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Advantage of SPOT data for land use mapping in Slovenia

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Abstract : The primary purpose of the federal agricultural statistics service of the yugoslav statistical office, *Zavod SR Slovenije za Statistiko*, is to provide information about current and future supplies of agricultural commodities. The current methodology for collecting agrostatistical data is discussed and a need for georeferenced data is expressed. The author suggests high-resolution digital satellite data combined with other georeferenced databases would provide the most appropriate data source for agricultural management, planning, and decision-making. A case study at municipality level of the classification of SPOT PAN and XS data into major land use and agricultural classes is presented. The results are compared with official statistics of this area.

Résumé

Intérêt de SPOT pour la catographie de l'occupation du sol en Slovénie

Le principal objectif du Service Fédéral de Statistiques Agricoles de l'Office de Statistiques de Yougoslavie est de fournir des informations sur les productions agricoles actuelles et futures. La méthodologie utilisée actuellement pour la collecte de données agrostatistiques est discutée et un besoin de données à références spatiales est exprimé. L'auteur suggère que l'utilisation de données satellitaires digitales à haute-résolution, combinées avec les autres bases de données géoréférencées constituerait la source de données la plus appropriée pour la gestion, la planification et la prise de décisions agricoles. Un cas d'étude, au niveau d'une municipalité, d'une classification de données panchromatiques et multispectrales SPOT, entre les principales classes agricoles et d'occupation du sol est présenté. Les résultats obtenus sont comparés avec les données statistiques officielles de cette région.

I. – Introduction

Sustained increase of agricultural production is one of the main government priorities in Yugoslavia. Realistic planning needs to be based on a reliable inventory of land resources and on assessment of land potential for agricultural production and development.

In Yugoslavia, reliable data on agricultural land use at the national or federal level are not available. The available estimates are too crude to provide a basis for planning better land utilization to increase production.

Land use, field acreage, and crop forecasting estimates are based on information provided by agents of the reporting service. The principal disadvantage of the existing method is the risk of subjective bias and lack of geographic coordinates of individual acreage data. As a result the estimates cannot be combined with other ground information (analog or digital), such as soil maps, digital relief model, hydrometeorological data, etc.). Agroeconomic methods needed for sound economic planning cannot be used, particularly for reliable forecasting of crop production.

Over the past 10 years intensive efforts have been devoted to social planning in Yugoslavia. New laws and regulations have integrated the human environment within social planning. In SR Slovenia an analog database of Land Cover was established with data derived mostly from interpreted aerial photographs as cadastral data are obsolete. The basic map scale is 1:25 000, which is mainly used in planning at municipality and national level.

One of the main reasons for not using the photointerpreted data in agrostatistics is that it is a time-consuming technique. Moreover, the analog form does not allow combination of photointerpreted data with other existing digital databases.

The research project "Remote sensing: application of digital satellite scanned techniques in the fields of land use and agrostatistics" was launched in 1982. It was initiated to develop a federal-level methodology for collecting agrostatistical data that would provide timely, objective, and accurate information. Its ultimate goal is to develop a land use information system that will be incorporated with other relevant geocoded data into a Geographic Information System, GIS (**Figure 1**).

II. – Previous land use maps based on remotely sensed data

In 1986 and 1987 the remote sensing project received assistance from FAO through its TCP program; the following digital products were generated:

- Landsat MSS (all final output at 1:500 000 scale):

– geometric oriented mosaic of SR Slovenia compiled from three MSS scenes with main land use classification satistics
– delineation of homogeneous land units within the territory of SR Slovenia, based on geological and geomorphic vegetation characteristics.

- Landsat TM (all final output at 1:50 000 scale):

– classification of Ptuj municipality into main agricultural land use classes
– estimation of hop field acreages based on multitemporal analysis in the Savinja valley
– location and acreage estimates of various forest stands on the hilly region of Pohorje

- SPOT PAN and XS (final output at 1:50 000 scale):

– unsupervised classification of the Krško municipality into main land use classes.

This work was published and presented on the International Workshop on "Application of Satellite Remote Sensing Techniques to the needs of Agricultural Statistics" held in Ljubljana in June 1987.

III. – Land use map of the Krško municipality

1. SPOT data

In the FAO-YUG project two SPOT scenes, both covering the Krško municipality of the Republic of Slovenia, were analyzed (**Figure 2**). The XS SPOT CCT is a vertical scene (K/J: 069/257, date: 19 May 1986); the PAN CCT has a scanning angle of 5.8° W degrees (KJ 069/257, date: 5 July 1986).

The work was done at the FAO Remote Sensing Centre in Rome, with access to the Dipix-Aries-II Image Analysis System.

Among the existing scenes of the area, scenes with the least cloud coverage were ordered. However, the extreme southern part of the municipality area was still not covered (**Figure 3**). As the missing part is mainly hilly and predominantly under forest, the two scenes were retained for further analysis. Unfortunately both images had quite large portions under clouds, far above the stated 0-10% cloud coverage.

2. Geometric corrections

Due to strict national regulations concerning any ground or map data, only the map of SR Slovenia at 1:400,000 scale and the map of the Krško municipality at scale 1:50 000 scale were used.

After generating a working window to cover the Krško area, the PAN data were registered to the Krško map (scale 1:50 000). The linear transformation and cubic convolution resampling algorithm were used with 17 ground control points with a standard error of 14.12 m and 13.28 m for the x and y axes, respectively. Residual error was acceptable because it only produces a difference of 0.28 mm and 0.26 mm respectively, at the final output scale of 1:50 000.

The municipality boundaries were digitized on the geometrically oriented PAN working window. The municipality area according to scanned data is 34 590 ha and differs by +0.4% from official data.

3. Classification

The PAN data were classified using histogram slicing (**Table 1**).

Table 1. Reflectance values of different land use classes.

Reflectance values	Land use classes
01 - 51	Forest
52 - 57	Grassland
58 - 60	Haze, clouds, shadows
61 - 70	Large fields, haze
71 - 76	Large fields, open land
> 77	Industrial area, open land

The results were used to determine average cluster values for the nonsupervised classification of PAN and XS data; XS data of bands 2 and 3 were previously resampled to the 10 m × 10 m pixel resolution and merged with PAN data.

In addition, the nonsupervised classification was refined by integrating individually sampled pixels of each land use and agricultural class (**Table 1**).

4. Results

Only the classes forest and grassland were compared with official statistical data due to lack of ground truth data and the poor quality of scanned data (cloudiness). The forest class had a difference of −5.2% compared with statistics, while grassland differed by +4.6%. The other classes were too biased by prevailing atmospheric conditions but their position on the map was located precisely.

A comparison of the information obtained from each band confirmed that the panchromatic band contributed most to facilitate separation of linear features such as roads, paths, and field boundaries. These data would suffice for updating the cadastral data or maps.

IV. – Conclusion

On the basis of the experience gained from the analysis and interpretation of digital satellite data, we believe that data derived from Landsat MSS, Landsat TM and SPOT earth resource satellites, combined

Table 2: Results of the nonsupervised classification of merged SPOT PAN and XS data on the Krško municipality.

Clusters	Land use class	Area (ha)	% of total area
CLU - 1	Forest	15 261	44.1
CLU - 2	Grassland	9 358	27.1
CLU - 3	Small fields, built up areas	739	2.1
CLU - 4	Large fields	501	1.4
CLU - 5	Water & clouds	2 219	6.4
Unclassified		6 510	18.8
Total		34 590	100.0

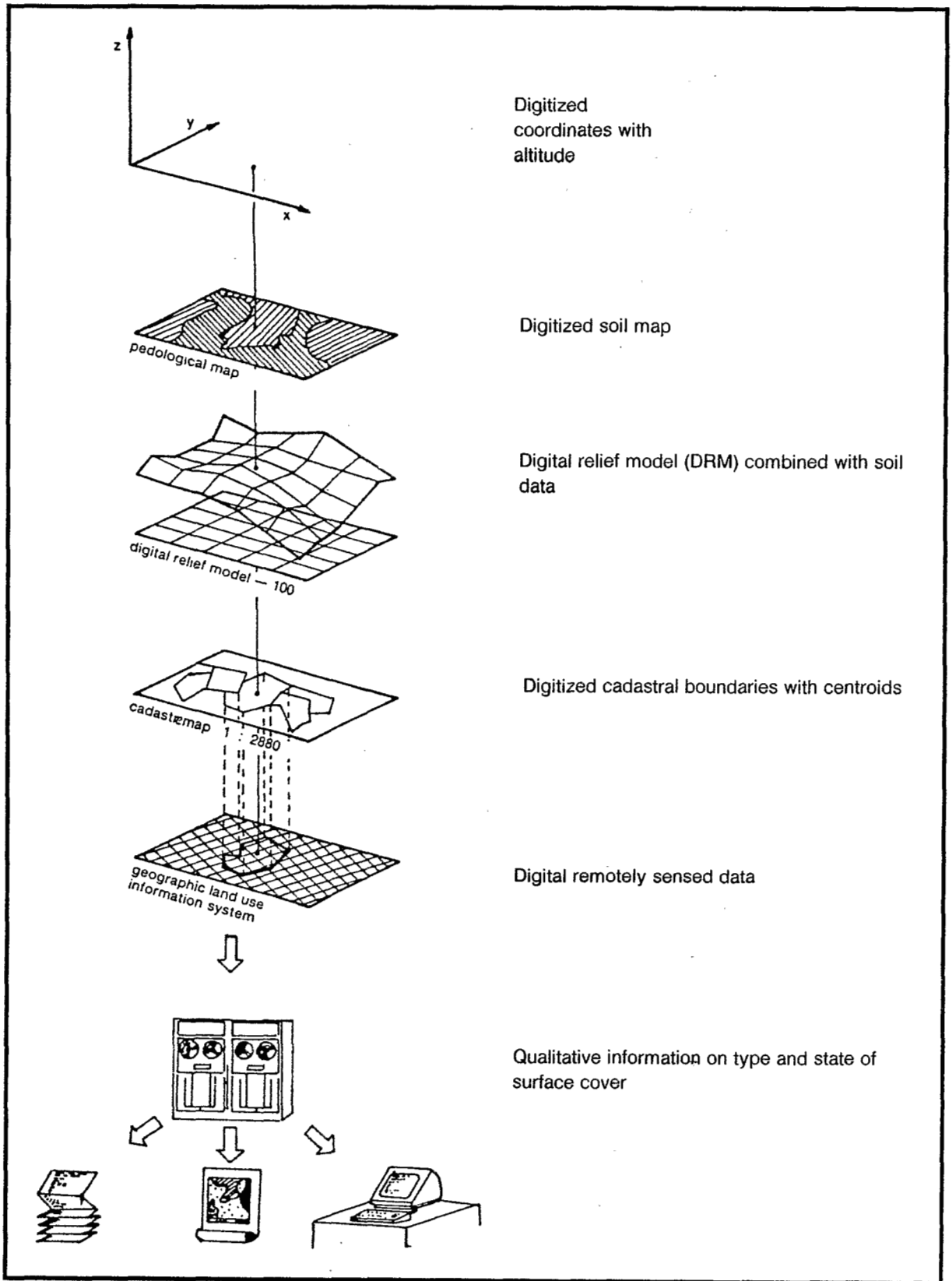
with digitized aerial photographs and ground surveys in a multistage sampling design can provide information on agricultural land use that is suited to national requirements. Such method presupposes an adequate area sampling frame that stratifies the area into homogeneous land units according to land use types. Each unit has a specific sampling density. The configuration of such a multistage remote sensing design and the selection of the scanned pixel size will depend on the requirements of particular applications, climatic and soil conditions, local farming practices, availability of remote sensing data, and cost-effectiveness of various options.

Follow-up work for a federal remote sensing project will concentrate on:

- analysis of spectral signatures for main land use categories and crops in Slovenia in various bands throughout the growing season
- establishment of a computerized based land use information system integrated with other relevant geocoded databases and existing socio-demographic databases, resulting in a geographic information system
- extension of the project to other republics and autonomous provinces of Yugoslavia, taking into consideration their specific environmental conditions and local agrarian systems

The digital multistage remote sensing method based on an adequate area sampling frame would enable the incorporation of the resulting digital data into a national and federal geographic information system which will be linked to various existing databases. The data could then be processed for various applications (**Figure 4**), including modeling, to provide farmers and planners with reliable data for their agroeconomic analyses.

Figure 1. Schematic presentation of the use of a computerized database with satellite data on land use, agriculture, and forestry.



Source: Banovec T., personal communication.

Figure 2. Location of SPOT PAN and XS scenes covering the area of the Krško municipality, SR Slovenia.

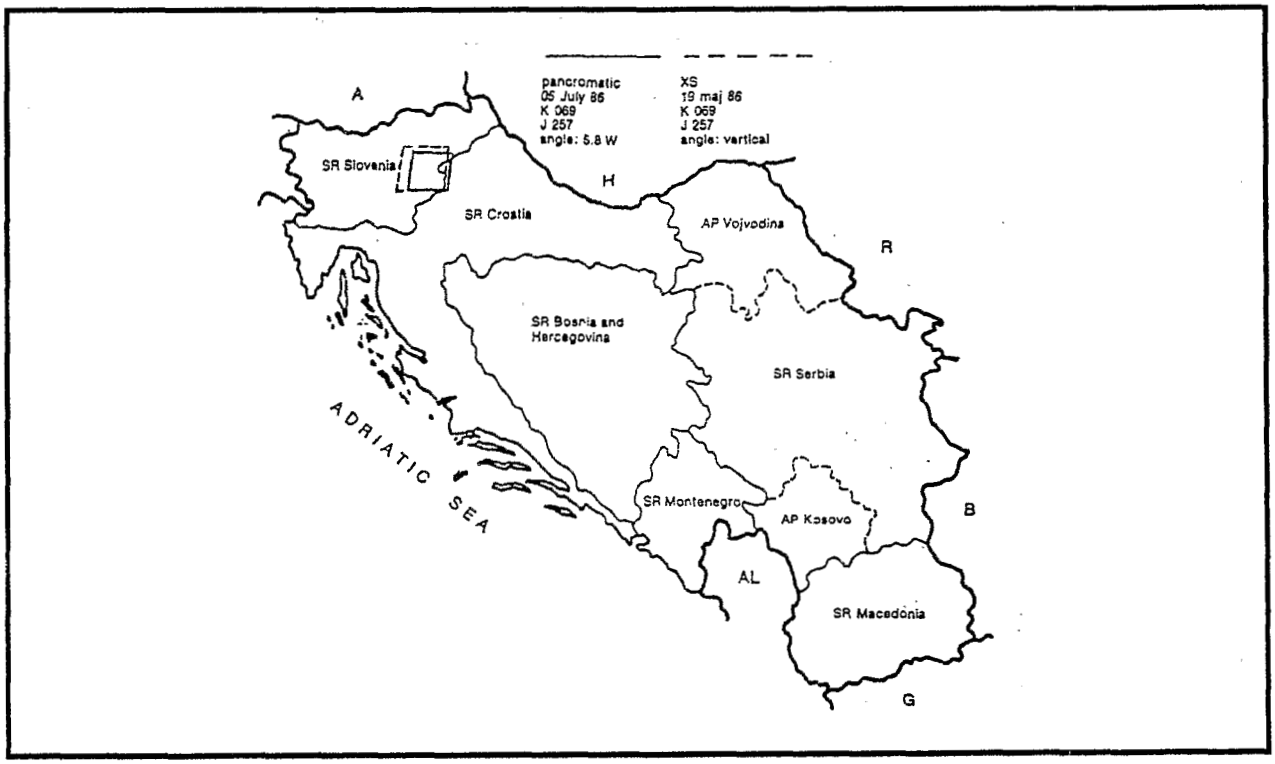


Figure 3. Coverage of Krško municipality by SPOT data.

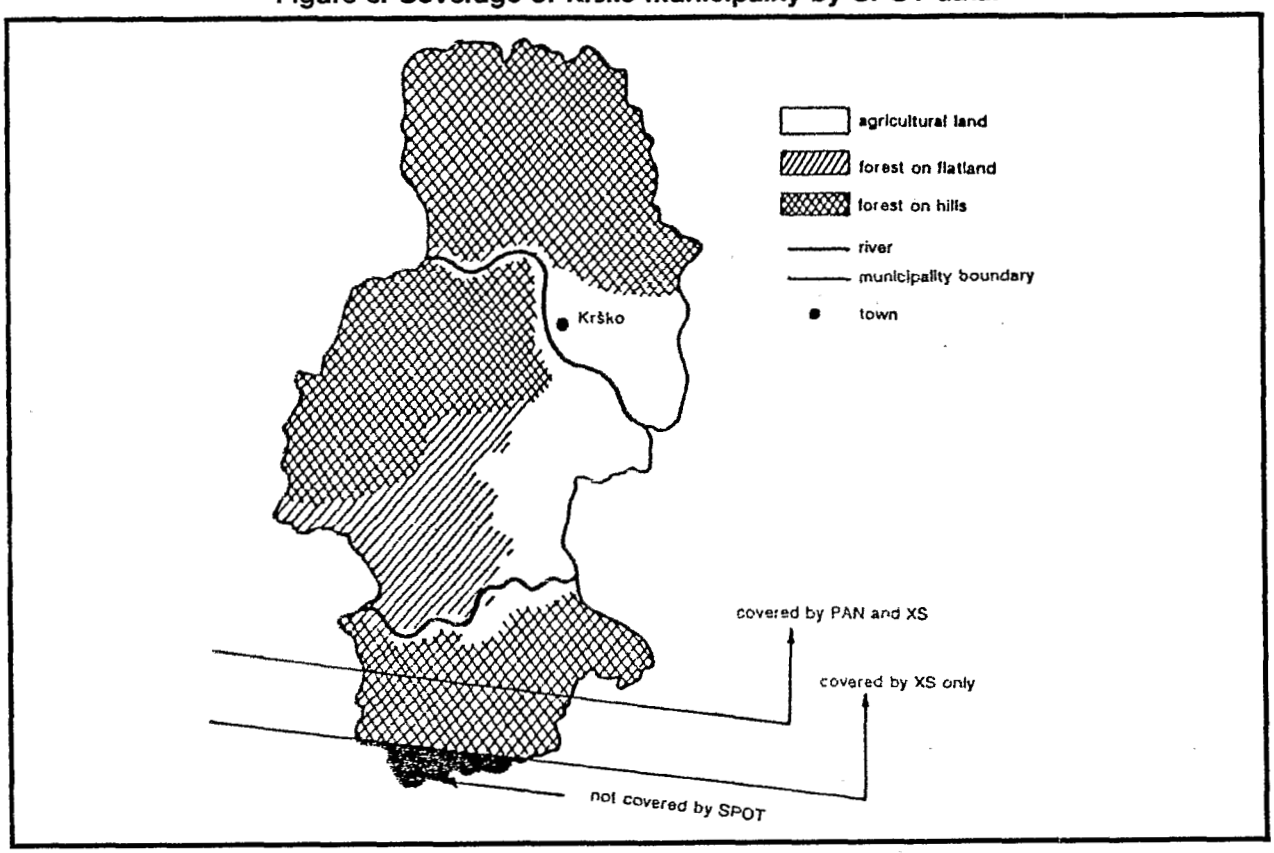
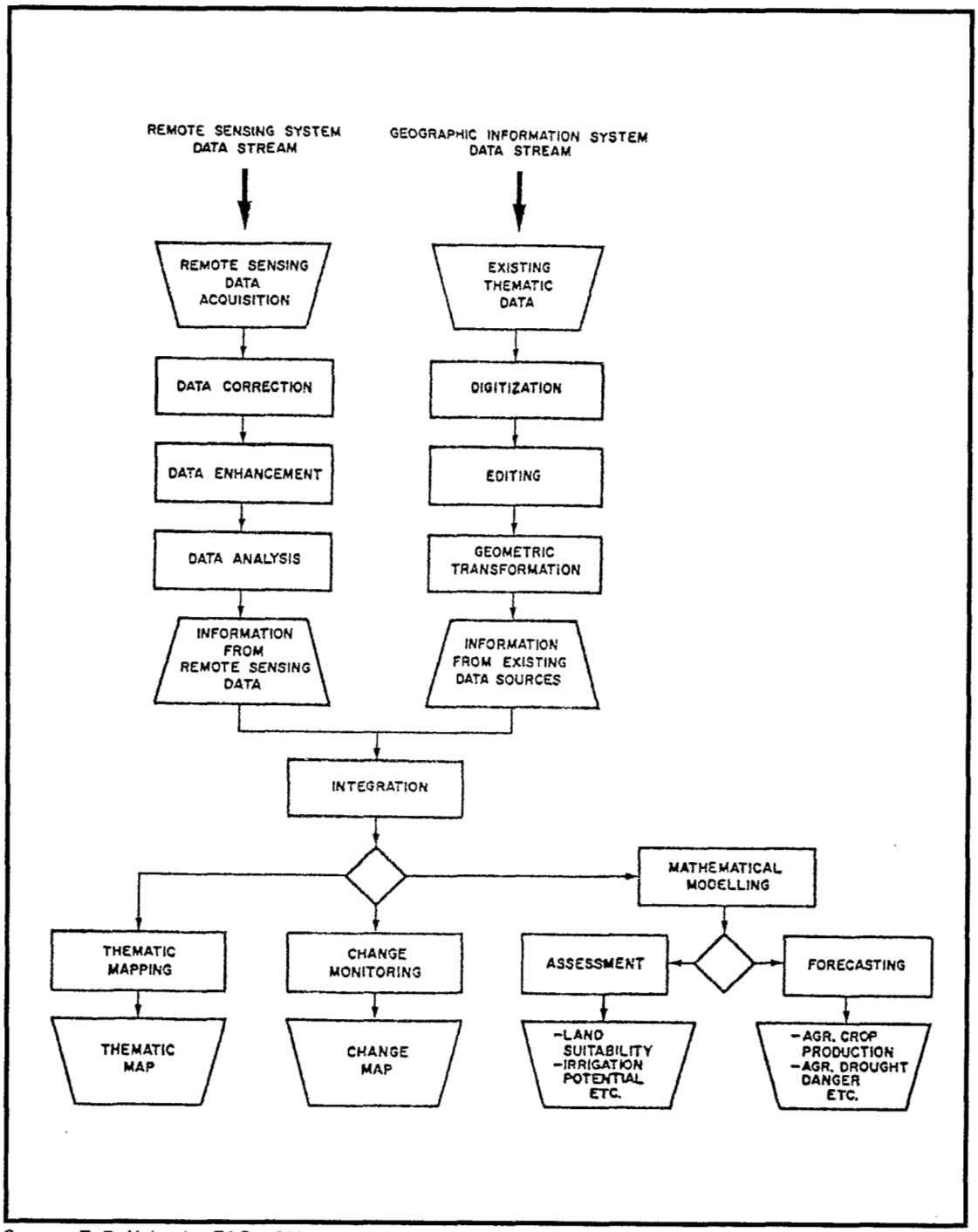


Figure 4. Flowchart processing and integration of remotely sensed and geographic information system data.



Source : Z. D. Kelensky, FAO, 1987.