Visualizing the difference between the geometric and administrative surface area of the Cadastral Map of the Netherlands.

Matthijs Hoogmoed, Peter van Oosterom and Eric Hagemans, Netherlands.

Key words: LADM, Cadastre, Digital Cadastre, Education, Parcel legal/administrative area, Parcel geometric/map area.

SUMMARY

The research explored the differences between the cadastral parcels' geometric and administrative surface area in the cadastral map and was done on behalf of the Dutch Cadastre.

The research employed a literature study, different methodologies, and different tests and used feedback from the Dutch Cadastre experts to visualise and analyse the surface area discrepancy of parcels. To better understand the differences between the computed geometrical surface area of parcels and the administrative surface area of the complete Dutch cadastral map.

The research primarily used data from the Basisregistratie Kadaster (BRK) and other open data sources like the Basisregistratie Topografie (TOP-10nl) and the Basisregistratie Adressen and Gebouwen (BAG). The analysis was done using open-source tools like PostGIS, QGIS and GeoDa. These tools were used to visualise the differences at individual parcel levels and aggregated levels like cadastral municipalities and sections. The area differences were visualised in different manners (relative/absolute sizes, acceptable/not acceptable), and the direction of change (smaller, bigger). These area differences are relevant for many organisations apart from the Dutch Cadastre, like owners, municipalities, water boards and provinces, because a change in the area may imply a change in value and taxation.

The current results show a significant preliminary variation in the area differences between parcels in rural and built-up areas in the Netherlands. Furthermore, clusters of parcels with the most considerable relative difference can be found in the natural areas of the Netherlands, which exceed the limits set by the Dutch cadastre. Furthermore, new-urban and agricultural areas with consolidated land show a high correlation between the registered and calculated surface area of parcels.

Visualizing the difference between the geometric and administrative surface area of the Cadastral Map of the Netherlands.

Matthijs Hoogmoed, Peter van Oosterom and Eric Hagemans, Netherlands.

EXTENDED SUMMARY

1. Visualizing the difference between the geometric and administrative surface area in the Netherlands

The Dutch cadastre was established to enhance the Dutch taxation system by measuring, processing, and archiving cadastral parcels throughout the Netherlands in field sketches. This resulted in complete country coverage within the Dutch Cadastral system. The coverage was visualised in an analogue map showing the relative locations and shapes of parcels in the Netherlands (Hagemans et al., 2022). This cadastral map was continuously improved throughout its history with new modifications, improvements, and renovations. These improvements to the map were not always done for each region, and certain regions still use cadastral data from the 19th century (Kruizinga & van Doornmalen, 1997). Furthermore, renovations like the harmonisation with the BGT did not always lead to a better representation of the field sketches (Salzmann et al., 1998). As such, the current Cadastral Map consists of parcels of varying quality, which differ per region and area. The varying quality can be attributed to the presence or absence of measurements and different attempts to change the map in the past.

The difference in the quality of boundary measurements can result in large differences between the geometric and the administrative surface area of parcels inside the cadastral map, which is important because the administrative area is used for taxation purposes and is mentioned in the deed. Consequently, users could potentially misinterpret or misunderstand the Cadastral Map, as the exact location of the cadastral boundaries of parcels and the resulting surface area are only explicitly specified in the field sketches in the Netherlands and are not displayed in the Cadastral Map (Grant et al., 2020).

This risk of misunderstanding would be further amplified by the growing accessibility of web mapping applications and functionalities such as zooming and overlays. They are making it easier for users to notice discrepancies between the registered area and the calculated surface area from the Cadastral Map. Users now expect an area accuracy of at least 5 m^2 for a parcel of 100 sqm in 95% of the cases. The 5m is based on the tolerance formula of $q\sqrt{a}$, in which q stands for the quality requirement in cm and stands for are (100sqm). The currently used tolerance inside the Cadastral Map is $10\sqrt{a}$ for rural areas and $5\sqrt{a}$ for urban areas (Hagemans et al., 2022).

As such, this research aimed to measure and accurately visualize the disparities between the geometric and administrative surface areas of the Cadastral Map of the Netherlands to understand the difference between the computed geometric and the administrative surface area of parcels in the Cadastral map.

2. Methodology

This research primarily uses data from the Kadaster to calculate and visualise the difference between the geometric and administrative surface area and their spatial characteristics. These datasets are the Basisregistratie Kadaster (BRK) for the cadastral map, Basisregistratie Adressen en Gebouwen (BAG), parcel ownership data, and TOP10NL for selecting the contours of built-up areas. Parcels inside nature areas were selected using a Natura2000 dataset. The selections can be expanded with other data sources.

The analysis was done using open-source tools like PostGIS, QGIS and GeoDa. These tools were used to visualise the differences at individual parcel levels and aggregated levels like cadastral municipalities and sections. The difference amount was visualised (relative/absolute sizes, acceptable/not acceptable), and the direction of change (smaller, bigger). These area differences are relevant for many organisations apart from the Dutch Cadastre, like owners, municipalities, water boards and provinces, because a change in the area may imply a change in value and taxation.

The data itself was primarily done inside a PostgreSQL database, with the BRK as the primary data table. The parcels BRK table was then modified by using the earlier mentioned datasets. Furthermore, each parcel did get a relative M-value based on the relative difference between the geometric and administrative surface area and the length-to-width of the parcel to calculate a normalised metric number. This data was then visualised at individual parcel levels and aggregated levels like cadastral municipalities and sections. By linking the PostgreSQL database to GeoDa (Anselin et al., 2006) it was possible to apply a spatial autocorrelation to the dataset on the M score and make statistical comparisons. Lastly, the data was visualized using QGIS. An overview is given in Figure 1.

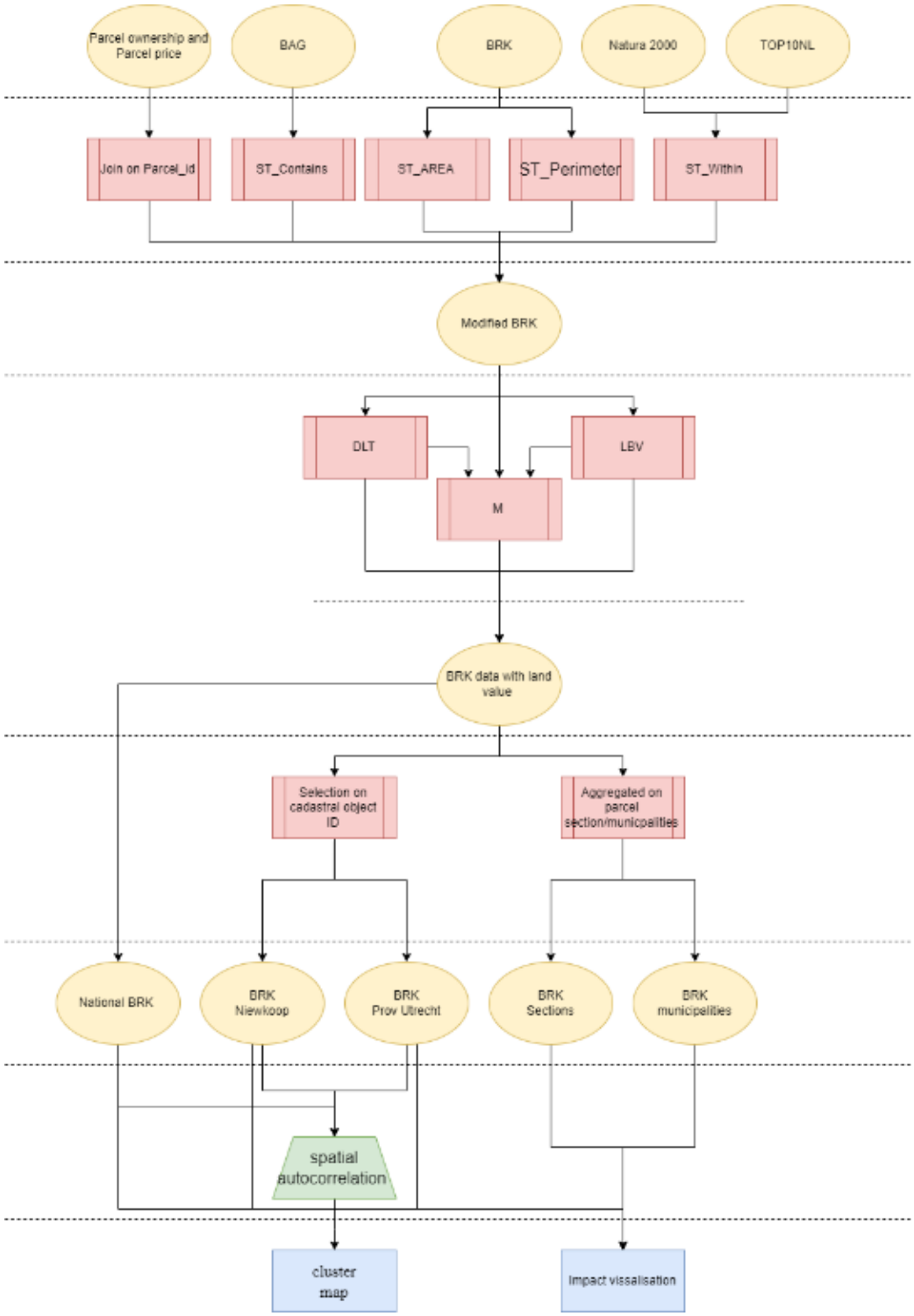

Figure 1 on overview methodology

3. Results

The results showed a total 0.078% difference between the geometric and administrative surface area of the Cadastral Map of the Netherlands, corresponding to a surface area difference of 32309515 m^2. The results also showed an area difference between parcels in rural and built-up areas of the Netherlands. More specifically, it shows a significant difference between parcels within built-up areas (m = 0.10, SD = 0.22) and those inside rural areas (m = 0.35, SD = 0.85). Which corresponds to the higher quality requirements of built-up areas (Van Den Heuvel et al., 2022).

A similar result is shown for parcels containing a residential property (m = 0.10, SD = 0.22). The other way around is seen for parcels in the Natura2000 areas (m = 0.77, SD = 1.75), indicating that parcels inside Natura2000 areas have a significantly higher difference in surface area between the geometric and administrative surface area. While the surface area difference of governmental-owned parcels (m = 0.25, SD = 0.89) is between the difference of nature2000 and residential properties.

The spatial correlation using the Local Moran's I show for the whole of the Netherlands (I = 0.193) that the relative surface difference of parcels is predominantly random from the mean but that there is a weak clustering of similar values. The High-low relationship only applies to 28925 parcels, meaning that it is rare for a parcel with a high M-value to be surrounded by low M-value parcels.

Visualization allows for visual analysis of the difference between the geometric and administrative surface area of the around 8 million parcels, which is done using mainly a choropleth map using 7 OD classes based on the relative M-value and the quality requirements set by the Dutch cadastre (Hagemans et al., 2020). The colours and style used are based on (Brewer, 1994; Kraak & Ormeling, 2020). The map shows ODA clusters in the countryside of the province of Groningen and the south of the province of Utrecht; inspection shows there is land consolidation of agricultural parcels. Other agricultural areas show a similar low OD value. In contrast, nature areas are within the highest categories of ODG and ODF. The results are also shown in Figure 2.

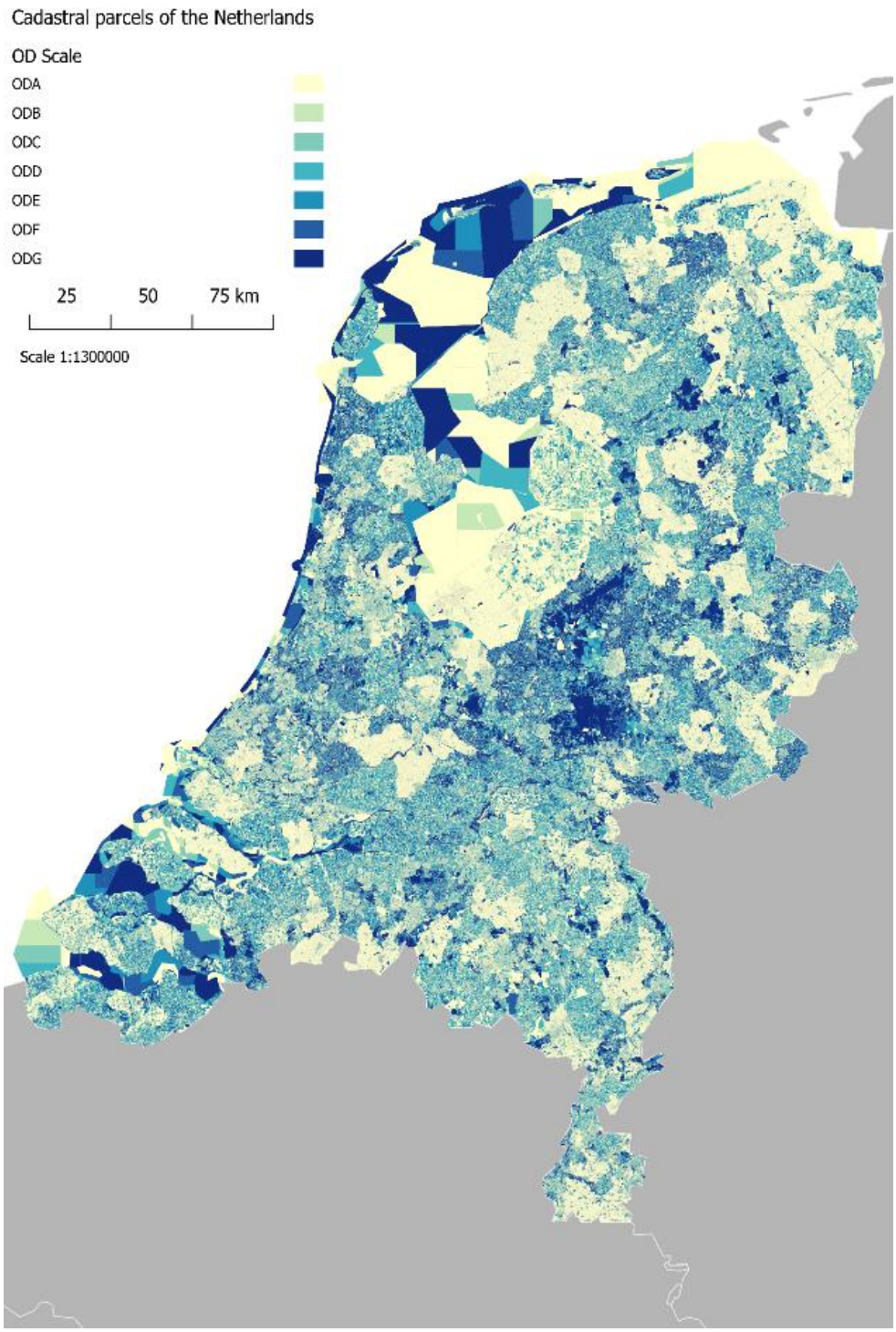

Figure 2 OD map Netherlands with alternative colour scale

REFERENCES

Anselin, L., Syabri, I., & Kho, Y. (2006). GeoDa: An Introduction to Spatial Data Analysis. *Geographical Analysis*, *38*(1), 5–22. https://doi.org/10.1111/J.0016-7363.2005.00671.X

Brewer, C. A. (1994). Color Use Guidelines for Mapping and Visualization. *Modern Cartography Series*, *2*(C), 123–147. https://doi.org/10.1016/B978-0-08-042415-6.50014-4

Grant, D., Enemark, S., Zevenbergen, J., Mitchell, D., & McCamley, G. (2020). The Cadastral triangular model. *Land Use Policy*, *97*, 104758. https://doi.org/10.1016/J.LANDUSEPOL.2020.104758

Hagemans, E., Liem, V., Grift, J., Schepens, P., & van Haselen, F. (2020). Geometrische kwaliteit beschrijving en beslisboom informatiekaart V1.6. *Kadaster*.

Hagemans, E., Unger, E. M., Soffers, P., Wortel, T., & Lemmen, C. (2022). The new, LADM inspired, data model of the Dutch cadastral map. *Land Use Policy*, *117*. https://doi.org/10.1016/j.landusepol.2022.106074

Kraak, M.-J., & Ormeling, F. (2020). *Cartography : Visualization of Geospatial Data*. https://doi.org/10.1201/9780429464195

Kruizinga, P., & van Doornmalen, S. E. M. (1997). De kadastrale kaart, 1812-1990. In *Nederlandse Geschiedenis*. Instituut voor Nederlandse Geschiedenis.

Salzmann, M., Hoekstra, A., & Schut, T. (1998). *Cadastral Map Renovation: A Dutch Perspective*. https://www.oicrf.org/documents/40950/43224/Cadastral+map+renovation+a+Dutch+perspective.pdf/852209f3-126f-637f-501d-e13e2e0751f9?t=1510160569008

Van Den Heuvel, F., Lucassen, J., Van Den Broek, M., Swaenen, L., Vestjens, G., Florijn, W., Bussemaker, S., & Hagemans, E. (2022). Renewal of the Cadastral Map of The Netherlands, an iterative adjustment approach. *FIG*.