# Foreword. The Critical Problem of Integrating Remote Sensing Data and G.I.S. in Less-Favoured Areas

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## 1. GENERAL CONSIDERATIONS

The integration of the data provided by earth observation satellites and of information issued from statistical enumeration, samplings or field surveys in less-favoured areas appears nowadays as a priority. Such a necessity can be explained by the deterioration of the standard of living in these regions which requires urgent solutions. These cannot be elaborated without a good knowledge of the strategic variables influencing the degradation of the physical and human environment. Now, as much at the global environmental level as at that of economic and social conditions, the underdevelopment or the unequal development appears as forming structures or even systems with elements functioning interdependently.

Hence, it seems necessary, before any coordinated action aimed at improving the conditions of life, to enter the knowledge of those structures and of such "deviating" systems. Remote sensing can supply much useful information to identify some variables of the underdevelopment. But, it can also put in evidence, due to its synthetic character, landscape structures typical of such disturbed systemic relations. It cannot claim however to identify all those parameters and interconnections and must be associated with field inquiries and information coming from regional sources of traditional statistics. This is the role played by the GIS, or in a first preparatory phase, by data banks (fig. 1). If the information processing has to be thought as a coherent whole allowing interactions between the layers containing the data, nevertheless one must consider that a first step in this direction consists in a query of pertinent parameters. These will be organized into "sheets" of retrievable and transformable data sets.

Now the elaboration of operational data banks into a GIS is not easy in underdeveloped regions. Besides the difficulty of identifying the characteristic patterns and structures of regional dysfunctional systems, there should be taken into account the numerous inaccuracies and errors included in the constitution of GIS. BURROUGH in his manual (1989, p 104) enumerates 14 possible sources of errors. They occur as well at the stage of data input as in their measure, temporal evolution or handling. Such sources of errors disturb also the information processes in developed countries; but they are more important and so more harmful in less-favoured areas (see 4). Thus they require a specific examination. This was one of the principal objectives of the workshop.

## 2. THE SPECIFIC PROBLEMS OF LESS-FAVOURED AREAS (L.F.A.)

The usefulness of satellite-data for the L.F.A. arises from the indigence of the ground data collections specific to these regions. Hence, spaceborne information appears as an essential substitute to the lack of statistical data in a very wide range of domains such as land cover, forest resources, urban areas or even topographic cartography.

As a matter of fact, four unfavourable characteristics bear upon the statistical organization of the less developed States:

- the unequal areal distribution of their information network. Some regions are covered by a sufficient number of census places; others seem to be ignored by central Administrations and data collection is lacking or is inadequately distributed.
- So the areal density of the information is unequal. This results in a distribution of data with a scale unsuitable for the purpose.
- The data collection rate is often too slow and the census interval too long and mostly irregular. In consequence, the results quickly become obsolete and a lack of synchronism is observed with the return of strictly associated data (e.g. cultivated areas and productions).

- Lastly, the accuracy of data can be questioned in some regions. This unfavourable characteristic is worsened by an unequal reliability of the distributed figures from place to place. This results in an unfeasibility of error computations.

The satellite registrations thus have a double objective in the less-favoured areas.

1. First, they partially or totally make up the gaps in information in several statistical sectors. They also allow to speed up the frequency of this information in order to set up more numerous and homogeneous data serials.

2. They are also used to verify the accuracy of the data into strategic information sectors where traditional statistics seem locally unreliable.

However, this important aspect of the problem which is often highlighted in studies concerning less developed areas is not fully comprehensive of its complexity. As a matter of fact, another condition is essential for the elaboration of a documentation previous to any planning concerning the less-favoured areas: this is a basic knowledge of the structure specific to each regional system. For each of them owns particular elements and this induces characteristic development schemes: here land dereliction disjoints the ancient rural communities; there, environmental pollution or social disputes have a particular importance among the regional components. Remote sensing is not a miracle-medicine for the information deficiencies. However, many aspects of those regional characteristics find a sort of glance in the spaceborne features. Hence the task of the remote sensing analyst consists in making conspicuous these specific spatial organizations in collaboration with specialists having a good knowledge of the local background. It happens often even that remote sensing data combine several aspects typical for local situations; this is the case namely for the land facets or land systems which integrate the physical landscape elements with the

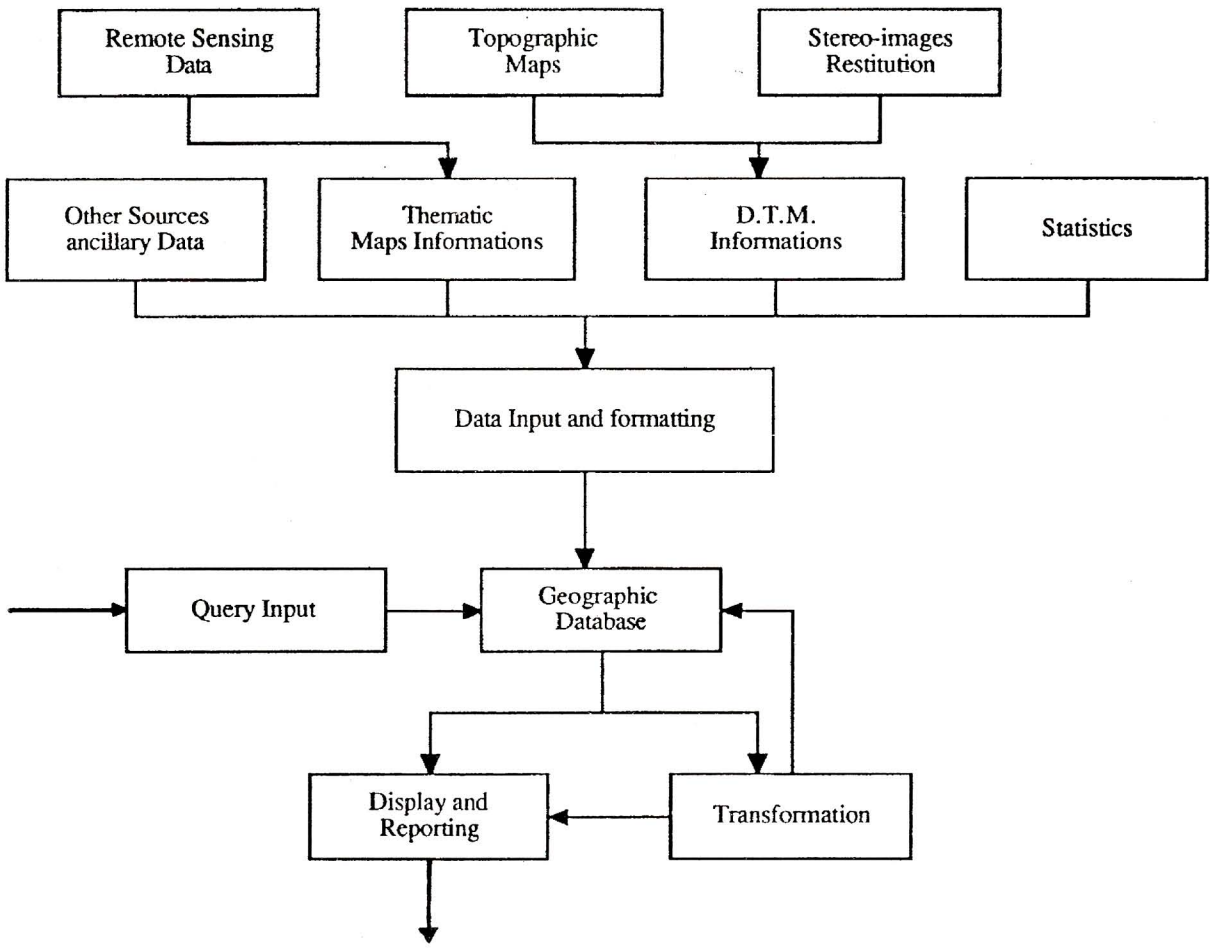


*Fig. 1 - Scheme of a Geographical Information System (partly from Burrough, 1989).*

output of land use. Nevertheless we have to bear in mind that these integration structures may induce technical problems in the elaboration of G.I.S. layers. This will be enhanced hereafter.

## 3. THE ABILITY OF R.S. DATA TO SUBSTITUTE FOR THE DEFICIENCY OF STATISTICAL GROUND- COLLECTED INFORMATION

The discussion of this ability of spaceborne data to fill the gaps of the traditional statistics takes places in a wider overview than the concern of this workshop. However, some aspects of this question have been tackled during the discussions and even in the contributions and so need to be mentioned.

3.1. The analysis of less-favoured areas cannot be considered without the use of several platforms and sensors. The choice of the remote sensing systems is dependent not only on the elements to be identified but also on the aggregation scale of the data. In the framework of the integration of satellite information into a data base, this choice thus is not trivial for it depends on the spatial resolution of the ground data collections. Now in the less-favoured areas of developing countries the statistical data show very often a high degree of aggregation at the level of their official issue (department, province, circle, ...). The discrepancy of the scales between the resolution of satellite imagery and ground based statistics can preclude any data comparison even after the aggregation of spaceborne pixels. Thus the point is to make a good statistical assessment on the different information sources in order to adjust their levels of significance.

3.2. It is also obvious that for extensive regions, the identification of remotely sensed elements is rarely comprehensive. The amount of data to be interpreted is surely the limiting factor. Hence stratification techniques and statistical sampling are commonly used in order to ensure good accuracy of further extrapolations. However, in little known regions, difficult to access and having incomplete documentation, it is sometimes difficult to realize a land stratification into homogeneous areas. Consequently the use of geostatistics can be considered in order to extrapolate (or interpolate) the results of aerospatial samplings.

A georeferenced plotting of the data raises critical problems in areas with incomplete or hasty map coverage; nevertheless it is essential to the elaboration of GIS. The satellite matrix can eventually be used as a reference layer for lack of a better topographical base. However, this matrix itself has to undergo several geometric corrections. In the absence of a sufficient number of ground control points or a high order triangulation, the solution consists in using a G.P.S. with a window supplying a convenient number of satellites in view in order to obtain a geometric accuracy equal to the pixel size.

3.3. Finally we should mention the problem of data updating. It is partly linked to the cycle of the satellite, but in reality, this repetition of orbital registrations is more theoretical than actual. The reasons for this situation are numerous: influence of meteorological conditions, of plant phenology, seasonal illumination, seasonal succession of agricultural operations and, we cannot forget, high resolution satellite programming. As a matter of fact, many unfavoured areas are located in developing countries most of which are facing increasing financial problems. Often, these countries are not only considered as generating little profit but even sometimes as reluctant customers by the product distribution centres. Moreover, for many of these countries, most of the registrations are operated at the request of international institutions in the perspective of development projects, of private companies or in the framework of bilateral cooperation. Hence no wonder that, even in good meteorological conditions, numerous zenith crossings over these countries do not give rise to any registration. However, even in the hypothesis of data captations convenient for an efficient follow-up of the information in the most operational sectors of the satellite activities, the question of the integration of those multitemporal layers into a GIS would remain open. In the absence of any synchronism between these spaceborne data and the results of ground collected samplings, censuses or enumerations constitute a heavy handicap for local planning organizations. The lack of continuity and the day-to-day policy hampers the progress of any regional inventory. To this day, no solution has been found and the planners or applied researchers are often reduced to make sometimes dubious extrapolations.

## 4. SPECIFIC DIFFICULTIES OF MULTI-SOURCE DATA INTEGRATION IN THE LESS-FAVOURED AREAS (L.F.A.)

### 4.1. Technical difficulties

The most constraining of these proceed from the heterogeneity of data types and formats to include in the data bank. This heterogeneity shows two principal characteristics (besides the formatting problems which will not be considered here): the frequent absence of pertinent variables and the diversity of measurement units added to their relative accuracy.

The first one results from the gaps in L.F.A. statistics but also from the spatial resolution of satellite data. For example, we can obtain figures from samplings about the population but it is impossible to distinguish dwellings on the satellite images because of their dispersion among fruit-tree plantations; furthermore, it has been possible to evaluate accurately on satellite images the cultivated areas but yield samplings are too scattered to be directly correlated with these areal estimations.

The second proceeds from the lack of reliable statistics. They force the researcher to use indirect indicators providing the estimation of a phenomenon in semi-quantitative terms or even in figures but with levels of accuracy too different to allow a comparison between their values.

A good example is provided by deforestation. Cleared areas may be measured from the satellite at the village scale but the density of population can only be obtained at the province or "department" level. It would be hazardous to sum up the deforested areas in order to compare the value obtained with that of the population density, for no information is given about the spatial distribution of the latter. This is an example of the discontinuity of the observation levels.

### 4.2. Psychological and political difficulties

These have been outlined during the workshop, especially in the course of the fourth session which was devoted to this theme (see the position paper of H. Le Men). We would stress here some of them. As was underlined by Professor Adeniyi in his contribution, the tool of remote sensing cannot be imported in developing countries just as it is. It seems difficult from the psychological point of view to introduce the critical scheme of satellite interpretation whereas the operational use of aerial photo-interpretation is often just beginning. In this case, technology transfer and psychological adaptation are closely associated. All the more, it is difficult, but however feasible, to integrate the procedures of satellite methodology to the more classic techniques of collecting traditional statistics under the constraint of a georeferenced canvas. A real danger arises also from the ignorance of the enthusiastic reactions of political decision makers who often consider remote sensing and G.I.S. as radical remedies to the relative underdevelopment of some of the regions under their authority. This spontaneous enthusiasm for these new techniques may be as dangerous as incredulity about their efficiency or reluctance to adopt a new technology which could increase their subordination to developed countries.

## 5. TENTATIVE STATEMENT ABOUT THE INTEGRATION OF BOTH TECHNIQUES

It is obvious that this integration is still in an exploratory phase. Although some authors allege good issues in this domain and many others call for their dissemination, the reality shows some limitations to this operation and their restriction to case studies, pilot projects and special areas of integrated development (e.g. irrigated zones). Several communications presented during the workshop dealt with such particular cases. We would add some remarks concerning the main themes or variables involved in the constitution of data banks or G.I.S.

1. The "integration" concerns mainly physical parameters: digital terrain models, land cover, vegetation indices, ..., i.e. variables which can be directly extracted from satellite data or topographic maps and so easily measured and georeferenced.

2. The "population" variable is still less easy to compute; some communications confirm this opinion. In urban areas, aerospatial sampling is the unique way to support terrain investigations; it allows an areal division in homogeneous zones as a basis for demographic enumerations. In rural areas, we remain dependent upon more or less reliable statistics which often concern administrative units too large to be integrated into the matrix of a satellite registration ...

3. The evaluation of agricultural production is another important parameter of regional data banks. Here, the researcher or planner often has to face unreliable estimations according to the region at stake. Remote sensing is able to verify the figures to some degree, using the by-pass of the biomass production or better, quantitative estimations of the regional yields (at least for a limited number of species). In this case, the traditional statistics support the estimations mainly based on satellite observations. The situation of the less-favoured areas in Europe is peculiar. As a matter of fact, most of them depend upon Central States which generally enjoy a more elaborate statistical tool, an accurate cartography, a fairly good number of remote sensing and data analysis institutions and some economic regional observatories.

So we could expect a better handling of their regional problems. Such a case is made conspicuous by the financial aids provided to them in particular by the EEC.

However, one is forced to observe that numerous difficulties occur in the elaboration of such assistance. One reason which explains the partial inefficiency of the support pro-

vided is the relative ignorance of the conditions peculiar to each of these less-favoured areas.

Many of the characteristics or factors which influence this unfavourable situation are badly revealed or completely ignored by official statistics. Moreover, a great number of less-favoured areas show potentialities in terms of human, physical or economic development which could be adequately carried out. One can regret the parsimonious support which has been provided to the initiative of the JRC-Ispra in the realm of the collaborative programme on remote sensing of less-favoured areas. The improvement of methods and techniques of great usefulness at the present time has been neglected as far as the problems of Eastern Europe are concerned. The limited number of contributions devoted to the regional underdevelopment in Europe is, in our view, an indicator of the lack of interest dedicated to this question.

Let us tackle some specific elements which should be taken into consideration in these regions:

- a more precise and more accurately localized measurement of agricultural and pastoral dereliction;
- correlatively, a survey of the patterns of evolution to fallow or reforestation;
- the relief and accessibility parameters associated with the former two phenomena;
- an inventory of the land systems and land facets, i.e. the landscape structures of these areas with the aim of highlighting their potentialities and weaknesses in terms of integrated economic development: pastoralism - forestry - tourism or water resources-tourism-environmental protection (natural parks, restricted areas, ...). This example, valuable for Western European situations, should be adapted, *mutatis mutandis*, for other parts of the continent. This list, of course, is not restrictive.

Such developing structural schemes could be elaborated from geographical information systems especially designed to integrate these types of variables.

Remote Sensing would supply a significant part of their information layers.

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## REFERENCE

P.A. Burrough (1989), Principles of Geographical Information Systems for Land Resource Assessment, Oxford Univ. Press, Monographs on Soils and Resources Survey, No. 12, 194 p.