

6 ACKNOWLEDGMENT

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ID 1624 | MEASURING BUILDING DENSITIES (FSI/GSI) FOR THE NETHERLANDS

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1 INTRODUCTION

Densities are a key feature in urban planning and design. Density influences amongst others energy consumption, mobility, livability, food production and economy.

Building densities (that is Floor Space Index (FSI) or Floor Area Ratio(FAR)) relate the gross floor area to the surface of the accompanying base land area. The surface of the base land area can be defined on

many scales, from plot to municipality. By now floor areas, parcels shapes and building footprints etc are available as open data for the whole of the Netherlands, so we can script the calculation of building densities for the whole of the Netherlands. We did this according to the recent Dutch standard: NEN 9300:2013 nl, Areas and densities in urban planning - Terms, definitions and methods of determination. The first results have been tested in a mobility study. The results can be applied as well for morphology studies and as reference projects for future urban design.

Along with FSI we can easily calculate the Ground Space Index (GSI) which relates the footprint of a building to the surface of the accompanying base land area and an index for the mixed use of functions (MXI). This paper describes the datasets used in the script and the main steps that were scripted to calculate the building densities on several scales.

2 THE SCOPE OF DENSITIES

Densities play a key role in urban planning and urban design. High densities are supposed to have positive qualities: less mobility (Kenworthy and Newman 1999, 2015), less energy use (UNEP 2017, Bettencourt 2013, Rode et al 2014, Salat 2009), higher productivity (Bettencourt et al 2007, Raspe et al 2015),

more fine grained businesses (Hausleitner 2012) and less material use (so fewer costs) for infrastructure (Coppola et al 2014). In the social field high densities are supposed to work out in a positive way for example a higher modal share for walking (Moudon and Lee 2009), less criminality (Hillier and Sahbaz 2008), better conditions for circular economy (Rood and Hanemaaijer 2016) and higher vitality (Jacobs 1961).

Many international organisations therefore recommend to build in high densities and to densify existing cities (IEA 2009, UNEP 2011, European Commission 2014, OECD 2012, UN-HABITAT 2012, Worldbank 2014). However, higher densities may lead to a decrease of open spaces in the existing urban tissue and to an accumulation of traffic congestion, noise nuisance and air pollution (Coppola et al 2014, Breheny 1992), an increase of real estate prices and social disclusion (Coppola et al 2014), social problems (Leidelsemeijer et al 2014), urban heat islands (Heusinkveld et al 2014) and health issues (Peen et al 2010).

The density effects mentioned above occur depending on the context. Effects can be tempered or intensified through flanking social, spatial, economic or mobility policies. Same goes for the design of the buildings and the public spaces that can either make or break liveability. A certain density alone is no recipe for a “good” spatial planning. It actually is a condition for “good” planning.

Knowledge about densities and being able to compare urban tissues can help finding spatial solutions for a specific intended density in a specific context. This is important in considering inner city or suburban urban growth (Van Duinen et al 2016). In the case of city extensions not only the landscape quality is under pressure, but the food supply as well (Swilling 2016).

3 INDICATORS

3.1 FLOOR SPACE INDEX

In Dutch spatial planning densities are usually measured in dwellings per hectare. This unit counts the number of dwellings (or households) on a certain land area. This unit is interesting for the residential project developers market, but doesn't give full insight in the spatial density, since schools, offices and ware houses and the like are not included here. Utility buildings can be included in the Surrounding Address Density, that counts the number of addresses within a specific radius. This method, however, doesn't take into account the wide range of square meters that buildings can have. A building can for instance be a 5 m² pavilion or a 200.000 m² office building. So address density is not the perfect indicator either. Besides, address densities are not available on the scale of the building block.

By using Floor Space Index (FSI, or its synonym Floor Area Ratio (FAR)) as a unit for density, the restrictions mentioned above are being overcome. On top of that the FSI is a more accurate indicator for an area's physical morphology, especially in combination with GSI and MXI (see next chapter).

FSI calculates the ratio of one or more buildings' total floor space to the accompanying base land area. In case an area is covered all over with one storey, the FSI is 1. In case half of the base land area is covered with a 2 storey building, the FSI is 1 as well.

3.2 GROUND SPACE INDEX AND MIXED USE INDEX

Parallel to the FSI calculation, we can calculate the Ground Space index (GSI), indicating the share of a base area that is covered with buildings. GSI is a worldwide used indicator in urban design and urban planning.

Additionally the Mixed Use Index (MXI) being the ratio between residential floor areas to the total floor area can be calculated for a specific area (Van den Hoek 2008). A mixture of residential and working related uses contributes to a reduction of mobility, a sharing (over time) of infrastructure and parking lots (van den Hoek 2008), more vitality (Jacobs 1961, Gehl et al. 2006), a higher safety perception (Gehl et al. 2006), and, in relation to density, less criminality (Jacobs 1961, Hillier and Sabbaz 2008, Traunmüller et al 2016). On top of that a mixed use areas allow for higher densities, since locations that are unequipped for housing, for instance because of lack of daylight, can often be used for non-residential uses.

Pols et al. (2009) observe that existing mixed use urban areas do not interfere with a high liveability. PBL (2010), however, observes that an increase of mixed uses not necessarily leads to a better liveability. There seems to be a relationship between mixed use urbanism and liveability, but this is depending on the type of jobs, the grain size of the mixture and the type of neighbourhood.

4 DATASETS

So far, FSI, GSI and MXI have been hardly used in the Netherlands. Data on floor space has not been available on a large scale and had to be determined manually. That is why FSI is only being used in small scale urban design studies, such as Urhahn and Bobic (1994), dRO (2001), Nabielek et al (2012) and Faro architecten et al. (2012).

Since the availability of new datasets for the whole of the Netherlands we are able to automatically generate FSI, GSI and MXI for the whole of the Netherlands. We mainly use the following datasets: BAG (Basisregistraties Adressen en Gebouwen) which contains the floor space and use for every address in the Netherlands; National Land Registry data, containing every single parcel shapes, the digital zoning schemes and the BGT (Basisregistratie Grootchalige Topografie) containing detailed topographical information on a map (scaled 1:5000).

5 SCALE AND STANDARD

Densities differ depending on the aggregation level on which they are being calculated. The building density of a municipality is generally lower than the building density on district level, since areas for nature and agriculture are included on a municipality level. In a similar way, district parks lower densities on district level compare to the neighbourhood level. The smallest scale that we will publish is the building block, being the space between surrounding streets, in which one or more buildings are located.

Since 2013 there is a Dutch standard: (NEN 9300) on areas and densities in urban planning (NEN 2013). In this standard is laid down which elements (such as streets, railways, parks, water) to count in for a certain level of aggregation: Parcel, building block, neighbourhood, district and municipality. The standard distinguishes in nett and gross areas on all aggregation levels. For the building block, for instance, the adjacent built-upon parcels make up the nett building block. To the gross building block half of the street profiles as well as small unbuilt parcels are being added.

This standard has never been intended to generate areas and densities automatically. Often the standard's interpretation depends on the spatial context and the user's expertise. So the results that are being generated automatically may differ from manual, analogue results. Nevertheless we have tried to

remain as close as possible to the standard and we describe the steps that we have not been able to script.

6 DESCRIPTION OF THE SCRIPTED PROCESSES

When calculating the FSI the gross floor area is the numerator and the base land area is the denominator in the fraction.

6.1 GROSS FLOOR AREA

The gross floor area is a building's floor space according to the NEN standard 2580 (NEN 2005). The gross floor area includes construction and circulation areas, as well as underground and cantilevered building parts. The gross floor area is based on the floor areas provided by address in the BAG dataset. As BAG provides usable floor area and leasable floor area, the values are multiplied by index numbers for different uses (based on IGG Bointon de Groot (2014)) in order to estimate the gross floor areas.

In case a building does not have an address (for example glass houses, barns) the footprint of the building is taken as the gross floor area. The assumption here is that these building types have only one storey. Buildings smaller than 4 m² with no address will be excluded, in accordance with NEN9300. The buildings' footprints are being retrieved from the BGT dataset.

The gross floor area remains unchanged on every level of aggregation, but the base land areas usually increase with every step of aggregation.

6.2 BASE LAND AREA

The base land areas will be determined on four aggregation levels: building block, neighbourhood, district and municipality according to NEN9300. Below we describe the scripted process for the selection in brief.

6.2.1 DETERMINING THE NETT BUILDING BLOCK

In accordance tot NEN9300, the nett building block is determined by "land registry or other borders". In general this means adjacent built-upon parcels form a nett building block. For this scripted method we use 4 types of borders. The buildings' footprint on ground level is the connecting thread here.

1. Each built-upon parcel (from the land registry dataset) belongs to the nett building block. Since buildings sometimes exceed the parcel's perimeter minimally, we use a 2 meter buffer: Only if a building footprint takes more than 2 meter of a parcel, the parcel is added to the nett building block. Buildings that have no address and that are smaller than 4 m² are excluded here as well.
2. Some (municipal) parcels consist of large parts of public space. Schools, children's farms or council housing for instance are located on municipal parcels that contain besides the yard, the surrounding street networks. In order to exclude the street networks here, we use the zoning schemes and select the built-upon zoning perimeters that are schemed as residential, catering, social, park, mixed or business, including adjacent garden zones.
3. From buildings situated on zones schemed for infrastructure and green, such as railway stations, road houses or bridge control buildings, we only select the footprint as nett building block, because the accompanying parcels can stretch out for kilometres long.
4. Underground buildings, such as parking garages or subway stations, contribute to the gross floor area. In case these buildings do not have a footprint, they will be excluded from the 3 steps described above. By taking the building contours from the BAG dataset - that contains (besides the footprints) projections of cantilevers and underground building parts – we can select underground buildings. For these cases we construct a symbolic square meter place holder as a nett building block.

From these surfaces, we deduct all infrastructure (roads, foot paths, cycle lanes), even if they are on private property. This infrastructure is taken from the BGT and digital zoning schemes datasets. Besides parking lots larger than 500 m² and areas that are not schemed for building purposes will be subtracted from the nett building blocks. These non-building areas are selected from the BGT dataset categories: sand, agriculture, meadows, forest, heather, dune and the like.

Large parks and ponds are also excluded from the building blocks. They are selected from the CBS dataset on Ground Use (BBG) and will be added, depending on their size, to the neighbourhood, district or municipal aggregation levels.

6.2.2 DETERMINING THE GROSS BUILDING BLOCK

The gross building block consists of the nett building block and the tare building block. Tare is the difference between gross and nett. The tare consists on the one hand on public space smaller than 4000 m² (such as public green and playgrounds) and on the other hand the infrastructure that is needed to disclose the nett building block. The surface of the total street profile is split and assigned to the two adjacent building blocks. If there is no nett building block available the street profile will locally not be assigned to the gross building block.

6.2.3 DETERMINING THE NETT NEIGHBOURHOOD

The nett neighbourhood is the aggregated gross building blocks within the neighbourhood contours derived from Statistic Netherlands (CBS)

6.2.4 DETERMINING THE GROSS NEIGHBOURHOOD

The gross neighbourhood is the nett neighbourhood combined with the neighbourhood's tare. The tare contains the roads that are higher in hierarchy. These are (parts of) roads that do not disclose addresses and only disclose other roads. The tare is also composed of exclusive tram - and bus lanes. All of them are selected from the BGT dataset (proxy: regional roads, tram rails, public transport lane). Parks and ponds between 4,000 and 60,000 m² are also added to the gross neighbourhood.

6.2.5 DETERMINING THE NETT DISTRICT

The nett district is the aggregated gross neighbourhoods within the district contours derived from Statistic Netherlands (CBS)

6.2.6 DETERMINING THE GROSS DISTRICT

The gross district is the nett district combined with the district's tare. The tare contains the motorways (from TOP10) and railways (from BGT). Parks and ponds between 60,000 and 400,000 m² are also added to the gross neighbourhood.

6.2.7 DETERMINING THE NETT MUNICIPALITY

The nett municipality is the aggregated gross districts within the municipality borders.

6.2.8 DETERMINING THE GROSS MUNICIPALITY

The gross municipality is the whole municipality. The surfaces for agriculture, nature and public spaces larger than 400,000 m² are added to the nett municipality.

6.2.9 ALTERNATIVE BASE LAND AREAS

Perhaps the base land areas above do not suit specific purposes. Alternative land areas can be composed from for instance handpicked (nett or gross) adjacent building blocks.

In a similar way densities can also be calculated per neighbourhood as aggregated building blocks.

Another possibility is to project the gross floor areas in a grid and select the surface of a grid cell as a base land area.

6.3 FLOOR SPACE INDEX (FSI)

The floor space index is calculated by dividing the gross floor areas by the base land areas.

6.4 GROUND SPACE INDEX (GSI)

For calculating the GSI, we use the buildings' footprints from the BGT dataset. This one is without projections of cantilevered building parts and underground buildings.

6.5 MIXED USE INDEX (MXI)

The Mixed Use Index is calculated by dividing the gross floor area for residential uses by the total gross floor area for a specific land area. There is no difference here in nett and gross land areas. The BAG dataset differentiates in 11 uses, for instance residential, sports, industry, office, retail etc.

7 DISCLAIMERS

Spatial densities can be determined much more accurate if done manually instead of scripted. However, it would be a sheer drudgery to manually calculate densities for a single municipality let alone for the whole country. Scripting the calculation process has some drawbacks:

- Human interpretation is missing: Manual determination of base land areas can be more accurate. For instance tram lanes are added to a district's tare, but sometimes tram lanes are to be found in fun parks as well, where a human would classify the tram lane to the tare of a building block.
- The quality of the results depends partly on the quality of the datasets. Some datasets contain (obvious) mistakes. We expect them to be adjusted in future updates.
- Not all datasets are available for the whole of the Netherlands. The BGT datasets and the digital zoning plans are not yet complete by now. This influences the results. We expect these datasets to be fully covered soon.
- The various datasets are not internally synchronized. In the case of new constructions or demolition some datasets might not be up to date while others are.
- The gross floor area is based on the floor areas provided by address in the BAG dataset. As BAG provides usable floor area and leasable floor area, the values are multiplied by index numbers for different uses in order to estimate the gross floor areas. This estimation might be way off for individual cases.

8 RELATION TO NEN9300

In scripting the FSI and GSI we tried to follow the NEN9300 standards. In some cases we were, for the time being, not able to script this standard, because of complexity reasons.

- Whether public spaces are classified to a certain scale depends on their surface. According to the standard this also depends on the average width. We did not consider the width in our script.

- The tare of a building block is, in general, half of the street profile. According to the standard the whole street profile is assigned to a building block in case the parcel across the street is not zoned for buildings. For the time being, we did not script this exception.
- The neighbourhood's tare contains the roads that are higher in hierarchy. These are (parts of) roads that do not disclose addresses and only disclose other roads. As a proxy we selected regional roads from the BGT dataset. This proxy is quite weak.
- All water bodies have been excluded from the nett building blocks even if it is a part of private property, such as small ponds in gardens. We have not yet scripted this differentiation.

9 TENTATIVE RESULTS

We are able now to calculate all FSI, GSI and MXI for the whole of the Netherlands. We will run the script in late summer 2017. Figure 1 shows an earlier test, the FSI in nett building blocks in Leiden.

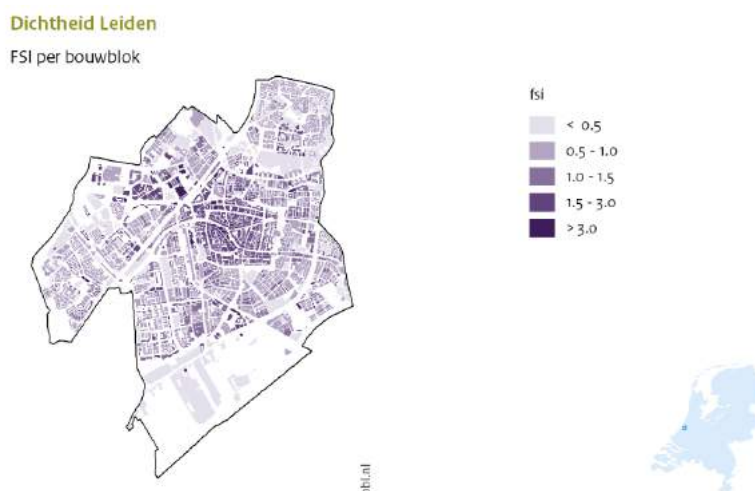


Figure 1 – FSI on nett building blocks for the Leiden municipality (draft)

The results have also been tested in a pilot study on mobility for province Noord Holland, carried out by Vereniging Deltametropool. See figure 2.

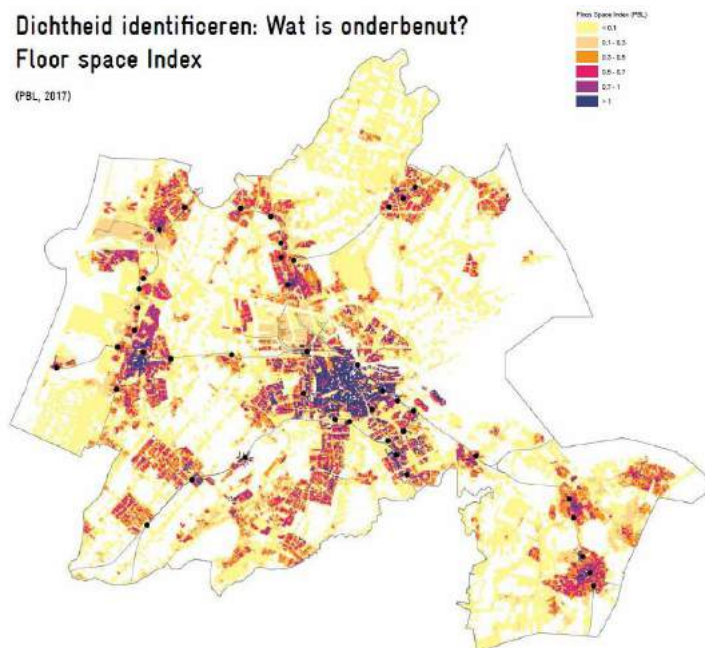


Figure 2 – FSI in the Amsterdam region

10 FUTURE APPLICATIONS

The produced FSI, GSI and MXI on several scales provide material for a wide range of research (for instance on real estate prices, liveability mobility, building capacities) and morphological comparisons.

Further ideas for the near future include:

- a website that links FSI, GSI and MXI to Google Streetview and Bing Maps (bird's eye views)
- developments over time. We can rerun the script in let's say every 3 years and monitor the changes.
- International comparisons: Berlin, Vienna, Zürich and Paris have similar datasets available

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ID 1634 | A LAND CAPACITY ANALYSIS METHOD USING GIS TOOLS, AS EXEMPLIFIED BY THE CITY OF WARSAW, POLAND

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1 INTRODUCTION

The generation of forecasts regarding the further physical development of urbanised areas is a key part of spatial planning, and indeed integrated planning as conceived more broadly. A key role in the process is played by land capacity analysis, which permits both an assessment of the current state of utilisation and management of an area and the possibilities for development – by transformation or augmentation or else