# INFORMATION

## LAND USE MONITORING BY SPACE REMOTE SENSING AND FOOD ISSUES IN DEVELOPING COUNTRIES

Advances in satellite remote sensing during the last twenty-two years have greatly increased our capacities for mapping, assessment and monitoring of the earth natural resources. This is particularly important for developing countries, whose economies are primarily based on agriculture, forestry, fisheries and mineral resources. Rational planning of their faster economic development has to be based on realistic baseline data. Yet, in most developing countries the inventories of natural resources have not kept pace with modern management requirements and are often incomplete or out of date. The government agencies responsible for development and management of natural resources do not have the capacities to complete and maintain these inventories by traditional, ground-based surveys at the level and within the timeframe required by economic planners and resource managers.

Satellite remote sensing provides a possibility to significantly speed up mapping of natural resources and to establish an efficient system for monitoring of their changes. Resource managers are now able to monitor changes in vegetation cover and land use patterns over large areas, using data recorded by remote sensing systems from the space platforms. Acquisition of remote sensing data is not hindered by remoteness of the area nor by its difficult accessibility. Not surprisingly, the developing countries early understood the importance of remote sensing for management of their natural resources and became interested in the development of application techniques appropriate for their conditions and needs. Yet the progress of operational remote sensing applications in developing countries has been slower than expected. This was partly caused by underestimating time and effort required for a successful transfer of remote sensing technology. Furthermore, it was soon discovered that the potential of remote sensing in natural resource inventories is best fulfilled when its data are integrated with other available relevant data, such as topographic, climatic, soils, demographic, etc., in a geographic information system (GIS).

### FOOD ISSUES AND FOOD SECURITY

Within the next 35 years, that is during the life span of the majority of this generation, the world population will increase by 50%, from about 6 billion

in 1995 to about 9 billion in 2030. After reaching this level, it is expected that population growth will slow down to a sustainable rate. Hence, during the next 35 years food production will have to be increased to unprecedented levels and yet the quality of the natural environment will have to be safeguarded for mankind to survive.

Such an increase of food production cannot be achieved in all regions where it will be needed. While increases of food production have been exceeding population growth at the global level, many developing countries have already experienced severe food shortages. In Africa, population growth has already outpaced the increase in food production by 5% during the last ten years. Food security is further threatened by continuing decrease of the area of cultivated land per capita combined with soil degradation and finite water supplies. Mankind has never faced a task of this magnitude because there has never been such an increase of population in real terms in such a short period of time. Yet, attainment of the goal of assuring adequate food supplies for a growing world population is possible even during the coming critical period through wise applications of new scientific developments and technologies combined with well focused international cooperation.

While the introduction of new scientific developments and technologies are essential requirements for a steady increase of food production, this has to be achieved in the framework of sustainable management of natural resources and environmental protection. Otherwise, the benefits would be short-lived and the global food security situation would be further aggravated.

## ROLE OF REMOTE SENSING AND GIS

New information technologies of remote sensing and geographic information systems will play an important role in the fulfillment of this task. Rational planning of new strategies for reaching the goal of assuring adequate food supplies worldwide has to be based on reliable and timely information on present state of land and water resources, current land use and land use potential. In the course of the last twenty-two years, satellite remote sensing has become one of the most efficient data source for information on natural resources and environment over large areas. When remote sensing data acquisition and analysis are combined with GIS processing capabilities, then the decision makers responsible for food security, natural disasters mitigation, natural resources management and environmental protection have at their disposal a comprehensive, dedicated computer-based system for processing, storage, integration and analysis of all types of geographic data. Its output products are tailored to particular applications and defined jointly with end users. They can be in the form of thematic maps, statistics and mathematical



models for harvest prediction, assessment of trends, risks, suitability, etc. As a result of advancement in computer technologies, the cost of such systems is continually decreasing while their performance and thus the range of their applications are increasing.

Several practical examples on the application of remote sensing and GIS to assessment and monitoring of land use, land degradation and vegetation cover over large areas are presented in this paper. These examples are drawn from the author's experience at the Canada Centre for Remote Sensing (CCRS), which is a part of Geomatics Canada, a sector of the Federal Department of Natural Resources; the Food and Agriculture Organization of the United Nations (FAO); the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) and the International Bank for Reconstruction and Development (World Bank).

## CANADIAN EXAMPLES

A major Canadian initiative, which will have a significant impact on global land use and vegetation cover monitoring, is the development of an operational, applications-oriented earth observation satellite, Radarsat, with synthetic aperture radar (SAR) as its remote sensing payload. The development of Radarsat follows a series of experimental SAR earth resources satellites launched by the USA (Seasat), former USSR (Almaz), the European Space Agency (E-ERS) and Japan (J-ERS). In addition to the SAR all-weather, day and night recording capability of the earth's surface, Radarsat will have a truly global monitoring capacity. Its onboard SAR data recorders will make Radarsat data recording and storage independent of foreign ground receiving stations.

In order to shorten the usual time-lag between the availability of new types of remote sensing data and their operational application, CCRS, in cooperation with the private sector, has initiated a preparatory technology transfer program, GlobeSAR, for early and effective application of Radarsat SAR data. GlobeSAR is a successor to the European Space Agency's SAR Experiment (SAREX 92), executed with the CCRS Convair 580 radar research aircraft in Central and South America in 1992. The GlobeSAR program, led by CCRS, with major funding from the Canadian Space Agency (CSA), the International Development Research Centre (IDRC), and CCRS, has been assisting users from participating countries in acquiring the necessary technology and skills to be ready for applications of Radarsat SAR data when they become available in 1995. The following countries have been participating in the GlobeSAR program: China, Jordan, Kenya, Malaysia, Morocco, Tanzania, Thailand, Tunisia, Uganda and Vietnam.

Other Canadian examples include the interactive, digital global change encyclopedia, GEOSCOPE, which was jointly developed by CCRS and Canadian industry with funding from CSA in the context of the International Space Year 1992. GEOSCOPE integrates geographically referenced data related to global change (existing maps, image data from earth observation satellites, socio-economic data) and provides a user-friendly workstation for data display and analysis. A follow-on Canadian initiative based on GEOSCOPE technology, is the development of an electronic atlas for Agenda 21 (Elada 21). Agenda 21 contains wide-ranging recommendations adopted by the United Nations Conference on Environment and Development (UNCED) in Brazil in 1992. It is a large document which is difficult to use as a handy reference. Elada 21, in its first phase, will provide a digital database for the Agenda 21 biodiversity chapter to make its text, selected background materials and information on new related developments readily accessible by decision makers through their desk-top computers. It will facilitate implementation of biodiversity case studies and thus contribute to better understanding, appreciation and protection of biodiversity. Elada 21 is being developed by CCRS in cooperation with the private sector and funded by IDRC. Several international and national institutions are participating in this project.

## FAO EXAMPLES

FAO examples consist of three projects designed to monitor environmental conditions in Africa and to assess their effects on food security, and one project designed to produce baseline geographic information on current land use and vegetation cover of the whole African continent.

The first project, the Africa Real Time Environmental Monitoring Information System (ARTEMIS), was a result of close cooperation between the FAO Remote Sensing Centre, the National Aerospace Laboratory of the Netherlands (NLR), the Earth Resources Branch of the NASA Goddard Space Flight Centre, USA, and the Meteorological Department of Reading University, England. ARTEMIS has pioneered the use of image data from environmental satellites, the geostationary Meteosat and polar-orbiting NOAA, for operational monitoring of precipitation and vegetation cover over the whole of Africa. Resulting assessments, distributed in digital and paper map formats in 10-day and monthly intervals, are used by the FAO Early Warming System on Food Security and the regional and national food security early warning systems in Africa.

Two regional projects, for Eastern and Southern Africa, located in Nairobi, Kenya and Harare, Zimbabwe, were initiated jointly by FAO and Japan to develop regional capacities for the use of remote sensing inputs in regional



and national food security early warning systems. Both projects closely cooperate with ARTEMIS and significantly contribute to strengthening of African capacities for the use of remote sensing for forecasting of agricultural drought and identifying areas with high risk of desert locust infestations.

FAO is starting to implement a new project, AFRICOVER, for production of a digital geographic database and associated thematic map of land use and vegetation cover of the whole African continent. The first phase of the AFRICOVER project is funded by Italy and will be implemented in East Africa. The map of the whole continent will be produced at scales 1 : 250 000 and 1 : 1 million. The overall project objective is to provide the African decision-makers, United Nations agencies and international development organizations with reliable information about the current land use and vegetation cover. An equally important objective is to strengthen capacities of African organizations for maintaining such a geographic database, monitoring of land use and vegetation cover changes and for using the AFRICOVER database as a reference for development of more detailed, national land use and vegetation cover databases.

## ESCAP EXAMPLE

In 1979 ESCAP, with funding assistance from the United Nations Development Program (UNDP), started formulation of a Regional Remote Sensing Program for Asia and the Pacific. The Program, which became operational in 1982, aims at strengthening of remote sensing capacities of participating countries through cooperation between the relevant organizations in the region. Its activities consist of exchange of information, organization of regional training courses and workshops and implementation of joint pilot studies. The Program, which this year became part of the ESCAP Natural Resources Division, has significantly contributed to the advancement of practical applications of remote sensing and GIS technologies in the region. Its priority areas remain to be food security and environmental protection.

## THE WORLD BANK EXAMPLE

In 1989, the World Bank has established an Advisory Committee on Environmental Information Systems (EIS) for Africa. The aim of this Committee is to focus and accelerate the operational use of GIS and remote sensing by natural resources managers and environmental planners in Africa. Work of the Committee consists of assessing the case studies implemented by participating countries, drawing conclusions from their experience and advising on the most appropriate and cost-beneficial mode of the GIS and remote sensing operations for sustainable management of natural resources and en-

vironmental protection in each country. An important feature of this Program is full local participation in the formulation, implementation and evaluation of each case study. Furthermore, the design of follow-up operational activities is not generic but tailored to specific conditions and priorities of participating organizations. The Program has contributed to more realistic assessment of new technology-absorbing capacities by prospective users of remote sensing and GIS and thus to more sustainable modi operandi for these new disciplines in Africa.

## CONCLUSION

In conclusion, it should be stressed that introducing sustainable management of natural resources and thus assuring adequate food supplies and protection of the environment for future generations in all regions of the world will be difficult, lengthy and costly, but there is no alternative. The consequences of environmental degradation may not be felt for a long time, but once they appear they have serious effects on population and are difficult to rectify.

Remote sensing and GIS technologies are contributing to fill the information gap in many developing countries on the current state of their natural resources, land use and impact of natural disasters such as agricultural drought, floods, etc. However, some developing countries will need short--term assistance with provision of such information to their decision makers, and long-term assistance with strengthening of their national capacities to be able to generate such information, effectively and in a timely manner, themselves.

Prevention of widespread famines and protection of the natural environment are tasks which no country can solve in isolation. International cooperation in implementation of these tasks is the only hope for their effective and lasting solutions.

## Monitorování způsobů využívání půdy pomocí dálkového průzkumu Země a otázky produkce potravin v rozvojových zemích

Dálkový průzkum Země z družic poskytuje nové možnosti pro mapování, hodnocení a monitorování přírodních zdrojů, využití půdy, degradace půdy a rozsahu přírodních katastrof. Tyto nové způsoby průzkumu zemského povrchu jsou zvláště důležité pro rozvojové země, ve kterých jsou informační databáze často neúplné nebo zastaralé a kde instituce specializované na hodnocení a mapování přírodních zdrojů nemají dostatečné kapacity pro uspokojení informačních požadavků moderního řízení.

Rychlý růst populace spojený s degradací životního prostředí podtrhuje nutnost nového, racionálnějšího přístupu k využívání přírodních zdrojů. V roce 1992 konaná Konference Spojených národů o životním prostředí a rozvoji (UNCED) zmobilizovala pozornost světa na potřebu obnovy souladu a harmonie mezi hospodářským rozvojem a životním prostředím jako podmínky pro přežití lidstva.

Vhodnost použití dálkového průzkumu Země z družic pro poskytování informací o využívání půdy, degradaci půdy a rostlinném pokryvu byla dokázána mnohými výzkumnými pracemi a operativními projekty jak v průmyslových, tak v rozvojových zemích.

Tento příspěvek obsahuje několik aktuálních příkladů aplikace této metody z Kanady, Organizace Spojených národů pro výživu a zemědělství (FAO), Hospodářské a sociální komise OSN pro Asii a Tichomoří a ze Světové banky.

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