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Erik Engelien and Per Schøning

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Land Use Statistics for Urban Settlements

Methods based on the use of administrative registers and digital maps

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Abstract:
Statistics Norway is now developing methods for producing land use statistics for the build-up part of urban settlements based on administrative registers and GIS. This makes it possible in a cost efficient way to follow the status and changes of land use for the most intensively exploited areas in terms of physical, demographic and economic parameters.

Keywords: Land use, urban settlements, GIS analyses, Economic statistics

Addresses: Mr Erik Engelien, Statistics Norway, Economic statistics
N-2225 Kongsvinger, Norway. E-mail: eer@ssb.no

Mr Per Schøning, Statistics Norway, Economic statistics
N-2225 Kongsvinger, Norway. E-mail: per@ssb.no

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Summary

From 1999, Statistics Norway produces urban settlement boundaries based on information from administrative registers and GIS. Important by-products of the project are population, building and ground-property information distributed on addresses with co-ordinates available for statistical purposes. This information, combined with geo-referenced information from the Central Register of Establishments and Enterprises, as well as digital maps, is the basis for producing statistics for the physical use of build-up land within urban settlements. During 1998 and 1999 work has also been conducted to develop and quantify indicators for sustainable development of urban areas, and to define and localise centre areas in urban settlements.

The purpose of this document is to make available an English documentation of methods developed for producing land use- and related statistics. In addition some statistical results are presented in a case study of the urban settlement of Fredrikstad.

This is the second out of 3 reports planned to be published 1999-2000 as outputs from the project "Land use statistics for Urban Settlements" conducted by Statistics Norway. The first report was a documentation of a method adopted by Statistics Norway used for register-based delimitation of urban settlement areas (SSB, 1999a). The third and final report will be a documentation of the work done in order to establish links between economic activity and physical land use in urban settlements.

The project is partially funded by Eurostat and the Norwegian Ministry of the Environment.

1. Background and objectives

Urban settlements comprise per 1998 only 0.7 percent of the total mainland area of Norway. These areas are intensively used, both for residential purposes and as location for commercial and industrial activity.

The exploitation of land in urban areas and the environment for the residents is now more and more frequently debated in Norway. Area- and transportation planning, localisation of shopping centres, urban sprawl and revitalisation of city-centres as well as the population's access to green areas, are some of the most important subjects on the agenda. Especially attention is given to the environmental conditions in the biggest Norwegian cities.

There is urgent need for timely statistical information describing status, changes of land use as well as speed, pattern and direction of urban area growth. The objective for the statistical information will be to give an overview over the general situation and development. The statistical information is enabling for result-control, comparative analyses and indication of trends.

The aim for the work on land use statistics conducted in Statistics Norway is to establish an objective and sound statistical basis for sustainable urban area policy and planning. A precondition for a durable statistical system is that it comprises requested information of acceptable quality. The statistics must be produced in a cost-efficient way, and be flexible enough to adapt to future changes in data-sources and tools.

On this background, Statistics Norway has during 1997 and 1998 developed and documented a method for automatic and computerised delimitation of urban settlement as basis for this regional unit in the statistical portfolio. The method takes advantage of already compiled information in continuously updated administrative registers on buildings and population. Thus the dynamics of urban settlement development can be objectively followed.

Precise settlement boundaries, resident population distributed geographically at the level of addresses with co-ordinates, information about buildings, enterprises, roads, railroads, coastline and inland waters are the basis for deriving key-parameters for land use statistics for the build-up part of the urban settlements.

Land use statistics for urban settlements should emphasis to measure the changes over time compared to actual national policies and strategies, as well as for forming future strategies. In this context a link between physical land use and economic parameters will improve the possibilities for understanding the under-laying driving forces for land use changes. The scope of this report is however limited to document the work on statistics for physical land use. Much work has also been conducted to strengthen the statistical portfolio by developing indicators for sustainable land-use in urban settlements.

The project of developing methodology for land use statistics for urban areas is partially funded by the Norwegian Ministry of the Environment and the Statistical Office of the European Commission, Eurostat.

2. Former work on land use statistics conducted by Statistics Norway

The first comprehensive work on land use statistics for urban settlements in Norway was conducted as a part of the environment and resource accounting systems developed in the early 1980ies. The method was based on point-sampling and manual interpretation of aerial photos and was very resource demanding. Thus the work was abandoned, and until the 1990ies very little work was done in order to update the land use statistics for urban settlements.

When continuously updated registers on buildings and ground-properties, enterprises and roads as well as better basic digital maps were established during the 1990ies, new possibilities for producing land use statistics appeared.

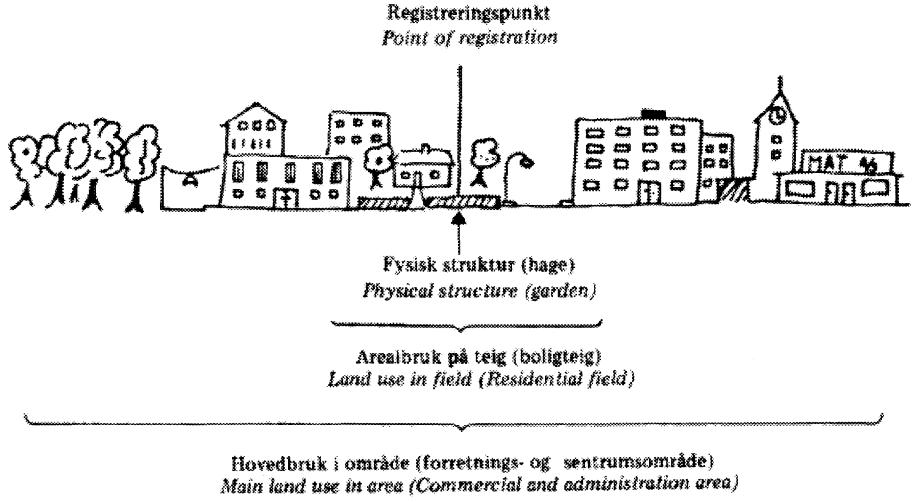
2.1 Use of aerial photos and manual interpretation

In the former land accounting system, the land cover/land use was derived from aerial photos with a grid of points, 100x100 metres. The interpretation was done at 3 levels of observations:

- An ***area*** was classified by the dominating use of land within a homogenous area of at least 0,5 hectares.
- The ***site/field*** was classified due to the activity close to each centre-point in the grid.
- Finally physical structure of land cover exactly at the ***point*** was described.

The three levels for registration of land use are illustrated in figure 1.

Figure 1. Classification of land use at different levels



The characteristics in each grid point were transferred to the 100x100 metre squares of which the observation points formed the centre. By this methodology the land use in each 1-hectare square was derived from the centre-point. One important advantage of using the point-sampling technique was that statistical expressions on accuracy could be made.

2.2 Use of administrative registers

A new approach for land use accounting, based on the use of administrative registers, was developed in the second half of 1980ies. This accounting system was based on the official Ground property-, Address- and Building Register (GAB) and large scale analogue maps. The purpose of this work was to measure the changes of land use due to building activity in a limited period of time, and thus not to calculate the total land use. This accounting system did also give information on the change of land use from not build-up land to build-up land.

A land use class was assigned to the buildings due to type of building and related activity as it was registered in GAB. The GAB-register also comprised information about the ground property around each building. Based on this information it was possible to perform a simultaneous point-sampling as follows:

If the centre point of a 100x100 metres grid cell were positioned inside a modelled ground-property area, the sample grid cell was given the land use class of the building situated on the property.

3. Definitions and terms

An ***urban settlement*** is, compared to a municipality or a basic statistical unit, a dynamic regional unit. The boundaries change continuously according to construction activity and changes in population.

The Statistics Norway official definition of the term urban settlement (SSB, 1998) is as follows:

> 1. A hub of buildings shall be registered as an urban settlement if it is inhabited by at least 200 persons (60 - 70 dwellings).
>
> 2. The distance between the buildings shall normally not exceed 50 metres. Distances more than 50 metres are allowed in areas that can not or should not be build up. This can f.exe. be green-parks, facilities for sports, industrial areas and natural barriers such as rivers or arable land. Smaller hubs of buildings that naturally belongs to the urban settlement should be included if situated in a distance up to 400 metres from the main urban settlement
>
> Urban settlements are geographical areas with dynamic boundaries. Thus number of urban settlements and their boundaries will change over time, depending on construction activity and changes of population.
>
> (Unofficial translation 1999)

A ***ground property*** is a legal unit of land as reflected in the land register.

A building ***site*** is here defined as the whole, or a part of the ground property area on which a building is constructed. The land use of the site is characterised by the type of building and the activity linked to the building. If several buildings are constructed on the same ground property, a site-area is allocated to each building proportional to the buildings ground surface.

The term ***area*** is used to identify large clusters of sites with the same main land use characteristics. An area can therefore comprise one large building site, or more often, hubs of

adjacent building sites with the same land use class. The total area of the hub of sites should be at least 0,5 hectares.

The term area is in the land use statistics vocabulary always combined with an adjective or a supplementary description of the main land use class of the area concerned, such as *residential area*, *industrial area*, *area for transportation* etc.

4. Classification of land use

The operational and preliminary classification-system for land-use for the build-up part of urban areas used in the project, is extracted from former work done in Statistics Norway (SSB, 1982) with some minor adjustments. The original classification-system was based on the guidelines from Nordic system of land use classification (Nordisk statistisk sekretariat, 1982) and on the recommendations from ECE (ECE, 1989). The operational classification-system is also checked and harmonised with the most central land use classes reflected in the Norwegian Planning Act and its Provisions.

The system is classifying land-use at two separate levels; detailed land-use classification at the level of building site, and generalised land-use at the level of area. The land-use at the area-level is characterised by the dominating site-class - f.exe within a residential area instances of commercial sites, roads and green public parks may occur.

The original classification system is extensive, and only land-use classes that we have used so fare are listed below. These classes are mainly concerning the build-up part of the urban settlement:

Level 1. Dominating land use in area:

01 Residential (split on residential low-houses and blocs of flats)
02 Manufacturing and store houses
03 Commercial use and administration
04 Institutions - public service
05 Communications and technical constructions
06 Unclassified land use

Level 2. Land use on the building site:

011 Residential, low houses
012 Residential, blocs of flats
021 Manufacturing and store houses
031 Commercial and administration
032 Mixed use - commercial and residential
041 Institutions - public service
044 Sports installations
050 Communications (railways, roads and building sites related to communications)
060 Other land use n.e.s.
070 Agriculture (building-sites)

As work with urban settlement statistics is in continuous progress and new data-sources become available, it will be necessary to further develop and extend the classification system. Also updated international standards or guidelines are expected to influence on the future classification system for land use in Statistics Norway.

It is necessary to use both information on type of building and for activity performed in the building in order to classify the build-up areas. Thus information about types and activity-class, as they are coded in the GAB-register and the activity classes of NACE from the Central Register of Establishments and Enterprises, are inter-linked in order to classify the use of the build-up area optimally.

5. Data sources

In urban settlements the density of buildings is high. Therefore the use of most of the urban settlement is characterised by the use of the buildings, roads and other constructions. Based on information about building's size and use, as well as register information on roads etc., land use statistics for the most intensively used urban settlement area can be derived.

Administrative registers are well suited for deriving land use statistics because information is up-dated at regular intervals of time. A preposition is that the information is geo-referenced.

The core system of land use statistics developed in Statistics Norway is based on the following 3 administrative registers:

- The Central Population Register (CPR)
- The Official Ground-property-, Address- and Building-Register (GAB)
- The Central Register of Establishments and Enterprises.

The official register for Ground-properties Addresses and Buildings (GAB)
GAB consists of three mutually linked registers where the A- and G-part comprise all addresses and ground-properties. The B-part comprises information of all buildings larger than 15 m^2 including co-ordinates. The G-part comprises information about ground-property size etc. The register is under the responsibility of The Norwegian Mapping Authority. The following parameters are extracted from GAB:

- Estimated ground-surface of building
- Date for building taken into use
- Type of building (class 0-99)
- Ground property size
- Different geo-referencing identifiers including co-ordinates (municipality, basic statistical unit, street-address, ground property address etc.)

The Central Population Register (CPR)
CPR is The Official Central Population Register under the responsibility of the Norwegian Tax Authority. The following parameters are extracted from this register:

- Number of persons resident on the actual address
- Different geo-referencing identifiers matching the data from the GAB register

The Central Register of Establishments and Enterprises
This is a register established as a tool for production of statistics by Statistics Norway. The register comprises active joint-stock enterprises and enterprises organised in other corporate legal forms. Also subdivisions of these enterprises - *establishments*- are recorded.

Establishments are defined as Local Kind of Activity Units. The register is linked to several administrative registers and it is continuously updated.

Geo-referenced information about activity (NACE) of enterprises is extracted from this register in order to improve the quality of land use classification. The register also comprises information about sales and number of employees, and opens therefore for economic analyses related to the use of land.

Other data sources used
Additional information about digital centreline of roads from the annually updated national database (Vbase) as well as railroads from digital maps with national wide cover (scale 1:50 000), is used to have a more complete statistics on transportation areas. Information about sport facilities is also extracted from a central administrative register.

Information on inland water is derived from digital maps and used to separate land- and inland water cover inside urban areas.

Other potential data sources
For further development of the statistics it is possible to use register information about income and wages as well as more information from GAB about buildings and properties - both economic and physical parameters.

6. Methods

Two different approaches for producing land use statistics have been developed and compared in this project. Both methods are based on the same data sources and have the common purpose of aggregating statistics for land use characterised by the activities linked to the buildings.

The grid method
The grid method is based on a fixed grid overlaid the cover of centre-point of building and the buildings attributed parameters. The land use in each grid-cell is classified based on the type and use of the dominating building in the specific cell. Cells with no overlaid buildings are left unclassified.

The method is sensitive to the size of the grid. Large grid-cells yields high cover of land use, but also high generalisation of information. Small grid cells yields a huge number of unclassified areas. After some tests we concluded on a grid size of 50*50 metres as the optimal solution for the biggest Norwegian urban settlements. The method was further developed by overlaying the grid with the digital road-net and thereby adjusting the area of each cell. The white squares in figure 2 are of unclassified land use. The work was based on extensive use of a geographical information technology (GIT).

Figure 2. Land use classified by use of the grid method

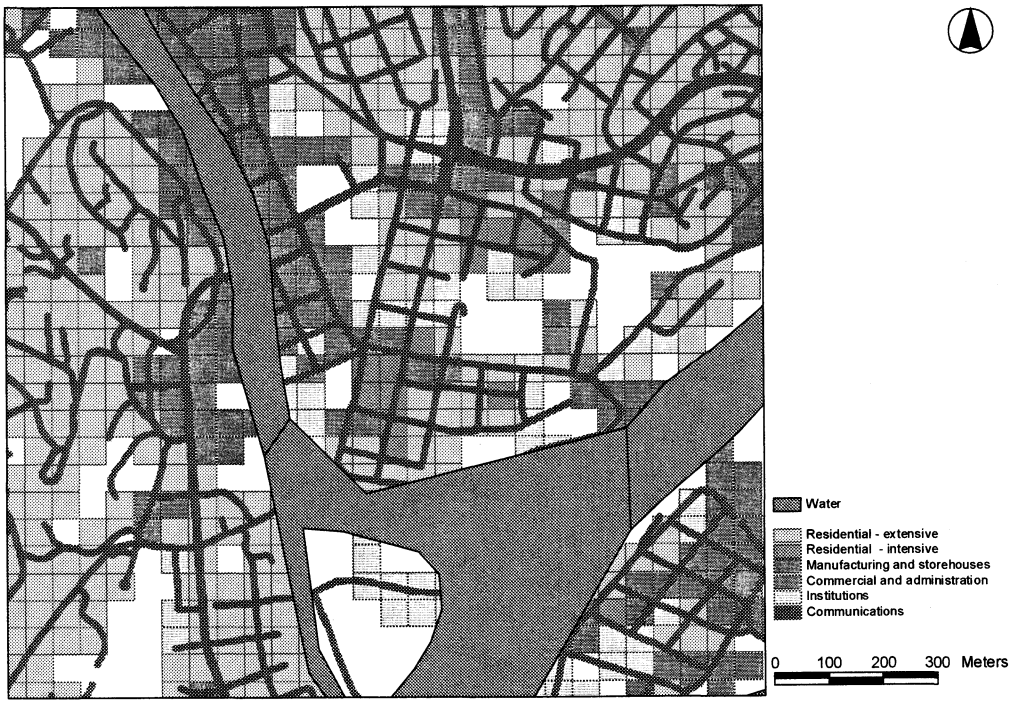
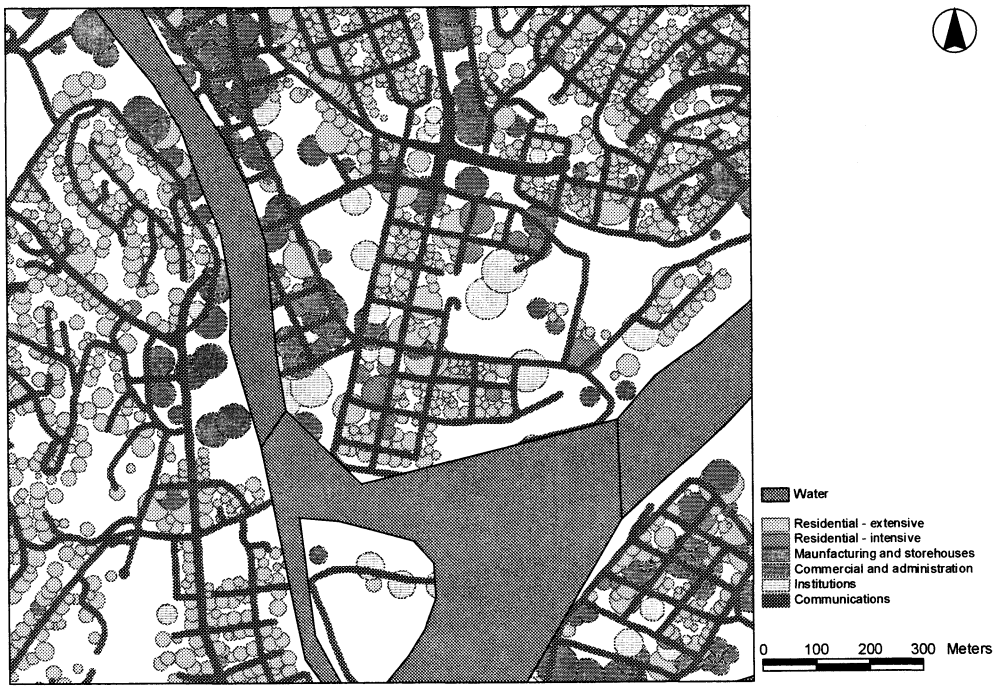


Figure 3. Land use classified by use of the register method



The register method,
The register method takes direct advantage of the information of ground-property-area given in the G-part of the GAB register.

Land use statistics is with the register-method made by allocating the area of each ground-property given in the register to each building constructed on this property proportional to the

size of the buildings ground-surface (figure 3). The quality of the result is depending on the quality of the register and of imputation methods. The proportion of land allocated to each specific building is called the building site. For aggregating statistics on building sites, the method is solely based on traditional use of register information. For aggregation of areas, GIS is required.

The register method yields approximately the same statistics as the grid method and both give results that are acceptable compared to field work controls taking the purposes of the statistics into consideration.

The choice
An important argument in favour of the register method is that this method returns more information about the diversity of land-use. This method is also better harmonised with the methodology already developed and used for delimitation of urban settlement boundaries. Therefore the register method is chosen as the best method as basis for a national statistical system for information about the build-up parts of the urban settlements.

6.1 Land use statistics derived by using the register method

The procedure is firstly to classify building sites based on information of buildings and activities linked to buildings. Thereafter clusters of sites with the same classification of use are aggregated to larger and more generalised areas such as residential areas, industrial areas etc.

6.1.1 Allocation of land use class to building sites

The basic supposition for the method is that the criteria for the use of a building also can be used to characterise the land use in the near surroundings of the building - the influence area. The method is a further processed version of the former work with land use in 1989 - 1993 in Statistics Norway. Instead of performing a simulated point sampling on the register information, all buildings with related information on area of ground property are now used.

The building type and code for activity linked to the building from the GAB register is used as basis for classification of land-use on the building site. Where enterprises are localised in a building, the activity code (NACE) from the Central Register of Establishment and Enterprises is used to adjust the land use on the site. When several enterprises are located to the same building, a dominating activity is selected (or the class mixed use - commercial and residential).

For many instances the ground property area given in GAB and related to the building constructed on it, can be used directly. Then the ground property area equals the site.

There can be more than one building on a ground property. If so, the area of the ground property is allocated to each building proportional to the ground surface of each building - the building site. Several buildings positioned on the same ground property will therefore give several sites, and each site on the same ground property can sometimes have different land use.

The ground properties are sometimes very large compared to the related buildings. To avoid that one- or a few small buildings classify the land use on all parts of the area of such large

ground properties, so far a rule for maximum allowed site-size is set to 15 * ground surface of the building. During the process of utilising the register and deriving statistics it has become clear that this criteria is too general, and work is ongoing to make a better and more diverse criteria for site-allocation depending on building-type.

The information on buildings ground-surface size is not complete in the register. It is therefore necessary to estimate missing values. This is done by stratification at the level of all buildings of the same type in the actual county (100 types buildings in GAB and 19 counties in Norway). So far a simple approach has been used; an average value for each building type with respect to ground surface filled-in is, by imputation, allocated to all buildings of same type with missing values

Also the information about ground properties is not complete in the GAB register. On total country level approximately 50 percent of all ground properties have information of size filled in per 1998. However, for urban areas the rate of filled-in values for area of ground properties is considerable higher than for rural areas and the ground-property information is also more completely filled in for new buildings.

For each of Norway's 19 counties, register information given for buildings and ground properties is used to calculate size of building sites. Thereafter an average size of building site per type of building is calculated and added to compensate for missing ground property values in the original register.

6.1.2 Aggregation of large homogenous areas of land use

In order to establish an overview over geographical extent and distribution of different land use and functions in urban settlements it is necessary aggregate information from the level of each building site to larger clusters - *areas*.

The methodology, based on buffering, merging and smoothening of outlines of polygons, already developed while working with delimitation of urban settlements, is used.

Until further residential sites- low houses and commercial sites are merged and thereafter buffered with a direction-dependant buffer if the theoretical distance between the sites (sites represented as a circle) does not exceed 30 metres. For residential building - blocs of flats, institutions-public service and industrial sites the maximum distance between sites in an area is 100 metres. An area should have a minimum size of 0,5 hectares.

Areas are distributed in a GIS and overlaid with the boundaries of the settlement, the water and railroad theme from 1:50 000 scale maps and digital road-data. By using the level of area, statistics for specific parts of the urban settlement can be derived. Statistical indicators like m^2 or length of roads per hectare of residential areas, or the resident populations access to service functions, can be quantified. The level of area is considered as important in order to give statistics for the variation within the urban settlements in addition to statistics describing the variation between urban settlements. Unclassified areas can be geographically located and statistics for their size and fragmentation can be produced.

6.1.3 Further development of the method

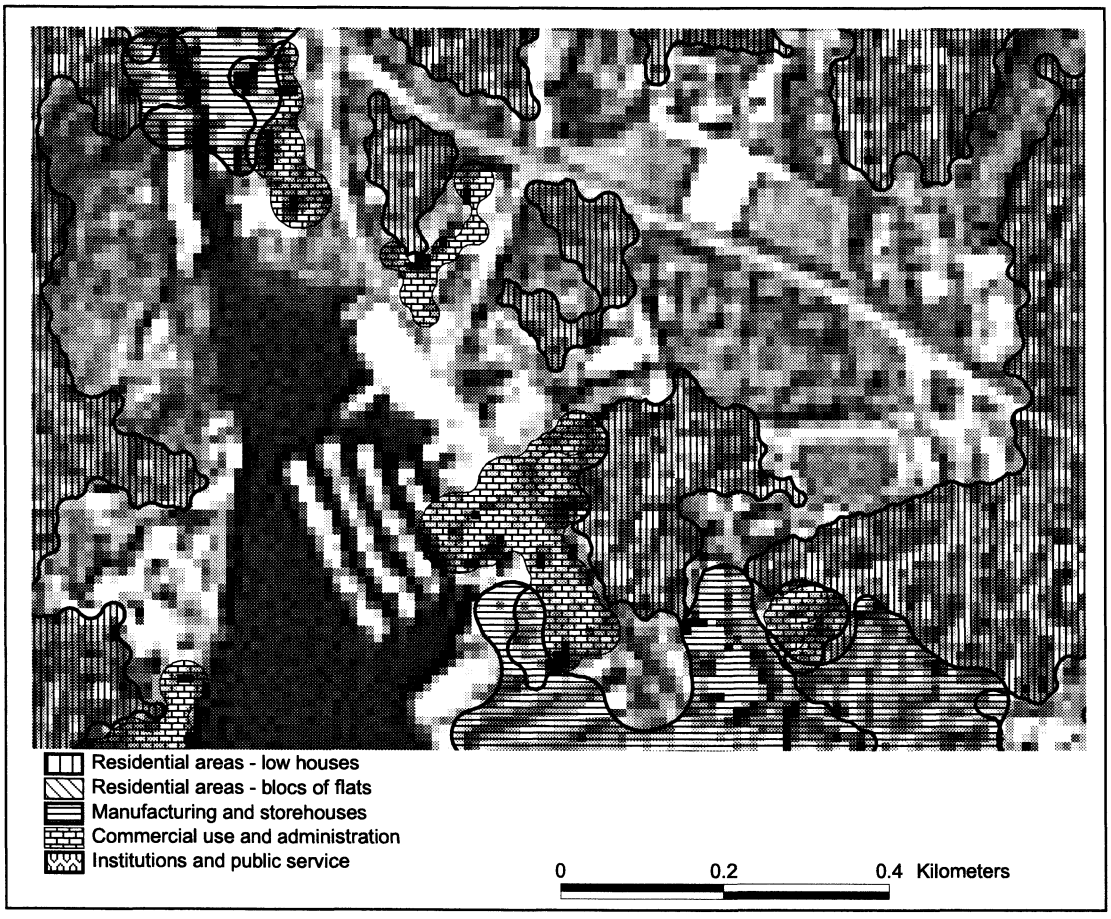
As more experience with the use of the GAB-register is gained, it turns out to be necessary to improve the imputation techniques for missing area-values. The problem is first and foremost

concerning the older buildings and thus the possibilities for producing acceptable statistics for the status on ground-surface of buildings and the land use on sites. For buildings constructed after 1983, the relevant information in the GAB register is more or less complete.

Work is also going on in order to take more data-sources into use and to make a more complete statistical cover for the urban areas. Especially the use of aerial photos or high-resolution satellite images for filling in land cover statistics for the not build-up parts of the settlements seems very interesting. The amount and distribution of green areas and public parks as well as information about sealed "grey" areas such as parking-lots, airports and harbours is requested.

A pilot project in co-operation with The Norwegian Mapping Authority was conducted in 1998 to achieve more experience with the combination of register-information and satellite images for production of land use statistics in urban areas (Statens kartverk, 1998). Satellite images from IRS and SPOT were used in the project. The possibilities for more detailed analyses of the pattern of land cover in the part of the cities not covered by buildings and roads were promising, as manual interpretation of the images supported by register information and digital maps yielded good results compared to ground-truth. At the present a sufficient cover of images is unfortunately not available in Norway.

Figure 4. Land use areas combined with a satellite image



Source: Statistics Norway
Digital map data: The Norwegian Mapping Authority © The Norwegian Mapping Authority 1996 SPOT ® CNES 1995

7. Some indicators for sustainable use of urban areas

The Norwegian Ministry of the Environment is conducting a special Environmental Town Programme, with the aim of developing models for sustainable urban development. A number of specific goals for environmental friendly urban settlements and accompanying indicators have been developed. For example, land use for expansion and transport purposes shall be reduced while the share of environmental friendly transport shall be increased. Air pollution and noise levels shall be reduced. Nature and nearby recreational areas shall be preserved for biological diversity and recreation. The town centre shall be enhanced as the most important meeting place in towns for commerce and culture. The programme was started in 1993 and will be concluded in 2000.

Statistics Norway was partially funded by this programme in 1998 in order to quantify some of the key land use indicators developed (SSB, 1998). The following goals and related indicators where measured in a pilot project:

Goal:	Indicator:
Secure nature and near-by public leisure-areas for biological diversity and out-door activity	- Percentage of resident population with more than 200 meters distance to public leisure areas/play-grounds bigger than 0,5 hectares. - Percentage of residential population living more than 500 meters distance to touring-grounds bigger than 20 hectares.
Reduction of energy-use for heating- and transport purposes / reduction of air-pollution and noise	Average distance from town centre to new constructed buildings
Secure the residents a safe and stable environment, including access to local service	Percentage of resident population (in relevant age-group) within walking distance to: - School - Kindergarten - Post office - Doctor - Grocery shop - Public transportation - Part of population living in town centre

The pilot-project was conducted based on extensive use of central register information, local geo-referenced information from a co-operating municipality administration and by use of GIS, including a system for network analyses.

8. Localisation of centre-areas in urban settlements

Even if several theories and research-reports exist on the subject, there is not any official definition or criteria for delimitation of centre areas in Norway. Traditionally the delimitation of such areas is conducted by the local government for different planning purposes. In this situation the type of plan and the local situation is decisive for the selection of criteria. Thus the results are not suitable for comparing statistics between municipalities.

Due to a regulation approved by the Norwegian Government 1. January 1999, it is until further not allowed to establish new shopping-centres outside the easily accessible central parts of urban settlements. The implementation of this regulation has stressed the need for a consistent and operational definition of the term *centre*.

During autumn 1999 Statistics Norway developed a preliminary set of criteria for localisation of commercial- and administrative centre-areas in urban settlements. It was presupposed that a centre of the above mentioned kind could be characterised by occurrence of a minimum of retail-sale, hotel- and restaurant activity, banking and other commercial services, cultural- and entertainment facilities, public-service and public administration.

The starting point for the definition developed was the Central Buisness District (CBD) found in the international literature. Some national adjustments concerning diversity of functions and density-criteria were introduced. If a certain physical concentration and functional diversity of criteria were present in a specific area, this area should be defined as central. The following preliminary criteria for localisation of centre-areas were used in the project:

- At least 1 enterprise with retail-sale should be present in the centre area.
- At least 1 enterprise with public administration or health- and social service or other social services should be present
- At least 3 enterprises with different major activity classes must be present
- The maximum distance between the buildings in which the enterprises are located must not exceed 50 metres in the centre areas
- A transition-zone of 100 metres is added outside the nucleus of the centre

By combining geo-referenced building information with information on activity in enterprises from the Central Register of Establishments and Enterprises, it was possible in a cost-efficient and automatic way to aggregate centre-areas by using a GIS-tool.

A pilot project was conducted in co-operation with the county administration of Oslo and Akershus. The result from this project was very promising, and showed that by using the developed methodology it was possible automatic to locate centre-areas with an acceptable accuracy (figure 5).

Work is now conducted in order to further develop and yield more experience with the methodology and to find out if the term centre should be implemented as a new regional unit in the portfolio of Statistics Norway.

Figure 5. Centre-areas in the urban settlement of Oslo. 1998

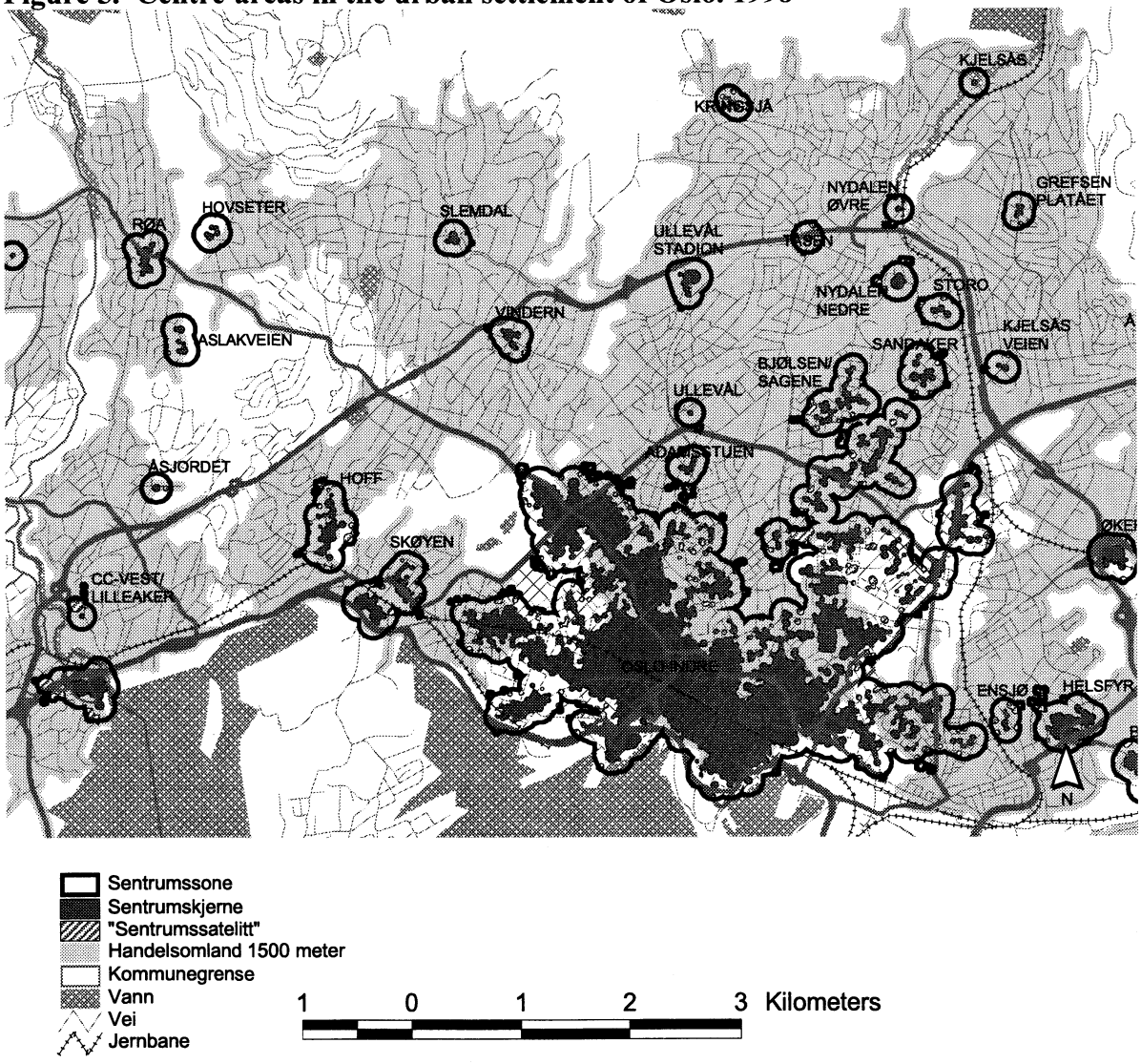


Figure 5 illustrates the centre areas of Oslo as they were automatically delimited in the pilot project. From south, part of the Oslo-fjord can be seen. The road-net is marked with thin grey lines. The dark raster indicates the nucleus of the centre areas. Around each centre it is established a "transition-zone" - a buffer of 100 meters of which the boundary is marked with a black line in the figure. The grey raster is the adjacent trade-area up to 1 500 metres from each centre. In this zone, statistics for population, average income and potentials retail trade was calculated in the pilot project.

9. Results - case Fredrikstad

The urban settlement of Fredrikstad/Sarpsborg is the 5th largest settlement in Norway. This settlement consists of the cities Fredrikstad and Sarpsborg located in two adjacent municipalities situated south-east in Norway - near the Swedish border.

The city of Fredrikstad is here used for a case-study with the objective to illustrate some of the possibilities for producing land use statistics based on the methodology developed.

Originally the Fredrikstad-area comprised several small municipalities, each with their own administrative centre. Over the years the urban areas in this region have grown together, and the result is today a continuous urban settlement with several sub-centres, enclaves of agriculture areas and extensively used residential areas in between. From 1994, all the small municipalities in the Fredrikstad-area are merged into one large administrative unit.

Glomma, Norway's largest river, meets the sea in Fredrikstad, and the river is dividing the urban area into several geographically separated units connected with bridges.

The city of Fredrikstad has been appointed as one out of five "environmental towns", and in the recent years the town has participated in a special development-programme initiated by the Ministry of Environment in 1995.

For the case-study, the urban settlement boundaries of Fredrikstad have been aggregated for the year 1994 and 1998. Thereafter land use and population statistics are produced for the two years respectively.

The urban settlement of Fredrikstad had per 1. January 1998 a total of 53 424 inhabitants which is 80 percent of the total population in the municipality. The total urban settlement area of Fredrikstad was the same year 36.3 km^2. The urban settlement of Sarpsborg had for the same year a total population of 38 018 inhabitants and a total area of 26.7 km^2.

Figure 6. Fredrikstad city-centre

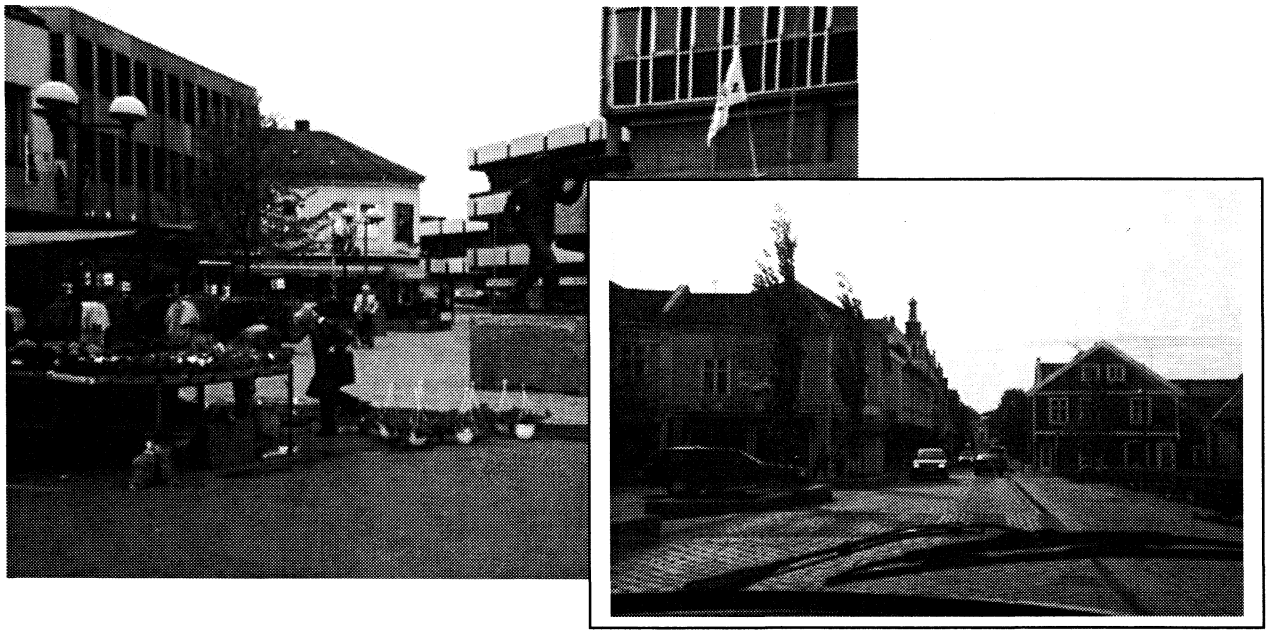
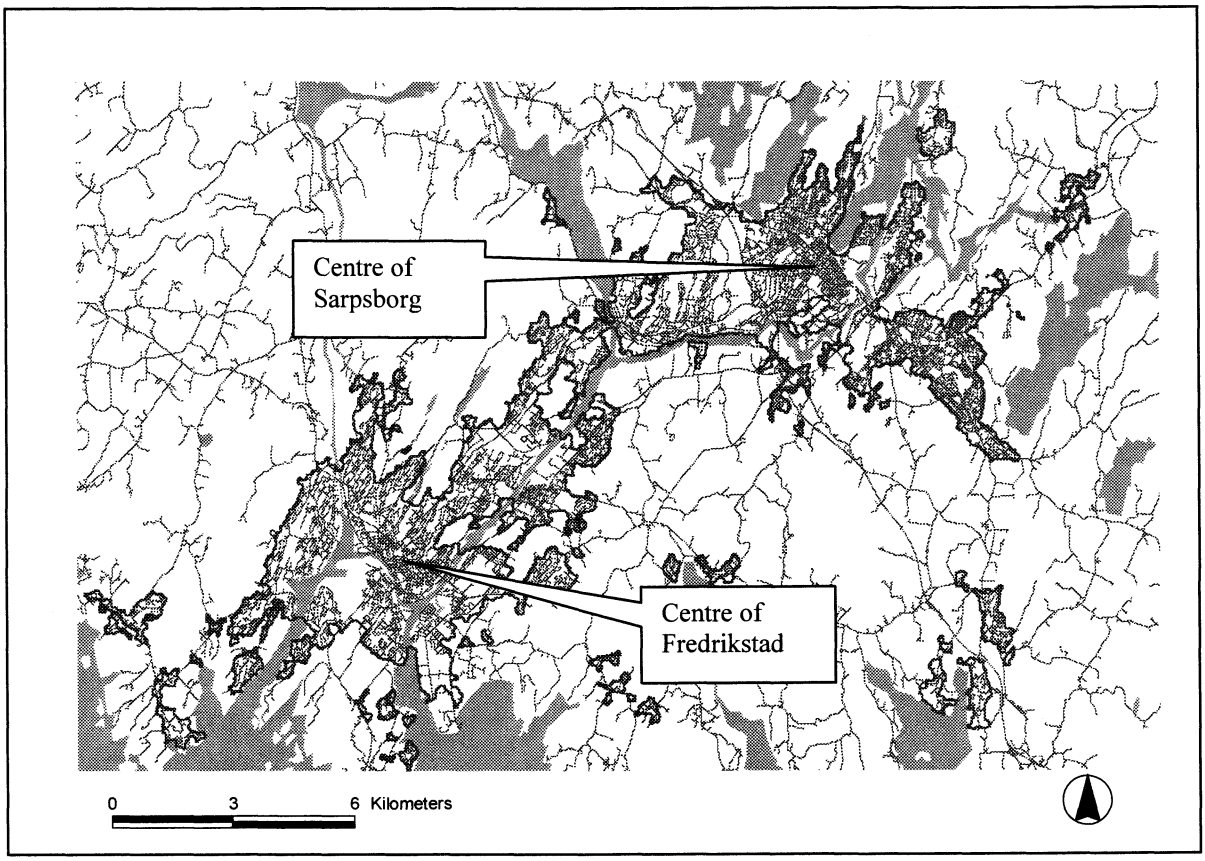


Figure 6. The urban settlement of Fredrikstad/Sarpsborg. Boundaries 1998



Source: Statistics Norway
Digital map data: The Norwegian Mapping Authority

Table 1. Land use in Fredrikstad[1]. 1994 and 1998 (Statistics at the level of site)

Land use	hectares	
	1994	1998
Residential - low houses	1 079,9	1 120,0
- of which ground surface of buildings	179,5	185,3
Residential - blocs of flats	40,3	41,7
- of which ground surface of buildings	7,3	7,4
Manufacturing and storehouses	202,8	205,0
Commercial and administration	292,3	303,4
Mixed use commercial and residential	23,8	26,0
Institutions - public service	90,1	92,7
Sports innstallations	47,6	47,6
Communications	506,8	508,9
- of which roads	483,0	484,8
Agriculture (build-up part)	31,6	32,2
Other land-use	35,0	36,7
Water	234,6	234,6
Total area of urban settlement	3 595,0	3 630,4

[1] The part of the urban settlement Sarpsborg/Fredrikstad that is distributed within the municipality of Fredrikstad. Preliminary figures

Table 2. Change of land use in Fredrikstad[1]. 1994 to 1998 (Statistics at the level of site)

Land use	Net change 1994-1998 m^2	Net change 1994-1998 Percent
Residential - low houses	400 177	3,7
Residential - blocs of flats	9 110	2,3
Manufacturing and storehouses	25 088	1,2
Commercial and administration	111 500	3,8
Mixed use commercial and residential	21 791	9,1
Institutions - public service	25 679	2,8
Sports innstallations	0	0,0
Communications	20 584	0,4
Agriculture (build-up part)	6 237	2,0
Other land-use	16 892	4,8
Water	368	0,0
Total area of urban settlement	353 719	1,0

[1] The part of the urban settlement Sarpsborg/Fredrikstad that is distributed within the municipality of Fredrikstad. Preliminary figures

Figure 7. Variation in land used for residential purpose from town centre to periphery. Fredrikstad. 1994 and 1998 (Statistics at the level of area)

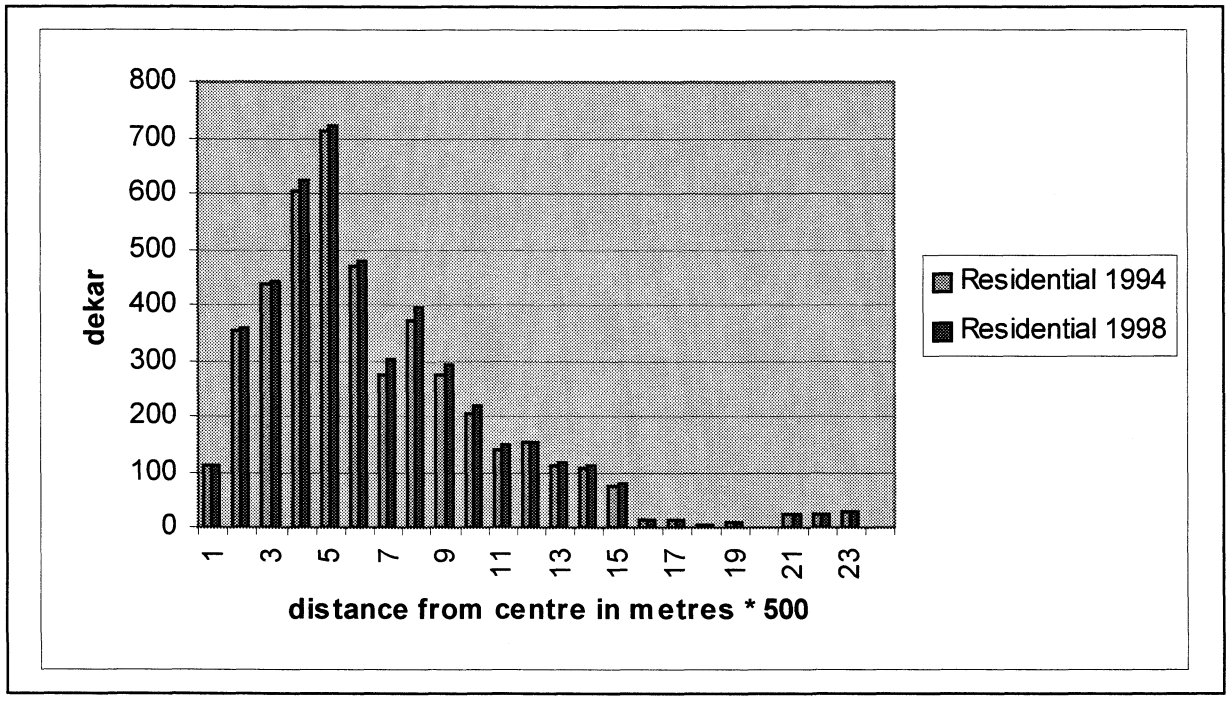


Table 3. Inhabitants and density of inhabitants in Fredrikstad*. 1994 and 1998

	1994	1998
Inhabitants	51 951	53 424
Inhabitans in residential areas	45 217	47 279
Inhabitans per km^2 of urban settlement area	1 445	1 472
Inhabitants per km^2 of residential area	3 160	3 149
Residential areas	14 307 090	15 011 891
Percentage of inhabitants living in residential areas	87,0	88,5

* Preliminary figures

Figure 10. Variation in total population from town centre to periphery in the urban settlement of Fredrikstad. 1994 and 1998

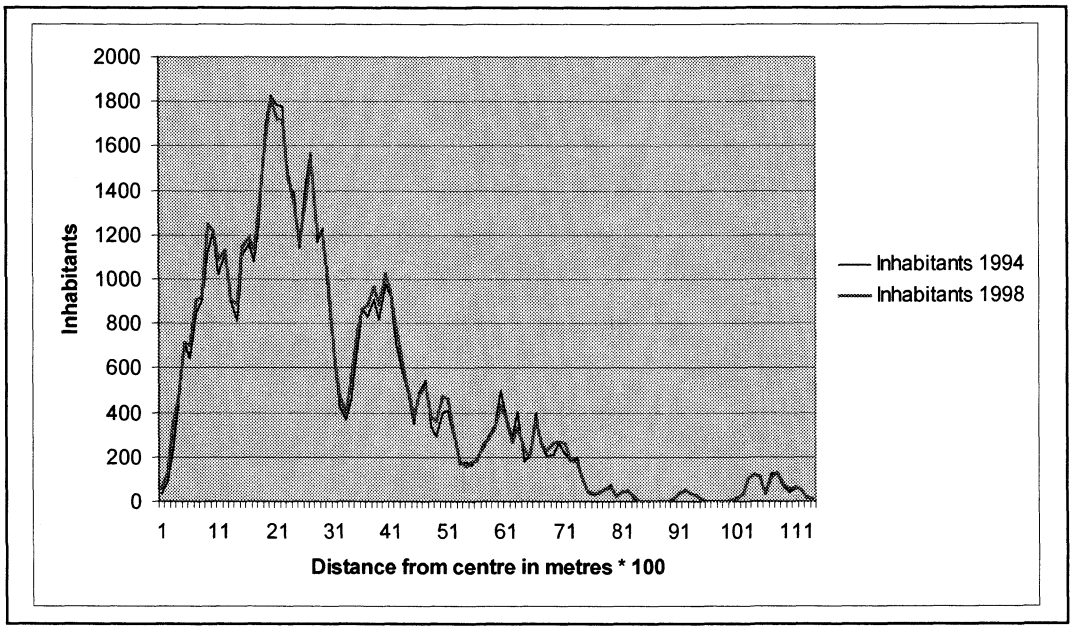
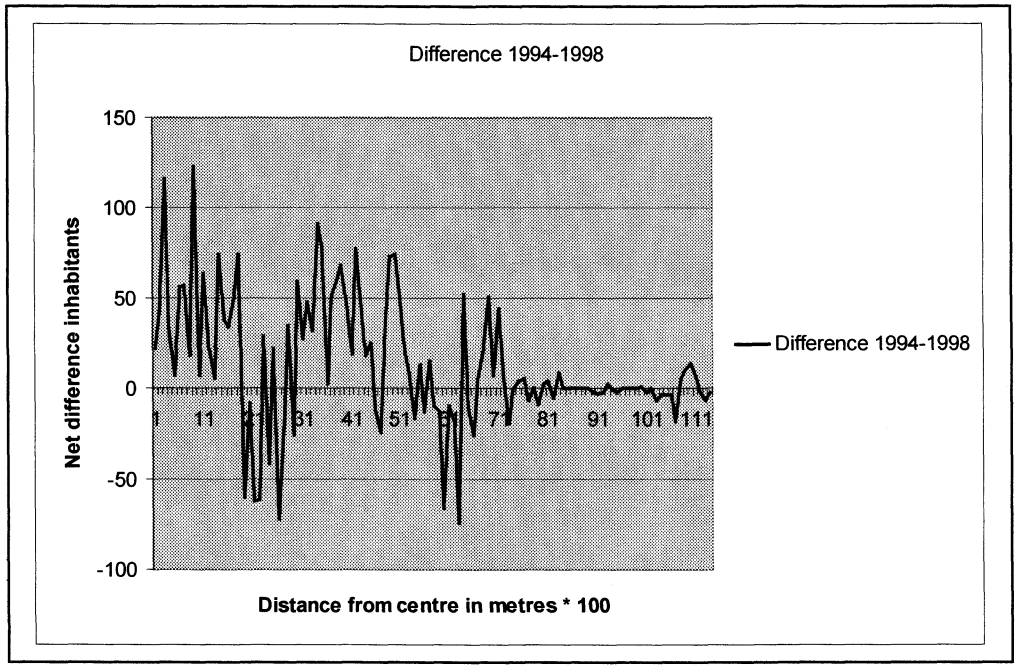


Figure 11. Changes of total population from town centre to periphery in the urban settlement of Fredrikstad. 1994 to 1998. Number of inhabitants



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