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Land Use Statistics for Urban Agglomerations

Development of a method based on the use of geographical information systems (GIS) and administrative records

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Abstract:
A method ("buffer method") of demarcating and analysing land use within urban settlements has been developed and evaluated. The method is based on GIS analysis of existing administrative records, initially GAB data (Ground properties, Addresses and Buildings) from the Norwegian Mapping Authority and population data from the National Register at the Directorate of Taxes.

The buffer method shows that it is technically possible to establish the demarcations of an urban settlement solely on the basis of information from administrative records. Where the data basis is of a good quality, the method will show good results compared to official demarcations.

There are major perspectives for the statistics, and they include monitoring the physical growth of the urban settlement as well as the development of its green structure, economic factors and living-quality indicators.

Keywords: Land use, urban settlements, GIS analysis, method development.

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Summary and conclusions

Key land use statistics show that urban settlements demarcated by the buffer method in most cases yield lower figures for important indicators than do official urban settlement demarcations. The main reason is that the method has yet to include satellites and large, developed areas (industrial estates, parks, sports installations, etc.) that are a part of the urban settlement. As for the number of people living within the different urban settlement concepts, there is greater concordance. Part of the reason, of course, is that nobody lives in the above-stated developed areas.

The project shows that the method yields interesting results, particularly regarding changes in urban settlements over time. An example of this is shown by studying how the urban settlement of Svelvik has developed from 1980 to 1995. The fact that the method can generate "historical" urban settlements opens new possibilities of showing how the urban settlement has developed. To make that possible, however, the quality of existing basic data must be good enough. Census figures go way back in time, but GAB data was first systematically registered as of January 1, 1983.

Proposed future measures include generating more "method urban settlements" and carrying out calculations on them in order to find out how good the system is. The method should also be further developed. Industry and service grounds must be included. Roads and railways should be treated equally with building elements for demarcating the urban settlement. Satellites should be taken into account when calculating area and population.

The results should be quality-checked and compared to the individual municipalities and also to results from other projects. More urban settlements must be analysed in order to verify the method and develop the results.

1. Introduction and background[1]

The Statistics Norway has carried out a project for trying out new methods of producing national statistics on land use in urban settlements. The statistics shall provide information on how national goals and guidelines are being followed up through planning and development. The project is supported by the Ministry of the Environment (ME).

In the project, the software tool PC ARC/INFO has been used for GIS analyses of land and land-use data on selected urban settlements in Norway. The analyses are based on existing administrative records and map data, chiefly data from the GAB register from the Norwegian Mapping Authority and the National Register from the Directorate of Taxes.

The project has the following objectives:

- Evaluate the method in question for producing continuous land use statistics for urban settlements.
- Evaluate available data bases and quality.
- Procure data bases for selected indicators.
- Produce land use statistics for selected urban settlements.
- Evaluate various existing urban settlement demarcations.
- Propose a possible nationwide main project.

Initially, the project has focused on an automated method of establishing the physical demarcations of the urban settlement. The aim has been to establish a standard method of physical demarcation that can apply to all types of urban settlements and which can show the development of an urban settlement over time. In addition, land use statistics have been produced for central indicators for some urban settlements, such as total area per inhabitant, utilisation of ground properties, total built-up area, area for transport and "green" areas (public parks, sports installations, forest, etc.).

Unlike municipalities, urban settlements reflect functional regions which are interesting for statistics and analyses. Urban settlements are important because these are areas where:

- Most people live (74% in urban settlements as at January 1, 1995).
- The majority of the population spends its workdays and leisure time.
- There is major pressure with respect to land utilisation.
- There is major economic activity.
- Major investments are made, in infrastructure, among other things.
- Many environmental problems arise - affecting the dwelling and living conditions of many people.
- The service offerings are concentrated.
- There is major traffic density due, among other things, to people commuting to and from work.

Monitoring land use in urban settlements is one element in the monitoring of land use in Norway. Other key elements include monitoring the coastal zone and large, untouched areas.

Urban settlements are geographical areas without static boundaries. The boundaries of an urban settlement will vary over time, depending on building activity and population trend. Consequently, it has proven difficult to establish regular presentations of the size of urban settlements. The demarcations that have been presented are usually linked to specific dates and carried out as specific

[1] Paper presented by Ms. Dysterud at the joint *ECE/EUROSTAT Work Session on Methodological Issues of Environment Statistics,* at Lysebu, Norway, 14-17 October 1996

projects. Most of this type of mapping has been conducted by the Statistics Norway in connection with census taking and counting dwellings.

2. Method

2.1. Definition of urban settlement

The Statistics Norway's definition of urban settlement is based on a modified version of Professor Halstein Myklebost's (Myklebost 1969) definition of the same term.

The Statistics Norway's definition is rendered in its 1986 publication: *SSB 1986* (see also *SSB 1993*). In this publication the definition is discussed in greater detail, definitions from previous dates (previous population and dwelling counts) are reviewed. Also reviewed is the urban-settlement definition as practised through concrete demarcation.

Urban settlement is defined as an agglomeration having at least 200 residents and where the distance between the houses is no more than 50 metres. Some houses or clusters of houses that naturally belong to the urban settlement may be included even if the distance exceeds 50 metres. In practice, clusters of at least 5 houses located up to 400 metres from the nearest house in the hub of the urban settlement have been included.

Buildings embraced by the urban-settlement definition are: dwellings, industrial buildings, shops, public buildings, sports installations, etc. In some cases, the term "other building element" is used. This includes sports fields, parks, paved areas, storage areas, etc. Cabins and agricultural buildings shall be included in the urban settlement only if they are located in, or in connection with, the urban settlement, i.e. less than 50 metres from the nearest house at the hub of the urban settlement or the small cluster of houses located 400 metres away from the hub.

In practice, you might find areas within the urban settlement where the distance between the houses exceeds 50 metres. Such areas might be industrial estates or sports installations adjoining the urban settlement. Furthermore, the urban settlement may include natural (building) barriers such as rocky knolls, rivers or arable land that is off limits to building development.

The urban settlement definition is based on purely formal criteria, i.e. linked to physical structures. It does not take into account more functional criteria such as extent of commuting to and from work and service functions within the urban settlement.

The Statistics Norway has the formal responsibility of demarcating urban settlements. Urban settlements are demarcated in collaboration with municipal authorities and the Norwegian Mapping Authority.

Urban settlement boundaries have usually been revised in connection with the population and building census every 10th year. The last review of urban settlement boundaries was carried out in 1994 and 1995 in a revision made of the 1990 count. The municipalities worked out a proposal for urban settlement boundaries based on local knowledge and the criteria in the Statistics Norway definition. The Statistics Norway has only altered the municipality's proposed boundaries where it was clear that the boundaries had been drawn too wide or too narrow with respect to the definition.

The Statistics Norway's quality control is based on updated economic maps. Such maps are not always available, and comprehensive monitoring of the municipality's work is conducted only for the largest and "most important" urban settlements. In practice, the municipality's urban settlement boundaries are most often used as a basis. Consequently, the surveys may, of course, have been a little

inconsistent with regard to where the urban settlement boundary is drawn with respect to built-up areas, what is included in the urban settlement concept, how boundary drawing is practised along coasts and rivers/lakes, etc.

All of the urban settlement boundaries were digitized by a private firm.

2.2. Other, related concepts

Dense/sparse code in GAB
All addresses in the GAB register must be assigned a code showing whether the address lies inside or outside an urban settlement (Norwegian Mapping Authority [NMA] - 1991). The municipalities register dense or sparse for an address based on the boundaries of the urban settlement drawn up by the municipality, see the section above. In practice, this means that the registration is conducted on the basis of the maps of urban settlement boundaries drawn up by the municipality.

Densely populated areas
The Statistics Norway defines the number of people living in urban settlements as the equivalent of "number of people living in densely populated areas." The total number of people living in the urban settlements in a municipality corresponds to the number of people living in densely populated areas in the municipality. Moreover, population statistics will also include "unspecified or not georeferenced with respect to densely or sparsely built-up area."

These population statistics are based on the code for dense/sparse in the GAB register.

Densely built-up areas - terms used on topographical maps from the Norwegian Mapping Authority
The Norwegian Mapping Authority uses the term *densely built-up area* and *town area* on some of its products. The term is defined as follows for the various products (NMA 1995):

Product	Term	SOSI theme code*	Definition
N50 Kartdata	Densely built-up area	LTEMA 4007	Area with a maximum of 50 metres between dwellings. Minimum area: 20,000 m2. Minimum width: 100 metres.
N50 Kartdata	Town district	LTEMA 5021	Town-like, with more or less connected city blocks (town hub). Buildings with 2 or more floors.
N250 Kartdata	Densely built-up area	LTEMA 5022 FTEMA 5022	Area with a maximum of 50 metres between dwellings. Minimum area: 60,000 m2. Minimum width: 250 metres.

* SOSI = Norwegian standard for exchange of digital geographic information.

The terms are not used consistently and precisely in all contexts in NMA products. For example, the product specification for N50 Kartdata (dated May 1996) uses the term *urban settlement* for the NMA term *densely built-up area*. Furthermore, the NMA uses the term *dwelling*, not *building*, when defining densely built-up area. The discrepancy was probably not made intentionally by the NMA (cf. Kjekshus, *pers. medd.* August 26, 1996).

These definitions are used on topographical maps on scales of 1:50,000 (M711 series) and 1:250,000. The definitions are also included in the deliveries of digital map data from N50 Kartdata and N250 Kartdata.

2.3. Method of demarcating urban settlements in this project

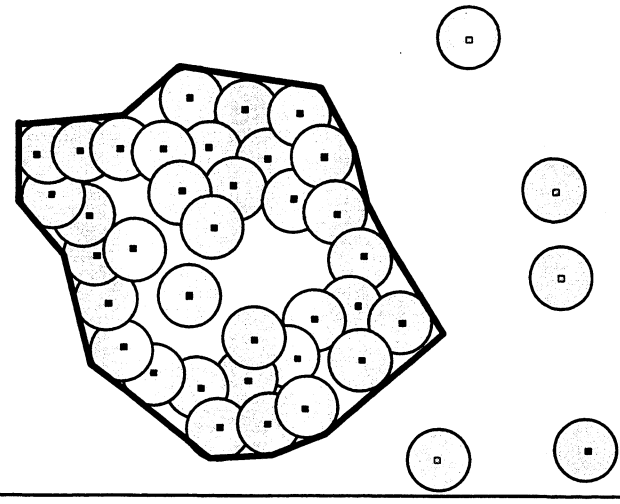
The project will further develop and try out a method of "automatic demarcation" of urban settlements, based on building data from the GAB register and population data from the National

Register. The method was developed through a pilot project in 1995 and is further described in Ottestad (1995).

Buffer method - digital register-based demarcation
The method may be called "digital register-based demarcation" because it is based on existing register data which is automatically processed in a computer programme. A key element of this method is the use of geographical information systems (PC ArcInfo) for comparing and analysing the register data. The method in this report is also called the "buffer method" because it is based on the use of buffer distances between buildings. Urban settlements demarcated by this method are also called "buffer urban settlements."

The method is based on the existing Statistics Norway definition of urban settlement (see section XX) by which there is a maximum distance of 50 metres between buildings and a minimum of 200 inhabitants. All of the buildings in the GAB register are defined by coordinates. Population data from the National Register is linked to each building, based on address information for buildings and population.
A buffer distance is placed around each building, and overlapping (touching) buffer zones will be included in the potential urban settlement area. By totalling the number of inhabitants within each potential urban settlement area, you can see whether the area satisfies the urban settlement definition. This is illustrated in the figure below.

Figure 1. Demarcation of urban settlement based on buffer distance around each building



The figure shows buildings, each with a buffer around it. The area inside the solid, thick line shows an area of contiguous buffer zones. If the number of people living in the buildings (inside the line) is 200 or more, this area may be defined as an urban settlement in keeping with the Statistics Norway definition.

The project does *not* aim to revise the existing definition of urban settlement, but to make it operational and dynamic so that it can be used for urban settlements at a randomly chosen time and serve as a general framework for classifying land use within the urban settlement. It illustrates the different practical applications of the definition and can be linked to corresponding terms:

- The Statistics Norway's urban settlement demarcation (together with the municipalities and the Norwegian Mapping Authority).
- Research and study reports in NIBR.
- Dense/sparse code in the GAB.
- Urban settlement / densely built-up area in maps from the Norwegian Mapping Authority.

2.4. Development of urban settlement area and land use over time

Based on regular analyses at specific times (e.g., annually, every 5 years), time-based series can be built up for the various indicators. However, the method also allows you to calculate historical data.

The urban settlement can be demarcated at different times. Using information such as the year each building was built and the population at given times, the urban settlement can be demarcated at a randomly selected time, and the size of the population can be calculated. That provides a basis for studying changes in urban settlement growth, development of population density, ground property utilisation, etc.

There exists solid data on population location (addresses) for previous times. The systematic recording of the buildings' construction year did not start until January 1, 1983. Only a few municipalities have dates for when each and every building was constructed. Consequently, it is not practically possible to calculate urban settlement data by this method for periods before 1983 for Norway as a whole.

2.5. Urban settlements selected for the project

The method has been tested for selected areas.

The following criteria have been key to selecting areas to be included in the study project:

i) The urban settlements shall be included in other, ongoing and similar projects, such as e.g., the Ministry of the Environment's environment-friendly town programme, municipal environment reports, area monitoring of the Oslo Fjord region and the areal project in the county of Vestfold.
ii) Good basis data must be available.

Based on the above criteria, urban settlements in the following municipalities have been selected for the project:

0106 Fredrikstad (not the part of the Sarpsborg urban settlement located in Fredrikstad Municipality)
0427 Elverum
0626 Lier (not the parts of Drammen and Oslo urban settlements located in Lier Municipality)
0628 Hurum
0706 Sandefjord
0711 Svelvik
1702 Steinkjer

During the project it became necessary for capacity reasons to further limit the selection of urban settlements. The urban settlements of Hurum, Sandefjord and Svelvik municipalities have been selected for analyses in this first phase. Hurum and Svelvik were selected because the extent of GAB data was manageable and suitable for test purposes. Svelvik was particularly interesting because *that* municipality has GAB data of a particularly good quality. Sandefjord was chosen because we also wanted to include a major municipality in the selection. Sandefjord also had access to digital ground property data (DGPD) and land-type data (DLTD).

2.6. Data basis

GAB

GAB is Norway's official register of ground properties, addresses and buildings. The main reason for establishing GAB was to secure efficient and rational routines for administrating ground properties, buildings and addresses.

More detailed documentation of the GAB system is to be found in the "User Manual (GAB) with registration instructions. Norway's official nationwide register of ground properties, addresses and buildings. The Norwegian Mapping Authority, October 1, 1991" (NMA 1991) and in "Rationalising municipal administrative tasks through the use of GEO information" (NMA/GEO 1996).

The GAB system is built on the three main elements: ground properties (G part), addresses (A part) and buildings (B part). Links are established between the different parts in order to secure the different relations. The GAB register currently contains information on approx. 2.3 million ground properties, 1.7 million addresses and 3.4 million buildings.

The GAB register was established "bit by bit" from the end of the 1970s. The first "GAB people" were employed in 1979. Part of the GAB (the G part) was put into trial operation for some municipalities in 1978. The A part was started in 1983 by transferring the Statistics Norway address register from FoB 1980. The B part was established by implementing mandatory reporting of *new* buildings as of January 1, 1983. The B part was substantially expanded through the MABYGG project (see below).

Basically, the A and G parts shall include all addresses and ground properties in Norway. The B part includes all buildings of more than 15 m^2 . The work in geo-referencing and numbering all buildings larger than 15 m^2 was completed in 1995 (MABYGG project) (NMA 1995). In that project, 2.7 million buildings were registered in GAB. For those buildings, only a few parameters were registered (coordinates, building type, reference to attached property (land number and property number)).

In 1995, work commenced on geo-referencing all the addresses in the A part with map coordinates (the "address project") (NMA, update). The project was carried out in close co-operation with each municipality. The address project shall set co-ordinates for all addresses in the GAB register. The municipalities update the GAB directly or by way of the NMA's regional apparatus (county mapping offices). The municipalities register new ground properties, addresses and buildings. The registry offices report title transfers by computer.

VBASE - Roads Database

VBASE contains information on all serviceable roads. The database contains the centreline of all serviceable roads extending more than 50 metres. The road links are organised into thematic groups based on road category and with attributes. All road links have a road ID making it possible to connect them to the GAB and Public Roads Administration's road data bank.

The following categories are used:

- European routes
- State roads
- County roads
- Municipal roads
- Private roads
- Forest-vehicle roads

So far, VBASE is not updated annually. The updating arrangement is still in the initial phase. VBASE is better updated than the theme group "transportation" in N50 and N250 Kartdata.

3. Results

3.1. Demarcation of urban settlement area

In this chapter, the term *Statistics Norway urban settlement* is used as the official urban settlement boundary as established by the municipality and approved by the Statistics Norway, cf. subsection 2.1. *Buffer urban settlement* is used to denote the demarcations carried out in this project.

Demarcation of the buffer urban settlement refers to 1996 - result of the buffer method.
The urban settlements of Hurum, Sandefjord and Svelvik municipalities are demarcated by this method. Subsection 3.2 (urban settlement area) sums up the results with regard to the area sizes.

The buffer method can help provide a more unambiguous demarcation of urban settlements regardless of local differences in estimation and "guesswork." The buffer method might reveal weaknesses in existing demarcations and in the rough estimations used. The buffer method can be used as a common methodological basis, although we would still have to consider using other methods based on, e.g., local knowledge of the areas, updated economic maps, aerial-photo interpretations, satellite pictures, etc.
Below are a few examples of urban settlement demarcations using this method. Special factors are discussed in greater detail.

The figure below shows the demarcations of the urban settlement of Svelvik. In this case there is very good concordance between the demarcation based on the buffer method and the official urban settlement demarcation. For Sandefjord and Tofte urban settlement (the next figures), the concordance is somewhat poorer, the reasons for which will be discussed later.

Figure 2. Demarcation of Svelvik urban settlement, compared to the Statistics Norway's official demarcation (dot-and-dash line)

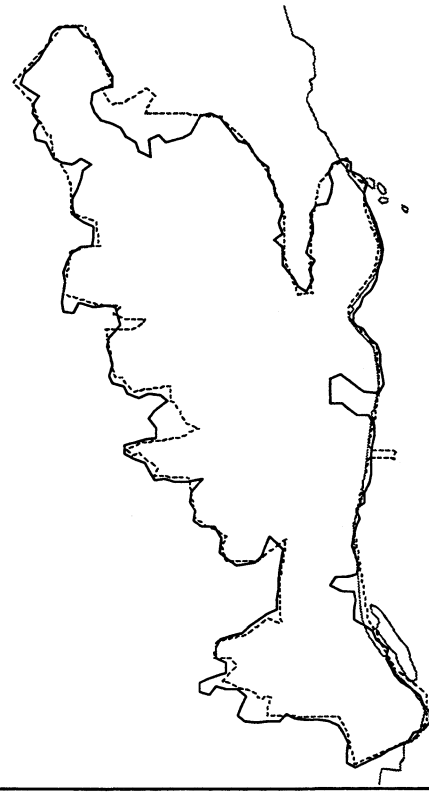
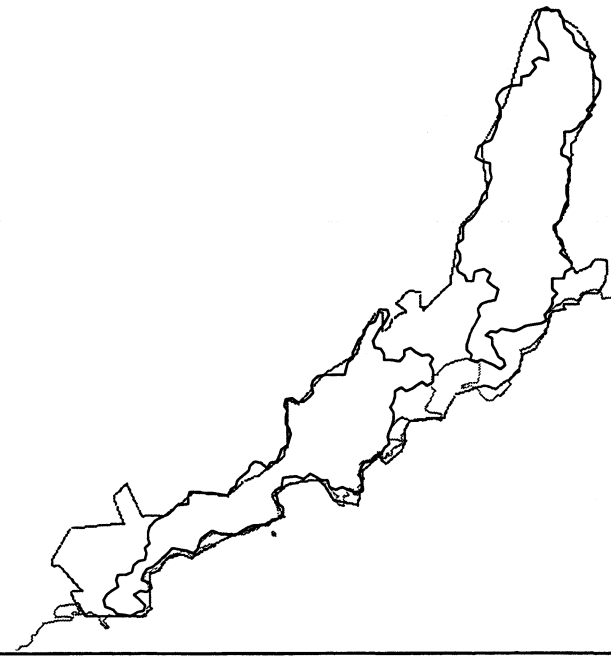


Figure 3. Demarcation of Sandefjord urban settlement, compared to the Statistics Norway's official demarcation (dot-and-dash line)

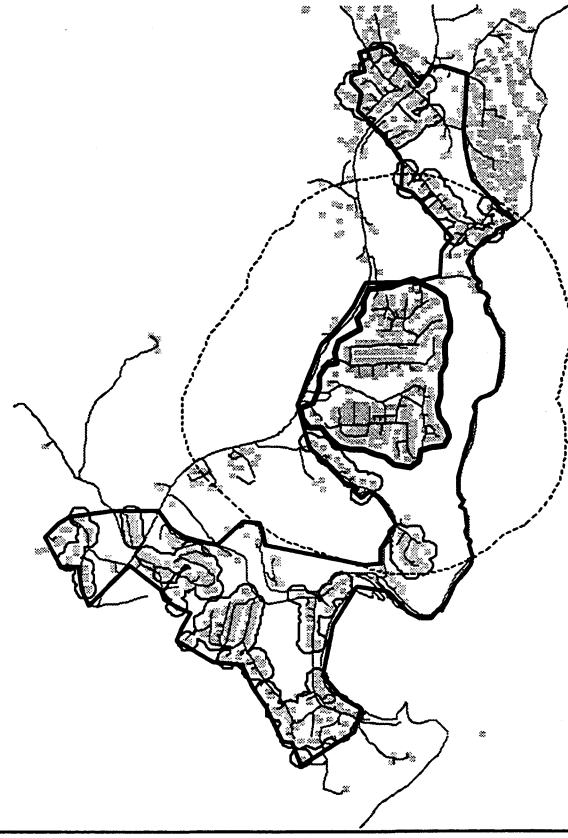
Figure 4. Demarcation of Tofte urban settlement, compared to the Statistics Norway's official demarcation (dot-and-dash line)



Inclusion of satellites
According to the definition, "individual houses or clusters of houses naturally belonging to the urban settlement (may) be included even if the distances exceeds 50 metres. In practice, clusters of at least 5 houses located up to 400 metres from the nearest house in the urban settlement main agglomeration have been included."

The figure below shows the urban settlement of Berger in Svelvik Municipality. The hub of the urban settlement and an area located 400 metres from the hub are marked. Also, clusters of house dwellings (satellites) are also marked.

Figure 5. Demarcation of urban settlement of Berger, 400-metre distance zone, satellites and the Statistics Norway's boundary.



The urban settlement definition includes the term "house clusters" when referring to satellites, whereas in practice, the term "dwellings" is used when satellites are demarcated. In this project, *dwellings* is used when satellites are identified.

Satellites should be included in the urban settlement main agglomeration, cf. definition, but it is unclear as to how the connection between satellite and hub shall be drawn. One solution could be to include the satellite area without establishing the connection line to the hub. Another possibility is to use the road system as the connection line and area. Factors such as "satellite to satellite" must also be considered. Cf. subsection 4.1 on further developing the method.

Cabins
The definition of urban settlement states that cabins shall be included in the urban settlement "if they are situated in or in connection with the urban settlement, i.e. less than 50 metres from the nearest house in the urban settlement hub." However, this may also produce somewhat peculiar results, and

practices from one municipality to another may vary, as evidenced by an example from the Holmsbu urban settlement in Holmsbu Municipality.

Figure 6. Demarcation of Holmbu urban settlement, compared to the Statistics Norway's official demarcation (dot-and-dash line)

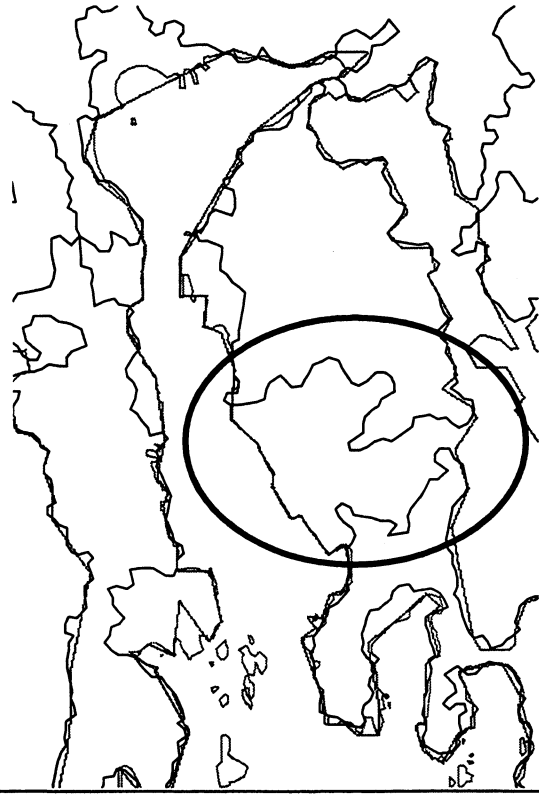
The figure shows that the buffer method has placed the urban settlement boundaries at the extremities the cabin areas south and north of the urban settlement, while the municipality's demarcation has adhered to the central area where the population resides.

In addition, this example also raises issues regarding quality of register information, e.g., whether all registered holiday dwellings are actually used only as such and not as permanent homes, and vice versa.

Large, buildingless estates

The buffer method is based on the evidence of *buildings*. This entails that large areas without buildings such as industrial estates, parking lots, storage grounds, etc., that are a natural part of the urban settlement will in some cases not be included, as illustrated by an example from Sandefjord.

Figure 7. Sandefjord urban settlement, compared to the Statistics Norway's official demarcation (dash-and-dotted line) and evidence of large industrial estates without buildings on Vesterøya



The large area between the two urban settlement demarcations (ellipse) is a large, uninhabited industrial estate. This area is not identified with the buffer method, but naturally belongs to the urban settlement.

Urban settlement growth 1970-1995

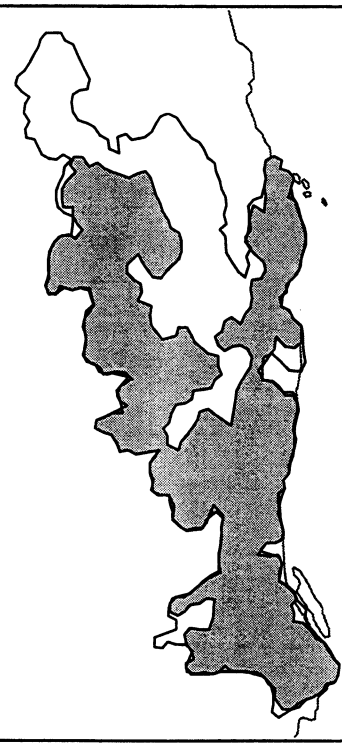
The table shows building distribution based on construction year for the various municipalities. This is used for showing the urban settlement demarcation for the urban settlement of Svelvik in 1980.

Table 1. Buildings and construction year

Constr. year	Hurum	Sandefjord	Svelvik
Unreported (0001)	7 410	20 701	3 288
Before 1970		1	50
1970 - 1980		1	539
1981 - 1990	316	1.628	639
1991	27	171	45
1992	25	172	42
1993	19	201	13
1994	4	213	27
1995	1	214	57
1996	1	43	

The figure shows the extent of the urban settlement of Svelvik in 1980 compared to its extent in 1996. The calculation for 1980 is based on buildings constructed before 1980. Population figures are used for 1995 (and not for 1980), so that the demarcation is obviously not "correct." However, the figure provides a good illustration of the method's inherent possibilities.

Figure 8. Urban settlement of Svelvik 1980 and 1995. Example:



The land area in 1980 was 1,413 decares or 68 percent of the land area in 1996.

The Statistics Norway's official urban settlement boundaries

The boundaries are compared to the Statistics Norway's official urban settlement boundaries. This is shown through the previous map examples.

The urban settlement area of the "Statistics Norway urban settlements" is based on the last review of the urban settlement boundaries, cf. subsection 2.1.

Table 2. Urban settlement areas, BUFFER and Statistics Norway, decares and percent

Municipality no.	Urban settlement no.	Name	Area BUFFER, 1996, decares	Area Statistics Norway, 1995, decares	BUFFER area as percent of Statistics Norway area
0628		Hurum, all urban settlements	5 400	7 515	72
0706	2531	Sandefjord	18 530	23 572	79
0711		Svelvik, all urban settlements	2 980	3 916	76
0628	2161	Klokkarstua	262	479	55
0628	2162	Holmsbu	913	405	225
0628	2163	Tofte	1 834	2 780	66
0628	2164	Filtvet	742	721	103
0628	2165	Sætre	1 649	2 840	58
0628	2562	Svelvik (in Hurum Municipality)	0	290	0
0711	2563	Nesbygda	658	629	105
0711	2562	Svelvik (in Svelvik Municipality)	2 084	2 096	99
0711	2561	Berger	238	1 191	20

For some urban settlements there are major differences between the Statistics Norway's official demarcation and the result of the buffer method, while for other urban settlements the figures are more in agreement. For all urban settlements in the municipality as a whole, the buffer method

unequivocally tends to demarcate the urban settlements more "narrowly" and make them less expansive than the official urban settlements. This is natural, being that the buffer method does not embrace large, buildingless areas that are a natural part of the urban settlement, such as buildingless industrial and commercial estates, parking lots, etc. Furthermore, the "buffer urban settlements" do not include satellites.

Demarcations on topographic maps N50/N250
The figure shows the demarcation of urban settlements compared to the Norwegian Mapping Authority's demarcations of densely built-up areas on topographic maps (cf. subsection 2.2).

Figure 9. Urban settlement demarcations and densely built-up areas, demarcations on topographic maps from the NMA

The figure above shows major variations in areas representing the Statistics Norway's urban settlement concept, cf. subsection 2.1, and the NMA's concepts of densely built-up areas, cf. subsection 2.2. The NMA's N50 area in this case is the sum of LTEMA 4007 and LTEMA 5021. There are relatively major discrepancies between areas representing NMA densely built-up areas as well. The reason is that the definitions of densely built-up area are different for the two scales, cf. subsection 2.2, and that the map on the scale of 1:250,000 is not as detailed as the map on a scale of 1:50,000.

The large area making up the difference between the Statistics Norway and NMA definitions has few buildings and large mutual distances, see Figure 3.2.1. According to the definition, those areas should not be included in Statistics Norway urban settlements either. However, this difference arises because the buffer method runs a smoothing function which draws a connecting line over the "sound" to the north and because the method also includes wedged-in islands.

The total area of N50 in this figure comprises approx. 47 percent of the area of the buffer urban settlement, while the total area of N250 comprises approx. 80 percent of the area of the buffer urban settlement. Figures show that corresponding percentages for N50 and N250 as compared to Statistics Norway official urban settlement boundaries are the same, within decimals, as for the buffer urban settlements.

Dense/sparse code GAB
For all addresses in GAB it is indicated whether the address is situated in a densely built-up or sparsely built-up district, cf. subsection 2.2. All buildings with the *dense* classification shall in principle identify the urban settlement.

The quality of the data used in registering codes for dense/sparse has been discussed extensively in separate works, see Strand (1996). In addition, a separate steering group has been established with representatives from the Statistics Norway, NMA and Directorate of Taxes to address these issues, among other things.

Figure 10. Urban settlement of Berger, buildings registered with the code "dense" compared with Statistics Norway official urban settlement boundary

3.2. Indicators

The project was to produce figures for a number of indicators. The indicators are selected on the basis of input from the Ministry of the Environment. The table is an overview of the indicators used. Definitions and methods are discussed in further detail in connection with each indicator.

Table 3. Overview of indicators

Indicator		Unit
1	Total urban settlement area	decare
2	Urban settlement area per inhabitant	m2/inhabitant
3	Built-up area on built-up grounds"	Percent of total urban settlement area
4	Utilisation of ground properties	Percent m2 building area in relation to m2 dwelling area
5	Ground property area per dwelling for new projects	m2
6	Area for transport purposes	Percent of total urban settlement area
7	"Green" areas (biological diversity)	Percent of total urban settlement area
8	"Green" areas with public access	Percent of total urban settlement area

Urban settlement area

The total area of each urban settlement is calculated and compared with Statistics Norway official boundaries (and areas), see subsection 3.1 above. The total area also includes lakes and rivers, i.e. all freshwater areas.

Population

Population figures for the urban settlements are calculated and compared with Statistics Norway official figures. For some urban settlements there are major discrepancies, but for the municipality as a whole, the figures agree for the most part with Statistics Norway official figures, with smaller discrepancies than for the area figures.

Table 4. Population of urban settlements, Statistics Norway and BUFFER, number and percent

Municipality	Urban settlement	Name	Population Jan. 1, 1995 Statistics Norway	Population Oct. 1, 1995, BUFFER	BUFFER as percent of Statistics Norway
0628		Hurum, all urban settlements	6 182	5 906	96
0706	2531	Sandefjord urban settlement	33 654	32 509	97
0711		Svelvik, all urban settlements	5 327	4 619	87
0628	2161	Klokkarstua	478	372	78
0628	2162	Holmsbu	214	271	127
0628	2.163	Tofte	2 367	2 306	97
0628	2164	Filtvet	436	400	92
0628	2165	Sætre	2 476	2 557	103
0628	2562	Svelvik (in Hurum Municipality)	211	-	
0711	2563	Nesbygda	734	640	87
0711	2562	Svelvik (in Svelvik Municipality)	3 467	3 405	98
0711	2561	Berger	1 126	574	51

Urban settlement area per inhabitant

In its work regarding "environment-friendly urban settlements," the Ministry of the Environment uses m^2 urban settlement area per inhabitant as one of the indicators. This is an indicator for measuring overall population density of the entire urban settlement, and can provide information on rationalising land utilisation and concentration of the land-development pattern.

Table 5. Urban settlement area (m2) per inhabitant, Statistics Norway and BUFFER

Urban settlement	SSB	BUFFER
Hurum Municipality, all urban settlements	1 216	914
Sandefjord urban settlement	700	570
Svelvik Municipality, all urban settlements	735	645
Klokkarstua	1 002	704
Holmsbu	1 893	3 369
Tofte	1 174	795
Filtvet	1 654	1 855
Sætre	1 147	645
Svelvik (in Hurum Municipality)	1 374	
Nesbygda	857	1 028
Svelvik (in Svelvik Municipality)	605	612
Berger	1 058	415
Average, all urban settlements	775	625

The sum of the urban settlement areas within each municipality is lower in the buffer urban settlements than in the Statistics Norway official urban settlements. This is initially because the buffer method does not include large, buildingless areas and satellites that naturally belong to the urban settlement. For some urban settlements, the buffer area is larger than the Statistics Norway official urban settlement. The most striking example of that is Holmsbu, cf. Table 3.2.3. The chief explanation is that the buffer method includes contiguous cabin grounds located within 50 metres to the hub of the urban settlement. This is also the main explanation for the other urban settlements that yield a larger area with the buffer method.

Table 6. Urban settlement area (m2) per inhabitant from different surveys, average and variation

Survey	Average	Variation
BUFFER	615	415 - 3 369
Statistics Norway	775	605 - 1 893
NIBR	554	

The figures for urban settlement area per inhabitant also show that the buffer method harmonises well with, e.g., earlier figures from NIBR.

Built-up area

This indicator is a general density measurement for the entire urban settlement. The indicator shows the built-up area as measured in percent of the total urban settlement area.

"Built-up area" is a somewhat narrower term than the broader term built-up ground properties." "Built-up area" does not include areas such as parks and "green" areas, even if they appear "developed." The same applies to areas such as sports installations, ball parks and parking lots.

In this project we have chosen to define *built-up area* are the base area of all buildings, regardless of size or type, that are located within the urban settlement. *Built-up area* will thus be dependent on a physical structure (building); landscaping and pavement alone are not enough. Parking lots and roads are thereby not included in this concept.

The base area of all buildings are totalled. For buildings lacking base-area data, average figures for corresponding types of buildings are used. For the urban settlements in Hurum Municipality, where

only a small percentage of the buildings have data on their respective base area, average figures for similar types of buildings in Svelvik are used

Table 7. Built-up area, all urban settlements, decares and percent

	Hurum	Sandefjord	Svelvik
Number of buildings in urban settlements with information on the area of building bases.	269	2 897	2 642
Percentage of buildings with base-area data	7	17	98
Total area built up, decares	298	1 440	245
Built-up area in percent of total area	6	8	5

NIJOS has developed a definition of the term *built-up* area for its work (NIJOS 1995):

"Built-up area" is defined as the area of ground properties that does not belong to agricultural properties and where a significant part of the area is covered with buildings and construction elements such as roads, paved areas, etc. Agricultural areas, wilderness and outdoor recreation areas (including sports installations, parks, etc.) are not embraced by the term "built-up area."

Demarcation of built-up areas shall as a rule follow property boundaries. This means that lawns, gardens, etc., connected to, e.g., dwelling properties shall be included in the term "built-up area when ...

This definition embraces virtually all of the area within the urban settlement, in that the definition of urban settlement is indeed based on the requirement that the area must contain buildings. Consequently, we have not used this definition or method of demarcating built-up areas in this project.

Ground property utilisation
"Ground property utilisation" is defined as the total gross building-base area (applied area) in relation to the area of the ground property.

This is a general density measurement for built-up areas. Ground property utilisation is measured in percent as the ratio of the building area (m2 AREA_T in the building table) to the size of the attached ground property (m^2 - AREA in the ground property table).

Calculating ground property utilisation requires that you have data on both buildings and building grounds. For the urban settlement of Svelvik, this applies to approx. 40 percent of the pairs of buildings and grounds.

Table 8. Ground property utilisation (preliminary figures), Svelvik urban settlement, in percent

Type of building	Percent of grounds
Total for all types of buildings	21
Dwellings	21
New dwellings (based on 34 dwellings built after 1990)	41

Transportation area
"Transportation area" includes many types of areas.

Table 9. Transportation area, different types, data source

Transportation type/purpose	Possible data source	Definition	Definition, method, comments
Transportation connected with dwellings (parking for/on dwelling property)	GAB	Commercial group 9 Building group 45	Can separate major parking facilities for dwellings. Can find out the building's base area.
Parking spaces - surface parking for things other than dwellings.			Cannot be calculated
Area of parking garage for purposes other than dwellings.	GAB	Building type 44	Large independent parking/garage facilities *and warehouses*
Area of roads for motor vehicles.	VBASE		All road links. Buffer around each road link.
Area of pedestrian and bicycle paths.	N50	LTEMA 7042	
Area of flood-lit tracks	N50	LTEMA 7423	
Area of railways	N50	LTEMA 7101, 7111	
Area of harbour facilities	N50	LTEMA 6601	
Area of airport	N50	LTEMA 7900	

The transportation area is measured in percent of the total urban settlement area.

In this project, *area of all motor roads* is used as an indicator of total transportation area.

This entails that the area of parking facilities and garages for dwellings is not included. Pedestrian and bicycle paths, railways and harbour facilities are not included either, but including said areas is a relatively simple matter when further developing the indicator.

Road information was obtained from VBASE. A standard road width is used for the various road types, based on empirical figures from the Directorate of Public Roads (E. Lundebrekke, June 1996, pers. med.).

Table 10. Standard road width for various road widths

Type of road	Code	Width
European route (motorway)	E	15 m
State highway	R	15 m
County road	F	13.5 m
Municipal road	K	11 m
Private road	P	10 m
Forest-vehicle road	S	4 m

Source: Directorate of Public Roads.

Any further development of the method may include linking the VBASE with the VDB information system (road data bank) in the Directorate of Public Roads. That would make it possible to obtain exact road widths for each road link and possibly a better basis for estimating the width of the various types of roads.

Table 11. Road area, urban settlement, percent

Urban settlement	Road area, percent
Hurum, all urban settlements	17
Sandefjord	16
Svelvik, all urban settlements	21
Nesbygda	19
Svelvik (in Svelvik Municipality)	22
Berger	19

Ground map N50 from the Norwegian Mapping Authority contains information on transportation. The table below shows relevant data elements and total length for this theme for the urban settlement of Sandefjord.

Table 12. "Transportation elements," N50, Sandefjord urban settlement, total length (m)

Code (LTEMA)	Type of transportation	Length, metres
6601	Quay/dock	866
7001	Roads, various types	273,055
7042	Pedestrian/bicycle paths	4,192
7101	Railways, single track	4,902
7401	Tractor roads	1,430
7414	Footpaths	546
7423	Flood-lit tracks	1,939

Given that standard widths for these transportation elements can be provided, this information can be used to calculate areal figures corresponding to those for roads.

"Green" area

One of the aims of area planning is to secure a good, physical-environment quality for inhabitants. Mainly, it has to do with securing access to areas for play and recreation. Relevant indicators may include number of secured areas and number of kilometres of paths. The most important thing is to obtain an overview of green areas in the urban settlements.

"Green area" embraces "everything that is green" within the building zone (i.e. within the total urban settlement area), both public and private, including gardens ("definition" in indicator list from the Ministry of the Environment). The Directorate for Nature Management (DNM) uses the following definition in its guidelines for planning the green structure of urban settlements: *"Green structure is the weave of large and small nature areas in the urban settlement"* (DNM 1994). *"... all green and mainly vegetation-covered areas on public as well as private ground"* (DNM 1994).

Green areas are important areas for play, recreation, outdoor life and sports, activities which collectively we may call "local recreation." The green areas may also be denoted as "remaining areas" within the urban settlement after deducting areas with buildings and areas used for transportation. A simple approach may thus be:

GREEN AREA = TOTAL AREA - BUILT-UP AREA - AREA FOR TRANSPORTATION PURPOSES.

In the guidelines from the DNM (DNM 1994) list a number of examples of green areas:

- Paths
- Forest area

- Other untouched areas
- Sports installations, including indoor sports centres and ball parks
- Developed green areas such as parks, churchyards, play areas, free areas, institution areas, etc.
- Nursery schools, day-care centres
- Schools
- Grounds connected to institutions, homes for the elderly
- Museum and church grounds

The term *green area* is one of six priority areas in the Ministry of the Environment in its work regarding environment-friendly urban settlements. The work includes mapping and planning green areas and developing indicators for reporting on the development of green areas.

It is difficult to render a clear and unambiguous definition of the term *green area,* in spite of there being an obvious and generally accepted understanding of the types of areas the term implies. There is no operational and unique definition of the term that can be used in further developing indicators (Erik Stabell, Akse Østebrøt, DNM, Kine Thoren, NIBR, pers.med. June 1996).

In working with green areas in Oslo Municipality, five elements are emphasised as important to planning and managing green areas (from *Arbeid med grøntplan for Oslo*, 1992, Oslo Town Planning Office, adopted as a municipal sub-plan, November 1993 (DNM 1994)). Some of these elements are commented below:

1. General park system
2. General path and trail system
3. Areas with private houses
4. Ecological area principles
5. Contiguous, buildingless areas of more than 50 decares

General path systems can be measured on updated maps. For the Sandefjord urban settlement, this is shown in the table below. Also shown is the total length of footpaths. The data is from N50.

Table 13. Pedestrian and bicycle paths and flood-lit tracks in Sandefjord urban settlement, total length in metres

Code (LTEMA)	Type of travel	Length in metres
7042	Pedestrian/bicycle paths	4 192
7423	Flood-lit tracks	1 939
7414	Footpaths	546

This is a suitable indicator of green area. However, there is major uncertainty regarding data quality and updating frequency for this type of information.

Areas with private houses could be a serviceable indicator of green areas within the urban settlement, being that areas with private houses often have a green characteristic and set themselves significantly apart from the more densely utilised part of the urban settlement close to the hub. As a definition of area with private houses, one could include areas where essentially most of the buildings (e.g. more than 90 percent of all buildings) are classified as detached houses, semidetached houses, row houses or small houses in GAB. That definition has not yet been tried out in this work.

Ecological area principles (ref. also Nyhuus 1991) is a "desk work" based on studies of maps and existing material.

Contiguous, buildingless areas of more than 50 decares.
These areas are important to emphasise because they may be of major interest both for developers and in with respect to green structure. In this work, "buildingless is defined as areas situated more than 15 metres from buildings and more than 8 metres from roads (all types).

This is shown for the Svelvik urban settlement:

Figure 11. Buildingless areas of more than 50 decares, Svelvik urban settlement, 1996

For the Svelvik urban settlement, there buildingless areas make up 174 decares or 8 percent of the total urban settlement area.

3.3. Method assessment

For the urban settlements that we have studied, it is quite clear that the method is successful and that it provides very interesting possibilities for viewing the development of urban settlements over time. Compared to the Statistics Norway's official urban settlement boundaries, the results of the buffer method are very good in most cases. One may also argue whether there is any one answer, and whether that answer should be the Statistics Norway's official urban settlement boundaries. These are digitised based on human estimates and local knowledge, and might therefore result in different practices for different urban settlements. On the other hand, the buffer method will generate urban settlement boundaries based on equal criteria. This method will yield the best possible "comparable" urban settlements. Some differences, due among other things to smoothing functions, etc., may also arise here, but they will be marginal.

To check the quality of this method, it should be tried out on most urban settlements. The method should also be further developed so that satellites (clusters of dwellings outside the urban settlement), roads, railways, industrial estates, parks, etc., are included in the buffer urban settlements. The size of the buffer formed around each building should be differentiated according to what type of building it is. This should be included in the method.

3.4. Assessment of basic-data quality

Below is a table showing completeness of some key data fields in GAB

Table 14. Completeness of some key data fields in GAB

Data field		Hurum	Sandefjord	Svelvik
Number of buildings		7 803	23 346	4 764
Number of buildings, after 1985		296	2 254	631
Number of buildings, after 1990		77	1 014	185
Base area, total	*% complete*	7	17	96
Base area after 1985	*% complete*	100	100	100
Base area after 1990	*% complete*	100	100	100
Gross area, total	*% complete*	6	13	95
Gross area after 1985	*% complete*	98	100	100
Gross area after 1990	*% complete*	95	100	100
Commerce group, total	*% complete*	8	21	53
Commerce group after 1985	*% complete*	36	46	53
Commerce group after 1990	*% complete*	35	43	72
Number of properties		6 916	19 540	3 638
Area	*% completed*	64	79	70
Area use	*% completed*	41	48	84

The table above shows generally large differences in degree of completeness of GAB data in the three municipalities on an overall level. After 1985, however, all of the municipalities have a very high (approx. 100%) degree of completeness for the buildings' base area and gross area, while the degree of completeness is far lower for the properties' area and area use.

The table illustrates the major differences between the three municipalities with regard to degree of completeness of overall GAB data in the GAB register. The totals for Svelvik are far better than for both Sandefjord and Hurum. A reasonable assumption is that such differences exist also for the rest of Norway.

For the buffer method to yield good results, it is crucial that the quality of the basis data be as good as possible. To achieve this, the quality of GAB data must be improved. In realistic terms, this applies especially to buildings constructed after January 1, 1983. As of 1983, all buildings 15 m^2 or more in size must be recorded in the GAB register. Consequently, this should be a basis year for land use statistics based on this method. For buildings erected before 1983 there will be fragmentary information in GAB and the statistics will be similarly incomplete. Therefore, in order to operate with time series farther back based on GAB, new directives on data input must be issued by central authorities and followed up locally.

4. The work ahead

Time series for land use

Based on what has been said before, land use calculations should be made for previous years back to 1983 and the results should be compared to show the trend.

Urban settlements should be generated by way of the buffer method for other areas as well in order to gain additional experience and results from the method. The municipalities of Fredrikstad, Elverum, Lier and Steinkjer were areas originally included in the urban settlement project, but they were excluded because of capacity problems. Those areas should be tried out first.

4.1. Further development of the method

Below is an outline of the problems that should be treated in future projects. For some of those problems, we have already indicated a possible solution. However, trials will most probably lead to revisions of methods.

Regarding poor GAB data

In further developing the method, it is important to select test areas with GAB data of adequate quality so that the results will be maximally representative for the method.

It must be possible to use the method on any urban settlement. Consequently, it is important to choose representative urban settlements for further developing the method. To date, it has been important to select urban settlements having what we believe to be good GAB data in order to emphasise how the basic method works. It will also be important to analyse urban settlements where we perhaps do *not* have good GAB data, in order to enhance the method even further.

Linking population and buildings

The linkage made between DSF (*Det sentrale folkeregistered* = National Register) and GAB in this project has involved using the first 13 positions in the numeric address code. The linkage between DSF and GAB should be tested at a more detailed address level such as, e.g., a 17-digit link.

It is important that GAB and DSF data maximally correspond with respect to time when extracting this data.

Demarcation of urban settlement

The buffer width around the building points has been the same regardless of building type or base area. The method should be upgraded so that a building point will depend on building type, base area or a combination of the two.

The method should also be developed so it will include large, buildingless commercial (industrial) estates, parks, etc.

Roads and railways should be treated similarly as construction elements when demarcating the urban settlement, as those facilities may be considered urban functions. This will initially embrace roads and railway systems directly connected to or within the urban settlement. One will usually encounter methodological and technical problems with such an approach.

Satellites

In the work ahead, the method must also include land areas and inhabitants of satellites, all of which are clusters of 5 dwellings or more within 400 metres from the urban settlement's main agglomeration.

It should also be considered whether satellites shall be physically linked to the main agglomeration and, if so, how it can be done. One possible method is to use the road system as a link between the agglomeration and the satellites. This may pose major technical problems, but it should be tried out to see whether it can yield a serviceable result.

Land use based on commercial group

New variables may be produced or linked to buildings, based on information on building type and commercial group for the building, cf. Engebretsen 1989 and 1993. This will provide possibilities for producing new statistics relating to urban settlements for linking to economic activities such as model apparatus, projections and land use, etc.

4.2. Evaluation/follow-up/verification of land use figures

The results of the buffer method for each urban settlement must be checked against "reality."

Contact relevant municipalities directly - municipal engineering services

The demarcation of each urban settlement must be reviewed. Where there are differences between the two demarcation methods, they must be analysed in order to find the cause of the discrepancy. The differences, if any, might be due to errors in basis data (GAB), different estimation criteria, or that the method is inadequate and must be adjusted if possible. It may also be useful to compare the results against DGPM (Digital Ground Property Maps) to see if the differences, if any, are due to different boundary choices.

Compare with other land use surveys

The results of the method should also be checked against other surveys of urban settlements. Both NIBR and TØI have conducted surveys the results of which may be suitable for comparison with those of our project.

4.3. Improving data quality in GAB

The quality of GAB data varies. Consequently, we must develop quality indicators for the different fields used for statistical purposes. The indicators may, e.g., tell us something about the completeness of certain data fields in GAB. Relevant data fields in this connection include: building type, commercial group, construction year, total floor area, area per floor, area per dwelling, revised status, area and use of the ground property. Some preliminary indicators are shown in subsection 3.4.

Another important indication of data quality is the degree of consistency of the data material. In the GAB data used in this project it is important to view the consistency between:

- Building type (e.g., semidetached house) and number of dwellings
- Areal figures - for each floor and in all
- Areal figures - for dwelling, other and in all

References

DN 1994	Planlegging av grønnstruktur i byer og tettsteder. A-K. H. Thorén og S. Nyhuus, DN-håndbok 6, Direktoratet for naturforvaltning. Trondheim, 1994
Engebretsen 1989	Utbyggingsregnskap. Dokumentasjon av metode og resultater fra prøveregnskap 1986 og 1987. Øystein Engebretsen, Rapporter 89/6, Statistisk sentralbyrå, Oslo/Kongsvinger, 1989
Engebretsen 1993	Arealbruk i tettsteder 1955 - 1992. En analyse av utviklingen i Oslo, Bergen, Trondheim, Fredrikstad og Sarpsborg. Øystein Engebretsen, TØI rapport 177/1993, Transportøkonomisk institutt, Oslo, 1993
NIJOS 1995	Bebygd areal. Forslag til samordnet opplegg ved arealkartlegging. Utredning i forbindelse med prosjektet DMK-2000. Ås, 14.9.95
Larsen og Saglie 1995	Tettstedsareal i Norge. Synnøve Lyssand Larsen og Inger Lise Saglie, NIBR-rapport 1995:3, Norsk institutt for by- og regionforskning, Oslo, 1995
Myklebost 1969	Norges tettbygde steder 1875-1950. Hallstein Myklebost, Ad novas nr. 4, Universitetsforlaget
Nyhuus 1991	Økologiske arealprinsipper i Oslos byggesone. Signe Nyhuus, Oslo byplankontor, 49s
Næss 1995	Transportenergi og ulike mål for befolkningstetthet. Petter Næss, NIBR-notat 1995:130, Norsk institutt for by- og regionforskning, Oslo, 1995
Ottestad 1995	Ny arealstatistikk for byer og tettsteder - forprosjekt. Arne Knut Ottestad og Øystein Engebretsen, notater 95/16, Statistisk sentralbyrå
Schøning 1993	Arealstatistikk 1993. En sammenstilling og vurdering av tilgjengelig arealstatistikk som plattform for videre arbeid på området. Per Schøning, Notater 93/44, Statistisk sentralbyrå
SK 1991	Brukerbok (GAB) med registreringsinstruks. Norges offisielle landsdekkende register for grunneiendommer, adresser, bygninger. Statens kartverk, 1.10.91
SK 1995	MABYGG. Informasjonsblad for bygningsregisterprosjektet. Statens kartverk, nr. 1 (april '93) - 4 (mars '95)
SK 1995	SOSI standard versjon 2.2. Håndbok. Statens kartverk, juni 1995
SK/GEO 1996 (udat.)	Effektivisering av kommunale forvaltningsoppgaver ved bruk av GEO-informasjon. Kurshefte, Statens kartverk, Geoservice AS, udatert
SK udat.	Koordinatfesting av adresser i GAB. Informasjonsbrosjyre, Statens kartverk, udatert
SSB 1982	Arealbruksstatistikk for tettsteder. NOS B 333, Statistisk sentralbyrå 1982
SSB 1983	Grunnkretser, tettsteder og menigheter. Dokumentasjon 1980. Rapporter 83/13. Statistisk sentralbyrå 1983
SSB 1986	Statistikk for tettsteder. Rapporter 86/11. Statistisk sentralbyrå 1986
Strand 1996	Kobling av adresseregistrene i DSF og GAB. Dokumentasjon og resultater. Børge Strand, notater 96/7, Statistisk sentralbyrå

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