15-Minute City: Transforming raw points of interest into accessibility metrics

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1. Introduction and Research Question

1.1 Background: uhe urban inclination of the 15-Minute City

The "15-Minute City" (15MC) has recently emerged as a dominant model in sustainable urban planning, popularized by Moreno et al. (2021) during the coronavirus-outbreak. This concept conceives that urban residents should be able to access all essential daily functions: work, supplies, healthcare, education, and entertainment, within a 15-minute walk or cycle from their homes. By reducing car dependency, the 15MC aims to improve environmental sustainability and boost livability (Albayati et al., 2021).

However, current academic literature and policy applications exhibit a significant "urban bias". Most 15MC models are designed for high-density metropolitan environments like Paris, Barcelona, or Utrecht. As noted by (Knap et al., 2023) there is a lack of research into the theoretical feasibility of this model in non-metropolitan or rural regions. In regions such as Northern Netherlands (Groningen, Friesland, Drenthe), lower population densities and the centralization of services are a fundamental challenge to the 15-minute ideology (Assis et al., 2026; NOS Nieuws, 2026).

1.2 Problem statement

In the less-urbanized provinces of the Netherlands, the retreat of public services, often referred to as "verschraling", poses a threat to social participation. While residents in urban centers may easily meet the 15-minute threshold, people in the periphery may experience "transport poverty" (Mattioli, 2021; Mattioli et al., 2017) if they do not have access to a car. This research addresses the gap between the metropolitan 15MC ideal and the rural reality by analysing how population density and socioeconomic status influence the feasibility of the 15-minute cycling city.

1.3 Research gap

Despite the growing library of 15-minute city research, the literature exhibits an “urban bias”. The omission of non-metropolitan region is largely driven by a “low-density penalty” in availability of data and planning. Rural regions experience data sparsity and fragmentation across institutions or municipalities. The 15-MC model is driven by urban efficiency, where the impact of research, due to the higher population affected by policy decisions, is a lot higher (Poorthuis & Zook, 2023). This creates a self-fulfilling prophecy. By leaving low-density areas out of accessibility reports, researchers reinforce car-dependency as a rural default (Mattioli, 2021). Rural service decline does not affect all residents equally. Students who might be limited by budget (students, assumption) or mobility (elderly) face lower car ownership rates and are limited by public transport or bike. This report shifts away from aggregated regional metrics to evaluate the 15-MC framework for different socio-economic groups.

1.4 Research Question

To address this gap, the primary research question of this study is:

How can a standardized GIS-based processing procedure be developed to quantify and visualize the initial spatial distribution of 15-minute city functions for different socio-economic groups in Northern Netherlands?

2. Sources

2.1 Geographical boundaries

In this research the location of the research area is Groningen, Drenthe Friesland, also known as the Northern Netherlands. To extract the boundaries of these provinces, the dataset "Bestuurlijke Gebieden" (Kadaster, 2026b) has been used. Demographic data (CBS, 2026) about the postcodes (4-digit level) are also included and will be used in follow-up research. For this research the data from 2023 was taken because it was the most complete and finalized data available at the start of this research.

2.2 Residential locations

For the residential locations to determine the starting point for the Network Analysis, residential building centroids were taken from the "Basisregistratie Adressen en Gebouwen (BAG) database. In the downloaded GeoPackage are all main buildings in the Netherlands mapped (Kadaster, 2026a).

2.3 Points of Interest

The points of interest to determine the destinations were extracted from Geofabrik (2026), based on OpenStreetMap (OSM) data. This data contains a lot of 'noise'; therefore, a classification protocol was created, visible in *Table 1*.

Category	**Specific OSM fclass data entries**
Food	supermarket, bakery, butcher, greengrocer, convenience, beverages
Commercial	gift_shop, bicycle_shop, outdoor_shop, mobile_phone_shop, bookshop, travel_agent, clothes, car_dealership, department_store, jeweller, furniture_shop, doityourself, sports_shop, kiosk, newsagent, shoe_shop, toy_shop, beauty_shop, optician, computer_shop, mall, general, laundry, chemist, stationery, hairdresser, florist, garden_centre, marketplace
Bars & Rest.	restaurant, fast_food, pub, cafe, bar, food_court, biergarten
Recreation	playground, picnic_site, theme_park, attraction
Entertainment	museum, theatre, cinema, community_centre, library, nightclub, arts_centre
Healthcare	doctors, hospital, clinic
Sports	sports_centre, fitness_centre, swimming_pool, pitch, ice_rink, track, sports_hall

Table 1: 63 categories were grouped into 7 pillars. Education and parks were left out here, these were compiled through another procedure.

Parks and education are excluded from the table. This is because parks have a different recreational value based on their size (Rigolon, 2016; Stessens et al., 2017). The choice allows for the preservation of surface area data for parks. For these parks a lower boundary on the area of 0.25 ha is applied, as suggested by Poelman (2018).

2.4 Education data

To distinguish categories between elementary and secondary schools (for households with kids) and higher education (students). This data has been sourced from DUO (2026). This data is only available as spreadsheet, with addresses, but without spatial data to be used in QGIS. These addresses were also joined to a BAG-layer using postcodes, house numbers and suffixes and converted to centroids. Information about education level was kept for later processing. This data is then isolated. Primary and secondary schools for the socio-economic group "Households with kids", and higher education institutions (MBO, HBO, WO) are utilized as students destinations.

2.5 Road network

The network analysis is not possible without a network layer. The "Nationaal WegenBestand (NWB) data was retrieved from Rijkswaterstaat (2026). This data is updated monthly. For this research, the most recent available data was updated on April 2nd, 2026. The NWB was chosen over the also available OpenStreetMap data because of its completeness. The attribute fields are a lot more readable; there is simply less clutter. This makes it easier to filter and isolate the cycling paths from the highways.

3. Data preparation

3.1: Research boundaries

ensure that no computational power and time would be wasted during this research, all residential datasets were clipped to the administrative postcode boundaries. The amenities (destinations) and road network have been processed differently and will be discussed further in this report. First, a buffer was established on 6 kilometres from the province borders, visible in Figure 1. This distance is roughly what a fast cyclist can cycle in 15 minutes, in a straight line. This approach guarantees that residents living close to the provincial border are not excluded from reaching amenities just outside of their province and postcode.

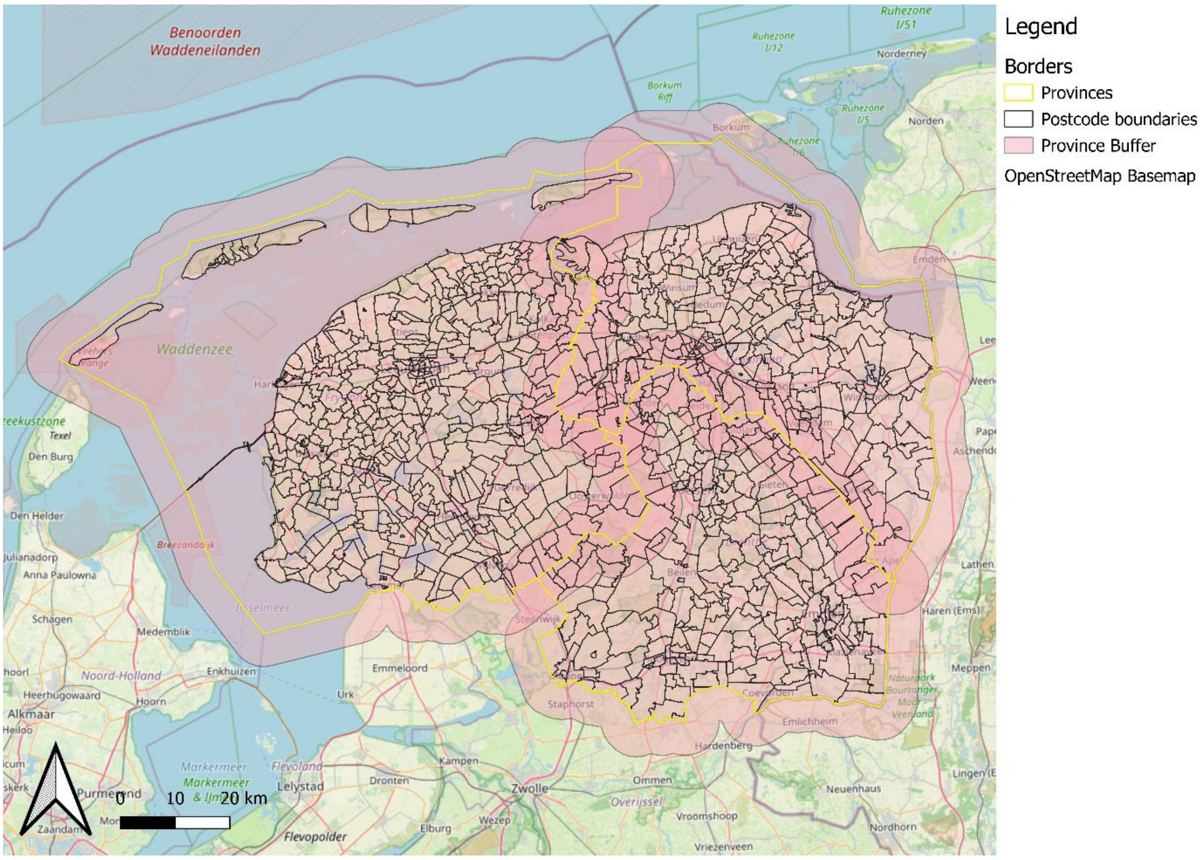

Figure 1 Bufferzones around the borders of Friesland, Groningen and Drenthe.

3.2 BAG origin modelling

Residential locations were modelled using the BAG-dataset (Kadaster, 2026a). This BAG-dataset includes all sorts of buildings. In rural areas, it shows that stables or shelters for farm animals are also mapped. The function of a building is shown in the column “gebruiksdoel” (intended use). For a house, the intended use is noted as “woonfunctie” (residential use). But since buildings can have multiple functions, such as housing a barber downstairs and living area upstairs, the dataset can have multiple intended uses for one building. To overcome that problem, filtering the column with percentage signs (%), in front and behind “woonfunctie” to keep all entries which include at least “woonfunctie” once. Also, some people live in houseboats or on mobile home sites. Due to the low or unknown percentage of permanent residency in these mobile homes (Overheid.nl, 2025) this group is left out of this research. The other special residence property of houseboats is included in this research, since these show a high proportion of permanent residents (Tweede Kamer der Staten-Generaal, 2011). After filtering and combining these layers, we have the total amount of buildings that are suitable for residential usage.

Drawing a network from each point is computational expensive, thus all houses are combined and a population-weighted average is created for each postcode on PC4 level. By taking the population-weighted average, the residential locations are more accurately presented compared to taking a simple geometric middle point of the PC4 code. The resulting map is visible down below in Figure 2.

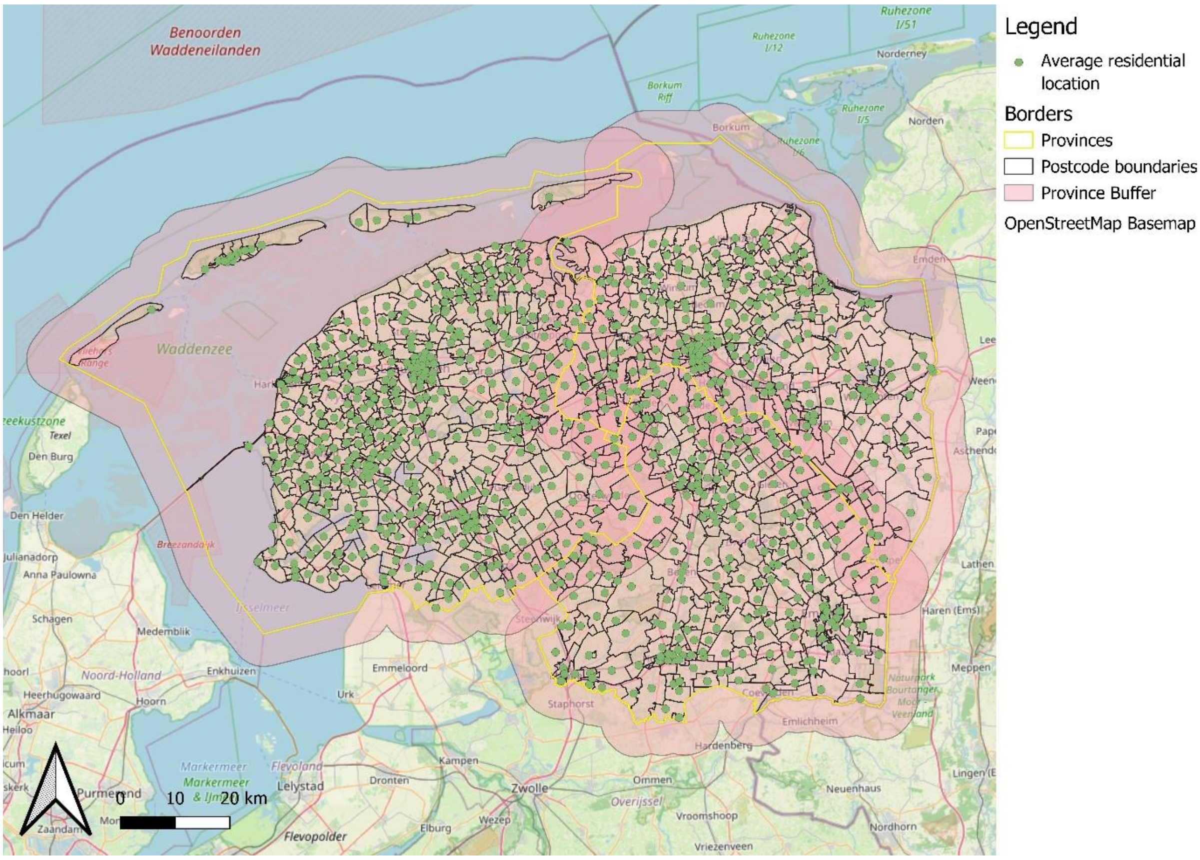

Figure 2 Map of population-weighted residential properties.

3.3 Points of Interest

The destinations that are included in the 15MC are adapted to fit the data availability. In the basis this report focuses on the categories mentioned by Knap et al. (2023), but without jobs. The data about job availability was not available (for free) and has been left out. This choice will be discussed later in the report. Like mentioned in 2.3 Points of Interest, the data of column “fclass” is filtered and visible in Table 1. The data taken from OSM and DUO is combined to create one layer, visible in Figure 3 below.

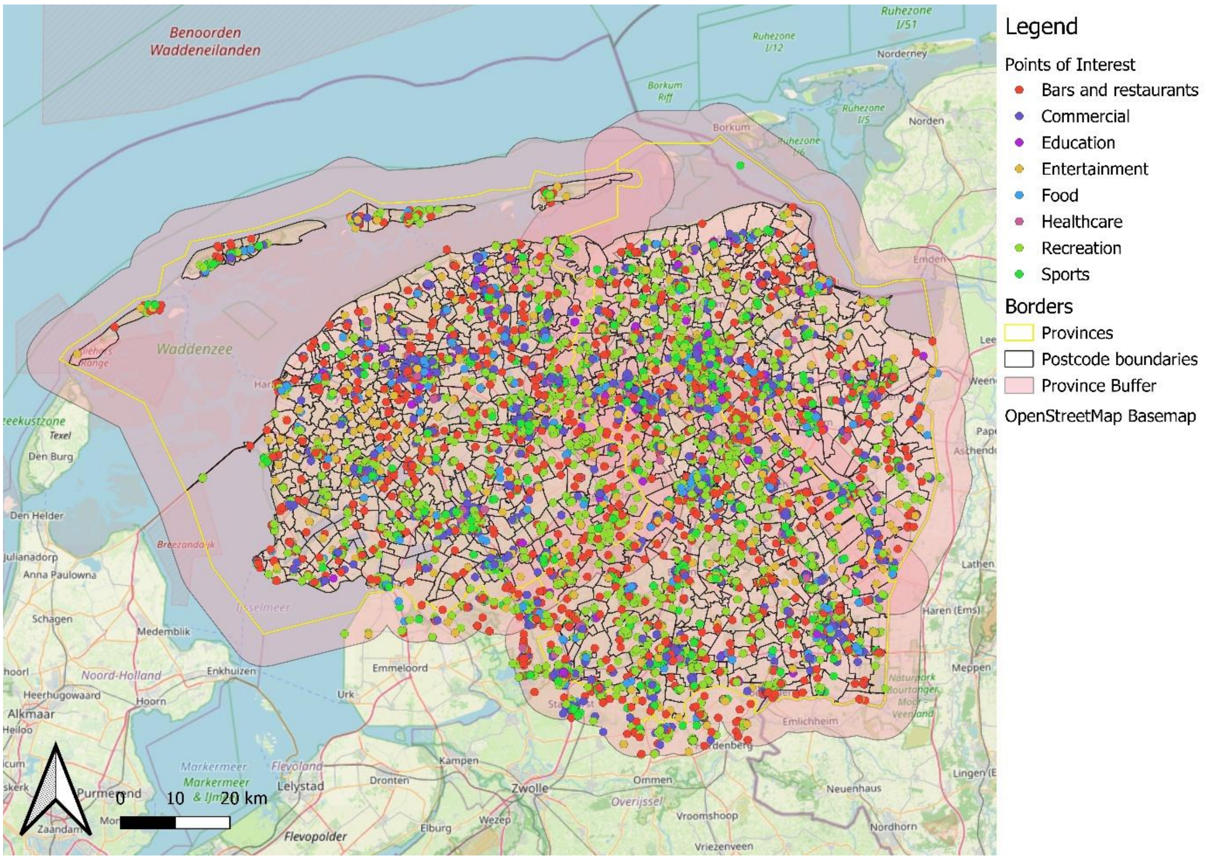

Figure 3 All amenities and locations (15225 data points). Clearly visible is that the buffer function works like intended. The amenities in for example Steenwijk and Dedemsvaart are also included.

3.4 The network

The final step in the data preparation process is to prepare the network layer. The road network was filtered on highways, highway entries and major N-roads while always keeping any cycling infrastructure. After this processing, all the weighted residential points and amenities were snapped to the nearest roads, with a tolerance of 25 meters. Points that did not snap were placed to the nearest road manually. More information was necessary to start the Network Analysis, such as maximum distance and what kind of amenities should be reached. Along with the categories, the following speeds and destinations have been identified. Based on these speeds four different networks were created to incorporate the differences in speeds and therefore availability of amenities.

There is one distinction between education for students and for households with kids. Students are all residents between ages 15 and 25, in line with available CBS data. For the category "Households with kids" the assumption has been made that all kids are under the age of 15. Therefore, the school requirements of the groups are different. Students are looking for secondary vocational education (MBO), higher professional education (HBO) or universities (WO), while households with kids are looking for elementary and secondary schools. The overview of the cycling speeds and assigned amenities are visible in Table 2. After the speeds were finalised, the Network Analysis has been executed. The previous maps capture the overview of the research area, while this is not useful for the network analysis. That is why the focus in Figure 4 is on one single postcode. Here is visible how far the network reaches considering the population-weighted centroid as starting point.

	Speed in km/h	Catchment in km in 15 min	Cycling speed sources	Most important amenities	amenities sources
Student	18.5	4.625	(Westerhuis et al., 2026)	Food, commercial, Bars & restaurants, education, sports	(Ramello et al., 2026)
Households with kids (cargo bike)	18	4.5	(Jelmer et al., n.d.)	Education, food, parks, healthcare, recreation	(Sánchez-De-Val et al., 2025)
Households without kids	18.7	4.675	(CROW, 2014)	Food, bars & restaurants, commercial, parks	(Elldér et al., 2022)
Elderly	16.4	4.1	(Westerhuis et al., 2026)	food, commercial, recreation, parks, entertainment, healthcare	(Ulloa-Leon et al., 2023; Vilhelmson et al., 2025)

Table 2 Cycling speeds and preferred amenities

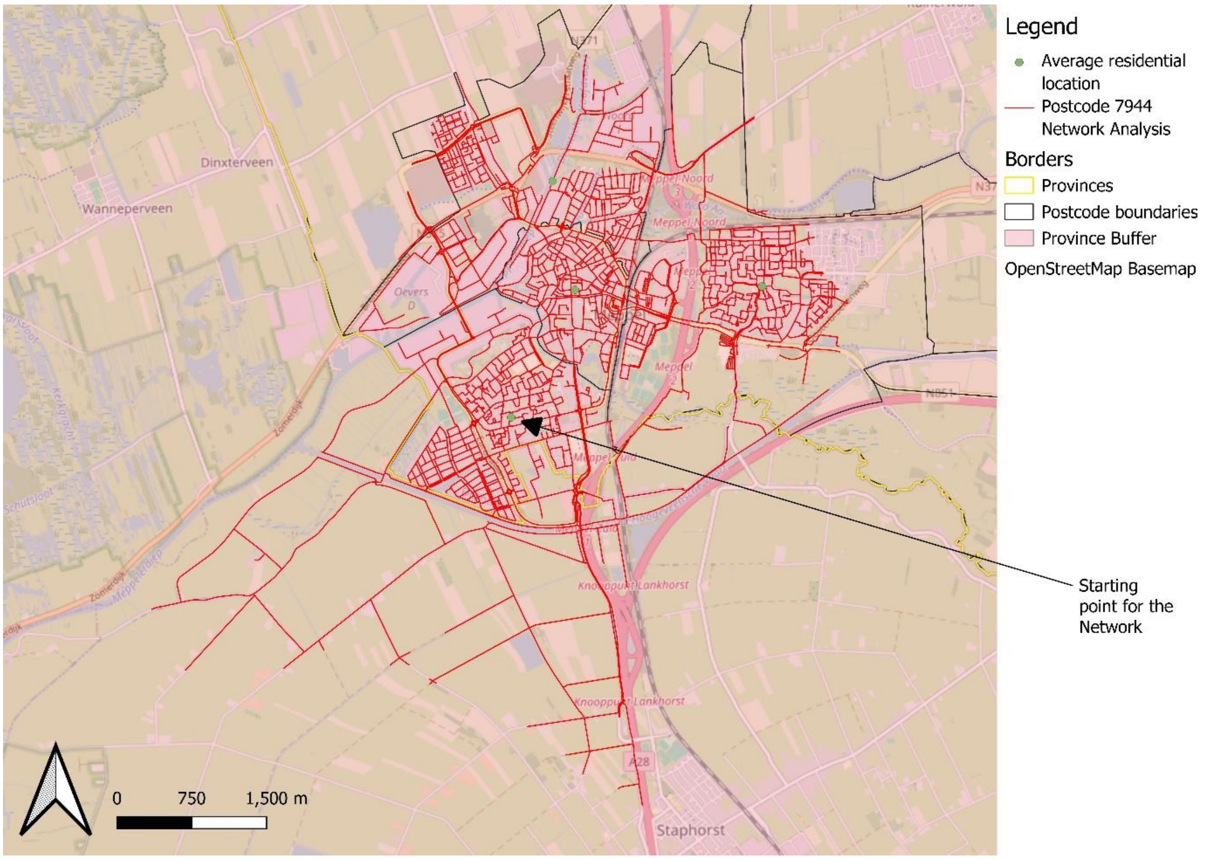

Figure 4 Network Analysis for the group 'Households without kids'. This group has the highest cycling speed, and thus the biggest network. From the most southern postcode in Meppel, Staphorst can almost be reached.

4. Accessibility

This chapter will show how all layers come together. With all the amenities snapped to roads accessible by bicycle or removed, the buffer around the amenity centroid was increased as precautionary measure. The next step was simply checking if polygons did not only snap to the bicycle network as explained in chapter 3.4 but were also within a 15-minute threshold from the weighted population centroids in Figure 2. This is done by verifying by how many networks the amenity was reached. For each PC4 network that touched the amenity, a data entry field was created automatically.

Once the point counts were finalized, this data was aggregated into the postcode polygons from Figure 1 to link the number of accessible amenities to specific postcodes. By using the field calculator, every amenity which could be reached at least once was counted as 1, and if the amenity was missing from the postcode, it would receive a score of 0. If the postcode has access to all amenities, it has received a full score (for students, 5). And if no amenity could be reached, the postcode has a score of 0. This is visualized by postcode in Figure 5 and Figure 6.

In the figure for the students, it is clearly visible where the cities with MBO, HBO and WO schools are found. These are often bigger and more specialized than elementary and secondary school and attract students from further away.

When comparing the two maps, two patterns emerge. The centralization of specialized infrastructure like higher education, and the decentralization of basic social amenities. Student-oriented services demonstrate a highly centralized profile. Maximum accessibility scores can be found in the major cities such as Leeuwarden, Groningen, Assen and Emmen. But when moving away from the urban centers, accessibility drops quickly. Parts of Northern Groningen and rural Friesland are missing more than 2 amenities. Another striking result is the cluster of 2 red postcodes in Drenthe, next to Assen. When zooming in, this appears to be the settlement Huis Ter Heide, mainly natural area.

For the households with kids, the map looks a lot better. The dark green (score of 5) and medium green (score of 4) are both a lot more abundant. Smaller villages score high on this scale. The Wadden islands also receive high scores, with almost perfect availability across all categories and are suited well for small kids. Students are scoring high as well, all 4/5. The only category missing is education.

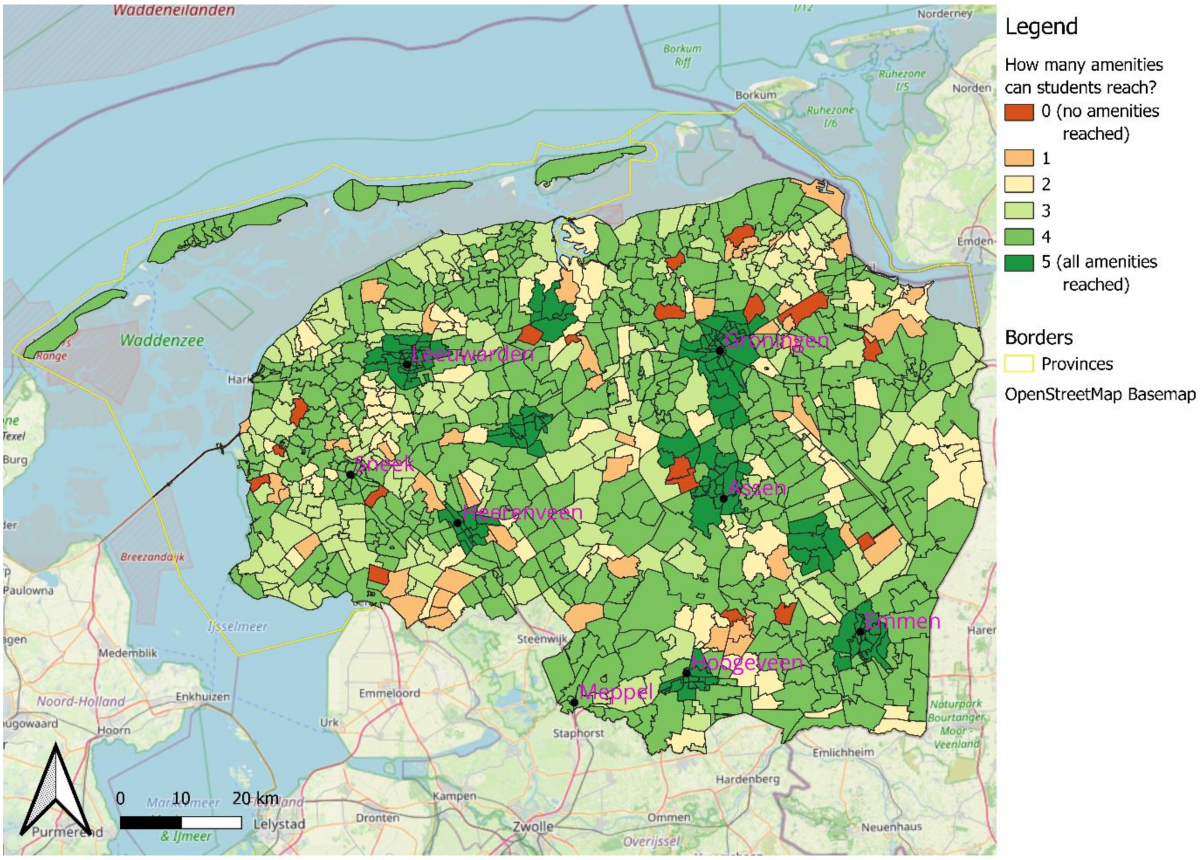

Figure 5 Result of the network analysis for students.

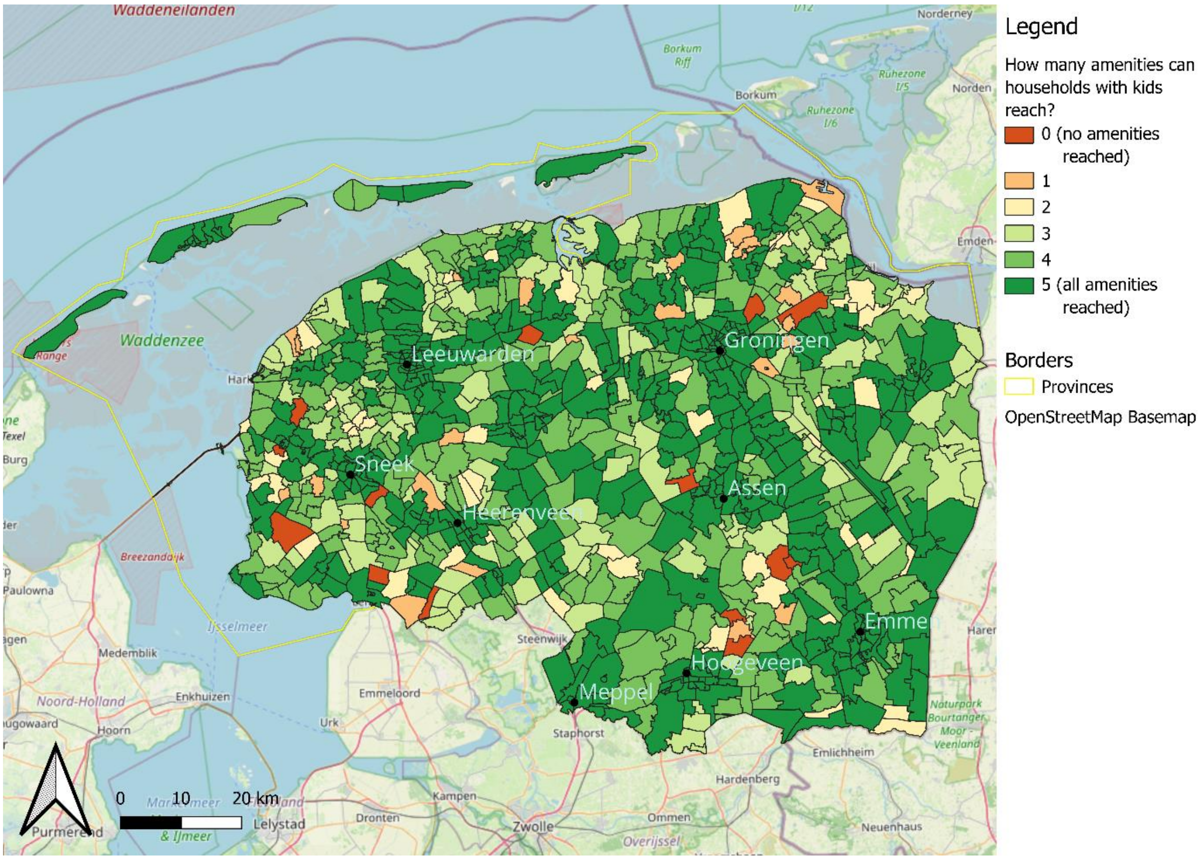

Figure 6 Result of the network analysis for households with kids.

5. Discussion

These maps serve as a baseline for insights into accessibility across Groningen, Drenthe and Friesland. However, there were some technical- and data limitations, and the variables must be discussed.

5.1 The missing category “work”

A limitation of the current database and maps is the exclusion of the “work” category when comparing against Moreno et al’s. (2021) original model. While the supermarket or school can be mapped as a single point, employment cannot. For some, school serves as a job, while for others it serves the educational purpose. A supermarket is for some a place to shop for groceries, for others a place for employment. But more important: By using this way of counting amenities/categories, one giant factory would get the same rating as a local bakery. And how to display farms?

This is also where the 15MC model might fall short in rural areas, where it is unrealistic to live within 15 minutes of the place of employment. And then there is also the fact some people work from home, sometimes multiples days a week. For this bachelor thesis (extension), that is simply too complex to map.

5.2 Groups and amenities

By comparing these two groups (leaving elderly and households without kids here out of the picture), it already becomes clear how services are distributed. Households with kids ‘enjoy’ a decentralized network of available amenities (Gong et al., 2025; Villar-Abeijón et al., 2026).

On the other side there are students, for whom services are highly centralized in the bigger cities. Higher education and sporting facilities are often centralized. This creates a disadvantage for students living outside of major urban hubs.

5.3 Cycling speeds

Assuming uniform cycling speeds ignore geographic and demographic realities. Therefore, this study used group-specific cycling speeds. The sources that were identified might not reflect Dutch cyclists’ behavior (Huang et al., 2024; Schrapel et al., 2024). This is partially due to the rise of e-bikes, but also the difference in speeds between urban and rural cycling. Although there might be no dedicated cycle lanes in rural areas, there is also a lot less other traffic. In the city it is the other way around; by protecting cyclists, more people are going cycling and congestion forms (Trout et al., 2026).

Furthermore, for households with kids, the assumed 18 km/h speed might mask a behavioral tradeoff. Here the assumption is made that parents with kids travel by cargo bike. But Dutch kids are learning to cycle at an average age of 4.2 years old (Veldman et al., 2026). Some are even cycling before even visiting the first grade of elementary school. Letting children cycle independently drops travel speeds and limits the distance traveled in 15 minutes. Another angle could be that parents might not take their kids shopping, and parents ‘alone’ should be just as fast as households without kids.

6. References

Albayati, N., Waisi, B., Al-Furaiji, M., Kadhom, M., & Alalwan, H. (2021). Effect of COVID-19 on air quality and pollution in different countries. *Journal of Transport & Health*, *21*, 101061. https://doi.org/10.1016/J.JTH.2021.101061

Assis, L. B. M. de, Monari, M., Segantine, P. C. L., & Amado, M. J. das N. P. (2026). Measuring spatial accessibility to healthcare services for older adults: a case study for the Lisbon Metropolitan Area. *European Transport Research Review 2026 18:1*, *18*(1), 25-. https://doi.org/10.1186/S12544-026-00771-Y

CBS. (2026, March 21). *Dataset: CBS Postcode 4*. https://www.pdok.nl/introductie/-/article/cbs-postcode4

CROW. (2014, November 30). *CROW Kennisbank*. https://kennisbank.crow.nl/public/gastgebruiker/WOBU/Inspiratieboek_snelle_fietsroutes/Ontwerpeisen/24332

DUO. (2026). *Adressen - DUO Open Onderwijsdata*. https://duo.nl/open_onderwijsdata/primair-onderwijs/scholen-en-adressen/#

Elldér, E., Haugen, K., & Vilhelmson, B. (2022). When local access matters: A detailed analysis of place, neighbourhood amenities and travel choice. *Urban Studies*, *59*(1), 120–139. https://doi.org/10.1177/0042098020951001;REQUESTEDJOURNAL:JOURNAL:USJA;WGROUP:STRING:PUBLICATION

Geofabrik. (2026). *Download OpenStreetMap for Netherlands*. https://download.geofabrik.de/europe/netherlands.html

Gong, X., van den Berg, P., Dane, G. Z., & Arentze, T. (2025). Parental perception of child friendliness and its impact on residential location choice: A stated choice experiment. *Cities*, *161*, 105914. https://doi.org/10.1016/J.CITIES.2025.105914

Huang, B. (Amelia), Wüst, H., & de Haas, M. (2024). Assessing the E-bike trends and impact on sustainable mobility: A national-level study in the Netherlands. *Journal of Cycling and Micromobility Research*, *2*, 100027. https://doi.org/10.1016/J.JCMR.2024.100027

Jelmer, Renate, Dirk-Jan, Santo, & Alexander. (n.d.). *How comfortable are cargo bikes actually for children?* Retrieved May 15, 2026, from https://www.tudelft.nl/en/me/education/student-stories/how-comfortable-are-cargo-bikes-actually-for-children

Kadaster. (2026a). *Dataset: Basisregistratie Adressen en Gebouwen (BAG)*. https://www.pdok.nl/introductie/-/article/basisregistratie-adressen-en-gebouwen-ba-1

Kadaster. (2026b, January 21). *Dataset: Bestuurlijke Gebieden*. https://www.pdok.nl/introductie/-/article/bestuurlijke-gebieden

Knap, E., Ulak, M. B., Geurs, K. T., Mulders, A., & van der Drift, S. (2023). A composite X-minute city cycling accessibility metric and its role in assessing spatial and socioeconomic inequalities – A case study in Utrecht, the Netherlands. *Journal of Urban Mobility*, *3*, 100043. https://doi.org/10.1016/J.URBMOB.2022.100043

Mattioli, G. (2021). Transport poverty and car dependence: A European perspective. *Advances in Transport Policy and Planning*, *8*, 101–133. https://doi.org/10.1016/BS.ATPP.2021.06.004

Mattioli, G., Lucas, K., & Marsden, G. (2017). Transport poverty and fuel poverty in the UK: From analogy to comparison. *Transport Policy*, *59*, 93–105. https://doi.org/10.1016/J.TRANPOL.2017.07.007

Moreno, C., Allam, Z., Chabaud, D., Gall, C., & Pratlong, F. (2021). Introducing the "15-Minute City": Sustainability, Resilience and Place Identity in Future Post-Pandemic Cities. *Smart Cities 2021, Vol. 4, Pages 93-111*, *4*(1), 93–111. https://doi.org/10.3390/SMARTCITIES4010006

NOS Nieuws. (2026, February 4). *Van café tot huisarts: dorpen in hele land zien voorzieningen verdwijnen*. https://nos.nl/collectie/14016/artikel/2600865-van-cafe-tot-huisarts-dorpen-in-hele-land-zien-voorzieningen-verdwijnen

Overheid.nl. (2025, July 26). *Woonwagen- en Standplaatsenbeleid | Lokale wet- en regelgeving*. https://lokaleregelgeving.overheid.nl/CVDR742850/1#

Poelman, H. (2018). *UPDATE USING COMPLETED COPERNICUS URBAN ATLAS DATA Working Papers*. https://ec.europa.eu/regional_policy/sources/work/2018_01_green_urban_area.pdf

Poorthuis, A., & Zook, M. (2023). Moving the 15-minute city beyond the urban core: The role of accessibility and public transport in the Netherlands. *Journal of Transport Geography*, *110*, 103629. https://doi.org/10.1016/J.JTRANGEO.2023.103629

Ramello, R., Mugnano, S., & Gaspani, F. (2026). University students and urban independent living: Neighbourhood priorities and residential profiles. *Cities*, *172*, 106872. https://doi.org/10.1016/J.CITIES.2026.106872

Rigolon, A. (2016). A complex landscape of inequity in access to urban parks: A literature review. *Landscape and Urban Planning*, *153*, 160–169. https://doi.org/10.1016/J.LANDURBPLAN.2016.05.017

Rijkswaterstaat. (2026, March 2). *Nationaal Wegenbestand (NWB)*. Rijkswaterstaat. https://www.nationaalwegenbestand.nl/nwb-downloaden

Sánchez-De-Val, A. P. M., Sánchez-De-Val, M. M., & López Hernández, F. A. (2025). Are 15-minute cities for children? Exploring the socio-economic factors in Madrid. *Teruleti Statisztika*, *15*(4), 653–676. https://doi.org/10.15196/RS150403

Schrapel, M., Graf, T., Zappalà, D. M., Campolo, C., Molinaro, A., & Vinel, A. (2024). When the E-bike Takes Over: Speed Precision and Perception of Cruise Control for Cyclists. *16th International Conference on Automotive User Interfaces and Interactive Vehicular Applications, AutomotiveUI 2024 - Main Proceedings*, *1*, 272–282. https://doi.org/10.1145/3640792.3675714

Stessens, P., Khan, A. Z., Huysmans, M., & Canters, F. (2017). Analysing urban green space accessibility and quality: A GIS-based model as spatial decision support for urban ecosystem services in Brussels. *Ecosystem Services*, *28*, 328–340. https://doi.org/10.1016/J.ECOSER.2017.10.016

Trout, I., Salomons, M., Afghari, A. P., & Farah, H. (2026). Riding the circle: Cyclists' perceived safety and comfort in urban roundabouts. *Transportation Research Part F: Traffic Psychology and Behaviour*, *118*, 103539. https://doi.org/10.1016/J.TRF.2026.103539

Tweede Kamer der Staten-Generaal. (2011). *Ligplaatsen voor woonboten ; Verslag van een schriftelijk overleg; Verslag van een schriftelijk overleg inzake de huurprijsherziening van ligplaatsen voor woonboten*.

Ulloa-Leon, F., Correa-Parra, J., Vergara-Perucich, F., Cancino-Contreras, F., & Aguirre-Nuñez, C. (2023). “15-Minute City” and Elderly People: Thinking about Healthy Cities. *Smart Cities 2023, Vol. 6, Pages 1043-1058*, *6*(2), 1043–1058. https://doi.org/10.3390/SMARTCITIES6020050

Veldman, S. L. C., Westerbroek, M., & Singh, A. S. (2026). Understanding cycling to school behaviour in Dutch primary school-aged children. *Transportation Research Interdisciplinary Perspectives*, *37*, 101998. https://doi.org/10.1016/J.TRIP.2026.101998

Vilhelmson, B., Thulin, E., & Gil Solá, A. (2025). Active aging in place: neighborhood practices and preferences among urban older adults in Sweden. *Urban Geography*. https://doi.org/10.1080/02723638.2025.2531686

Villar-Abeijón, P., Miralles-Guasch, C., & Marquet, O. (2026). The impact of proximity to amenities on housing affordability: Insights from Mediterranean 15-minute cities. *Cities*, *172*, 106859. https://doi.org/10.1016/J.CITIES.2026.106859

Westerhuis, F., Sporrel, B., Stuiver, A., & de Waard, D. (2026). Cycling behaviour of older and younger adults: Differences in performance and the relation with infrastructure and neuropsychological test performance. *Transportation Research Part F: Traffic Psychology and Behaviour*, *118*, 103497. https://doi.org/10.1016/J.TRF.2025.103497