Site analysis for a multifunctional centre in the municipality of Berg en Dal, The Netherlands

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Introduction

The Municipality of Berg en Dal came into being on January 1st, 2015 through the merger of the municipalities Groesbeek, Millingen aan de Rijn and Ubbergen.

Berg en Dal faces a challenge regarding the living conditions for starters (middle aged adolescents who want to rent or buy their first home) and senior citizens (people aged 65 and over), (Groesbeek 2025 Structuurvisie, 2013). The municipality is also confronted with the problem of a total decrease in turnover of retail of 3% (2016, Visie Retail en Leisure Berg en Dal). Both issues incite the Council of Berg en Dal to investigate the development of multi-functional centres accumulating dwellings for starters and senior citizens, and independent shops selling durable consumer goods.

UNIGIS received the assignment to perform a GIS based (multi) criteria evaluation technique to identify the best site for a multi-functional centre. This report describes the set of data and the criteria used in evaluating the optimal location, the suitability analysis process (its advantages and disadvantages), the main findings and finally used references.

Problem definition

What is the best site for a multifunctional centre in the municipality of Berg en Dal to attract starters, to take care of senior citizens and reinforce the local economy?

- The zoning plan should allow developing a multifunctional centre on the selected area
- The site should have a minimum area of 1.800 m^2
- The maximum travel time by ambulance to an emergency is 15 minutes
- The maximum walking distance to the nearest bus stop is 300 meters respectively 450 meters

Study area

Berg en Dal lies west of Nijmegen in the province of Gelderland, The Netherlands, contains 12 villages and covers 93,3 km^2. The Municipality of Berg en Dal has 35.574 inhabitants (Statistisch Zakboek Gelderland, 2017).

Figure 1: Study area.

Criteria

In addition to the predefined criteria, the municipality formulated the following criteria for the development of a multifunctional centre containing dwellings and stores.

Zoning plan

The zoning plan describes which function(s) have been attributed to a given area inside the border of the municipality of Berg en Dal by the (local) government. These, by law established functions, are filtered on the purposes dwelling, retail and mixed land use (Kadaster, 2017).

Size

To develop a three-storey building containing five stores, a community centre, nine apartments for starters, nine apartments for senior people, and outdoors a minimum area of 1.800 m^2 is requisite.

Slope

A slope value between 1- 5% is considered ideal for many exterior spaces and functions (Booth, N. K.,1989). It is without causing grading problems, and it provides the maximum flexibility for development and can accommodate massive site elements such as major buildings.

Infrastructure

A residential area and a shopping street will be defined as sufficient accessible if the nearest slip road of a motorway is within 2.000 meters (Compendium voor de Leefomgeving, 2016). This suitability analysis employs a broader definition of motorways including regional roads (N and S roads). Easy access to stores and parking lots is necessary to attract customers.

Flood risk

The companion of the Handboek Overstromingsrisico's op de kaart (Deltares, 2014) discerns three different scenarios of high-water level:

- A good chance of a flood in the valley of a river: happens once every ten years
- A medium-sized chance of a flood in the valley of a river: happens once every 100 years
- A small chance of a flood in the valley of a river: happens once every 1.000 years

Drive time ambulances

The accessibility standard for ambulances in The Netherlands, in the case of an emergency, is a driving time of maximum 15 minutes (Overheid.nl, 2017). There is a growing appeal to senior citizens to call the emergency centre in case of an (in)valid reason of an emergency (Bijzijn XL, 2016)

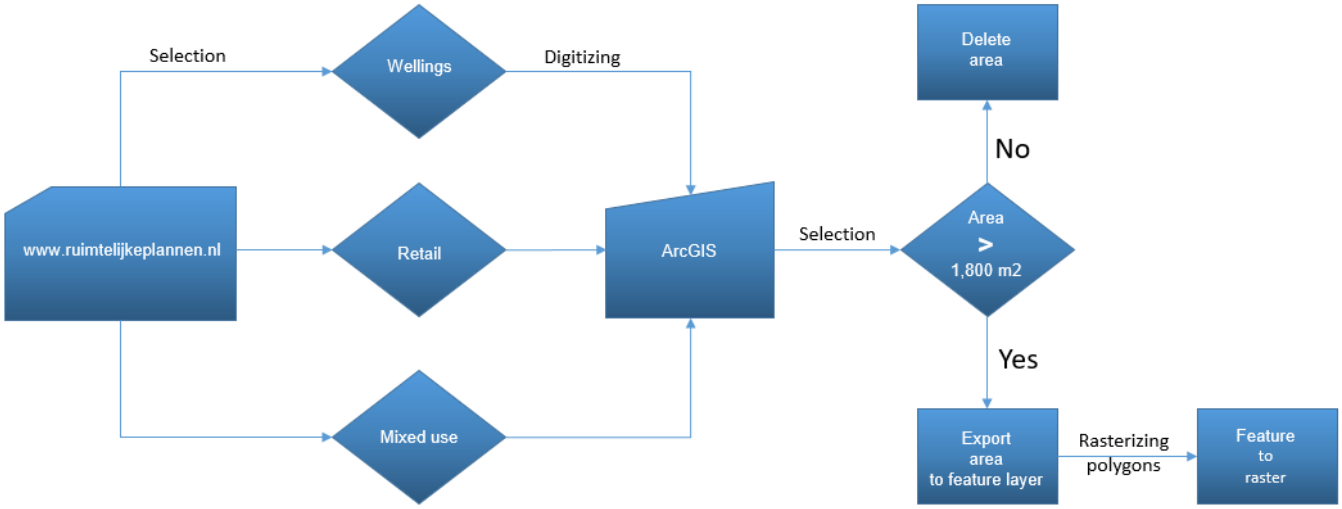
Access to public transport

The maximum distance senior people are willing to walk to a bus stop (interurban) is 300 meters and 450 meters for an average person (Kors, 2004). Public transport is necessary for citizens without a car, who need to commute, visit family or have to consult a medical specialist.

Data preparation process

Preceding the binary overlay process, the additional collected data has been converted to raster data taking into account the criteria as described in the previous paragraph. In addition to the data sets originating from the briefing notes the data preparation process included the following steps:

a) Zoning plan data
The proposed sites for retail, dwellings and mixed-use have been digitized using the zoning planning data at Ruimtelijkeplannen.nl.



Model 1: Data preparation zoning plan.

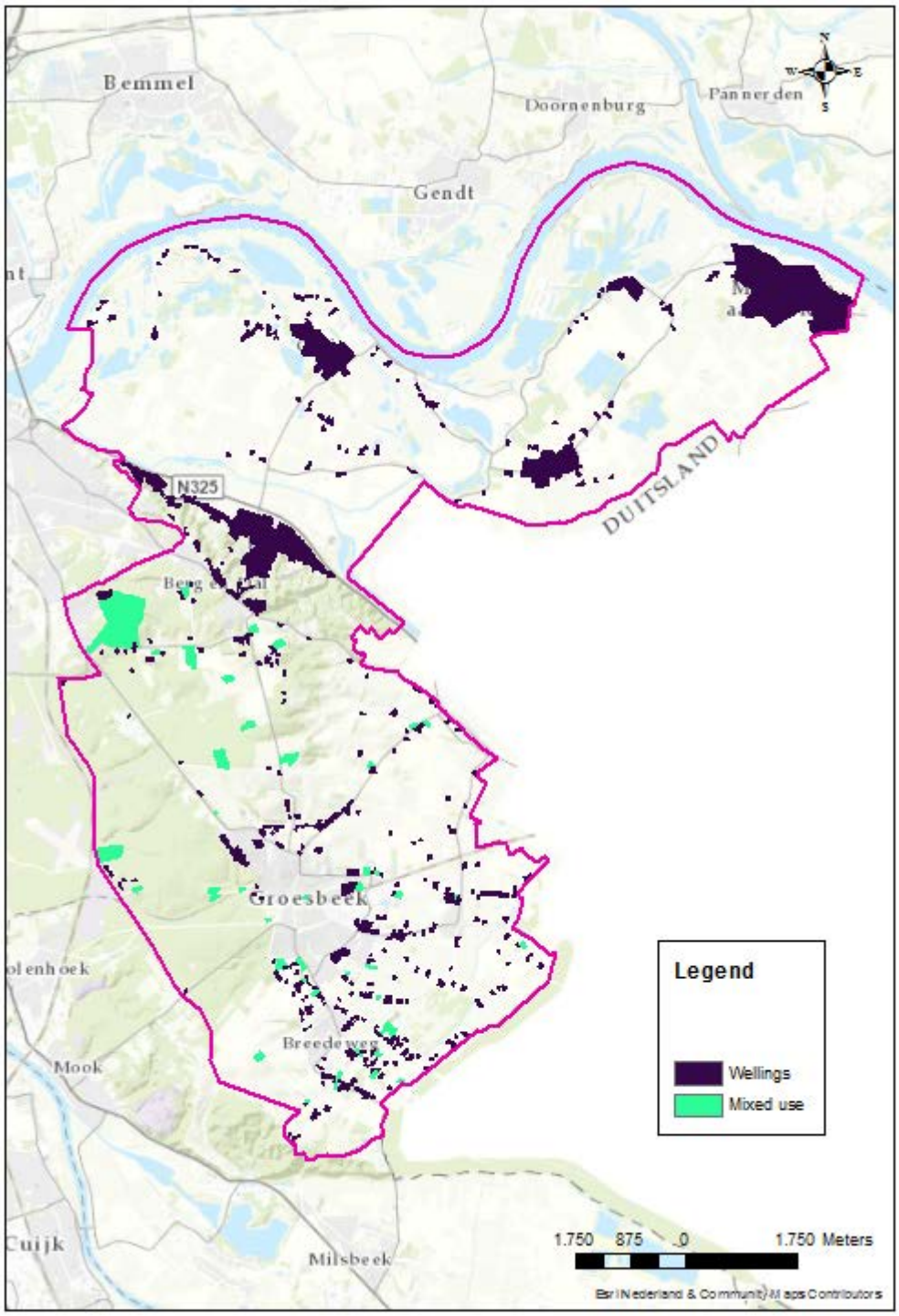
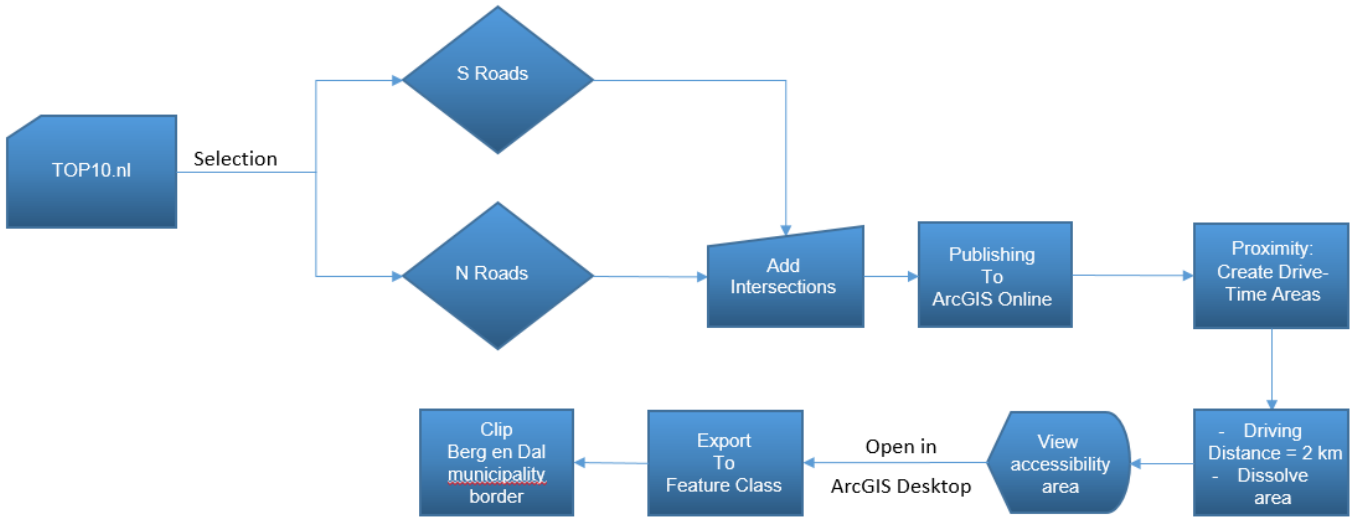


Figure 2: Zoning plan Berg en Dal, areas > 1.800 m²

b) Infrastructure
Also, S and N roads that are most likely accessible within 2 km driving distance outside the local authority boundary have been selected. Second, all the intersections on the S and N roads have been digitized. ArcGIS Online (Analysis > Create Drive-Time Areas function) calculated the accessible area.



Model 2: Data preparation infrastructure.

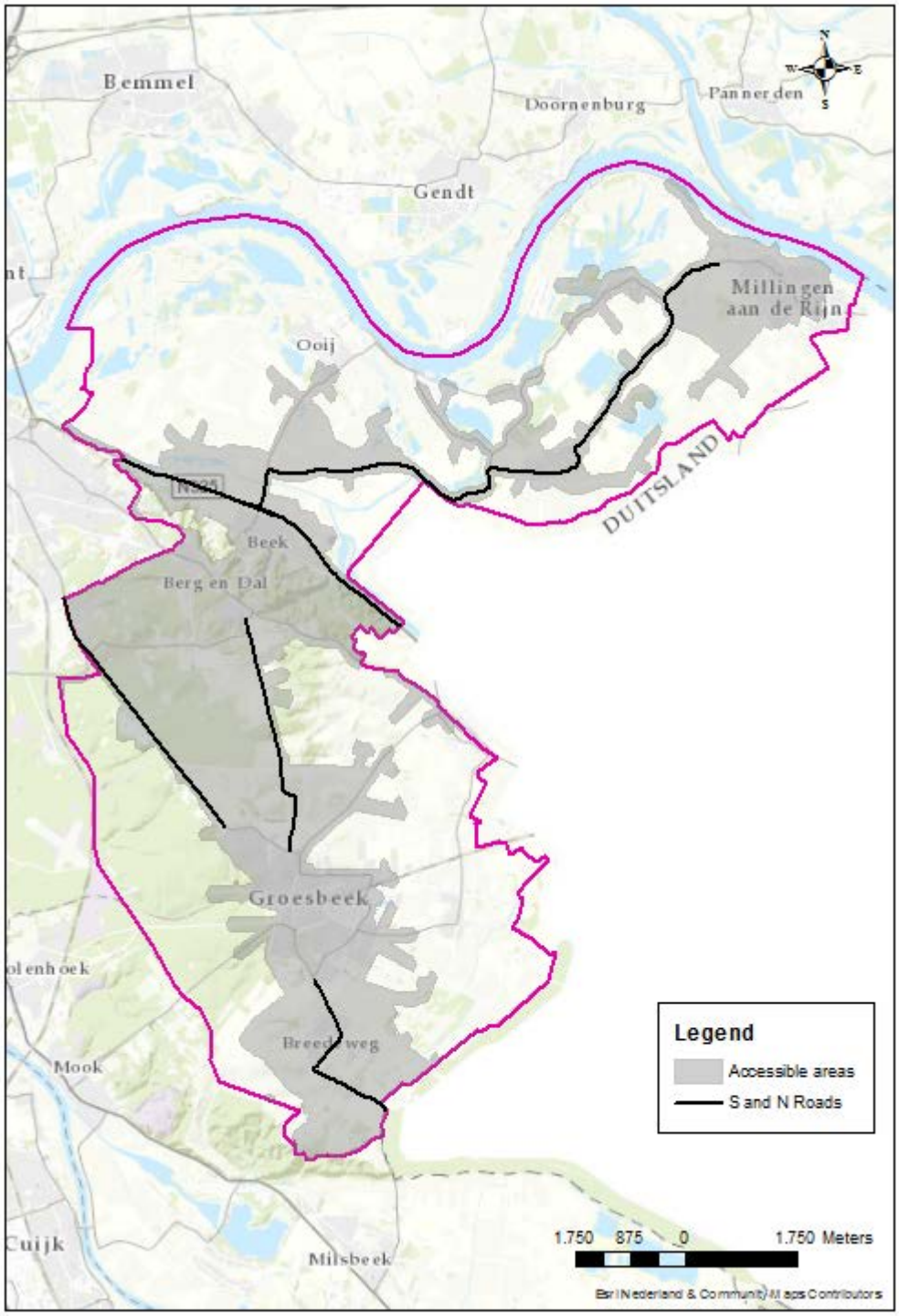
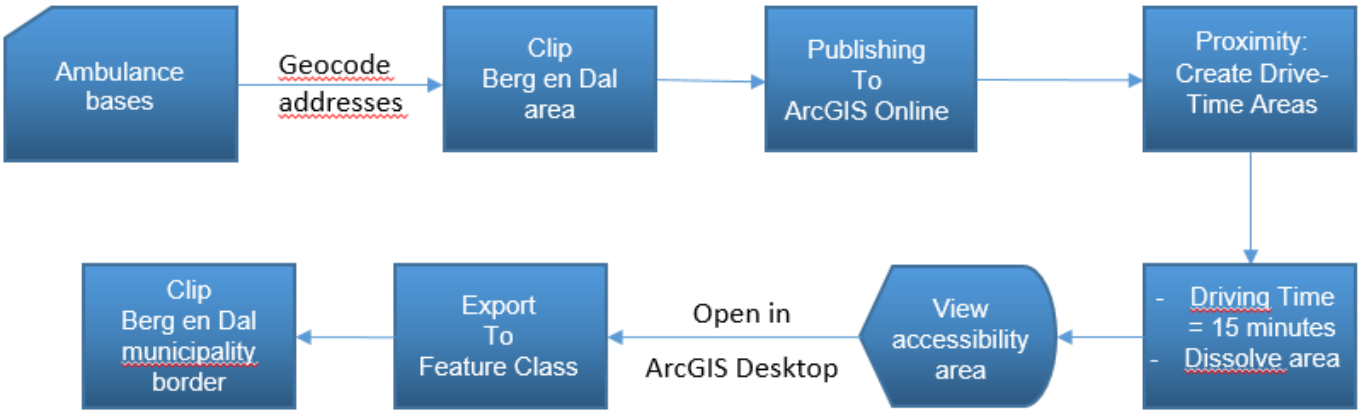


Figure 3: Accessible areas within 2 km from S or N roads in Berg en Dal

c) Drive time ambulances
An excel file including all the ambulance bases in The Netherlands (IFV, 2014) has been geocoded.



Model 3: Data preparation driving time for ambulances.

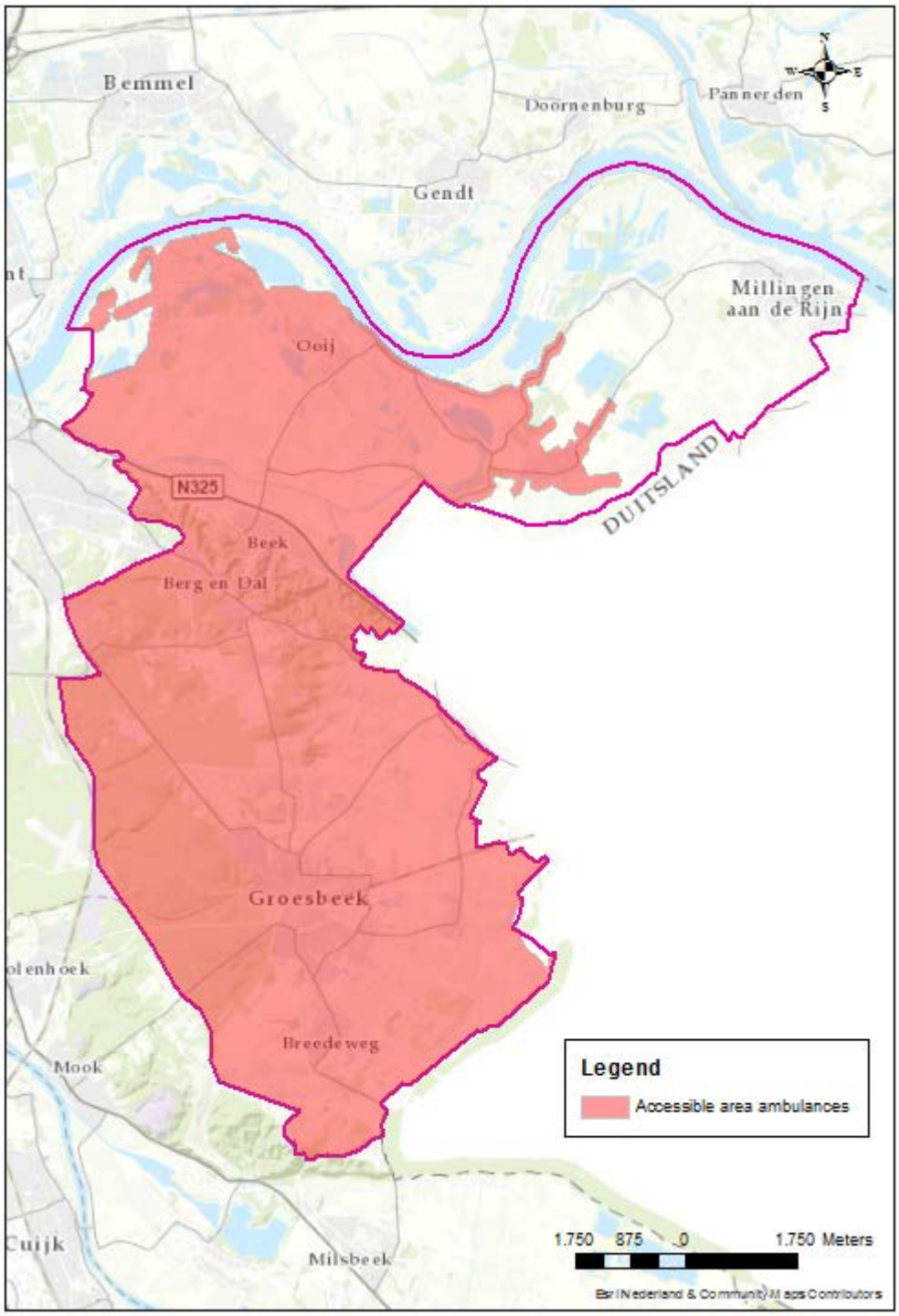
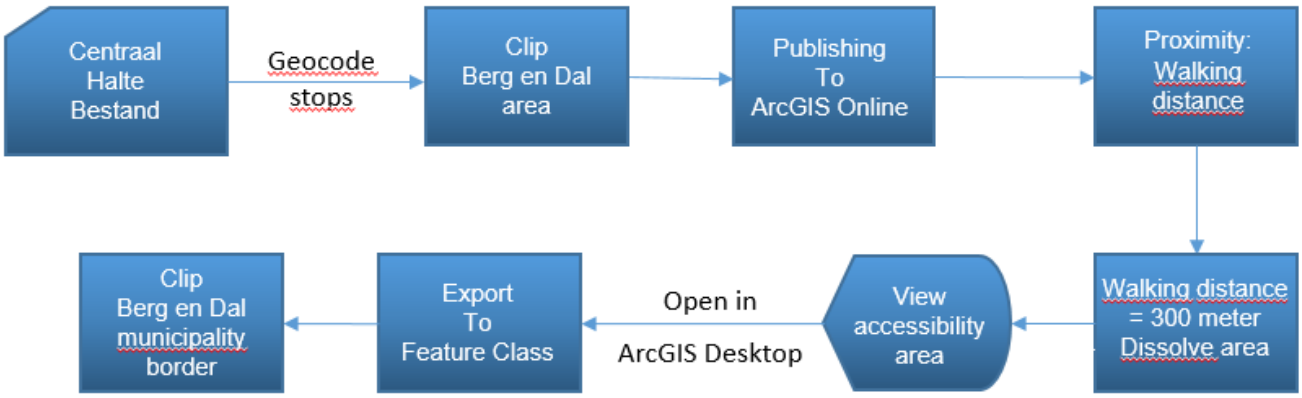


Figure 4: Accessible area within 15 minutes by ambulance in Berg en Dal

d) Public transport

The Dutch public transport bus stops file (CHB, 2017) has been used to define all the bus stop in and around Berg en Dal. ArcGIS Online contains a useful tool to calculate areas within a specific walking distance to reach a bus stop.



Model 4: Data preparation walking distance to bus stop.

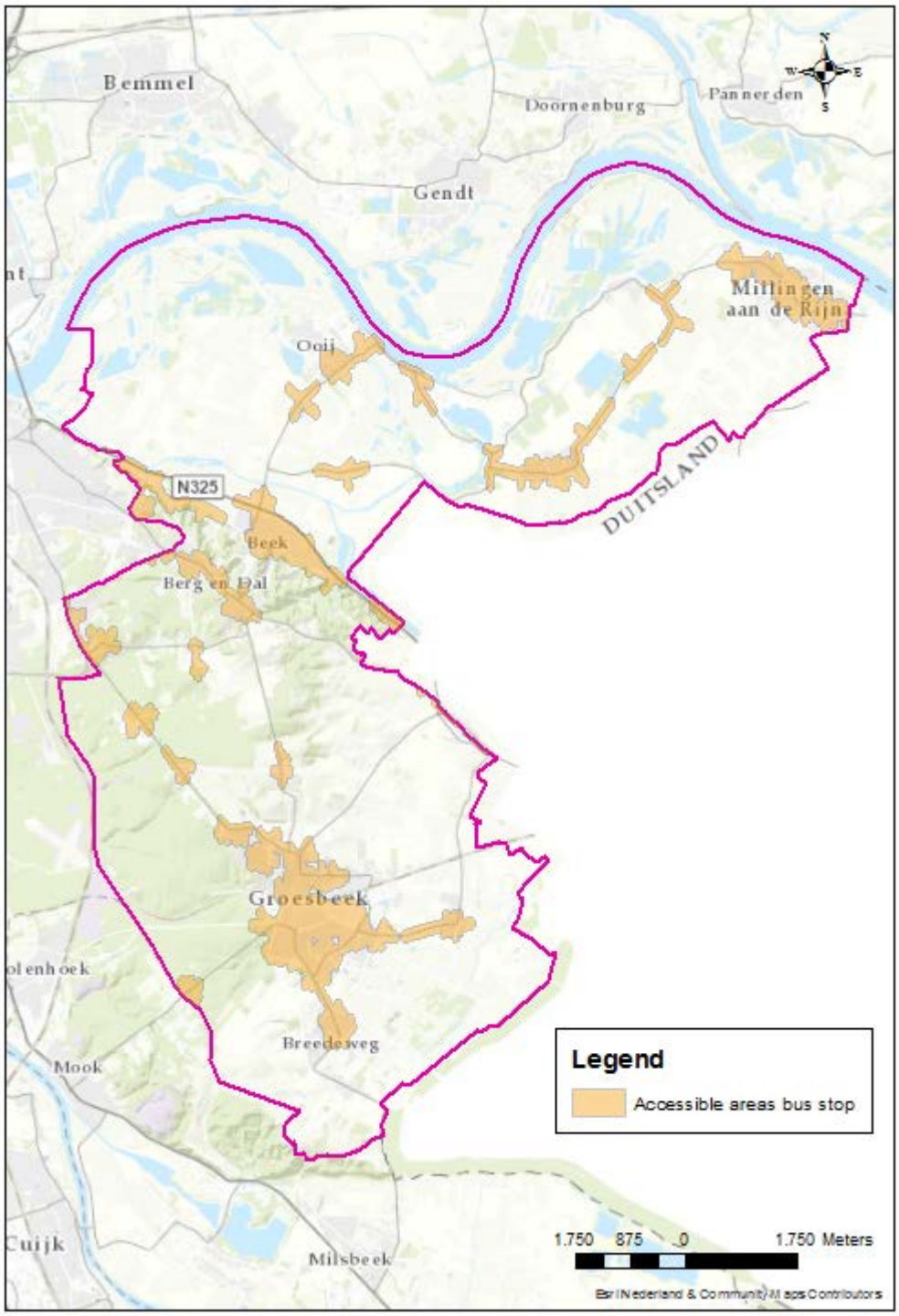


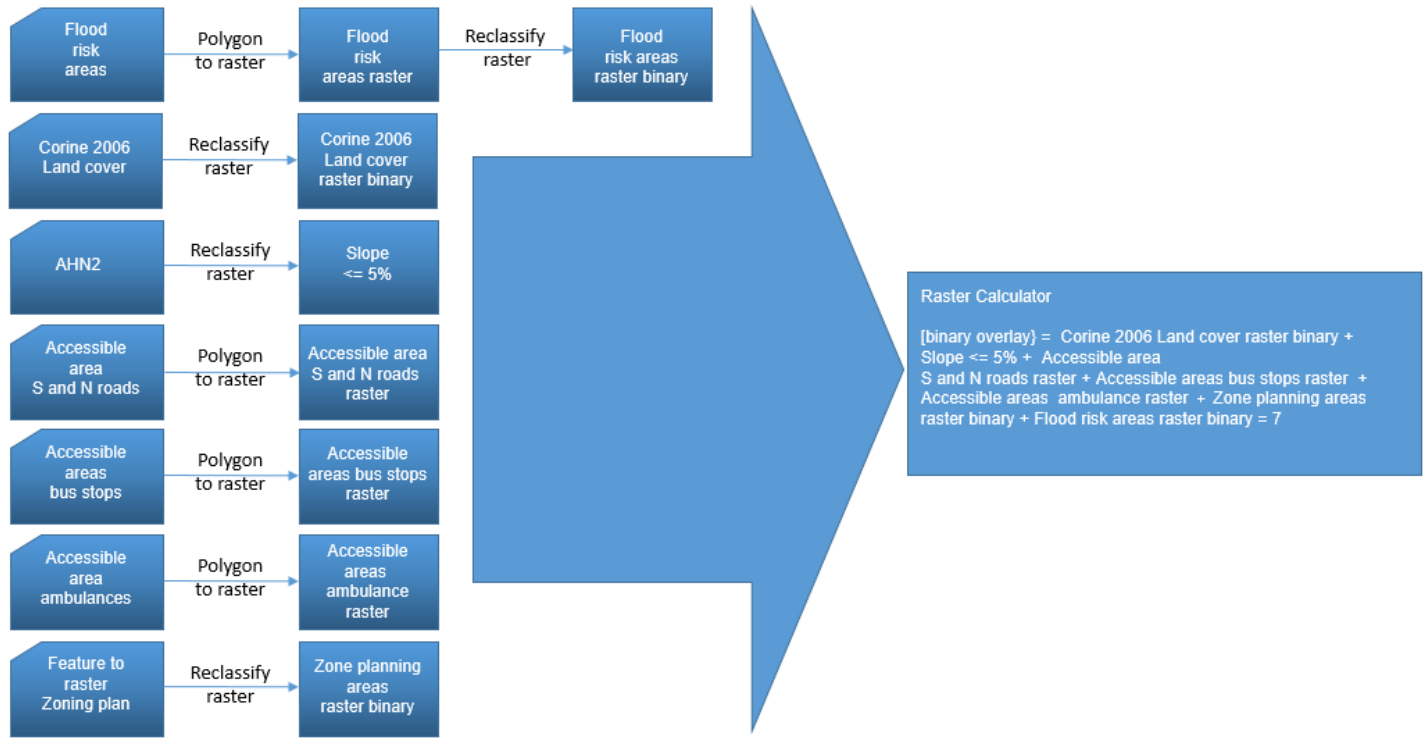
Figure 5: Accessible areas within 300 meter walking from a bus stop in Berg en Dal

Methodology

Two different approaches have been carried out to define the best site: the binary overlay process and the multi-criteria analysis (MCE). Both methods are described in the next paragraphs.

The binary overlay process

The laid down data set Corine 2006 Land cover has been reclassified before added to the binary overlay process. Only areas with a possibility to develop multifunctional centres (urban development, building land, sports fields, arable land, fruit tree areas and pasture land) were classified with the value 1.



Model 5: The binary overlay process.

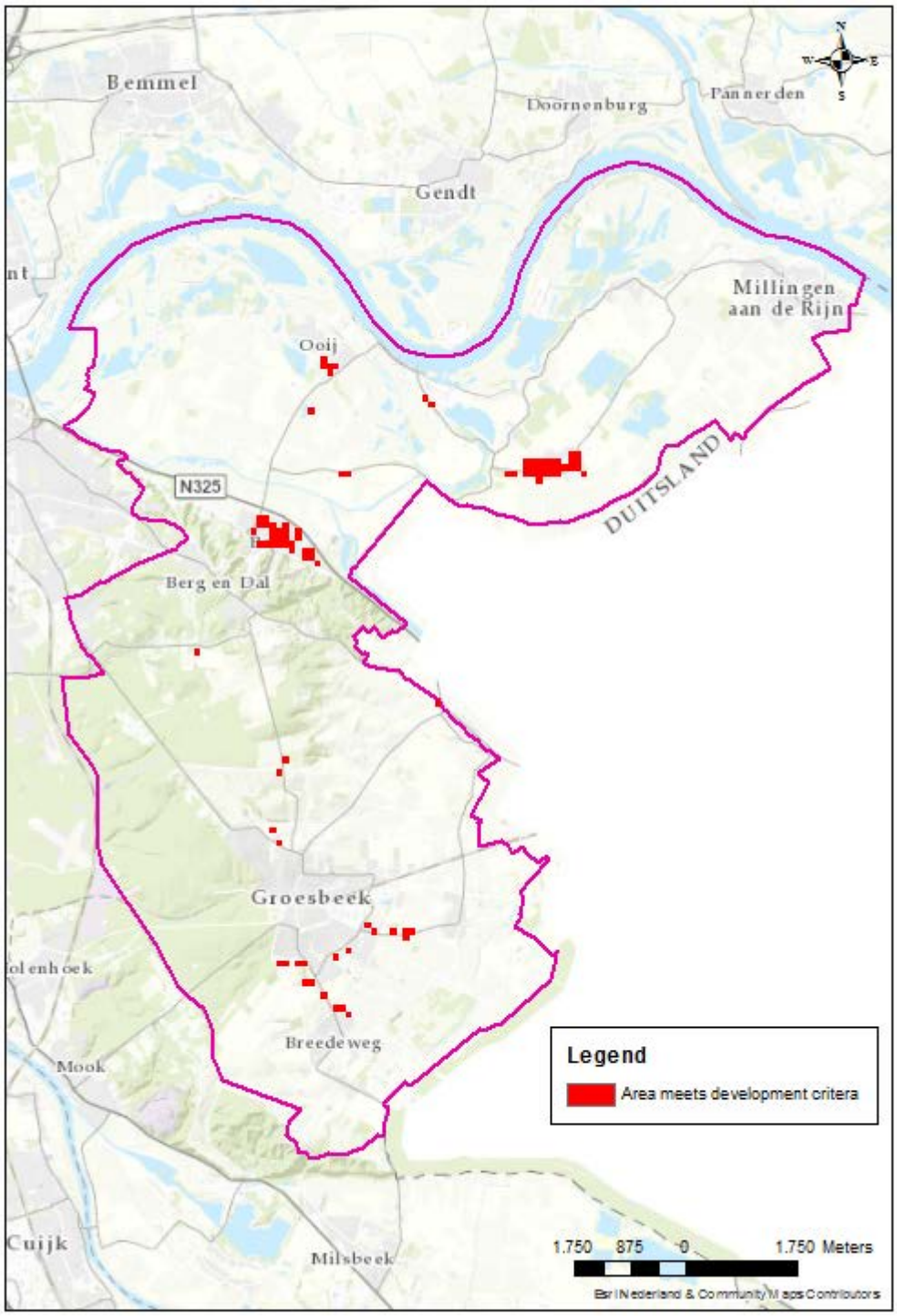
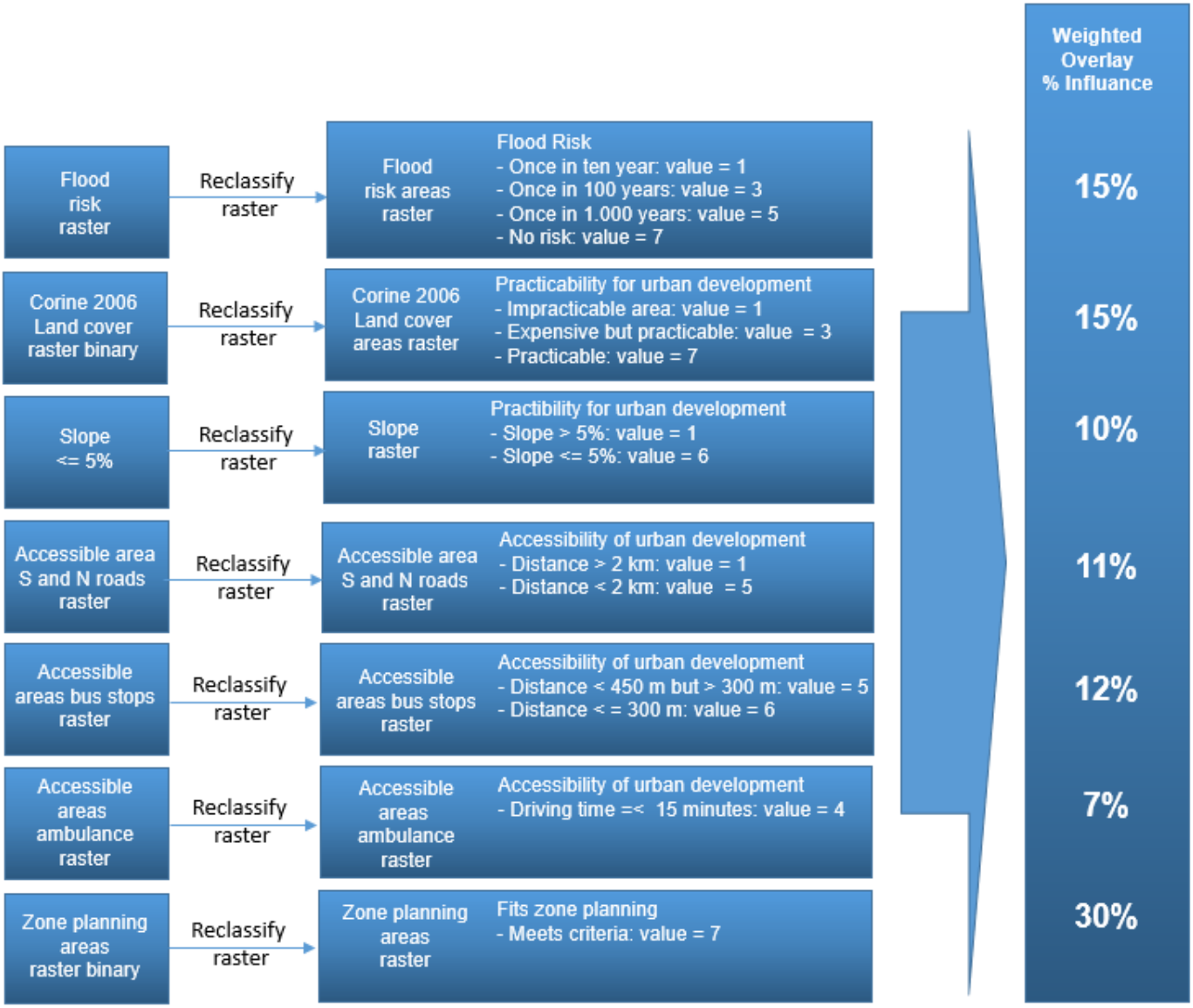


Figure 6: Binary overlay process - areas that meet all the criteria to develop a multifunctional centre in Berg en Dal

The Multi-Criteria Analysis – General Scenario

The seven data sets have been all reclassified to attribute values for each class utilise a seven-point scale assign each alternative a rating for how well it satisfies a particular interest, risk factor and suitability. For example, 7 = excellent / no risk / Highly accessible; 1 = poor / high risk / not accessible. The weighted overlay influence percentage creates the possibility to adjust emphasis on criteria that are important for a target audience.



Model 6: The multi-criteria analysis process – General Scenario.

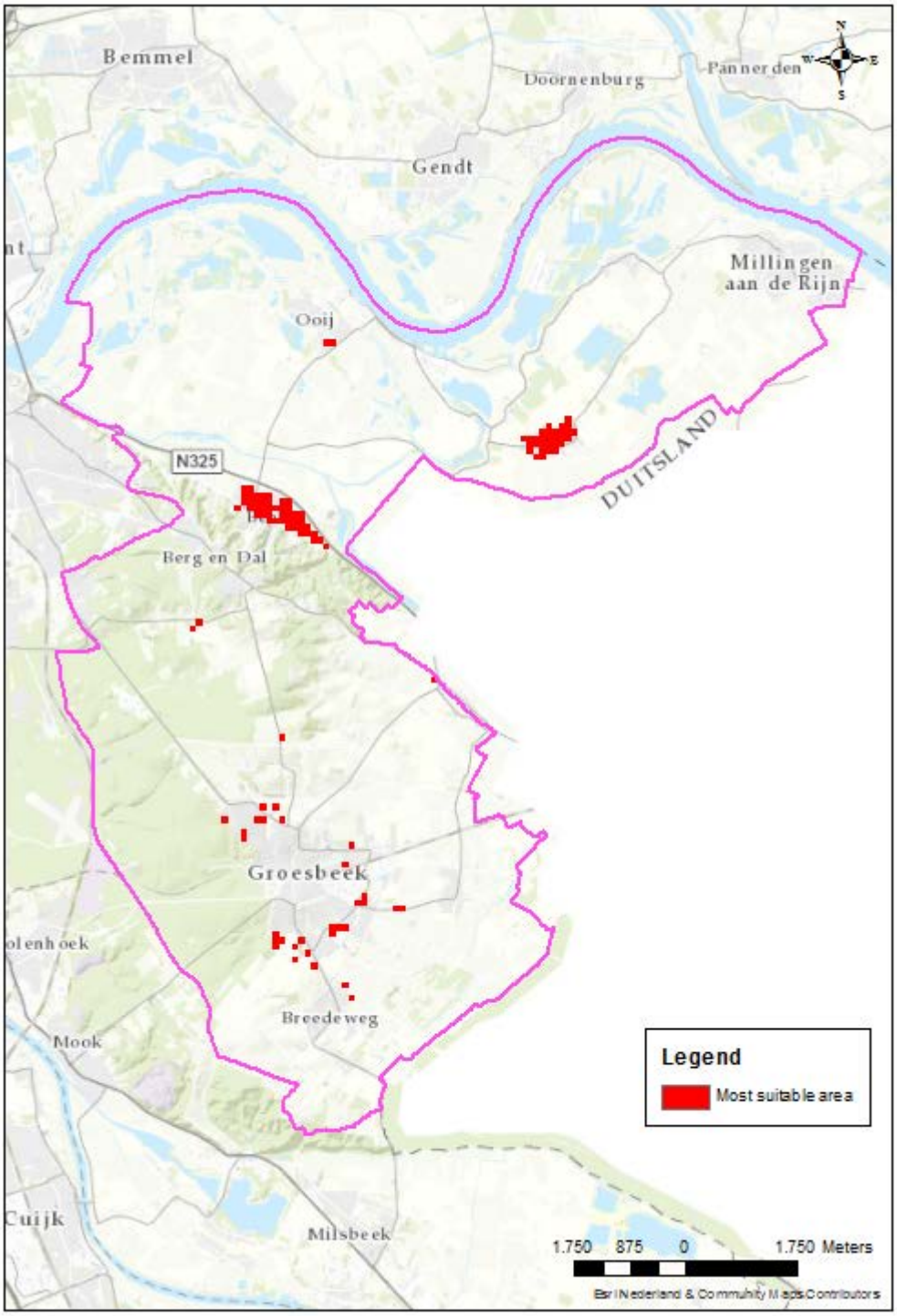


Figure 7: Areas that suits best on all the criteria to develop a multifunctional centre in Berg en Dal using a multi-criteria analysis

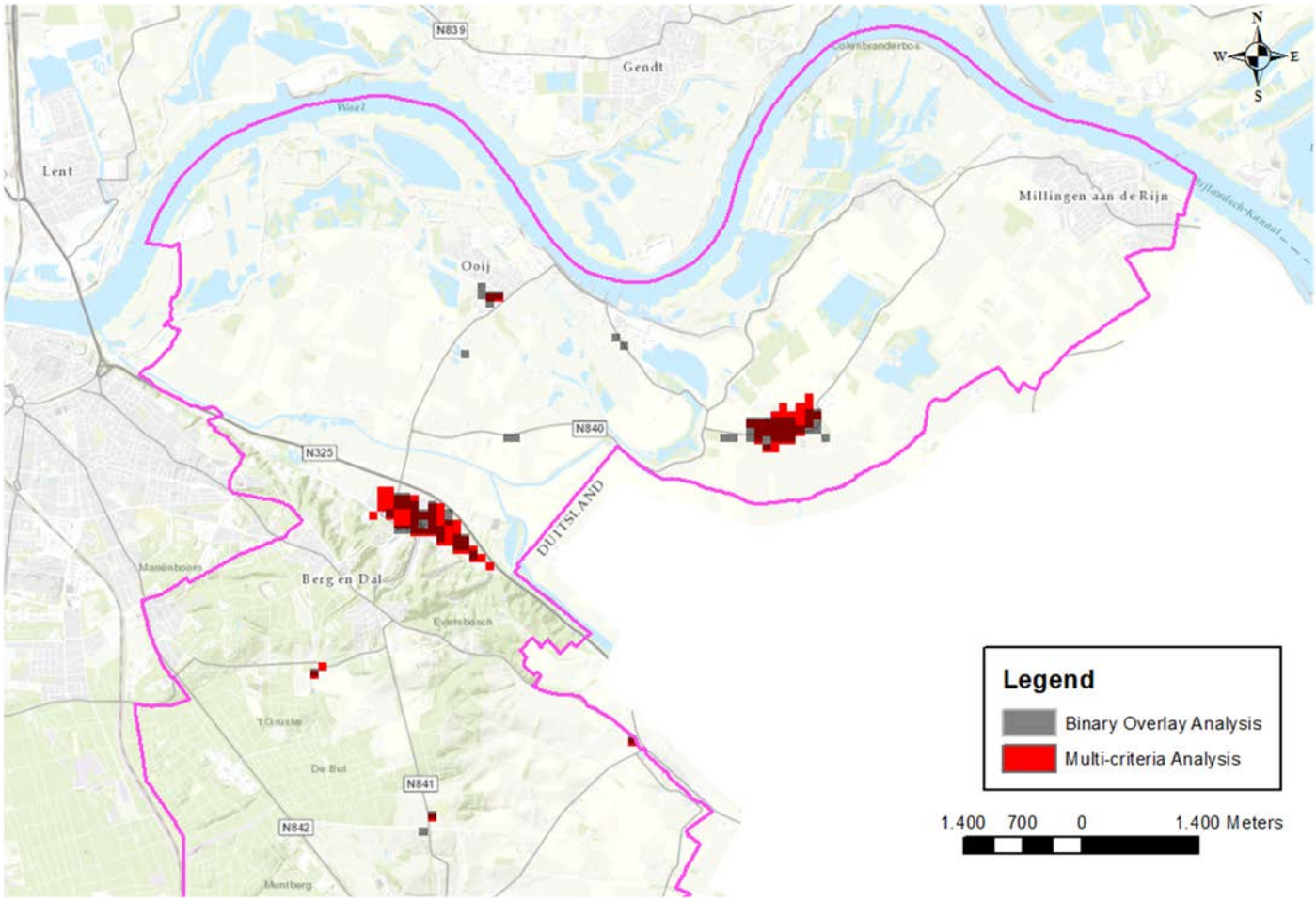


Figure 8a: Differences in results between the binary overlay process and the multi-criteria analysis (Northern part Berg en Dal)

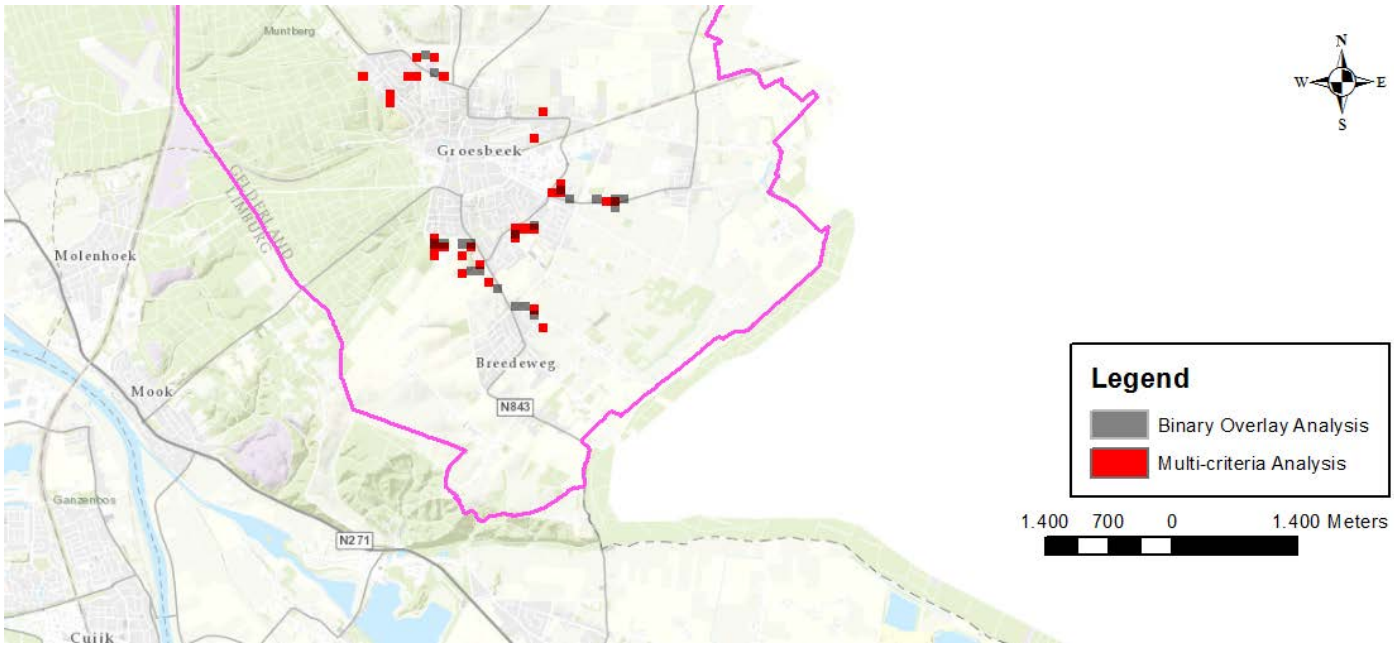
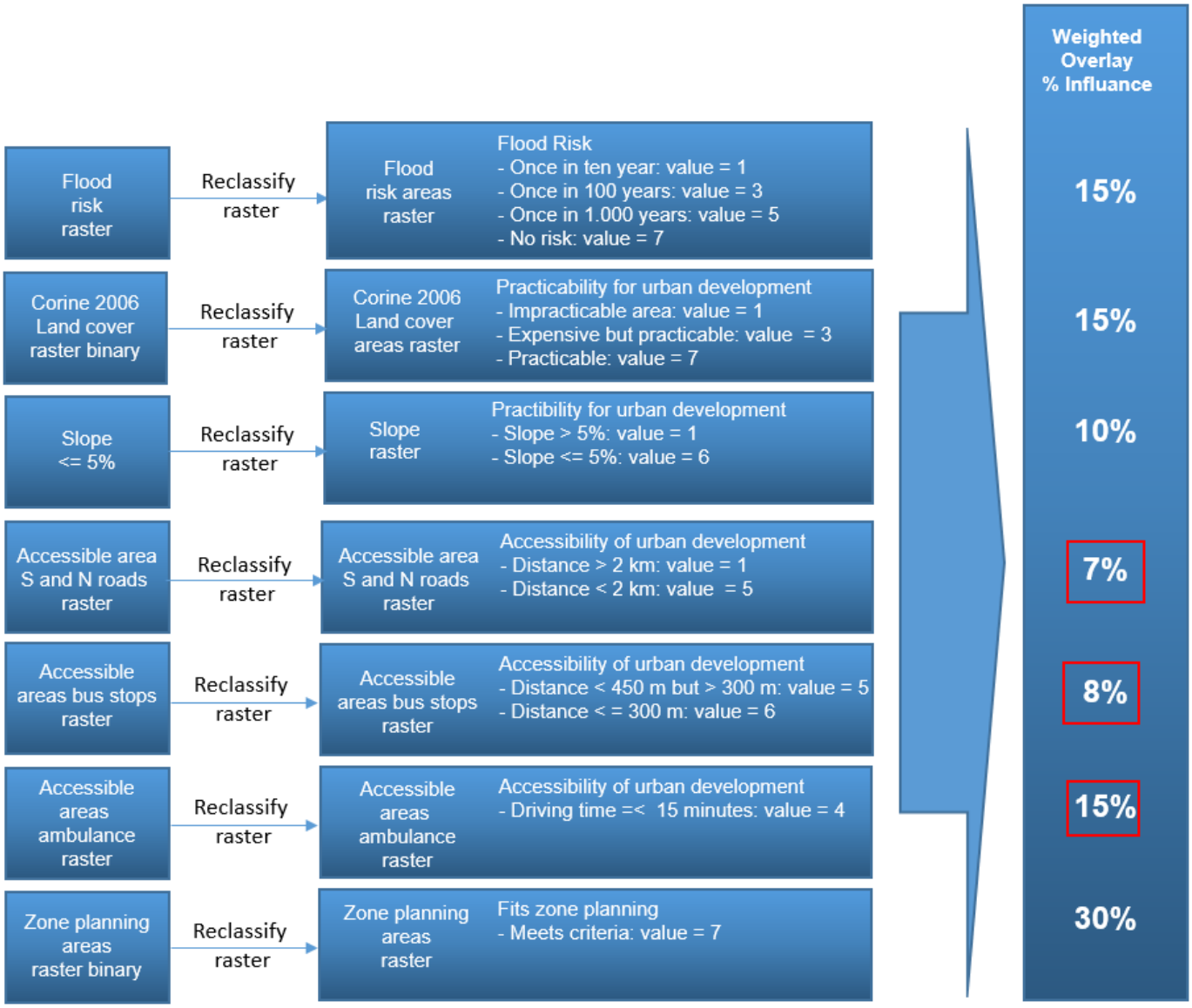


Figure 8b: Differences in results between the binary overlay process and the multi-criteria analysis (Southern part Berg en Dal)

The Multi-Criteria Analysis – Senior Citizens Scenario

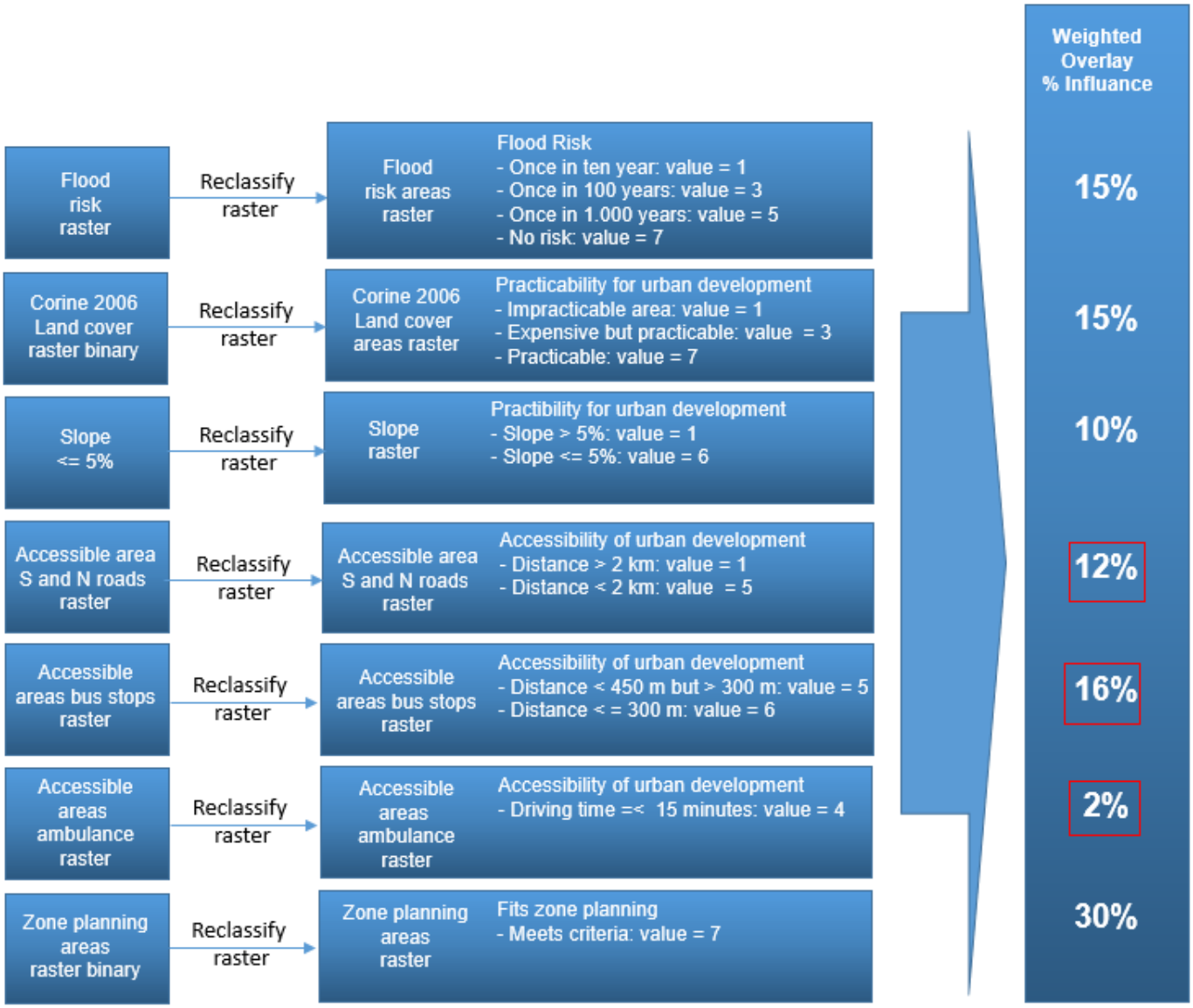
Extra weight has been added to the criteria 'Accessible areas – Driving time ambulances'. The criteria accessible area S and N roads have been decreased in weight. Although senior citizens still have a high level of car ownership, they start to drive fewer kilometres when they quit working, and their children all have left home (CBS, 2017).



Model 7: The multi-criteria analysis process – Senior Citizens Scenario.

The Multi-Criteria Analysis – Starters Scenario

Starters commute to work and have a higher need for public transport and a road infrastructure. The use of the emergency department by senior citizens exceeds the use by starters by a factor of 1.6 (65 – 75 years old) as far as 3.7 (85 years and older) (Letsel Informatie Systeem, 2013).



Model 8: The multi-criteria analysis process – Starters Scenario.

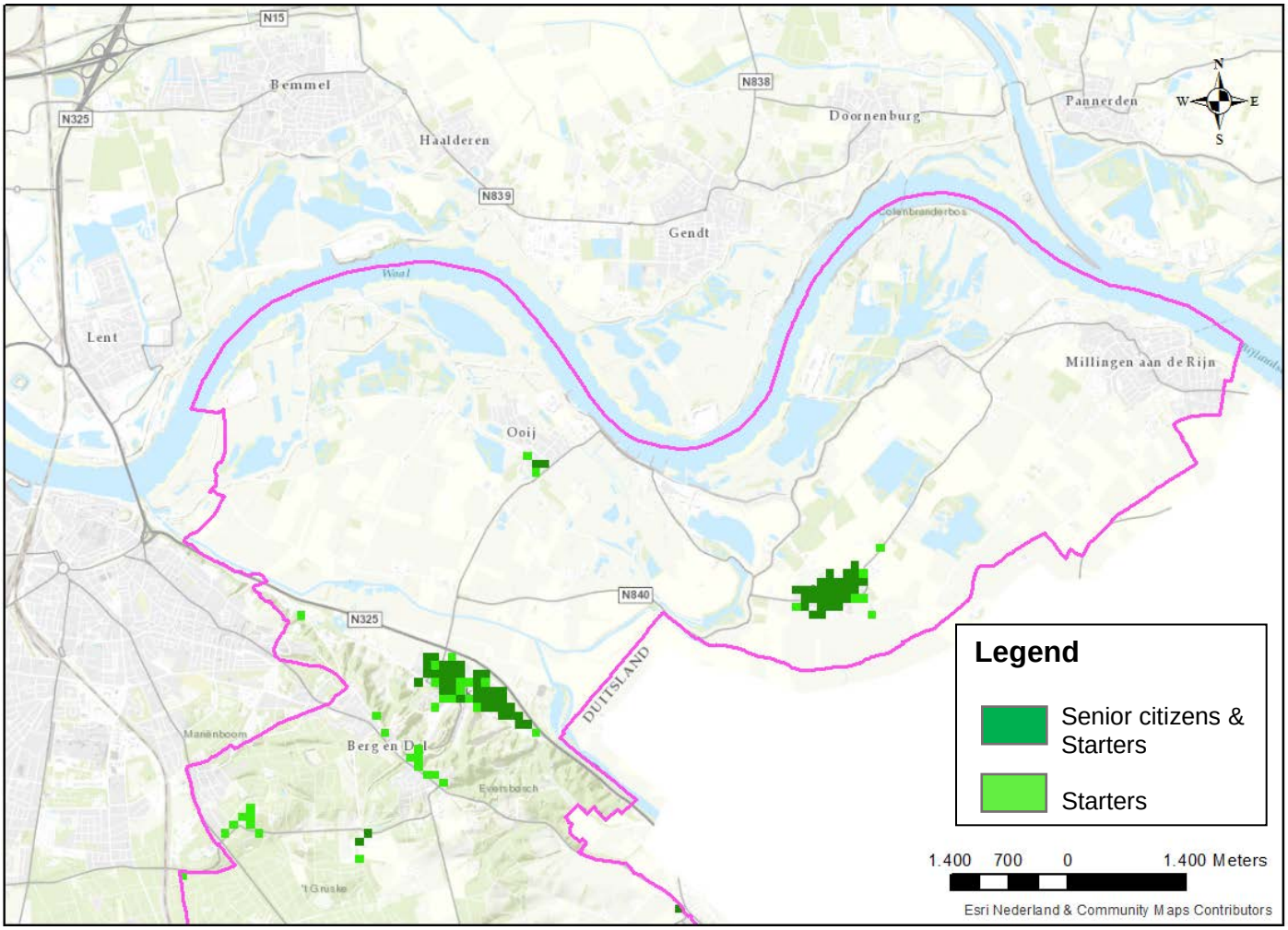


Figure 9a: Differences in suitable areas between the multi-criteria analysis for starters and senior citizens (Northern part Berg en Dal)

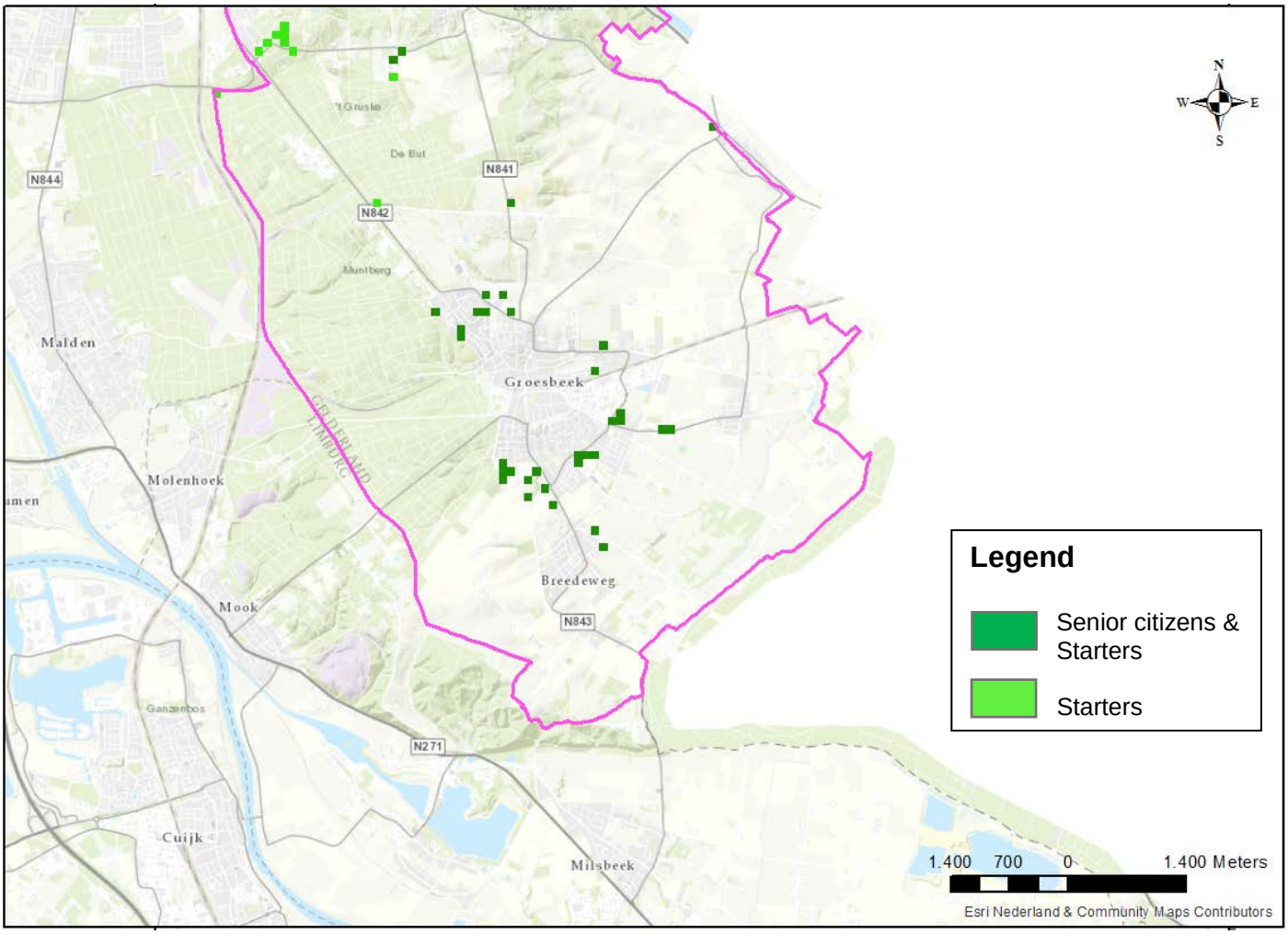


Figure 9b: Differences in suitable areas between the multi-criteria analysis for starters and senior citizens (Southern part Berg en Dal)

The binary overlay process versus the multi-criteria analysis

The maps depicted in the figures 8a, 8b, 9a and 9b explain the differences in utilisation of the binary approach and the multi-criteria method. Because most of the defined criteria have a strong infrastructure component, it did not come as a surprise that the suggested and suitable areas are near roads and urban areas.

Based on objective and measurable criteria, the binary overlay process is a quick and useful approach to defining which area(s) meet the formulated criteria and which ones do not. A major disadvantage in comparison with the multi-criteria analysis is the rigid process to decide an area is suitable or not (Jansen and Rietveld, 1990). The MCE approach offers more flexibility. Areas that did not surface at the binary process are suggested in the MCE because of specific criteria, deviating weights and classification calculates new possible areas. Another significant advantage of MCE over the binary process is the concentration on a target audience or specific situations. Figure 9a and 9b demonstrate how different weights for criteria influences the suitable areas. The binary overlay process lacks this function completely.

Advice to the Municipality of Berg en Dal

This multi-criteria analysis allocates suitable areas to develop a multifunctional centre in or near the villages Leuth, Beek and Groesbeek. Urban development focused on starters has additional opportunities in Berg en Dal and Heilig Landstichting. Not only experts but also non-experts should be involved in the planning and decision-making processes to define a suitability building site (Malczewski, 2013).

Considerations and Conclusions

Executing the binary overlay process and multi-criteria analysis both involve points of interest. First, rasterizing detailed polygons leads to a shift in the exact location of the data. Depending on the chosen settings of the GIS a cell is placed in an area where no data was located before or data for a location is removed because of the centre point or size of the cell does not reach the specific area. Additional, rasterized different datasets may use various cell resolutions. Combining raster data results in a dataset with a resolution based on the biggest cell size, losing detail.

Fortunately, more GIS functions are available to calculate distances and areas using driving time and network datasets instead of calculating distances in a straight line. However when an area is analysed adjoining a different territory (in this report Germany), criteria of infrastructure, medical care are not involved and influence the result. Using European data will bridge this problem.

Next, various economic, social, and environmental costs and benefits associated with each alternative were not considered in this report. At this moment ArcGIS does not contain an optimised tool to incorporate these critical parameters. GIS specialists have to collaborate with other disciplines, for instances financial and social geographers, economics and urban developers, to determine the best suitable area for urban development.

Both the binary overlay process and multi-criteria analysis represent their value to (pre)select an area. They can save an organisation much money filtering the unsuitable areas upfront without visiting each one by one. However, the contribution of experts (geographers, landscape architects or geologists) and future users of a zone are essential. In this analysis, only a small set of quantitative criteria were applied. In real terms decision-making also involves qualitative criteria and a soft sensitivity analysis where stakeholders negotiate the weight of all criteria and discuss their concerns (Ligmann-Zielinska and Jankowski, 2008). Co-creation, involving experts and users, will improve involvement leading to a livable building and habitat.

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Digital (spatial) data

Comment: as requested the data sets mentioned in the briefing notes are not included in this survey.

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Reference: Adressen Ambulanceposten eind 2014 (addresses ambulance bases), IFV / Imergis, 2014 Arnhem, The Netherlands

Title	Adressen Ambulanceposten eind 2014
Source	IFV - http://www.ifv.nl/kennisplein/geografische-informatie-im/publicaties/adressen-ambulanceposten-eind-2014
Year	2014
Scale	No scale
Format	Microsoft Excel

2.
Reference: Open Data Site, 2017. 9292, The Netherlands

Title	CHB (Centraal Halte Bestand)
Source	https://reisinformatiegroep.nl/ndovloket/datacollecties
Year	2017
Scale	No scale
Format	XML file

3.
Reference Overstromingsgevaar- en gevolgenkaarten risicokaart.nl, 2014. GBO Provincies - Landelijk functioneel beheerder CDS Inspire/Risicokaart/OGR, The Netherlands

Title	t1000_vg1b.shp (A small chance of a flood in the valley of a river: happens once every 1.000 years) t100_vg1_o_v2Polygon.shp (A medium-sized chance of a flood in the valley of a river: happens once every 100 years) t10_ovgebied_oPolygon.shp (A good chance of a flood in the valley of a river: happens once every ten years)
Source	Landelijk functioneel beheerder CDS Inspire/Risicokaart/OGR
Year	2014
Resolution	50 meter
Format	Shapefile

4.
Reference: ArcGIS Online, 2017. Esri, The Netherlands

Title	BRT TOP10NL
Source	https://www.arcgis.com
Year	2017
Scale	1:10.000
Format	File Geodatabase