

GIS Applications and Database Development Within FAO's Land and Water Development Division

1. FAO: What it is, what it does

The Food and Agriculture Organization of the United Nations (FAO) is the largest autonomous agency within the UN which has worked since its inception to alleviate poverty and hunger by promoting agricultural development, improved nutrition and the pursuit of food security. The Organization offers direct development assistance; collects, analyses and disseminates **information**; provides policy and planning advice to governments; and acts as an international forum for debate on food and agriculture issues (e.g. the World Food Summit recently held in Rome).

FAO is active in **land and water development**, plant and animal production, forestry, fisheries, economic and social policy, investment, nutrition, food standards and commodities and trade. It also plays a major role in dealing with food and agricultural emergencies. A specific priority is the encouragement of **sustainable agriculture** and **rural development**, a long-term strategy for the conservation and management of **natural resources**. It aims to meet the needs of both present and future generations through programmes that do not degrade the environment and are technically appropriate, economically viable and socially acceptable.

2. Information

In addition to encouraging the direct transfer of skills and technology through field projects, FAO undertakes a variety of information and support services. Development and maintenance of digital databases - on topics ranging from soils, hydrology, climate, vegetation and other aspects of land use/land cover and production statistics to name but a few - play an essential role in the accomplishment of FAO's mandate. Satellite imagery is among many tools used to map, evaluate and monitor land resources. This information is made available as (paper) maps, databases, on CD-ROM, in publications, etc. Many of the databases are currently installed on the computers of **FAO's Geographic Information System Unit**.

This Unit stores large quantities of data from a variety of sources and of different types. Spatial analyses, which are the real GIS application, are often applied by specific Field Projects or to specific Programmes of the Organization (e.g. Irrigation Water Requirements in Africa, Agro-ecological Zoning in Kenya). With more and more emphasis on sustainable and/or integrated development, the necessity for multi-sectoral studies increases and hence the combination of multi-disciplinary data. This would be practically impossible to do without GIS tools. The integration of socio-economic data bases into the GIS and the linkup of the GIS with international data bases outside FAO is proceeding. Global and regional-level applications of FAO's GIS are carried out at headquarters.

3. Agriculture Department: Land and Water Development

The Agriculture Department assists developing countries and countries in transition to achieve sustainable increases in food production and agricultural productivity with the principal objective of ensuring adequate food for all (food security). This is achieved by helping member countries to formulate and implement national policies, strategies, programmes and projects in resource assessment, land-use planning and soil conservation and by providing technical assistance, advice and training required to create or strengthen national capacities in these areas. FAO has taken a lead in developing and introducing new techniques for irrigation potential assessment, riverbasin management, soil survey, land evaluation and land-use planning.

Among other priority sectors within the Agricultural Department are **land** (e.g. soil resources, land use, land cover) and **water** (water resources, irrigation potential) within the **Land and Water Development Division**. This paper is limited to the GIS applications and related database development within this Division.

3.1 Land

Soil and water underlie all agriculture. The ultimate potentials of land resources for arable agriculture are not known precisely. To evaluate the agricultural potential of the soils, FAO developed a method of combining information on soils, terrain and climate so as to define agro-ecological zones (AEZ).

Agro-Ecological Zone (AEZ) Database: land resources information and evaluation systems (LRIS) can be installed as a basis for decision-making by governments and land users for improved land resources management. The agro-ecological zones (AEZ) methodology is promoted at national, sub-national and international levels to assess agricultural production potentials. The methodology is further developed to provide more precise evaluations and decision support at sub-national and local level, e.g., by identification of socio-economically defined resource management domains; by characterisation of zones for land development and natural conservation, land management and research planning, and by assessing land degradation. Activities will cover improvement of computerised geo-referenced databases combining information on terrain, soils, climate, crops/production systems, land uses and socio-economic factors such as land tenure, markets and prices; dissemination of computerised models, software packages, reports and training materials for land resources analysis, land resources optimisation and decision support systems; dissemination of AEZ information products for practical use in the field. Documented examples of Kenya, Mozambique, Bangladesh and China are available.

Lebanon Pilot Study to Transform Land Cover Map into Land Use Map: this study in collaboration with FAO's Remote Sensing Centre, aims to transform the existing 1:50,000 remotely sensed data derived Land Cover Map of Lebanon into a Land Use Map by combining various data layers in a GIS to derive decision rules for this transformation. The Land Use Database was used for data collection and storage (described below).

Advances in soil science, surveying, photogrammetry and remote sensing underlie the evolution of the GIS. This is in particular illustrated by the Digital Soil Map of the World which evolved from paper map into a geo-referenced database with derived soil properties.

Digital Soil Map of the World (DSMW) on CD-ROM (version 3.5, November 1995): this version is based on the paper FAO/UNESCO Soil Map of the World, original scale 1:5,000,000. The CD-ROM contains two types of files: DSMW map and derived soil properties files with images derived from the Soil Map of the World. More information can be found on Internet under:

- [HTTP://WWW.FAO.ORG/WAICENT/FaoInfo/Agricult/AGL/agls "Soil Resources"](http://WWW.FAO.ORG/WAICENT/FaoInfo/Agricult/AGL/agls/SoilResources).

The Digital Soil Map of the World consists of ten map sheets: Africa, North America, Central America, Europe, Central and Northeast Asia, Far East, Southeast Asia, and Oceania. The maps are available in three formats: one vector format (ARC/INFO Export) and two raster (scale 5 x 5 arc-minute) formats called ERDAS and IDRISI (or flat raster) formats. The scale of the original map (and the vector-formatted data) is 1:5,000,000. The Derived Soil Properties files consist of interpretation programs and related data files. The programs are written in QuickBASIC version 4.5 and can be read using DOS or OS/2 operating system. Included are programs that interpret the maps in terms of agronomic and environmental parameters (e.g. pH, organic carbon content, C/N ratio, clay mineralogy, soil depth, soil and terrain suitability for specific crop production, soil moisture storage capacity and soil drainage class). Special country analyses can be made for specific soil inventories, problem soils and fertility capability classification for every country in the world. Also included are maps of classification units of the World Soil Reference Base units and topsoil distribution, which can facilitate the teaching of soil science. In addition there is a soil database developed specifically for environmental studies on a global scale, which includes soil moisture storage capacity, soil drainage class and effective soil depth.

The following major land resources databases have been developed:

Soils and Terrain Database for East Africa: this is a recently produced stand-alone software program for storage, display, interpretation and analyses of the soil maps of 10 East-African countries (Burundi, Djibouti, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, Somalia, Sudan, Uganda) at scale 1:1,000,000. This database contains a soil database (based on the revised

FAO Soil Legend) and terrain database with corresponding digital maps as well as data layers containing vegetation, geology and data reliability. Various interactive querying and selection tools provide easy access to specific parts of the database for display as thematic map, data browser or data entry form.

FAO/ITC Land Use Database: a knowledge-based program for structured storage and retrieval of user-defined land use data sets. This database itself does not contain any data.

ECOCROP1: The information in this database permits the identification of 1710 plant species whose most important climate and soil requirements match the information on soil and climate entered by the user. It also permits the identification of plant species for defined uses. It can be used as a library of crop environmental requirements and it can provide plant species attribute files on crop environmental requirements to be compared with soil and climate maps in AEZ databases or GIS map-based display.

3.2 Water

The Water resources, development and management Service of FAO has developed two main programmes using GIS. They both are related to water resources assessment:

AQUASTAT: It is an information system on water availability and use in agriculture and rural development, which produces country profiles on water resources development, with emphasis on irrigation and drainage. This database is not geo-referenced but contains data which can be integrated in a GIS for specific purposes. In the assessment of the irrigation potential for Africa, for example, information on water resources was available from the AQUASTAT survey and the breakdown by basin was obtained through GIS by using simple rainfall-runoff relationships. To assess irrigation water requirements, FAO's CROPWAT software was combined with FAO's climatic database CLIMWAT through GIS after having identified representative cropping pattern zones. Combining land and water resources with the irrigation water requirements leads to the estimation of the irrigation potential.

GIS Hydrology Programme: This programme is developed in co-operation with the University of Texas, Austin, and UNESCO. Available information on climate, soils and river systems is used in GIS to simulate the distribution of water resources over the river basin. Pilot experiments are being carried out in the Niger River Basin and the Souss river basin in Morocco. Both a surface water and a groundwater model were developed using GIS, making use of already available information on runoff, climate, physiography and irrigation. The model once operational will be used to assess the impact of development scenarios on water resources in the basin.

In addition to these programmes, satellite imagery is increasingly used in field studies on the engineering, economic and environmental aspects of surface and groundwater development, on utilisation of poor quality water for agricultural purposes, and on social and institutional aspects of irrigation water management. All these topics are directly related to the activities of the Water Resources, Development and Management Service.

Two computer programs and one database have been developed for water management. Although they do not use directly GIS, they constitute a basis which can be combined with other existing information on GIS for specific studies (such as the assessment of irrigation potential in Africa).

SIMIS: a PC-based computer program developed to facilitate the management tasks of irrigation systems (water delivery, day-to-day management activities, accounting, crop production, control of maintenance, water fees...). Using the model, indicative irrigation schedules can be derived from average climatic (rainfall) and agricultural field data, taking into account the specific requirements of the irrigated crop. Key to the model is the daily assessment of the water balance. Soil moisture status is determined from calculated evapotranspiration and water supply from rainfall and irrigation. FAO methodologies for determining crop water requirements and yield response to water application are used.

CROPWAT: a computer program which calculates reference evapotranspiration, crop water requirements, irrigation requirements, scheme water supply, to develop irrigation schedules under various management conditions and to evaluate rainfed production and drought effects.

CLIMWAT: is a climatic database used in combination with the computer program CROPWAT and allows the ready calculation of crop water requirements, irrigation supply and irrigation scheduling for various crops for a range of climatological stations world-wide.

The Land and Water Development Division has organised workshops aiming at the identification and evaluation of the possible uses of GIS and remote sensing techniques for irrigation and drainage (in 1993) and for hydrology (in 1995). It collaborates with the **Remote Sensing Centre** and other relevant services in FAO on the development of computer-based tools for analysing and disseminating remote sensing data and information products.

4. Collaboration with the Environment and Natural Resources Service - Remote Sensing Centre

The Environment and Natural Resources Service of which the **Remote Sensing Centre**, as well as the **Geographic Information System Unit** already mentioned are part, helps developing countries use remote sensing and geo-referenced data to monitor and better manage natural resources.

This Service will under the **AFRICOVER Programme** establish for Africa a digital geo-referenced database on land cover and a geographic referential at a scale of 1:250,000 (1:100,000 for small countries). This base will also be homogenised at a 1:1,000,000 for the whole African continent. A further objective of AFRICOVER is to reinforce and to build up the national and sub-regional capacities for the establishment, updating and operational use of this geographic referential and the geo-referenced land cover database. From a technical point of view, the preparation of AFRICOVER products relies essentially on remote sensing data and GIS. The land cover will be mainly derived from visual on-screen interpretation of recent high resolution satellite images. The first operational phase of the AFRICOVER Programme will be **the East Africa Project** covering 10 North and East African countries.

Under the Africover Working Group on Legend and Classification the **Land Cover Classification** concepts were developed. At present the first full operational version of the classification and its software program is being developed for implementation by the East Africa Project, its first user, in collaboration with the Land and Water Development Division. This program will be integrated in existing digital image processing software. The Land Cover Classification is a comprehensive standardised a-priori classification system which can be used as reference system because the diagnostic criteria used allow correlation with existing classifications and/or legends.

More information can be found on Internet pages:

- [HTTP://WWW.FAO.ORG/WAICENT/FaolInfo/SustDev/Eldirect/Elan0003.htm](http://WWW.FAO.ORG/WAICENT/FaolInfo/SustDev/Eldirect/Elan0003.htm)
- [HTTP://WWW.FAO.ORG/WAICENT/FaolInfo/Agricult/AGL/agls/infolulc.htm](http://WWW.FAO.ORG/WAICENT/FaolInfo/Agricult/AGL/agls/infolulc.htm)

5. Further Information

Contact address:

FAO - Food and Agriculture Organization of the United Nations,
Viale delle Terme di Caracalla
00100 Rome, ITALY

Internet: [HTTP://WWW.FAO.ORG/WAICENT/Agricul.htm](http://WWW.FAO.ORG/WAICENT/Agricul.htm)

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Technical information:

There are several pages on Internet which give more detailed information per Department. You may be interested in the following sites:

- **land , land resources, land use (planning):**
<http://www.fao.org/waicent/Faoinfo/Agricult/AGL/agls/aglshome.htm>
- **water (resources), irrigation:**
<http://www.fao.org/waicent/Faoinfo/Agricult/AGL/aglw/aglw.htm>
- **sustainable development, natural resources:**
<http://www.fao.org/waicent/Faoinfo/SustDev/Eldirect/EIhomepg.htm>

This information on GIS applications and database development within the Land and Water Development Division and its collaboration with the Environment and Natural Resources Service has been compiled by:

Louisa J.M. Jansen
Soil Resources, Management and Conservation Service
Land and Water Development Division (AGL)

in collaboration with the Environment and Natural Resources Service (SDRN).

With thanks to Matthieu Bousquet and Karin Frenken (AGLW), Denis Sims, Freddy Nachtergaele and Jacques Antoine (AGLS) for review of the paper.