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Research Department

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Land use statistics for urban settlements

Statistics Norway
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Abstract:
Statistics Norway is now developing methods based on the use of administrative registers for, in a simple and cost-efficient way, to produce urban settlement boundaries and land use statistics for urban settlements. The objective is to monitor urban settlement growth and the land use changes in urban settlements and in peri-urban areas.

In addition to several ongoing projects concerning physical land use, a first attempt to link economic and demographic parameters to the land use statistics is done in order to better understand the actual land use changes and the driving forces behind.

The objective of a pilot project conducted 1999 was to yield practical experience with localisation of centre areas in urban settlements, and to produce statistics about enterprises turnover and the adjacent resident populations purchasing power.

Keywords: Land use, urban settlements, centre areas, socio-economic parameters, GIS-analyses.

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Summary

The objective of a series of sub-projects conducted by Statistics Norway during the years 1999 and 2000, has been to develop land use statistics for the built-up part of urban settlements and peri-urban areas. Further more a first attempt to establish a link between the land use statistics developed and some economic parameters has been made. The purpose of this document is to make available an English documentation of the part of the projects on land use statistics that has been co-financed by the Statistical office of the European Commission - Eurostat.

Statistics Norway introduced the term "urban settlement" as a regional unit in connection with the Population and Housing Census 1960. However, until now it has been difficult to establish time series statistics for the spatial growth of the urban settlements because the process of delimitation has been subjective, decentralised and resource consuming.

A new method based on objective criteria, administrative registers combined in a geographical information system (GIS) is now introduced and officially approved by Statistics Norway from 1999 onwards. Land and population statistics for urban settlements will now be updated annually.

Important preconditions for the project of delimitation of urban settlements are information about population, building, ground-property and enterprises distributed on addresses with co-ordinates. This information combined with themes from digital maps is the core basis for production of land use statistics for the physical use of built-up land within the urban settlements and in peri-urban areas.

The work with land use statistics has been extended also to implementation of economic parameters. In a project conducted in the autumn 1999, the implementation of parameters like enterprises turnover and number of employees, the resident population's purchasing power was addressed. The potentials for further development of economic parameters related to physical land use are very interesting.

Especially two ongoing projects are of importance for the further improvement of the possibilities for implementation of economic statistics:

- Statistics Norway is in the year 2000 conducting work with the objective to have all units in the Central Register of Establishments and Enterprises geo-referenced by co-ordinates.
- In connection with the Population and Housing Census 2001, a dwelling register will be established as a part of the existing ground property, address- and building register. This means that it will be possible to make statistics for the important statistical unit - the household.

A complete system of land use accounting for urban settlements requires information also about the land use changes of the area adjacent to the urban settlement areas. In the autumn 1999 a pilot project on methodology for establishing land use statistics for peri-urban areas was conducted in co-operation with the Norwegian Land Inventory Institute.

All these projects constitute a total framework of a comprehensive statistical system for following land use, demographic and economic statistics for urban settlements. The information available at the level of addresses with geographical co-ordinates gives a high degree of flexibility for aggregation of new parameters or indicators. Therefore, when national- and international agreements on indicators for land use are achieved, it will be easy to adapt the statistics to the new requirements.

1. Background

Urban settlements comprise per 1998 only 0.7 percent of the total mainland area of Norway. However, 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 monitoring effects of the implementation of policies, for 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 information 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.

In the Governmental White Paper no 29 (1996-97), the aspects of regional planning and sustainable urban settlement development are the main subjects addressed. Planning of a environmental-friendly growth pattern shall have the objective of strengthening the city-centres, reduce the need for transport, secure efficient land use and access to green areas for the urban population.

In 1999 the Governmental White Paper no 8 (1999-2000) was published by the Ministry of Environment. The main purposes for this paper was to introduce concrete national objectives for sustainable and environmental friendly policy. Both goals on maintaining the cultural heritage, the bio-diversity and leisure activities are of importance for land use inside and adjacent to urban areas.

Since 1997 work has been going on in statistics Norway to improve the portfolio of land use statistics. Traditional forest- and agriculture statistics are already well covered. For other categories of land, the information is scattered and characterised by research- and project work.

With limited resources allocated to the work on land use statistics, Statistics Norway has given priority to produce statistics for the part of the land where most of the people live and where the economic activity is at the highest - the urban settlement areas. The priority of urban settlements statistics is also partially anchored in the extensive ongoing work in the Norwegian civil administration in order to develop key figures/indicators according to agreed superior strategic goals for sustainable development (Governmental white paper no 8 1999-2000).

2. Objectives

The objective of the work on land use statistics for urban areas, is to establish an overview over status for the actual land use, to follow the changes of the use of land over time as well as to try to explain what driving forces are putting pressure on the land resources. In addition the ambition is to develop the land use statistics within in the context of the driving force, pressure, status and response model. Of pragmatic reasons, SN has started with traditional land-use accounts/matrixes concentrated on the pressure and status side of the model.

Statistics Norway has also started the process of implementing economic and demographic parameters on the pressure side of the model. In addition, the aim is to add planning and policy data on the response side. However, the latter will require more methodological- and research work before operational statistics can be presented. Time is needed to mature and to do empirical experiences.

This report is the third and final report to be delivered to the Eurostat according to the contract signed in December 1999 (Eurostat 1999). The two preceding interim reports have given extracts of method for delimitation of urban settlements, for aggregation of land use statistics and for localisation of centre-areas.

According to the EU-contract, the main tasks agreed to be dealt with are as follows:

- Evaluation of available sources to be used
- Development of a land use classification system including linkage to NACE
- Development of an operational set of criteria for delimitation of land use classes
- Development of a system for production of land use statistics
- Evaluation of possible linkages between land use and economic activity
- A case study for linkage between physical land use accounts on urban areas and economic
- parameters

3. Organisation and outputs

In the year 1999 and 2000, Statistics Norway, Division for Environmental Statistics launched a series of sub-projects with the common goals of further improvement of the land use statistics for urban settlements. The project work has been conducted along several inter-linked tracks such as:

- Further improving the method and routines for automatic register based delimitation of urban settlement areas – with emphasis on the production of time series to monitor urban sprawl
- Development of methodology for making land use statistics for the use of land in urban settlements and peri-urban areas - a start for a physical resource account
- Delimitation of central areas inside urban settlements - a new regional unit
- Pilot study on the possibilities for linkage between physical land use and economic parameters
- Establishing a system of a basic statistical portfolio for urban settlement statistics

The work is supervised by a reference group comprising representatives from the Ministry of the Environment, the Ministry of Agriculture as well as from several directorates and research institutes.

In addition to the present report, the following deliverables from the project have been produced during 1999 and early 2000:

Rapporter 1999/29:	Tettstedsavgrensing og arealdekke innen tettsteder. Metode og resultater .
Documents1999/17:	Computerised delimitation of urban settlements. A method based on the use of administrative registers and digital maps
Documents 1999/21:	Land use statistics for urban settlements. Methods based on the use of administrative registers and digital maps
Notater 1999/76:	Sentrumsstatistikk for Oslo og Akershus. Et pilotprosjekt
Rapporter 2000/19:	Utvikling av arealstatistikk for tettstedsnære områder - muligheter og begrensninger
Notater 2000/46:	Fagseminar om arealpolitikk og arealstatistikk i opptakten til et nytt årtusen

4. A link between economic parameters and physical land use

4.1. Introduction

Due to long traditions with agricultural statistics and the direct link between the products and the amount of land used for production, it is relatively easy to derive economic parameters like value/crop per hectare of agricultural land. More complex relations occur when multiple use of forest areas and value for recreation purposes etc. are to be calculated. However, both for agriculture and for forest areas, methods for calculation of ground interests, for the production capacity, revenues and the value of standing volume of timber etc. are well developed.

When it comes to urban areas, the work in the crossing field of economic parameters and the use of land is more complicated and not well established in the statistical portfolio of SN. However, a lot of relevant activity- and economical parameters exist in the total stock of different administrative registers and statistical databases at central- and regional level. The challenge is, in a cost efficient way, to select and extract the most relevant data and combine these data into meaningful statistical expressions. Possibilities for updating must be ensured. Finally, it must be possible to use the selected socio-economic parameters at a low geographical level and to relate them to the physical use of land.

Concerning the geographical distribution of data, the possibilities are rapidly improving in the Norwegian administrative and statistical system amongst other due to:

- A well established administrative register with geo-referenced addresses, buildings and properties
- A population-register including geo-referenced addresses
- An ongoing project in order to establish a complete dwelling-register, that will return an overview over the important socio-economic unit - the household
- An ongoing project of geo-referencing the kind of activity units in the administrative register for establishments and enterprises
- A complete cover of digital large to medium-scaled maps (1:50 000)
- An annually updated database with digitalised centre lines of the total network of roads

In the present chapter some actual ongoing projects concerning economic parameters linked to land - use are briefly described and/or the potentials for such links are discussed in a more theoretical way.

In order to present more practical experiences and results, a thorough description of a case study where the resident population's purchasing power was compared to total turnover in retail sales establishments for a selected area.

4.2. Statistics on total turnover and income at the level of addresses

As a first approach for linking of economic parameters to the geographical dimension it is possible to derive information at the level of addresses from the Central register of Establishment and Enterprises and from the Register of Taxation for statistical use. This returns the following raw data:

- Total income after taxes per person
- Total turnover per enterprise
- Enterprises by activity class
- Number of employees per enterprise

From the primary data it is possible to derive parameters/indicators like:

- Number and kind of activities total and per unit of land occupied by activity - (diversity and sustainability)
- Number of employees total and per unit of area occupied by activity - (efficiency, socio-economic importance)
- Total turnover per unit of area occupied by activity - (economic intensity)
- Total income per household distributed geographically - (economic segregation)
- Residents purchasing power vs. retail-sales turnover - (economic relevance)

The suggested parameters/indicators, their relevance and user needs for such statistics must be further explored. It is also necessary to establish a policy and to define to which extent SN should enter into the field of commercial market analyses and local/regional area planning. The problem of quality and transparency/confidentiality will also have to be addressed.

For calculation of the relationship between land use and activity for instances where several activities/enterprises are located on the same address, the problem of double counting of areas has to be solved.

4.3. Transport and travel to work

With geo-referenced information about important functions like public services and commerce, local kind of activity unit, employees and residents addresses combined with a digital network of roads, the possibilities for deriving accurate statistics for the residents travel to work and access to functions are good. Such statistics can be the basis for further research and analyses on transport planning, price- and subsidies impacts on use of public transport etc.

4.3.1. Resident population's access to public service and leisure areas

The Norwegian Ministry of the Environment is conducting a special Environmental Town Programme, with the aim of developing models for sustainable urban development. The programme was started in 1997 and will be concluded in 2001 (MD, T 1204).

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 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.

Main conclusions from the project are:

- Needs for a harmonised delimitation, reporting and understanding of the terms green structure and leisure areas
- All roads must be digitised, also bicycle roads and footpaths to enable correct measures of accessibility
- The term centre-area should be defined precisely
- More empirical experience with the use of the suggested indicator should be yielded before they are implemented

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

Box 1. Selected indicators

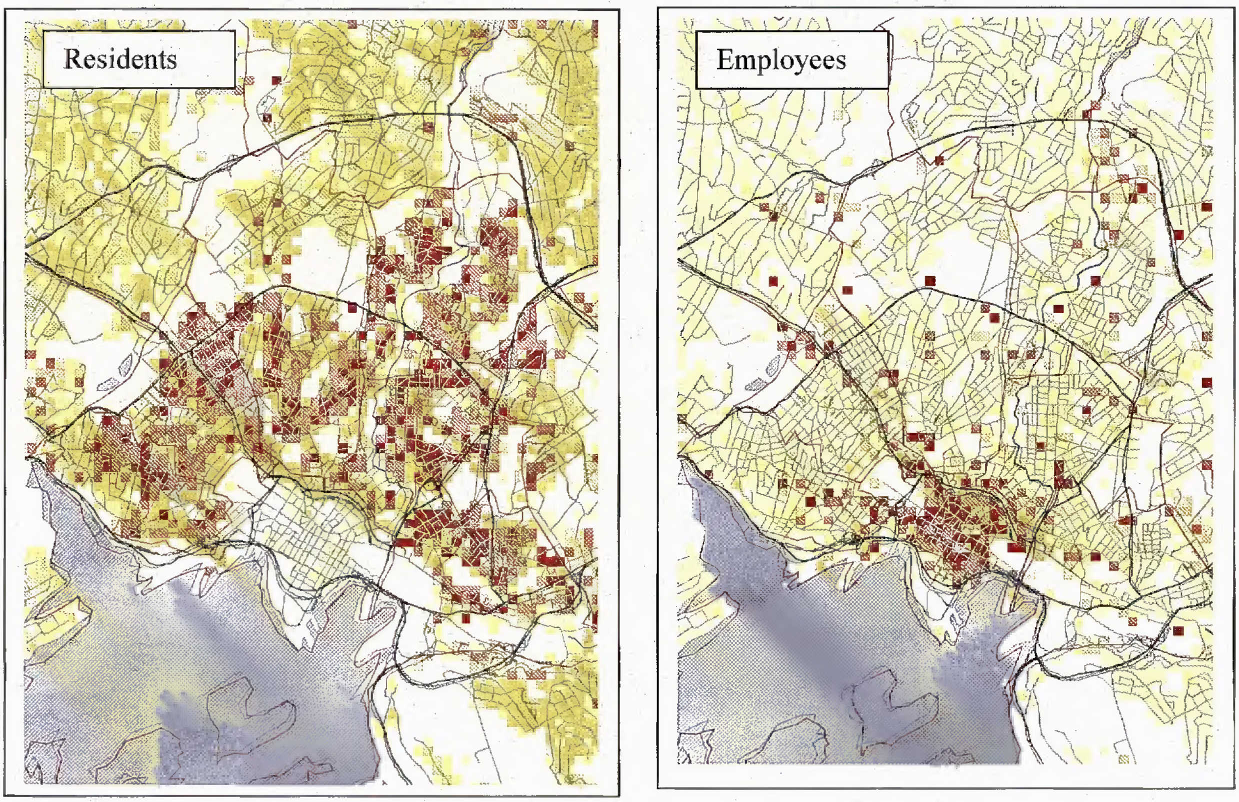
Objective:	Indicator:
Secure nature and near-by public leisure-areas for biological diversity and out-door activity	- Percentage of resident population with more than 200 meters distance to public leisure areas/play-grounds bigger than 0,5 hectares. - Percentage of residential population living more 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

4.3.2. Day and night populations - new possibilities for travel to work statistics

The population present, and thereby the intensity of the use of land in urban areas, is varying dramatically during day and night. For illustration purposes geo-referenced figures for the resident population from the Central Population Register and the total number of employees by place of work was loaded into a GIS, and distributed by density on a grid of 100 x 100 metres. The urban settlement of Oslo was chosen for a case-study (figure 1).

The importance of tracing the population's pattern of use of land during day and night is obvious. With GIS-tools and geo-referenced information about the network of roads, statistics for the canals- and means of transport can be produced.

Figure 1. Concentrations of resident population and employees. Oslo. 1998



4.4. Statistics for notified transfers- and taxation of real property

Statistics Norway produces annual statistics for number and value of notified transfers of real property distributed on region and type of property. The source for this statistics is The Official Ground-property-, Address- and Building Register (GAB) and the extended part with information about the owner.

Also data on taxation on real properties from The Official Register of Income and Taxes is available as a source for economic statistics linked to land.

Relevant information from both these registers is- or can be geo-referenced and implemented into a broad system of statistical indicators bridging parts of the gap between economy and land use. However, problems like the often artificial level on the taxation values of real property, and varying rate of sales of real properties due to type of property and region are obvious obstacles. With the planned expansion of the building register with new a section that comprises dwellings and attributes, the possibility for better statistics in the crossing field of economics and land use is improved.

4.5. The NAMEA approach

National Accounting Matrix including Environment Accounts (NAMEA) is an accounting system with the objective of linking national accounts (NA) with environmental data. The NAMEA system uses tables from the NA as a starting-point, and the idea is then to extend the economic supply and use tables from the NA with information of the physical environment according to the NACE classification.

With geo-referenced information of activity class and total turnover of enterprises combined with information from the system of physical land use accounts about the building and the site on which the enterprise is located, it is theoretically possible to extend a matrix comprising activities with the dimension of land.

The feasibility and needs for establishing NAMEA like matrixes of information at the regional level of urban settlements will have to be further discussed.

4.6. The KOSTRA approach - municipal expenditures vs. physical activity

KOSTRA is the abbreviated name for an ongoing Norwegian project with the overall goal of implementing a more efficient flow of data between the municipalities, counties and the central administration. SN plays a key role in this extensive system.

Both activity data and economic data are reported, quality checked, processed and published annually. The scope of this system is to develop a cost-efficient reporting system and to link the local activity and the physical results achieved with the monetary resources allocated/used. Most of the statistics is related to the regional level of municipalities and counties, and at the present only a very few parameters are related directly to urban settlement areas. Possibilities for better links between KOSTRA data and the spatial dimension will have to be further explored in parallel with the process leading to full implementation of KOSTRA in the year 2002.

4.7. A case study on geographic- and economic parameters in Oslo and Akershus county

4.7.1. Introduction

Optimal localisation of industries, service- and sales enterprises is a challenge for modern area- and transport planning, especially in urban areas. An overall objective is to reduce the energy use and thereby reduce emissions to air and improve the environment for the inhabitants. As a consequence, activities that many people are supposed to visit should be localised in areas that easily could be reached by public transport and/or near the residential areas. On the other hand, enterprises that are depending on transport facilities of great amounts of goods and not depending on a great number of visiting customers, should ideally be localised outside- or in the margins of urban areas.

The Norwegian Government has per 8. January 1999 introduced a regulation that prohibits constructions of large shopping centres outside central areas of urban settlements (MD 1999). If new shopping centres are to be constructed they should be well adapted to the size of the settlement, the functions of the settlements and the potential markets in the neighbourhood.

The objective with the ban is both to reduce the use of private cars, and thereby improve the air quality, as well as to revitalise the centre areas in the urban settlements. In addition, the reuse of settlements centre areas can prevent urban sprawl in the margins and secure more efficient use of already built-up land.

The need for a clear definition, or at least a harmonised understanding, of the term *centre* became evident.

4.7.2. Background and objective

Statistics Norway conducted a project in order to yield more experience with the term centre, and the possible consequences of the ban introduced. Tasks like operationalisation of the term centre and to analyse localisation of potential consumers in the surrounding of the enterprise were addressed. Therefor it was necessary to link demographic and economic parameters to small regional units. Questions like how big is the influence area /service area of the retail sales enterprises or, opposite, how big should a shopping centre be to cover the local population demands for specified goods, had to be dealt with. The project was conducted during autumn 1999 (SN, 1999).

The project had the overall objective of yielding practical experience concerning possibilities and limitations for linking information on land use, socio-demographic- and economic parameters.

The information was also required as input to the local planning authorities and as a tool for central monitoring of the consequences and the follow -up on the implementation of the ban.

The following four approaches were formulated:

- localise and delimit the centre area
- calculate the turnover in retail sales enterprises within the centre area
- calculate the surrounding purchasing power potentials by distance to the centre area
- calculate the size of population and consumers potentials within the surroundings/service area

To ensure objective- and cost efficient solutions, the project should as far as possible be based on centrally stored registers and digital information from maps.

4.7.3. Localisation and delimitation of centre areas

In Norway, there is no officially agreed definition or criteria for the term centre in urban settlements. The closely related term central business district (CBD) does normally not include public activities/services which in Norway is a traditional and well established precondition for general public understanding of the term centre.

Definitions

Due to different planning purposes and variations in local conditions, the understanding of the term centre is not harmonised in local and regional land use planning. The first task to handle for the project was therefor to develop a preliminary approach for an operational definition of the term centre. The definition should be relevant and possible to implement as a national understanding of the term for comparative analyses between regions and settlements. It should also enable for following the changes of the centre areas over time.

From former research projects and from descriptions of the term available from the text in the actual regulation, the following characteristics were available as a start for the operationalisation:

- the historical town centre
- variety of functions present (retail sale, hotels, restaurants, banking- and commercial service, public and private administration, entertainment, cultural- and recreational possibilities)
- occurrence of public open space - squares and markets
- good accessibility by public transport accommodations
- not distinctly separated from the rest of the urban area

4.7.4. Calculation of turnover in retail sales activity

From the Central Enterprise and Establishment Register (CBR), information about activity code according to the NACE system, turnover, employees etc. is available for statistical purposes.

Work is now going on in SN to assign geographical co-ordinates to each local kind of activity unit in the CBR. For several counties this work is already completed, and thus it is relatively easy to calculate total turnover in retail-sales within a given geographical zone.

The challenge is then mainly to select the relevant activities from the system of NACE that should be included in the calculations. In addition quality checks of the co-ordinates and economic parameters should be conducted. Necessary aggregation of data must be conducted in order not to reveal sensitive information.

4.7.5. Service district and purchasing power

Several assessments of the populations trade- and transport habits reveals that a service area is a rather dynamic entity – continuously developing and changing with respect to area and inhabitants. In addition, it is difficult to calculate the importance of the resident population versus the high concentration of places of work and day-time present employees in central areas.

The variety of assortments of goods included in the retail sale activities is depending on different consumer patterns. Due to the objective of a simple approach based on a limited number of data sources, the attempt to define and delimit a dynamic service area that covers all aspects listed above was abandoned at an early stage of the project. Alternatively a simple approach with geographically fixed zones with areas in a specific interval of distance from the centre was established and the present resident population and potential consume were calculated.

The distance was calculated based on the digital network of roads (Vbase). Possible restrictions in the net, such as on-way-drive or closed streets/pedestrian-areas, were not taken into considerations. Neither was public transportation and/or accessibility measured as travelling time/cost.

4.7.6. Delimitation of centre areas - methodology

The bearing principle for delimitation of centre areas is that a centre area is presupposed to have a physical concentration of local kind of activity units related to retail trade as well as private and public services and cultural- entertainment activities. The processing of basic data with the objective of delimiting centre areas can be illustrated as follows:

Figure 2. Schematic description of the delimitation process

Steps	Variables used				
	Kind of Activity	Ground surface of building	Direction dependent buffer	Variation and composition of kind of activity	Satellites
1	Selection of relevant enterprise due to NACE				
2		Link between enterprise and ground surface of building from GAB			
3			max. distance between adjacent enterprises 50 + 10 metres		
4				Selection of polygons that contains main activities G and (L or N or O) and more than 3 main activity classes	
5					Selection of enterprises and agglomerations of enterprises localised up to 100 metres from the centre nucleus

Step 1: Selection of enterprises

All enterprises in the CBR are classified by activity according to the NACE system. From this register all local kind of activity units within the following activity codes were selected as relevant for centre functions:

Section G : Whole sale and retail trade; Repair of motor vehicles, motorcycles; retail sale of automotive fuel

52	Retail trade, except of motor vehicles and motor cycles; repair of personal and household goods
52.1	Retail sale in non-specialised stores
52.2	Retail sale of food, beverages and tobacco in specialised stores
52.3	Retail sale of pharmaceutical and medical goods, cosmetic and toilet articles
52.4	Other retail sale of new goods in specialised stores
52.5	Retail sale of second-hand goods in stores
52.62	Retail sale via stalls and markets
52.7	Repair of personal and household goods

Section H: Hotels and restaurants

55.1	Hotels
55.3	Restaurants
55.4	Bars
55.5	Canteens

Section I: Transport, storage and communication

60.1	Transport via railways
60.2	Other land transport
63.212	Parking places and parking houses
63.3	Activities of travel agencies and tour operators; tourist assistance activities n.e.s.

Section J: Financial intermediation

65.1	Monetary intermediation
65.2	Other financial intermediation
66	Insurance and pension funding, except compulsory social security
67	Activities auxiliary to financial intermediation

Section K: Real estate, renting and business activities

70	Real estate activities
71	Renting of machinery and equipment without operator and of personal and household goods
72	Computer related activities
73	Research and development
74	Other business activities

Section L: Public administration and defence; compulsory social security

75	Public administration and defence; compulsory social security

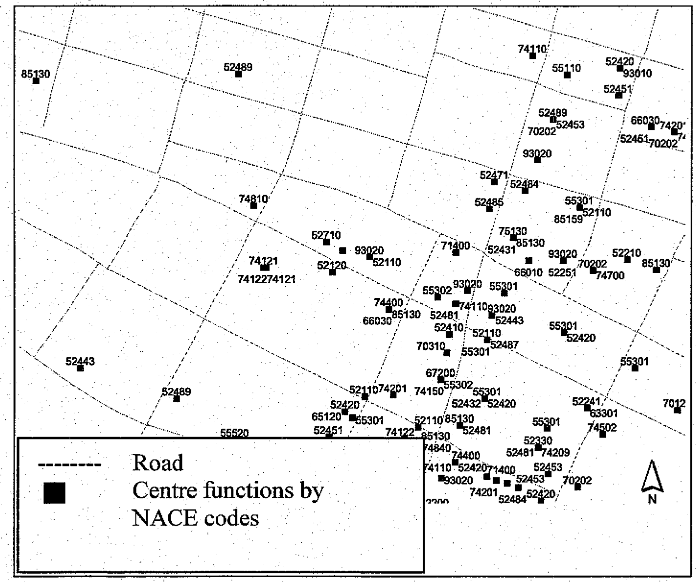
Section N: Health and social work

85.121	General practitioners
85.13	Dental practice activities
85.143	Physiotherapeutic treatment
85.144	Health visitor service
85.145	Other prophylactic health service
85.159	Other health activities

Section O: Other community, social and personal service activities

92.130	Motion picture projection
92.32	Operation of arts facilities
92.33	Fair and amusement park activities
92.34	Other entertainment activities n.e.s.
92.4	News agency activities
92.51	Library and archives activities
92.52	Museums activities and preservation of historical sites and buildings

Figure 3. Enterprises with centre functions selected



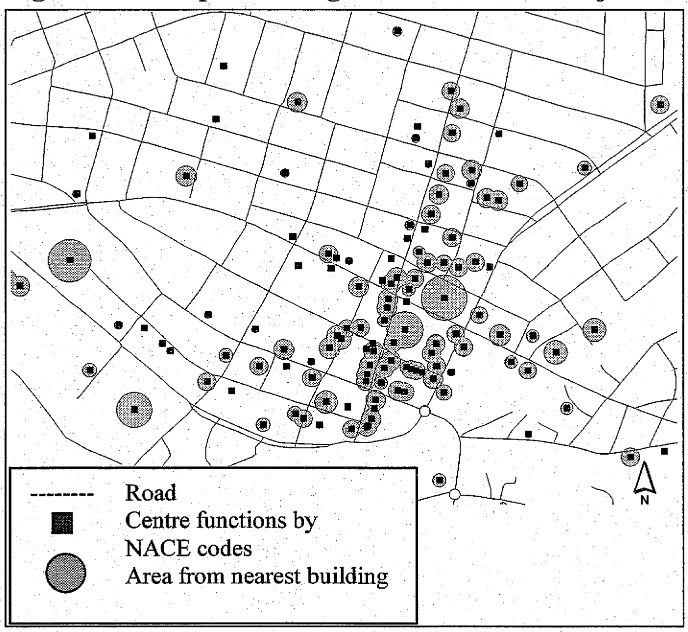
Step 2: The geographical extent of an enterprise

In the CBR, each enterprise is represented geographically solely as an address point. In reality the enterprise is distributed geographically to a whole- or a part of a building and often also to some surrounding out-door influence area. Present available register information allows for letting the enterprise be represented with the ground surface of the nearest building found in the GAB-register.

Several enterprises can be located in the same building, but a more accurate calculation of the extent of each enterprise is not possible to do based on the sources available for this specific project.

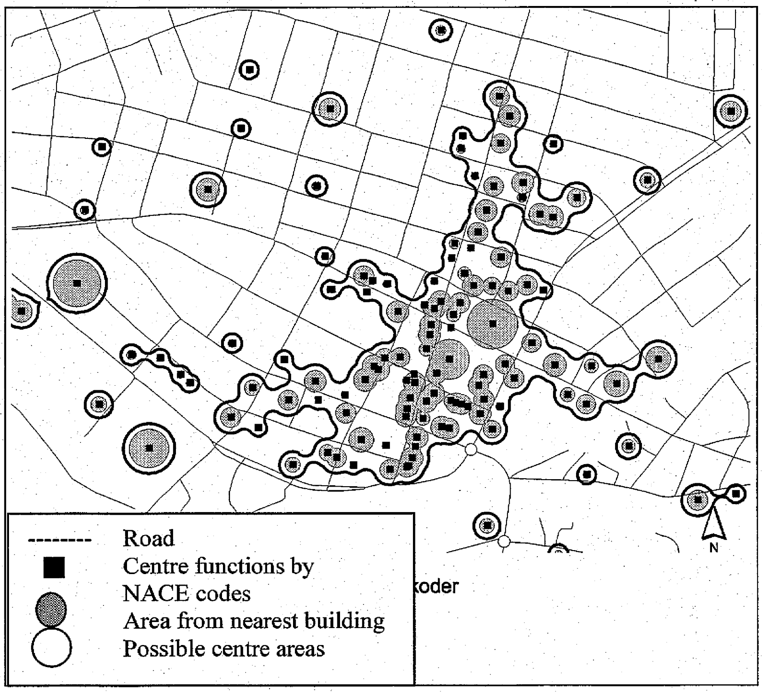
Buildings with less ground surface than 50 m^2 are excluded. If it was not possible to allocate a near by building's ground surface to the enterprise, a fixed value for the extent was chosen (314 m^2).

Figure 4. Enterprises assigned to the area of adjacent buildings



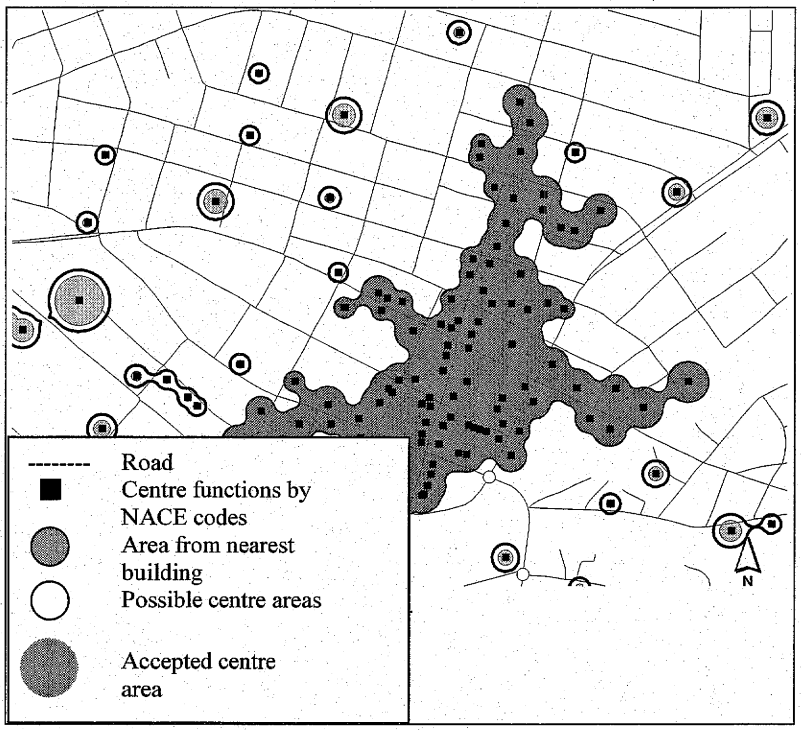
Step 3: The requirement for density
With all enterprises geographically distributed and represented by a certain ground surface area, the next step is to locate concentrations of enterprises with centre characteristics - the possible centre areas. Around each enterprise a buffer of 25 metres is constructed. In areas where the buildings are positioned within a distance of 50 metres, the buffers are merged and the potential centre area is aggregated/delimited.

Figure 5. Possible centre areas full filling the criteria of density



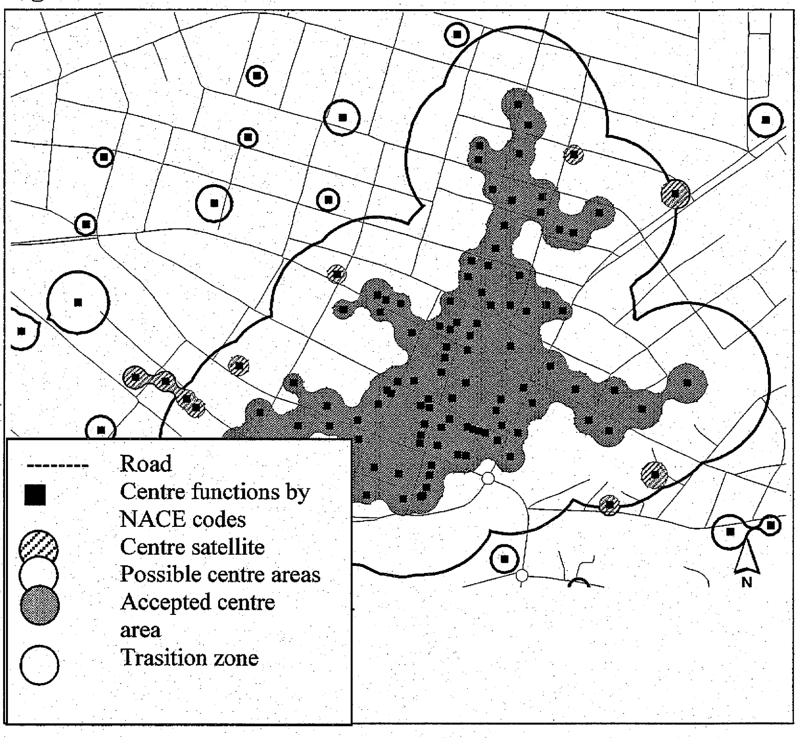
Step 4: Check of requested kind of activity composition
If a hub of enterprises localised and aggregated in step 1-3 actually is a centre, is depending on the number and the composition of the enterprises present. Within the centre it must be present at least 1 enterprise from the main activity class G. In addition at least 1 enterprise from main activity class L or N or O and at least 3 main activity classes must be present totally in the hub. Polygons that fulfil these requirements can now be selected as true centre areas.

Figure 6. Centre areas selected due to composition of activity



Step 5: Enterprises in the margins of the centre areas – the transition zone
In order to avoid a too rigid and narrow delimitation of the centre areas, all enterprise positioned in a zone of 100 metres surrounding the centre polygon is calculated as belonging to the centre.

Figure 7. Transition zones and satellites



4.7.7. Calculation of turnover, purchasing power and service area - methodology

The total turnover in the centre zone is calculated as the sum of all retail sales. The potential consume in the service area is calculated as number of residents multiplied with average potential consume in the area. The service area is defined as fixed concentric zones surrounding the centre area. The zones are calculated along the network of roads outwards from the centre areas.

Figure 8. Schematic description of calculation of turnover, purchasing power and service area

Steps	Variables used				
	Actual turnover	Calculation of consume	Calculation of service area	Calculation of consumers purchasing power	Calculation of the ratio turnover over purchasing power
1	Summing up the turnover in retail sales enterprises				
2		Average consume from consumers assessment adjusted with local figures for personal income – allocated to addresses			
3			Construction of concentric zones surrounding the centre		
4				Personal consumers purchasing power summarised in each service area zone	
5					Calculation of the ratio turnover over purchasing power

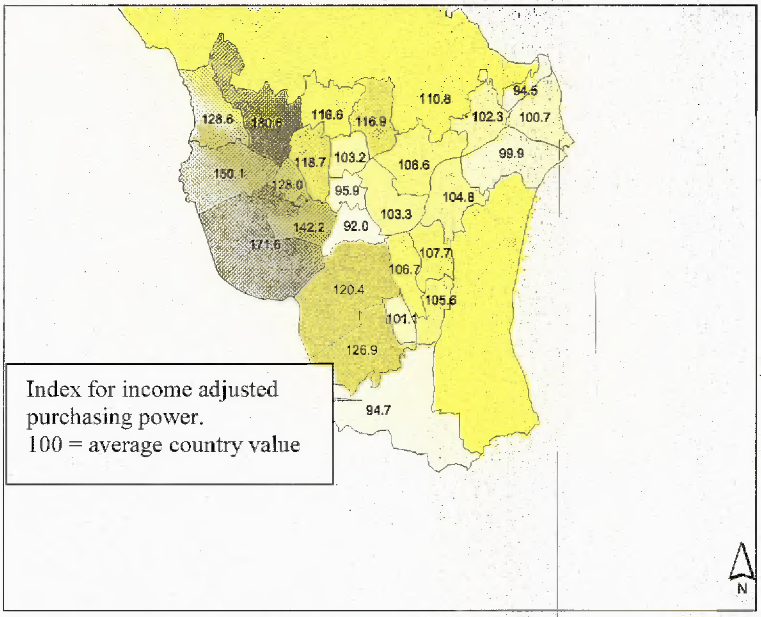
Step 1: Calculation of retail sales in the centre area

The total turnover of retail sale enterprises within the centre area is summarised for activities in class G. Turnover is calculated as the sum of annual invoiced services and goods exclusive VAT and including internal deliveries between enterprises in the same company.

Step 2: Calculation of purchasing power

In the pilot project the personal consumer's purchasing power is calculated based on information from municipality administrations and adjusted with personal income statistics. The purchasing power is adjusted with an index, where the average value for the country total is 100. The adjustment is based on the relation between the income and the consume. The income elasticity equals to 0.5. The index ensures that in an area with high average income, the potential purchasing power is higher than in an area with low average income.

Figure 9. Index for adjustment of potential purchasing power. Parts of Oslo

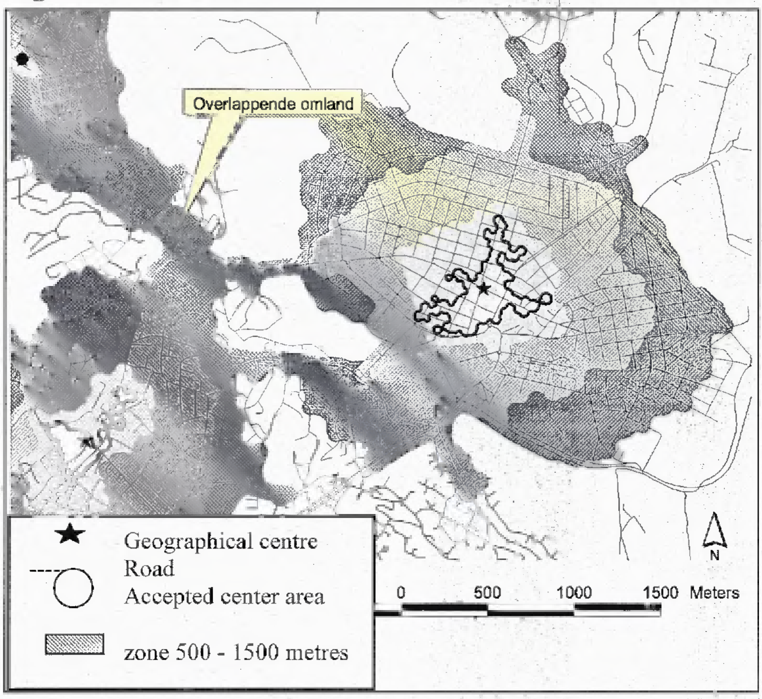


Step 3: Calculation of service area

From a geographical centre-point, the service area is calculated as concentric zones measured based on the network of roads 500 metres, 1000 metres and 1500 metres out from the centre point. A buffer of 50 metres on each side of the road is created.

Each concentric distance zone is treated separately. Overlap between service areas from neighbouring centre areas can occur. This implies that the sum of potential purchasing power can not with out further adjustments be summarised f.exe at the level of municipality.

Figure 10. Service areas as concentric distance-zones



Step 4: Calculation of total purchasing power in the service area
Within each concentric service area zone, number of persons and personal potential consume is calculated.

Step 5: Calculation of the ratio total turnover over purchasing power
The ratio is calculated for each centre and for each concentric service area zone surrounding the centre. The figure indicates the required size of service area. If turnover is greater than purchasing power, this indicates over capacity. A ratio less than 100 indicates leakage of trade i.e. that consume is directed to enterprises outside the service area of the actual centre.

$$\textit{Ratio} = \frac{\textit{Total turnover in centre areas x 100}}{\textit{Total purchasing power in the service area}}$$

4.7.8. Results
The results from the project were presented with centre- and service areas distributed on maps supported by tables comprising number of establishments, employees, turnover as well as the purchasing power in the service area for each distance zone. The results for the county of Oslo, which can have some elements of relevance and recognition at an international level are illustrated in figure 11 and table 1.

Figure 11. The main centre and selected local centre areas. Oslo. 1998

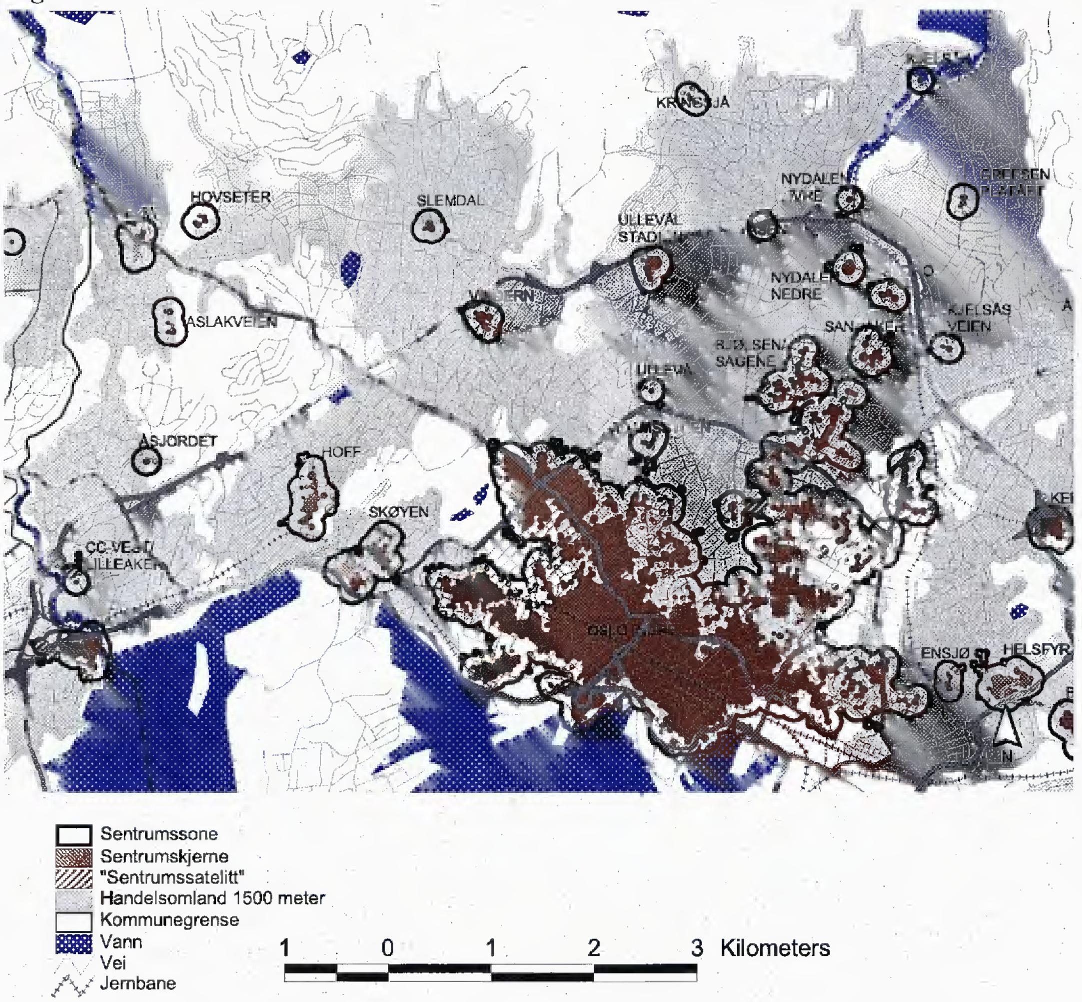


Table 1. Calculated retail sales and service areas in central parts of Oslo. 1998

Centre name	Retail sales enterprises in the centre zone			Total turnover for retail sales in the centre, in percent of purchasing power in the service area. Distance from centre		
	No	Turnover (NOK1000)	Employees	500 meters	1000 meters	1500 meters
Kjelsås	3	44 771	9	122	25	11
Kringsjå	2	:	14	41	22	10
Grefsenplatået	11	22 334	30	21	6	3
Nydalen øvre	4	2 560	11	50	3	1
Hovseter	9	36 746	22	139	41	16
Slemdal	7	36 608	84	37	10	5
Tåsen	11	56 492	46	78	19	9
Røa	32	233 192	164	274	98	53
Nydalen nedre	3	38 865	53	338	29	7
Ullevål stadion	22	238 207	163	460	107	52
Storo	45	513 021	388	925	184	60
Aslakveien	8	17 052	2	29	19	8
Vindern	23	67 771	69	70	20	11
Kjelsåsveien	3	27 080	18	42	8	3
Bjølsen/Sagene	71	183 675	121	56	22	11
Ullevål	6	120 498	107	194	28	10
Oslo (inner city)	2 853	11 352 459	9574	4 988	1 417	655
Adamsstuen	15	18 156	13	6	2	1
Åsjordet	3	10 359	7	42	12	3
Hoff	22	130 182	108	307	58	28
Skøyen	63	249 246	215	614	132	36
Cc-vest/Lilleaker	42	624 509	441	880	305	156
Økern	21	165 463	74	2 125	262	63
Helsfyr	19	142 834	69	614	67	26

4.7.9. Discussion and conclusion

Even if the term centre is well known in the general public opinion and every day life, it is not easy to establish an unambiguous operational expression that covers all sides of the term. However for statistical purposes it is considered as most important to define centre areas as functions of certain economic and social activity.

The method developed in the pilot conducted by SN in 1999, is a preliminary and first approach focusing on an adjusted understanding of the term Central Business District (CBD). Even if the method and the centre area delimited is interesting in a context for statistical analyses, it is probably not «good enough» for planning purposes because it does not cover specialised shopping-centres and "green" and "grey" areas such as parks and markets. This is a challenge for further development.

The calculation of purchasing power is based on the SN Consumer Survey. These figures are representative for the whole country and have to be adjusted to be valid at a local level. The results from the Consumer Survey are therefore adjusted with local information about income after taxes. More work on elasticity index and factors for adjustments have to be conducted if this method should be used in other counties.

The calculations of the ratio of purchasing power over total turnover illustrates the important characteristics of the relation between centre zone activities and its adjacent service area but does not necessarily return the actual service area and the «real» market conditions. Due to the limited resources allocated to this project it was not possible to follow up with manual routines on the approximately 10 percent of establishments that it was not possible to geo-reference. Therefore it is important to take reservations concerning the accuracy of the results.

Having in mind that this was a first approach, the project gave promising results. It can be concluded that it is possible to localise and delimit centre areas for statistical purposes and also to calculate relevant information on turnover and purchasing power in a harmonised and very cost-efficient way. Further work with this kind of statistics will be conducted when more geo-referenced information of enterprises are available. Full cover of geo-referenced enterprises/local kind of activity units in all counties is expected available onwards from November 2000. The centre area delimited may not be suitable and accurate enough as a unit for local planning purposes.

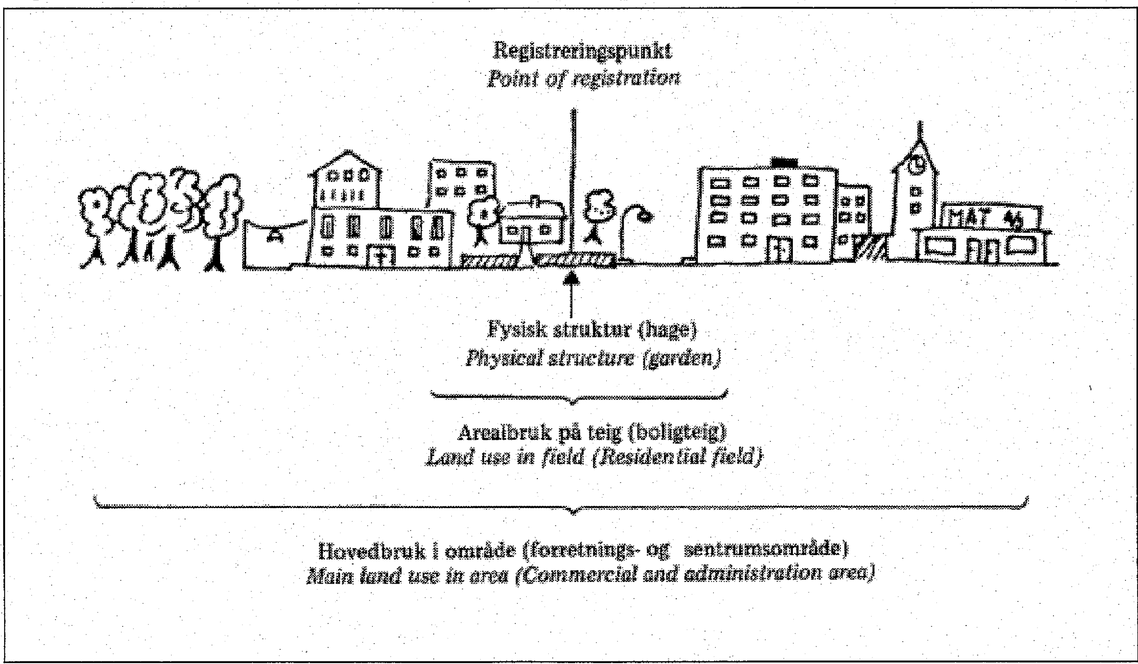
5. Former work with land use statistics for urban settlements

5.1. Land use statistics based on pointsampling and aerial photos

The first comprehensive registration of land use in Norwegian urban settlements was conducted as a part of work with resource accounts early in the 1980's, (SN1982). This work was based on manual interpretation of aerial photographs and was very work intensive. The method was therefor abandoned after the pilot phase. During the following decade very little work was done on further development of land use accounts in Statistics Norway.

The land use account for urban areas was made by manual interpretation of aerial photos. The area was registered around points positioned in a 100x100 metre grid. However for some big cities, the grid distance was 200 or even 300 metres. The classification was done based on the visible use. No attention was paid to the ground property boundaries.

Figure 12. Classification of land use at different spatial levels

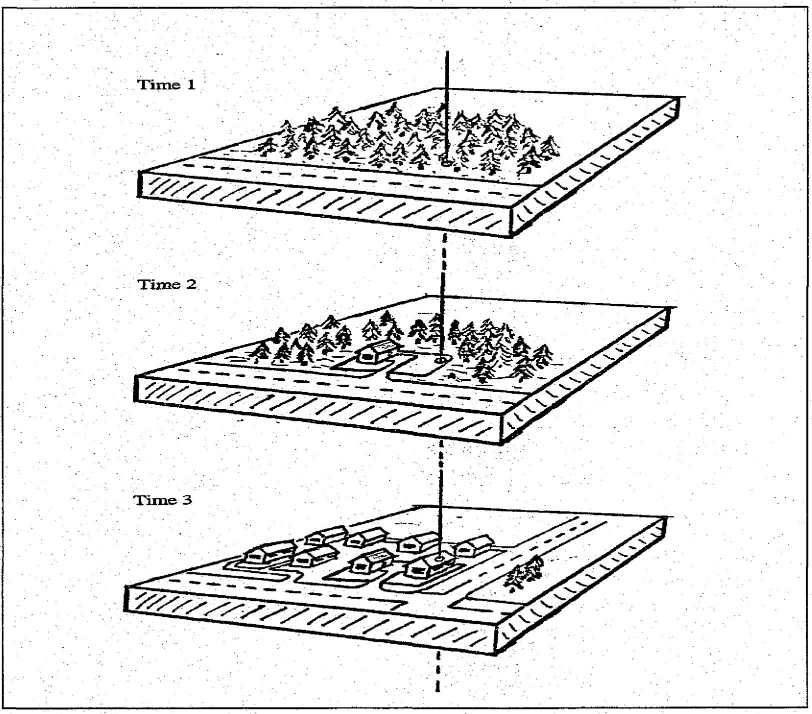


The interpretation was done at 3 levels (figure 12). The <u>area</u> was classified based on the dominating use of land within a more or less homogenous area at least 0.5 hectares wide. The <u>site</u> was constructed based on the activity that could be registered exactly in- and close to the point, and could comprise several physical structures, such as buildings with access roads, parking lots and gardens. As a build up site was counted the physical built-up part and the influence area adjacent. Finally the physical structure in the point was registered.

The attributes for each point were assigned to the 100m x 100m grid that surrounded the registration point. By this methodology the Land use on 1 hectare squares was registered. The advantages that were argued for the use of point sampling was first and foremost the possibilities for good control with the quality. The possibilities for analyses of the accuracy of a point sample depend very much on the number of points. Separate and thorough studies on the subject of inaccuracy were conducted.
A system of classification of land use/land cover was designed for the point sampling. At the level of the point of registration the physical land cover was observed. For the site (land use in the field) and the land use in the larger surrounding area, classification systems for the main use of land in the area were established.

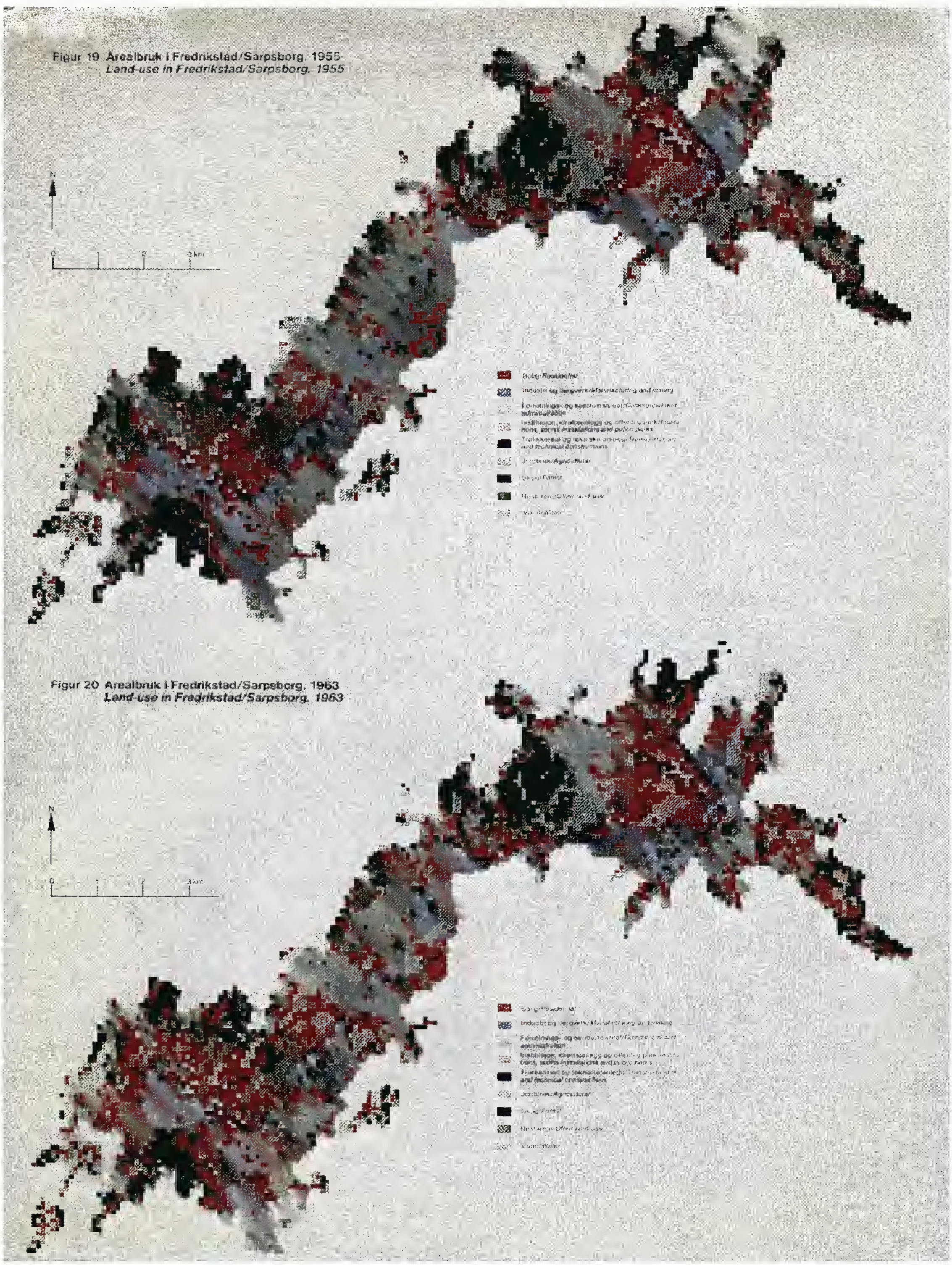
The whole system was designed for monitoring for status as well as for land use/land cover changes over time (figure 13).

Figure 13. Principles for registration of land cover changes at the level of point



The map below illustrates the land use registered at the level of site pr 1975 in the urban settlement of Fredrikstad/Sarpsborg. Each observation is done on a grid of 100 x 100 metres. The land use statistics showing the total distribution on the main classes of land use is aggregated (figure 14).

Figure 14. Land use statistics maps based on point sampling on aerial photos 1975. The urban settlement of Fredrikstad/Sarpsborg. 1963 and 1975



5.2. Land use statistics based on the use of registers

The establishment of a complete building and property register combined with the implementation of geographical information systems (GIS), opened up for new approaches for production of land use statistics for urban settlement and other built up areas. The development of methodologies and production of basis statistics was done in 1989 and 1993. At the same time the need for statistics showing the urban sprawl was more explicit requested.

In 1989 methodologies for calculation of urban settlement growth were developed as a pilot. The data sources were the official Ground Property, Address and Building Register (GAB) and analogue economical thematic maps (ØK) with the scale 1:10 000 or 1:5 000. With this accounting system the transition from not build up areas as found in ØK changed into built-up areas as new buildings were registered in GAB. The objective was to be able to follow the irreversible transition of land. The method was based solely on registration of building licences in the GAB register, and based on experiences from earlier more complete statistics, it was assumed that built-up land in connection with buildings would account for 4/5 of the total built-up land.

Land use class was assigned to the areas adjacent to the new buildings based on activity codes and building type.

Information on the actual ground property on which the building is constructed can be found in the G part of GAB. A square proportional to the ground property size was constructed around each building point, and if the point from the sample was overlaid this grid, the grid was assigned the land use class from the attribute files of the building (statistics at the level of a site). For some buildings there were lack of information about the area of the ground property. For some instances the areas also could be so large that it was not reasonable to assign the land use characteristics of the building to the total area of the ground property.

A special routine for handling these instances was developed; if the ground property area was within the limits of 1.5 to 15 times the size of the ground surface of the building, the site was designed with the same size as the ground property area. If the ground property area was less than 1.5 times the building's surface, the site was set to 1.5 times the building surface. Finally if the ground property was larger than 15 times the building's surface or, if the ground property area was missing, the site was fixed at 6.4 times for buildings less than 900 m^2 and 5.1 times for buildings equal or larger than 900 m^2.

A collection of points, representing buildings, and other set of points (a sample net with grid equal to $100m^2$) were compared for nearness. Sample points that were found within a certain distance of building points in the direction north and east of centre points of buildings were assigned values as built-up. The square of which the building-point formed the centre was assigned the attributes for land use according to the building type.

In a more recent version of the method and the update of land use statistics, it was used an automatic simultaneous sampling with GAB as the basic information. In this project land use classes were retrieved from earlier versions of land use accounting points, and two data sets based on the agricultural census 1979 and 1989.

6. Evaluation of available data sources

6.1. Introduction

The Nordic countries have, out of historical reasons, long traditions with the use of administrative registers. Norway has a relatively power-full and centralised administration. The power is partially delegated to a regional administrative level with 19 counties and a local level with 435 municipality administrations. Information on population, construction activity etc. that is registered and used in the daily work at the administrative level of the municipalities, is automatically flowing to and from central registers for storage and common benefit. Statistics Norway has, according to a special law, access to these registers in order to enable for exploitation of the data for production of official statistics.

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

The core system of land use statistics that now is under development in Statistics Norway is mainly 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 (CBR)

The most important advantage of using administrative registers, with geo-referenced information, for deriving land use statistics, is the possibility of establishing a direct link between physical land use and socio-economic parameters. Continuously updated information is available and allows for following the dynamic nature of urban activity.

The disadvantages of using administrative registers are that only constructions/observations of high importance for administrative purposes are found in the registers. The possibilities for deriving land use statistics are also limited to the already established classifications in the register systems and to the quality of the register information.

6.2. The official register for Ground-properties, Addresses and Buildings (GAB)

GAB consists of three mutually linked registers where the A- and G-part comprise information about addresses and ground-properties. The B-part comprises information of all buildings larger than 15 m^2 including co-ordinates. The register comprises information on 2.3 million ground properties, 1.7 million addresses and 3.4 million buildings. It is under the responsibility of The Norwegian Mapping Authority and is anchored in a separate law. The municipalities are obliged to report to the register.

For production of land use statistics, the following parameters are extracted from GAB:

- type of building (class 0-99)
- building ID-number
- estimated ground surface of building
- date for building taken into use
- different geo-referencing identifiers including co-ordinates (municipality, basic statistical unit, street-address, ground property address etc.)
- activity class (the user)
- size of ground property on which a building is located

The GAB information concerning ground surface of building and the date for the building taken into use for older buildings (built before 1983) is not completely filled in. Also the information about the size of the ground property is far from complete in the register for older buildings. However, the register will be improved due to initiatives like:

- The Mapping Authority has launched a project where the objective is to make a close link between large-scale digital property maps and the GAB. This will improve the ground-property part of the register.

- With the Population and Housing Census planned for 2001, Statistics Norway and The Mapping Authority is now co-operating on a project in order to introduce the flat/dwelling as a parameter in an extended GAB - the dwelling register.
- The Norwegian Authorities for National Heritage has in the recent years co-operated with the Mapping Authority with the objective to extend the GAB register with special information about older buildings - the SEFRAK register.

As a sum, all these activity and active use of the GAB register is expected to improve the quality of the register considerably. It will also open up for new possible statistical products due to better information about dwelling sizes and market prices per m^2 of dwelling area and better possibilities to monitor the changes in the stock of older buildings of special cultural heritage value.

6.2.1. Type of building and kind of activity - quality and completeness

The kind of activity linked to the building is classified according to the Standard Industrial Classification (NACE). The information on kind of activity is not completely filled in for all building in the register. This is the situation especially for buildings constructed before the year 1983. In addition it is difficult to evaluate the quality of the information about type of building and activity without knowledge of local conditions.

However, from end of year 2000 will it for statistical purposes be possible to update the activity classes for all buildings in which registered activities are taking place. This will be based on information from the continuously updated Central Register of Establishments and Enterprises. For the residential buildings, situation of use is more stable over time and the up dating routines of GAB should be sufficient.

For buildings registered after the year 1983, the information on type of building and kind of activity is much more complete, and thus GAB constitutes a sound basis for statistical approaches on recent and future changes.

6.2.2. Ground surface of the building - quality and completeness

For the whole country 26 percent of all buildings registered in GAB has information about the size of the largest floor/level in the building. This is used to calculate the ground surface of the building by a simple vertical projection. The completeness of information filled in varies to a large extent between the municipalities. The median value of completeness for this parameter in the municipalities is 17 percent (figure 15).

For calculation of the ground surface size of each building, it is used a system for imputation of missing values stratified on each building type. Routines for calculation of accuracy for estimated ground surface of buildings are developed (standard deviation and confidence interval):

For buildings where information about the ground surface is lacking, statistical methods for stratification and imputation are used. A special routine for calculation of a statistical quality expression is introduced (Box 2).

As for all information in the GAB register, the information is much more complete for buildings constructed after 1983.

Box 2. Estimates for accuracy of ground surface of buildings

t urban settlement.
h stratum. With a total population of H strata.
N_{th} is number of buildings in stratum h in urban settlement t.
n_{th} is number of buildings with information about ground surface in stratum h in urban settlement t.
N_h is number of buildings in stratum h.
n_h is number of buildings with information about ground surface in stratum h.
a_{thi} is ground surface of building number i in stratum h in urban settlement t.
r_h is number of buildings with registered ground surface in stratum h.

$\overline{r_h}$ is number of buildings without information about ground surface in stratum h.

1) $\overline{a_h} = \frac{1}{n_h} \sum_{i \in r_h} a_{hi}$ is average ground surface of buildings with registered area in stratum h, and this is used as imputation value in this stratum.

2) $s_h^2 = \frac{1}{n_h - 1} \sum_{i \in r_h} (a_{hi} - \overline{a_h})^2$ is estimated variance in stratum h.

$s_h = \sqrt{s_h^2}$ is estimated standard deviation in stratum h.
r_{th} is number of buildings with registered ground surface in stratum h in urban settlement t.
A_t is estimated total ground surface of buildings in urban settlement t.

3) $V(A_t)$ is estimated variance of total ground surface of buildings in urban settlement t.
$se(A_t) = \sqrt{V(A_t)}$ is estimated standard deviation of total ground surface of buildings in urban settlement t.
4) Formula of variance of estimated total ground surface of buildings in urban the settlement

$$A_t = \sum_{i \in r_{th}} a_{thi} + (N_{th} - n_{th})\overline{a_h} \ .$$

5) Formula of estimated standard deviation of calculated total ground surface of buildings

$$V(A_t) = \sum_{h=1}^{H} \left[\frac{(N_{th} - n_{th})^2}{n_h} + (N_{th} - n_{th}) \right] s_h^2$$

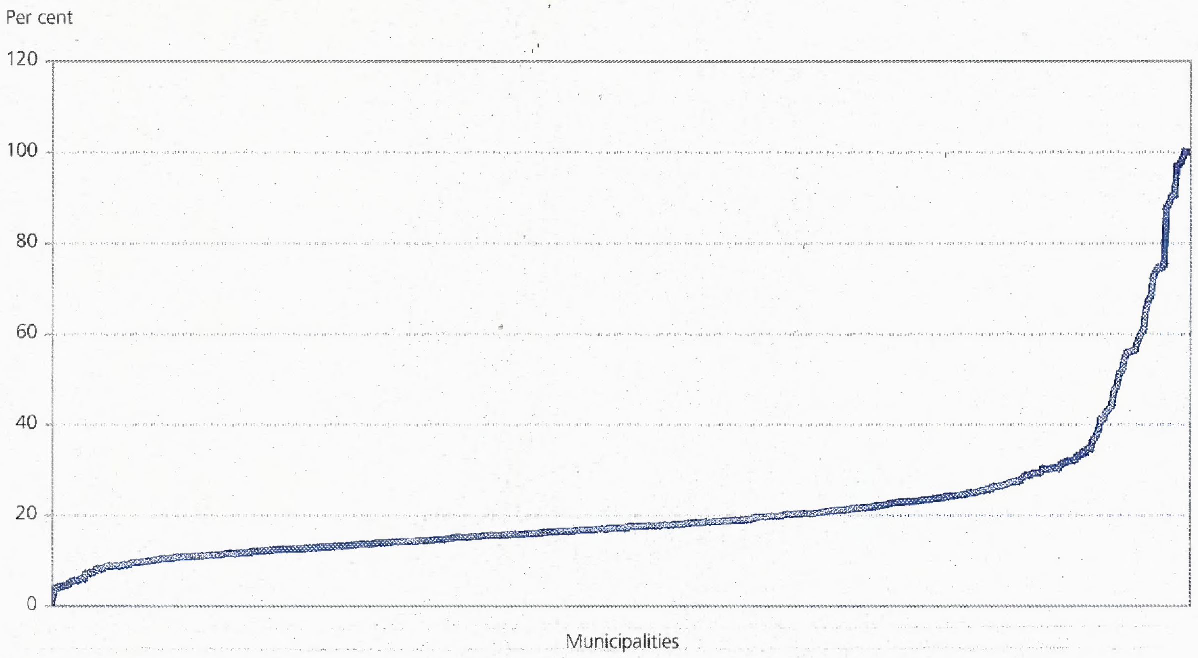
.is formula for estimation of standard deviation for total ground surface in the urban settlement
$se(A_t) = \sqrt{V(A_t)}$ is formula for confidence interval.
Lower limit for confidence interval of 95% is $A_t - 2 \cdot se(A_t)$.
Higher limit is $A_t + 2 \cdot se(A_t)$.

6.2.3. Other parameters extracted from GAB - quality and completeness

The completeness of information about the size of the ground property is 52 percent filled in at the level of the whole country. The variation at the level of municipalities is considerable. However also for this parameter the information is more complete for recent established properties. The quality is continuously improved amongst others due to the better link between digital maps and GAB.

A simple control of the quality of geographical co-ordinates reveals only a few out-layers of buildings. These are either hundreds of kilometres wrongly positioned with obviously wrong registration of x or y co-ordinates, or they are positioned in water when checked towards digital maps.

Figure 15. Completeness of the information about ground surface. Municipalities. 1998. Percent



6.2.4. Conclusions

The main objective with the statistics produced is to observe the changes of land use over time and to deliver a rough estimate or indication of trends for comparison between municipalities and over time. Figures for the total stock of buildings or land use will be approximations until the register is considerably improved.

It is the information about ground-surface of each building and the size of the ground property that are the two most important parameters for the statistics. Through extensive use of the GAB data and due to combination with other data sources, having the objective of the work in mind, it is concluded that the information is «good enough» for delimitation of urban areas and aggregation of land use statistics.

The work concerning quality and quantity improvement is continuously ongoing. It is considered as very important to take the register information into use, and thereby visualise the importance of improving the register information.

6.3. The Central Population Register (CPR)

The Official Central Population Register (CPR) is under the responsibility of The Norwegian Taxation Authority. The register is continuously updated and a copy of this register is available in Statistics Norway. The following parameters are extracted from this register for land use purposes:

- Addresses and number of persons resident
- Age and sex
- Different geo-referencing identifiers matching the data from the GAB register

This register is well established and is of high quality and it is complete.

6.4. The Central Register of Establishments and Enterprises

This is a statistical "shadow" register established as a tool for production of statistics, and it is managed by Statistics Norway. The register is constructed with links to several administrative registers and also updated with survey information. The information available is 1-2 years delayed compared to real time.

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.

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 total turnover and number of employees which opens for analyses of economy, related activity and the use of land.

6.5. The Official Road Database (Vbase)

The mapping authority has, in co-operation with the responsible sector authority, a geo-database (Vbase) comprising the centre line of all roads (except special roads for bicycling and footpaths) and a few linked attribute data such as type of road and segment number.

This information is accurate and timely. Every new constructed segment of roads longer than 50 meters are registered annually. At the present it is a weak point with this register that routines for storage of historical data is not implemented.

This database is used to calculate length and area of roads in urban settlement. The following tentative width of roads inside urban areas are used (including pavement and shoulders):

- National and European roads 15.0 metres
- County road 13.5 metres
- Municipal road 11.0 metres
- Private road 10.0 metres
- Forest road 4.0 metres

The above average figures are not suitable for all conditions and local variations of roads. Therefore expressions like length of roads per urban settlement area etc. will return the most accurate statistics. Nevertheless also statistics in terms of km^2 or hectare are calculated in order to have complete land cover statistics, but such figures should be used with care.

The authority that is responsible for roads has a comprehensive database with attribute data for the administration of national- and county standard roads. Therefor it is possible to perform accurate calculations of area covered by this kind of roads. However, inside urban settlements the network of municipal/local roads is dominating. It is the local administration that is responsible for these roads, and the detailed information about quality and width is not at the present submitted to the central databank - Vbase.

For complete network analyses used as basis for area- and transport statistics, information on short-cuts, foot-paths and bicycle roads is required. Some of the biggest and most resource-full municipality administrations have already implemented these kind of roads in Vbase or products derived from Vbase.

The Norwegian authority responsible for the roads, has now launched a project in order to improve the availability of information about the road network (NORVEG). A new database and improved users interface will be established. The main advantage will be a closer relation between attribute information and the digital net of roads as well as better topology and improved possibility for network analyses.

6.6. The Official Register for Sport Grounds (KRISS)

The Norwegian Ministry for Culture is responsible for a register covering geo-referenced information on all sport grounds and athletic fields. The register is updated annually by the municipalities and is centrally managed.

For some establishments the total area covered can be found in the register. For others length and width are available and area can be calculated. It is the centre- /representation point that is given with co-ordinates in the register. This point can for some instances represent several adjacent sport grounds and objects.

The part of the register that comprises geo-referenced information is in the year 2000 exploited for the first time by Statistics Norway. So far it is observed a considerable amount of missing values, and the register must be characterised as not having the best structure for the purpose of creating land use statistics. However, during the spring 2000, the information is implemented in our land use statistics as an important source enabling us to calculate estimates for land use/cover of green parks and sport installations.

Communication with the register owner is established, and steps for improvement of the register are being taken.

6.7. Digital data from maps

Digital data from maps in the scale 1:50 000
The Norwegian Mapping Authority delivers digital vector data with full topology on coastline, rivers and lakes in scale 1:50 000. Also administrative boundaries and railroad are delivered in this format. According to the producer, these maps are recommended for use in the interval of scale between 1:20 000 and 1: 100 000. This scale has been the basis for calculation of general area statistics for decades in Norway (total land, freshwater, glaciers by county or municipality etc). This map will also be used as a basic source for urban settlement statistics.

Digital data from maps in the scale 1:10 000
Digital ground-property map (DEK) is the geographical expression of the G-part of GAB. Ground properties are represented with polygon topology and attributed information about municipality-, property-, site- and parcel number.

By implementing DEK into the process of producing land use statistics, it will be possible to draw the accurate geographical extent and shape for each property. At the present this source is in the phase of being established for many parts of Norway. This means that for many of the Norwegian municipalities this map is not yet ready for practical use in a GIS system.

The Mapping Authority is establishing DEK for rural areas, while the municipality administrations have the responsibility for mapping of urban areas. A copy of work done in the municipalities is distributed to the Mapping Authority.

The integration of DEK and GAB will in the future lead to a more complete database for ground property areas, but the work with land use statistics will have to be conducted without the use of DEK until this source is more complete.

Digital soil map (DMK) is the national map series for arable- and wooded land. The database describes geographical position, boundaries and extension for type of soil, potentials for biological growth and area condition. Especially in connection with urban expansion, DMK will be a useful data source for analyses on what was the original use of land before it was built-up.

Per January year 2000 it is available approximately 3 700 km^2 of area covered by DMK fully digitalized. This covers more than one third of the total Norwegian agricultural area. For the next years it is planned to finish 220-230 km^2 of area covered by new maps per year.

The responsible institution for this map is the Norwegian Institute for land Inventory (NIJOS).

6.8. The Official Register for Income and Taxes

This register comprises information about personal income and taxes for the population, and is an important data source when economic parameters are linked to land use.

6.9. Other data sources for possible use

The discussion on the possibility for establishing a centrally managed and regularly updated archive with processed satellite images is going on in Norway. If this archive is established, it is expected to become an important source for additional information on the use of land (land cover) in urban settlements and adjacent areas.

The combination of satellite images and register based delimitation of urban settlement can also make it possible to compare urban area statistics with other European countries that do not have the advantage of possessing comprehensive administrative register data. More important is however the possibility for localisation and delimitation of "green" and "grey" areas. This has been successfully tested in co-operation with the Mapping Authority (Project report 2-98).

An archive of satellite images will be an important and positive step if the system of Corine Land Cover is to be established in Norway. It is at the present not clear if such an archive actually will be established, and if Statistics Norway will have economic and physical access to processed data from this register for statistical purposes.

7. Land use classification with links to NACE

7.1. Land use classes and terminology

Classification means in general terms a division of objects into distinct separated groups. Each object must belong only to one group. The goal is that the variation between groups of objects should be larger than the variation within groups. Classification is conducted in order to compress and make information more easily available.

A classification system should normally comprise a set of classes, criteria for classification and a corresponding nomenclature. Characteristics such as flexibility, continuity and simplicity are often highlighted as important for classification systems. It is important that the classification system can be adapted to new methods and tools that are becoming available.

In the early 1980s the Nordic countries had-, or were about to develop, comprehensive systems of land use statistics. In order to secure comparability it was agreed to utilise a common land use classification (Nordic Statistical Secretariat 1982). This classification was based on, at that time, preliminary suggestions for an ECE-standard classification of land use.

The Norwegian classification system was adapted to the point sampling technique, but still it was well harmonised with the Nordic initiative at a certain level.

A preliminary classification of land use in urban settlements

The now operationalized and preliminary classification for the built-up parts of the urban settlements is based on the classification developed for the former system of land use account in SN in 1982. Only a few minor adjustments have been introduced as follows:

- the class mixed use is removed from the first level of the hierarchy
- a separate class for land under agricultural buildings is introduced
- several subdivisions at the second level of the hierarchical system are not yet specified

The classification covers what traditionally is considered as the main classes for land use related to buildings and roads in urban settlement areas.

The classification comprises two levels and it is open-ended so that it can be expanded both horizontally and vertically due to future needs.

Table 2. Main classes and terms for the use of land with buildings and roads in urban settlements

Level 1 - Dominating use on larger areas		Level 2: Land use on the site	
11	Residential land	111	Residential, low houses
		112	Residential, blocs of flats
12	Industrial land	121	Manufacturing and storehouses
13	Commercial land	131	Commercial and administration
		132	Mixed use - commercial and residential
14	Land used for public services	141	Institutions and public service
		142	Sport facilities
15	Land under transport and communication facilities	150	Communications[1]
16	Recreational land	161	Leisure houses
17	Agricultural land	171	Agricultural buildings
18	Other land use n.e.s.	180	Other land use n.e.s.[2]

[1] Subdivisions will be introduced for type of roads, railways, harbours and high voltage power lines etc.
[2] Subdivisions will be introduced for waste water treatment plants and land used for disposal of municipal waste

Level 1 is necessary as statistical units for division of the total urban settlement area into subdivisions that can be characterised by a dominating use of land on larger continuous areas i.e. industrial areas and residential areas.

Level 2 is designed to cover the need for classification of the area actually covered by a building and its adjacent influence area - the site.

The two levels are inter-linked, but not in a strict one-to-one relation. For example will an entity of residential land at level 1 normally comprise roads and open areas such as green parks in addition to one ore more residential sites as classified at level 2.

The classification is also in accordance with the most commonly used terms in the Norwegian system for municipal area planning activity. Only classes that can be assigned values from available registers are included.

The total area of an urban settlement can normally not be classified based on information about buildings, roads, enterprises etc. found in administrative registers. In order to establish classes that covers the whole universe of the urban settlement, the residual is called *not classified.*

A preliminary and simple classification of land cover in urban settlement areas
As a spin-off product of the work with land use, and in order to establish a complete systematic division of urban settlement areas as a tool for further work, a simple classification of physical land cover is drafted.

Table 3. Main classes and terms for the cover of land in urban settlement areas

100	Land under buildings and roads etc and adjacent influence areas
200	Open land
300	Water

7.2. Classification due to activity - national and international standards

Both buildings in the GAB-register and kind of activity units in CBR have attributed information about the actual activity linked to each record in the register. Activity information in the B-part of GAB (the activity of the main user) is classified by two systems, before and after 1996.

Before 1996 the buildings were classified due to the national Standard Industrial Classification (SIC83) system, which again was based on The Standard Industrial Classification (ISIC Rev 2). The highest level of this system had 9 divisions. A more recent classification system is now established - SIC94 - based on the Nomenclature générale des Activités economiques dans les Communautés Européenes (NACE Rev 1) at the first 4 levels.
Onwards from 1996, the attributes for the main user's activity in GAB are in accordance with NACE Rev. 1.

Table 4. The relations between different classification of activities in the old and the new system

SN83	SN94	Description
0	X	Dwellings
1	A	Agriculture
2	B	Fishing
3	C, D	Mining and quarrying, manufacturing
4	G,J	Whole sale and retail sale etc.
5	H	Hotels and restaurants
6	L	Public administration and defence etc.
7	M	Education
8	N	Health and social work
9	E, F, I, K, O, P, Y	Other activities

7.3. Types of buildings as registered in the GAB register

The B-part of the GAB-register contains for each record an attribute field with a code for the type of building. It is a total of 100 types of buildings in the system that is valid up to 1999. A more detailed division with code comprising three digits for the type of building is recently introduced, but not commented upon here.

Table 5. Building types in GAB register 1999

1	Residential house -general
2	Residential house- plain
3	One family house with studio etc.
4	Two family house vertically divided
5	Two family house horizontally divided
6	Chain house
7	Chain house in atrium
8	Other small residential house
9	Blocks of flats 3-4 storeys
10	High houses and blocks of flats 5 storeys or more
11	Terrace house
12	Farm house/one family house on farm
13	Farm house/two family house on farm vertical divided
14	Farm house/two family house on farm horizontal divided
18	Other type of residential
19	Annexe
20	Undetached houses with 3 and 4 dwellings
21	Undetached houses with 5 or more flats
22	Linked one family house with up to 4 flats
23	Linked one family house with 5 or more flats
24	Two storey house with 5 or more flats
25	Combined dwelling house and other type of building –less than 50% of area used for dwelling
36	Combined dwelling house and other type of building –more than 50% of area used for dwelling
30	Industry/power plant
31	Storey building for industry or engineering work shop
32	Storey building for industry or engineering work shop combined with office
33	Manufacturing hall
34	Manufacturing hall combined with office
35	Silo
37	Telephone box
38	Transformer station
39	Other buildings for production
41	Office and administration
42	Shopping centre and other shop
43	Expedition and terminals
44	Storehouse and garage
45	Garage or annexes for dwelling house
46	Petrol station
47	Boat-house annexed to dwelling house
49	Other buildings for office, shop or communication
51	Hotel
52	Other hostel
53	Restaurant, cafe
54	Kiosk
55	Hut for rent, camping hut
56	Tourist hut
61	Building for education/research
62	Hospital, home for the aged etc.
63	Kindergarten
64	Church, chapel
65	Parish house, community centre
66	Theatre, cinema
67	Sports installations
68	Prison
69	Other building for public/private service
71-89	Different buildings for farming activities
91	Leisure buildings (cottages, summer houses)
92	Barrack/cabin
93	Outhouse/boat-house
94	Dwelling house used as holiday home
95	Year-round house, except farm house, used as holiday home
98	SEFRAK (building with special heritage value)
99	Other building

7.4. A link between Land Use- and NACE classification

The updating routines and completeness of the activity class in GAB is of varying quality in the 435 Norwegian municipalities. With the information on enterprises from the continuously updated CBR linked to buildings from GAB by their common numeric address, the CBR data are used to improve the information about the activities located to a specific building.

Some buildings can not be assigned one specific land use class, and accordingly they are compiled into the rest group *080 Other land use n.e.s.*

In order to operationalize the procedure of classification at the level of site, some criteria have been set up:

- If local kind of activity units of the class NACE: G,J,H,L,M or N are linked to residential houses, these buildings are coded as mixed commercial/residential.
- If several local kind of activity units are located in the same building, the building is classified based on the unit with the dominating representation.
- If several local kind of activity units are located to the same building, but non is dominating in number of units, the building is assigned the activity class of the unit with the highest number of employees.
- The Sports Ground register is used to classify 042 Sport facilities.

Table 6. Land use classification at the level of site. Building type and NACE

Land use class on site	Combination	Activity - NACE	Type of building - GAB
011 Residential, low houses	1	X	00-07,18,19,20-23,25,26,45,91,94,95
	2	E,F,I,K,O,P,Q,Y	00-07,18,20-23,25,26
	3	..	00-07,18,20-23,25,26,45
012 Residential, blocks of flats	1	X	08-10,24
	2	E,F,I,K,O,P,Q,Y	08-10,24
	3	..	08-10,24
021 Manufacturing and store houses	1	B	00-89
	2	C,D	00-89
	3	E,F,I,K,O,P,Q,Y	30-36,39
	4	..	30-36,39
031 Commercial and administration	1	G,J	30-42,44-89
	2	H	30-89
	3	L	30-59,71-89
	4	N	41-49
	5	E,F,I,K,O,P,Q,Y	41,42,44,46,49-54
	6	..	41,42,44,46,49-54
032 Mixed use –commercial and residential	1	G,J,H,L,M,N	00-29
041 Institutions and public service	1	L	61-69
	2	M	30-66,68-89
	3	N	30-39,51-89
	4	E,F,I,K,O,P,Q,Y	61-69
	5	..	61-66,68,69
042 Sports installations	1	M	67
	2	..	67
050 Communications	1	G,J	43
	2	E,F,I,K,O,P,Q,Y	43
	3	..	43
061 Leisure houses/huts	1	E,F,I,K,O,P,Q,Y	91,94,95
	2	..	91,94,95
070 Agriculture (building sites)	1	X	11-13
	2	A	00-89
	3	E,F,I,K,O,P,Q,Y	11-13,71-80,82-89
	4	..	11-13,71-80,82-89
080 Other land use n.e.s.	1	X,A,B,C,D,E,F,G,H,I,J,L,M ,N,O,P,Q,Y	92,93,99
	2		19,37,38,45,47,55,98,70,81
	3	E,F,I,K,O,P,Q,Y	19,37,38,47,55,92,93,98,99,70,81
	4	..	

7. 5. Further improvement of the system of classification

The work with land use statistics for urban area is in a continuous process. New data sources become available step by step, as well as new software and machinery enlarges the possibilities for taking data into use.

Working with classification in the project period, it soon became clear that it was very difficult to cover all the relevant dimensions of information required for complete statistical cover of the use of urban settlement areas both at a national and at a local level in one hierarchical classification system.

However, new possibilities for combination of data are opened by the introduction of GIS technology. This makes it possible to develop or combine already existing systems of classification through several «layers» and along different dimensions such as:

- Actual land use
- Planned land use
- Restrictions on land use
- Physical land cover
- Soil quality
- Value of land (physical/monetary)
- Centre/periphery
- Intensity of use/potential use - density of population and constructions - brown areas

The objective with the preliminary classification for use of urban settlement areas developed in this project is that it should constitute a basic layer for a future more comprehensive system of classification.

During the project period, several dimensions of land use/land cover have been combined with the basic layer developed:

- A simplified classification of soil condition
- Classification of planned use according to the municipalities area planning and the legal act on planning
- Classification of different restrictions on land use (cultural heritage, environmental regards)

Work with comprehensive classification systems for area statistics is going on at national- and international level. Examples and important as guidelines for traditional and hierarchical classification systems are Corine Land Cover, Eurostat CLUSTERS and the UN/ECE Land Use Classification.

The Finnish project SLICES goes further and combines several dimensions of land statistics through a set of thematic layers (National Land Survey of Finland, 1999). The objective with the Finnish project is to establish a national standard that also can be used for international reporting. A Norwegian version of this work seems to be a highly actual direction to go for further work.

It is clear that the classification system developed for this project will have to be expanded further as a continuous process according to national development work and signals from users. In addition we will have to adapt to agreements on European standards, when such are achieved.

8. Delimitation of urban settlement areas

8.1. Introduction and definition

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

Statistics Norway introduced the term «Urban Settlement» as a statistical unit for the first time in connection with the Population and Housing Census 1960. Since then the work with delimitation of urban areas has been conducted every ten years in connection with population and housing censuses in Norway.

Since 1980 the definition has not changed, but due to manual and subjective work with delimitation done by different local administrations, it has been difficult to follow the change over time of physical distribution and growth of urban settlement in terms of areas.

Statistics Norway has during 1997 and 1998 developed and documented a method for automatic and computerised delimitation of urban settlement. The method is based on the use of continuously updated administrative registers on buildings and population. The method developed ensures that the dynamic boundaries of urban settlements can be objectively delimited in a cost-efficient way.

The method and the derived boundaries of urban settlements are onwards from January 1999 implemented in the portfolio of Statistics Norway's standards. Annual statistics on population, total area of settlements as well as geographical distribution of settlements will be produced.

Box 3. The Norwegian definition of an urban settlement

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 built-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 belong 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 the number of urban settlements and their boundaries will change over time, depending on construction activity and changes of resident population.

(Unofficial translation 1999)

Compared to the recommendations given by ECE (UN/ECE, 1998) and the common Nordic definition from 1980, the most important difference to the Norwegian definition of urban settlements is found in the criteria of distance between buildings.

The Norwegian pattern of built-up areas, often stretching in long continuous bands along fjords, coastline and narrow valleys, has made it necessary to establish a strict criteria for maximum distance between buildings in the general definition of urban settlements. In the Nordic definition and in the ECE recommendations this criteria is decided with a maximum of 200 metres between buildings while the Norwegian definition has 50 metres as the general requirement for maximum distance between buildings.

The now operationalised Norwegian definition opens for some more flexibility for accepting distances more than 50 metres. It should therefore be clear that the intention of the Norwegian definition, and the results of delimitation due to the new method, can be regarded as being very close or equal to the Nordic- and international (UN/ECE) recommendations and understanding of the term urban settlement.

8.2. An operational set of criteria

The definition of urban settlement was primarily created for use in demographic statistics and analyses in order to trace concentrations of population. The definition is thus not very precise when the objective is accurately to define the boundaries and land related to the concentration of population. The wording of the definition comprises several terms of which the meaning have to be specified before an automatic routine for aggregation of boundaries can be programmed.

Work on developing a methodology and testing out criteria have been conducted in 1997 and 1998 by Statistics Norway. After a broad external hearing and thorough discussions in the project's reference group, the following additional operational criteria were agreed to be used for automatic delimitation of urban settlements:

- For a specified selection of building-types (building-blocks, industrial buildings, shopping-centres, office-buildings, store houses, hospitals, educational- and official administrative buildings) the general rule of maximum allowed distance between buildings is increased from 50 to 200 metres.
- The distance between the outermost building in the urban settlement and the settlement boundary shall be 25 metres measured from the building's wall.
- Urban settlements situated up to 400 metres apart shall be merged and counted as one settlement.
- Smaller hubs of buildings («satellites») with at least 5 dwelling-houses, industrial-buildings or other building as specified above, should be counted as belonging to the near by urban settlement as long as the hub is situated not more than 400 metres from the main urban settlement.
- Cottages and huts in the peripheral areas of an urban settlement should not be included
- The settlement boundaries shall be generalised and smoothed so that enclaves of land occurring due to irregular forms of the urban settlement boundaries («fjords») should be enclosed into the urban settlement area. This applies as long as the distance between neighbouring buildings on both sides of the «fjord outlet» does not exceed 200 metres.
- To secure continuity, especially for smaller urban settlements with longer tradition, special routines must be performed before such settlements are reclassified as rural. This in order to avoid "on/off" of marginal settlements The coastline will form the boundaries of urban settlements towards the sea.
- The area of rivers and freshwater is normally included in the total urban settlement areas.
- Manual adjustments of automatically aggregated urban settlements can be done in exceptional cases, but then with thorough documentation. Such adjustments occur f.exe. when large and typical rural areas is enclosed in the urban settlements. As a guideline such areas should be excluded manually if they exceed 1 km^2 of land.

8.3. Methodology and process

Computerised and automatic delimitation of urban areas is done in two separate steps. Firstly number of residents is geographically distributed to co-ordinates of addresses or buildings. Secondly a geographical information system (GIS) is used to aggregate polygons of urban settlements due to the agreed set of criteria. Thorough technical documentation is available (Rapporter 1999).

Linking information of resident population with building-attributes and co-ordinates
The merging of population from CPR and co-ordinates from GAB is done in several steps:

1. Based on A-part of GAB: Match on numeric addresses (municipality-code x ground-property-number or street number x parcel-number or the entrance-number's first level)
2. Based on G-part of GAB: Matching another numeric address on the same ground-property number
3. Based on B-part of GAB: Matching population to building co-ordinates due to address
4. By use of GIS: Simple allocation of unmatched rest population per municipality/basic statistical unit and ground-property-number, to the residential-buildings with no resident population allocated in the first three steps

The amount of match between population and addresses is depending on the status and quality of registration-work for the GAB register done by the municipalities. Also the quality of the address part of CPR is influencing the degree of success with matching (simple wrong spelling etc.). The rest group of unmatched population is for most of the 435 Norwegian municipalities less than 2.5 percent of the municipality's total resident population, which is regarded as an acceptable accuracy for delimitation of urban areas.

The final product of the process of matching population and addresses and thus adding co-ordinates is two data-files:

1. A data-file with addresses, co-ordinates and resident population
2. A data-file with attributes concerning buildings and building co-ordinates

Aggregation of urban settlement area
Firstly the data-file with building attributes and co-ordinates is loaded into a GIS (ARC/INFO). Thereafter a buffer representing the theoretical vertical projection of the building (the buildings ground surface) is created around each centre point of building as registered in GAB (figure 16). Outside this "building wall" it is constructed a buffer with radius 25 metres (or 100 meters depending on type of building). The criteria of density/max distance between buildings can then be checked. If also the criteria of at least 200 residents present is fulfilled, the polygon is registered as a urban settlement and established as a record in the database.

The final urban settlement boundary is established 25 metres outside the walls of the outermost building in the settlement, and the line is smoothened. The smoothening process is done by expansion/contraction-buffering; first outwards with 200 metres, and then inwards with 200 meters. The result is illustrated in figure 16 and 17.

Polygons that are registered as urban settlements and situated up to 400 metres a way, are merged to one polygon/urban settlement. The area and population of small hubs of buildings (satellites) situated up to 400 metres from the main urban settlement are coded as belonging to the main urban settlement, but not physically attached to it (figure 17).

Figure 16. Principles for delimitation of urban settlements

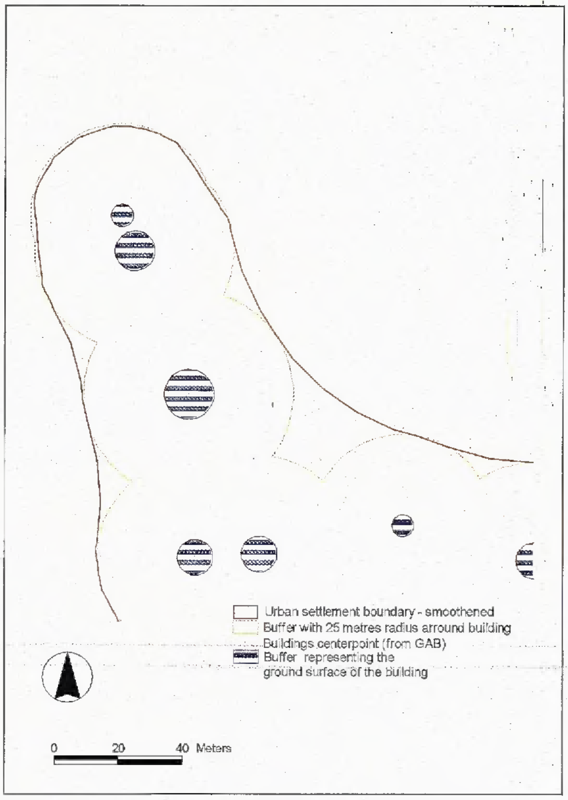
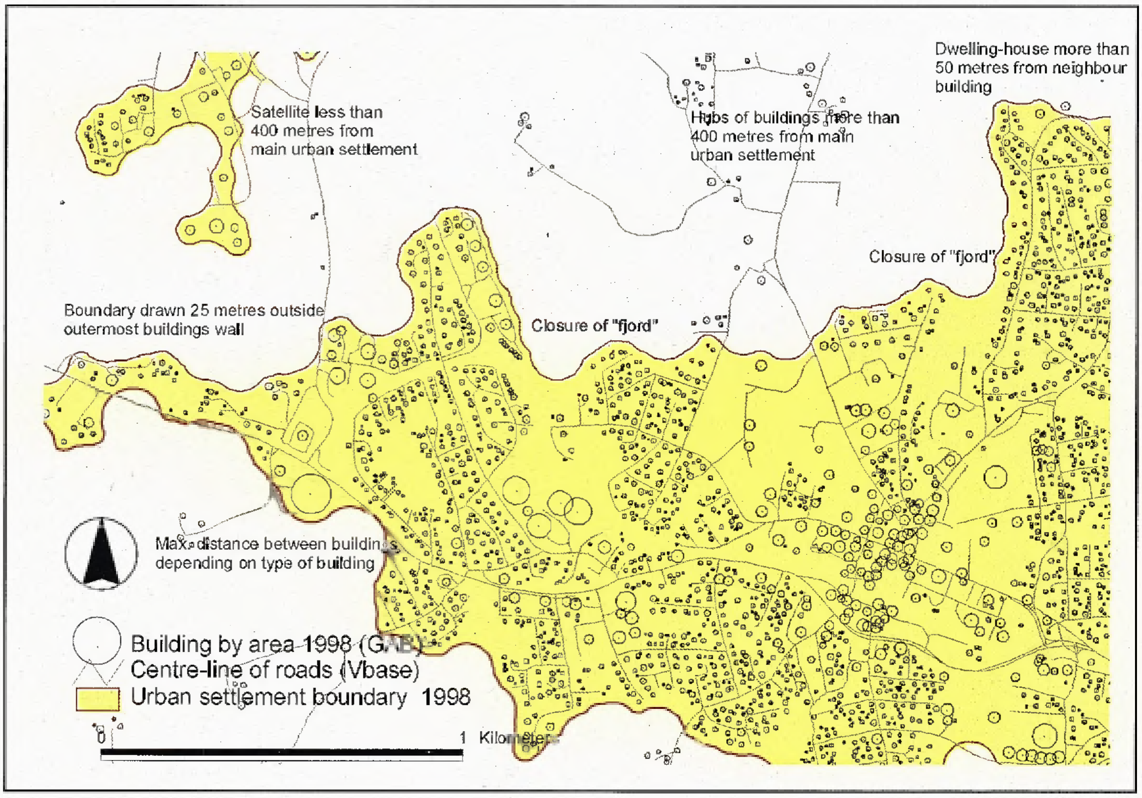


Figure 17. Part of an urban settlement. Buildings represented as circles with area proportional to the ground surface. Part of the urban settlement of Askim. 1998



Improved method based on extended data sources
Early the year 2000 some improvements were made to the method. This was initiated due to three reasons:

1. Available digital network of roads for the whole country made it possible to use roads to connect related urban settlements and neighbouring satellites with hubs of buildings in a geographically more correct way than what could be achieved solely by using buffer and smoothening techniques.
2. Introduction of register data for sport grounds (KRISS) made the delimitation criteria more complete.
3. Necessity of improving the methodology in order to achieve a consistent system for comparative statistics over time.

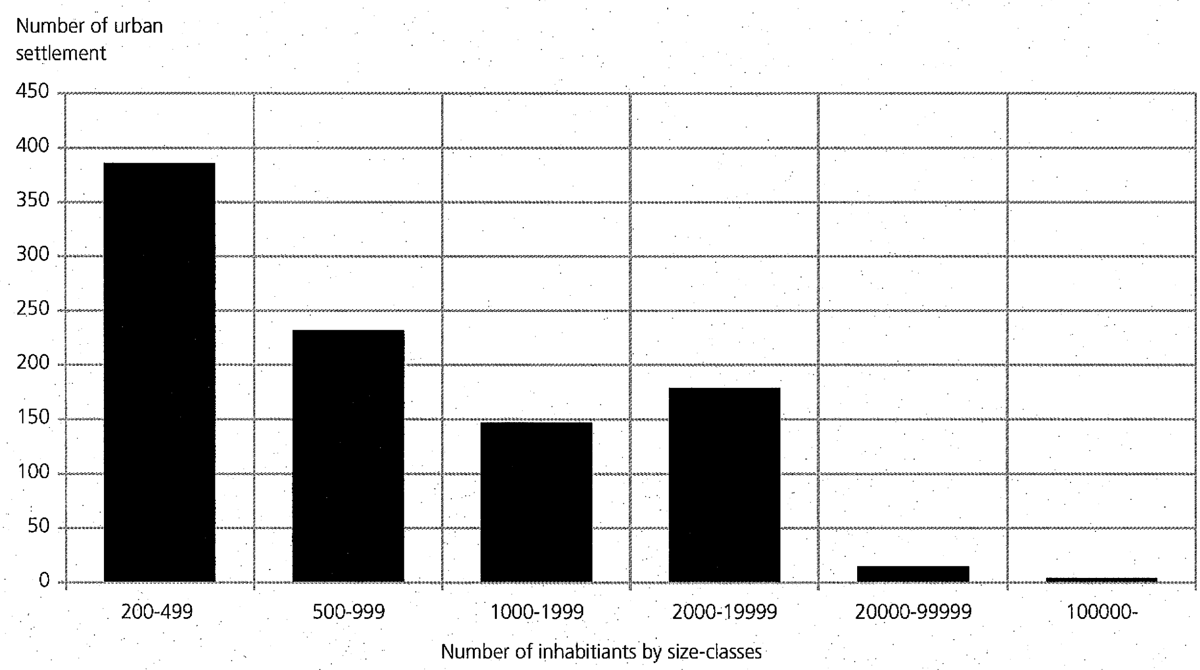
The result of the improvement is an urban settlement boundary more in accordance with the geographical and functional reality. The boundaries will be more closely connected to the areas with buildings. Finally, when establishing time series of urban settlement areas, characteristics from the previous delimitation process will be inherited. This will ensure consistent statistics and objective measures on the possible urban sprawl.

8.5. Results

For the year 1998, a total of 952 urban settlements with at least 200 inhabitants were delimited by use of the method. The total area of urban settlements was 2 026,1 km^2 or 0.7 percent of the total Norwegian mainland area. A total of 3 279 195 inhabitants, or 74,2 percent of the Norwegian resident population were living in urban settlements.

With the purpose of increasing the information-value of the statistics yielded, an overlay with the digital road-database was made and the land cover was calculated. Also the land covered by buildings was calculated.

Figure 18. Number of urban settlements by number of inhabitants. 1998



The capital Oslo with 754 552 inhabitants pr. 1998 is the biggest urban settlement in Norway measured both by area and by number of inhabitants. Most of the Norwegian urban settlements are small, and only 8 out of the 952 urban settlements had more than 50 000 inhabitants pr. 1998.

Figure 19. Urban settlements with at least 5 000 inhabitants. 1998

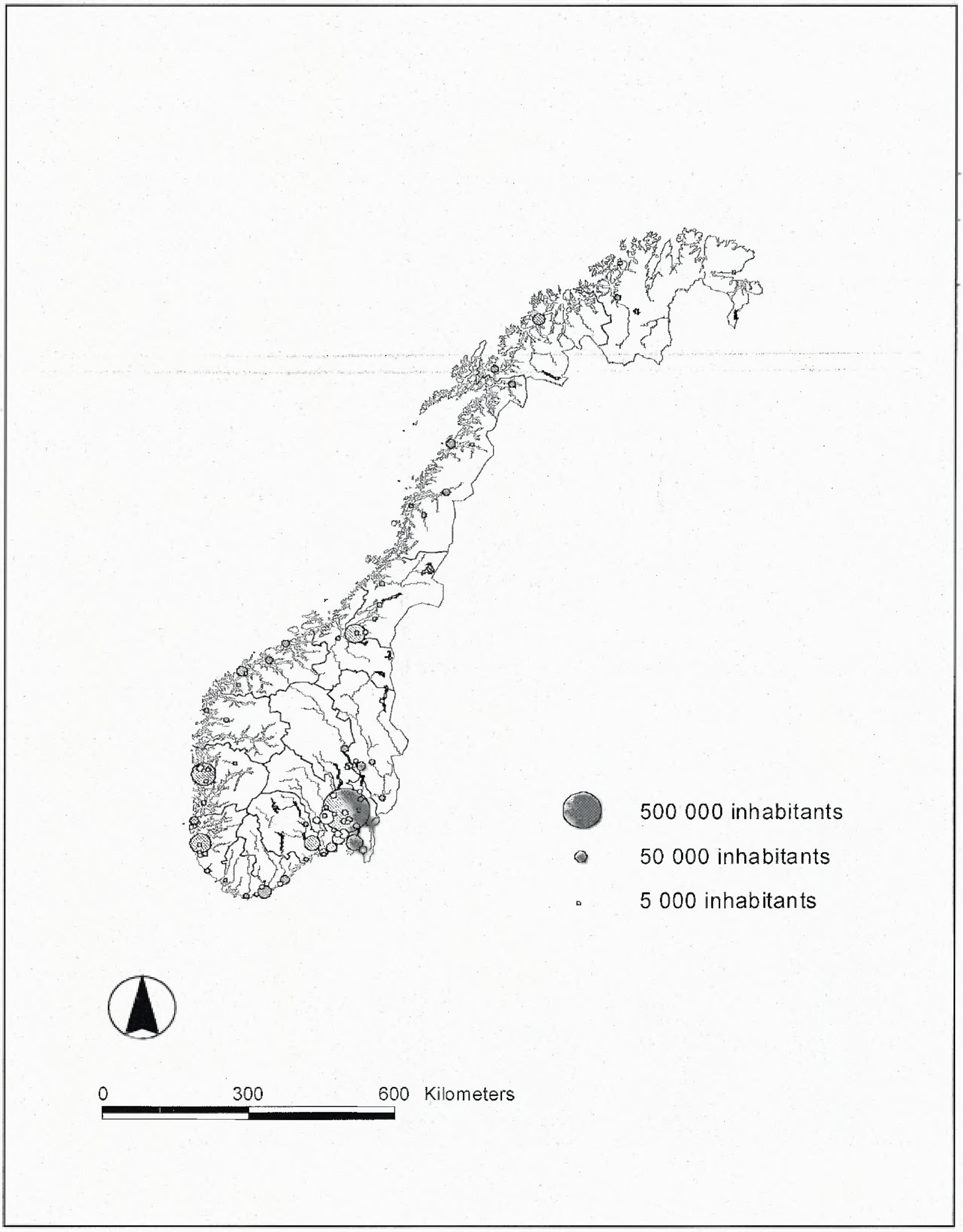


Figure 20. The urban settlement of Oslo. 1998

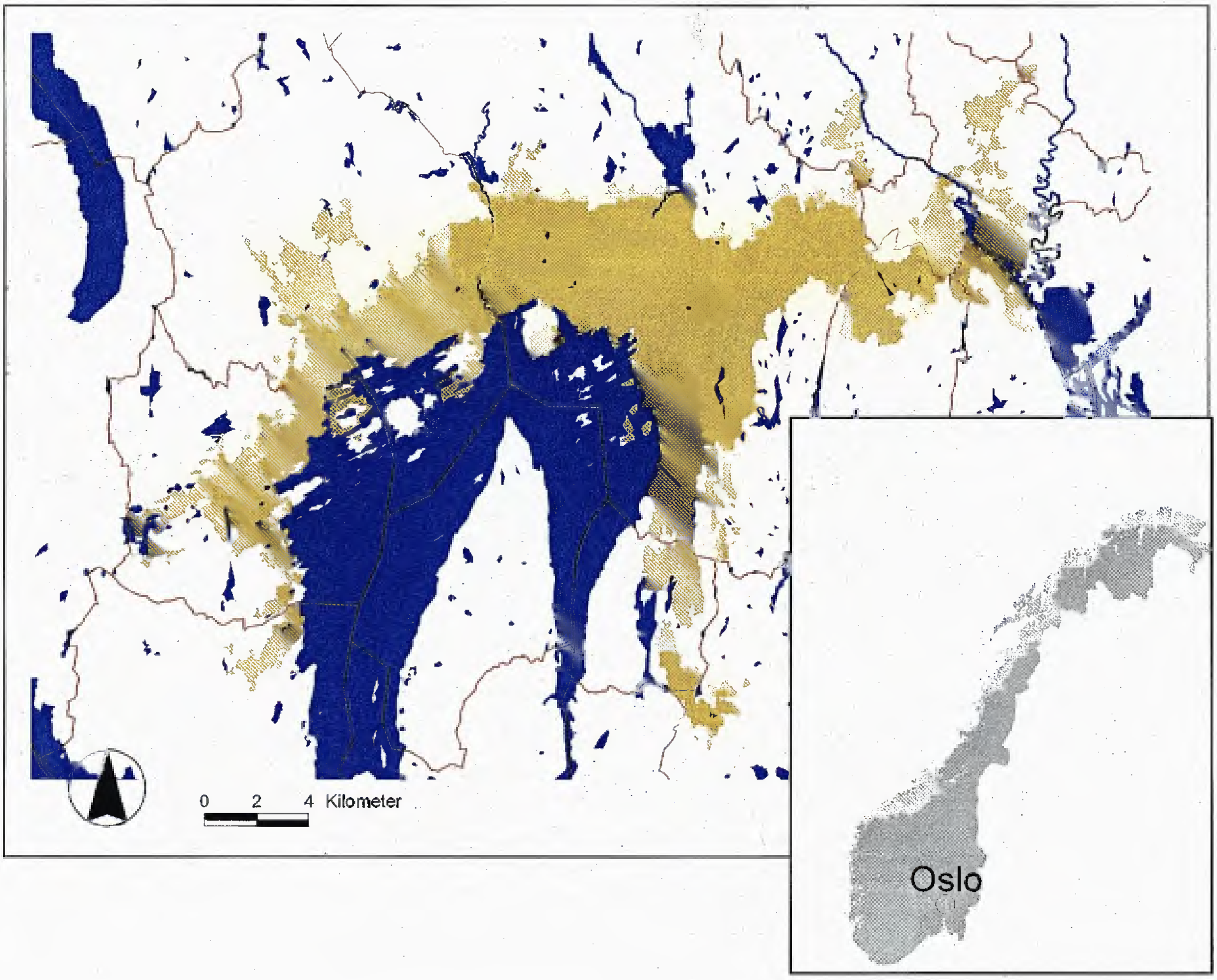


Table 7. Area, population and land cover of the five largest Norwegian urban settlements 1998

Name of urban settlement	Total urban settlement area km^2	Resident population	Area of roads km^2	Total ground surface of buildings 1000 m^2	Of which ground surface of dwellings 1000 m^2
Oslo	259.5	754 552	32.9	32 400	15 039
Bergen	79.3	197 573	14.3	7 015	4 323
Stavanger/Sandnes	59.6	143 857	9.5	7 768	3 700
Trondheim	56.1	137 108	6.7	5 258	2 853
Fredrikstad/Sarpsborg	61.6	91 442	9.1	5 860	2 801

Therefore the register method is chosen as the best method as basis for a national statistical system for information about the built-up parts of the urban settlements.

Figure 21. Land use classified by use of the grid method

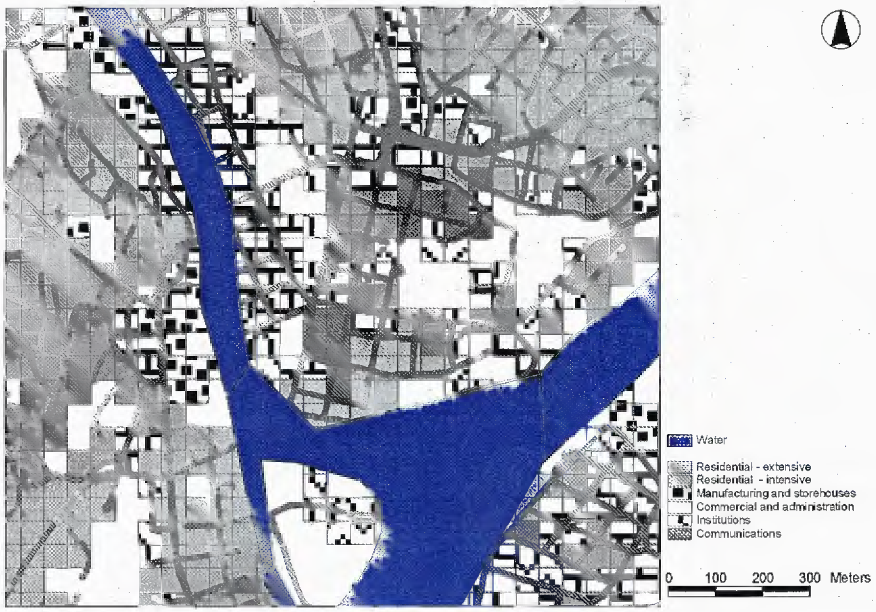
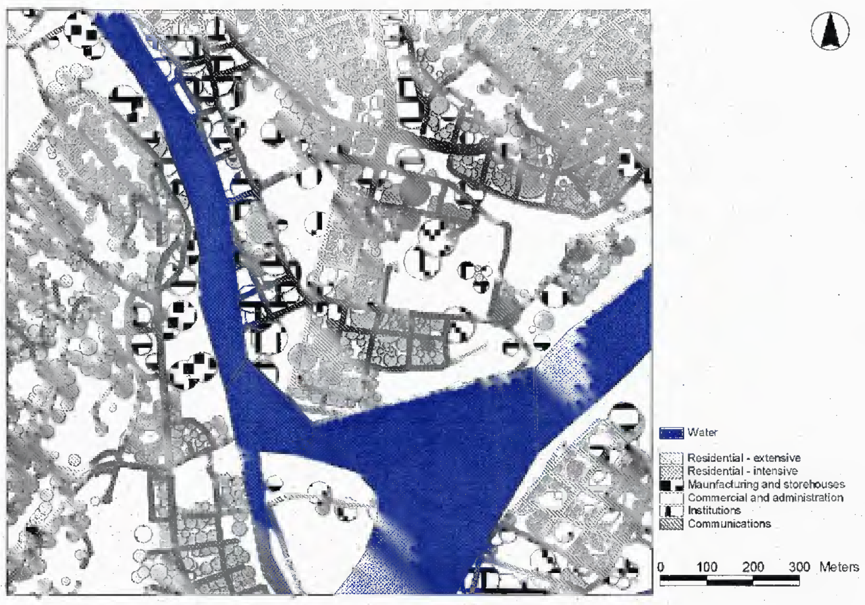


Figure 22. Land use classified by use of the register method



9.2. Methodology and an operational set of criteria

9.2.1. Land use on sites

The chosen register method is a further processed version of the former work on land use statistics conducted in Statistics Norway in the years 1989 – 1993. Instead of performing a simulated point