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Geographic information for land-use management

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Introduction

The interest in non-urban areas in the Netherlands has increased strongly. This necessitates careful management especially in rural areas where the influence of urbanization is present. Knowledge of the local situation becomes more and more important. These trends have an important impact on the development of land-use planning and on land-use policy making. For an efficient process it is important to use automation. The number of computerized information systems for geographic information has increased considerably (Visser et al., 1979). New techniques have been developed to collect and to present geographic information, by means of digitizing maps and the use of drawing machines in direct communication with computers (Visser, 1984; van Kleef, 1985b).

The application of fast techniques in the field of operational research improves the evaluation of the consequences of making decisions (van Kleef, 1983). The present paper gives a brief discussion on the requirements of geographic information systems. Two requirements will be discussed in more detail because of their importance for land-use management in general. Finally some developments in land-use management are given.

Requirements of geographic information systems for land-use management

In general the requirements of systems of geographic information for land-use management (van Kleef, 1983) can be presented in the following points.

- The concepts to be used in the framework of a geographic information system have to be defined strictly consistently. On the one side this is necessary for the decision makers for weighing out in decision making. On the other side this is necessary to create possibilities for calculations with the computer. The best solution for these requirements is to create files with data in a central place.
- A geographic information system requires data concerning the total of parcellation of the area including all kinds of land-use. Therefore this information system not only concerns the use of land of farmers, but also the land-use of others such as allotment gardens, hobby farming, and so on.
- To make it possible that a geographic information system can be used for a long time it is necessary that the available data are of current interest and easy to update.
- Geographic information systems have more value if the input data are flexible.

– The possibility for data linking with other information systems is important. If the systems are automated, it is necessary that the same data carrier is used.
– It is advantageous when data files can be used decentralized. In order to make it possible that every user of the information system can work at his own terminal, the software has to be user-friendly. Not every user is an expert in the different software systems and many users, policy makers for instance, want to use information systems only incidentally.
– The information systems should have possibilities for a flexible output. Flexible output and free selection of boundaries in tables, cartographic data and mapping play a prominent role in land-use management.

Linking of geographic data

A proliferation of automized geographic information systems about land-use, relief, soil, traffic and roads, water courses, nature, landscape, outdoor recreation and so on has occurred in land-use management in the Netherlands. These information systems are mostly stand-alone systems used for a specific purpose. An example is the Land Division Survey of the Netherlands (CIN, Cultuurtechnische Inventarisatie Nederland; van Wijk & Linthorst, 1977). This system is used for the preparation of land-consolidation projects particularly for the description of the allotment, the research of reallotment and the evaluation of reallotment. Especially for the preparation of land consolidation projects there is an increasing need to link the stand-alone automized geographic information systems. To automate the creation of a water management plan, for instance, information about soil, water sources, bridges, roads, and land-use is necessary. Most of these data are fixed on maps. The

Fig. 1. Part of the digitized topographic map of the land consolidation project Duiven-Westervoort (DIGTOP-LI).

automized calculation of combinations of independently digitized maps is possible. Systems of INTERGRAPH and ARCINFO software can supply this. Identification of the same elements in the field on different maps is, however, a problem (Visser, 1984).

In co-operation with the Department of Land Use Management of the Technical Computer Centre RAET, the Institute for Land and Water Management Research (ICW) has developed a low-cost system to combine different data bases. A geographic data base is constructed that is derived from the topographic map 1:10 000

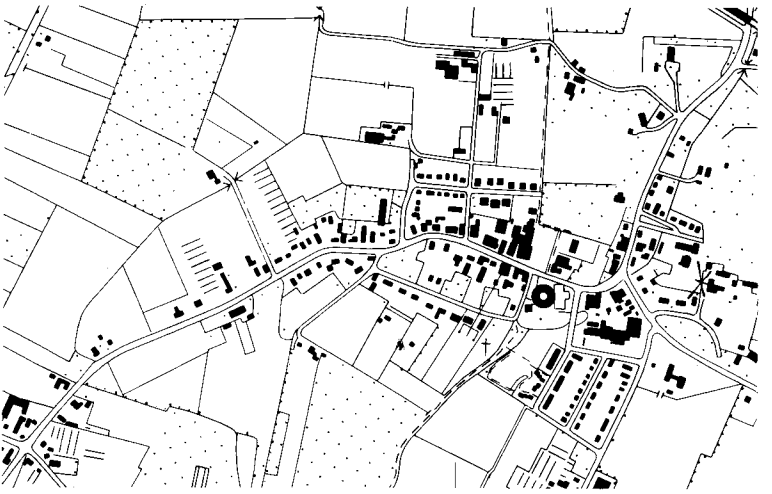

Fig. 2. Part of the topographic map of the land consolidation project Duiven-Westervoort.

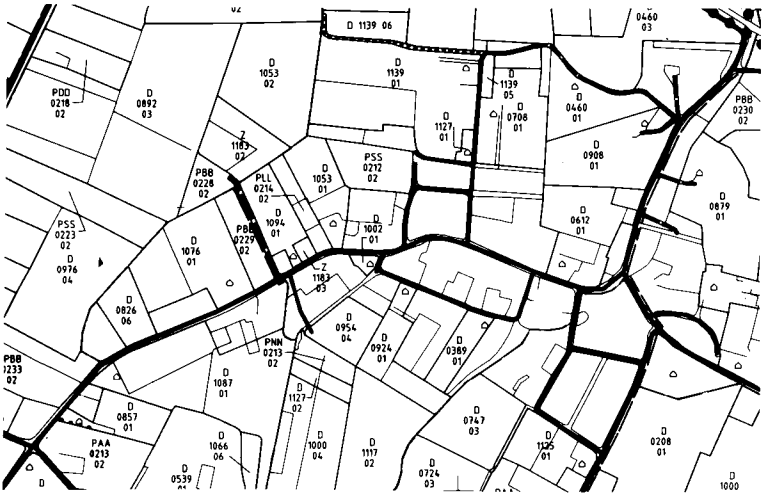

Fig. 3. Part of the land-users map of the land consolidation project Duiven-Westervoort; result of linking of DIGTOP-LI and Land Division Survey.

of the Topographic Service (Topografische Dienst). The base is called Digitized Topographic Map for Land Consolidation (DIGTOP-LI, Fig. 1; van Kleef, 1985a, b).

The most important function of the digitized topographic map is to serve as a common base for the different stand-alone geographic information systems that are relevant for a land consolidation project. In this way data entry, data linking, calculation, and production of tables and graphics output can be automated. It means that the map has to satisfy the following conditions:
- geographic orientation must be possible;
- it must contain the elements which are necessary to link attributes;
- it must approximate the exactness of the photogrammetric map 1:10 000 of the Netherlands (Fig. 2).

When Figs. 1 (DIGTOP-LI) and 2 are compared it will be clear that all line elements in the rural area are included in the data base. Buildings and symbols for smaller features such as dams, bridges and churches are not part of the base. The data of the base are trigoniometric coordinates for the Netherlands according to the photogrammetric maps of the Topographic Service, but also other coordinates are possible. The system supplies a phased data entry and data editing. The data of the map sheets are linked to each other, so it is possible to produce maps that in terms of scale, form and orientation are turned to the particular requirements of the user. Other benefits of the system are that maps can be produced in different qualities and costs (printer, hard copy, drumplotter, flatplotter, ink, ballpen, etc.) and that non-graphic linking is possible by generating unique area and line numbers. The most important benefits by using this system is the fact that digitizing and other activities which are necessary to build up a data base including control plotting etc. are minimized.

The DIGTOP-LI is used for the preparation of land consolidation projects. This means that each year 36 000 ha is added to the base. More important is that the base is used as a frame for a lot of geographic information systems such as the Land Division Survey of the Netherlands, water management survey and so on, that are carried out as part of land consolidation projects, as practised by the Government Service for Land and Water Use. An example of a land-users map as a result of the linking of DIGTOP-LI and the Land Division Survey is given in Fig. 3.

Flexible output

The most important agricultural data base in the Netherlands is the annual inquiry of farm data. This investigation is executed by the Central Bureau of Statistics (CBS). Each farmer has to co-operate with this investigation. This means that the base contains information about more than 160 000 agricultural holdings. Per holding 200 data are collected. It concerns data about the farmer (such as age and main occupation), about the labourers, the holding size, acreage, and production of individual crops and similar details concerning animal husbandry. A disadvantage of this data base is that the system is not designed for a flexible output. Moreover, the data are given in relation to inflexible geographic areas, which limits the possibili-

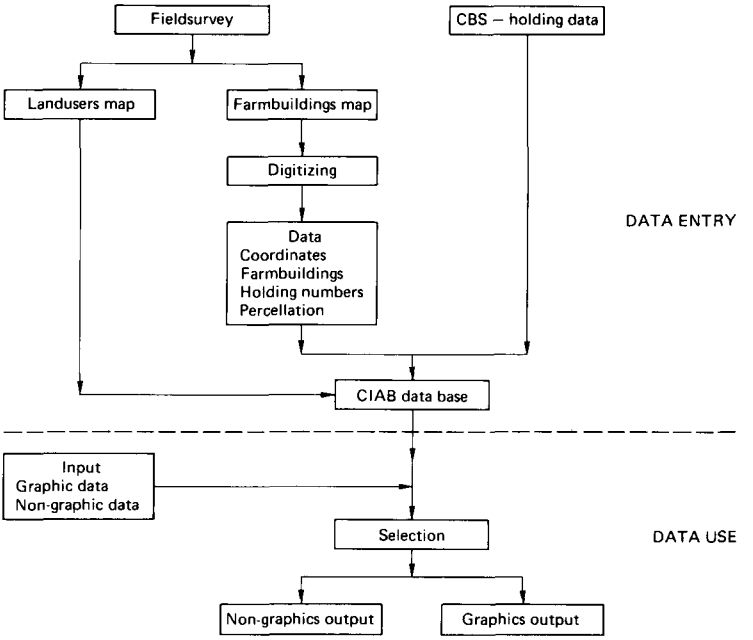

Fig. 4. Outline of the organization scheme of the Land Division Survey for General Land-Use Management (CIAB).

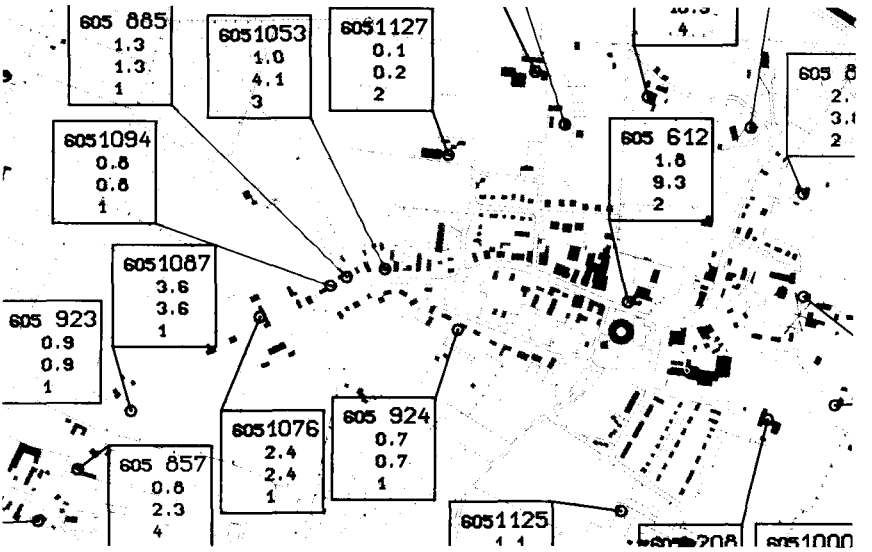

Fig. 5. Part of the farm buildings map of the land consolidation project Duiven-Westervoort (6051094 etc.: holding number, area of house compound lot, total area of the holding, and number of lots respectively).

ties. These areas are: the whole country, the provinces, the municipalities and some large agriculture areas. ICW was contracted by the Province of Gelderland to develop a geographic information system about agriculture for land-use management based on the combination of the land-users map and the CBS information. This system is called Land Division Survey for General Land-Use Management (CIAB from Cultuurtechnische Inventarisatie Algemene Beleidsvoorbereiding; van Kleef, 1985a, b).

Method

The method of CIAB is outlined in Fig. 4. After a visit to the farmers a land-users map and a farm buildings map scale 1:10 000 are composed and some parcellation data are collected. These data are the size of a holding, the acreage of land around the farm building and the number of lots. The land-users map is a map on which the lots of each holding are marked. Through this map the graphic data and parcellation data are kept up-to-date. This happens once a year. On the farm buildings map the location of the farm buildings are marked together with the holding number and the mentioned parcellation data (Fig. 5). Together with the CBS data per holding these constitute the CIAB data base.

Use of the CIAB data base

So far, the data base has been used for the selection of holdings relevant to a particular issue and for the production of tables and maps. Selection of holdings is possible with a list of holding numbers, a list of attributes such as the number of breeding-pigs and fattening-pigs or a list of expressions or attributes such as the sum of breeding-pigs <50 kg and fattening-pigs $\geqq 50$ kg. Selection can also be done by digitizing the boundaries of one or more areas drawn on a map.

Table 1. Selection of holdings with pigs within a particular distance to holding number 17400861; the distances are 250, 500, 750 and 1000 m. The table is taken from the Land Division Survey for general land-use management in the province of Gelderland in 1983.

Holding number	Map	x Coordinate	y Coordinate	Number of pigs	Distance (m)	Distance class (m)
1740 349	40BZ	199185	438667	104	605	750
1740 757	40BZ	199460	438216	42	556	750
1740 768	40BZ	199412	438525	5	403	500
1740 797	40BZ	199336	438622	199	456	500
1740 810	40EZ	200233	438768	39	455	500
1740 833	40BZ	199443	439038	530	510	750
1740 861	40BZ	199790	438664	363	0	0
1740 871	40BZ	199956	438716	148	174	250
1740 880	40BZ	199768	438128	110	536	750
1740 898	40EZ	200103	438614	100	317	500
1740 927	40BZ	199413	438375	358	475	500
1740 951	40EZ	200287	438985	557	529	750
1740 1003	40EZ	200413	439274	32	872	1000

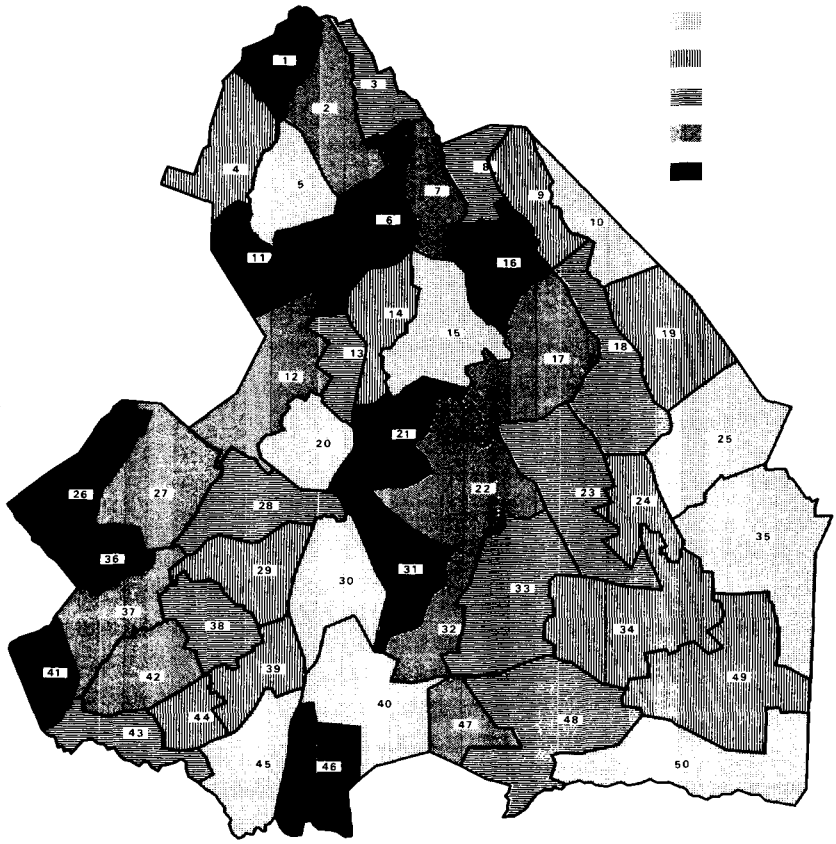

Fig. 6. A secondary map of the province of Drenthe showing five characteristics in 50 arbitrarily chosen areas. In this case the numbered areas were chosen because of the homogenity of the agricultural situation. The illustration is a practical example; the quality is in accordance with the poor output by the cheap printer-plotter.

With the selected holdings it is possible to produce primary and secondary tables and maps. The primary tables and maps give information on holding level. The tables are lists of holding data. It concerns the basic data or data that are translated by using an expression. For instance, it is possible to give a list of holding numbers which are situated within x kilometers from a defined holding (Table 1). The layout of the tables and the use of expressions are flexible. A primary map is a map on which the calculated results of the primary table have been plotted.

The secondary tables are cross tables with a high degree of flexibility. The secondary maps are plots of (sub)areas in which a characteristic is reproduced by marks or colours. The presentation of characteristics can be given in grids. Another example is the presentation of characteristics in chosen areas produced by a printer plotter (Fig. 6).

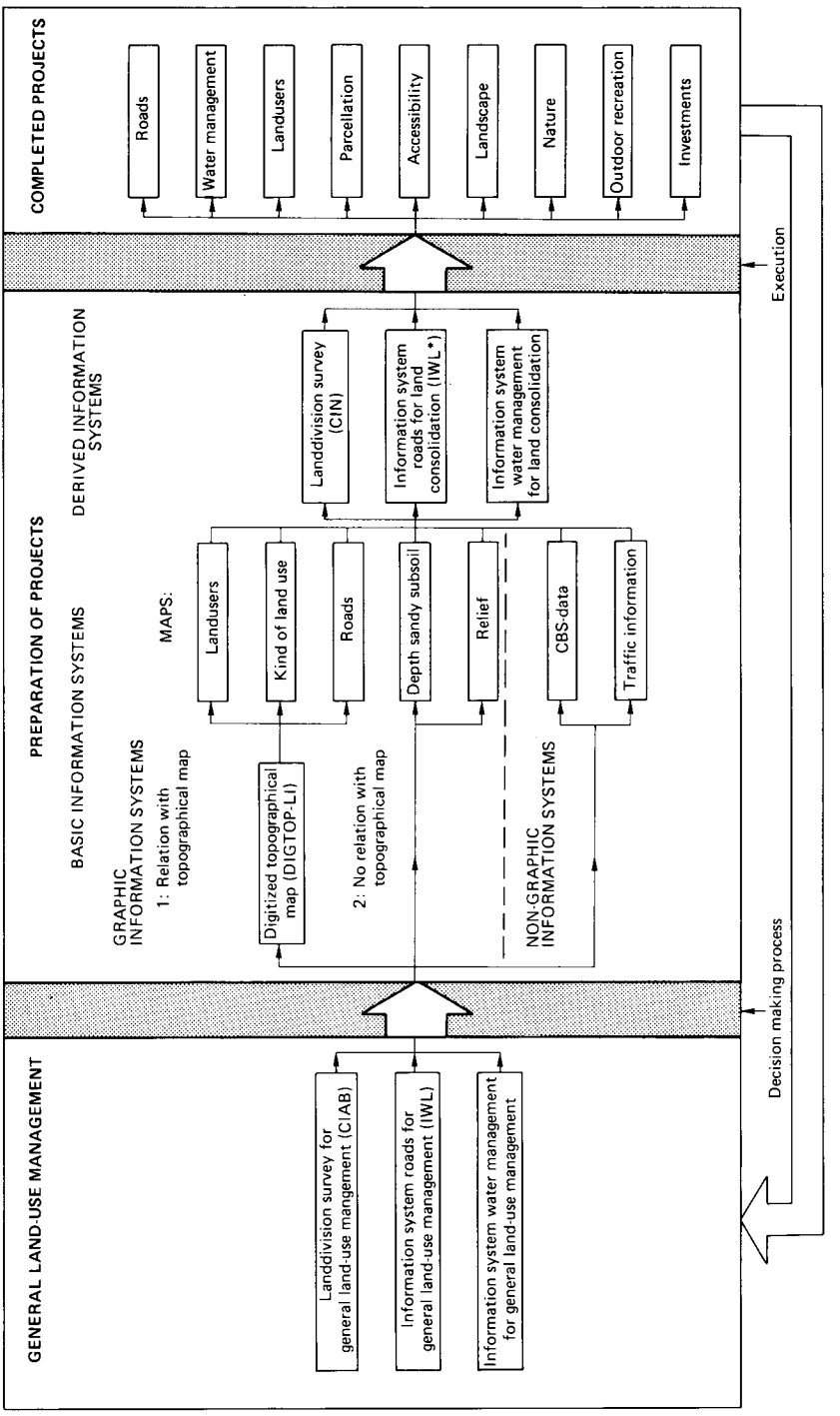

Fig. 7. Outline of the supply of information for land consolidation. The left-hand side shows the information systems for General Land-Use Management. The central part concerns the preparation of projects. It shows the division of the basic information systems and how to combine these systems into derived information systems. The right-hand side shows the collection of data concerning completed projects. After about 40 years these data on completed projects are input data for the left-hand part of the outlined system. (IWL*: information system of roads to be improved; van Kleef et al., 1985, and van der Heijden, 1986).

The application

The system is currently used in connection with the land-use management of the provinces of Gelderland and Drenthe for the following applications:

- the draft, review and approvement of local and regional land-use plans;
- the choice and delimitation of areas which are considered for reallotment and land consolidation;
- the indication of effect of changing the land use in agriculture areas (outdoor recreation, urbanization, sand mining);
- the control of plant and cattle diseases;
- the control of manure surplusses;
- the supply of energy in rural areas;
- the effect of inundation by rivers.

Developments and perspectives

Fig. 7 gives an outline of the current supply of information for land consolidation as practised in the Netherlands nowadays. It is also an example how the supply of geographic information for General Land Use Management in the near future will be developed. The term 'general land-use management' covers the control and guidance of developments in rural areas on the basis of a policy that has been accepted by the parties concerned. In order to prepare and formulate such a policy on any particular issue a reliable data base is required, which is regularly updated. Examples of issues on which a policy is presently in preparation or revision include the excavation of sand for urban growth and infrastructural works and the surplus of manure in areas with intensive animal husbandry. In view of these activities the information systems for general land-use management have to contain data on large areas of the rural area. It is also necessary that the presentation of the data corresponds with the changing questions (flexible output). The third requirement is that data-linking to the information systems for preparation of projects must be possible.

The information systems for preparation of projects are divided into systems for basic information and for derived information. The derived information systems are directed to a specific use during the preparation of the project. This system requires a certain flexibility of input and output of data (project-dependent). Also, the user on his work-place (decentral) can handle the data on an easy way. These systems get their information from the basic information systems.

All data necessary for preparing the project are contained within the basic information systems. The presented division of systems is especially based on the organizational and technical possibilities of data collecting and data assimilation. They can also be divided into geographic and non-geographic systems. Data-linking in geographic systems is a problem. A solution of this problem is the presently described division of the geographic systems in systems that have a relation to topographic maps and systems without a relation to the topographic map. For the first systems the digitized topographic base map for land consolidation (DIGTOP-LI) has been developed. This means, for instance, that during construction of the

digitized land-use map all relevant line elements from DIGTOP-LI are copied. The same will be done with the digitized land-users map which means that for building up a derived information system the acreage of land-use per lot can be calculated without problems.

For the linking of geographic systems and in general the building up of all geographic systems the use of polygonic processors is important.

Up to a few years ago data about completed projects of land consolidation were mostly absent (Werkgroep Afgesloten Ruilverkavelingen, 1985). Data collecting occurred incidentally to make comparisons between the situation before the start of a project and after its completion. Nowadays data collecting is usual for a lot of purposes. One of them being updating the data in the information systems for general land-use management.

The present description of information systems is not only important in land consolidation projects. The supply of information is increasingly important in the modern approach of land-use management. In the near future information systems as described here may also be used for the management of landscape and nature, for both qualitative and quantitative water management, for surveys on waste materials, and for decisions on settlements and destinations.

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