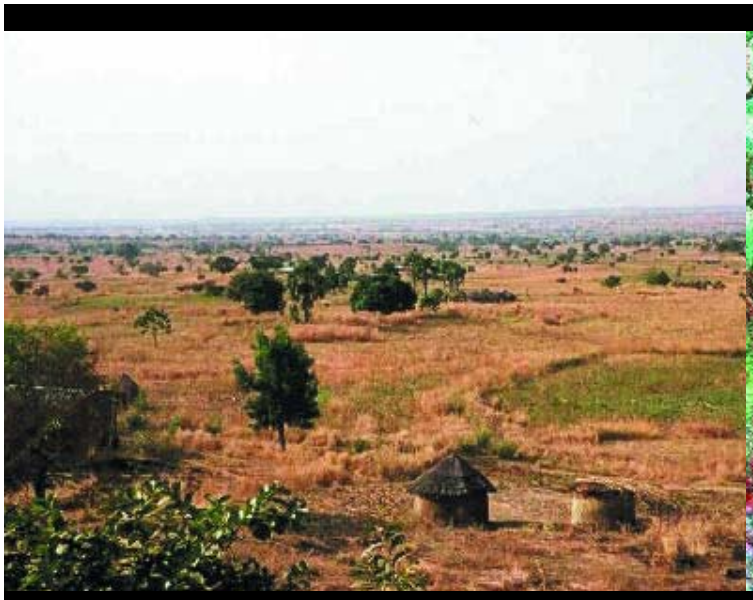
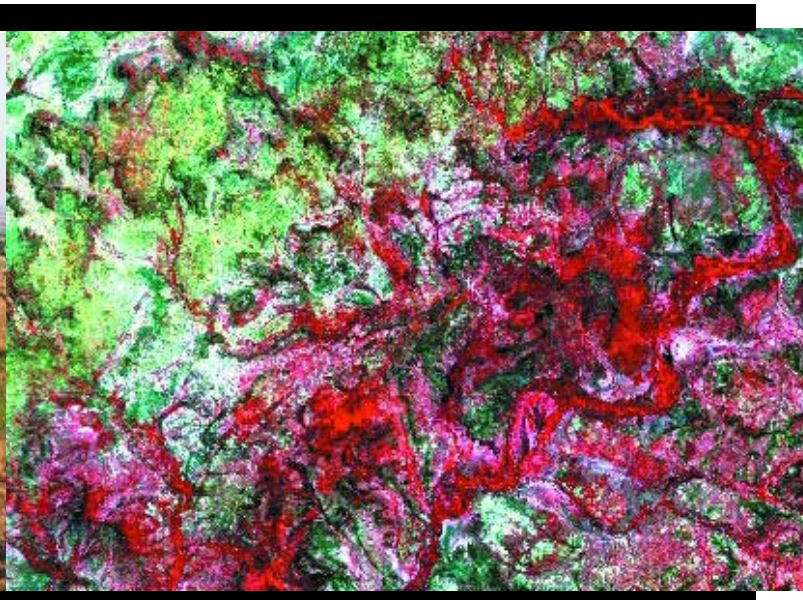
Remote Sensing for Decision-Makers Series N. 20

ASSESSMENT OF PRIORITY AREAS FOR TRYPANOSOMIASIS CONTROL ACTIONS BY SATELLITE DATA AND FUZZY LOGIC

Pilot study In Togo





Food and Agriculture Organization of the United Nations

THE DECISION-MAKERS SERIES FOR WHOM AND FOR WHAT?

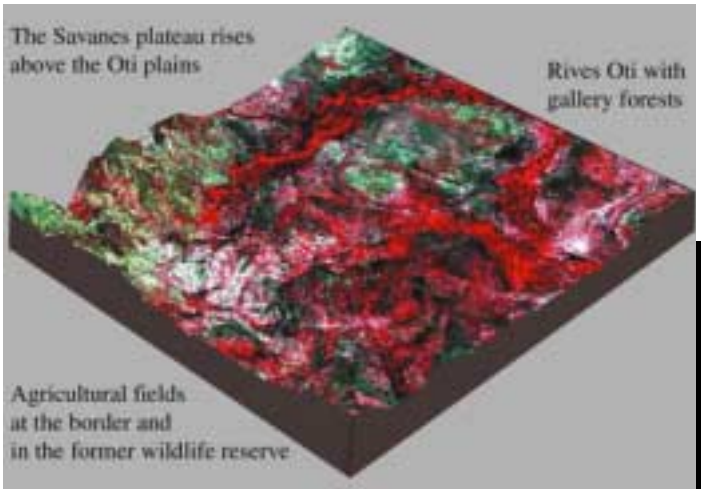
This series, produced by the FAO Environment and Natural Resources Service, is intended for decision-makers such as heads and division directors of national and international organizations and administrations, as well as for project managers, planners and policy-makers of development institutions. Its aim is to present new possibilities of using remote sensing and geographic information system techniques to aid planning for, and management of, renewable natural resources in agriculture, forestry and fisheries. This issue is specifically intended for decision-makers concerned with the control of vector-borne diseases and the management of rangeland resources.

THE NEED FOR PRIORITY AREAS IN CONTROL ACTIVITIES

Trypanosomiasis is endemic in 36 countries of sub-Saharan Africa and causes death and loss of production among cattle. Indiscriminate control actions against the disease might lead to an increase in the number of cattle above the carrying capacity of the land and thus to overgrazing and eventually irreversible vegetation and soil loss. By applying satellite imagery and fuzzy logic in a knowledge-based monitoring system, veterinary services or relevant government agencies are able to detect those areas where control activities might result in a sustainable increase of animal production.

WHAT IS FUZZY LOGIC?

Natural phenomena, like the fragility of the environment, rarely have crisp boundaries and therefore cannot be approached in the classical way with binary logic (fragile or not: 0 or 1). With fuzzy logic, entities are allowed to have a partial membership to a class, which is assigned by membership functions. With fuzzy relational calculus a mathematical basis is constructed to deal with all kinds of problems where the “fuzziness” of natural environment cannot be neglected.



Landsat Thematic Mapper (TM) colour composite image superimposed on the digital terrain model. In the Oti plains vegetation is denser than in the heavily cultivated plateau.

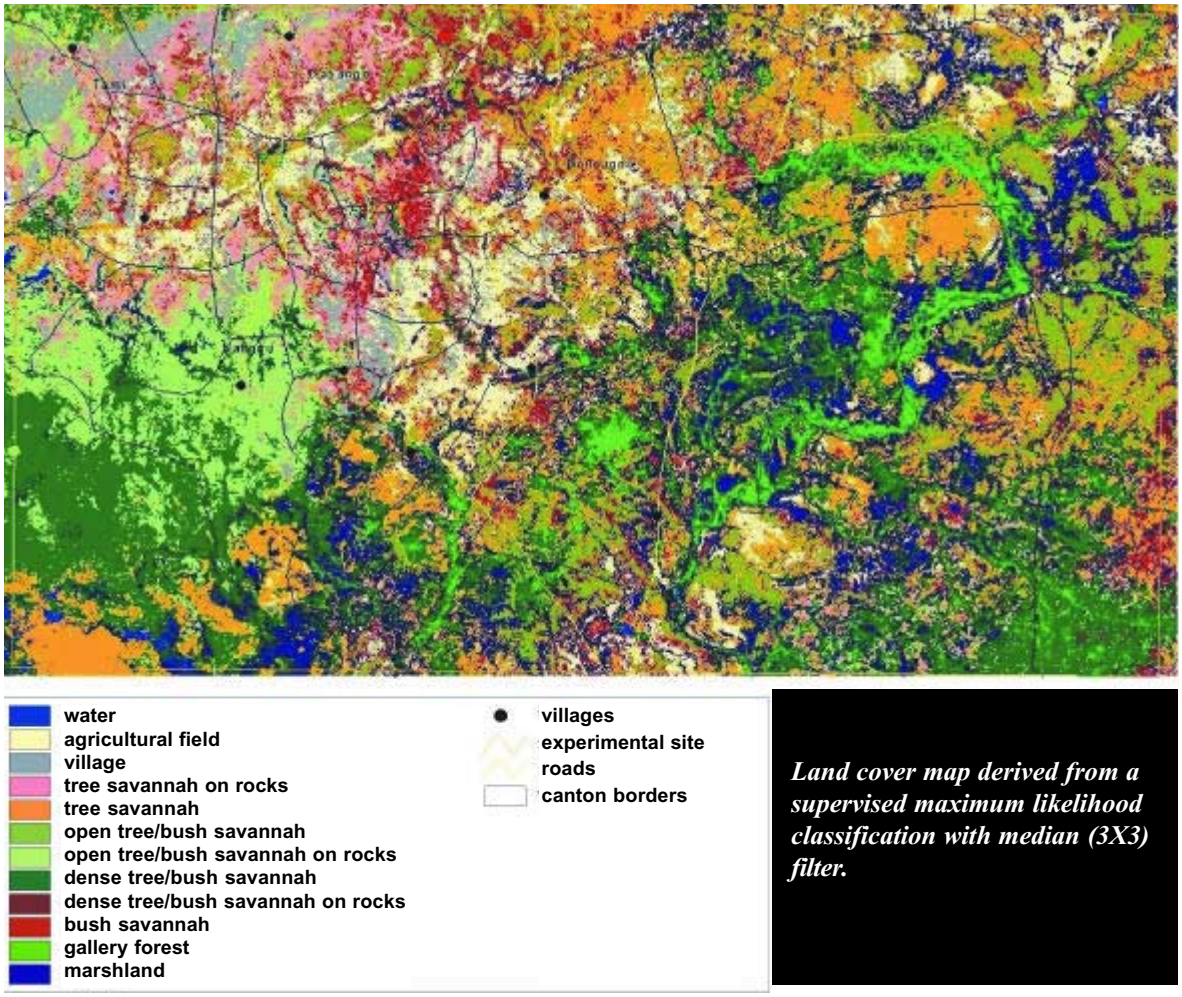
WHAT IS REMOTE SENSING?

Remote sensing covers all the techniques related to the analysis and use of data from environmental and earth resources satellites (such as Meteosat, NOAA-AVHRR, Landsat TM, SPOT and ERS-SAR) and from aerial photographs. The main objective of remote sensing is to map and monitor the earth's resources. Compared with traditional survey techniques, satellite remote sensing is accurate, fast and cost-effective.

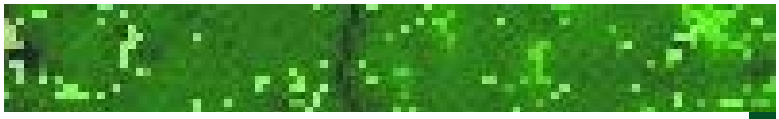
HIGH-RESOLUTION SATELLITE IMAGERY

The operational availability of high-resolution satellite images combined with data from other sources (thematic maps and numerical data), provides new possibilities for land-cover analysis. These data offer a number of advantages:

- They provide synoptic coverage and therefore give an exhaustive view of vast areas at the same time.
- They can be acquired for the same area at a high rate of repetition, thus permitting selection of the most appropriate seasonal data.
- They allow for large-scale mapping.
- Satellite imagery is recorded in various wavelengths, visible and non-visible, which provide accurate information on ground conditions.



Land cover map derived from a supervised maximum likelihood classification with median (3X3) filter.



CASE STUDY IN TOGO IN THE KARA AND SAVANES-L'OTI REGIONS

A successful suppression of trypanosomiasis requires a multidisciplinary and ecologically safe approach. Thanks to adequate disease-suppression activities, adapted to local environmental situations, it should be possible to control animal trypanosomiasis without dramatic consequences for the environment and eventually for the people. In this framework the project T4/DD/21 of the TELSAT4 programme joined the existing FAO project GCP/RAF/347/BEL in Togo and Burkina Faso. The TELSAT project aimed to include environmental parameters in the database and to construct a workable monitoring system, based on information derived from satellite images and other physical land resources. The monitoring system combined physical parameters derived from satellite images and other land resources in the technique of fuzzy relational calculus. Thematic maps based on the physical parameters and monitoring results were processed in a Geographic Information System (GIS).

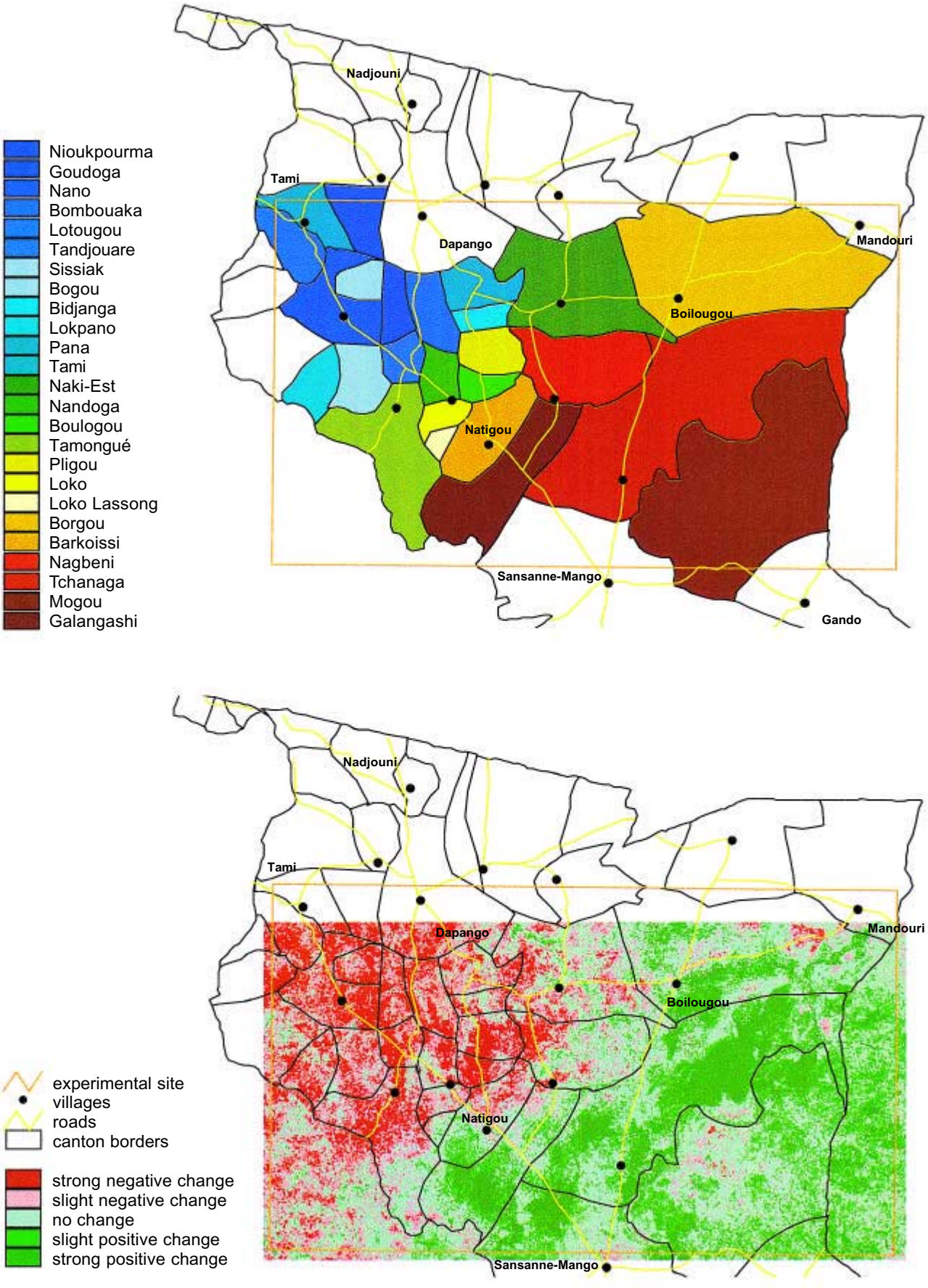
Implementation of the monitoring system required several successive steps:

– Delineation of the smallest administrative entities for the control programme. In Togo this resulted in mapping each region's cantons.
– Generalization and storage of all parameters describing the fragility of the environment in a relational database.
– Construction of the characteristic matrix through conversion of the values in the relational database by user-defined membership functions. These membership functions are derived from reviewed expert knowledge.
– Application of the combined relations on the created fuzzy parameter set.
– Ranking of the cantons according to their environmental fragility.

REMOTE SENSING AND FUZZY LOGIC: DECISION-MAKING AIDS

The methodology created by the project based on Landsat TM images and physical land resources enables veterinary services to derive priority areas for trypanosomiasis control activities. The following information is provided:

– **High-resolution land cover maps** (1:75 000 scale) by supervised classification of the satellite images with a classification accuracy of 65 percent to 95 percent based on intensive field surveys.
– **A detailed database for each canton**, comprising the measured and calculated parameters and the monitored relative fragility status in a GIS.
– **Ranking maps** (1:75 000 scale) as a result of the fuzzy relational calculus, showing the priority areas for trypanosomiasis control actions.



Similarity between the negative change areas (1995 compared to 1986) from the NDVI difference image (Landsat TM) and the fragility ranking map (blue areas: high fragility – no priority; red areas: low fragility – priority). Areas with a low fragility correspond with the green areas in the difference image.

EVALUATION AND RECOMMENDATIONS

Costs and delivery times

Operation	**Costs** (US$/km^2)	**Time** (months)
Purchase of satellite images	0.55	1
Image processing and interpretation	0.16	6
Field survey	0.09	0.5
Fuzzy relational calculus	0.08	4
Database construction-GIS	0.03	5
Map production	0.02	1
Total	**1.3**	**17.5**

REMARKS

The evaluation of costs and delivery times is based on the actual time and costs that were necessary in the pilot project to achieve the results. Delivery time will be reduced in an operational status for several reasons:

- image processing and ground surveys will be reduced;
- database construction in the starting phase is time-consuming, but once the digitization of the documents is completed , the application of the GIS techniques will be limited to analyses and updating;
- the extraction of physical parameters for the fuzzy relational calculus takes place only when constructing the relational database. Updates are necessary when new data become available.

ADVANTAGES OF THE FUZZY METHODOLOGY

The methodology is based on physical parameters that are extracted from digital maps, satellite images or numeric land resources. As a consequence application is not restricted in time or space. Furthermore, data collection combined with satellite image data extraction at canton level ensures a high-resolution fragility calculation for large areas. It is a low cost and user friendly monitoring system based on physical parameters stored in a relational database.

RECOMMENDATIONS

The system created by the pilot project can be successfully applied in any area where enough land resources are available to construct the relational database. For country coverage a pixel unmixing technique with RESURS images combined with Landsat TM can be considered in order to reduce costs. The same procedure can be applied on a regional scale with SPOT VEGETATION and SPOT XS images.

Study conducted by the Laboratory for Forest Management and Spatial Information Techniques, University of Gent, Belgium, in collaboration with The Prince Leopold Institute for Tropical Medicine (ITG), Antwerp, Belgium and the FAO Regional Project for Trypanosomiasis Control, Togo, Burkina Faso (GCP/RAF/347/BEL).
(For further information contact Ms Nancy Van Camp, nancy.vancamp@rug.ac.be)

The Remote Sensing for Decision-Makers Series can be obtained from:
Environment and Natural Resources Service
Sustainable Development Department
FAO, Viale delle Terme di Caracalla, 00100 Rome, Italy
Tel.: (+39) 06 570 55583; fax: (+39) 06 570 53369
e-mail: Changchui.He@fao.org

A list of the issues available in this series is reported on the Internet:
www.fao.org/waicent/faoinfo/sustdev/Welcome_.htm