual population development for the whole province (0.37 %) differs from the average annual population development measured as an average for the

416 Frisian cores (0.12 %). As stated in chapter 4 the population growth of the province of Fryslân is mainly driven by the absolute growth of a select number of large cities, which is ruled out by the averages of all the other cores in a relative growth measure.

12.1.4. Provincial borders

This research is focussed on the provincial territory. Mostly, only factors inside the provincial borders are taken into account. The only exception is the location of the city of Amersfoort, but all other data is on the provincial level of Fryslân only. This is not representative for variables like the travel distance to amenities like stations for example.

12.1.5. Statistical analysis

In this research the final choice is made for a universal statistical analysis method: classifying the explanatory factors into groups and compare those groups on the ratio between growing and declining cores and on the average annual population development. The main advantages are the mutual comparisons between statistical outcomes and the easy to understand and interpret meaning of the outcomes. The disadvantage is that for the ratio and interval variables detail is lost by classifying data.

For some hypotheses that have an interval/ratio explanatory variable experiments are done with the Pearson's chi-square test. This test helps to detect a correlation between two interval/ratio variables and generates to results: the strength of the correlation and the statistical significance of this result. The latter is to determine how representative the sample's correlation is in relation to the population. Because the 416 Frisian cores that are researched make up the whole statistical population of Frisian cores this significance figure is not of relevance. The strength of the correlation is expressed in a value between 0 and 1 for a positive correlation and between 0 and -1 for a negative correlation. An outcome closer to the absolute value of 1 means a stronger correlation.

In practise an outcome of the Pearson's chi-square test between -0.3 and 0.3 is regarded as not correlated. Almost all the explanatory factors in relation to the average population development have an outcome that does not exceed this range, so by the rule all suggested correlations needs to be rejected. This can be interpreted in two ways. There is no correlation between the explanatory factors and population development or the method to demonstrate the relations is not suitable. Applying a different method (as described in chapter 5) leads to useful results. But it has to be noted that the relations between individual explanatory factors and population development are statistically not very strong.

12.2. Future research

Suggestions for future research include improving the current research setup by adding more explanatory factors, creating a new (supplemental) methodology and directions for follow-up research based on this report.

This research is not complete: not all explanatory factors behind population development are included in the analysis. Some of the missing explanatory factors can be identified others remain unknown.

12.2.1. Housing

As stated in chapter 3 housing is an important topic related to population development. This research deals with this topic by taking the average annual change in housing stock over the years 2000-2007 in account. The correlation between change in housing stock and population development is clear (see chapter 8). This might imply that there are more correlations between housing related factors and population development. Two most prominent factors are the housing price and the vacancy rate.

These factors can be monitored in various ways. Data about the selling price of houses can be requested at the Kadaster[1]. Another alternative is a monitoring system of the real estate value, WOZ (Waardering Onroerende Zaken). The WOZ-value is monitored by municipalities for reasons of taxations, but the database can also be used to monitor changes in both average house prices and vacancy rates. The Province of Limburg recently started a project on the monitoring of WOZ-values to cope with and monitor population decline in the province[2]. Implementing these municipal WOZ databases can also prove to be a valuable addition for the Province of Fryslân.

12.2.2. Amenities

On the topic of amenities seven basic amenities are determined and inventoried: a primary school, a general practitioner, a community building, a supermarket, a bank, a nursing home and access to public transportation. This selection of seven basic amenities might be a bit limited, but it is based on practical reasons: these seven were relatively straightforward to inventory. The eighth amenity that could be added to the list of basic amenities is the sport club. This is also often regarded as a social meeting place that strengthens the liveability of a village. Data about sport clubs could be derived from “De Bosatlas van Fryslân”, but the completeness of that inventory is not undisputed[3]. Also on-line listings could be used, but again this might not be of the needed accuracy and completeness.

An additional amenity of importance is the religious meeting place: in Frisian villages the church. Data about church buildings is available at the Provincial administration, but information about how often congregations are held is presumably less up-to-date. Also the determination of the church as a basic amenity is not so clear as the other eight.

12.2.3. Economy

Economy related factors are often linked to population development and population decline. In this research the topic of the economy is only treated by taking the employment into consideration. The topic of employment has three aspects: absolute employment within the core, relative employment within the core and absolute employment within a ten kilometre radius. All three aspects have in common that they describe a stable situation of the year 2006. Addition of the growth in employment between the years of 2000 and 2008 might prove beneficial.

Other economy related topics that might prove useful in research are for example average incomes and unemployment rates.

[1] Kadaster 2010
[2] Etil 2009
[3] Noordhoff Atlas Productions 2009

12.2.4. Other explanatory factors

In the conceptual model of this research (figure 3-2) six defined themes are described and one header called "unknown". Some elements of this group of unknown factors can be converted into known factors and some extra explanatory factors can be added.

An example of a possible relevant factor concerning housing is the "Water kansen kaart"[4]. This map is the result of a spatial multi criteria analysis to determine where the best options for the construction of new houses are. Locations where new housing is proposed this might have a positive influence on population development, whilst restrictions because of flooding risks might have a negative influence on population development.

12.2.5. Soft GIS

This research focuses on explanatory factors that are of a "hard" nature: statistical data, physical objects or clear contours made by policy makers. Together with the statistical analysis it makes research quite quantitative.

There are many clues that population development is not only explainable by using this hard data. Perception and the image of a village is a very important push- and pull factor. Some villages have a very good image and people like to live there, but it is hard to identify what causes this positive image. Because this image is hard to quantify and explain it does not mean it is not of importance. A way to overcome this situation is to introduce a so-called "soft" GIS methodology. This implies using local knowledge of citizens by letting them participate by means of a (web)GIS application[5].

A research could be commissioned where the inhabitants of Fryslân are asked to rate a number of villages they would like to live in and a number of villages they would not like to live in. This can be done in the form of a plain list of villages which can be georeferenced in a GIS application or people are asked to pinpoint the locations in a web-based GIS application. The advantage of the latter is that also other spatial entities can be utilized. For example by asking questions like: which road do you think is unsafe? Or what part of the landscape do you appreciate the most? Both can be regarded as important factors in the push- and pull constellation of migration.

12.2.6. Causality

As already described in both the scope of the research (chapter 4) as above, this research only states correlations between explanatory factors and population development, not their causality. In order to truly understand the phenomena of population development knowledge is needed about these relations. Is population development caused by the explanatory factors or is it vice versa? Or is the relationship both ways?

A method to research this is to focus on changes over time. Does the disappearance of a supermarket in 2004 lead to a sudden population decline in the following years? Or did the population decline started before 2004 and therefore forcing the supermarket to close? Research in this direction is very complicated because of the interrelated nature of all the factors.

[4] Samenwerken aan water 2010
[5] Kytta 2010

12.2.7. Spatial statistics

A key contribution of GIS in population development research is analysis by using maps. This gives key insights on spatial distribution of both population development as well as the explanatory factors. Applying "traditional" statistics on GIS processed information has proven to be a useful addition, albeit tricky. Applying spatial statistics, taking relations between factors and spatial relations in account, is determined very troublesome. More in-depth research on the addition of spatial statistics in population development research might lead to valuable results.

Regarding the spatial statistics analysis methods only two are applied in this research: average nearest neighbour and Moran's I. Two additional spatial statistics analyses could be implemented: Cluster and Outlier Analysis (Anselin Local Moran's I) and Hot Spot Analysis (Getis-Ord Gi*)[6]. The first is a local application of the Moran's I function and can be used to determine which areas close to each other have similar or opposite values. The latter determines which areas of the map are clusters of high or low values.

12.2.8. Monitoring and prognosticating population development

This research on the spatial factors behind population development gives insight in the relations and therefore a better understanding of population development and more specific, population decline. The results of this research can be used to monitor or even prognosticate population development. Therefore some explanatory spatial factors can be transformed into indicators. Examples could be the development of the housing stock or age composition.

[6] Mitchell 2005

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Appendix A: Data

General

Cores: points	
Name	Dorppunt
Data type	Point
Source	Internal GIS
Producer	Province of Fryslân
Description	This layer contains all the 416 Frisian cores represented as points
Year	2010

Cores: areas	
Name	Dorpsgebieden
Data type	Polygon
Source	Internal GIS
Producer	Province of Fryslân
Description	This layer contains all the 416 Frisian cores represented as polygons
Year	2010

Road network	
Name	OpenStreetMap
Data type	Lines
Source	
Producer	OpenStreetMap community
Description	An open source user generated road network dataset
Year	2010

Population characteristics

Inhabitants per core	
Name	Inwoners per kern
Data type	text
Source	Kerncijfers Fryslân
Producer	CBS
Description	The datasets contains the number of inhabitants per core for each year (first of January)
Year	2000-2008

Age composition	
Name	Bevolking naar leeftijd
Data type	Text
Source	CBS Statline (http://statline.cbs.nl/statweb/)
Producer	CBS
Description	Dataset that contains the age composition per neighbourhood
Year	2001

Average household size	
Name	Gemiddelde huishoudensgrootte
Data type	Text
Source	CBS Statline (http://statline.cbs.nl/statweb/)
Producer	CBS
Description	Dataset that contains the average householdsize per neighbourhood
Year	2001

Planning & Infra

Urban concentration zones	
Name	Kaart 2: Stedelijke bundelingsgebieden en woningbouwregio's (Streekplan Fryslân 2007)
Data type	Polygon
Source	Internal GIS
Producer	Province of Fryslân
Description	A layer file containing the urban concentration zones (NL: stedelijke bundelingsgebieden)
Year	2006

Main cities and regional cores	
Name	Kaart 3: "Complete" dorpen (Streekplan Fryslân 2007)
Data type	Point
Source	Internal GIS
Producer	Province of Fryslân
Description	A layer file containing the classification in main cites (NL:stedelijke centra) and regional centres (NL: regionale centra)
Year	2006

Recreational centers	
Name	Kaart 7: Recreatiekernen en toeristische netwerken (Streekplan Fryslân 2007)
Data type	Point
Source	Internal GIS
Producer	Province of Fryslân
Description	A layer file containing the locations of recreational cores
Year	2006

Ecologische hoofdstructuur	
Name	Kaart 11: Provinciale ecologische hoofdstructuur (Streekplan Fryslân 2007)
Data type	Polygon
Source	Internal GIS
Producer	Province of Fryslân
Description	A layer file containing the contours of the provincial EHS
Year	2006

National Landscapes	
Name	Kaart 9a: Nationaal Landschap Zuidwest-Fryslân; kaart 9b: Nationaal landschap Noordelijke Wouden (Streekplan Fryslân 2007)
Data type	Polygon
Source	Internal GIS
Producer	Province of Fryslân
Description	A layer file containing the point locations of railway stations
Year	2006

Railway stations	
Name	Kaart 5: Netwerkverbindingen (Streekplan Fryslân 2007)
Data type	Point
Source	Internal GIS
Producer	Province of Fryslân
Description	A layer file containing the point locations of railway stations
Year	2006

Highways	
Name	Nationaal Wegen Bestand (NWB)
Data type	Lines
Source	Internal GIS Province of Fryslân
Producer	Ministerie van Verkeer en Waterstaat
Description	Dataset containing all the roads in the Netherlands, from which the highways in Fryslân can be derived
Year	2010

Housing stock	
Name	Woningvoorraad
Data type	Text
Source	Kerncijfers Fryslân
Producer	CBS
Description	This dataset contains the housing stock per core in the years 2000 and 2007, form which the average annual change can be derived
Year	2000-2007

Amenities

Inventory primary schools	
Name	Inventarisatie basisscholen
Data type	Text
Source	BGI
Producer	Dienst Uitvoering Onderwijs – Centrale Financien Instellingen (DUO-CFI)
Description	A list containing the number of primary schools per core
Year	2008

Inventory general practitioner	
Name	Inventarisatie huisartsen
Data type	Text
Source	BGI
Producer	Regionale Ondersteunings Structuur (ROS) Friesland
Description	A list containing the number of general practitioners per core
Year	2008

Inventory community buildings	
Name	Inventarisatie dorpshuizen
Data type	Text
Source	BGI
Producer	Doarpswurk
Description	A list with all the Frisian cores that have a community building
Year	2008

Inventory supermarkets	
Name	Inventarisatie supermarkten
Data type	Text
Source	BGI
Producer	Werkgelegenheidsregister Fryslân
Description	Dataset contains all the employers in the province with the number of employees and field of work. A list containing the number of supermarkets and village shops per core is generated
Year	2006

Inventory banks	
Name	Inventarisatie banken
Data type	text
Source	BGI
Producer	Werkgelegenheidsregister Fryslân
Description	Dataset contains all the employers in the province with the number of employees and field of work. A list containing the number of banks per core is generated
Year	2006

Inventory postal agencies	
Name	Inventarisatie postagentschappen
Data type	text
Source	BGI
Producer	TNT Post (www.tntpost.nl)
Description	The website gives an overview of all the postal agencies in the Netherlands. A list with the number of postal agencies per is generated
Year	2010

Inventory nursing- and retirement homes	
Name	Inventarisatie verpleeg- en verzorgingstehuizen
Data type	Text
Source	BGI
Producer	Partoer
Description	A list containing the number of nursing- and retirement homes per core
Year	2008

Inventory access to public transportation	
Name	Inventarisatie toegang tot openbaar vervoer
Data type	Text
Source	BGI
Producer	Province of Fryslân: Afdeling verkeer & vervoer
Description	A list containing the cores that have at least one stop connected to regular public transportation.
Year	2009

Spatial locations of primary schools	
Name	Spatial locations of primary schools
Data type	Points
Source	GIS
Producer	Werkgelegenheidsregister Fryslân
Description	The WGR dataset contains spatial referenced locations of all employers from which the primary schools are derived.
Year	2006

Spatial locations of employers	
Name	Spatial locations of employers
Data type	Points
Source	GIS
Producer	Werkgelegenheidsregister Fryslân
Description	The WGR dataset contains spatial referenced locations of all employers including the number of employees
Year	2006

Appendix B: Creation of the road network of Fryslân

For the research on travel times from and to various specified locations in Fryslân a specified road network dataset is needed. Goal of this road network is to calculate travel times by car. This will be implemented in a GIS analysis in a desktop GIS application (ESRI ArcGIS). For this reason website based or satellite navigation based route planners are not applicable.

Two datasets are eligible for application: The NWB dataset (National road dataset) from Rijkswaterstaat and OpenStreetMap. OSM is a user generated and open source road map of the world[1]. The maps are updated daily. Because the calculation of travel time in the key functionality, both datasets are compared on how the roads are classified. The OSM dataset is determined to be better classified and it includes more road segments with stated maximum speeds.

The procedure of the creation of the road network consists out of four basic parts: acquiring and preparing of the data, processing road segment data, the creation of the network and calibration. This last step is added because of the perceived oversimplification of this modelled road network. The followed procedure is described below and graphically represented in figure 1.

[1] http://www.openstreetmap.org/

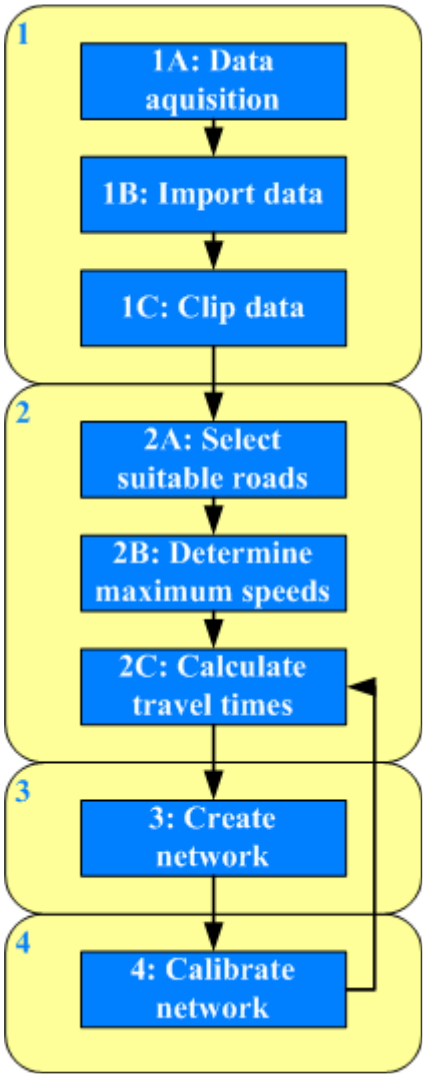


Figure 1: procedure to create car and cycling networks

Part 1: acquiring and preparing the data

1A: acquisition of data

The used dataset is downloaded in a shapefile format from a server of Geofabrik[2]. The specifications are:

Name dataset: Netherlands.shp.zip
Production date: November 2 2009
Downloaded from: http://download.geofabrik.de/osm/europe/
Used layer: roads

1B: importing data

To be sure the OSM data is interoperable with the other geo-data used in this research it is imported into a feature dataset within the geodatabase. Important is that the projection of the data is equal to the rest of the data and the standard used by the provincial administration of Fryslân: the Rijksdriehoeksstelsel.

[2] http://download.geofabrik.de/osm/europe/

1C: clipping
The extent of the roads layer is the whole of the Netherlands, this is regarded as unnecessary. Therefore the road layer is clipped to the size of the province of Fryslân with a buffer of 10 km in order to model shortest paths outside of the provincial perimeter.

Part 2: process road segment data
2A: selecting suitable roads
The roads layer of the OSM dataset contains many types of roads, not all accessible by car. Therefore the appropriate road types need to be selected. The classification of road types is given by the OSM community and described on their website[3]. This road classification determines highway tags and these are primarily based on the road network of the United Kingdom. In table 1 all the road types determined as suitable for cars are listed. Unpaved roads are not regarded suitable.

2B: determine maximum speeds
In order to calculate driving time, the maximum speed for all the road segments is needed. 28% of the road segments have been assigned a maximum speed by the OSM community, but the other 72% lack an assigned maximum speed. From the road segments with an assigned maximum speeds this is copied. For the other road segments a maximum speed is determined based on their road class and the maximum speeds map by Rijkswaterstaat[4]. Determining maximum speeds by road class means generalization, ignoring specific road segment values. The determined maximum speeds are stated in table 1.

2C: calculate travel times
The time it takes to traverse a road segment can be calculated with the following formula:

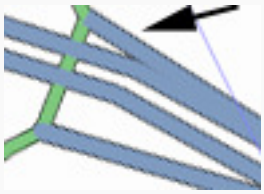
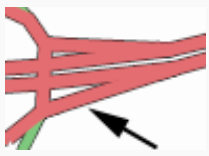
$$Time_{(\min)} = \frac{LengthOfSegment_{(m)}}{Speed_{(km/h)} * 1000} * 60$$

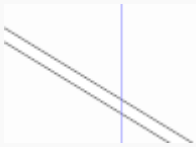
For the speed variable the maximum speed of the road segment is used. The length of each road segment is calculated, so with both variables known, the travel time for each road segment can be calculated.

Table 1: Relevant road (highway) classifications

Type	Description[5]			Max speed (km/h)
motorway	A restricted access major divided highway, normally with 2 or more running lanes plus emergency hard shoulder. Equivalent to the Freeway, Autobahn, etc.			120

[3] http://wiki.openstreetmap.org/wiki/Key:highway
[4] http://www.maximumsnelheden.info/kaart.php
[5] Described on: http://wiki.openstreetmap.org/wiki/Key:highway

Motorway_link	The link roads (sliproads/ramps) leading to/from a motorway from/to a motorway or lower class highway. Normally with the same motorway restrictions.			120
trunk	Important roads that aren't motorways. Typically maintained by central, not local government. Need not necessarily be a divided highway. In the UK, all green signed A roads are, in OSM, classed as 'trunk'.			100
Trunk_link	The link roads (sliproads/ramps) leading to/from a trunk road from/to a trunk road or lower class highway.			100
Primary	Administrative classification in the UK, generally linking larger towns.			70
Primary_link	The link roads (sliproads/ramps) leading to/from a primary road from/to a primary road or lower class highway.			70
Secondary	Administrative classification in the UK, generally linking smaller towns and villages			70
Secondary_link	The link roads (sliproads/ramps) leading to/from a secondary road from/to a secondary road or lower class highway.			70
Tertiary	A "C" road in the UK. Generally for use on roads wider than 4 metres (13') in width, and for faster/wider minor roads that aren't A or B roads. In the UK, they tend to			70

	have dashed lines down the middle, whereas unclassified roads don't.			
Unclassified	No administrative classification. Unclassified roads typically form the lowest form of the interconnecting grid network. Note: This is *not* a marker for roads where we still need to choose a highway tag (see **highway**=road for roads that require classification).			50
Road	road of unknown classification. This is intended as a temporary tag to mark a road until it has been properly surveyed. Once it has been surveyed, the classification should be updated to the appropriate value.			50
Residential	Roads accessing or around residential areas but which are not a classified or unclassified highway.			50
Living_street	A street where pedestrians have priority over cars, children can play on the street, maximum speed is low. In the UK this is called "Home Zone".			50
Service	Generally for access to a building, motorway service station, beach, campsite, industrial estate, business park, etc.. This is also commonly used for access to parking and trash collection. Sometimes called an alley, particularly in the US. Use with service=*, e.g.			50

	service=parking_aisle to mark a service way inside a amenity=parking			

Part 3: Creation of road network

The individually processed road segments are needed to be integrated into one road network in order to apply travel time calculations. The network impedance on which the travel times will be based is set to be the travel time by car. Additionally, the road net work is created with a minimum of limiting settings. Elevation, one-way streets and turns are not modelled.

Part 4: Calibration network

Because the road network is modelled in a simplistic manner (disregarding one-way traffic, turns, traffic lights, etcetera) the travel time is lower than the real life situation. In order to cope with this effect 10 routes are calculated and compared with renowned internet route planning websites: Google Maps[6] and ViaMichelin[7]. Test results are listed in table 2.

Table 2: Car travel times calculations by OpenStreetMap based model (OSM), Google Maps (GM) and ViaMichelin (VM)

No	Departure address:		Destination address:		OSM	GM	VM	Avg	Factor
1	Jansoniusstraat	Leeuwarden	Lage Esch	Oosterwolde	31	44	42	43	1,39
2	Meerweg	Stavoren	Bronlaan	Dokkum	62	88	87	87,5	1,41
3	Waddenpromenade	Harlingen	Metaalstraat	Wolvega	39	49	46	47,5	1,22
4	Doctor Postmastraat	Buitenpost	Partuurstraat	Sneek	38	49	50	49,5	1,30
5	Kievit	Lemmer	Kerkeveen	Appelscha	41	56	57	56,5	1,38
6	Sterappel	St. Annaparochie	Lauwersweg	Suurhuisterveen	35	55	46	50,5	1,44
7	Tjalk	Franeker	Scholeksterstraat	Heerenveen	29	39	36	37,5	1,29
8	De Warren	Joure	De Vlieren	Veenwouden	31	42	40	41	1,32
9	De Oppers	Bolsward	Nijkamp	Harkema	38	50	49	49,5	1,30
10	Fugelikkers	Workum	Robijnekamp	Drachten	42	49	48	48,5	1,15
							Average:		1,32

The travel time of Google Maps and ViaMichelin is averaged and the factor between that travel time and the generated OSM network is calculated. The original car travel time of step 2C is adjusted with this factor and the car network is generated again.

Limitations

The generated road network model is a simplification of reality. It can be used for global travel time determination, but some main limitations need to be accounted for:

- Travel speed is determined equal to assumed max speed of the road segment
- The max speeds of the road segments are not always reliable
- Turns and traffic lights are not modelled
- One-way traffic is not modelled
- The limitations of the above four points are party undone by the calibration of the car network, but this only leads to a global fit
- Traffic congestion is not modelled
- Travel time is modelled and measured between centres of the cores.

[6] http://maps.google.com/
[7] http://viamichelin.com/