PUSH AND PULL FACTORS THAT CONTRIBUTE TO LAND USE CHANGE

Bachelor thesis spatial planning
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PUSH AND PULL FACTORS THAT CONTRIBUTE TO LAND USE CHANGE

A GIS based research about the push and pull factors that dictate dairy farming land use change over a 12 year period 2000-2012.

Bachelor thesis Spatial planning

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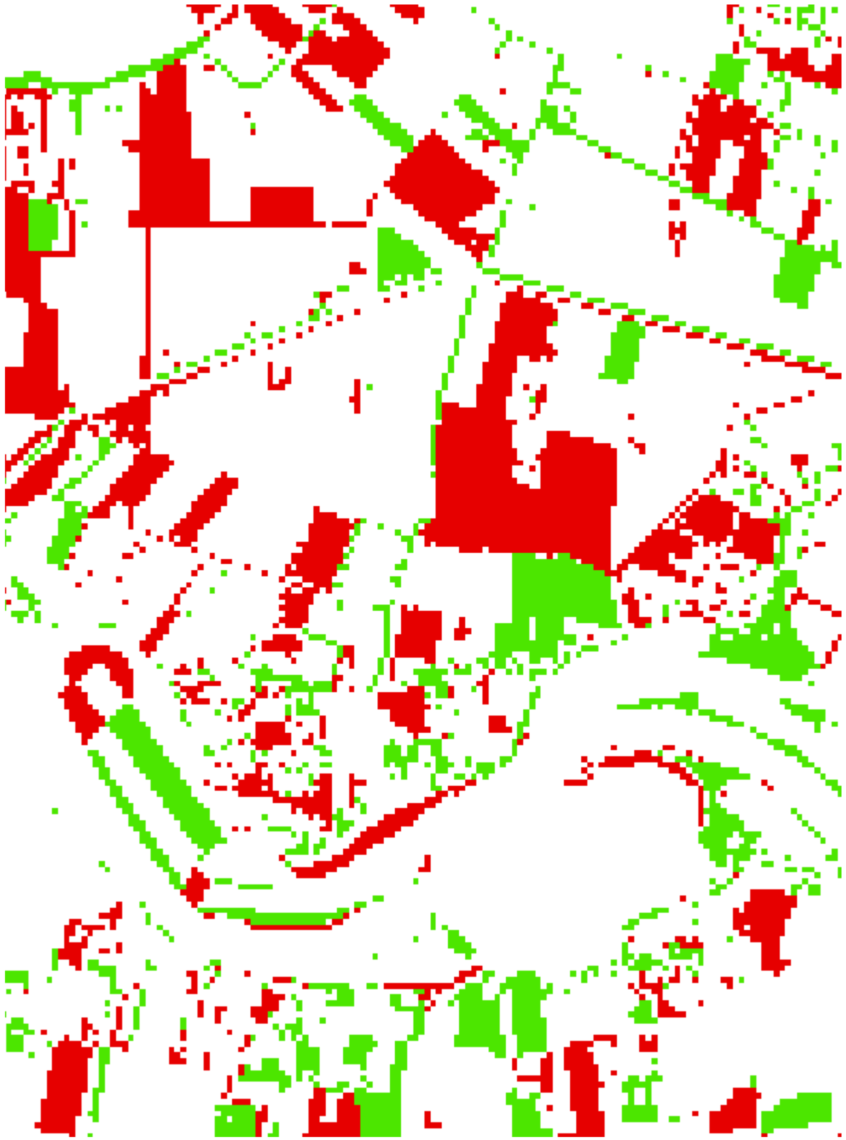


ABSTRACT

This paper analyses the causes that dictate dairy farming land use change. The causes are split up in two parts, the push and the pull factors. Pull factors are the attributes that make distant places appear appealing. Push factors are the life situations that give reason to dissatisfaction with the present location.

In short this research focuses on the reason why dairy farming leaves a certain place and allocates at another. To test what the push and pull factors are a hypothesis is set up. The hypothesis for push factors states that the push factors are mainly urban sprawl and the development of new nature. The hypothesis for pull factors states that the main pull factors for dairy farming are distance to the market, economies of agglomeration and plot prices.

To analyse whether these hypothesises can be accepted a research is done based on the LGN databases. The databases show the land use at 2000, 2004, 2008 and 2012. At first a transition matrix is set up so the changes that occurred between 2000 and 2012 are visible. The transition matrix shows that the main push factors are indeed urban sprawl and nature developments but is also shows that dairy farming is often pushed away by arable farming. The transition matrix also showed which land uses transformed into the new locations for dairy farming. Mainly arable farming land uses where used for the allocation of dairy farming. To analyse what the pull factors of these locations are the plots that stayed arable farming where compared to the plots that transformed from arable farming into dairy farming. With a multiple regression analysis it became clear that the amount of dairy farming neighbours (economies of agglomeration) dictated the occurrence of new dairy farming lands.

Overall the results of this research can be of importance to spatial planners. When understanding cause-consequence relations the impact of new plans can be known in advance. Still a lot of research is needed before planners can model the impact of their plans, this research only investigated a small part of push and pull factors that dictate dairy farming land use change.

CONTENTS

INTRODUCTION

Land use is the most visible result of human interaction with the environment. Almost the whole earth has been altered by mankind with the exception of the most remote deserts, mountains and deep seas (Koomen et al, 2008, a). Agricultural settlement has a long 10,000-year history. Within these years the land use change of agriculture has been scattered in space and time. Large changes occurred long ago in Europea, Asia, Africa and Mesoamerica (Houghton, 1994). Land use changes in the past were scant compared to current day changes. Current day land use changes are so pervasive that they affect key aspects of system Earths functioning. Land use changes determine the vulnerability of certain places to effects like climate, economic and socio-political changes (Lambin et al, 2001). It is of great importance that planners and policy makers understand those changes in advance (Verburg et al, 2004, a). To understand those changes historic land use patterns, have to be analysed. In this way cause-consequence relations can be identified.

For the past decade the land use in the Netherlands has changed. One of the reasons that the Netherlands is changing is the heavy urbanisation pressure, having a land surface of approximately 4 million hectares and being inhabited by 16 million people (Koomen et al, 2008, b). Some land uses are very dominant in economic purchasing power like urban land uses. Urban sprawl pushes other land uses like agricultural land away. The land uses that are driven away either decrease in total size or they find a new place to settle. The disappearance of land uses can be explained by the indirect land use change theory(ILUC) (Plevin et al, 2010). ILUC has a big impact on the land cover of the Netherlands, since land uses reallocate to other countries the land cover of the Netherlands changes.

PROBLEM DEFINITION

The land use of the Netherlands is constantly changing. Land use change can be explained by a complex interaction of behavioural and structural factors. These factors can be associated with demand, population growth, social relations, economic growth, technology and the nature of the environment in question (Verburg et al, 2004, b). According to Turner transformations in land use are not easy to analyse nor to provide a simple explanation (Turner et al, 1990). Despite the complexity it is of great importance to understand land use changes. Why do certain land uses outcompete other land uses and what aspects determine whether a location attracts new land uses? Aspects that attract new land uses can be seen as pull factors while aspects that drive land uses away can be seen as push factors. But what pushes a land use away and what pulls a land use? Answers to these questions could help spatial planners and policy makers with designing appropriate policies and plans. Also understanding land use change would help with the prediction of future land use change. Knowing the consequences of a certain change in advance helps with the decision making.

Because of the complexity of change this research will only focus on agricultural land use changes and in particular dairy farming. Dairy farming is one of the main agricultural sectors in the Netherlands, around 2013 this sector used 61 hectares of infield and produce around 1,1 million kg milk (K&K, 2013). Dairy farming is both in size and economically a leading agricultural sector in the Netherlands and therefore chosen to investigate in this research.

Also a small part of agricultural land is chosen because even within agricultural land use one can distinguish six types of land: dairy farming, arable farming, vegetable growing, fruit growing, flower growing and tree nursery. All those types of agricultural land uses have their own characteristics it would be too complex for this thesis to identify these characteristics.

RESEARCH QUESTIONS

Land use change is driven by a lot of different factors. For this research the factors that determine land use change in dairy farming are analysed. The indistinctness about which factors dictate the land use change in dairy farming leads to the following research objective:

"Explaining the current dairy farming land use patterns by analysing the push and pull factors that dictate dairy farming land use change"

And the general research question:

"Which push and pull factors dictate dairy farming land use change?"

This research is a quantitative research that uses a GIS- and literature analysis to investigate which push and pull factors dictate the dairy farming land use change. To structure this research a few sub questions are drafted. The answers to the sub questions lead to the answer of the main research question. In the main research question push and pull factors are mentioned. This research will mainly focus on the pull factors that attract dairy farming because the push factors are more apparent. Also the push factors will be briefly analysed, but this is not the main focus of this research.

1. What are the changes in dairy farming land uses over the period 2000 till 2012?
2. What are push factors that drive dairy farming away?
3. What are the pull factors that attract dairy farming?

OPERATIONALIZATION

The main research question introduced 3 concepts: dairy farming, push factors and pull factors. In the following paragraphs the interpretation of these concepts are put apart.

DAIRY FARMING

Dairy farming is one of the biggest agricultural land uses and therefore of interest for this research. In this research it is assumed that dairy farming includes maize and agricultural grassland. The agricultural grasslands are used to let the animals graze and the maize is used to feed them (Diogo et al, 2015). For dairy farming milk is the main product, since maize and grasslands are needed for this production these two land uses are the base for the calculations for milk production.

A regulation that influences the dairy farming land use is the "Mestwetgeving". This legislation states that farmers have to be able to process all the excess manure. Farmers can only expand their businesses when they have enough land to drive out their excess manure (RVO). The expansion of dairy farming companies is therefore dependent on the "Mestwetgeving" and influences the land use in the Netherlands.

PUSH-PULL MODEL

In migration literature push and pull factors are a regularly used terms. In land use change literature this is not commonly used. In this research about land use change these terms are used. The terms are based on the theories of geographer Ernst Ravenstein. He stated that you can formulate a migration process as push factors and pull factors. Pull factors are attributes that make distant places appear appealing. Push factors are life situations that give reason to dissatisfaction with the present location (Dirogo and Tobler, 1983).

In this research the allocation of the land use dairy farming is seen as the migration. Dairy farming is pushed away from a certain location and pops up at another location. The factors that lead to the allocation of dairy farming are the push factors while the pull factors are the attributes that attract dairy farming to the new location.

PUSH FACTORS

Push factors in this research are factors that drive dairy farming away from their original location. An example of a push factor is when a farmer gets a significant amount of money to move away, or when urban sprawl takes away all the possibilities for a farmer to expand his business.

PULL FACTORS

Pull factors are factors that attract dairy farming to another location. An example of a pull factor are inexpensive plots or good access to transport systems.

HYPOTHESIS

For the push factors it is expected that urban sprawl and the creation of new nature are the causes. In the Netherlands central government and the EU provided push factors like EHS (National Ecological network) and Natura 2000 making it farmers increasingly difficult to maintain their traditional land-use practices. On top of that the central government has set the goal to transform 42,000 ha of agricultural land into nature (Leneman, 2014). Based on these goals the expectation is that dairy farming is losing surface and is not regaining all the lost surface in the Netherlands. Agricultural land is usually not as well protected as nature so when in conflict nature will always win. The same goes for urban developments. Urban developments are always more profitable than agricultural land so again when in conflict urban developments will always win (Koomen et al, 2008, b). This relation is shown in figure 1. Urban areas have been expanding over the past years. From 1989 till 2008 the urban areas have increased with 16% (PBL). The expectation is that agricultural land had to give place for urban developments.

For the pull factors three factors are possible explanations of the dairy land use change:

1. *Distance to market*. It is expected that areas that are well connected to dairy farming markets, are chosen as a new location. Since the abolishment of the "melkquotum" prices of milk have dropped. According to the LTO (The Dutch organisation for agriculture and horticulture) the milk prices have been extremely low, 25 cents per litter. This is eight to ten cents under cost price which means that dairy farms lose money on the production of milk (LTO). Seen the fact that the milk prices are extremely low one would expect that farms want to decrease transportation cost and locate near markets.
2. *Economies of agglomeration*. It is expected that areas where other dairy farming companies are situated are attractive for new dairy farming locations.
3. *Last option*. It could be that dairy farming does not have any other option than to go to the last possible locations. The last possible option in this research is that the dairy farmers buy the cheapest possible plots to allocate their business.

Whether the above mentioned possible push and pull factors dictate the dairy farming land use change will be investigated in the following research.

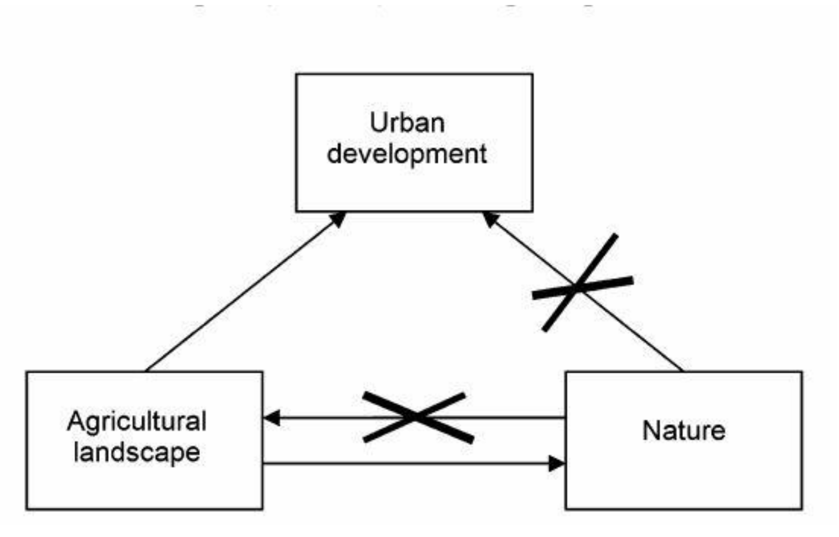


Figure 1 Agricultural versus urban versus nature (Koomen et al, 2008, b)

RESEARCH DESIGN

To answer the main research question *"Explaining the current dairy farming land use patterns by analysing the push and pull factors that dictate dairy farming land use change"* a few steps have to be made. At first the change in land use has to be analysed. What land uses are replaced and if so what did replace them? When the changes are clear the reason for the changes (push and pull factors) have to be identified.

THEORETICAL FRAMEWORK

In the following subsections the theories that are used to analyse whether the hypothesis can be accepted or not are explained.

DETERMINANTS OF LAND-USE CHANGE

A lot of methodological approaches about location choice exist, not one of them explains the land use correctly so often combinations of the theories are used. According to Koomen seven methodological approaches are used to explain land-use patterns and their dynamics. The first approach are *the economic principles.* These principles take all the costs into consideration when choosing a location that suits the land use best. The second approach is the theory of *spatial interaction*. In this theory it is assumed that interaction between two entities is dependent on the size and distance between the two. The third approach is the theory of *cellular automata*. In this approach every land use grid-cell is in a certain state that can be influenced by his neighbour cells. If or when a cell changes is dependent on pre-set transition rules. Cellular automata is a method to simulate spatial interaction. The forth approach is the theory of *statistical analysis*. This approach uses regression analysis to quantify the contribution of a force to the land use change. The fifth approach is the theory of *optimisation techniques*. Optimisation techniques calculate what the optimal land use should be given a set of prior criteria, this means that within optimisation economic theories are implemented. The sixth approach is the theory of *rule-based simulations*. Rule-base simulations can only explain already known processes. The seventh approach is the theory of *the multi-agents*. Multi agents try to simulate human decision making (Koomen et al, 2008).

As mentioned in the hypothesis three factors are possible explanations of the dairy farming land use change in the Netherlands: distance to market, last option and economies of agglomeration. These factors are based on the statistical analysis methodology. Statistical analysis is chosen in this research because the allocation process of dairy farming is unknown and therefore the data itself has to identify the driving forces of dairy farming land use change.

Methodological approaches like cellular automate, multi-agents and spatial interaction are not used because the allocation of dairy farming is not an understood process and can therefore not yet be simulated. Economic theories are not used in this research because these theories usually do not explain allocation as in empiricism.

DISTANCE TO MARKET

In economic theory a lot has been written about the distance relations between the market and the land use. Ricardo introduced the first theory called law of rent. He stated that rent is dependent on the quality of the soil and the scarcity of the land (Ricardo and Mcculloch, 1846). Von Thünen stated that the location of an activity was dependent on the transportation costs and the distance to the markets (Grotewold, 1959). But are those theories still applicable in a changing world? Due to the decrease in transport costs it is no longer necessary to be situated near a commodity (Tubachi, 1998). One of the assumptions made in the hypothesis is that the land use change of dairy farming is dependent on the distance to the market.

To determine what the markets are it is necessary to understand the milk transportation process. At first a distinction is made in cooled and uncooled milk. Uncooled milk has to be transported to a collection point with cooling, even though the tank or truck is nog fully loaded. The transportation of uncooled milk has to be a lot faster and is therefore less efficient. Usually small companies transport uncooled milk. Cooled milk has a lower probability of getting contaminated, this means that cooled milk can be stored a lot longer. In figure 2 the transportation route for cooled and uncooled milk is show (Delaval).

Knowing how the milk transportation process works it is clear that markets not only involve the selling points but also storage points to cool the milk.

ECONOMIES OF AGGLOMERATION

Agglomeration economies are the benefits that come when firms locate near to each other. These benefits are a decrease in transportation costs and the exchange in goods like people, ideas and information (Glaeser, 2007). For dairy farming agglomeration clusters would decrease costs in for example storage of milk and transportation costs. In Figure 2 the transportation scheme is shown. When farms cluster the transportation cost to and from a collection point would decrease a lot. Also the farms that transport uncooled milk can collect their milk together, this minimizes transport costs because it would occur less than a half empty truck has to transport milk.

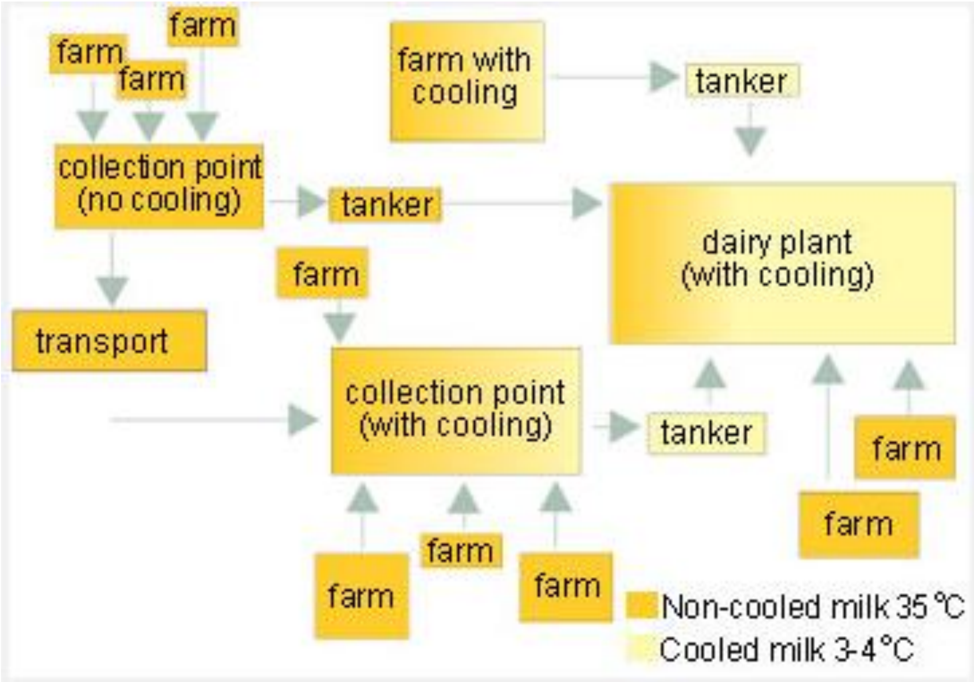


Figure 2 Transportation scheme (Delaval)

LAST OPTION

In this research the last option to choose a new location for dairy farming is based on the choice for the lowest plot prices. Usually the choice for a location is dependent on more factors than just the lowest plot price. Of course a low price is always a positive asset, but not the main driver (Filatovea et al, 2009). In this research the last option for location choice is purely based on economic driving forces, famers do not have another option than to look at the finances when allocating.

FRAMEWORK APPLICATION

All the above mentioned theories will be used to determine what caused the current dairy farming land use patterns. At first the changes in time have to be analysed. These changes will be identified with a grid-by-grid analyses. The LGN 7 and the LGN 4 will be used to determine where dairy farming left and where it reoccurred. The LGN 5 and LGN 6 will also be analysed, this will identify abrupt changes. The second step is identifying areas (Gemeenten) where net more dairy farming left and areas where net more dairy farming came. For the areas where dairy farming left the push factors that are listed in the hypothesis have to be tested. Are these push factors really the reason that dairy farming was pushed away to another location? For the areas where dairy farming came the pull factors have to be identified, are economies of agglomeration, a good transport network or plot price the reason for allocation?

METHODS

In the following paragraphs the methods used per individual sub-research questions are explained. The order of the questions is of importance because the next question cannot be answered without the results of the previous question.

THEORY OF METHODS

To determine what the push and pull factors were that dictate the land use change a few methods are used. Most of the methods are executed in ArcMap. The rationale behind these methods are explained per sub-research question where the method was used.

METHODS SUB-QUESTION 1: DETECTING LAND USE CHANGE IN DAIRY FARMING

The first sub-research question was:

What are the changes in dairy farming land uses over the period 2000 till 2012?

LGN DATABASES

To analyse what the dairy farming land use changes are the LGN datasets were used. The LGN databases are land cover datasets that are based on satellite images (landsat TM and SPOT). These satellite images are reclassified according to a number of land use classes (Thunnissen and de Wit, 2000). Currently there are seven LGN databases available. The first three LGN databases have a very different classification system, therefore these LGN databases are not used in this research. The other four LGN databases have a more comparable classification system, see annex 1 for the complete classification legend per LGN database.

In table 1 below information about the four LGN databases that are used in the research are shown.

Table 1 LGN databases

LGN	Year	Classes
LGN4	1999, 2000	47
LGN 5	2003, 2004	46
LGN 6	2007, 2008	46
LGN 7	2012	46

The LGN datasets contain 46 or 47 land use classes and do not all have the same content. For example, LGN 4 and 5 do not contain fruit farming while LGN 6 and 7 do. To get a comprehensive picture of the land use change a land use change map was made. The change map will show all the land uses that transformed into another land use. But first the four LGN databases have to be aggregated.

RECLASSIFICATION

To be able to compare data the data used had to be in the same format. In this research the LGN 4, LGN 5, LGN 6 and LGN 7 are used. These LGN databases do not have the same values and as shown in table 1 above not even the same amount of classes.

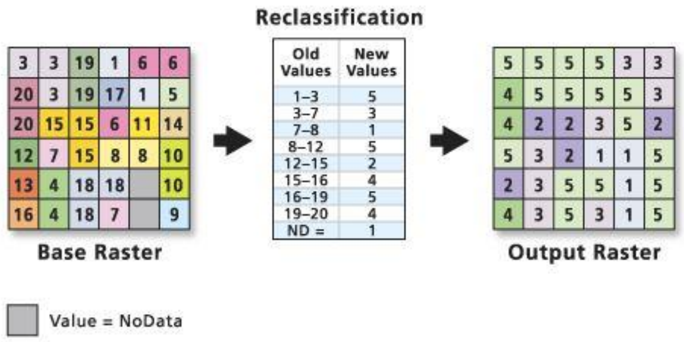


Figure 3 reclassify (Esri 1)

In figure 3 an example of reclassification is shown. The reclassification tool in ArcMap aggregates data. For this research it is necessary to aggregate data because for example dairy farming exists out of agricultural grassland and maize. In table 2 below the aggregation of 4 types of agricultural land use is shown.

Table 2 Aggregation agricultural land

Agricultural type	Aggregation
Dairy farming	Gras and Maize
Arable farming	Potatoes, grain and remaining crops, beets
Tree nursery	Orchards and nurseries
Flower growing	Bulbs
Remaining	This category includes fruit growing if this class is mentioned in the LGN database

The reclassification has been done in ArcMap with the reclassify tool in the spatial analyst toolbox. Table 3 below shows the classes in the LGN databases after reclassification.

Table 3 Reclassification classes

	Number of classes	Classes
Aggregation of all land uses	9	Dairy farming, arable farming, tree nursery, flower growing, water, nature, urban, transport and remaining

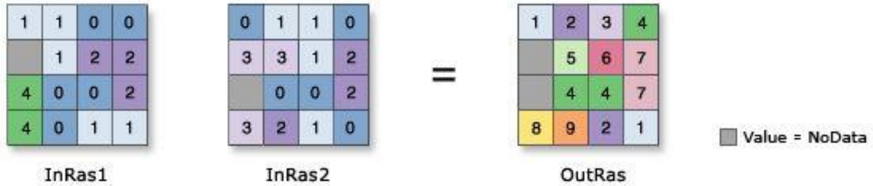
After the aggregation the data was used to determine the changes in dairy farming between 2000 and 2012. This data had to be graphic and numeric. This was done with the combine tool. The combine tool does a grid-by-grid analysis and sets a transition matrix up.

GRID-BY-GRID ANALYSIS

With a grid-by-grid analysis two raster layers are compared to each other. Two raster's are combined so that a unique output value is assigned to each unique combination of input values. The result of a grid-by-grid analysis is a map that shows all the gains and losses of dairy farming between 2000 and 2014.

TRANSITION MATRIX

A transition matrix shows the transition between raster A and raster B. In figure 4 this transition is shown. When comparing the LGN databases with each other these transition matrixes are of importance because they show what land use is replaced by or replaces other land uses.



Value	Count	Code
0	5	002
1	5	004
2	3	005
4	2	008

Value	Count	Type
0	5	PAX
1	4	HAR
2	3	WIN
3	3	SAN

Value	Count	InRas1	InRas2
1	2	1	0
2	2	1	1
3	1	0	1
4	3	0	0
5	1	1	3
6	1	2	1
7	2	2	2
8	1	4	3
9	1	0	2

Figure 4 Transition matrix (Esri 2)

The result of the grid-by-grid was a map that showed all the changes. The transition map of all land uses has 81 different classes. This is quite simple because you compare two datasets that both have 9 classes, so the possible number of combinations is 81. All the *'number of classes'* in the LGN 4 are set to times ten. When calculating the sum of the 'number of classes' from the LGN 4 and LGN 7 it is easy to see what changed in the grid cell. For example the land use in grid cell x was in the LGN 4 arable which sets the number of classes to 20, the land use in the LGN 7 is dairy farming which sets the number of classes to 1. Calculating the sum gives 21, so what used to be arable farming changed into dairy farming.

It is hard to say something about the transition matrix and therefore the maps are aggregated to municipality level. This means that every municipality shows whether net more dairy farming left or whether net more dairy farming came. The aggregated municipality maps should show a spatial pattern of the change in dairy farming land use. The aggregated municipality map was made with the zonal statistics tool.

ZONAL STATISTICS

Zonal statistics is a function in ArcMap that calculates statistics on values of raster within the zone of another dataset. This means that you can calculate: minority, minimum, maximum, majority, mean etc. of a raster dataset within a given polygon shapefile. The result of the zonal statistics will be a map that shows the average gain or loss for dairy farming per municipality. In figure 5 the zonal statistics are schematically drawn. The zone layer and the value layer combined give the average statistics within the zone.

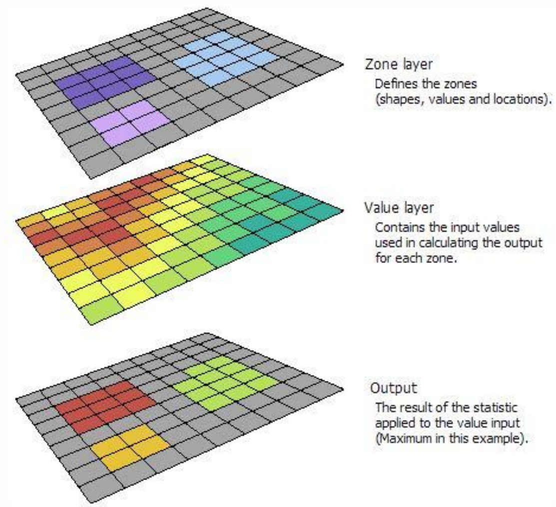


Figure 5 Zonal statistics (Esri 3)

Before it was possible to use the zonal statistics tool all the grid-cells that did not change between 2000 till 2012 and other land uses than dairy farming had to be filtered out of the grid map. The majority of the grid-cells did not change and this will lead to an aggregated municipality map that visualises no change. To visualise the change, the grid-cells with a number that did not show dairy farming losses or gains where filtered out. This was done with the set null tool in the spatial analyst. With the following SQL code, the following values where set to NoData.

```
VALUE = 11 OR VALUE = 22 OR VALUE = 33 OR VALUE = 44 OR VALUE = 55 OR
VALUE = 66 OR VALUE = 77 OR VALUE = 88 OR VALUE = 99 OR VALUE = 23 OR
VALUE = 24 OR VALUE = 25 OR VALUE = 26 OR VALUE = 27 OR VALUE =28 OR
VALUE = 29 OR VALUE = 32 OR VALUE = 34 OR VALUE = 35 OR VALUE = 36 OR
VALUE = 37 OR VALUE =38 OR VALUE = 39 OR VALUE = 42 OR VALUE = 43 OR
VALUE = 45 OR VALUE = 46 OR VALUE = 47 OR VALUE =48 OR VALUE = 49 OR
VALUE = 52 OR VALUE = 53 OR VALUE = 54 OR VALUE = 56 OR VALUE = 57 OR
VALUE = 58 OR VALUE = 59 OR VALUE = 62 OR VALUE = 63 OR VALUE = 64 OR
VALUE = 65 OR VALUE = 67 OR VALUE = 68 OR VALUE = 69 OR VALUE = 72 OR
VALUE = 73 OR VALUE = 74 OR VALUE = 75 OR VALUE = 76 OR VALUE = 78 OR
VALUE = 79 OR VALUE = 82 OR VALUE = 83 OR VALUE = 84 OR VALUE = 85 OR
VALUE = 86 OR VALUE = 87 OR VALUE = 89 OR VALUE = 92 OR VALUE = 93 OR
VALUE = 94 OR VALUE = 95 OR VALUE = 96 OR VALUE = 97 OR VALUE = 98
```

After this the zonal statistics tool is used to aggregate the data (only the cells that show the losses and gains for dairy farming). The municipality map that shows all the borders of the municipalities is used as the zone layer, the grid map that shows the losses and gains for dairy farming between 2000 and 2012 was used as the value layer. The function majority is used to calculate whether the majority of the dairy farming lost land or gained land per municipality. The ignore NoData is checked in the zonal statistics window. This results in a map that shows per municipality if the municipality net gained more dairy farming land or net lost more dairy farming land.

METHODS SUB-QUESTION 2: IDENTIFYING PUSH FACTORS

As seen in previous results dairy farming is mainly driven away by 1. Nature 2. Arable farming 3. Urban areas. In this part of the research a literature analysis will be used. In the hypothesis it was expected that dairy farming would be driven away by nature and urban areas, it was not expected that the land use would be replaced by arable farming. To answer this sub-research question a literature review is conducted. With the literature research it has to become clear why dairy farming is pushed away by nature, urban areas and in particular arable farming.

METHODS SUB-QUESTION 3: IDENTIFYING PULL FACTORS

As mentioned in the hypothesis possible pull factors are economies of agglomeration, distance to market and last option. To investigate whether distance to the market, economies of agglomeration and last option have an influence on the occurrence of dairy farming, the grid cells that represent arable farming that changed into dairy farming (change) where compared to the grid cells where arable farming stayed arable farming (no-change). In the previous sub-research question it became clear that new dairy farming lands usually replaces arable farming lands (see figure 9). By comparing the places where arable farming stayed arable farming (no-change) with the locations where arable farming changed into dairy farming (change) the pull factors can be identified.

SAMPLING METHODS

The datasets used in this research are very detailed which means that sometimes the amount of data is too much to process for programs like ArcMap and SPSS. To decrease the amount of data the random sampling method in ArcMap is used. This method assigns random numbers between 0 and 1 to all rows and after that sorts all the values between 0 and 1 ascending. When the numbers are sorted the first X rows are chosen depending on the number needed for the sampling.

The points that are randomly sampled were used for all the three factors (distance, last option and economies of scale) and therefore needed to be at the exact same location. For arable and dairy farming the same amount of points have to be drawn. 1400 grid cells that did not undergo change (i.e. where arable stayed arable) where randomly selected and 1400 grid cells that did undergo change (i.e. where arable changed into dairy) are randomly selected.

MULTIPLE LOGISTIC REGRESSION

To analyse if the locations for dairy farming where different in terms of distance to the market, economies of agglomeration and plot price from the plots that stayed arable farming, a logistic regression analysis was performed, with change (1) and no-change (0) as the dependent variable and distance to market, agglomeration and plot price as independent variables. The logistic model describes the expected value of the land use change or the probability of a land use change depending on the formula used (Bakker et al, 2005).

DISTANCE TO MARKET

To analyse whether distance is a pull factor, the distance to the market was calculated from all the arable and dairy grid cells. To do this the change (1) and no-change (0) had to be filtered out of the transition matrix. This was done again with the set null tool in the spatial analyst. With the following SQL code all the values that are not 22 or 21 are set to NoData. (22 = arable stays arable, 21 = arable changes into dairy farming).

```
VALUE = 11 OR VALUE = 12 OR VALUE = 13 OR VALUE = 14 OR VALUE = 15 OR
VALUE = 16 OR VALUE = 17 OR VALUE = 18 OR VALUE = 19 OR VALUE = 23 OR
value = 24 OR VALUE = 25 OR VALUE = 26 OR VALUE = 27 OR VALUE = 28 OR
VALUE = 29 OR VALUE = 33 OR VALUE = 44 OR VALUE = 55 OR VALUE = 66 OR
VALUE = 77 OR VALUE = 88 OR VALUE = 99 OR VALUE = 23 OR VALUE = 24 OR
VALUE = 25 OR VALUE = 26 OR VALUE = 27 OR VALUE =28 OR VALUE = 29 OR
VALUE = 31 OR VALUE = 32 OR VALUE = 34 OR VALUE = 35 OR VALUE = 36 OR
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VALUE = 43 OR VALUE = 45 OR VALUE = 46 OR VALUE = 47 OR VALUE =48 OR
VALUE = 49 OR VALUE = 51 OR VALUE = 52 OR VALUE = 53 OR VALUE = 54 OR
VALUE = 56 OR VALUE = 57 OR VALUE = 58 OR VALUE = 59 OR VALUE = 61 OR
VALUE = 62 OR VALUE = 63 OR VALUE = 64 OR VALUE = 65 OR VALUE = 67 OR
VALUE = 68 OR VALUE = 69 OR VALUE = 71 OR VALUE = 72 OR VALUE = 73 OR
VALUE = 74 OR VALUE = 75 OR VALUE = 76 OR VALUE = 78 OR VALUE = 79 OR
VALUE  = 81 OR VALUE = 82 OR VALUE = 83 OR VALUE = 84 OR VALUE = 85 OR
VALUE = 86 OR VALUE = 87 OR VALUE = 89 OR VALUE = 91 OR VALUE = 92 OR
VALUE = 93 OR VALUE = 94 OR VALUE = 95 OR VALUE = 96 OR VALUE = 97 OR
VALUE = 98
```

After this for every grid-cell the distance to the market had to be determined. This was done with a map with all the commodities for dairy farming. The map with all the commodities that are of importance for dairy farming was extracted from the Land Use Scanner. They based their list of important commodities on the LISA dataset which includes all the businesses in the Netherlands (Diogo et al, 2015). This list also includes the previously mentioned storing commodities that store either warm or cold milk. See Annex 3 for the exact description of how the data used for the commodities was extracted from the Land Use Scanner.

With the map of the commodities a distance map was made. The Euclidian distance tool in the spatial analyst was used for this. It was important that the new raster that shows the distances to the commodities had the same cell size as the original raster data you want to compare the results with (in this case 25 x 25 meter). Also the extent of the maps was of importance. The extent was set within the Euclidean distance menu, in this case the extent of the commodities map has to be the same as the raster dataset. (environment settings → processing extent). The distance raster dataset that was constructed is a floating dataset without an attribute table. To add the data from the distance map to the raster with the dairy/arable farming map the data had to be integer and an attribute table was added. After this the two datasets were combined and the result is a table with the distance to a commodity per grid cell that represents either dairy farming or arable farming. After this only the data from the points selected in the previous paragraph were saved in an Excel file.

ECONOMIES OF AGGLOMERATION

For the multiple regression analysis the number of dairy farming neighbors per grid-cell is needed. To calculate the number of dairy farming neighbors the dataset with change and no-change grid cells from the previous paragraph was used. In the attribute table a new row was added and all the dairy farming grid cells (change) were given value 1 and all the arable grid cells (no-change) were set to 0. After this all the grid cells were converted to points. The points were placed in the exact middle of the grid cells. After the point layer was made the point statistics tool was used.

POINT STATISTICS

The point statistics is a tool in ArcMap that performs neighbourhood operations. This tool can calculate how many neighbour point a point has using a neighbourhood of 3 by 3 rectangles see figure 7. The size of the rectangles can be adjusted and set to for example the size of the LGN raster’s. The points used in the calculations are the exact middle points of the LGN raster dataset, when using a 3 by 3 rectangle as a neighbourhood the maximum amount of neighbours would be 9.

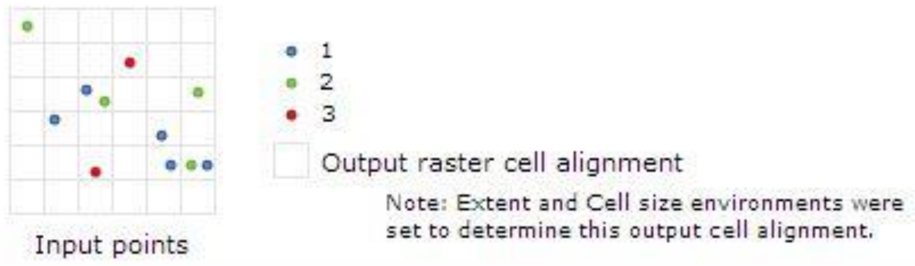


Figure 6 Point statistics (Esri 6)

For this research the setting *sum* was used in the point statistics menu. This tool sums the values in a chosen field. When setting every dairy farming point to 1 and all the other point to 0 one can calculate how many dairy farming neighbours every point has.

To calculate the amount of dairy farming neighbors for all the dairy and arable farming points a very fast computer is needed which was not the case. Therefore the resolution of the grid cells was multiplied by 3, which means that what used to be 9 cells is now 1 cell. The count of neighbors every grid-cell had was calculated after the change in resolution.

LAST OPTION

To calculate whether new dairy farming lands were chosen based on the cheapest grounds the following steps are taken. At first the prices per agricultural zone are assigned to every zone. The prices vary from €23,202 per ha to €105,401 per ha. After this these prices were joined to the map that showed the change and no change in arable farming. The result is a map that shows the plot price per grid-cell.

STATISTICS

In SPSS a binary multiple logistic regression analysis was conducted. The regression analysis investigates whether there was a causality between the influence distance to the market, number of dairy farming neighbours and plot prices have on the occurrence of dairy farming. A binary multiple regression analysis predicts the possibility that an observation falls into one of the two categories. The dependent variable was in this case the land-use (change or no-change) the independent variables were the distance to the market, number of neighbours and plot prices. As seen in the hypothesis the following null hypothesises and alternative hypothesises can be drafted.

1. **H0**: There is no relation between distance to the market and the occurrence of dairy farming
   HA: There is a negative relation between distance to the market and the occurrence of dairy farming
2. **H0:** There is no relation between the amount of dairy farming neighbours and the occurrence of dairy farming
   HA: There is a positive relation between the amount of dairy farming neighbours and the occurrence of dairy farming
3. **H0:** There is no relation between the plot price and the occurrence of dairy farming
   HA: There is a negative relation between the plot price and the occurrence of dairy farming

To analyse whether the hypothesis is right or not the data was transported into SPSS. Four rows with data were inserted 1. The land use and 2. The distance 3. Number of neighbours 4. Plot price. The land use was nominal data and the distance, neighbours and price were set to scale. After this some basic analysis were done in the analyse drop down menu. The first basic analysis was a frequency analysis that shows how much percent of the data is arable and dairy farming. The second basic analysis was a descriptive analysis that shows the distribution of the independent variables. The third basic analysis was a mean analysis and that shows the mean distances to the market, the mean neighbours and the mean plot prices for dairy farming and arable farming separate. After the basic analysis a correlation analysis was done to investigate whether the change into dairy farming was correlated with distance toward a commodity. This was done with the bivariate correlation tool with the correlation coefficients set to Pearson.

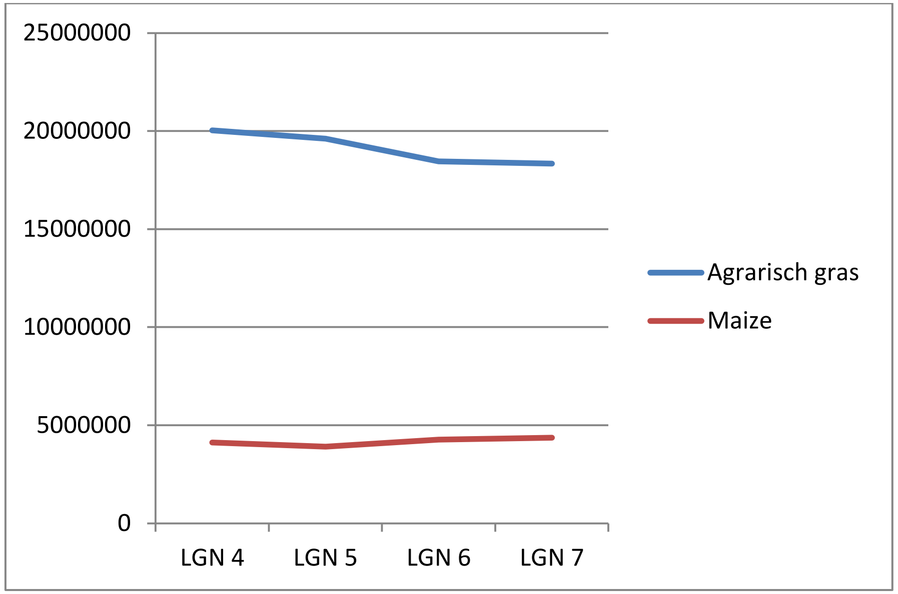
Last the binary logistic analysis was conducted, this analysis showed whether the independent variables explained the dependent variable.

RESULTS

RESULTS SUB-QUESTION 1

As mentioned before dairy farming comprises maize and agricultural grassland. In graph 1 below the total amount of grid cells that are either maize or agricultural grassland are show for the four LGN databases.

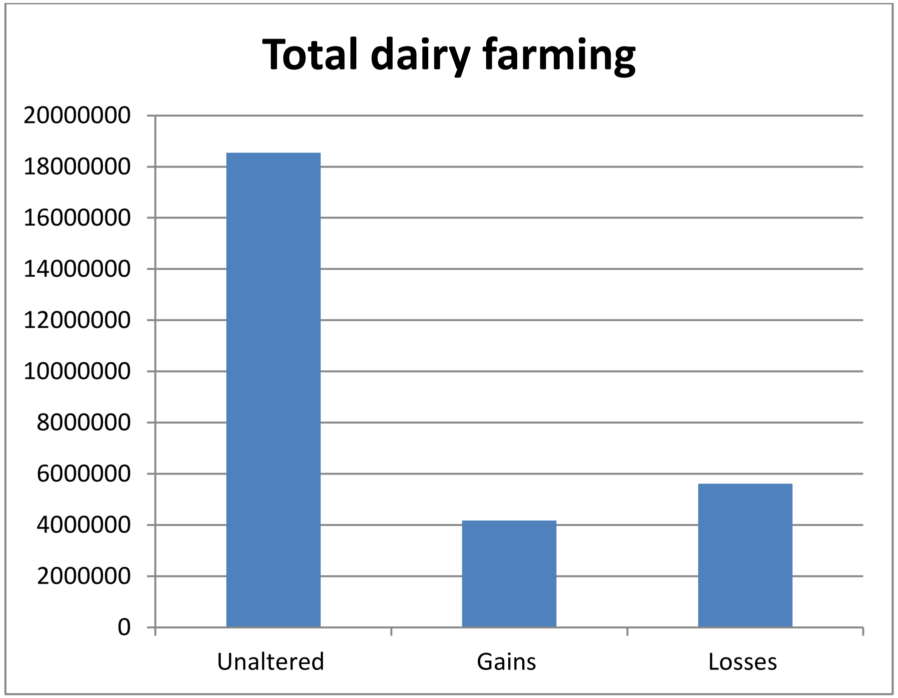
Graph 1 Surface agricultural grass and maize between 2000 - 2012



In graph 1 it is visible that the total amount of agricultural grassland is decreasing while the maize is increasing over the years. Still the total amount of dairy farming is decreasing by the years.

In graph 2 the total change in dairy farming land use is shown. Most of the land use is unchanged between the year 2000 and 2012. Also visible is that dairy farming is slowly losing surface in the Netherlands.

Graph 2 Total surface gains and losses dairy farming



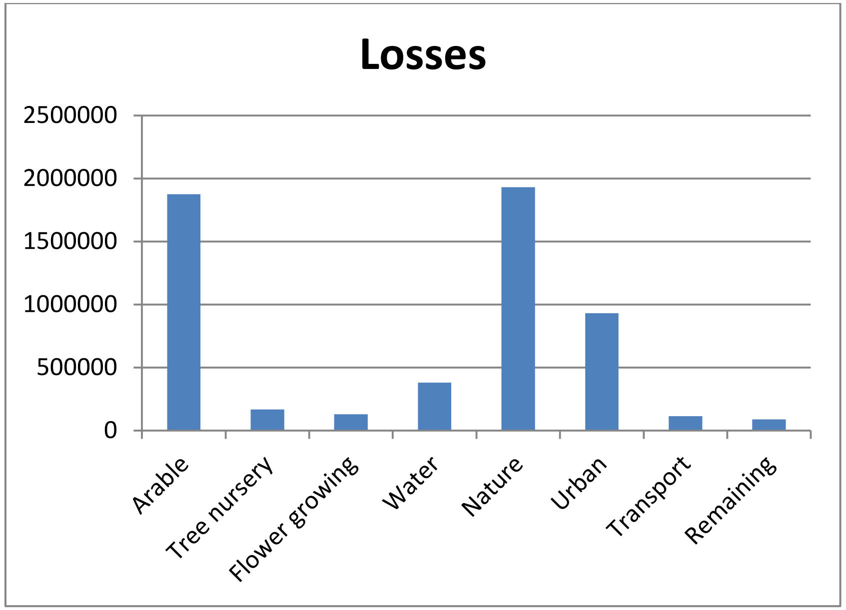
The results of the transition matrix are shown in figure 8. 81 Different combinations are possible, which is obvious because you compare 9 classes with 9 classes. In the table all the possible changes are visible. The red cells show the land uses that stayed the same over the time period 2000-2012.

	1 Dairy farming	2 Arable farming	4 Tree nursery	5 Flower growing	6 Water	7 Nature	8 Urban	9 Transport	10 Remaining
1 Dairy farming	18.545.691	1.873.919	166.580	128.682	379.383	1.931.913	929.939	113.259	88.689
2 Arable farming	2.614.693	6.732.694	198.608	176.970	114.012	325.867	321.269	39.939	97.997
4 Tree nursery	90.689	48.826	17.552	1.601	3.134	10.470	23.482	2.082	248.574
5 Flower growing	96.965	101.368	3.568	133.721	6.008	7.300	14.401	941	2.736
6 Water	113.689	13.988	1.030	480	11.942.046	239.608	108.601	19.298	1.151
7 Nature	377.543	38.997	6.182	1.238	226.979	7.108.997	202.048	35.632	1.583
8 Urban	467.599	36.631	10.894	2.744	225.038	502.042	6.880.326	330.895	8.109
9 Transport	366.204	63.725	4.113	3.159	30.315	137.790	195.482	802.742	4.524
10 Remaining	39.039	2.233	1.760	580	5.194	121.330	43.728	1.489	123.037

Figure 7 Transition matrix

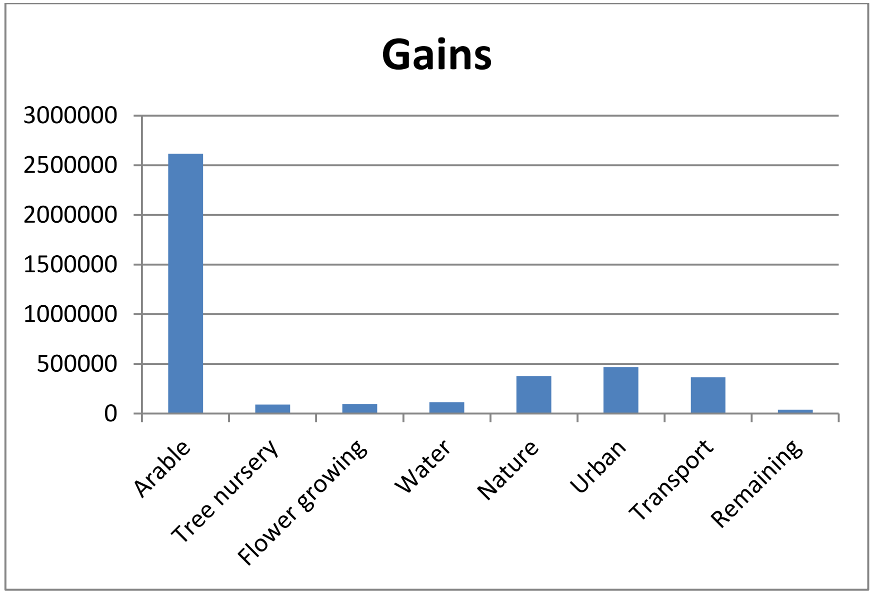
Below three graphs are shown that visualise the changes in dairy farming land use in numbers. Graph 3 shows all the dairy farming land uses that transformed into another land use. Graph 4 shows all the land uses that transformed into dairy farming. Graph 5 shows the differences between the land uses that transformed into dairy farming and the dairy farming that transformed into another land use.

Graph 3 Dairy farming losses



In graph 3 it is visible that dairy farming loses a lot of land to nature, arable farming and urban sprawl. In the hypothesis it was expected that dairy farming would lose land to nature and urban sprawl, the loss to arable farming was not expected in the hypothesis. Why dairy farming is losing surface to arable farming is investigated in the following sub-research questions.

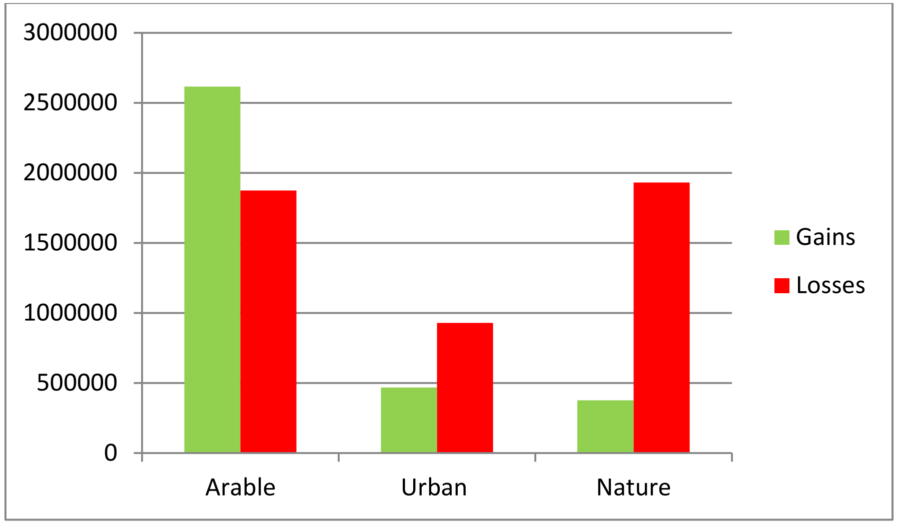
Graph 4 Dairy farming gains



In graph 4 it is visible that dairy farming mostly transforms arable farming into dairy farming. In graph 5 the ratio of gains and losses from and to dairy farming is shown. In the graph the gains and losses for dairy farming to nature, arable and urban is shown. For nature and urban, dairy farming is losing more surface than it is gaining. For arable dairy farming is gaining more than it is losing.

As shown before the total dairy farming land is losing surface, it is mostly losing surface to nature and urban sprawl just like expected in the hypothesis. What is new is that dairy farming and arable farming are losing and gaining a lot of land from each other. Spatial analysis has to show if these land uses exchange their land or if there is another explanation for this observation.

Graph 5 Ratio between gains and losses



The results above are all numeric values, the results below show these changes spatially. In Figure 8 the total change in dairy farming land use is spatially shown. The green grids represent the gains for dairy farming and the red grids represent the losses. It seems like the red clusters are situated near big cities. For example, the red cluster in the North is near the capital city of Groningen.

The grid cells that represent the gains and losses of dairy farming land seem mostly equally distributed over the surface of the Netherlands. A few exceptions of this distribution are the top over Noord-Holland and some parts of Zeeland, here the green grid-cells seem to bulk. In dense populated areas the red grid cells seem to bulk, like in the area Utrecht and the Randstad. An aggregation of this map has to municipality level has to show what the exact distribution is.

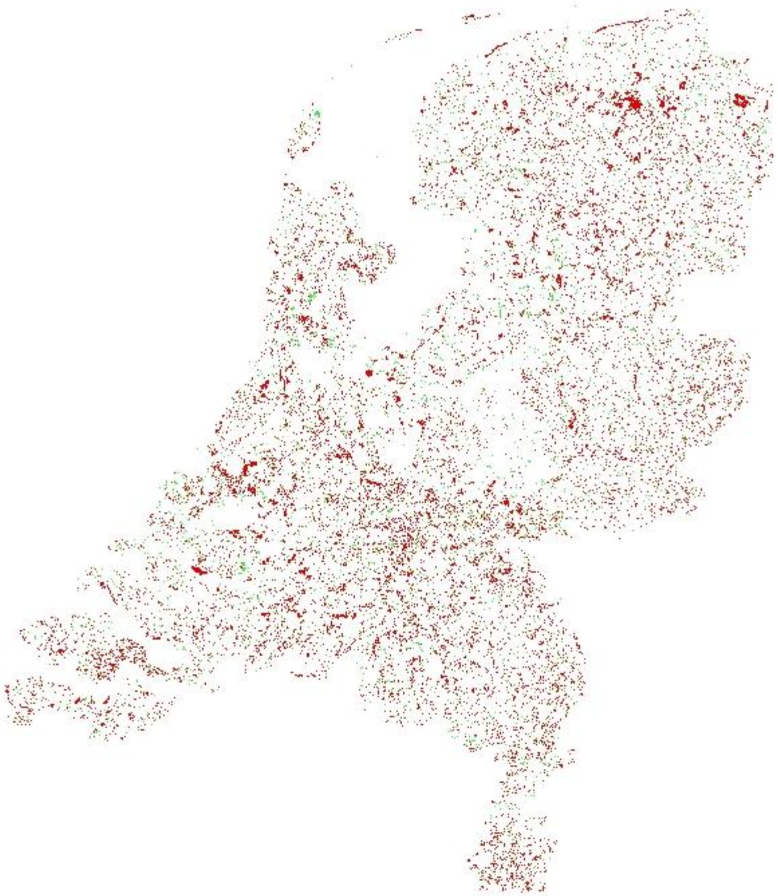


Figure 8 Total change dairy farming LGN 7 - 4

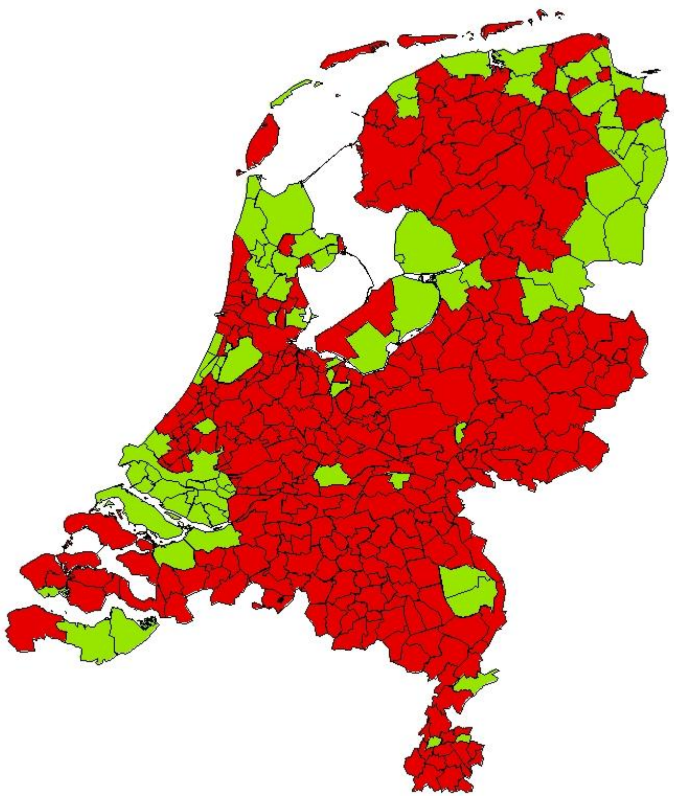


Figure 9 Aggregation to municipality level

In figure 9 shown above it is visible that in the most parts of the Netherlands dairy farming is being pushed away to other locations or dairy farming disappears entirely. It seems like the new locations where dairy farming pops up are near the borders of the Netherlands. In only a few municipalities in the middle of the Netherlands dairy farming is gaining more land dairy than it is losing.

Figure 10 Change arable farming

It is also interesting to see where in The Netherlands dairy farming is losing and gaining land to other land uses . In figure 10 above the gains and losses to arable farming is shown. In total more land is gained from arable farming then lost. The distribution of the green and red grid cells seems to be equal, except for the borders. Near the borders the green is more dominant.

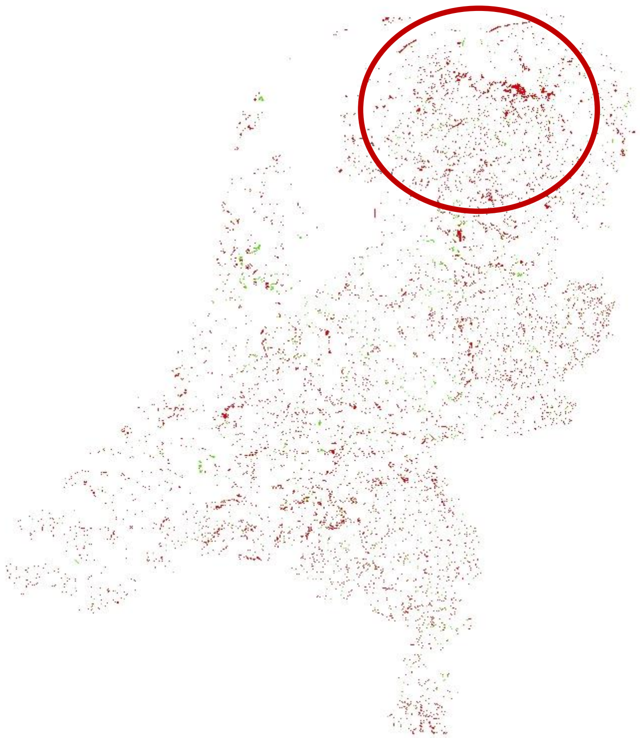


Figure 11 Change nature

Figure 12 Change urban

Figure 11 above shows the change in land use for dairy farming and nature. It is visible in the map above that dairy farming is losing more land to nature than it is gaining. Especially clusters of red grid-cells are dominant in the north of the Netherlands. In Zeeland, Limburg and Noord-Holland, the loss of dairy farming is a little less than in the rest of the Netherland.

Figure 12 above shows the change in land use for dairy farming and urban land. Some clusters of red grid-cells are visible this is probably around existing cities. Also a lot of green grid cells are visible in the whole Netherlands, this means that sometimes urban areas do make place for dairy farming. The explanation for this phenomenon will be searched in the following sub-research questions.

As seen above a lot of lost dairy farming land is reoccurring at other places but overall dairy farming is losing surface. It is in economic sense an well-known fact that agricultural land use is decreasing when a country is industrialising and develops services. Besides that salary is really low in the agricultural sector. This means that they either have to quite or scale their production up. From 1998 till 2003 4,000 agricultural companies quit because they were not profitable enough (Vereijken, 2003). In 2014 only 65,000 of the 80,000 agricultural companies from 2003 are remaining. If the companies are decreasing at the current pace a lot of agricultural land will disappear (CBS). Farmers are currently upscaling their plots but to keep up with the current pace of companies that quite they need to upscale to 40 ha which is not realistic. This means that the total number of farms will keep decreasing in the future (Vereijken, 2003).

RESULTS SUB-QUESTION 2

This sub question is divided in 3 parts: 1. Urban areas 2. Nature 3. Arable farming. The results of the literature review is disclosed in the following paragraphs .

URBAN AREAS

Urban areas have been growing a lot since 1989. Since 1989 till 2008 the urban areas have grown with 16% (compendium voor de leefomgeving). Functions like living, recreations, working and traffic need an increasing amount of space in the Netherlands. As seen in the results from the previous sub-research question the growth of urban areas is at the costs of arable farming and in particular dairy farming. This is not unique for the Netherlands, the US department of agriculture natural resource conservation service estimates that half of the 12 million hectares of changed urban areas was at the loss of agricultural land (Hasse and Lathrop, 2003).

NATURE

As mentioned in the hypothesis nature is taking the place of dairy farming. This is mainly due to plans like Natura 2000 and EHS (national ecological network). These plans mainly lead to a function change from agriculture to nature (Leneman et al, 2004). Farmers do have the choice whether they want to leave for the creation of new nature or whether they want to stay. Farmers get a significant amount of money if they decide to leave the EHS zone. This money seems like a big amount but that is delusive, it is not enough for a farmer to start a new farm somewhere else. When changing a lot of agricultural land into nature or urban areas the amount of agricultural land that remains is less. This means that the areas that do remain are scarce and that drives up the price, also when a lot of farmers want to purchase a plot this increases the price. In short the development of new nature drives farmers away because they receive big amounts of money, this has as a side effect that it is harder for farmer to purchase a new plot to start a farm.

ARABLE FARMING

The results show that arable farming is taking land from dairy farming which seems remarkable. Arable farming is a relative weak sector within the agricultural sector. Arable farming has many to endure from other countries that can produce products at a lower price. According to literature arable farming will lose a lot of land in the battle with dairy farming. A seen in the results arable farming does lose a lot of land to dairy farming but it is also gaining a lot of land from dairy farming (Eck et al, 2002).

A possible explanation for the change from dairy farming into arable farming is that half of the 55+ farmers do not have a successor, this is mainly due to the low labour remuneration (Vereijken, 2003). With dairy farming this means that farmers that reach retirement are selling their animals. The farmers still produce some maize, but without the animals this production is classified as arable farming (Bakker et al, 2015).

RESULTS SUB-QUESTION 3

As mentioned before sub-question 2 is divided into 3 parts: 1. Distance to market 2. Economies of agglomeration 3. Last option. The results are shown in de paragraphs below.

DISTANCE TO MARKET

The map on the right shows the aggregated distances from every grid cell in the Netherlands to a commodity (red points). Most no-change and change grid cells (black parcels) are relatively near commodities. The aggregated maps show that the north, the south the south-west and some parts of the Veluwe in the Netherlands are more remote from commodities then other parts of the Netherlands.

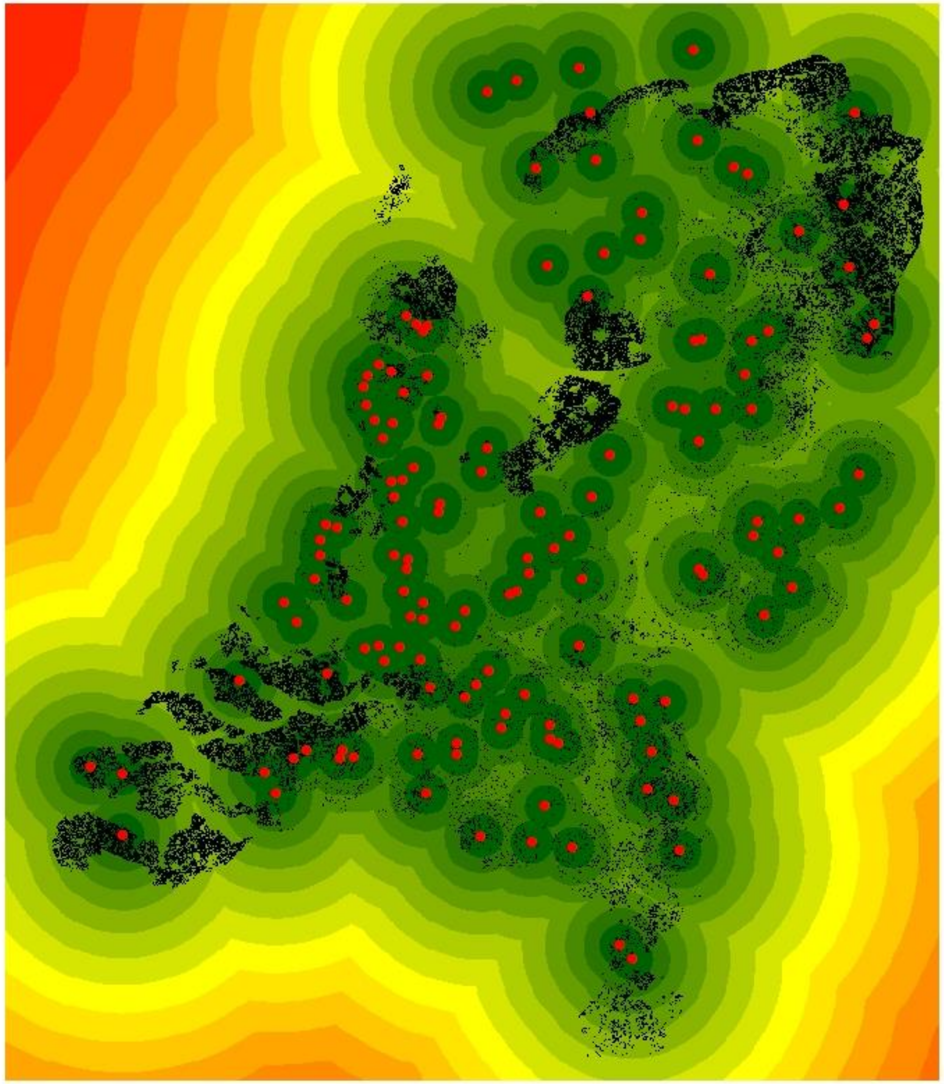


Figure 13 Distance to market

ECONOMIES OF AGGLOMERATION

Figure 14 shows a small part of the amount of dairy farming neighbours the change and no-change grid cells have. The red cells show grid-cell that do not have a dairy farming neighbour. The greener the grid cells the more dairy farming neighbours. The maximum count of neighbours is nine, because only the the grid-cells that intersected with the centre cell are counted.

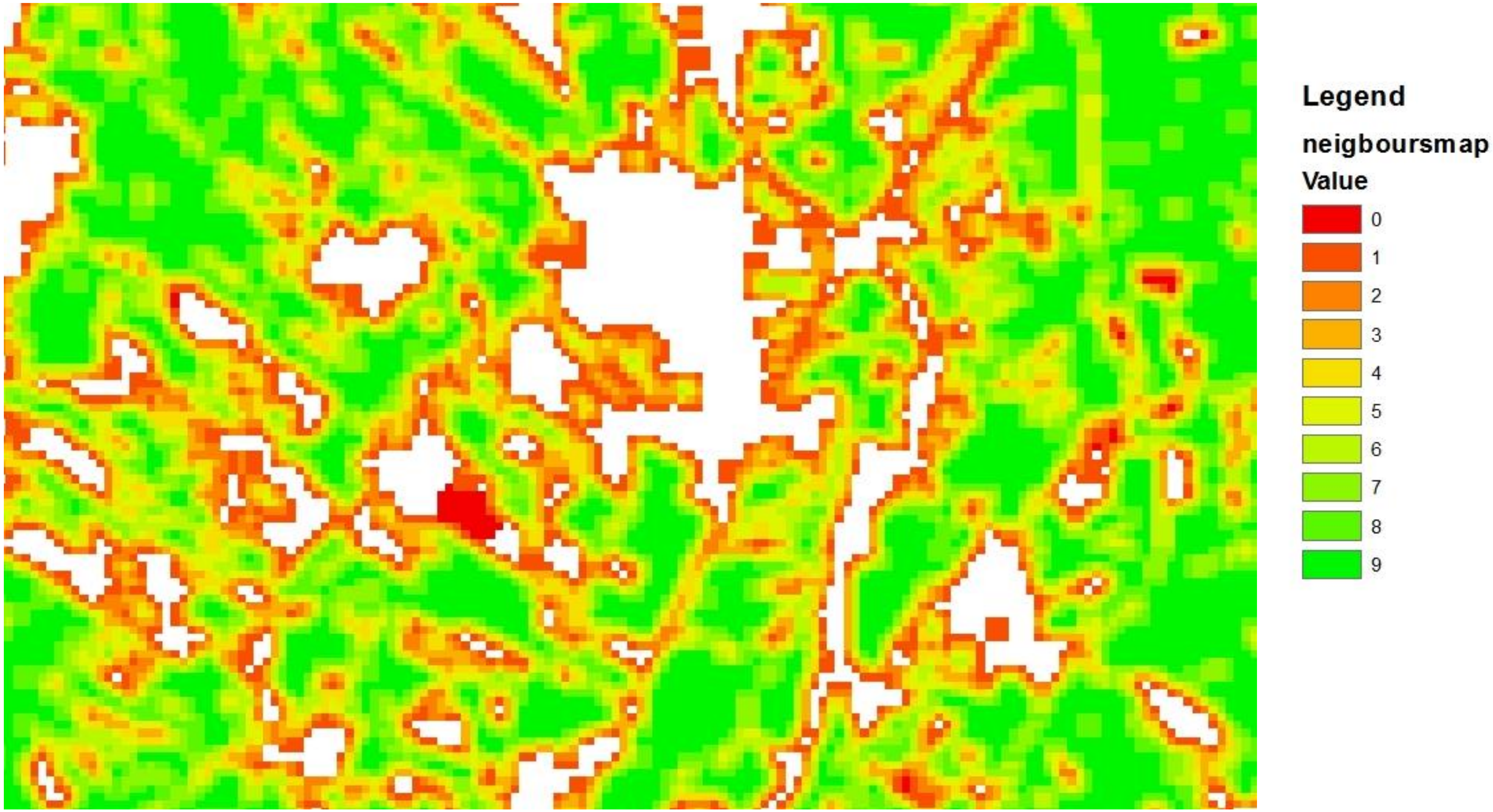


Figure 14 Neighbours Grid

LAST OPTION

In figure 17 the average price per agricultural zone is shown. The red zones show the agricultural zones with the highest average plot prices. The greener the zones the lower the plot prices. The average price dairy farmers pay for a plot of land is €49,530. This is considerably less than the maximum price of €105,402 per ha. The dairy farmers obviously do not choose for the cheapest grounds but also not the most expensive plots. This means that other factors like economies of agglomeration have a bigger impact on location choice.

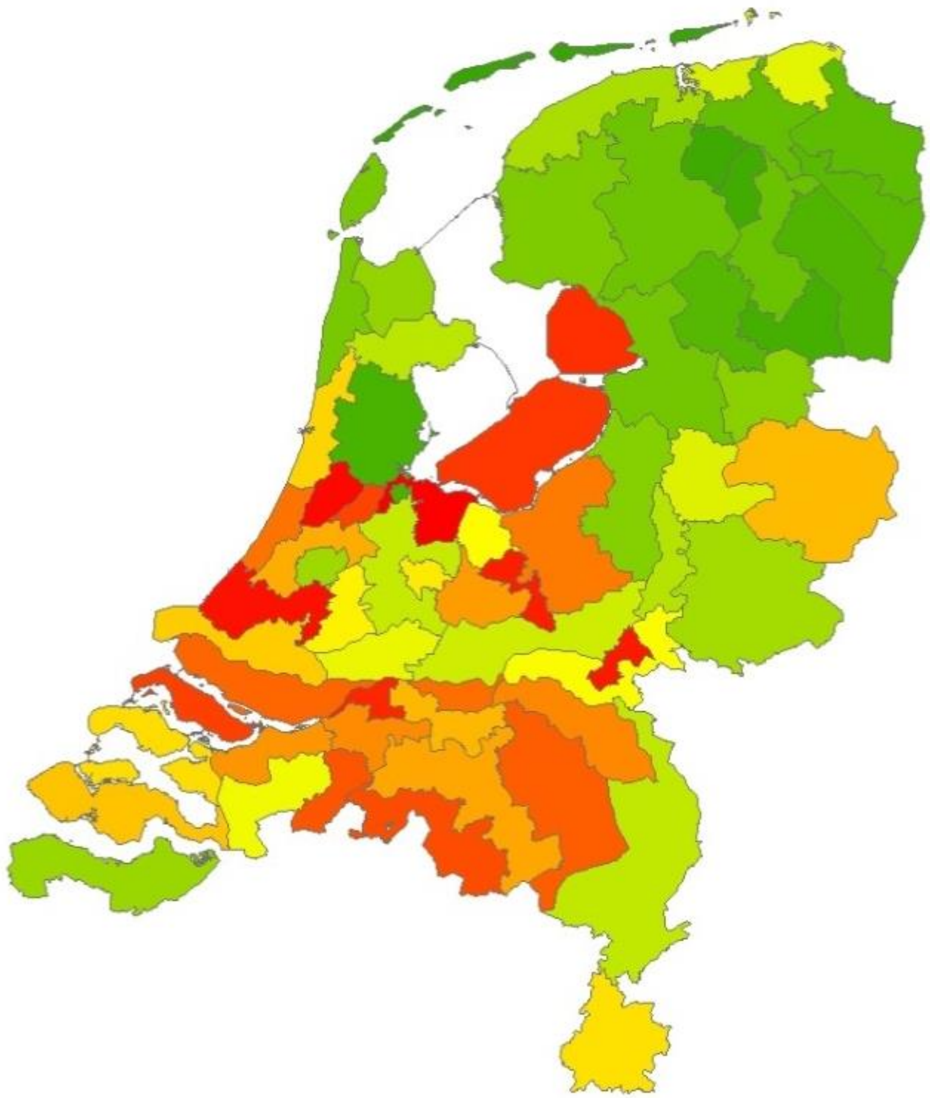


Figure 17 Prices per agricultural zone

STATISTICS

In the frequencies table it is visible that there are 2 groups in this analysis. One group is the group with change (1) and the other group is the group with no-change (0). Figure 18 shows the ratio between change and no-change compounded by random sampling.

Frequencies

Statistics

LANDUSE

N	Valid	2835
	Missing	0

LANDUSE

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no-change	1400	49,4	49,4	49,4
	change	1435	50,6	50,6	100,0
	Total	2835	100,0	100,0	

Figure 18 SPSS output frequencies

Also the data that shows the distance (DISTANCE) has to be looked at before starting the regression analysis. In figure 19 it is visible that there is a big difference between the maximum 39.8 km and minimum 117 meters distance to a commodity. The mean distance is 10.89 kilometres with a standard deviation of 5.9 kilometres. The output shows that there are big differences between the distances from the change/no-change grid cell to the commodity.

Descriptives

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
DISTANCE	2835	117,2388850	39869,84974	10886,52927	5914,944704
Valid N (listwise)	2835				

Figure 19 SPSS output descriptives distance

Looking at the descriptives of the count of neighbours (NEIGHBOURS) in figure 20, it is visible that cells have between 0 and 9 dairy farming neighbours. The mean amount of neighbours is 3.67 with a standard deviation of 3.399.

Descriptives

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
NEIGHBOURS	2835	0	9	3,67	3,399
Valid N (listwise)	2835				

Figure 20 SPSS output descriptives neighbours

Looking at the descriptives of plot prices (PLOTPRICE) figure 21 it is visible that the plot prices vary a lot. The plot prices vary from a minimum of €25,798 per ha to a maximum of €104,053 per ha. The mean plot price is €44,302 per ha.

Descriptives

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
PLOTPRICE	2835	25798	104053	44302,87	14207,258
Valid N (listwise)	2835				

Figure 21 SPSS output descriptives plot price

In figure 22 the relation between distance for the two different land uses change and no-change is shown. It can be seen that the average distance to a commodity for "no-change" is 11,836 meters and for "change" this is 9,959 meters. On average no-change is 1,877 metres further away from commodities than change.

Means

Case Processing Summary

	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
DISTANCE * LANDUSE	2835	100,0%	0	0,0%	2835	100,0%

Report

DISTANCE

LANDUSE	Mean	N	Std. Deviation
no-change	11836,69077	1400	6261,365545
change	9959,542441	1435	5399,489677
Total	10886,52927	2835	5914,944704

Figure 22 SPSS output means distance

In figure 23 the relation between the land uses and the amount of dairy farming neighbours is shown. "no-change" grid cells have on an average 0.82 dairy farm neighbours while "change" grid-cells have on average 6.45 dairy farm neighbours. This is a big difference.

Means

Case Processing Summary

	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percei
NEIGHBOURS * LANDUSE	2835	100,0%	0	0,0%	2835	100,0

Report

NEIGHBOURS

LANDUSE	Mean	N	Std. Deviation
no-change	,82	1400	1,405
change	6,45	1435	2,283
Total	3,67	2835	3,399

Figure 23 SPSS output means neighbours

In figure 24 the relation between the land uses and the plot prices are shown. On average "no-change" plots are worth €39,448.80 per ha and "change" plots are worth €48,999.51.

Means

Case Processing Summary

	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
PLOTPRICE * LANDUSE	2835	100,0%	0	0,0%	2835	100,0%

Report

PLOTPRICE

LANDUSE	Mean	N	Std. Deviation
no-change	39488,80	1400	11218,888
change	48999,51	1435	15212,346
Total	44302,87	2835	14207,258

Figure 24 SPSS output means plot prices

In the correlation table in figure 25 it is visible that the Pearson correlation between the distance to the market and the land use is low -0.159. The correlation between the plot price and the land use is also low with 0.335. The correlation between the amount of neighbours and the land use is high with 0.829. The factors are reciprocally not correlated.

Correlations

		LANDUSE	PLOTPRICE	NEIGHBOURS	DISTANCE
LANDUSE	Pearson Correlation	1	,335**	,829**	-,159**
	Sig. (2-tailed)		,000	,000	,000
	N	2835	2835	2835	2835
PLOTPRICE	Pearson Correlation	,335**	1	,247**	-,054**
	Sig. (2-tailed)	,000		,000	,004
	N	2835	2835	2835	2835
NEIGHBOURS	Pearson Correlation	,829**	,247**	1	-,164**
	Sig. (2-tailed)	,000	,000		,000
	N	2835	2835	2835	2835
DISTANCE	Pearson Correlation	-,159**	-,054**	-,164**	1
	Sig. (2-tailed)	,000	,004	,000	
	N	2835	2835	2835	2835

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

Figure 25 SPSS output correlation

In the method section a few hypothesises were set up:

1. **H0**: There is no relation between distance to the market and the occurrence of dairy farming
   HA: There is a negative relation between distance to the market and the occurrence of dairy farming
2. **H0:** There is no relation between the amount of dairy farming neighbours and the occurrence of dairy farming
   HA: There is a positive relation between the amount of dairy farming neighbours and the occurrence of dairy farming
3. **H0:** There is no relation between the plot price and the occurrence of dairy farming
   HA: There is a negative relation between the plot price and the occurrence of dairy farming

With the help of a binary regression analysis it will be clear if the land use can be predicted by one of the above mentioned independent variables.

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	1174,078[a]	,622	,829

a. Estimation terminated at iteration number 7 because parameter estimates changed by less than ,001.

Figure 26 SPSS output model summary

In the model summary in figure 26 the Cox & Snell R square and the Nagelkerke R square is visible. Both say something about how much of the variation in the dependent variable can be explained by the independent variables. In this model the variation varies between 0.622 and 0.829 depending on the type of measure used. In this research the Nagelkerke R square is used because the Cox& Snell r square cannot reach the value 1. So overall this model explains 82% of the variation in the dependent variable.

Classification Table[a]

Observed			Predicted LANDUSE no-change	Predicted LANDUSE change	Percentage Correct
Step 1	LANDUSE	no-change	1293	107	92,4
		change	136	1299	90,5
	Overall Percentage				91,4

a. The cut value is ,500

Figure 27 SPSS output classification table

The classification in figure 27 shows the percentage of correct predicted land uses. The cut value is 0.5 which means that a value below 0.5 falls into the category "no-change" and above 0.5 in the category "change". The amount of right predictions is high, for no-change 92.4% and for change 90,5%.

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	DISTANCE	,000	,000	3,840	1	,050	1,000
	PLOTPRICE	,000	,000	117,668	1	,000	1,000
	NEIGHBOURS	1,070	,041	688,666	1	,000	2,917
	Constant	-5,769	,345	280,064	1	,000	,003

a. Variable(s) entered on step 1: DISTANCE, PLOTPRICE, NEIGHBOURS.

Figure 28 SPSS output variable in the equation

The variables in the equation table in figure 28 shows the contribution of each independent variable. Looking at the data it is visible that the distance to the market and the plot prices do not contribute to the transformation from arable farming into dairy farming. Both B values are 0 with an $p<0.05$. The only independent variable that contributes to the model is the amount of dairy neighbours. With a B of 1.070 and a $p<0.05$ the whole prediction of the model is based on the count of dairy neighbours. This lead to the equation based on the B values.

$$\boldsymbol{Logit = -5,769 + (1.070 * \ Neighbours)}$$

The B values do not say anything about the probability of a arable farming grid cell to transform into a dairy farming grid cell. As mentioned in the method section 2 steps need to be taken to calculate the probability

$$\boldsymbol{p\ (dairy\ appears) = \frac{1}{1 + e^{-\ (logit)}}}$$

1. **H0**: There is no relation between distance to the market and the occurrence of dairy farming
   HA: There is a negative relation between distance to the market and the occurrence of dairy farming
   The null hypothesis is accepted because a B of zero eliminates the whole distance factor from the equation.
2. **H0:** There is no relation between the amount of dairy farming neighbours and the occurrence of dairy farming
   HA: There is a positive relation between the amount of dairy farming neighbours and the occurrence of dairy farming
   The null hypothesis is rejected because $p<0.05$, the alternative hypothesis is accepted. This means that many

dairy farming neighbours raise the change that arable farming transforms into dairy farming.

3. **H0:** There is no relation between the plot price and the occurrence of dairy farming
   HA: There is a negative relation between the plot price and the occurrence of dairy farming
   The null hypothesis is accepted because a B of zero eliminates the whole plot price factor from the equation.

CONCLUSION

Looking at the overall results dairy farming is losing surface. This is due to competition with other land uses, low salary farmers earn and the competition with other countries. Like mentioned before farmers either have to cease their company or scale up. A lot of farmers are upscaling their company but that is not an option for everyone. After being bought out or driven away by another land use it is also not always possible to allocate to another plot because of the high plot prices.

Going back to the hypothesis a few conclusions can be drawn. The hypothesis is split up in push and pull factors. For the push factors the main hypothesis came true. Dairy farming land use is mainly driven away by nature and urban areas. The growth of urban areas with 16% was at the cost of agricultural land uses and in this case at the cost of dairy farming. Also the creation of new nature drove dairy farming away. Nature is usually a lot better protected than agricultural land uses this leads to the disappearance or allocation of agriculture. Projects like Natura 2000 and the goal the central government set to transform 42,000 ha of agricultural land into nature (lineman, 2014), where the reason for a lot of land to reallocate or disappear. One unforeseen push factor was the change from dairy farming into arable farming. Arable farming is a lot less profitable than dairy farming which makes it improbable that dairy farming would transform into arable farming. According to literature arable farming loses a lot of land in the battle with dairy farming (Eck et al, 2002). A probable explanation is that older farmers that do not have a successor sell their animals their which leads over time to a different classification within the agricultural lands.

When dairy farmers are pushed away voluntarily or not they look for a new location when that is possible. Three assumptions where made in the hypothesis that could declare the pull factors that attract dairy farming to a new location.

1. Economies of scale
2. Distance to the market
3. Last option

The first hypothesis about economies of scale can be accepted. The results showed that dairy farming plots have clustered more over the years 2000 to 2012. Whether these clusters are really economies of agglomeration is not clear. A possible explanation for the results that dairy farming seems to cluster more over time is the scaling of Dutch dairy farms. Since 1980 the amount of dairy farms and cows is decreasing. Around 2000 this trend shifts the amount of dairy farms keeps decreasing but the amount of cows is increasing. Looking at the most recent numbers this trend is also visible. In April 2015 there were 18.3 thousand dairy farms which is 1.7% less than the year before, but on the other hand the amount of milk cows increased with 3.1% (CBS). The remaining farmers want bigger plots so they can increase profits and that possibly explains the observed clustering. So the observed clustering could be an expansion of dairy farming companies instead of the assemble of dairy farming companies. Whether the increase in clustered dairy farming land use is dependent on economies of scale or not one thing is clear, new dairy farming is usually located next to other dairy farming lands. The results of the multiple regression analysis showed that arable farming lands that where located next to dairy farming lands did transform into dairy farming lands more often. The arable farming lands that are not located next to dairy farming lands do usually not transform into dairy farming.

The second hypothesis about distance to the market stated that dairy farms would want to be near the dairy market. The binary logistic regression analysis showed that dairy farming is not dictated by the distance to the relevant markets. Arable farming lands that are located near the markets do not transform into dairy farming. The correlation table did show a small negative relation, this means that dairy farmers want to be near the markets, but the neighbour factor is much stronger and therefore the distance variable disappears from the logistic regression equation. This means that distance is a pull factor but not strong enough to compete with neighbours.

The third hypothesis states that the location choice for dairy farming is based on the last option. The assumption was that dairy farmers base their decision purely on the plot price, no other factors contribute to the decision. When comparing the new dairy farming plots to the prices per agricultural zone this seemed not to be the case. Most of the plots used for the allocation of dairy farming are more expensive than the cheapest plots available. When comparing arable land with dairy farming land in a binary regression analysis there was no relation between the plot prices and the transformation from arable farming into dairy farming. This means that plot prices are not a pull factor for dairy farming allocation.

Looking at the main research question the following can be stated.

"Explaining the current dairy farming land use patterns by analysing the push and pull factors that dictate dairy farming land use change"

Dairy farming is pushed away by urban developments and nature expansion. Dairy farming is pulled to locations that are next to other dairy farms.

Overall this research gives some insight in the allocation process of dairy farmers. With an R^2 of 0.82 the allocation of dairy farming is understood quite well. An improvement to this research could be an in depth analysis of the allocation itself. Are dairy farmers really moving towards other dairy lands or are the clusters just extensions from the already existing dairy farm lands.

DISCUSSION

In the discussion parts of the research that could be improved are discussed. The discussion is split in two sections the data section and the method section. In the data section possible distortions that influence the results are explained and in the method section the choice for methods is discussed.

DATA

In this research it is assumed that the LGN databases are validated well enough to use to analyse land use change. Whether this is true can be questioned. The techniques used in 2000 to classify remote sensing images are a lot different to the techniques used in 2012. That the LGN databases cannot completely be compared to each other is visible in the transition matrix, for instance water changes into all the other land uses. It is not likely that water would change into arable farming or tree nursery. But assuming that these classification differences are the same for every land use this bias does not affect the results.

Another point that needs attention is the data used to calculate the average plot price dairy farmers paid after allocating. This data is not very accurate since it covers very big areas of land. Besides this the availability is not mentioned in the dataset. For example there might be a lot less cheap plots available then expensive plots. This could give a distorted view on the choice farmers make when thinking about the financial part of allocating.

Like mentioned in the conclusion the cluster analysis used could be the result of bigger plot sizes and not the result of economies of agglomeration. The cluster analysis could show economies of scale instead of economies of agglomeration. There is no data available that shows the exact owners of the plots, so it is not possible to see whether it is one company or a cluster of more companies.

Another weakness of this research is that only a relatively small hypothesis is tested. In reality the allocation of dairy farming is dependent on a lot more factors than is investigated in this research. Due to the small time only the hypothesis is tested, this lead to an conclusion in which only the statements in the hypothesis are tested. It does not give an complete overview of the land use change.

Conclusions of this research might not give an complete overview but the findings are useful for further research. In the real world it is of importance for planners to know cause-consequence relations in an ever changing world like ours. When understanding the dynamics in land use change better adapted plans to the future can be made.

METHODS

Looking back on the methods used one could wonder if these are the proper methods to use. For example a neighbourhood analysis and a neighbourhood count was done. The neighbourhood analysis showed whether the pattern in dairy farming land uses was random, clustered or dispersed and the neighbourhood count showed the sum of dairy farmers neighbours for every grid cell. These two analysis did overlap too much and the neighbourhood analysis did not answer the main research question. After realising this the neighbourhood analysis was removed from this research.

The other methods used where very complementary and made it possible to carry out a multiple logistic regression. The methods together achieved to do a multiple logistic regression that gives a suitability for dairy farming to every arable farming grid-cell. The choice for a multiple regression analysis was made because it was expected that the allocation was dependent on more than one variable. Looking back on this choice three different logistic regressions with one variable could also have worked. The variable that showed the amount of neighbours was very dominant and made it seem like the other two variables did not add anything to the allocation. The correlation table did show a very small negative correlation between the distance to the market and the land use, which means that this variable did influence location choice.

Another debatable part of the method section is the choice to transform grid cells into points. When transforming points into raster data or the other way around data less precise. In this case I do not think that the transformation from raster to point created a less precise dataset. The point where situated in the exact middle point of grid cell. The transformation to points was necessary because of the random sampling plan made earlier, and some analysis were only possible in a vector dataset and not in a raster dataset.

Lastly the use of the reclassification tool is debatable. When reclassifying you add a not scientifically supported classification to the research. A lot could have gone wrong with the classification. For example the choice to add fruit farming to the class remaining. In older LGN databases fruit farming was probably classified as a different agricultural land use and not as remaining. This causes a classification bias, but considering the size of fruit farming this is t negligible for this research.

REFLECTION

When I started writing my thesis report I had some expectations. The first expectation was that I could do a lot more than I did in the end, and the second expectation was that I would work a bit more structured. When starting with my thesis proposal I wanted to analyse way too much and I had to narrow down my subject a lot of times. My second expectation was that I could work a lot more structured, I wanted to start with the first sub-research question and finish it before I started witch the next question. This was not the case, I had to go back to previous sub-questions a lot of time. What I expected to be a linear process was more a chaotic process. This was sometimes a bit frustrating, I had to do the same thing over and over again because I realised in a later step that for example my land uses where not classified right. A minor change in the beginning meant that I had to do everything again. I know that this is part of conducting a research but sometimes it seemed like I did not make any progress.

Looking back on the experience of writing a bachelor thesis I would have done a few things differently. At first I would have tested the idea I had for my initial thesis research in the first week. I have been working on my previous subject for a little more than two weeks, after these weeks I found out that this research was not executable. This was a disappointment for me and it put me behind on schedule because I had to write a new research proposal. On one hand this was a disappointment but on the other hand my new research suited me better because I could explore ArcMap a bit more. Also I think I did manage the time pressure to write a new research proposal quite well and it did not cause any delay for the rest of my thesis.

I have learned a lot during the period I wrote my bachelor thesis. It did improve my ArcMap skills and absolutely my SPSS skills. With ArcMap the most important part was to keep my patience. ArcMap can be a very slow program and I am someone that wants to work really fast. The data I used in this research involved the whole of the Netherlands in grid-cells of 25 by 25 meters, this is a lot of data and made ArcMap slow. Sometimes I got very frustrated because things did not evolve as fast as I wanted to because I had to wait until ArcMap finally calculated everything. Most of the times I did not use the right code or tool the first time, so after waiting a long time I had to do everything again and wait. I was not looking forward to doing the statistical research part, but in the end I learned a lot from it and that is of course the goal. If I am using SPSS for my master thesis I would do another statistics course at the WUR because I have never been very good at statistics and I find it hard to interpret the SPSS output.

Sometimes I found it hard to underpin the results I found with literature. There was simply not a lot written about for example the change from arable farming into dairy farming. Of course there is literature about the change of agricultural land in time, but not specifically about dairy farming. That dairy farming was a relatively unexplored field was on one hand very exciting because I could research something new, but on the other hand not very exciting because I could not underpin some data with literature.

To use the insights I gained during this thesis period I will use Korthagen's circle, so I will be prepared better during my master thesis. Korthagen's circle exists out of 5 steps as seen in figure X.

1. Act
2. Look back
3. Awareness
4. Choosing alternatives
5. Trying out alternatives

(Korthagen et al, 2002)

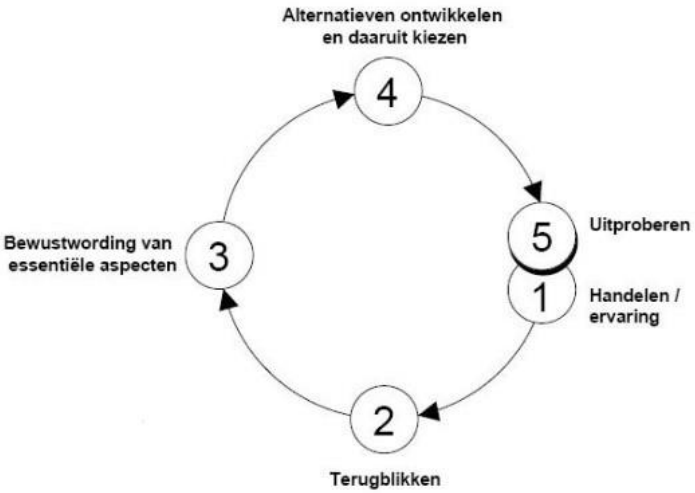


Figure 29 Korthagen's circle

This is the first time that I am working on a project this big on my own. I am used to working in a group and working on my own caused different problems. When I started with my research I wanted to do a lot, this was also a big pitfall for me because we only had 8 weeks to execute this research. In the beginning I was chewing more than I could swallow which lead to the problem that I had to narrow my subject a few times. At first this seemed frustrating because I wanted to look at the land use change for all land uses, but looking back on it that was way too much to handle. So choosing to only look at dairy farming was a good choice.

Being aware of what you can do in a certain time frame is a very important aspect of research. My problem this time was that I was to exited and a bit ignorant of the magnitude of my original research idea. An alternatives that I could try is writing down in a very early stage what steps need to be taken before an answer to the research question can be found. So the next time ,which will probably be my master thesis, I will pay more attention to my time planning. This time I also made a time planning but that planning was not detailed enough. Another part of my research that was time consuming was finding the right data. Looking for the right data takes a lot of time, the next time I will write down beforehand what kind of data I need. If the data is not easily accessible I can incorporate that in my time table.

Overall I have learned a lot of lessons that I can use during my master thesis. The first lesson is taking SPSS classes and the second lesson is that I should make a more detailed time schedule.

ANNEX 1 LGN CLASSIFICATION LEGEND

1 - gras
2 - mais
3 - aardappelen
4 - bieten
5 - granen
6 - overige landbouwgewassen
7 - ???
8 - glastuinbouw
9 - boomgaard
10 - bollen
11 - loofbos
12 - naaldbos
16 - zoet water
17 - zout water
18 - stedelijk bebouwd gebied
19 - bebouwing in buitengebied
20 - loofbos in bebouwd gebied
21 - naaldbos in bebouwd gebied
22 - bos met dichte bebouwing
23 - gras in bebouwd gebied
24 - kale grond in bebouwd buitengebied
25 - hoofdwegen en spoorwegen
26 - bebouwing in agrarisch gebied
30 - kwelders
31 - open zand in kustgebied
32 - open duinvegetatie
33 - geloten duinvegetatie
34 - duin-heide
35 - open stuifzand
36 - heide
36 - matig vergraste heide
37 - sterk vergraste heide
39 - hoogveen
40 - bos in hoogveengebied
41 - overige moerasvegetatie
42 - rietvegetatie
43 - bos in moerasgebied
44 - veenweidegebied
45 - overig open begroeid natuurgebied
46 - kale grond in natuurgebied

1 - gras
2 - mais
3 - aardappelen
4 - bieten
5 - granen
6 - overige landbouwgewassen
8 - glastuinbouw
9 - boomgaard
10 - bollen
11 - loofbos
12 - naaldbos
16 - zoet water
17 - zout water
18 - stedelijk bebouwd gebied
19 - bebouwing in buitengebied
20 - loofbos in bebouwd gebied
21 - naaldbos in bebouwd gebied
22 - bos met dichte bebouwing
23 - gras in bebouwd gebied
24 - kale grond in bebouwd buitengebied
25 - hoofdwegen en spoorwegen
26 - bebouwing in agrarisch gebied
30 - kwelders
31 - open zand in kustgebied
32 - open duinvegetatie
33 - geloten duinvegetatie
34 - duinheide
35 - open stuifzand
36 - heide
37 - matig vergraste heide
38 - sterk vergraste heide
39 - hoogveen
40 - bos in hoogveengebied
41 - overige moerasvegetatie
42 - rietvegetatie
43 - bos in moerasgebied
44 - veenweidegebied
45 - overig open begroeid natuurgebied
46 - kale grond in natuurgebied

1 - agrarisch gras
2 - mais
3 - aardappelen
4 - bieten
5 - granen
6 - overige landbouwgewassen
8 - glastuinbouw
9 - boomgaarden
10 - bloembollen
11 - loofbos
12 - naaldbos
16 - zoet water
17 - zout water
18 - bebouwing in primair bebouwd gebied
19 - bebouwing in secundair bebouwd gebied
20 - bos in primair bebouwd gebied
22 - bos in secundair bebouwd gebied
23 - gras in primair bebouwd gebied
24 - kale grond in bebouwd gebied
25 - hoofdwegen en spoorwegen
26 - bebouwing in het buitengebied
28 - gras in secundair bebouwd gebied
30 - kwelders
31 - open zand in kustgebied
32 - duinen met lage vegetatie
33 - duinen met hoge vegetatie
34 - duinheide
35 - open stuifzand en/ of rivierzand
36 - heide
37 - matig vergraste heide
38 - sterk vergraste heide
39 - hoogveen
40 - bos in hoogveengebied
41 - overige moerasvegetatie
42 - rietvegetatie
43 - bos in moerasgebied
45 - natuurgraslanden
61 - boomkwekerijen
62 - fruitkwekerijen

ANNEX 2 AGGREGATION ALL LAND USES

LGN 7			
New name	Combination land uses	Combination numbers	Value
Dairy farming	Gras and Maize	1 ; 2	1
Arable farming	Potatoes, grain, beets and remaining crops	3 ; 4 ; 5 ; 6	2
Tree nursery	Orchards, nurseries	9 ; 61	4
Flower growing	Bulbs	10	5
Water	Fresh water and saltwater	16 , 17	6
Nature	Coniferous, deciduous forest, deciduous forest in urban area, coniferous forest in urban area, grass in urban area, salt marshes, open sand coastal areas, open dune vegetation, closed dune vegetation, dune-heather, open drift-sand, heather, moderately enlarged heather, greatly enlarged heather, peat moor, forest in peat moor, remaining moor, reed vegetation, forest in moor, peatland area, remaining open overgrown nature, bare soil in nature	11, 12, 20, 22, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 45	7
Urban	Urban built-up areas, built-up areas in outer, grass in urban area, forest in dens built-up area, built-up in agricultural land, open areas in built-up land	18, 19, 23, 24, 26, 28,	8

Transport	Roads and railways	25	9
Remaining	???, greenhouses, fruit farming	8, 62	10
LGN 6			
Dairy farming	Gras and Maize	1 ; 2	1
Arable farming	Potatoes, grain, beets and remaining crops	3 ; 4 ; 5 ; 6	2
Tree nursery	Orchards, nurseries	9 ; 61	4
Flower growing	Bulbs	10	5
Water	Fresh water and saltwater	16 , 17	6
Nature	Coniferous, deciduous forest, deciduous forest in urban area, coniferous forest in urban area, gras in urban area, salt marshes,	11, 12, 20, 22, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 45	7
	open sand coastal areas, open dune vegetation, closed dune vegetation, dune-heather, open drift-sand, heather, moderately enlarged heather, greatly enlarged heather, peat moor, forest in peat moor, remaining moor, reed vegetation, forest in moor, peatland area, remaining open overgrown nature, bare soil in nature		
Urban	Urban built-up areas, built-up areas in outer, grass in urban area, forest in dens built-up area, built-up in agricultural	18, 19, 23, 24, 26, 28,	8

	land, open areas in built-up land		
Transport	Roads and railways	25	9
Remaining	???, greenhouses, fruit farming	8, 62	10
LGN 5			
Dairy farming	Gras and Maize	1, 2	1
Arable farming	Potatoes, grain, beets and remaining crops	3 , 4 ; 5 ,6	2
Tree nursery	Orchards, nurseries	9	4
Flower growing	Bulbs	10	5
Water	Fresh water and saltwater	16, 17	6
Nature	Coniferous, deciduous forest, deciduous forest in urban area, coniferous forest in urban area, salt marshes, open sand coastal areas, open dune vegetation, closed dune vegetation, dune-heather, open drift-sand, heather, moderately enlarged heather, greatly enlarged heather, peat moor, forest in peat moor, remaining moor, reed vegetation, forest in moor, peatland area, remaining open overgrown nature, bare soil in nature	11, 12, 20, 21, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46	7
Urban	Urban built-up areas, built-up areas in outer, grass in urban area, forest in dens built-up	18, 19, 22, 23, 24, 26	8

	area, built-up in agricultural land, open areas in built-up land		
Transport	Roads and railways	25	9
Remaining	???, greenhouses	8	10
LGN 4			
Dairy farming	Gras and Maize	1 ; 2	1
Arable farming	Potatoes, grain, beets and remaining crops	3 ; 4 ; 5 ; 6	2
Tree nursery	Orchards, nurseries	9	4
Flower growing	Bulbs	10	5
Water	Fresh water and saltwater	16, 17	6
Nature	Coniferous, deciduous forest, deciduous forest in urban area, coniferous forest in urban area, salt marshes, open sand coastal areas, open dune vegetation, closed dune vegetation, dune-heather, open drift-sand, heather, moderately enlarged heather, greatly enlarged heather, peat moor, forest in peat moor, remaining moor, reed vegetation, forest in moor, peatland area, remaining open overgrown nature, bare soil in nature	11, 12, 20, 21, 30, 31, 32, 38, 33, 34, 35, 36, 37, 39, 40, 41, 42, 43, 44, 45, 46	7
Urban	Urban built-up areas, built-up areas in outer, grass in urban area, forest in	18, 19, 22, 23, 24, 26	8

	dens built-up area, built-up in agricultural land, open areas in built-up land		
Transport	Roads and railways	25	9
Remaining	???, greenhouses	7 , 8	10

ANNEX 5 COMMODITIES

For this research the same commodities as in Diogo's research are used (Diogo et al, 2015). Diogo used the LISA dataset to determine which commodities are of importance for dairy farming. The LISA dataset is a protected data source that has to be paid for. This research did not have the resources to buy this dataset. Therefore, the commodities are filtered out of the distance map that can be found in the LUS. The distance map shows the distance from every grid cell to the commodity. Every grid cell with a commodity in it has a distance value of zero. To determine the locations of all the commodities all the values ≠0 are deleted from the distance maps. The exported distance map does not have any spatial references or an attribute table. Before the zero points can be filtered out these 2 components need to be added. To add an attribute table and spatial references the data has to be exported to ArcMap. It is really important when exporting the data into ArcMap that the correct reference system is added. For this research RD-new is used as a reference system. In ArcMap the tool Build a raster attribute table is used. To use the build raster attribute table tool the dataset has to be a single banded integer dataset. The dataset obtained from the Land Use Scanner is a three banded dataset. To create a single banded dataset the composite bands tool is used, this tool splits the three bands up into three single banded datasets. In the pop up menu you can export the band you would like to use for the calculations, for the distance dataset band 1 is used. After this the dataset needs to be transformed from a floating dataset to an integer dataset. This can be done in the spatial analyst tools → math → int. This tool creates an integer dataset. The dataset now has an attribute table. With this attribute table it is possible to filter all the values that zero. These values are transformed into polygons. The middle point of the polygons is used as the exact location of the commodities. This leads to a shapefile with the location of 117 points.

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METADATA

Name	Owner	Raster /vector	Projection	Temp- cover	Description
Location commodities	Diogo et al, 2008	Original is raster converted to vector	No spatial reference converted to RD-New	2012	This map has been altered for this research See appendix X.
LGN 4	Alterra	Raster	RD-New	2000	Land use anno 2000
LGN 5	Alterra	Raster	RD-New	2004	Land use anno 2004
LGN 6	Alterra	Raster	RD-New	2008	Land use anno 2008
LGN 7	Alterra	Raster	RD-New	2012	Land use anno 2012
Gemeenten (Bestuurlijke grenzen)	Kadaster	Vector	RD-New	2016	Municipal boundaries
Landbouwgrenzen	Esri	Vector	RD-New	2015	Agricultural zones