ANALYSING LAND USE

AND

RESIDENTIAL DENSITY CHANGE IN AMSTERDAM

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1. INTRODUCTION

Just over half of the world's population lives in cities today, and the number of city dwellers is expected to increase considerably in the coming years (UN, 2011). This urban growth process is steered by forces of agglomeration related to the attraction of urban areas for, employment and residences and dispersion stemming from excessive crowding (Anas et al., 1998).

This research follows work done by Broitman D., Koomen E., and Rietveld P., (resubmitted October 2014) that analyses the degree to which current urban development is in line with the general objective of increasing the efficient use of land. "By looking at actual urban development we want to step beyond general theoretical notions on density gradients and obtain an empirics-based understanding of urban densification and expansion processes".

Densification processes for the urban land use type residential area are demolish/new development and redevelopment. Brownfield development is the conversion to residential uses of vacant or underutilized locations within the city, generally former industrial or commercial properties (Tomalty R., Alexander D., 2005; Hayek et al, 2010). Infill means that small open parcels within urban areas are developed for residential uses, thus increasing urban densities (UTF, 2005). Using these detailed data we are able to describe the presence of local features such as industrial, commercial and retail land uses within urban areas that may allow brownfield development. The presence of open zones within urban areas (e.g. parks, allotment gardens or sports fields) is included to account for the potential for infill processes (Broitman D., Koomen E., 2014)

The density increase data are more robust and contain less "noise" than the density decrease data and therefore the research will focus mainly on densification. It aims to understand residential development in Amsterdam by assessing the share of the main processes and more specifically to achieve the following objectives:

1. assess the relative importance of different processes in residential developments.
2. assess the applicability of a GIS-based analysis to distinguish between different urban densification processes.
3. determine the extent to which the available data can be used for densification analysis by comparing it to actual field research results.

2. STUDY AREA

A rectangular boundary of approximately 526 km^2 is chosen as the study area for this research. This area is situated in the Netherlands and covers the most important part of the peri-urban area of the city of Amsterdam, it includes 19 municipalities of which the entire municipality of Amsterdam and Diemen and partially the municipalities of Aalsmeer, Amstelveen, Haarlem, Haarlemmerliede en Spaarnwoude, Haarlemmermeer, Landsmeer, Muiden, Oostzaan, Ouder-Amstel, Uithoorn, Velsen, Weesp, Zaanstad, De Ronde Venen, Waterland, Wijdemeren and Stichtse Vecht. Roughly 1.7 million inhabitants (CBS Wijk-en-Buurtkaart, 2013) live in this area, roughly more than 10% of the entire Dutch population.

Within the study area of this research a random area was selected in the municipality Amsterdam for field research. This area of 4.5 km^2, was used as a field check on the development processes suggested by the gis-analysis. It covers the following neighborhoods; Lutkemeer en Ookmeer, Middelveldsche Akerpolder en Sloten, De Punt, Osdorp-Midden, Osdorp-Oost.

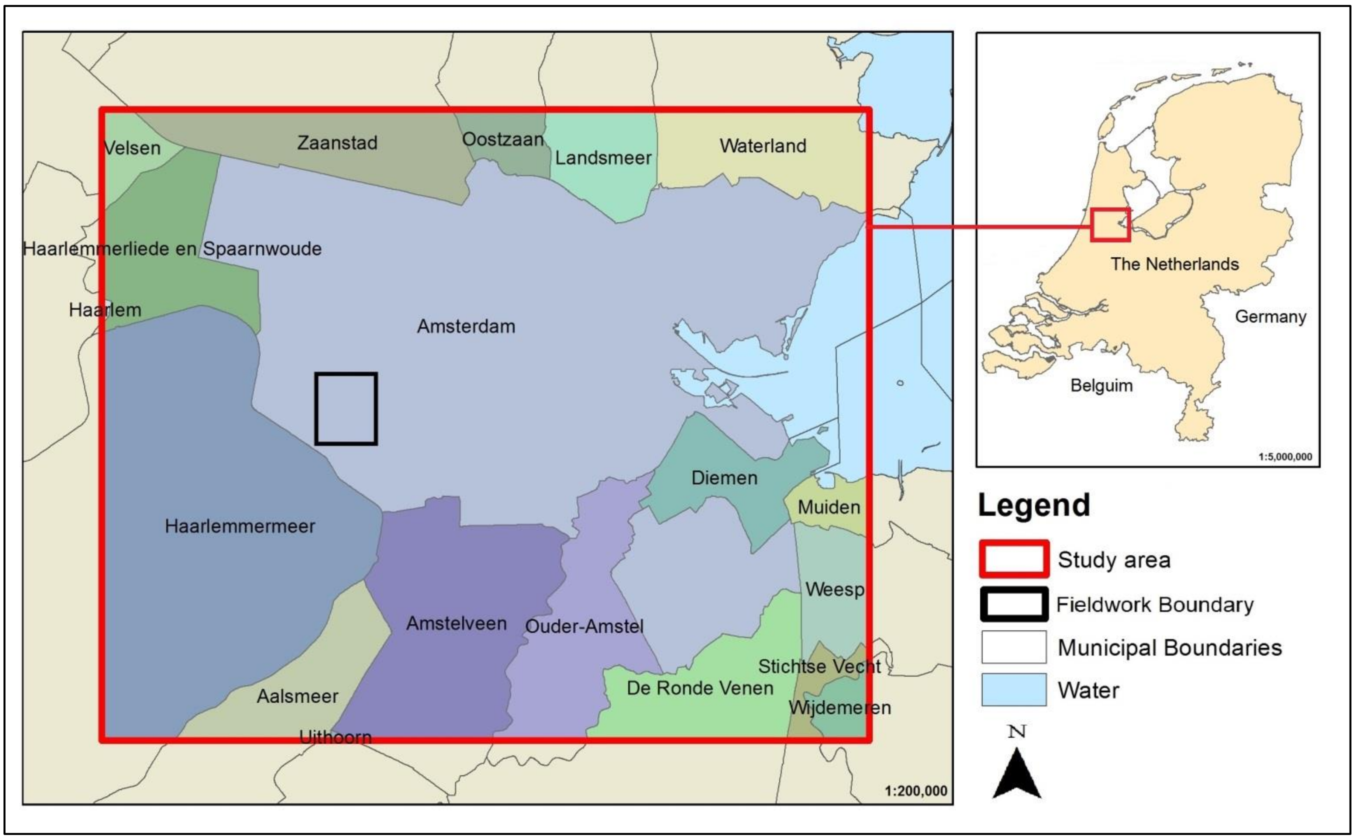

Figure 1: Research study area

3. METHOD

3.1 Data Sources

The BBG Raster ("Bestand Bodemgebruik" or Land Use Dataset): CBS land use map is available in raster format for the years 1989 and 2000 with a cell size of 25m. For each cell, the predominant land use is available based on an aggregated version of the spatially explicit land use database from Statistics Netherlands (CBS, 2008). This dataset is derived from the detailed geometry of digital topographical maps that are meant for usage at a 1;10,000 scale, typically mapping features that are larger than one hectare (van Leeuwen, 2004).

These land use datasets were initially classified into roughly 90 classes. However for this study it was considered more appropriate to reclassify the datasets into 15 general classes to distinguish predominantly residential areas, commercial areas, industrial areas, semi-paved areas (e.g. dumping grounds, wrecking yards and other semi-paved areas), agricultural land, building sites (i.e. sites prepared for development), transport infrastructure (rail roads, main roads and airports), recreational areas (e.g. day trip locations, campgrounds, amusement and holiday parks), water, saline water, natural vegetation (wetlands and heathland), greenhouses, forests and cells outside of the Dutch border. The classification definitions are given in Table 1.

Table 1: Land use classification

BBG	Benaming	15 Cl	Definition	BBG	Benaming	15 Cl	Definition
10	Spoorwegen	1	Transport infrastructure	50	Glastuinbouw	9	Greenhouses
11	Vliegveld	1	Transport infrastructure	51	Overig agrarisch gebruik	10	Agricultural
12	Hoofdweg	1	Transport infrastructure	60	Bos	11	Forest
20	Woongebied	2	Residential area	61	Droog natuurlijk terrein	12	Natural Vegetation
21	Detailhandel en horeca	3	Commercial area	62	Nat natuurlijk terrein	12	Natural Vegetation
22	Openbare voorzieningen	3	Commercial area	70	IJsselmeer/Markermeer	13	Water
23	Sociaal-culturele voorzieningen	3	Commercial area	71	Afgesloten zeearm	13	Water
24	Bedrijfsterreinen	4	Industrial area	72	Rijn en Maas	13	Water
30	Stortplaatsen	5	Semi-paved area	73	Randmeer	13	Water
31	Wrakkenopslagplaatsen	5	Semi-paved area	74	Spaarbekkens	13	Water
32	Begraafplaats	6	Greenfields	75	Water met een recreatieve hoofdfunctie	13	Water
33	Delfstoffenwinning	5	Semi-paved area	76	Water met delfstofwinningsfunctie	13	Water
34	Bouwterrein	7	Building site	77	Vloei- en/of slibveld	13	Water
35	Semi-verhard overig terrein	5	Semi-paved area	78	Overig binnenwater	13	Water
40	Parken en plantsoenen	6	Greenfields	80	Waddenzee, Eems, Dollard	14	Saline Water
41	Sportterreinen	6	Greenfields	81	Oosterschelde	14	Saline Water
42	Volkstuinen	6	Greenfields	82	Westerschelde	14	Saline Water
43	Dagrecreatieve terreinen	8	Recreational area	83	Noordzee	14	Saline Water
44	Verblijfsrecreatie	8	Recreational area	90	Buitenland	15	Dutch Border

The BAG data (Basisregistraties Adressen en gebouwen) consists of municipal basic information of all addresses and buildings within each municipality in vector format. This dataset was used to derive building year information ("2000-2010") and building status information ("Building in use", "Building not in use", "Construction permit granted").

Addresses of the Netherlands were included in the BAG as a point dataset. The addresses indicate the main purpose of use (Residential=''Woonfunctie"). The BAG data is open data and the most recent datasets are available online at https://data.overheid.nl/data.

Urban boundary of 2000 dataset (VROM, 2004), contains the urban areas of the Netherlands. The Ministry of VROM (Ministry of Housing, Spatial Planning and the Environment) released a report containing the details of the methods and technique procedures used to create the urban boundary 2000 dataset. It is available online at http://www.rijksoverheid.nl/bestanden/documenten-en-publicaties/brochures/2004/09/01/begrenzing-bebouwd-gebied-2000/w448.pdf.

A density change dataset is available for the Netherlands (see Figure 2). This information is retrieved from a rasterized data set with a 100 meters resolution containing the number of housing units for the years 2000 and 2010, provided by PBL Netherlands Environmental Assessment Agency. This data set is based on a combination of different, point-based data sets related to individual address location from the Netherlands' cadaster, land registry and mapping agency and numbers of housing units, inhabitants and businesses from other sources (Evers et al. 2005).

It is important to notice that the cells depict density changes (change in density between 2000 and 2010) and not the current density in that cell (dwellings per hectare).

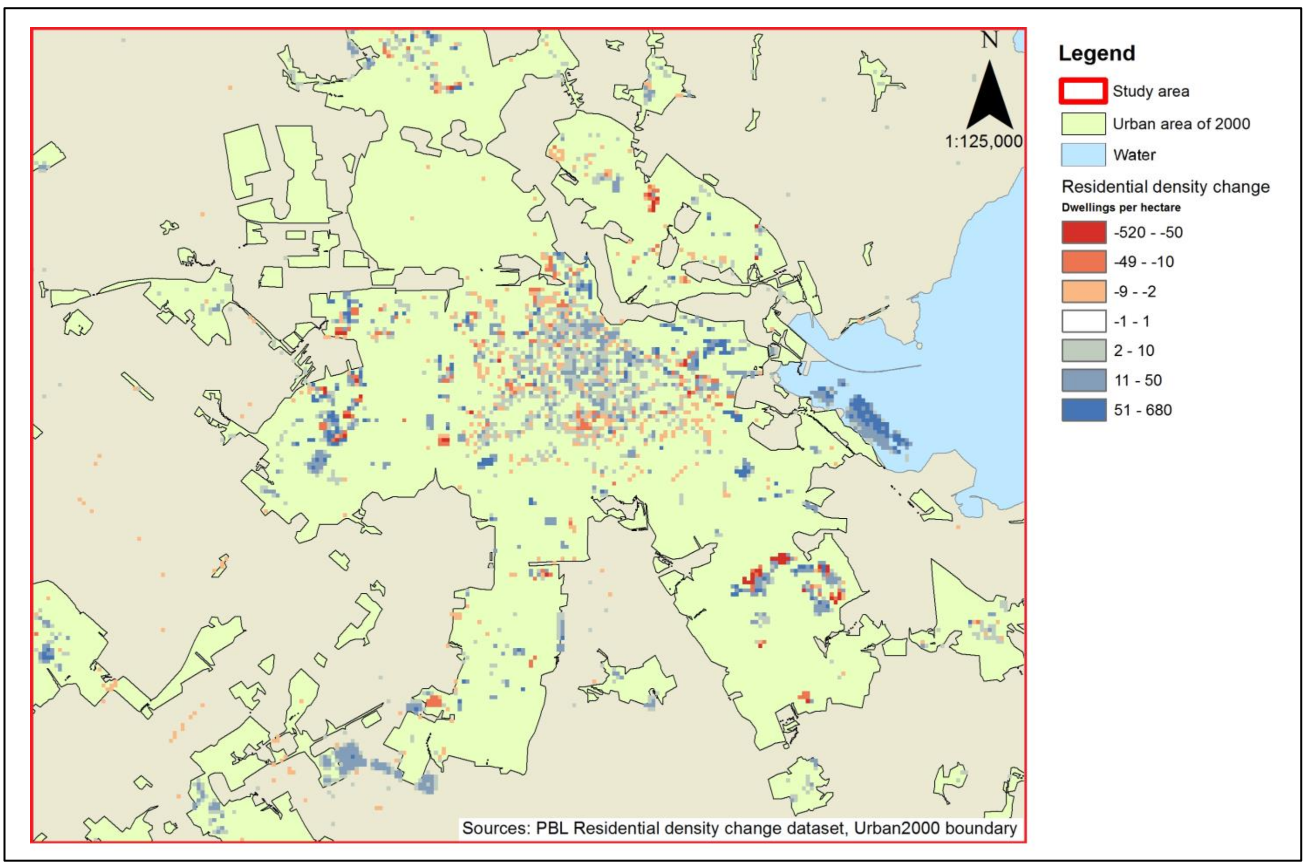

Figure 2: Residential density change

3.2 Data Preprocessing

Data preprocessing was necessary before analysis could be conducted. Firstly the land use datasets were reclassified using a more general classification scheme shown in Table 1.

Secondly, the land use dataset of 2000 contain cells classified as “Building Lot” (surface that is prepared for construction purposes). For this particular research it was decided that it would be more beneficial to know what the land use was before it was classified as being a “Building Lot”, this is regarded as a temporary classification before the final land use classification. The land use dataset of 1989 was used to reclassify the land use dataset of 2000 used for the analysis. See APPENDIX A for the preprocessing steps taken. Finally all datasets were ‘’clipped” to the study area extent as well as the field research area. In the BAG dataset only buildings within the Density change cells were selected and using the address point dataset only buildings designated as residential (“Woonfunctie”) were selected in the area.

3.3 GIS-based analysis

This research differentiates between density changes within the existing urban boundary of the year 2000 (VROM, 2004) called Urban Density Change and changes that occur outside this boundary called Expansion Density Change. The land use 2000 dataset was used to distinguish between different types of residential development processes during the time period of 2000-2010.

The resampling technique “majority” is used in this analysis to aggregate the land use dataset of 25m to a 100m resolution. The “majority” technique will be used to assign density changes to the land use type. See Figure 3: Aggregation of Land use dataset that illustrates the problems of aggregation. Further analysis was conducted using the Urban Density Change results to explain urban densification processes. The available datasets, BAG 2014 and Land Use 2000 have been used in the analysis and the results were then compared to field research results.

3.3.1 Density changes in expansion areas

Density changes in expansion areas are all the cells that are located outside the urban boundary of 2000. These cells (100m) were identified and used further in this analysis. The cell values were reclassified to “1” to be used in a raster calculator to identify the land use type of each of those cells. The land use dataset originally with cell size (25 meters) were resampled to the size of the residential density change dataset after the transport infrastructure land use type was removed. This land use type was removed from the analysis as it is argued that residential dwellings between 2000 and 2010 did not change in these areas but rather on the land use type adjacent to it. The following arguments are made: transport infrastructure changed little in the study period; it is more likely that residential dwellings are added or removed from other land use types than transport infrastructure. This resulted in most cells being classified to the neighboring cells but also some cells being classified as being “NoData”. The “NoData” cells (24 in total) were inspected and assigned the classification of the nearest neighbor (mostly residential cells). Figure 3 illustrates the land use maps with aggregation including “Water” and “Transport Infrastructure” and excluding the aforementioned land use types as used in the analysis. A flow diagram is given in APPENDIX B that elaborates on the steps taken. Density changes in these areas are due to the process “expansion”.

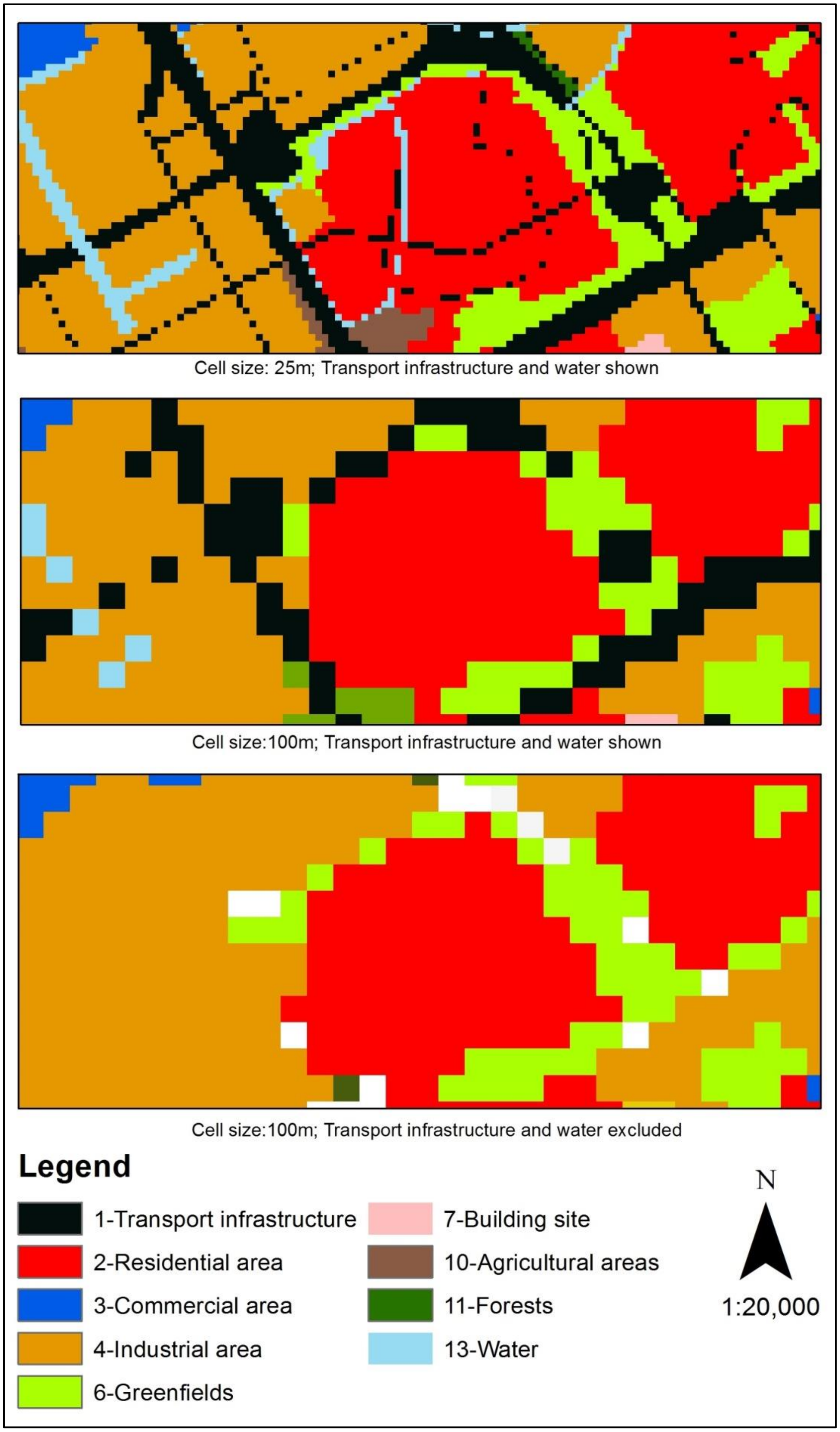

Figure 3: Aggregation of Land use dataset

3.3.2 Density changes within the urban area

Analysing density within the urban area follows the same methodology as the expansion analysis but only residential density changes within the urban boundary of 2000 are used instead. The land use dataset originally with cell size (25 meters) were resampled to the size of the residential density change dataset after the transport infrastructure and water land use types were removed. These two land use types were removed from the analysis as it is argued that residential dwellings between 2000 and 2010 did not change in these areas but rather the land use adjacent to them. As with the expansion density change the same was argued with the transport infrastructure within the urban areas. Removing the water land use type can be justified due to the fact that no new moorings ("ligplaatsen") were allocated after a decision had been made by the municipality of Amsterdam in 1974 to limit the amount of moorings in the canals of Amsterdam (with some exceptions) according to Waternet (water company for Amsterdam and the surroundings). A flow diagram is given in APPENDIX B that elaborates on the steps taken.

3.3.3 Densification processes

Densification processes include demolish/new development, brownfield developments, redevelopments and infill schemes. The results obtained will be compared to field research data that will indicate how accurate these processes have been identified according to the criteria used in the analysis. The density change cells and land use cells were clipped to the field research area and contained 144 cells. Densification in all the land use type areas where buildings built prior to the year 2000 are located contributes to the process "redevelopment". Redevelopment refers to the process where an existing building is transformed and there is a change in density. These changes can be due to construction or a change in the building purpose of use. If buildings were built between 2000 and 2010 then the intensification contributes to the process demolish/new development for the land use type residential. New development contributes to infill. Infill schemes are small open parcels within urban areas that are developed for residential uses, thus increasing urban densities (UTF, 2005). The land use types greenfields and forest also contributed to this process. Brownfield development is the conversion to residential uses of vacant or underutilized locations within the city, generally former industrial or commercial properties (Tomalty R., Alexander D., 2005; Hayek et al, 2010). If none of the criteria are fulfilled then it is categorized as "unsure".

3.4 Field research

The field research area contains 7 of the 13 classes (no transport infrastructure, greenhouse, building site, recreational, natural vegetation or water cells), this is a consequence of selecting an area is within the existing urban area of the year 2000. The cells were converted to center points. The tables were joined on point ID's used to capture field data. The field research consisted of visual interpretation of the buildings and taking field notes regarding physical changes and interviewing some residents. This proved to be efficient to some extent but could not give any indication whether a previous building existed on the particular site or not (to indicate demolish/new development or just new development). Satellite images of the year 2000 and 2010 were compared and from these it could be established if a development was demolished or new developments took place. Figure 4 illustrates the fieldwork set up and shows the land use type and buildings within the vicinity of the fieldwork points.

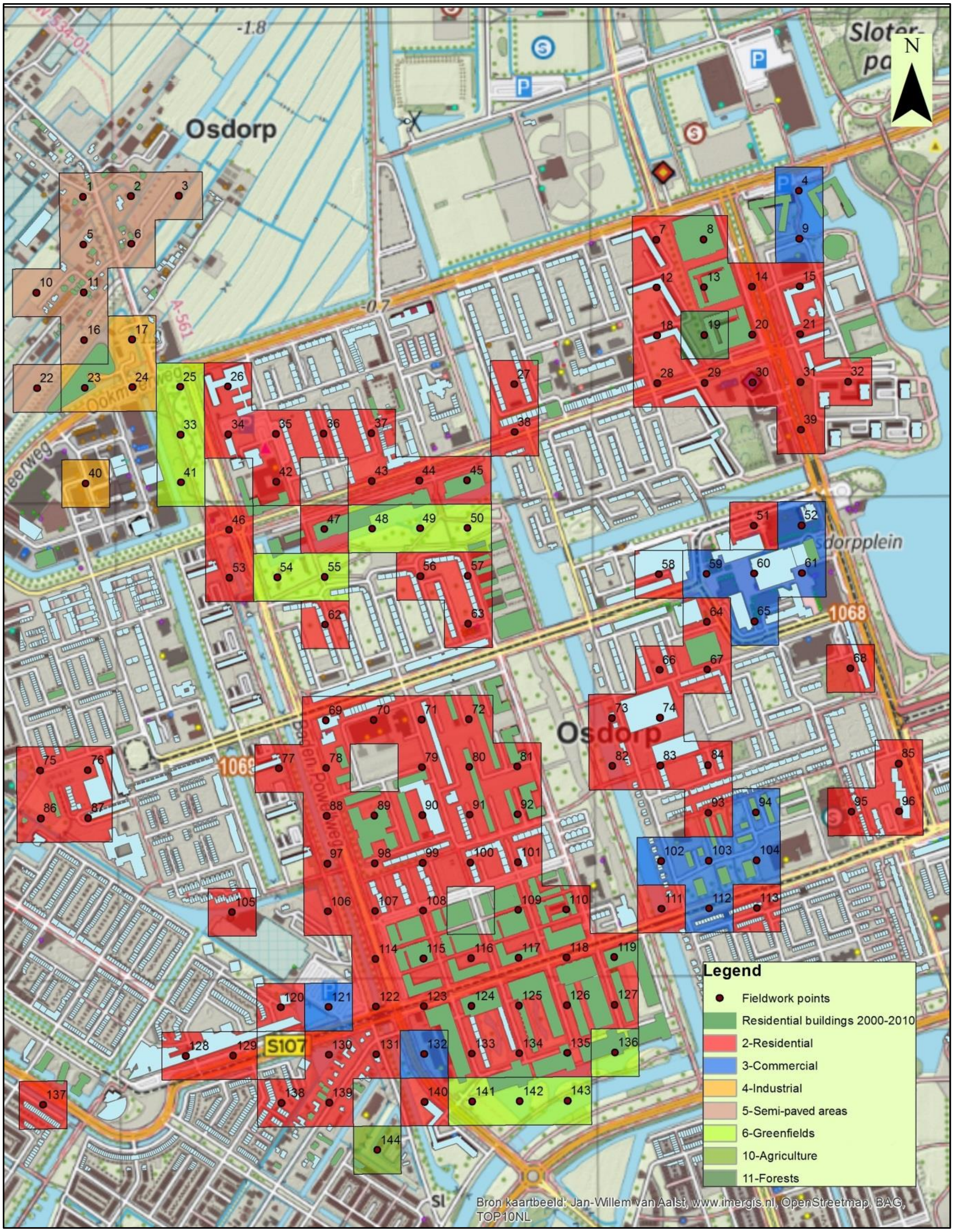

Figure 4: Field research

4. RESULTS

The analysis identified the land use and residential density changes according to the processes demolish/new development, redevelopment, infill and brownfield development. The land use types in the field research area are shown with their subsequent process share. The major land use types and their contribution to increase and decrease in density area also added as APPENDIX C: .

Table 2: Field work processes

	Process					
Land use type	**Demolish/New Development**	**Redevelopment**	**Infill**	**Brownfield Development**	**Unsure**	**Total**
2-Residential	1355	572	665	0	514	3106
3-Commercial	107	115	224	0	1	447
4-Industrial	0	0	0	3	1	4
5-Semi-paved a	0	0	0	24	1	25
6-Greenfields	66	0	445	0	4	515
11-Forests	0	0	43	0	0	43
Total	1528	687	1377	27	521	4140

Table 3: GIS analysis processes

	Process					
Land use type	**Demolish/New Development**	**Redevelopment**	**Infill**	**Brownfield Development**	**Unsure**	**Total**
2-Residential	1549	1422	0	0	135	3106
3-Commercial	201	124	0	0	122	447
4-Industrial	0	3	0	0	1	4
5-Semi-paved area	0	3	0	21	1	25
6-Greenfields	0	0	515	0	0	515
11-Forests	0	0	43	0	0	43
Total	1750	1552	558	21	259	4140

The process share for the GIS-based analysis and field research is illustrated in figure 5 and 6. Furthermore density decreased with 385 dwellings per hectare in expansion areas and increased with 9473. Within urban areas a density decrease of 10676 dwellings and increase of 35700 was observed. Densification is the prevailing process with 46476 dwellings added in the study area.

The field research resulted in a point classification list that describes the processes of each cell within the field research area. This list is compared to the GIS-based analysis on a point-by-point comparison and an accuracy percentage is given that shows how accurate the analysis was compared to the field research results. See Figure 7: Process classification comparison. Of all the points used in the field research area, 65.7% false values and 34.3% true values were obtained. This suggests a very low accuracy.

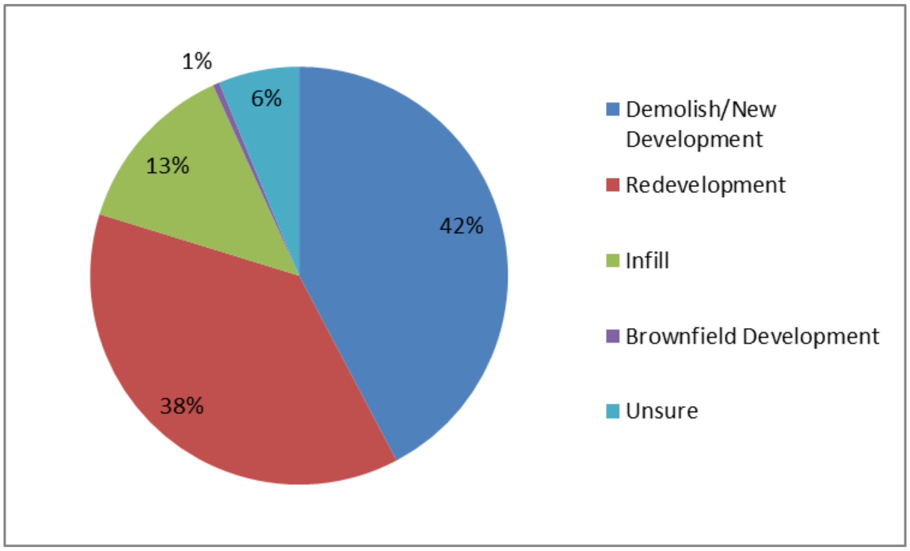

Figure 5: Process share based on GIS analysis

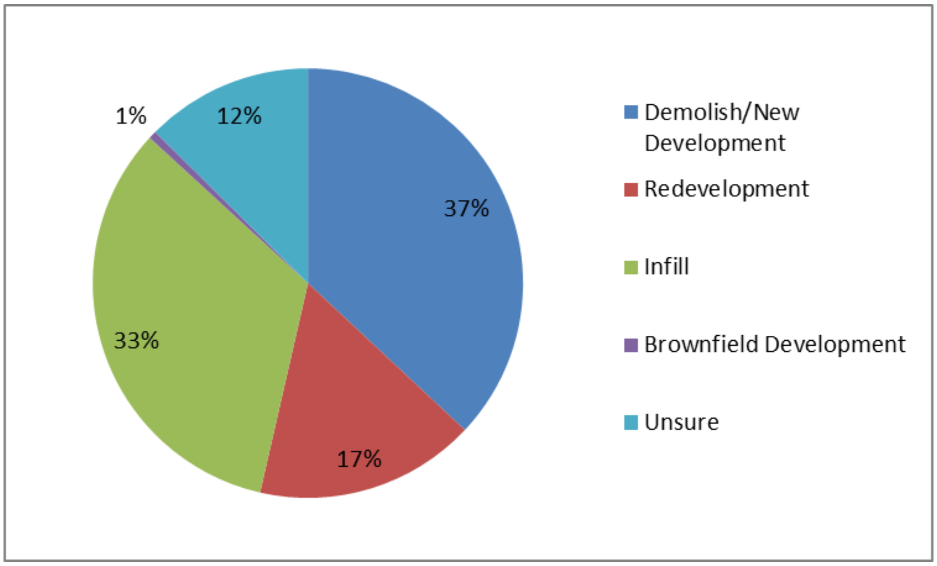

Figure 6: Process share based on field research

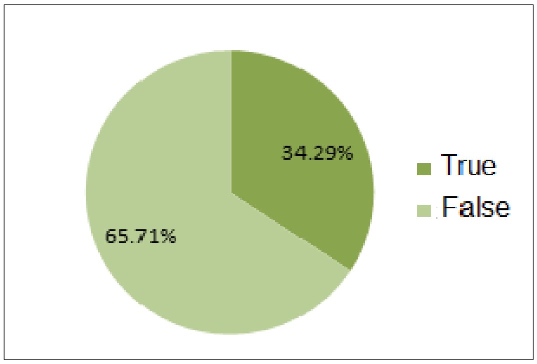

Figure 7: Process classification comparison

5. CONCLUSION

To conclude, the relative importance of different processes in residential development is given together with the land use type where density changes occurred. From the results it can be seen that the process demolish/new development plays a significant role in densification of the urban area for both the GIS-based analysis as well as the field research. The GIS results compared poorly to the field research results for the remaining processes as well as having a very low accuracy when compared on a point-to-point base. This is partly due to the BAG data capturing inconsistency and temporal mismatches and deemed not sufficient enough to explain density changes at a local level. To fully understand and explain residential density changes more detailed data is needed with a higher accuracy. The observed decrease will in part relate to an actual loss in density (e.g. due to merging of smaller units or demolition of residences in less popular locations). But the local alternation of increase and decrease in density will also result from data classification issues and the temporal dimension of urban regeneration and densification processes: housing blocks are often demolished before new construction work starts, thus leaving their locations temporarily empty. Similar temporal mismatches may occasionally also occur between the development of new residential areas (as captured in our land-use data) and the registration of the constructed number of housing units in our residential density data. The aggregate regional amounts of change in housing stock, however, match the figures reported by Statistics Netherlands (CBS, 2014).

6. DISCUSSION

The results of this research rely heavily on the accuracy of the source data and the interpretation of the urban developments and processes. The land use datasets were aggregated from 25m to a 100m cell size similar to that of which the Residential Density Change dataset is available. This introduced some problems regarding the allocation of the density changes to a particular land use type. In this research density changes were allocated to the majority of land use types within the 100m cells. A different approach worth investigating could be to resample the density change cells and allocate a share of density change to each 25m land use cell, but even this method cannot take into account the fact that all changes could have occurred in only one of the cells. The results do provide some good indications of patterns that provide information about the magnitude of dwellings added or removed and where (land use type) these took place. Many new developments from 2000 onwards were also depicted in the density change data set such as the area where field research was done as well as other areas for instance the Bijlmer neighborhood that saw large flats being demolished to make way for lower density developments. The field research emphasized the complexity in classifying intensification processes. It is not always possible to see physical changes (especially if the happened 14 years ago) or know whether it replaced a previous building or has been renovated or redeveloped. It was however effective to identify some buildings that only underwent some redevelopment (new floor added to existing building) that were given a new building year in the BAG although it was still the original building. These inconsistencies introduced many errors in the analyses on a local level.

However, the main densification process have been identified and in future can be improved by more accurate data and methods to provide information about changes in land use and densification within urban areas and expansion areas.

7. REFERENCES

Anas A., Arnott R., Small K.A. (1998) Urban Spatial Structure. Journal of Economic Literature, 36(3): 1426-1464.

Broitman, D., Koomen, E., Rietveld, P. Intensification and extension in urban residential dynamics. Computers, Environment and Urban Systems (resubmitted October 2014).

CBS (2008) Bestand bodemgebruik productbeschrijving. Centraal Bureau voor de Statistiek, Voorburg/Heerlen.

CBS (2014) StatLine, the electronic databank of Statistics Netherlands. Available at http://statline.cbs.nl/Statweb/. (Last accessed 30 September 2014).

Evers W., Vries L., De Man R., Schotten C.G.J. (2005) Woning- en populatiebestanden in het dataportaal. Overzicht van de basisbestanden, bewerkingen en kwaliteitsacties. RIVM, Bilthoven.

Hayek M., Arku G., Gilliland J. (2010) Assessing London, Ontario's brownfield redevelopment effort to promote urban intensification. Local Environment 15(4): 389–402.

Odijk M., Louwerse P., (2007): Begrenzing Bebouwd Gebied 2003, Den Haag (VROM, Directoraat-Generaal Ruimte). Ministerie van VROM.

Tomalty R., Alexander D. (2005) Smart growth in Canada: Implementation of a planning concept. Canada Mortgage and Housing Corporation (CMHC).

UN (2011) United Nations, Department of Economic and Social Affairs, Population Division. World Urbanization Prospects: The 2011 Revision. Available at: http://esa.un.org/unup/CD-ROM/WUP2011-F03-Urban_Population.xls and http://esa.un.org/unup/CD-ROM/WUP2011-F06-Urban_Growth_Rate.xls (Accessed 22/03/2014).

Van Leeuwen N. (2004) Bestand bodemGebruik en Top10Vector geharmoniseerd; CBS vernieuwt Bestand BodemGebruik. Geo-Info (5): 218-222.

VROM (1993) Vierde Nota over de Ruimtelijke Ordening Extra, deel 4: Planologische Kernbeslissing Nationaal Ruimtelijk Beleid. Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer, SDU uitgeverij, Den Haag.

VROM, LNV, V&W, EZ (2004) Nota Ruimte. Ruimte voor ontwikkeling. Ministeries van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer, Landbouw, Natuur en Voedselkwaliteit, Verkeer en Waterstaat en Economische zaken, SDU uitgeverij, Den Haag.

Zonneveld W., Evers D. (2014) Dutch national spatial planning at the end of an era. Chapter 4. In: Reimer M., Getimis P. and Blotevogel H. (eds.), Spatial Planning Systems and Practices in Europe. Routledge (forthcoming).

APPENDIX A: Data Preprocessing

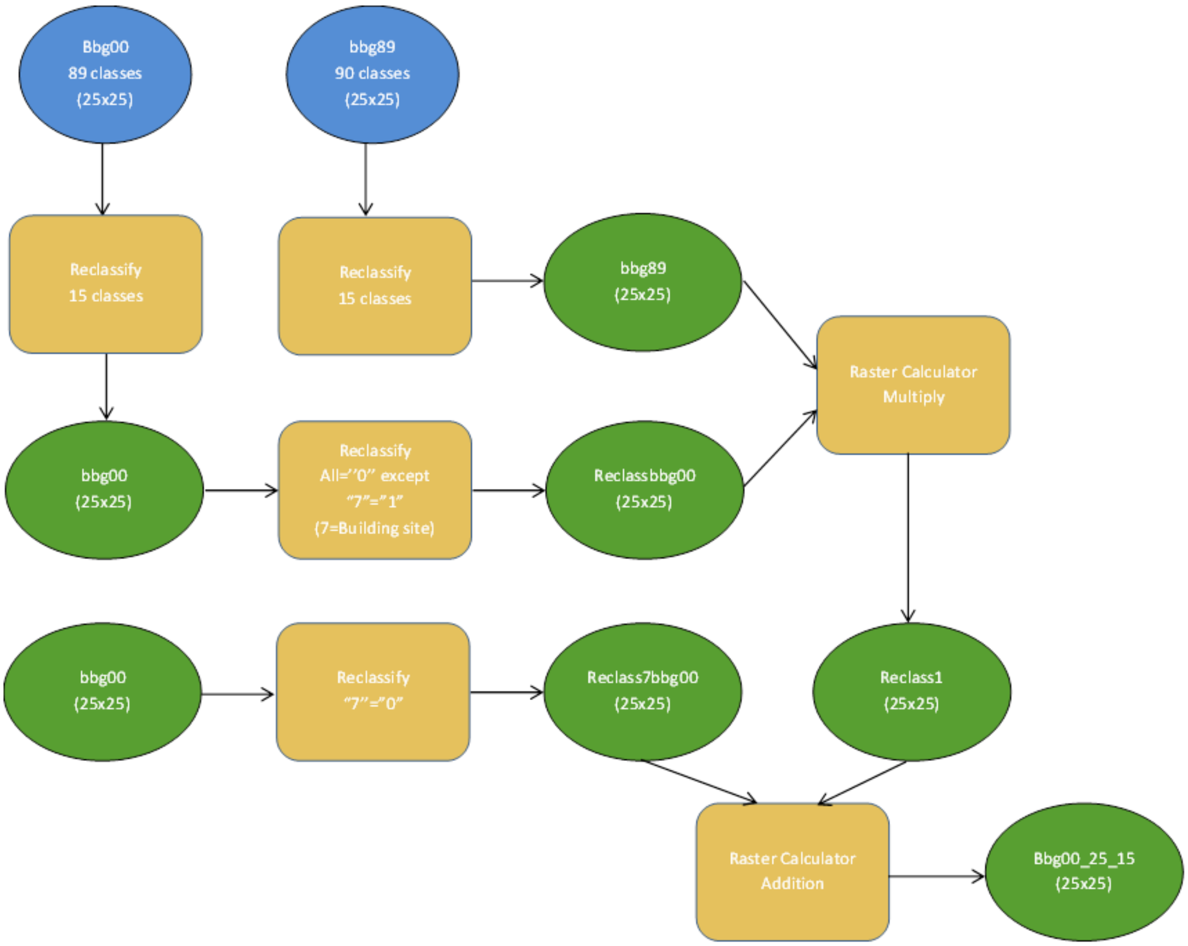

Figure 8: Data preprocessing

APPENDIX B: Density changes

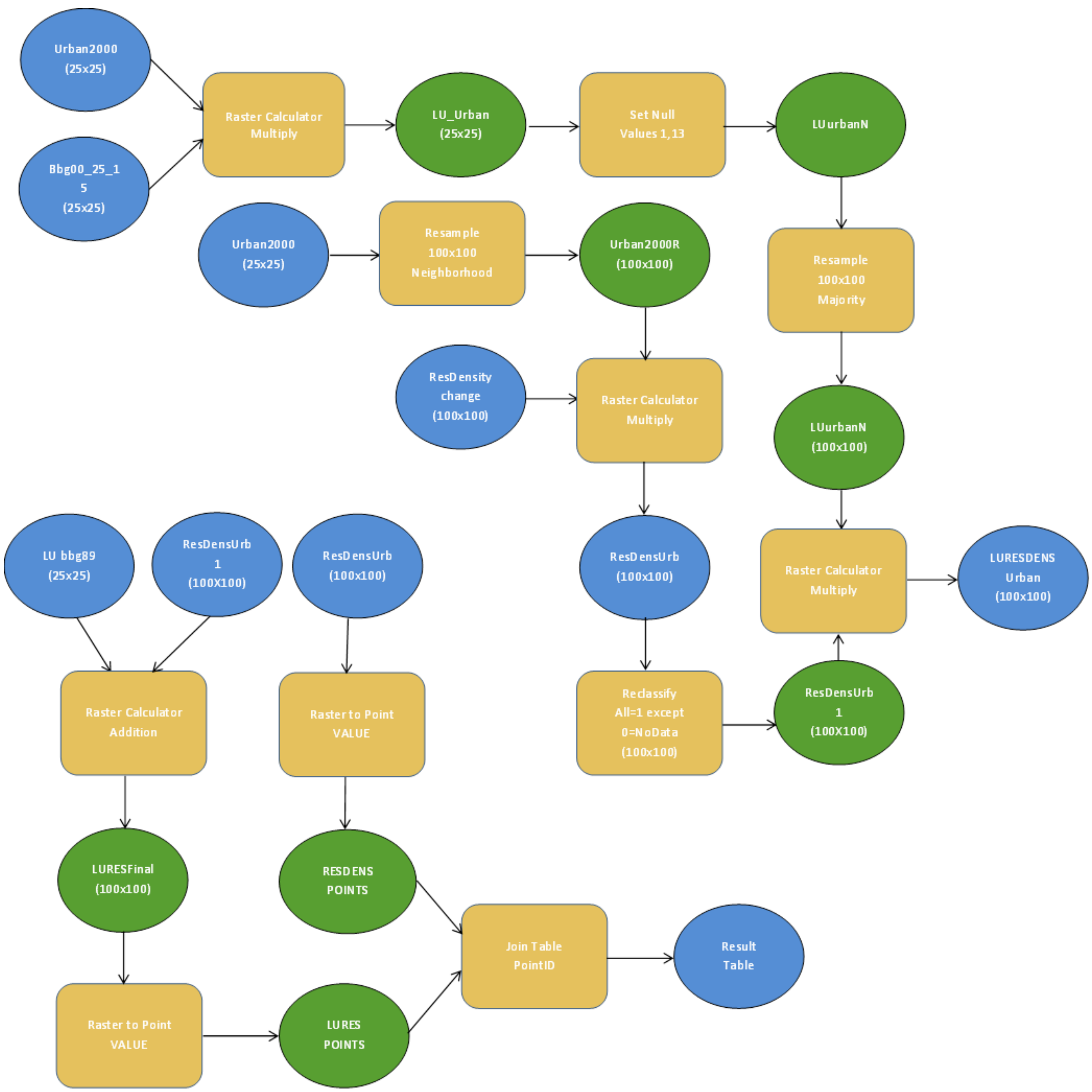

Figure 9: Density changes within urban areas

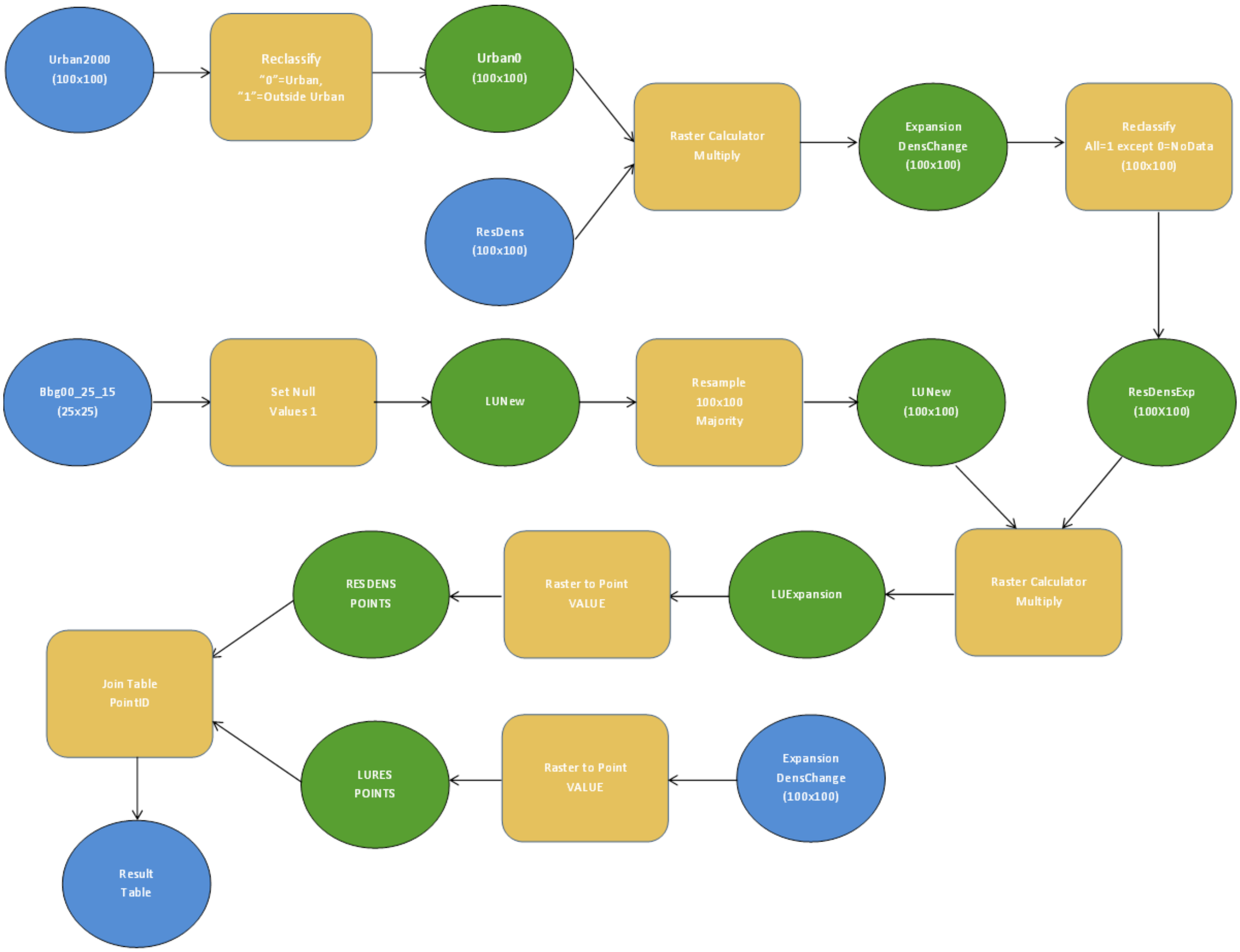

Figure 10: Density changes in expansion areas

APPENDIX C: Result tables

Table 4: Density changes in expansion areas of study area

LU code	LU type	Density increase	%	Density decrease	%	Netto Change
2	Residential	100	1.06%	-57	14.81%	43
3	Commercial	218	2.30%	0	0.00%	218
4	Industrial	112	1.18%	-4	1.04%	108
5	Brownfields	3	0.03%	-6	1.56%	-3
6	Greenfields	70	0.74%	-46	11.95%	24
7	Building site	210	2.22%	0	0.00%	210
8	Recreational area	10	0.11%	-4	1.04%	6
9	Greenhouses	523	5.52%	-31	8.05%	492
10	Agricultural area	2016	21.28%	-208	54.03%	1808
11	Forests	8	0.08%	-2	0.52%	6
12	Natural vegetation	2	0.02%	0	0.00%	2
13	Water	6201	65.46%	-27	7.01%	6174
	Total	9473	100%	-385	100%	9088

Table 5: Density changes within the existing urban area of study area

LU code	LU type	Density increase	%	Density decrease	%	Netto Change
2	Residential	22655	63.46%	-9875	92.50%	12780
3	Commercial	3051	8.55%	-432	4.05%	2619
4	Industrial	4021	11.26%	-174	1.63%	3847
5	Brownfields	51	0.14%	0	0.00%	51
6	Greenfields	4733	13.26%	-140	1.31%	4593
7	Building site	49	0.14%	0	0.00%	49
8	Recreational area	123	0.34%	-7	0.07%	116
9	Greenhouses	412	1.15%	-1	0.01%	411
10	Agricultural area	562	1.57%	-8	0.07%	554
11	Forests	43	0.12%	-39	0.37%	4
12	Natural vegetation	0	0.00%	0	0.00%	0
	Total	35700	100%	-10676	100%	25024