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FAO Africover Project
Contribution to Africa SDI Development

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Abstract

The Food and Agriculture Organization of the United Nations (FAO) began formulating a project for land cover mapping of Africa – the Africover project – in the early 1990s. It was done in response to requests from several African countries for assistance with the establishment of reliable land cover databases. Land cover data are essential for the sustainable management of agricultural land, forest and fresh water resources, environmental monitoring and protection, and development planning. The project implementation started in East Africa (Africover-EA) in 1996.

The overall objective of the Africover-EA project is to provide reliable, timely and location-specific land cover information in eleven East African countries covering an area of over 9 million km². The area includes the nine riparian countries of the Nile River Basin, as well as Somalia and Djibouti – a near complete coverage of East Africa.

A Land Cover Classification Standard: The Africover-EA project also produced the Africover Land Cover Classification System (LCCS). The LCCS is based on systematic and comprehensive land cover characterization, regardless of mapping scale or geographic location. Its use facilitates the harmonization of land cover mapping and monitoring methodologies, as well as the integration and GIS processing of their products. The LCCS represents a leading edge land cover classification methodology. As its use increases, it may become a worldwide land cover classification standard.

Integration and Access through Dynamic Atlas: The Africover project and several other projects in Africa are using FAO's Dynamic Atlas software – Dynamic Maps, Dynamic Web Maps and Dynamic Knowledgebase to publish and provide access to the data in conjunction with other project and/or national spatial and tabular data and documents. Dynamic Atlas effectively means the Africover data can be available to anyone for their reference and use.

Facilitating SDI: The Africover-EA project will be completed in mid-2003. An inventory of potential users of its products has been completed and a potential client network established. International projects that will benefit from its products include the Nile Basin Water Resources Project; Lake Victoria Water Resources Project, Lake Chad Basin Project, African Rangelands Assessment and Monitoring Project, Tropical Forest Resources Assessment Project, Africa Real Time Environmental Monitoring Information System (ARTEMIS) and the Global Land Cover Mapping Project 2000 of the E.U. Furthermore, the Africover harmonized geospatial databases will facilitate development of spatial data infrastructures at all levels.

The Africover project is helping make the management of renewable natural resources and environmental protection in East Africa more effective and efficient. Also, by publishing the information and making it readily accessible through tools like Dynamic Atlas, the project will increase the understanding of land use and land cover in Africa and facilitate the further sharing of information.

1. Introduction

Addressing Food Security Issues in Africa: A common objective of spatial data infrastructures is to help make reliable geospatial information available in harmonized, user-friendly formats, and to promote their effective and efficient use. The importance of having available information on current land cover, land use and land degradation, past changes and future trends, for sustainable development of natural resources and environmental protection was recognized at the World Summit on Sustainable Development (WSSD), recently completed in Johannesburg, South Africa. Such information is also essential to the FAO Sustainable Agriculture and Rural Development Initiative (SARD), which aims to conserve, restore and improve the environmental, economic and social well being of rural populations in developing countries while meeting their food needs. Yet, in most developing countries, land cover information is either not available or outdated. African countries are in the worst situation. They need reliable land cover information to plan the sustainable increase of their crop production and strengthen the food security of their people.

Geo-Information Technologies and the New Paradigm: Advances in geo-information technologies during the last two decades have changed the paradigm of land cover mapping and monitoring. Satellite remote sensing has become the main source of land cover data, while GIS provides the capacity for the integration of remote sensing data with geospatial data from other sources (such as existing maps and field surveys records), their joint analysis, development of geospatial database and generation of cartographic, statistical and modeling products. GPS enable precise positioning of sampling units for data calibration and field validation of results. As a result of these developments, land cover mapping projects can be now completed relatively quickly anywhere in the world, regardless of the remoteness of the area.

Barriers: However, geospatial information can be expensive. Developing countries in particular have difficulty allocating money for the acquisition of data and the production of information, even though they are an essential requirement for planning and implementing development strategies.

Existing maps and tabular data are often outdated, incomplete or lack the required accuracy. Their revision and the rate of their completion have been slow, and have not kept pace with the growing requirements for geospatial information by agencies responsible for environmental assessment, monitoring and protection.

There is usually no coordination among agencies entrusted with the mandate for collecting geospatial data, such as topographic, cadastral, soil, forest, hydrographic, land cover/use, etc. Even knowledge about data types, mapping scales, accuracy standards (if any), years of data collection and their availability is often sketchy.

Inter-agency cooperation is typically poor. Many agencies consider geospatial databases as their exclusive property and they are not willing to share – even if these databases were developed with public funding.

New Attention on SDI: Governments of developing countries are starting to realise that they have to change their traditional practices of geospatial data management in order to increase the economic, environmental and social returns and other benefits to be derived from their wider use and availability. Of particular importance then is the promotion of the development of Spatial Data Infrastructures (SDI) that facilitate the availability, harmonisation, sharing and use of geospatial data.

The importance of Land Information to NEPAD: In 2001, a group of African leaders, realising that international development programs have not fulfilled expectations of faster economic growth, and that their countries have been lagging behind, decided to formulate a new strategic framework for the socio-economic development of Africa, based on their own assessment of needs and priorities. The New Partnership for Africa's Development (NEPAD) is a call to the rest of the world to partner with Africa in her development on the basis of her own agenda. NEPAD is paying particular attention to the agricultural sector because of the urgent need to strengthen food security and to eradicate widespread poverty among the rural population. NEPAD's action program consists of projects that would develop the basic infrastructures and serve as a catalyst for sustainable growth and development. Access to reliable information on land cover, use, degradation, and potential is an essential prerequisite to the effective realisation of NEPAD's goals.

2. FAO Africover Project

FAO, responding to the critical for reliable land cover information in Africa and to recommendations by the United Nations Conference on Environment and Development (UNCED), initiated the Africover project, funded by the government of Italy, in the mid-1990s. The project is producing reliable land cover information, in uniform format, at a scale of 1:200 000 for all Africa. Another equally important objective is strengthening the technical capacities of participating regional and national organizations. This will enhance the effective use of project products at the regional and country levels and facilitate its follow-on activities, including the maintenance of land cover databases produced by the Africover project. Finally, the Africover project is helping harmonise land cover and other geospatial data in the whole region and increase their accessibility. It has started using Dynamic Atlas software to make the data available, it promotes the establishment of spatial data infrastructures at country and regional level, and it has initiated the development of the Global Land Cover Network (GLCN).

Capacity Building

The Africover project supports a gradual, systematic technology transfer through active participation of counterpart national institutions in all steps of project implementation -- from the selection of image data products, their processing, field validation of preliminary results, establishment of GIS-based digital land cover database, to the generation of 1:200000-scale land cover maps and change statistics. The project also includes the training of, in particular, land use planners and environmental protection officers, in the effective use of the land cover database. Hence, it combines capacity building with the

production of much needed information database on current land cover/land use and their changes.

The Africover project ensures the national institution with the mandate for environmental monitoring will have developed an adequate capacity to continue the project activities after its completion. This newly developed institutional capacity for land cover mapping and management of geospatial data will be used for the gradual extension of the core land cover database, generated by the project for pilot areas, to include other priority areas and, eventually, the whole country. The project is a catalyst, providing a capacity for continuous updating of land cover and land use data and monitoring their changes. The project also facilitates the improvement of existing forestry, water resources, soils and topographic databases by introducing the Africover mapping methodology in the country, providing new satellite remote sensing imagery of pilot areas, and by developing the Internet-based data exchange protocol.

FAO will provide technical advisory services throughout the project to assure that its objectives are met and that the counterpart institution has obtained the operational capacity to continue.

Dynamic Atlas and Broadening Information Access

Two key elements of an effective information management solution are:

- Broadened access to the information;
- Integration of multiple data sources and types of information.

By putting the information, and the tools that allow its effective management, into the hands of decision-makers, planners, and other end-users, the value of the information becomes significantly greater. Also, by enabling the data produced through the Africover project to be integrated with virtually any other data, maps, and documents within the user community, a much richer “picture” can be developed, and partnerships / sharing of information can be strengthened, developed and supported.

That is why this project also includes the implementation of the FAO’s Dynamic Atlas. Dynamic Atlas software provides the ability to easily integrate map (spatial) data, spreadsheet records, documents and other digital files into related “topics” of information for use on the desktop, or on the Internet with a browser. It also provides users with the ability to query the data and produce meaningful maps, analysis and reports quickly, after just a basic training. The software enables the creation of an “atlas” of project information by combining the spatial data, the relevant tabular findings along with any pictures, reports and communications materials from that project and from related projects. The software is available on SKE Inc.’s web site www.skeinc.com.

Spatial Data Infrastructure

The project’s role as “catalyst” will be further enhanced by initiating and facilitating the development of spatial data infrastructures at country and regional levels in Africa. SDIs

will promote linkages among sector geospatial databases, the harmonization of data formats and exchange protocols, and the increasing data accessibility by development of metadata databases. They will increase knowledge about geospatial data archived in specialised institutes and enhance their multiple and integrated use in such key applications as the assessment of land potential for specific agricultural use, irrigation potential, aquaculture potential, etc. An important factor facilitating SDI development is the formation of networks of Africover national collaborators, who represent the main stakeholders (governmental and non-governmental) that are producing and using geospatial information. Information on SDI principles and benefits are included in Africover training courses and workshops.

The Africover project is also a catalyst for standards in land cover classification and other related data and information. By publishing the information in meaningful ways and making the information readily available and usable, through technologies like Dynamic Atlas, the global community will become more in tune with the standards used in the data and will therefore be better able to develop standards. Data standards are often largely an issue of use – and Africover supports use.

The country-level and regional SDIs are components of the global SDI, which provides important inputs to global environmental initiatives. These include the Framework Convention on Climate Change (FCCC), the Convention on Biological Diversity (CBD), the Convention to Combat Desertification (CCD), the United Nations Forest Forum (UNFF), and the Global Terrestrial Observing System (GTOS).

3. Africover Methodology

The Africover land cover mapping methodology consists of the following main tasks:

- a) Development of common standards for land cover classification and mapping of Africa at a 1:200000 scale. These have included, in particular, the development of the Land Cover Classification System (LCCS).
- b) The design of a map legend applicable to such key applications as the sustainable land use planning, food security assessment and environmental protection.
- c) The development of a field sampling design for calibration and validation of interpreted data compatible with the requirements of land cover mapping at 1:200000 scale.
- d) The computer-aided interpretation of satellite imagery based on LCCS, GeoVIS and AIMS software, including field validation of interpreted results and accuracy assessment.
- e) The development of GIS database and production of digital land cover maps at the basic scale 1:200 000 and derived scale 1:1 million on CD ROMs. Hard copy mapping products are generated when required. After project completion, the land cover database will be maintained at the country-level by the national organizations that participated in the Africover project implementation.

- f) The development of a metadata database for land cover information produced by the Africover project. The database will be available on the Africover Internet web page.
- g) The strengthening the capacities for land cover mapping based on satellite remote sensing imagery in the regional and national organizations participating in project implementation. Training the national officers in the maintenance of the Africover database.
- h) The introduction of Dynamic Atlas software for integration and publishing of Africover data along with other data in structured “Atlases” on the desktop and over the Internet.
- i) The initiation of development of an African Spatial Data Infrastructure.

The main products of the Africover project are:

- Reliable information on current status of land cover.
- Strengthened capacity in each participating country to produce such information.

The information is in a digital land cover database with associated land cover maps at the scales of 1:200000 and 1:1 million on CD-ROMs. In addition, the project outputs include the methodologies and facilities for land cover mapping, such as the LCCS, GeoVIS and AIMS land cover classification and mapping methodologies; GIS and image analysis software packages; Dynamic Atlas publishing and access software, trained national personnel in their operational applications; and strengthened land cover mapping capacities of regional and national institutes that participated in project implementation. These additional project outputs are important for keeping the newly established land cover database updated and allowing the implementation of project follow-on activities, such as the land cover mapping at larger scale in selected areas. However, they are secondary to the Africover main output, that is the provision of reliable land cover data with uniform accuracy and based on standardized land cover classification and mapping methodologies.

The Africover project implementation is based on close cooperation with the relevant African regional and national organizations. Furthermore, two International Working Groups were established by the project:

- Africover International Working Group on Geodesy and Cartography;
- Africover International Working Group on Land Cover Classification and Map Legend.

They have been involved in its preparatory activities, including the specification of land cover information requirements (land cover classes, classification accuracy and mapping scales); geodetic and cartographic specifications (geodetic reference datum, cartographic projection and coordinate system) and specifications for field validation of preliminary interpretation results (field validation methodology, sampling design and frequency).

Participating East African countries appointed the Africover National Coordinators in order to assure a close link with the project. At the meetings organized by the project,

they were briefed on its progress and exchanged experience with its implementation related to their respective countries. The project has also organized a series of courses for training the national technical officers in the Africover Land Cover Classification System, interpretation of satellite images and field validation of interpretation results.

Project design is modular, to allow its implementation either at the sub-regional or a country level. Its original design was based on the following five sub-regional modules:

- 1) East Africa – 12 countries, 9 582 907 km² (includes Democratic Republic of Congo);
- 2) North Africa – 4 countries, 5 017 440 km² (excludes Egypt, which is part of the module #1);
- 3) Sahelian – 9 countries, 5 307 820 km² (includes Cape Verde);
- 4) West and Central Africa – 15 countries, 5 066 955 km² (includes Sao Tome & Principe);
- 5) Southern Africa – 13 countries, 5 350 747 km² (includes the Indian Ocean countries Madagascar, Mauritius, Comoros and Seychelles).

Only the East African module has obtained funding and is being implemented. Although negotiations regarding the implementation of other sub-regional modules are ongoing, it soon became obvious that some prospective sponsors preferred a more flexible approach, allowing them to select a country or group of countries according to their priorities and available budget. A revised concept of Africover project implementation accommodates this requirement and allows the project implementation at a country level as long as the Africover concept and technical specifications are followed. FAO prepared a template project document for implementation of the Africover project at a country level.

Five Africover scenarios were developed for project implementation at a country level. They differ according to the level of country involvement:

- a) Project inputs by FAO Africover staff are limited to training on Africover specifications, its Land Cover Classification System and the Interpretation and Mapping System. The country does the implementation of all project activities.
- b) FAO Africover staff select the satellite imagery, supervise its geometric rectification and enhancement and provide training as in (a). The country implements the remaining project activities.
- c) FAO Africover international consultant provides training and supervises the implementation of all project activities in the country.
- d) As above with the exception of development of GIS database. That task is contracted by FAO to an international company.
- e) International company implements the whole project according to Africover specifications. FAO certifies that the specifications were sustained and the Africover label can be used for the project products.

The majority of countries will likely adopt the scenario (c) in which the international consultant supervises the project implementation. Only the Republic of South Africa will likely select the scenario (a) for its proposed updating of the “South African National Land Cover (NLC) Database” project. This project provides a standardized, baseline inventory of land cover and land use (LCLU) maps at 1:200000 scale for the whole of South Africa, including Swaziland and Lesotho, based on Landsat-TM imagery recorded in 1994-95. It was recommended that the proposed follow-up project, the “National Land Cover 2000” be based on Africover specifications, including its Land Cover Classification System. Projects implemented at a country level, regardless of the scenario, will obtain the Africover certification only after it is asserted that they comply with the Africover specifications. This policy will assure the homogeneity of the Africover database for the whole continent and uniformity of its land cover mapping products in terms of their thematic content and accuracy.

4. FAO Land Cover Classification System (LCCS)

The Land Cover Classification System is an important spin-off development of the Africover-EA project. It is the most significant attempt for the establishment of standardized, systematic, multipurpose, land cover classification system. LCCS enables a comparison of land cover classes regardless of data source, economic sector or geographic location. It is the only universally applicable system in operational use. Most other land cover classification systems are single-purpose systems, tailored to meet the requirements of a specific project or sector. Land cover classes produced by such systems are generally not comparable. Despite the many land cover classification systems, none has been internationally recognized and selected as a standard because of the above-mentioned limitations. Yet, the increasing number of regional and global programmes and projects urgently need a universally applicable land cover classification system for objective international comparisons of the land cover’s state and its changes.

LCCS Design Principles

The *a priori* classification concept, in which the classes are defined before any data collection and their classification take place, has been selected for LCCS. The main advantages of *a priori* classification systems is that they allow standardization of classes and are independent of data collection methodology and geographic area. Their disadvantage is their inherent rigidity in having to select all the classes in advance. An enormous number of predefined classes would be needed for the consistent description of land cover occurring anywhere in the world.

The Africover project selected a new approach to *a priori* classification. Instead of predefining the classes, it predefined the classification criteria that uniquely identify the classes. The concept is based on the presumption that any land cover class, regardless of its type and geographic location, can be defined by a set of pre-selected independent diagnostic attributes, the “classifiers”. The number of classifiers used determines the detail with which the land cover is classified. Thus, a larger number of classifiers is needed when more detailed classification of land cover is required.

Another unique approach to the *a priori* classification adopted by the Africover project was driven by pragmatic, operational considerations. Instead of attempting to use the same, large set of pre-selected classifiers for the complete land cover of Africa, it divided the classifiers into eight groups tailored to eight major land cover classes corresponding to the third classification level. This has greatly reduced the number of classifiers needed for precise definition of any land cover class and thus significantly simplified the classification procedure. However, it required designing the LCCS implementation in two phases: the initial *Dichotomous Classification Phase*, consisting of three classification levels and resulting in eight major land cover classes in the third level and the follow-up *Modular-Hierarchical Phase*, during which each land cover class is defined by the specific hierarchical combination of classifiers.

The advantages of the Land Cover Classification System are many. It is a universally applicable system that is not limited by either geography or application. Each land cover class is clearly defined, thus providing internal consistency. Any land cover type can be readily accommodated. The system is hierarchical and applicable at a variety of scales. It can be used as an international classification standard because its diagnostic criteria allow correlation with existing classifications and legends. The LCCS thus contributes towards harmonization and standardization of land cover classification and mapping.

5. Global Land Cover Network (GLCN)

In May 6-8, 2002, FAO and UNEP organized an Expert Consultation on Strategies for Land Cover Mapping and Monitoring in Artimino, Italy. 60 participants representing major international land cover initiatives as well as developing countries from all regions attended it. Its objective was to brief the participants on plans to develop GLCN, discuss its design parameters and functions, and obtain their feedback. The meeting resulted in the Artimino Declaration on Global Land Cover Network, endorsing GLCN development.

Overall development objective of Global Land Cover Network is to facilitate informed decision-making related to sustainable management of land and water resources, strengthen food security, and improve environmental protection through easier accessibility to reliable land cover information products in harmonized formats. The project focus will be on developing countries, which lack the capacities to fully benefit from recent advances of geoinformation technologies, such as satellite remote sensing, geographic information systems and global positioning systems.

Specific aim of GLCN is to increase the benefits from the international land cover projects to developing countries. They urgently need the reliable and current land cover information for sustainable development and management of their natural resources. Yet, because of the lack of the effective infrastructure that would monitor the international land cover projects, provide information about their products and facilitate their accessibility, they remain largely unavailable to land use policy-makers and planners from developing countries that need them most.

GLCN will consist of linkages with organisations managing major land cover databases and provide information on international land cover projects and other relevant activities. It will provide direction, focus and guidance for harmonization of land cover mapping and monitoring projects at regional and global levels in order to achieve compatibility among their products. Furthermore, it will facilitate their synergetic use, through promotion of LCCS as the new standard classification system and development of LCCS-based technical specifications for international land cover mapping and monitoring projects.

GLCN design will be driven by the land cover information needs of land use planners and environmental protection officers, and based on convergence of geo-information technologies. Their recent advances and diminishing costs have opened new windows of opportunity for developing countries to bridge the gap in the availability and effective application of reliable land cover information. However, in the medium term, developing countries require assistance with technology transfer and strengthening of institutional capacities for effective use of geo-information technologies.

GLCN will be jointly managed by FAO, the United Nations lead agency for agriculture, and UNEP, the United Nations Environment Organization. It is expected that GLCN will develop a close cooperation with Global Spatial Data Infrastructure.

6. Dynamic Atlas

Dynamic Atlas is a suite of information publishing and access tools used by FAO in the implementation of numerous projects. These generic technologies enable the easy integration and publishing of maps, databases, and documents. The system architecture is built around the concept of a corporate warehouse(s). It is very easy to grow, add functionality through new systems, and maintain data – even in partnership with other departments or organizations.

1. **Dynamic Knowledgebase** provides the ability to quickly and easily set up and manage data warehouses containing spatial data, tabular data, documents and metadata. Dynamic Knowledgebase enables you to create “Atlases” with “topics” of these related integrated data for publishing to the desktop and the web. As a result, users are able to access spatial and tabular data and documents without needed to know the ins and outs of GIS, database management or the system architecture – that’s has all been taken care of in the building of the Atlas.
2. **Dynamic Maps** is a windows-based software application that makes it easy for *anyone* to access the data in the Atlas and use the maps and tabular data in their everyday work. It enables the user to take tabular data and display the in map form to create key indicator maps and trend maps. Dynamic Maps provides a “library” for related documents and URLs that a user can easily add to with their own information. Plus it is integrated with Microsoft Office to provide easy publishing of those maps as PowerPoint slides and related data analysis in Excel.

3. **Dynamic Web Maps** enables an organization to publish the Topics in any Atlas on the Internet. Click on a map feature and get its related document, web links, data, pictures, etc. on the Internet. The very same Atlas that is created in Dynamic Knowledgebase is automatically ready for publishing on the web in this way, with no additional manipulation. And because the data are “live”, as the data change, so too would the result the clients see.

Dynamic Atlas software can be downloaded from www.skeinc.com.

Conclusions

The purpose of this paper was to outline FAO’s approach towards achieving the goals associated with the support of sustainable land management strategies in Africa through the Africover project.

The SDI goals of data standards, integration, access, availability, and others are greatly enhanced by practical applications like Africover that deal with specific “business drivers” and meet specific needs, i.e. agriculture planning and food security, through improved information management systems. Africover’s success relies largely on its ability to create a “spatial data infrastructure” with integrated land use information, standards, policy, program and capacity.

Beyond this, the successful implementation of sustainable land use management depends on political will and support at all levels of government. Its impact at regional and global levels also depends on international harmonisation of databases, compatibility of land cover and other geospatial products, and development of effective international linkages.

I have appreciated the invitation to participate at this important EUROGI and HunAGI Conference and to share with you our experience with land cover mapping in Africa in the framework of the FAO Africover project. I hope that it will contribute to the achievement of our common goal, to bridge the gap in the availability of reliable, timely, and location-specific information on the state of land and water resources between industrialised and developing countries. Otherwise sustainable development cannot be implemented.

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