A Soil Information System for the Structural Analysis of Rural Areas

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Abstract

Belgium has surveyed its soils on a scale of 1:5,000 and has published those maps at a scale of 1:20,000. Geographical Information Systems (GIS) have made it possible to realize a large scale Soil Information System based on those digital soil maps and on a detailed, metrically corrected cadastral map (scale 1:2,000). From the suitability maps for the various cultivation groups, the inclusion of data on the situation of agriculture in LIS and through thematic processing, an agricultural map is obtained, which can serve as a basis to balance agricultural and environmental interests.

Keywords : Land Use Planning, Geographical Information System (GIS), Digital Soil Map.

1. Introduction

Belgium is the only country in the European Union that has surveyed its soils in such a detail viz. at a scale of 1:5,000 and that has published these maps at a scale of 1:20,000.

These detailed maps were laying dormant during the seventies and the beginning of the eighties but are now experiencing an unusual interest, not only in agricultural circles but also among environmentalists. Undoubtedly the introduction of Geographical Information Systems (GIS) at reasonable prices has contributed to this renewed interest. The potential of information contained in the soil maps has not been fully exploited, the time-consuming work to link soil data on the analogue maps to other environmental data was largely responsible for this (MAES, 1988; VANDENBROUCKE and VAN ORSHOVEN, 1991).

In the soil research at the Research Institute of Agricultural Engineering, that was largely based on those soil maps, an important evolution could be observed from planimetry (1980-1985) to digitizing (from 1985 onwards). In this transitional stage the need for userfriendly cartographic computer programs was seriously felt. Several attempts were made to write such computer programs but it never got beyond attempts and soon afterwards the first commercial GIS-packages were introduced onto the market (ARC/INFO e.g.).

Not only the storage of the coordinates of the polygons of the soil series was an important advantage, also the automation of the projection of the various maps onto each other (such as the regional zoning maps with scale 1:25,000 onto the soil maps with scale 1:20,000) and the automation for calculating the areas of the soil series within a given coverage. Additional map layers with the boundaries of among others the municipalities or parcels can always be added in overlay. Much experience on GIS applications for reallotment and land management projects have been gained during numerous research projects for the Flemish Land Society (DESMET and DE JONGHE, 1993). Reallotment is a powerful tool for improving and restructuring agriculture in rural areas. It takes into account the interests of environment, nature, landscape and recreation. Reallocation is the final process in which land users are allotted better situated parcels.

With regard to the EC-directives concerning the set-aside policy of agricultural land a map was developed on soil suitability for afforestation with poplar, willow and alder. Soils suited for afforestation were quantified and localised with the aid of a detailed soil information system (DESMET and MATON, 1989).

2. Analysis of the agricultural structure

2.1. A large scale digital base map

Based on this experience a research project was started aimed at working out a structural analysis on the possibilities for the local development of agriculture and horticulture in the municipality of Zwevegem (area: 6,323 ha; population: approx. 23,500; near the town of Kortrijk) in West Flanders. With the help of an interdisciplinary team this project was carried out and resulted in a better insight in the local agricultural sector.

A detailed enquiry after the agricultural situation of Zwevegem was carried out by the local council among the inhabitants employed in agriculture and horticulture. The data that were gathered in this way were checked for correctness and if necessary corrected or adjusted to the real situation.

The results of this municipal enquiry on the agricultural and horticultural situation were entered into municipal Soil Information System using GIS.

The application of such a Land Information System requires a large-scaled digital base map. This base map is a very detailed, metrically corrected cadastral map (scale: 1:2,000). The cadastral maps, which are on transparents, are fitted into the corresponding rectified aerial photographs or orthophotographs. The boundaries on the aerial photographs corresponding with the cadastral boundaries are then digitized. Boundaries which cannot be seen on the photograph but which can be deduced from the cadastral plan (e.g. by processing the various parcels as a whole) are then copied from the cadastral plan. A digital register of the parcels is subsequently made by linking the digital datafiles of the cadaster with those of the large scale base map.

2.2. The Soil Information System

The other layers in this Land Information System were built up by digitizing the soil maps (scale 1:20,000), the biological assessment maps (scale 1:25,000), the regional zoning maps (scale 1:25,000) and the "Green Main Structure", which is a land cover map (scale 1:100,000).

Based on the digital soil maps and because of the straightforward structure of the soil legend, thematic maps were drawn by carrying out a selection on one of the three basic characteristics viz. texture class, drainage class, profile development. From the thematic map on texture class (Z..: sand; S..: loamy sand; P..: light sandy loam; L..: sandy loam; A..: loam; E..: clay; U..: heavy clay) it is easy to locate the light and heavy soils. These simplified thematic maps generate a greater interest from the farmers than the traditional soil maps. Besides the network of roads, taken from a topographic map, the exact location of each farm was included on a separate map layer (among others further split up in different categories according to the farmer's economic prospects).

From another thematic map of drainage classes it appears that the percentage of drained soils varied between 40 and 50%. In the past the local council considered the need for a global drainage-project, taking into account the local drainage requirements.

In an earlier study on waterlogged soils in Flanders (DESMET, 1991) a matrix was made of the artificial drainage requirements, based on a range of natural drainage classes (.e. & .f.: permanent ground water table; .h. & .i.: temporary water table) and soil texture classes, for grazing or arable land (Table 1). Based on these guidelines it is possible to put forward some measures for improvement.

By linking those drainage characteristics to the attributes of the digital soil map it is possible to work out a map with artificial drainage requirements. After projection of the network of roads, derived from the topographic map, it becomes fairly easy to locate these soils.

With updating the soil maps it is important to project the regional zoning maps onto the soil maps, as the area of agricultural land on the latter no longer corresponds with the present situation. Through the zoning maps the final destination of the land is fixed by a national law and this makes it easy to distinguish between agricultural land and non-agricultural land.

By means of digital overlay techniques, applied to the zoning maps, it becomes possible to judge the claims made by the various sectors (among others agriculture and nature conservation). Biological assessment maps showing the biologically valuable and highly valuable areas are therefore digitally projected. This classification was done for each ecotope on the basis of four criteria: 1. rarity, 2. biological quality, 3. vulnerability and 4.

replaceability. Those biological assessment maps contain a wealth of biological information gathered through systematic surveying and description of the vegetation types and the flora and fauna elements.

Table 1. Overview of the artificial drainage requirements according to natural drainage and soil texture.

Natural drainage	Sandy soils (Z.., S.., P..)	Loamy soils (L.., A..)	Clayey soils (E.., U..)
Imperfect (.d.)	Grazing land :very suitable	Grazing land :suitable	Grazing land :drainage desirable
	Arable land :take care of discharge	Arable land :drainage desirable	Arable land :tightly installed drainage
Moderately poor (.e., .h.)	Grazing land :suitable	Grazing land : drainage essential	Grazing land :tightly installeddrainage
	Arable land :drainage desirable	Arable land :drainage essential	Arable land :drainage : poorresults
Poor (.f., .i.)	Only hayfields and broad-leaved trees	Only hayfields and broad-leaved trees	Only hayfieldsand broad-leaved trees
	Drainage :poor results	Drainage :poor results	Drainage :not justified
Very poor (.g.)	Unsuitable for agricultural use	Unsuitable for agricultural use	Unsuitable for agricultural use

2.3. Physical soil suitability

To establish the agricultural value of the land it is essential to determine its potentiality at reconversion to other crops. This may open new perspectives for a diversification of agriculture.

It is here that the physical soil suitability from matrixes (Table 2) fits in for all the soil series of the seven cultivation groups namely: grassland (1), arable land (2), extensive vegetable growing (3), intensive vegetable growing (4), vegetable growing in glasshouses (5), fruit growing (6), tree nurseries (7) (Table 3). Those soil series consist of a combination of soil texture, drainage classes and profile development.

The different suitability classes in both the morphogenetic and geomorphologic classification system should make it possible to link the individual suitability to a digital soil map. From the derived suitability maps for the seven cultivation groups and through thematic processing an agricultural and horticultural map is obtained that can serve as a basis to balance the agricultural and environmental interests (Yellow Main Structure).

Most of the soils are suitable or very suitable for growing industrial vegetables that favour heavier soils and that are grown extensively. The potential production capacity can still be increased on wet loamy soils by artificial drainage since water management and accessibility during spring and autumn are here the main limiting factors.

Table 2. Agricultural soil suitability for intensive vegetable growing and for vegetables with a preference for light soils in function of the range of soil textures (Z-U) and the range of drainage classes (b-f).

	.b.	.c.	.d.	.h.	.e.	.i.	.f.
Z..	4	3	3	5	5	5	5
S..	2	2	3	5	5	5	5
P..	1	1	3	5	5	5	5
L..	1	2	4	5	5	5	5
A..	4	4	4	5	5	5	5
E..	4	4	5	5	5	5	5
U..	5	5	5				

1 : very suitable : 90 - 100 % ; 2 : suitable : 75 - 90 % ; 3: moderately suitable : 55 - 75 %; 4 : hardly suitable : 30 - 55 %; 5 : unsuitable : < 30 %

Table 3. Agricultural soil suitability for seven cultivations, for elaborating the "Yellow Main Structure".

Soil series	Grassland (1)	Arable land (2)	Extensive vegetable growing (3)	Intensive vegetable growing (4)	Vegetable growing under glass (5)	Fruit growing (6)	Tree nurseries (7)
Lca	2	1	1	2	2	1	2
Lcp(0)	2	1	1	2	2	1	2
w Ldc	2	1	2		3	2	
u Ldc	2	2	3			3	
(u)Ldc	2	1	2		3	2	
u Ldp	2	2	3			3	
(u)Ldp	2	1	2		3	2	
u Lhp	2						
(u)Lhp	2	3	3			3	

1: very suitable: 90 - 100 %; 2: suitable: 75 - 90 %; 3: moderately suitable: 55 - 75 %; Blank: unsuitable: < 55 %

2.4. Structural analysis of agriculture at municipal level.

A very typical application of such a Soil Information System at municipal level is the study of the influence of the Flemish Regulations for Environmental Licensing (VLAREM or FREL) and more in particular the consequences of the distance rule as mentioned in this act. This distance rule stipulates that pig houses and poultry houses cannot be exploited (depending on number of animals and score obtained by a particular exploitation) within a certain distance of housing zones, extension zones for housing, park and recreation areas.

The map shows the various buffer zones that were created around these areas mentioned on the local zoning map. In this way it is possible to pinpoint the agricultural enterprises that are situated within this distance and establish which measures that are necessary to comply with the VLAREM regulations.

This can then be visualised on a map since the results of the questionnaire on agriculture are included in the Land Information System. Profitability of each agricultural and horticultural enterprise has been evaluated on the basis of useful agricultural area, cultivation plan, size of the herd and average level of labour income for the various specialisations.

Enterprises can therefore be classified in one of the following three categories:

- Viable enterprises with a sufficiently large annual income;
- Enterprises that approach this economic size of scale and that can be made more profitable by a restricted intensification of the activities;
- Non-viable enterprises.

Within the framework of the Flemish Nature Development Plan (1991-1995), the Green Main Structure has been worked out for the entire Flemish territory and this can serve as a basis for the whole of a future territorial environment and nature policy. Four distinct zones were defined on the map of the Green Main Structure viz.:

1. Green nuclei, which consist of nature reserves where nature is of prime importance;
2. Nature development zones, i.e. valuable land where nature conservation must be a priority;
3. Corridors or linking areas, which must guarantee a safe migration of organisms from one protected zone to another;
4. Buffer zones, which must screen off protected areas from interfering and polluting by human influences.

2.5. Structural analysis of agriculture at regional level

The same technique as that for the structural analysis of agriculture at municipal level is now being investigated for application at regional level. The Province of West-Flanders (area: 314,433 ha, population: approx. 1,116,000, in the north of Belgium) was the first to take the initiative of developing a provincial structure plan. The same basic conditions as those laid down in the Structure Plan of Flanders were included in the regional structure plan, viz. protection of the open space, revaluation of the urban network and control of mobility.

The agricultural sector is at this moment the only sector developing a sectoral structure plan in a digital way. At regional level the digital base map consists of the network of axes of the public roads (scale 1:10,000). In this network of public roads the cadastral parcels are fitted in on a separate overlay.

The agricultural area is divided into five different types of rural zones. This classification is based on soil suitability for various cultivations, spatial structure of the rural zone and nature of the agricultural activities. Guidelines are stipulated for each of these types of rural zones.

Rural zone with additional restrictions regarding nature and landscape conservation

These are unbuilt areas or low density development areas with a high scenic or natural value. They are mainly wooded areas with adjacent or enclosed agricultural parcels. The existing settlements are mainly land-linked enterprises which are given the possibility to expand their existing activities. New settlements, however, are not permitted.

Homogeneous rural zone

These are open spaces with scattered enterprises and with hardly any other buildings. Mainly land-linked enterprises are found here. Horticultural activities are mainly focusing on extensive vegetable growing. The conditions stipulate that existing activities are allowed to expand and that conversion is possible, excl. vegetable growing under glass and intensive horticulture not linked to land.

Rural zone with mixed urbanisation and specific agricultural suitability, in which glasshouses and intensive, not land-linked horticulture are not allowed

These areas are characterised by a large diversity in agriculture and horticulture. Glasshouses are hardly or not found in these areas. This situation must remain as such to conserve the landscape.

Rural zone with mixed urbanisation and specific agricultural suitability, no restrictions for glasshouses

These areas with scattered buildings are characterised by a large diversity in agricultural and horticultural enterprises, incl. horticulture, tree nurseries, glasshouses. Besides farms, residential buildings and small enterprises are found. The buildings are grouped in rural residential areas or are isolated. Some low density development areas with a specific suitability for alternative cultivations such as intensive vegetable growing fit in this type of zone and no restrictions are imposed on these activities.

Rural zone with disintegrated structure, adjoining an urbanised area

Mostly built-up areas or isolated agricultural land surrounded by non-agricultural land. The conditions for rural zones stipulate no restrictions for this type of rural zone.

Conclusions

The substantial efforts that have been made in Belgium to survey the soils in a detailed and systematic way viz. on a scale of 1:5,000 and to publish the soil maps (at a scale of 1:20,000) make it possible to integrate these data into a flexible Soil Information System for structural analysis at municipal level with the aid of Geographical Information Systems.

By implanting the results of a municipal questionnaire on agriculture in this Soil Information System several interesting agricultural applications became possible. The local councils have with this relatively new technique a powerful instrument in their striving towards a maximum protection of the remaining rural sites enabling in this way a coexistence between agriculture and nature conservation.

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