GEOGRAPHICAL RESEARCH IN BELGIUM

REMOTE SENSING and PHOTO-INTERPRETATION

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1. Introduction

1.1. The initial context

Until the mid of the '80, the Belgian geographers' studies principally make use of aerial photographs, in physical geography (ANTROP, 1985 a-b; OZER et al, 1985; OZER, DETRY, 1986) as well as in urban (DONNAY, LALOUX et al., 1986) or regional geography (DAELS et al., 1985). The researches covering the Belgian territory resorting to digital images are quite seldom and localized. Airborne scanned images, notably thermography, have been used in urban studies of Liège (DONNAY, NADASDI, 1986), while the first studies of Brussels made use of Landsat TM imagery (DE KEERSMAECKER et al., 1985). Landsat images also have been exploited in the frame of regional studies (e.g. DAELS, GOOSSENS, 1983), together with the first simulations of SPOT imagery (BARTHOLOME et al., 1984).

1.2. The TELSAT programme

Belgian research in remote sensing knew a very rapid expansion at the end of the '80 due to the start of the national remote sensing programme, so called TELSAT, under the direction of the Federal Office for Scientific, Technical and Cultural Affairs. This programme, which can be seen as a spin-off of the Belgian participation in the SPOT satellite development, permitted the emergence in the main universities of the country of research teams, well equiped and supplied in digital images.

At first, during the period needed for the researchers to get accustomed with the new available tools, most of the published papers dealt with methodology : remote sensing in general (ANTROP, 1986 a-b-c; ANTROP et al., 1986), image processing (DONNAY et al., 1987; RASSON et al. 1995), creation and assessment of ground thuth (BAUDOT et al., 1987; DE KEERSMAECKER, 1987), extraction of valuable informations (WILLEMSEN et al., 1988), etc. When applications were concerned, they generally were restricted to analogic interpretation and basic processing of the digital images (e.g. ERPICUM, 1987; LUCA et al., 1988; OZER et al. 1988).

However the teams rapidly turned to different domains of applications, geographically and thematically separate. This led, on the one hand, to a wide coverage of case studies in different areas and, on the other hand, to a strong specialization of the teams with few relations between them, at least until the first years of the nineties. During the TELSAT programme, new facilities occured (new sensors, new abilities of applications, etc.) which progressively were included and exploited. All things considered, the TELSAT programme, which the end is expected at the end of '96, will have given a significant positive effect to the Belgian remote sensing research, not only in geography, but in agronomy, geology or computer science as well.

In order to present the few hundred papers resulting of this stream of research, we follow the structure adopted by the research teams themselves. At first, the bibliography is separated according to the geographical area of interest : European countries, including Belgium, vs. intertropical regions. Then, the contributions are sorted according to the thematic classes which they belong to.

2. European Case Studies

2.1. Physical geography

2.1.1. Drainage and erosion processes

The soil drainage has been studied in Belgium by using Landsat MSS (GOOSSENS, 1986) and TM (GOSSENS et al., 1987; VAN CAMP et al., 1987), while SPOT images were included in a GIS solution for the achievement of researches related to soil salinity and water balance in Greece (GOOSSENS, BRACKMAN, DE VLIEGHER et al., 1990, GOOSSENS et al., 1992; HARDY et al., 1991) and other Mediterranean countries (see § 3). Connected to that, several contributions deal with the geomorphology of Greece (GOOSSENS, DE RAPPER, 1990; BRACKMAN et al., 1992) and particularly with the erosion process which is studied by the combination of satellite images and Digital Terrain Model (BRACKMAN, 1991, 1992). On this basis, the same author proposes a specific contextual algorithm to obtain soil erosion informations (BRACKMAN et al., 1993) while several papers are devoted to the mapping of these informations and other soil characteristics (DE VLIEGHER, 1988; BRACKMAN et al., 1990; GOOSSENS, BRACKMAN, LOUIS, 1990). The combination of satellite data and DTM for geomorphological purpose is also used in a Belgian case study (WILLEMS et al., 1993).

2.1.2. Coastal geomorphology

Another important stream of physical geography developed in the frame of the TELSAT programme is the coastal geomorphology. Initially SPOT data were used to analyse the sedimentology and the morphology of several beaches in Western Mediterranean (OZER et al., 1991, 1992). As soon as they were available, the SAR images provided by ERS-1, alone or in combination with other remotely sensed data, were used over the same regions to analyse the sediments dynamics and the swel characteristics (COMHAIRE, OZER, 1994; CORNET et al., 1994; OZER et al., 1993; OZER, CORNET, COMHAIRE, 1995; OZER, JASPAR et al., 1995). Similar data sources were used to study the bathymetry on the Belgian plateform (VAN DE VELDE et al., 1994) and the Schelde esturay (COMHAIRE, OZER et al., 1994).

2.1.3. Climatology

Although the daily use of remotely sensed data in climatology, the Belgian geographers' researches in this field are quite few as they din't really take advantage of the high resolution images promoted by the TELSAT programme. Nevertheless, some studies based on Meteosat imagery and concerning continental meteorological situations have been published (ERPICUM, 1985, 1993). Besides the same author presents an overview about the receiving, processing and display of meteorological satellite images (ERPICUM, 1995).

2.2. Landscape and environmental analysis

2.2.1. Landscape as a natural resource

Remotely sensed data particularly suit regional analysis, as it provides a synoptic view and a monitoring of the land covers in the landscape. The Belgian geographic literature has many contributions dealing with landscape analysis, considered as a natural resource, and based upon the processing of various remote sensing sources (ANTROP, 1983, 1989 b).

In the last decade, the Campine (or Kempen) region, a clearly differentiated part of Flanders for physical as well as human aspects, was the subject of several studies using firstly Landsat 2 images (DAELS, GOOSSENS, 1983, 1985a et b) and later SPOT imagery (GOOSSENS et al., 1991). In a similar way (DAELS, VERHOEVE et al., 1989) extented the study over the Flanders, while (BARTHOLOME et al., 1984) evaluated a simulation of SPOT imagery over Eastern Belgium.

More recently, the ecological dimension of the landscape extracted from remotely sensed images has been compared between different ecosystems (GOOSSENS, ONGENA et al., 1993) or different dates (GULLINCK et al., 1993). At last, the frontier-free characteristic of the remotely sensed information has been exploited to provide an homogeneous analysis of the landscape over a transborder region between Belgium, the Netherlands and Germany (NADASDI et al., 1990).

2.2.2. Environmental degradations

Belgian geographers also give a great place to applications carried out in Mediterranean Europe. The case studies relate to environmental issues and particularly to the degradation of landscape and soil due to natural hazards or caused by man (DAELS, 1995). Change detection and dynamics in the landscape have been studied in Sardinia (KEYMEULEN et al., 1990) and in Greece (DAELS et al., 1991, DE VLIEGHER, 1990 a). The last author endeavoured to the study, by remote sensing and GIS, of the risk assessment for environmental degradation caused by fires (DE VLIEGHER, 1992 a-b-c, 1993; DE VLIEGHER et al., 1993, 1994 a-b).

2.3. Urban remote sensing and satellite mapping

Urban analysis constitutes a new domain of application for remote sensing as it generally requires high and very high resolution images to be performed, only available for a decade. As early mentioned, the only study achieved at a rather coarse level with Landsat TM, together with aerial photos, concerned Brussels, the largest Belgian urban agglomeration (DE KERSMAECKER et al., 1985; DE KERSMAECKER 1986 a-b). Then SPOT imagery, sometimes combined with Landsat TM, was extensively used to analyse different urban issues (DONNAY et al., 1995).

2.3.1. Urban planning

The first aim of these applications was to provide consistent information about land use for town planning purpose (NADASDI, BAUDOT et al., 1987, 1988; DONNAY, 1992 a). The difficult separation between built-up land covers implied some new methodologic developements, as texture (BAUDOT et al., 1988 b) and gradient analysis (DE KERSMAECKER, 1990) or image segmentation (COLLETTE 1990; COLLETTE et al., 1991). Physical planning in urban areas is explicitely addressed in a few contributions (BAUDOT et al., 1988 a, 1993), sometimes with the meaning of urban ecology, mixing physical and social issues at urban and regional scales (NADASDI, DONNAY et al., 1987; NADASDI et al., 1991).

2.3.2. Social concerns

Social planning also took advantage of urban remote sensing, according to the ability of the reallocation of socio-economic data on the base of the urban built-up area (DONNAY, 1992 b). The delineation of the urban agglomerations by remote sensing (DONNAY, 1993, 1994 a), as proposed by EUROSTAT, and the use of adapted urban models (DONNAY et al., 1992, 1994; DONNAY, 1994 b) significantly improve the impact of remote sensing in social sciences. These methods concerning urban planning were mainly applied in the context of cities located in North-Western Europe but in Southern Europe too (BINARD, NADASDI., 1993). Besides, as it will be mentioned later, urban remote sensing found a distinctive but promising field of application in the developing countries.

2.3.3. Satellite mapping

For many reasons, such as the planning process, the high resolution of the images and the urban dynamics, urban remote sensing is closely connected to satellite mapping. It is the reason why this topic is addressed here, even though satellite mapping constitutes one of the main by-products of remote sensing whatever the application is. The impediments met in the compilation of thematic maps from remote sensing require the development of new procedures dedicated to digital cartography (DEPUYDT, 1988, 1991b; BINARD, COLLETTE, 1993; BINARD et al., 1994; CANTERS, 1995) and specific GIS facilities (DE MAYER, ONGENA, 1987; ANTROP, 1992; DONNAY et al., 1993). Moreover, the stereoscopic characteristics of SPOT imagery allows the extraction of topographic features (TAHIRI et al., 1992; PATTYN, CANTERS, 1995), while the update of topographic maps can make use of very high resolution offered by new sensors (MULLER et al., 1994). For further discussion concerning the cartographic and GIS publications, we refer the reader to the specific chapter devoted to "Cartography".

3. Remote Sensing and Photo-Interpretation in the Tropics

The last decade revealed very fruitful as far as tropical studies by remote sensing are concerned. Three main fields of research were explored or exploited : the Environment in a broad sense, the problems of the traditional agriculture and its evolution and the analysis and management of the Third-World fast growing cities (WILMET, 1995 b).

3.1. Environmental changes and natural hazards

3.1.1. Climatic evolution

Although many belgian studies were devoted to paleoclimatic and recent changes in the tropical realm (see related chapters), few researches, as far as we know, are directly considering the satellite data to interpret these changes in the last decade (KARIMOUNE et al., 1990). However, indirect relationships between orbital images or aerial photographs and the climatic evolution have been established (DAELS et al., 1993; DAELS, ELHAG, 1994; DE DAPPER, 1991; LAMBIN, WALKEY et al., 1994). On this opportunity, a new method based on the change vector was set up defining different types of magnitude in the recent evolution of land cover (LAMBIN, STRAHLER, 1994).

3.1.2. Natural hazards and land degradation

Here we have a great number of contributions.
A first attempt to classify types of faults was realized in the Equator using ERS-1 satellite data in order to avoid cloud cover diffusion (OZER, OZER et al., 1995). But the most numerous published works are dealing with desertification processes and their impact on the environment.

A general assessment considers the influence of spatial scales on the perception and identification of desertification processes and patterns (LAMBIN, 1988 a, 1992, 1993). The same author in collaboration with two other specialists considers the possibility to identify land cover changes in the Sahel using fuzzy neural networks with backpropagation techniques (GOPAL et al., 1994).

Numerous case studies illustrate the processes of land degradation in various environments : let's point out several contributions about erosion, soil drainage and soil degradation in the Shaba Region (DE DAPPER et al., 1988, 1989; GOOSSENS et al., 1988). Important researches were also performed in the Nile Valley where sand blowing winds and salinisation processes endanger the irrigated crops (DAELS, GHABOUR et al., 1993; GOOSSENS et al., 1993). A model for simulation and monitoring of soil salinity was developed using both remote sensing and GIS. The detection of the environmental change in the Kuwait Region

due to the Gulf war was also considered in a collective contribution (EL BAZ et al., 1993). A geomorphological and climatic research in the framework of Global Change interested the Southern Niger (KARIMOUNE et al., 1990, 1994).

3.1.3. Deforestation

The severe regression of tropical forests prompted some contributions among belgian remote sensing practitionners in geography. The urban explosion (see hereafter) and the growth of the rural population seem to be among the most effective factors of the process. A general assessment for Central Africa was produced in collaboration with Pathfinder Program (Maryland University) and the NASA in the framework of the Biodiversity Support Program in 1993 (MASSART et al., 1994). A belgian geographer investigated the causative models which could formalize the process (LAMBIN, 1994 a). Apart slashburn agriculture and logging, dry tropical forest or tree savannas are severely damaged by bushfires occuring along the dry season. An attempt to cartography the seasonal progression of the burned areas was performed using Landsat MSS data (DEFOURNY et al., 1991). The use of low spatial resolution satellites (NOAA) was also considered (LAMBIN et al., 1995). The use of normalized vegetation indices is sometimes questionable due to their high correlation with other parameters; the exploitation of data from a thermal channel with vegetation indices improves the discrimination of vegetation cover types at coarse resolutions for multitemporal series.

3.2. Traditional agrarian systems and rural planning

3.2.1. Analysis of the traditional agriculture

This research realm appears as very rich. Studies can roughly be divided into two types : the definition of agrarian structures and land cover analysis and mapping.

The first involves thematic discussions (DE KEERSMAECKER et al., 1987), spatial stratification according to ethnic entities (LAMBIN, 1986, 1988 b, 1994 b), the impact of migration on cultivated land allocation and use (LAMBIN, 1987), but also the detection of an ancient irrigation system (AL SAADI et al., 1987) and the discrimination of agricultural parcels into different vegetation covers near the fringe of the equatorial domain (DAELS, GOOSSENS et al., 1989).

Many studies concern the land cover mapping : Togo (DE VLIEGHER, 1991), Sudan (DAELS et al., 1987), Zaïre (DEFOURNY et al., 1987; JACQUES et al., 1989; DEFOURNY et al., 1990), Burkina Faso (LAMBIN et al., 1986), China (MENG, 1993; MING et al., 1993).

3.2.2. Tools for an improved rural management

Applied contributions to the critical problem of rural management in the Tropics are dealing mostly with the interaction of Remote Sensing data with Geographic Information Systems. A general overview and a proposal for the creation of Expert Systems can be found in (LAMBIN et al., 1986).

A general presentation of the problems occuring in the less favoured areas when statistics are partly unreliable, scarcely distributed and when the problem arises to define correctly the pertinent parameters (WILMET, 1993). A first step consists in an adapted stratification of the rural space in order to allow a good integration of remote sensing derived features and land cover with exogeneous data (WOLFF, 1991).

More specifically this stratification proceeds from a division into agro-ecological regions which in turn are subdivided in geomorphological land facets with the aid of a digital elevation model (TOTTE et al., 1993, 1995). The integration of a digital terrain model and remote sensing data into an hydrological model provides a good basis for the improvement of the "Tavi" agricultural system into a basin of Madagascar (RANDRIAMAHERISOA et al., 1993). Remote sensing combined with digitized topographical maps gives way to a simulation model useful for soil salinity monitoring in the Nile Valley (GOOSSENS et al., 1993).

3.2.3. Areal estimations, Yield measurement and forecasting

If the first item is a clearly defined subject of research in geography, the second can be estimated at the boundary of agronomy. However, the spatial point of view if considered (i.e. distribution of yields according to their relation with vegetation indices) awards an undeniable geographic character. It has been considered both from an empirical and theoretical point of view using for that purpose Advanced Very High Resolution Radiometer (AVHRR) data (BARTHOLOME, 1986, 1988 a-b, 1989 a-b).

3.3. Urban analysis and management

3.3.1. Core and fringe evolution

If the outskirts of the fast growing great cities of the Third-World undergo a rapid areal extent, their inner part is submitted to a densification which is not often easy to discriminate on satellite images (BAUDOT, WILBAUX, 1992). The multispectral profile of homogeneous areas helps for their identification (SOYER et al., 1987). Even on colour composites a rough discrimination of these areas of showing similar housing density and reflectance is possible (WILMET et al., 1986). But the characterization of their evolution often needs the interpretation of recent aerial photographs (BAUDOT, 1993).

3.3.2. Urban population estimation

The remote sensing data are unable to provide directly a measure of urban population densities. However, they allow a stratification of the cities in terms of homogeneous areas (see hereabove) which can be used in demographic samplings (BAUDOT, WILMET, 1992; BAUDOT, 1993).

3.3.3. Environmental aspects of urban growth

The fast growing outskirts of tropical towns generate a complete modification of their environment. The spreading of new settlements, the destruction of their vegetation cover in order to provide timber or fuel-wood is giving birth to a deforested and sometimes desertified patch around the city core (SOYER et al., 1986; CASTIAUX et al., 1991). This process endangers the environment not only in the proximate zone of direct impact of urbanization but creates also a diffuse degradation of the natural or semi-natural vegetation in a much more extended area supplying charcoal or even fuelwood for the needs of these "cities in flood" (VERBAUWHEDE, 1985; WILMET, 1987).

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