DETERMINATION OF THE IMPERVIOUS SURFACES IN AN URBAN DEVELOPMENT AREA USING GIS METHODS

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ABSTRACT: *Impervious surfaces can cause environmental problems, including flooding and contaminated runoff. There is little visibility of private paving. Infrared aerial photos can be used for the build-up to map this paving that can be used to add the correct areas to sewer hydraulic models. Chlorophyll from plants absorbs infrared light, making it possible to filter out unpaved surfaces from infrared images. In particular, driveways and paved front gardens are thus insightful and are included in the runoff areas of the sewer systems.*
This analysis provides a true-surface map for private paving. However, not including these pavements in sewer calculations produces a result that matches measurements better in most situations, due to the walk-in model used. The private pavements have their own characterization which allows them to be easily adjusted or switched on and off, for example depending on the type of analysis being performed. With the output from this analysis, the governments can be better equipped to prevent floodings and human or material damages

Keywords: *impervious; GIS; urban; pavement; flood;*

1. Introduction

Impervious surfaces are mainly man-made structures such as pavements (roads, pavements, driveways, and car parks, as well as industrial areas such as airports, ports and logistics and distribution centers, all of which use significant paved areas) that are covered by water-resistant materials such as asphalt, concrete, brick, stone, and roofs. Soils compacted by urban development are also highly impermeable. Impervious surfaces are an environmental concern because their construction triggers a series of events that alter urban air and water resources.

The total coverage by impervious surfaces in an area, such as a municipality or a river basin, is usually expressed as a percentage of the total land area. Coverage increases with increasing urbanization. In rural areas, impervious coverage may be as low as one or two per cent. In residential areas, coverage increases from about 10 per cent in low-density subdivisions to more than 50 per cent in multi-family communities. In industrial and commercial areas, coverage rises above 70 per cent. In regional shopping centers and densely populated urban areas, it exceeds 90 per cent.

Impervious surface coverage can be reduced by limiting land use density (such as several houses per hectare in a subarea), but this approach causes land to be developed elsewhere (outside the subarea) to accommodate the growing population. Alternatively, urban structures can be built differently to make them function more like naturally permeable soils Examples of such alternative structures are porous pavements, green roofs, and infiltration basins.

2. Research location

Midden-Drenthe is a municipality located approximately in the middle of the province of Drenthe in the north of the Netherlands. The municipality has 33,583 inhabitants (1 July 2021) and an area of 341.53 km². From 1998 until 2000 the name of the municipality was Middenveld.

The municipality was created in 1998 by merging the former municipalities of Beilen, Smilde and Westerbork.

Beilen is the largest town in this municipality with a population of 11,355 (1

July 2021) inhabitants and is located at an infrastructure junction between Hoogeveen and Assen. This strategic location is partly responsible for economic development and gives the city a clear regional supply function.

Most roads have several speed barriers across the width and generally consist of pavements on both sides of the road pavements. The pavements are separated from the roads by kerbs which are usually 6-12 centimeters high. In Beilen there are predominantly terraced houses. The front door thresholds of houses are in most places high (> 6cm). Furthermore, in front of the houses there is mostly room for small 'gardens' that slope up from the streets towards the houses. In large parts of the city, these gardens are completely paved over, so less rainwater might infiltrate, and more water will run off the surface.

to political and social pressure on urban drainage managers, in addition to costs in damages to municipalities. Furthermore, anticipated changes in air temperature and precipitation could affect the flow in receiving streams, alter the morphology and transport of sediments, and change the kinetics of chemical reactions and hence the mobility and dilution of pollutants discharged from urban wastewater systems and storm drains.

In the context of urbanization, we can accurately define stormwater as runoff from permeable and impermeable surfaces in predominantly urban environments. Impervious surfaces can be defined as concrete coal roads, highways, roofs, sidewalks, and paths. Land cover and rainfall pathways have created a condition in which watersheds, streams and their channels are adversely affected (fig. 1).

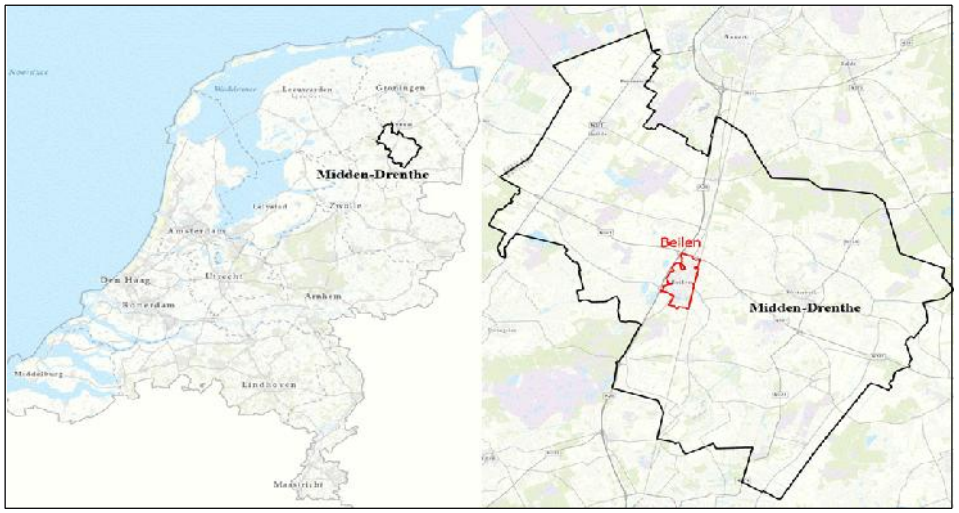

Fig. 1. Location of the study area

The impact of urbanization on the water cycle is essentially related to surfaces becoming impermeable, resulting in a marked reduction in the infiltration capacity of soils and more vulnerable drainage systems subject to higher and faster inflows of water. Unless urban planning measures are developed to counteract these historical trends, the percentage of rainfall runoff will increase with urban development, inexorably leading to higher flows and runoff volumes. This, when it happens, will have various repercussions on people and infrastructure, from complaints and grievances

3. Methodology

To determine which parts of the soil are permeable and which are impermeable, is necessary to classify the images into land use types. Pervious surfaces are represented by vegetation, bare ground, and water bodies. Impervious surfaces are usually those build by humans (buildings, roads, parking lots, etc.). Multispectral imagery can be used for this type of classification because each type of land use generally has unique spectral characteristics (fig. 2).

Fig. 2. Aerial image of the studied area

Segmentation combines neighboring pixels with similar spectral characteristics into segments. In this way, the image is generalized and can be classified more easily. Instead of classifying thousands of pixels with unique spectral signatures, will be classified a much smaller number of segments.

Features such as vegetation appear to be clustered into many segments that blur. Small segments that appear to consist of only a few pixels are also scattered throughout the area. However, this image is created on the fly, which means the processing changes as the map grows.

For classification, were created 543 training samples that represents distinct samples of the different surface types. The distinction was made in two main types: pervious and impervious. Classification is not an exact science, as some parts are classified incorrectly. Shadows of the houses or muddy ponds can be classified as impervious and sometimes, some roofs are classified as pervious surfaces. This method is just giving an insight of the approximative impervious surfaces from a parcel (fig. 3).

By using the result of the reclassified image, was determined the areas of pervious and impervious surfaces within parcels in the studied area (figure 4).

Fig. 3. Segmented and reclassified image

Fig. 4. Polygons of parcels

4. Results

In this study was performed an extraction of the impervious surfaces from a neighborhood from Beilen by using Aerial Imagery with a resolution of 25 cm. Figure 5 shows that the impervious surfaces are distributed in a disordered way. This can give an insight about how the heat will affect the citizens and about the locations where the rainwater can infiltrate in the ground or will be collected by the municipality's sewer systems (fig. 5).

Fig. 5. Percentages of impervious surfaces

In the below graph is visible that on each parcel the impervious surface represents about 80% of the total area. This should raise questions about the huge surfaces that became impervious, because losing vegetation and water areas should become a critical issue for mitigating the urban heat effect and flooding protection (fig. 6).

Bigger impervious areas mean more rainwater volumes that needs to be collected by the public sewer systems.

In the places where impervious surfaces areas are a lot higher than the pervious surfaces flood risks could be a serios problem due to climate change. In the graph is represented a comparison between total impermeable and permeable areas.

Runoff on impervious surfaces is higher than on the pervious surfaces and because it doesn't have where to infiltrate the risk of resulting material damages is increasing. An estimation of impervious surfaces could help in building reliable hydraulic models, necessary for correctly dimensioning sewers for future rainfall events (fig. 7).

5. Conclusions

One of the biggest challenges of remote sensing in cities is the correct distinction between impervious surfaces and other categories of land cover. Therefore, previous studies have used complicated methods to map impervious surfaces. So far, no index has been developed to improve the characterization of impervious surfaces, as a simple index with two bandwidths is unable to do so. This allows the new index to highlight the features of impermeable surfaces while suppressing background noise such as sand, soil and water, which might otherwise be mixed with the extracted information about the impermeable

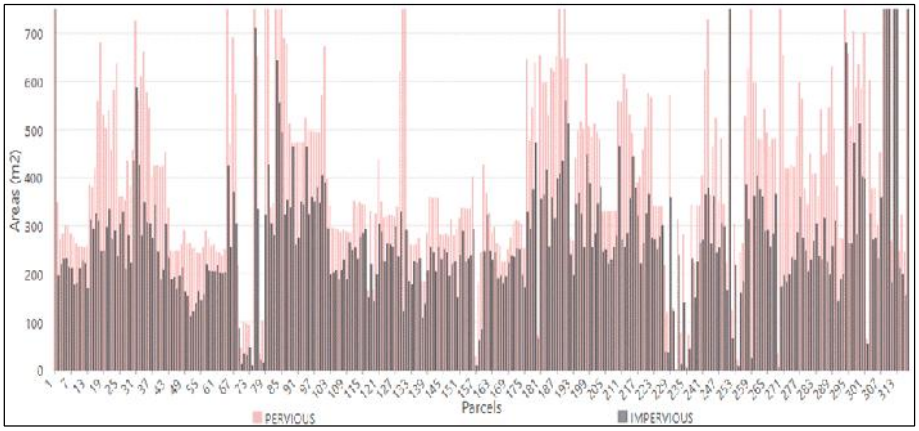

Fig. 6. Differences between pervious and impervious area

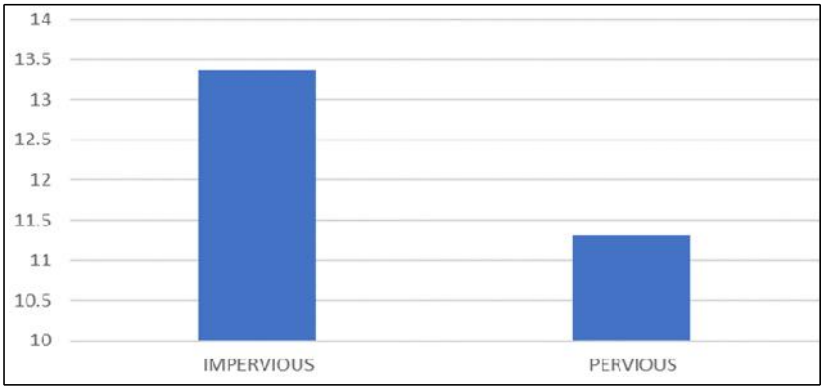

Fig. 7. Total areas (ha)

surface and therefore has to be masked beforehand. Aerial images can delineate the distribution of impervious surfaces and show the actual percentage of impervious surfaces.

It can be easily used and generally requires no pre-processing. It will therefore greatly improve the efficiency of mapping impervious surfaces over large areas and is a convenient and fast tool for extracting impervious surfaces.

References

1. Xu Hangiu - *Analysis of Impervious Surface and its Impact on Urban Heat Environment using the Normalized Difference Impervious Surface Index* (NDISI);
2. Qihao Weng - *Medium Spatial Resolution Satellite Imagery for Estimating and Mapping Urban Impervious Surfaces Using LSMA and ANN*;
3. Rudong Xu, Jin Liu, Jianhui XU - *Extraction of High-Precision Urban Impervious Surfaces from Sentinel*-2 Multispectral Imagery via Modified Linear Spectral Mixture Analysis;
4. Yingbin Deng, Fenglei Fan, Renrong Chen - *Extraction and Analysis of Impervious Surfaces Based on a Spectral Un-Mixing Method* Using Pearl River Delta of China Landsat TM/ETM+ Imagery from 1998 to 2008.