URBAN GREEN FROM ABOVE

A remote sensing-based housing price analysis

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TABLE OF CONTENTS

SUMMARY

This thesis researches the relationship between urban green space and housing prices through remote sensing of high resolution satellite imagery. Remote sensing is perceived as an underutilized method in the research of urban green space and is therefore explored in this thesis. This thesis not only aims to employ a new tool to an existing problem. Due to the all-encompassing nature of remote sensing, new insights could be gained through these innovative research methods.

Remote sensing techniques on high-resolution satellite imagery are used in order to measure the amount of green space in the municipality of Groningen, the amount of green space is measured through the calculation of the NDVI value per pixel. Subsequently, these calculated pixels were re-classified into two groups: high-structured vegetation and low-structured vegetation. After the classification, a multiple linear regression model was performed in order to find a relationship between measured urban green spaces and mean housing prices per 100 meter squares.

A positive linear relation between high-structured vegetation and housing prices was found, while no relation was found between housing prices and low-structured vegetation.

This proven relationship shows that urban green space like trees and parks hold a positive influence over housing prices. Meaning the higher the amount of high-structured vegetation in an area, the higher the housing prices in said area.

Minor limitations to remote sensing are observed in the research however, NDVI remote sensing has shown to be a promising alternative to measuring urban green space as opposed to the calculation of the distance of a house from a public park.

INTRODUCTION

Urban green space, UGS in short, holds various positive effects in urban environments. UGS consists of all green space in an urban environment, from trees to bushes from large public parks to the small grass fields in a playground. Urban green space has been linked to improving perceived general health and mental health for the residents living in the vicinity of urban green space (Richardson et al. 2013, Maas et al, 2016). Urban green space has been shown to affect health and well-being through creating an environment away from the stress and tension of the urban environment, while also constructing an environment which promotes physical activity and social interaction (Richardson et al, 2013. Javadi & Nasrollah, 2021). This improvement of environment and living conditions, especially in urban areas, which are oftentimes seen as the more stressed or tense living environments compared to its rural counterpart, shows the inherent value of urban green space. The influence of urban green space is not only remarkably positive when looking at health factors. The influence of urban green space reaches much farther. From a cooling effect in urban areas (Aram et al, 2019), to various crime rates (Kondo et al, 2018, Shepley et al, 2019. Sukartini, Auwalin & Rumayya, 2021), all previously mentioned topics demonstrate the wide variety of impacts that urban green space holds on its surrounding environment, especially in urban environments. This research puts a focus on housing prices and urban green space. Specifically focusing on urban environments is especially relevant in the current day and age. Since an increasing amount of the population lives in urban areas, gaining a detailed understanding of the various factors that influence housing prices will stay relevant in the current time and in the future. Urban green space is one of these factors where gaining a detailed understanding of its effects on housing prices holds importance for the development of cities in the current age as well as in the future.

Urban green space has been part of multiple studies regarding the relationship between the aforementioned concepts and housing prices. The majority of these studies have also found a positive relationship between UGS and housing prices (Kolbe & Wüstemann, 2014. Cho, Bowker & Park, 2006, Wu et al, 2015. Noor, Asmawi & Abdullah, 2015). While the relationship between urban green space and housing prices has been performed on numerous occasions, the variance in research methods when researching these two concepts has been limited. The most popular method has been the hedonic pricing method; however, the method cannot be seen as flawless. When using the hedonic pricing method, the variables that are selected have to be very precise and accurate in order for the model to work accordingly (Mason and Quigley, 1996). Within these studies that employ hedonic pricing, the main way of measurement has been the distance between a dwelling and the nearest publicly accessible park. (Cho, Bowker & Park, 2006. Kolbe & Wüstemann, 2014)

In this thesis, a new method in order to measure the amount of urban green space is suggested. Using an application of remote sensing this new method will be able to quantify all green space in an urban area instead of only the distance to a publicly accessible park.

Therefore, this study addresses the question: "How can remote sensing be applied in order to better understand the characteristics of the relationship between urban green space and housing prices?"

In the following chapters all relevant academic theory is listed, as well as the performed methods and the results forthcoming of the research.

The usage of remote sensing allows the research to incorporate all green space in urban areas, which will allow for a more comprehensive incorporation of all urban green space, as opposed to the usage of only publicly accessible parks or land-use mapping for measuring UGS. This research employs the following remote sensing approach: measuring the "greenness" of an area on satellite imagery of the city of Groningen through calculating the NDVI (Normalized Difference Vegetation Index), due to the city of Groningen being quite diverse in both urban green space as well as housing prices makes for suitable study area for this particular research. This research uses a split between high-structured and low-structured vegetation to classify the green space in urban settings. This classification is made in order to differentiate between different types of urban green space. Low-structured green space is defined as the more homogenous equal patches of urban green space. In reality, this often translates to being patches of grass between roads or sports fields. High-structured vegetation is defined as the more heterogeneous vegetation with a high amount of leaf structure. Examples of high-structured vegetation are trees, urban gardens or public parks (Schöpfer, Lang & Blaschke 2005).

This research expands on the possibilities of the usage of NDVI in housing price research. The research aims to use this new method to allow for more comprehensive and detailed understanding of urban green space, at both high- and low-structured vegetation levels in order to better understand the dynamics of urban green space and its effect on housing prices.

The results of this research shows the positive influence of vegetation on housing prices, showing that the influential green space in cities is more widespread than the influence of only public parks. However, this research shows that all other vegetation, which has not been researched as much, also has significant impact on urban housing prices. These results could also hold impact for the future development of hedonic pricing models. The previous consensus method for the measurement of green space was the distance of a dwelling to a public park(Cho, Bowker & Park, 2006. Kolbe & Wüstemann, 2014), this research indicates that using remote sensing is a viable alternative for the measurement in urban green space.

This research could incite a small change in the accepted paradigm concerning the hedonic price model.

A COMPREHENSIVE DEFINITION OF URBAN GREEN SPACE

Urban green space is the most vital concept in this research and has been heavily studied in a variety of ways. As mentioned before, urban green space with regards to housing prices has often been defined as the distance from a dwelling to a publicly accessible park (Kolbe & Wüstemann, 2014, Morancho, 2003). This method of defining urban green space is seen as incomplete, since green space does not only consist of publicly available parks. From every tree by the side of the road and every shrub in a garden to small football fields all contribute to the UGS and by extension in housing prices (Chen et al, 2018).

This research will not differentiate between privately and publicly available green space, due to the fact that all urban green space will be influential to the perception of a particular neighborhood and therefore also the housing prices. This has been implemented in other research that uses remote sensing in order to measure urban green space (Chen et al, 2018).

In this thesis, due to the fact that the research methods do not limit the kind of green space incorporated, the most general definition of urban green space is applied encompassing all green areas in urban environments. This means all trees and all patches of grass and all other imaginable green space in urban areas.

Panduro & Veie (2013) have used the hedonic pricing method in this subject in a slightly different manner, using multiple classifications in order to emulate the public perception of green space. Subsequently using these categories in order to improve on the hedonic pricing method. The results of this research show that not all green spaces are the same, even showing that some green spaces do not positively affect the nearby housing prices at all, this is mainly the case with green buffers next to busy roads, while other urban green spaces do.

In this research, it is hypothesized that a positive correlation exists between urban green space, consisting of high-structured and low-structured vegetation, and housing prices. This hypothesis is supported by previous research on this topic like Cho, Bowker & Park (2006), Kolbe & Wüstemann (2014) Wu, et Al. (2015). In Figure 1 below the conceptual model of this research is shown.

Expanding on the previously mentioned hypothesis: It is hypothesized that not all urban green space is the same and not all green space holds the same effects. The expectation for this research is that different levels of influences on housing prices will be observed from low-structured and high-structured vegetation.

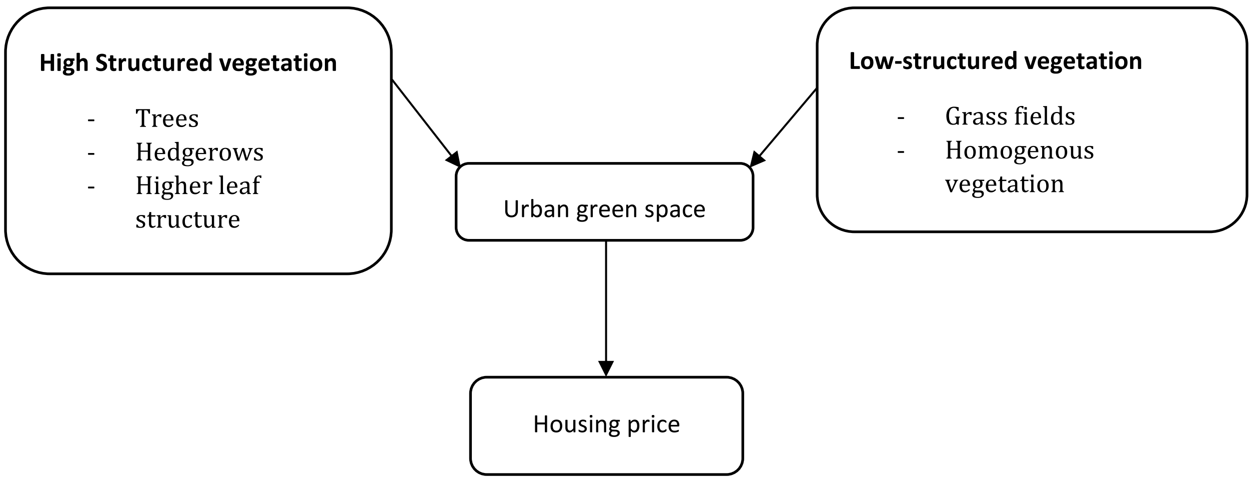

Figure 1. Conceptual model of this research

METHODOLOGY

The purpose for the methods of this research is to first measure each and every area of urban green space within the study area after which a linear regression will be performed in order to find a relationship between housing prices and urban vegetation.

In this research, in order to measure the green space in the municipality of Groningen, remote sensing techniques are applied. The program used for the remote sensing analysis of this research is ArcGIS Pro. In this research, a pixel-based remote sensing approach is used. Pixel based remote sensing will take every single pixel and individually calculate the corresponding NDVI value to that pixel, without taking into account neighboring pixels. This is done in order to take into account all potential small urban green spaces within the study area. After the calculation a reclassification will take place, reclassifying all pixels in the groups: non-vegetated and vegetated, consisting of low-structured vegetation and high-structured vegetation. The “vegetated” variable will be used in the first linear regression analysis. The variables of “low-structured vegetation” and “high-structured vegetation” are entered into a multiple linear regression model.

THE MEASUREMENT OF GREEN SPACE

For this research the Normalized Difference Vegetation Index (NDVI) will be used. This index is defined as follows:

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

Where “NIR” stands for the amount of near-infrared wavelength and “VIS” stands for the reflectance of visible red wavelengths. The NDVI in this research will be used to measure the amount of green space as well as the density of this green space (Earth Observatory, 2000). The result of this calculation will end up in the range between -1 and 1. The negative values are generally bodies of water, concrete or sandy soils while the positive values are generally vegetation including crops, trees, shrubs and grass fields (Huang et al, 2021).

Using NDVI as a measure in remote sensing studies has been conducted before. Schöpfer, Lang & Blaschke (2005) used NDVI remote sensing in research on green space and housing prices.

THE EMPIRICAL STEPS TO THE ANALYSIS

After the combination of both datasets, all statistics squares that were 100% within the acquired aerial imagery were selected for this research. The squares on the edges of the aerial imagery were therefore also taken out of the regression analysis in order to minimize extreme outliers or errors in the data. The total amount of cases in the analysis was not significantly affected by this procedure. Each square in the dataset (N=2347) was used as a singular case in the regression analysis which was performed later in the research.

After completion of the pixel-based NDVI remote sensing analysis. The analysis appointed an NDVI value between -1 and 1 for every pixel in the image. After completion of the remote sensing the results were re-classified into different categories. Firstly a binary classification was made based on the newly assigned values. All pixels with a NDVI value higher than 0.3 were classified as "vegetated" for the initial regression analysis. Previous research has shown that the 0.3 limit for vegetation is suitable to include moderate vegetation like shrubs and other low-structured vegetation which is the goal of this research (USGS, 2018).

All pixels with NDVI values lower than 0.3 were classified as non-vegetation. All vegetated pixels within each square were counted and the ratio of "vegetated" pixels was calculated. The descriptive statistics of this variable can be found in Table 1 below.

After the aforementioned regression analysis, a second regression is run in order to determine the relationship between housing prices and low-structured and high-structured vegetation. During the second regression analysis all pixels with values between 0.3 and 0.5 were classified as low-structured vegetation and all pixels with a higher value than 0.5 were classified as high-structured vegetation. This split was made to identify two general kinds of vegetation present in the study area, with these two kinds being the low-structured vegetation and high-structured vegetation.

The re-classified pixels were re-counted within each case, resulting in the data exhibited in Table 1 below. Per square, the ratio of high-structured and low-structured was calculated. The decision to make use of a ratio of vegetation coverage per square was made due to a slight variability in the number of pixels per square, a minimum of 160 pixels and a maximum of 170 pixels per square was observed. The usage of a ratio within this regression model also allows for better reproduction of the research, due to possible slight variations in pixel count within squares of varying aerial imagery. After this course of action the data was controlled on outliers, which resulted in 1 case being taken out of the sample for being an extreme outlier which would skew the data in a certain direction. The dataset outlined in Table 2 below was used for this research.

Table 1: Variables used in the research. *Made by Author*

N=2347	***Mean***	***Min***	***Max***	***Std. Dev***
*Housing price(*1000)*	231.47	46	878	114.193
Vegetated pixels Ratio(NDVI >0.3)	74.88	0%	100%	25.5%
Low-Structured Vegetation Ratio	35.9	0%	85.7%	17.1%
High-Structured Vegetation Ratio	38.04	0%	100%	22.9%

REGRESSION SPECIFICATION

Firstly, a linear regression model was performed with the binary categorization of the pixels. The dependent variable of the analysis is the average housing price per square. The independent variable entered into the first model is the ratio of vegetated pixels per square, this is used as the measure for “greenness” within a square.

After the first regression model, a secondary multiple linear regression model was applied. The dependent variable remains the average housing price per square. For the independent variables the ratio of high-structured and low-structured vegetation pixels per square was used. During this research a 95%confidence interval for the regression model was applied.

ETHICAL CONSIDERATIONS

One of the most important ethical considerations within this research is the use of secondary datasets. Since the research exclusively makes use of secondary data on housing prices and self-generated data on urban greenery procured from satellite imagery. It is important to consider the correct usage of this secondary data. Both data sources, in this case the Copernicus Program of the European Union for the satellite imagery and data from the CBS (2020) for the housing prices are publicly available sources which are published for, among other purposes, research purposes.

The data on housing prices did not bring many privacy and/or ethical considerations along, due to the core nature of the dataset being built up of squares of 100 by 100 meters. These squares make it possible to analyze housing prices without revealing this information on a per-house basis.

THE DATA

Data on housing prices within the municipality of Groningen was derived from the Dutch Central Bureau of Statistics (CBS). The data consists of a georeferenced grid of squares of 100 by 100 meters. One of the multiple variables available in this dataset is the average housing price in the square. The average housing price in this dataset is calculated through the WOZ-value ("Waardering Onroerende Zaak" in Dutch) of all dwellings in the associated square. The WOZ-value is the value of a dwelling after a yearly taxation which is performed by the local municipality (Kadaster, 2021).

Data of the year 2020 was used in order to keep consistent with the aerial imagery, since the aerial imagery used in this research is from the year 2020. The satellite imagery used in this research originates from the Copernicus program of the European Commission and was used for the remote sensing procedure. The satellite imagery was taken from the year 2020. The satellite imagery represents the median surface reflection of all available satellite images that cover the municipality.

There are multiple advantages associated with the use of this dataset as opposed to using the administrative borders of, for example, a neighborhood due to the unchanging nature of the squares in this dataset. This makes the dataset useful for research purposes in the future since administrative borders are subject to change over the years. The dataset of the housing squares has been observed for MAUP. However, no significant issues were found during the remote sensing phase of the research, with the dataset having the smallest squares possible for this kind of research without privacy concerns arising. In addition, the amount of squares is of such a volume where single cases with MAUP will not significantly affect the results.

The dataset of square statistics has been produced for the whole of the Netherlands, allowing for better reproducibility in other municipalities of The Netherlands as well as for the municipality of Groningen (CBS, 2020).

RESULTS

This research has aimed to identify the characteristics of the relationship between housing prices and the amount of urban green space using remote sensing to measure the urban green. The amount of urban green space was measured through pixel-based NDVI remote sensing, using a ratio of the amount of measured green within the statistics square. The relationship between the two variables was evaluated through successive linear regression models.

REMOTE SENSING

The results of the remote sensing analysis of the municipality of Groningen is shown below in Figure 2. For this map, the greener the area is, the higher the associated NDVI value. The redder the area, the lower the NDVI value.

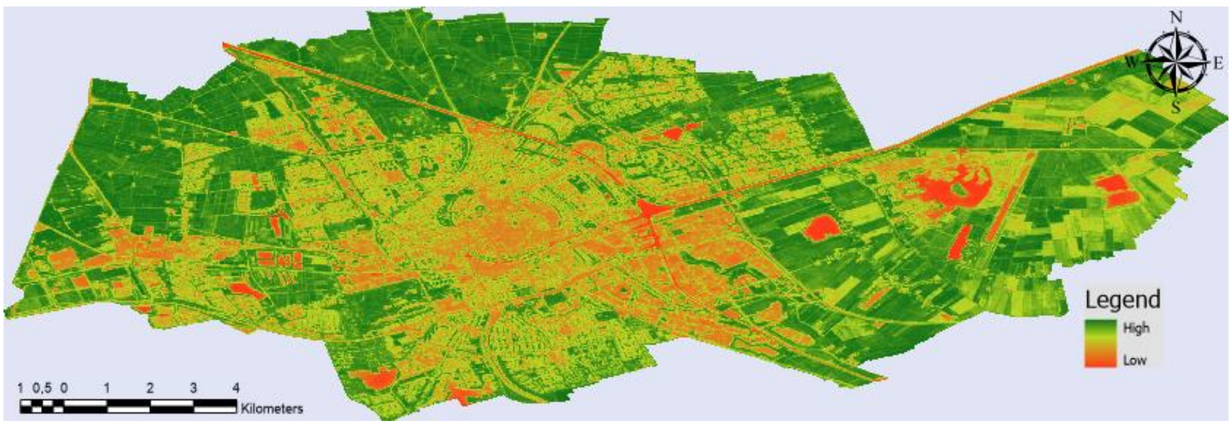

Figure 2. NDVI Map of the Municipality of Groningen

Note in Figure 2 above the low measurement of vegetated pixels in the city center of Groningen. The more one moves away from the city center or other smaller towns and villages the higher the associated NDVI value becomes. Notable for the readability of the map, some very red spots within the map are water bodies, since the NDVI value of water bodies tends to be near -1. It also needs to be noted that the area southeast of the city center is an industrial area, which together with the water bodies has not been included in the research since these areas do not contain housing and are therefore not relevant for this research.

Another notable part of this visualization are the more yellow areas to the northeast, northwest and south of the city center, being the largest residential neighborhoods or villages included in this research. These areas generally have a higher NDVI value through the many smaller elements of urban green space included in these areas. These areas often end up classified as low-structured vegetation as can be seen in Figure 4 below.

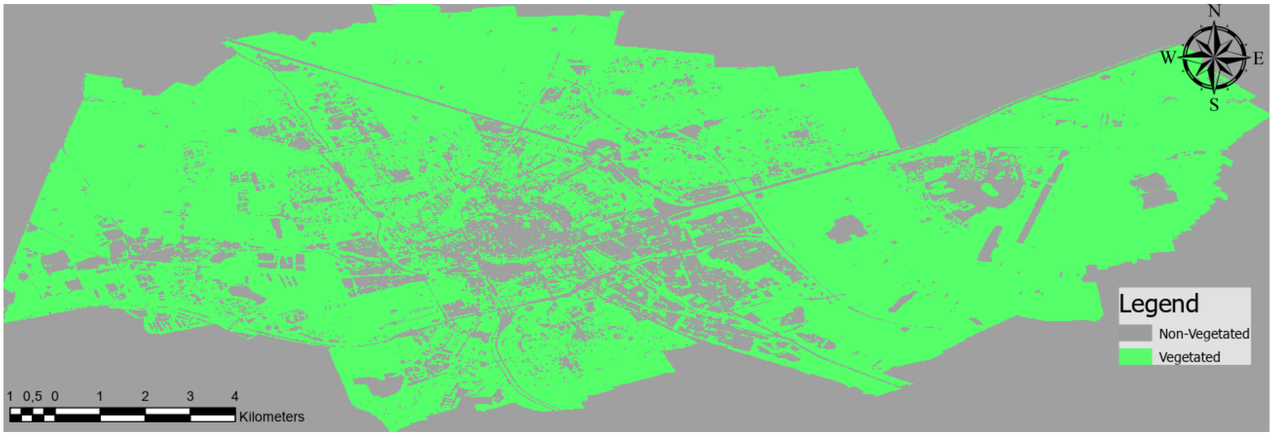

Figure 3. Municipality of Groningen categorized in two categories based on NDVI.

In Figure 3 and 4 above and below respectively the map with the categorized NDVI values can be observed. Figure 3 shows the municipality of Groningen with the binary categorization applied while Figure 4 shows the map with the classification of high-structured vegetation, low-structured vegetation and non-vegetation. Noticeable when looking at both figures is the additional information that the secondary categorization reveals. In Figure 4 the number of non-vegetated areas has stayed the same due to the nature of the categorization. However the figure does show more of the patterns of residential neighborhoods in the municipality of Groningen. This could have to do with the increase in green space in neighborhoods outside of the city center, therefore the measurement of NDVI in those neighborhoods could be higher.

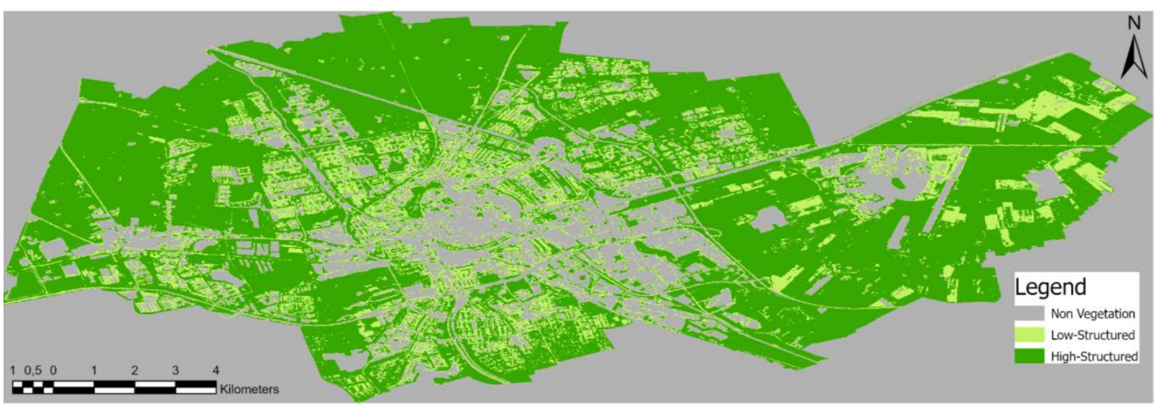

Figure 4. Municipality of Groningen categorized in three categories based on NDVI.

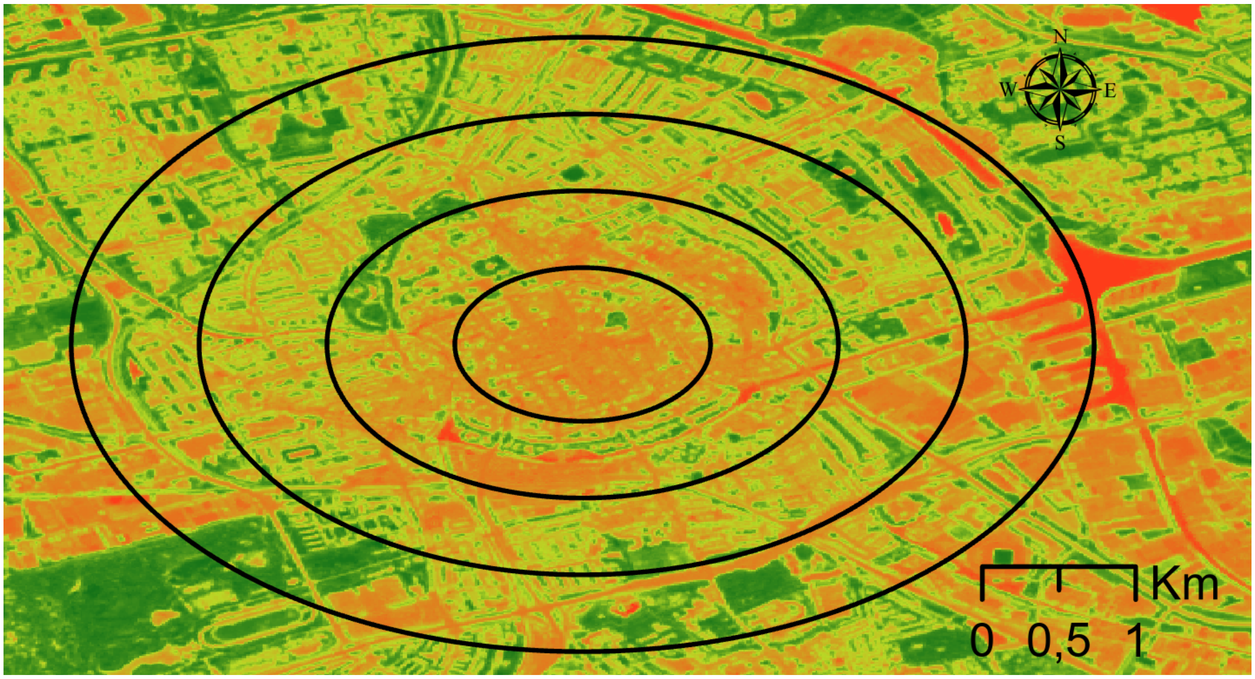

Figure 5. City center of Groningen in the NDVI analysis map.

Notable in the data is the absence of green space when looking closer to the city center of Groningen. This can especially be observed in Figure 5 above where each black line is drawn 500 meters apart from each other and the first circle is a 500-meter diameter of the city center. This map is zoomed in to the city center of Groningen in order to show the increase in green space when moving more and more out of the city center.

REGRESSION ANALYSIS

In Figure 6 below the distribution and one of the regression lines of the second regression analysis are shown, specifically a scatterplot between the ratio of high-structured vegetation and housing prices is shown. A clear positive regression line is also shown in Figure 6 above, showing the statistically significant positive relationship between the two variables. The circles shown in this figure represent different grouped cases, in which it is visible that the cases, or squares on the map, with higher housing prices also have higher ratios of high-structured vegetation within their associated square on the map. Notable in this graphic is that not all lower housing values are clustered together at the bottom-left corner of the graphic. The lower housing prices are still present even when the ratio of high-structured vegetation is high. The higher end of housing prices cluster together around the higher ratios of high-structured vegetation.

Figure 6. Graph of the regression trend between high-structured vegetation ratio and housing prices. Made by author.

In Table 2 below, the results of the first performed regression model is shown. In Table 2 below all results from both performed regression analyses are displayed. During the first regression model solely the vegetation Ratio variable (ratio of pixels with NDVI>0.3) was used.

In Table 2 below it can be seen that the Vegetation ratio variable holds statistical significance in this linear regression model. After a linear relationship was found between vegetation ratio and housing prices, the second regression model was performed dividing the vegetation ratio variable into the low-structured vegetation and high-structured vegetation ratio variables. From this model, it can be observed that only the high-structured vegetation holds a statistically significant relationship with housing prices, while low-structured vegetation holds no statistically significant relationship with housing prices.

Table 2. Results regression models

	Model 1	*Model 2*
Vegetation Ratio	0.000***	
Low-structured vegetation ratio		0.657
High-structured vegetation ratio		0.000***

Note: ***indicates significance at 1%

In the multiple linear regression model, including low-structured and high-structured vegetation, the variables did not suffer from collinearity, which happens when one predictor variable in a multiple linear regression is linearly predicted by the other predictor variables in the model. With a tolerance of 0.716 and subsequently a VIF-value of 1.397.

The model shown in Table 4 reveals the positive statistically significant relationship between housing prices and ratio of vegetated pixels. The direction of the relationship between these two variables is positive with a 99% confidence interval, the existence of a positive relationship between the two variables was within the measures of expectation due to the positive relationships found in previous research. The results of this statistical analysis suggests that the existence of green in a neighborhood holds a positive effect when looking at housing prices. Notable within these results is the positive relationship between high-structured vegetation and housing prices. While no statistically significant relationship is observed between low-structured vegetation and housing prices. The results of the second regression model indicate that the areas with a high-NDVI, like trees, parks or hedgerows with a high leaf structure, are the areas which influence housing prices. The relationship also indicates that an absence of high-structured green space in urban environments can negatively affect housing prices.

Another point in these results is the absence of a relation between low-structured vegetation and housing prices. Again, low-structured vegetation can be generalized as homogenous areas of green space. Examples of low-structured vegetation are areas like football pitches or grass playgrounds. These more homogenous green spaces seem to not be affecting housing prices.

The characteristics of the relation between urban green space and housing prices are identified in this research as follows; high-structured vegetation, defined as remotely-sensed pixels with an NDVI value higher than 0.5, holds a positive relationship to housing prices. Meaning the higher the amount of high-structured vegetation, the higher housing prices in that corresponding area will become higher.

DISCUSSION

INTERPRETATIONS

This research has shown the existence of a positive relationship between high-structured vegetation and housing prices, through the usage of remote sensing in order to measure the amount of green in the municipality of Groningen. These results suggest that, when the amount of high-structured vegetation increases, then housing prices will also increase. This research has shown that the usage of remote sensing is very viable when researching urban green space. In previous studies urban green space was generally calculated through the amount of distance between the dwelling of which the value is calculated and the nearest publicly accessible park. This research suggests the usage of remote sensing technology as a viable alternative. Remote sensing will take more urban green space into account, since every single tree or hedgerow is taken into account in the model, which will allow a model to become more comprehensive and all-encompassing.

This research explores the possibility and usability of NDVI remote sensing in urban environments. Although NDVI remote sensing has its popular use in the analysis of rural areas (Wójtowicz, Wójtowicz, & Piekarczyk, 2016. Ayala-Silva & Beyl, 2005), the technology has not been fully explored in urban areas. The results of this research show the viability and benefits of using remote sensing in this research context. Remote sensing not only takes into account more green space, it also removes the high amount of emphasis on publicly accessible parks by only taking into account the vegetation in smaller squares.

Finally, the results of the NDVI remote sensing show an interesting pattern which is made especially visible in Figure 5. The farther one moves from the inner city, the higher the amount of green space becomes. This together with the knowledge that this green space will increase the price of the housing in the areas with more high-structured vegetation leads to a situation which is the reverse of the Alonso bid-rent model (1964) which suggests that the most desirable locations would converge in the center of the city. High-structured vegetation can be expected to be desirable due to the various positive effects it has in residential areas.

One element to note when discussing the research of publicly accessible parks in relation to urban green space is the influence of parks in their own unique way. Within this research public parks have only been regarded as larger parts of, often, high-structured vegetation. This research has not taken the larger influence of public parks into consideration however, where previous research has shown that the influence of these parks stretches beyond the immediate vicinity of the public parks in question (Kolbe & Wüstemann, 2014. Wu et. Al, 2015). In this research the larger influence of public parks is not taken into account, it is only observed as a lot of high-structured and its influence is only calculated in the immediate vicinity. The influence of these parks will stay relevant within the research of housing prices due to this larger influence as well as the various other benefits that these parks bring to their neighborhood.

LIMITATIONS

There are some parts of this research which were limiting to the eventual results of this research. This research only takes into account the direct surroundings of a dwelling. The heavily researched influence of the proximity of public parks is not taken into account. This can be seen as a double-edged sword, on the one hand the direct surroundings could be perceived as the area most influential to the housing price and therefore most relevant in housing price research. However on the other hand if a publicly accessible park or a significant area of green space is not included in the square which the house is analyzed in then that green space might be misrepresented in the final results.

The classification method in this research is quite elementary, only having two categories, compared to the potential of remote sensing technology and has not been able to cover all green space. The sample used in this research unfortunately does not classify all green space in the correct category, this was especially prevalent with the classification of the low-structured vegetation. No major issues, however, were found with the classification of high-structured vegetation.

The main issues with the classification came with the classification of low-structured vegetation. Some pixels that included housing were classified as low-structured vegetation due to the relatively high NDVI value and the lack of calculations controlling for these occurrences. This occurrence should not be seen as a large limitation, it should be regarded as an avenue of improvement of the methods to classify vegetation based on NDVI.

Furthermore, the use of satellite imagery has limitations due to pixel resolution concerns. The smallest green spaces which the research wishes to include as well. Using smaller scale maps could resolve this issue. This was mainly the case with the classification of the low-structured vegetation.

These concerns with the classification of low-structured vegetation do not mean that the results of this research should be seen as objectionable or false, since the main results of this research concern the high-structured vegetation which did not have many problems like this during the classification process.

CONCLUSION

The presented research attempts to add to the scientific discourse of the usage of remote sensing in urban settings. The research shows the viability of measuring green space within cities using NDVI as a base variable. The presented research also indicates the influence of high-structured vegetation in urban areas.

Within this research, a statistically significant relationship has been found between high-structured vegetation (defined as green space with a NDVI value higher than 0,5) and housing prices. The research also shows the high potential for remote sensing technology within urban areas, especially when it comes to measurement of green space. The research hopes to start the dissolving of the consensus measurement technique for urban green space, being the measured average distance to a public park.

The relationship proven in this research suggests that, if high-structured urban vegetation decreases then the nearby housing prices also decreases. On a more societal level the results of this research should be carefully interpreted due to the plethora of benefits urban green space brings. A decrease in housing prices should not be achieved through a decrease in high-structured vegetation due to the aforementioned health and societal benefits associated with urban green space.

The results of this research shows the positive influence of vegetation on housing prices, indicating that the influential green space in cities is more widespread than the influence of only larger public parks. However, this research shows that all other vegetation which has not been researched quite as much also has significant impact on urban housing prices. From every tree by the side of the road to a small urban garden, all these small high-structured vegetation patches influence the nearby housing prices. The results of this research should be interpreted with some care, due to concerns with the exact measurements of the NDVI variable.

RECOMMENDATIONS FOR FUTURE RESEARCH

The usage of remote sensing for urban green space is not fully researched in the slightest. The presented research has only used the NDVI variable for the remote sensing measurement of urban green. Other variables or other combinations of variables in order to measure “greenness” in urban environments should be considered for future research. This could lead to a more detailed measurement of urban green space and therefore lead to a more detailed understanding of the relationship between housing prices and urban green space.

The inclusion of the newly explored variable of high-structured vegetation into the already existing hedonic pricing model, replacing the arguably selective proximity to parks variable, to gain more understanding of the overall influence of urban green space in the more comprehensive hedonic pricing model.

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