

# LAND RESOURCES INFORMATION SYSTEMS FOR FOOD SECURITY IN SADC COUNTRIES



# **LAND RESOURCES INFORMATION SYSTEMS FOR FOOD SECURITY IN SADC COUNTRIES**

**Proceedings of a subregional workshop  
held in Harare, Zimbabwe,  
3-5 November 1999**

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ISBN 92-5-104427-9

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## Preface

A Subregional Workshop on Land Resources Information Systems (LRIS) for Food Security in SADC countries was held in Harare, Zimbabwe, from 3 to 5 November 1999. The meeting was organized by FAO Land and Water Development Division (AGL), in collaboration with the Subregional Office for Southern and East Africa (SAFR) and SADC's Food Security Technical and Administrative Unit. The purpose of the meeting was to promote land resources information systems (LRIS) and their application in the assessment, mapping and monitoring of land in relation to food security in the SADC countries. The workshop was attended by 29 participants, including 17 from SADC countries and five TCDC resource persons from Egypt, Nigeria, Ghana, Iran and Kenya. The TCDC resource persons contributed LRIS experiences from their countries and assisted in the preparation of a plan of action to promote future reporting and exchange of information, data expertise and experiences in land information in the sub-region, using TCDC, within existing SADC regional networks on land and water. This includes the preparation of national and sub-regional reports on the state of Land, Water and Plant nutrient resources in SADC countries during the biennium 2000-01 using the existing FAO guidelines. It was proposed that the SADC Environmental Technical Unit (SETU) should serve as a coordinating point with the various SADC Member States in the LRIS activities, and that SETU and FAO should provide, where necessary, appropriate training, funds and technical support to ensure the preparation of the reports.

## Acknowledgements

These proceedings were compiled by Messrs. Jacques Antoine and Owen Hughes and edited by Mr R. Brinkman, Ms Chrissi Smith-Redfern and Ms Selina Vrionides. Thanks are offered to the various contributors, in particular Ms Karen Frenken and Mr Mark Smulders, SAFR, Ms Marleen Belder, RAF, Messrs Camille van der Harten, Lieven Verheust and Ben Opperman, SADC, and Jonathan Addo Allotey, Environmental Protection Agency, Ghana.

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## Acronyms

AEZ	Agro-ecological Zoning
AEZWIN	AEZ for Windows
ALCOM	Aquatic Resource Management Programme for Local Communities
ALES	Automated Land Evaluation System
APIS	Agricultural Potential Information System
DU	Development Unit
EIS	Environmental Information System
ELMS	Environment and Land Management System
FANR	Food, Agriculture and Natural Resources Development Unit of SADC
FAO	Food and Agriculture Organization of the United Nations
FIVIMS	Food Insecurity and Vulnerability Information and Mapping Systems
GIS	Geographic Information System
IGAD	Intergovernmental Authority on Development
ISRIC	International Soil Reference and Information Centre
LRIS	Land Resources Information System
LWRIS	Land and Water Resources Information Systems
RAF	FAO Regional Office for Africa
RRSU	Regional Remote Sensing Unit
SADC	South African Development Community
SAFR	FAO Subregional Office for Southern and East Africa
SOTER	Soils and Terrain Database
UNDP	United Nations Development Programme
WOCAT	World Overview of Conservation Approaches and Technologies

# Summary report and recommendations

## BACKGROUND

As an important result of the World Food Summit in November 1996, a major thrust of FAO's Mid-term Programme is Food Security and Nutrition within the framework of Sustainable Agricultural and Rural Development (SARD), with SARD activities directed to the attainment of food security, in particular in the low income food deficit countries (LIFDCs).

SARD has identified the sustainable management and use of the available natural resources and the environment as both a prerequisite and a means of achieving food security.

Natural resources in the SADC countries are under pressure because of high population growth, fragile soils in sensitive eco-regions, multiple demands on limited resources, resource poor farmers and limited or absent institutional support. As a result some of these natural resources are being rapidly degraded.

There is great concern about the growing vulnerability of the populations of SADC countries and their property, particularly from natural and other environmental disasters, impacts of climate change and depletion of renewal resources. During the past decade there has been an increasing awareness that these risks are high, as the SADC countries have been affected by natural disasters, in particular recurrent drought due to cyclical climatic variations and possibly longer term changes in climate. Such disasters often lead to the interruption of their sustainable development. In some cases like El Niño there can be significant losses to GNP and setbacks to the economy for several years.

SADC countries need to improve their ability to plan and monitor the use of their land and water resources for better use and management of the resources to increase agricultural productivity while maintaining land and water quality.

To establish a basis for sound decision-making for land and water resources use and for sustainable management of these resources there is an urgent need for land and water resources information systems providing access to a variety of information on the status of land and water resources in the SADC countries. This information must not only be gathered but also transferred to the users, including decision-makers, planners, scientists and rural land users.

The Land and Water Development Division of FAO (AGL) has made considerable progress in the last two decades in the development of land and water information systems. The systems include methods and tools for the inventory of soil, land and water resources, the delineation of agro-ecological zones; global and national soil databases; methodologies for land evaluation and land use planning and management; rural water use database (AQUASTAT) and numerous reports and documents, including digitized maps.

AGL is using the systems to develop more applied knowledge, policies, policy instruments, national capacities and technologies which can assist its member countries to develop their rural land and water resources more efficiently and sustainably and to cope, in a concrete and practical way, with the limitations, constraints and hazards affecting the use of their land and water resources for food and agriculture development.



In cooperation with member countries, other FAO units and other partners, AGL is currently undertaking a major exercise of building up an information base on monitoring and assessing the sustainability/vulnerability of present use of land and water resources in relation with food security, the related aspects of national policies and policy instruments, and the application of sustainable land and water management and rehabilitation technologies. One of several major outputs expected from the exercise is a series of reports on the World State (sustainability/vulnerability) of Land and Water Resources for Food and Agriculture by country and region. The reports are to be compiled in the form of a digital atlas to be made available through the Internet that can be easily updated in the future.

A first phase of methodology development and testing has been completed. A second phase of application of the methodology to prepare country and regional reports is being implemented. It is carried out with the collaboration of national and regional land and water institutions which compile information, prepare reports and post these on their Internet sites in linkage with the FAO AGL web site and underwrite commitments to maintain and update the reports. FAO AGL organizes workshops and expert consultations in the different regions to discuss the project and enroll country's participation in it. An expert consultation was organized in Asia in 1997 and a workshop in West Africa in 1998. As a result informal Asia and West Africa networks were established and several countries including Bangladesh, China, Malaysia, Ghana, Nigeria and Egypt have prepared or are preparing such reports.

## **OBJECTIVES**

The workshop was the first meeting of this kind in the SADC subregion. The overall objectives of the workshop were to discuss the contribution of LRIS information to improve decision for the rational use, management, conservation and for monitoring the condition of the subregion's land resources. Particular regard is given to promoting food production and food security in a sustainable and environmentally sound manner and to promote LRIS activities in the SADC countries using the SADC regional networks on land and water.

## **WORKSHOP ATTENDANCE**

Senior land resources specialists from Botswana, Egypt, Ghana, Iran, Kenya, Lesotho, Malawi, Mozambique, Namibia, Nigeria, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe participated in the meeting. In addition to representatives from the above mentioned countries, some ten land and water specialists and land/agricultural development planners from relevant departments of Zimbabwe as well as decision- and policy-makers attended the meeting. The list of participants is attached as Annex 3.

## **WORKSHOP ACTIVITIES**

The meeting focused on land resources information systems (LRIS) and their application in the assessment, mapping and monitoring of land in relation to food security and the preparation of the land and water reports. It discussed the methodology for preparation of the reports and the techniques of diffusion of information for practical use in food security programmes and actions in the field, as well using modern electronic communication tools. It discussed future exchange of information, data expertise and experiences in land information in the subregion using TCDC, preparation of national reports and a subregional report for the SADC countries.

The activities included presentations, computer demonstrations and discussions in working group and in plenary sessions. Participants were divided into five groups with one locally networked

computer per group. Issues were first discussed within the groups. The groups prepared draft reports and recommendations which were consolidated and finalized in subsequent plenary debates.

The workshop programme is given in Annex 2.

### **Inaugural address**

Mr. O. Hughes, Natural Resources Management Officer, Subregional Office for Southern and East Africa (SAFR), presided over the opening ceremony on behalf of Ms. V. Sekitoleko, Subregional Representative, SAFR (Annex 1).

### **Technical presentations**

Presentations on the development of information and decision support systems on land and water resources management in FAO, and a methodology for the preparation of Internet based reports on the state (quantity, quality, sustainability, vulnerability and use) of land and water resources for food and agriculture were made by J. Antoine. The FAO AQUASTAT programme and the status of Food Security Information System development in SADC were presented by Ms. K. Franken and Mr. M. Mulders, SAFR, respectively.

SADC experts presented the SADC LRWIS activities, including an overview of existing LWRIS programmes and initiatives, the SADC Agricultural Potential Information System (APIS) and the ALCOM SADC Water Resources Database.

Already a number of activities, directly or indirectly linked to LWRIS, are on-going in the SADC Member States. Some of these activities have a regional character. A regional example is the Environmental Information Systems (EIS) network which has been in existence since the early nineties. It is managed by the SADC Environment and Land Management System (ELMS) which is located in Lesotho. The EIS network has two Units, one responsible for training and education and one responsible for technical EIS activities. The first Unit is operated by the University of Botswana and the second unit is based at the SADC Food, Agriculture and Natural Resources (FANR) Development Unit (DU) in Harare - Zimbabwe. This unit, called the SADC EIS Technical Unit (SETU), is among others responsible for: (i) the EIS regional network; and (ii) development of a meta-database for environmental data. SETU is based at the FANR DU because of the already on-going activities of the SADC Regional Remote Sensing Unit (RRSU). Since 1994, this Unit has developed a number of environmental and climatological databases, mainly for use in early warning for food security. These databases are also very useful for environmental monitoring and natural resources management.

### **Demonstration of computer-based data and information systems**

Computer demonstrations were carried out on the structure, contents and functions of FAO LRIS tools, including the AEZ software and databases and the AGL Internet Web site on Land and Water Information Systems. These tools and applications were available for access and testing by participants throughout the Workshop.

### **Presentation of country reports on the state of land resources**

Country reports on the state of land, water and plant nutrition resources were presented for Egypt, Ghana and Nigeria. Country reports on LRIS in Kenya and Iran were presented by the representatives from these two countries.

### **Group review of guidelines country reporting on the state of land and water resources**

The groups reviewed the existing FAO guidelines for country reporting. Group findings were presented and discussed at a plenary session and consolidated comments were prepared for improving the guidelines. These comments are given in Annex 4 and the revised guidelines are reproduced in Annex 5.

### **Group review of the proposal to establish a land and water information system network in SADC**

The meeting agreed that it would be better to link the proposed activities with one or more existing SADC networks. It was further agreed that the workshop participants would serve as contact persons for their respective countries in an informal network on land and water information systems in Southern Africa within the existing SADC networks.

### **SUMMARY OF WORKSHOP RECOMMENDATIONS**

The participants identified the need for the preparation of national and subregional reports on the state of land, water and plant nutrient resources for food security and the following recommendations were made:

- That FAO SAFR should link up with SADC and send an endorsement of the activities of the workshop (national report compilation) to the various governments. FAO SAFR should also formally notify the relevant national authorities, indicating that the participants of the workshop should serve as focal points. The participants should take the initiative to follow up on the letters.
- The workshop recommended that the revised guidelines resulting from group discussions be accepted as a basis for preparation of reports on the state of land, water and plant nutrient resources.
- The workshop recommended that the respective participating countries should be responsible for the preparation of national reports and that the various countries should prepare such reports within twelve months, subject to availability of resources.
- The participants recommended that existing structures within the SADC region should be used and that the SETU should serve as a coordinating point with the various SADC Member States.
- The participants further recommended that the countries should submit progress reports to the SADC coordinating unit which in turn will submit progress reports at a subregional level to all the participating countries.
- The workshop recommended that SADC SETU should undertake the responsibility for all aspects of the development and implementation of the report on the state of land and water resources at SADC subregional level.
- The workshop recommended that respective countries should request technical and financial assistance from SADC and FAO in preparing the national reports.

**Definition of a plan of action**

The meeting recognized the need for a plan of action, as a follow-up, to prepare the country and regional reports. Discussions centred on the responsibility for the activity at national level and within SADC, and the availability of funds.

The workshop formulated the outline of a plan of action with a timeframe valid for all the countries, based on the Nigeria experience. It includes the following steps:

1. Receipt of official letter from FAO SAFR to lead institutions.
2. Call meeting of relevant agencies.
3. Assess data needs and identify available info and format and identify gaps.
4. Assess quality of data/information.
5. Obtain permission to access data or information from other institutions.
6. Prepare budget.
7. Establish time-frame.

An average timeframe was worked out, including:

- Official acceptance (one month).
- Information gathering, sorting and authentication (three months).
- Report writing (one month).
- Verification (half a month).
- Internet posting.

**WORKSHOP EVALUATION**

At the end of the meeting an evaluation was carried out through a questionnaire. The summary results are presented in Annex 6. Overall, the workshop was considered very useful and the participatory approach used in implementing the workshop was seen as a major factor in its success.



## **Technical papers**



## Land resources assessment and management systems

### WORLD SOILS AND TERRAIN DIGITAL DATABASE (SOTER)

(<http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGL/agll/soter.htm>)

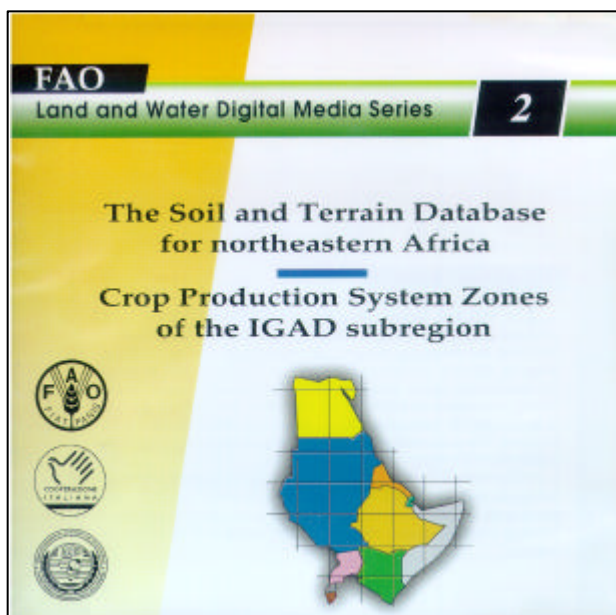
SOTER is an internationally endorsed land resource information system. It can store, at different levels of detail, soil and terrain attributes in such a way that these data can be assessed, combined, easily updated and analysed for thematic mapping and monitoring of changes to soil and terrain resources and for AEZ evaluation of land resources potential for land use planning, which can be used by scientists, planners, decision-makers and policy-makers.

SOTER utilizes a Relational Database Management System and Geographic Information System (GIS) to establish a World Soils and Terrain Database, containing digitized map units and their attribute data. SOTER uses a specific methodology and its own system for classification of terrain designed for universal application. SOTER has adopted the recently Revised FAO Soil Legend as a reference classification system for differentiating and characterizing its soil components.

The database translates SOTER's overall objectives into a workable set of arrangements for the selection, standardization, coding and storing of soil and terrain data. The input of soil and terrain data into the SOTER database is contingent upon the availability of sufficiently detailed information collected through previous surveys.

The SOTER project also intends to contribute to the establishment of national and regional soil and terrain databases, founded upon the same commonly acceptable principles and procedures, to further facilitate the exchange of land resource information and ultimate incorporation into a global database.

SOTER was implemented to provide an update of the soil resources of the world. FAO, UNEP and ISRIC consider the SOTER approach, at a scale of 1:5 million, as the official strategy to replace the FAO-UNESCO Soil Map of the World. The first version of a SOTER for Latin America and the Caribbean was published in 1998, and for northeastern Africa – at scale 1:1 000 000 – in 1998.



*Jacques Antoine*  
Senior Officer, Soil Resources Conservation and Management Service  
FAO, Rome, Italy



The SOTER for northeastern Africa contains a collection of land and natural resource information for the ten IGAD countries bordering the Nile basin (Burundi, Djibouti, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, Somalia, Sudan, Uganda). It includes data on administrative boundaries, rivers and lakes, soil and terrain, climatology, land use, physiography, geology and natural vegetation in easily accessible format (see plate). Other steps towards a global SOTER are being made in Central and Eastern Europe.

Soil and terrain databases at scales from 1:1 million to 1:50 000 have also been compiled by the national soil institutes of several countries (Argentina, Benin, Brazil, China, Costa Rica, Hungary, Jordan, Lebanon, Syria, Uruguay), including Botswana, Ethiopia, Kenya, Namibia, South Africa in southern and eastern Africa.

### **WORLD OVERVIEW OF CONSERVATION APPROACHES AND TECHNOLOGIES (WOCAT)** (<http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGL/agll/wocat.htm>)

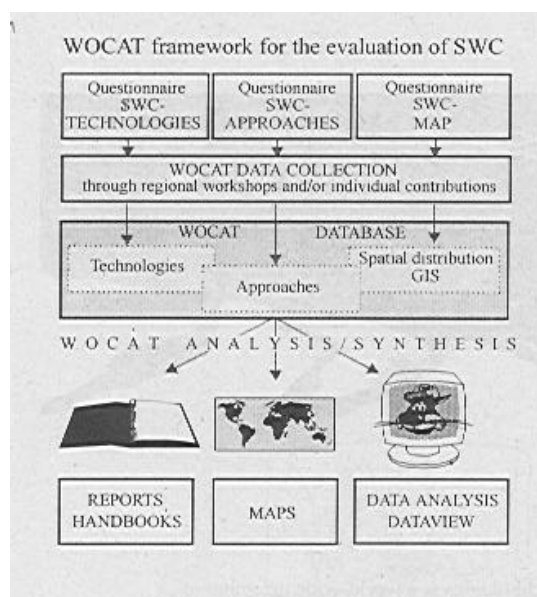
WOCAT is a worldwide programme, launched in 1992 by the World Association of Soil and Water Conservation (WASWC). It is organized as a consortium of several institutions (members/donors), including: FAO, ISRIC, Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Observatoire du Sahara et du Sahel (OSS) and others; coordinated by the Centre for Development and Environment (CDE), University of Bern, Switzerland.

WOCAT is a tool which aims at promoting improved decision making on land management and transfer of appropriate technology through collection, analysis, presentation and dissemination of knowledge on global soil and water conservation (SWC). In particular, WOCAT can be used to identify options for overcoming land degradation problems.

WOCAT uses a standardized framework for the evaluation of SWC and a methodology for data collection, by the means of questionnaires. Data are entered into an interactive database management and analysis system. Although developed as a global system, the WOCAT methodology is also applied at regional, national and even more detailed scales.

At the core of the system is the WOCAT database, which helps users to identify possible solutions by providing an inventory of SWC technologies and an inventory of respective approaches. A user-friendly query system allows the user to easily narrow down possible options and to trace appropriate solutions. Once possible options are identified, WOCAT gives a comprehensive description of the respective technologies and approaches.

The inventory of SWC technologies shows characteristics of the socio-economic and biophysical environment for each technology and lists advantages and disadvantages of the technology under investigation and explores the reasons why technologies were accepted or rejected by local users. WOCAT also provides an analysis of the technology by using evaluation criteria such as replicability, durability, adaptability, adoption/acceptance, etc. The inventory of SWC approaches



offers ways for the implementation of technologies on the ground by reviewing and analysing areas of intervention, land tenure, target groups, involvement of land users, incentives, training needs etc.

The programme organizes SWC regional workshops for data collection and exchange of experience, creates openly accessible databases, analyzes and exchanges collected information, and produces and disseminates outputs such as books and reports on appropriate SWC technologies and approaches, maps of SWC activities, databases, a decision support system and worldwide accessible information in paper or digital format (CD-ROM) and through the internet. The WOCAT database allows linkages with ECOCROP, Soil and AEZ data, and land use information.

For example, preliminary outcomes of the regional WOCAT data collection and analysis for East Africa show that SWC technologies are applied primarily on cropland in subhumid to semi-arid environments on small-scale farms with individual land use rights, and are rarely reported on grazing land (19%) and forest or woodland (5%). Technologies focus mainly on structural measures, often in combination with vegetative measures (e.g. grass on banks). There are important knowledge gaps for costs, benefits and impacts of the reported technologies. Technologies are mainly project-implemented, with few traditional or indigenous approaches. A shift from top-down approaches to bottom-up, participatory approaches can be observed. WOCAT's web site is: <http://www.cde.unibe.ch/programmes/global/glo20.htm>

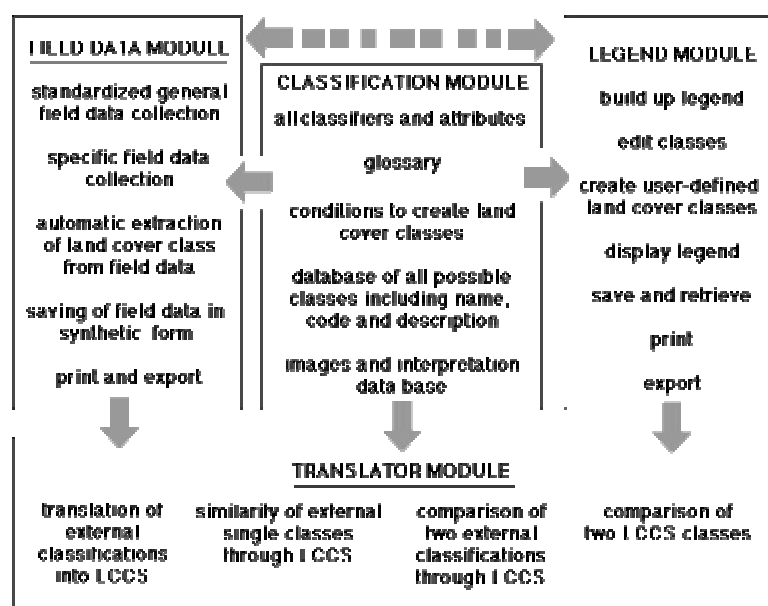
### LAND COVER / LAND USE DATABASE (**AFRICOVER**)

(<http://www.fao.org/sd/eidirect/eire0053.htm>)

The Land Cover Classification System (LCCS) is the result of the initiative by the Africover Programme of the FAO Environment and Natural Resources Service (SDRN) to develop an approach for concept, definition and classification of land cover. The classification concepts were developed, discussed and approved by the Africover Working Group on Classification and Legend with support from a French trust fund project. This Working Group gave FAO the mandate to fully develop the proposed classification. The first full operational version of the classification and its software program has been developed for implementation by the Italian trust fund GCP/RAF/287/ITA *Africover-East Africa Project*, based in Nairobi, in collaboration with the Land and Plant Nutrition Management Service (AGLL).

The LCCS software program contains four different modules:

1. **Classification:** land cover classes are defined by the combination of a set of independent classifiers, which are hierarchically arranged and which can be linked with environmental and specific discipline related attributes.
2. **Legend:** storage of defined land cover classes according to the domains to which these



classes belong. This module allows export of data in commonly used file formats and allows users to add user-defined names to the provided standard names.

3. **Field Data:** storage of the detailed field survey information and automated classification of the data. Retrieval and edit functions exist.
4. **Translator:** comparison and correlation of classifications or legends through the reference classification is possible at the level of the classifiers and entire classes.

The Land Cover Classification is a comprehensive standardized *a priori* classification system, designed to meet the needs of a variety of users and designed for mapping exercises, and independent of scale or means used. The proposed classification can be used as a reference system because the diagnostic criteria allow correlation with existing classifications or legends.

## REGIONAL AND NATIONAL ASSESSMENT OF LAND DEGRADATION (ASSOD AND NALD)

### **ALES expert system framework**

(<http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGL/agll/aez.htm>)

The ALES program facilitates carrying out land evaluations according to the method presented in the FAO Framework for Land Evaluation (FAO, 1976). Such evaluations are location-specific, usually require many data, involve numerous repetitive calculations or references to tables and are tedious if many possibilities are to be compared. ALES is a useful tool that provides an automated procedure of evaluation to replace manual procedures which are time-consuming and error prone.

ALES is a PC computer program shell in which evaluators can build their own expert systems taking into account local conditions. ALES provides a reasoning mechanism and constrains the evaluator to express inferences using the mechanism. ALES is not by itself an expert system and does not contain knowledge about land or land use. It is a framework within which evaluators can express their own local knowledge. ALES can also be thought of as a model of expert judgement, that is the codification in a constrained form of the inferences already present in the mind of an expert.

ALES has six components: (i) a framework for a knowledge base describing proposed land uses, in both physical and economic terms; (ii) a framework for a database describing the land areas being evaluated; (iii) an inference mechanism to relate these two, thereby computing the physical and economic suitability of a set of map or land units for a set of proposed land uses; (iv) an explanation facility that enables model builders to understand and fine tune their models; (v) a consultation mode that enables the user to query the system and (vi) a report generator.

ALES is a highly interactive program. ALES has a dBase interface and can be linked with GIS systems such as ARC/INFO and IDRISI. ALES has been used in numerous land evaluations worldwide. It has been used by FAO field projects in Botswana, Kenya, Malawi, Mozambique, Oman, Yemen, Grenada, Ecuador, Chile and Lithuania.

### **AEZ: AGRO-ECOLOGICAL ZONING SYSTEM**

(<http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGL/agll/aez.htm>)

The main system used by FAO for land resource assessment is the agro-ecological zoning (AEZ) methodology and supporting software packages for application at global, regional, national and sub-national levels. AEZ uses various databases, models and decision support tools.

The AEZ concept involves the representation of land in layers of spatial information and combination of the layers of spatial information using a Geographic Information System (GIS). The

combination (overlay) of layers produces agro-ecological cells. In this way a land resources database is created which contains information on the AEZ cells. AEZ integrates in the database various kinds of geo-referenced data sets, which can include the following:

topography; administrative boundaries; roads and other communications; towns and settlements; rivers/water bodies; geology; soil; physiography; landform; erosion; rainfall; temperature; moisture regime; watersheds; irrigable areas; land use, land cover and forest reserves; population.

AEZ models are applied on the database to analyze potentials of land for various kinds of use, such as assessment of land suitability, potential land productivity and analysis of optimal land use scenarios for land use planning. The AEZ models include models for the calculation of length of growing period, irrigation requirements, crop biomass, land suitability, land productivity, etc.

AEZ can be used in various assessment applications for better planning, management and monitoring of these resources, including:

- land resource inventory;
- inventory of land utilization types and production systems, including indigenous systems, and their requirements;
- potential yield calculation;
- land suitability and land productivity evaluation, including forestry and livestock productivity;
- mapping agro-climatic zones, problem soil areas, agro-ecological zones, land suitability, quantitative estimates on potential
- crop areas, yields and production;
- land degradation assessment, population supporting capacity assessment and land use optimization modelling.

Such results are recorded for each AEZ cell or record in the database and constitute an entry point for land use analysis, using decision support tools such as multi-criteria analysis and simulation.

Two PC software packages have been prepared in collaboration with the International Institute for Applied System Analysis (IIASA) to implement AEZ models: one software package for global and regional application; and another for more detailed application at country level. The second package is called AEZWIN and runs under WINDOWS 95 and WINDOWS NT.

The AEZ methodology and models have been applied in developing a global digital AEZ land resources database based on the digitized soil map of the world (DSMW). The database contains information on soil and landform, temperature regime and length of growing period, agro-ecological zones, forest and protected areas and land suitability for about 30 main crops.

The database has been used in global land productivity potential studies within the framework of FAO AT2010 study, including estimation of arable land potentials for agricultural expansion by country. It has been used in regional and country studies on land use change, population supporting capacity and land suitability for aquaculture. It has also been used in applications involving integration of biophysical and socio-economic data such as studies on land carrying capacity and the effects of climate change on agricultural productivity potentials. The database will be used in regional food insecurity and vulnerability information and mapping systems (FIVIMS) of the Committee on World Food Security (CFS).

The AEZ methodology and software packages have been used in studies which address a wide range of land management issues: improved land use planning (Botswana, China, Kenya, Mozambique, Grenada, Tanzania, Swaziland); formulation of population policies (Malaysia, Philippines, China); national agricultural development (Kenya, Bangladesh); agricultural research planning and management (Bangladesh and Indonesia); natural resources management (Brazil); technology targeting (Bangladesh); and disaster preparedness (Bangladesh).



## Water resources assessment systems

### **AQUASTAT: A DATABASE ON RURAL WATER USE**

(<http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGL/AGLW/aquastat/aquastat.htm>)

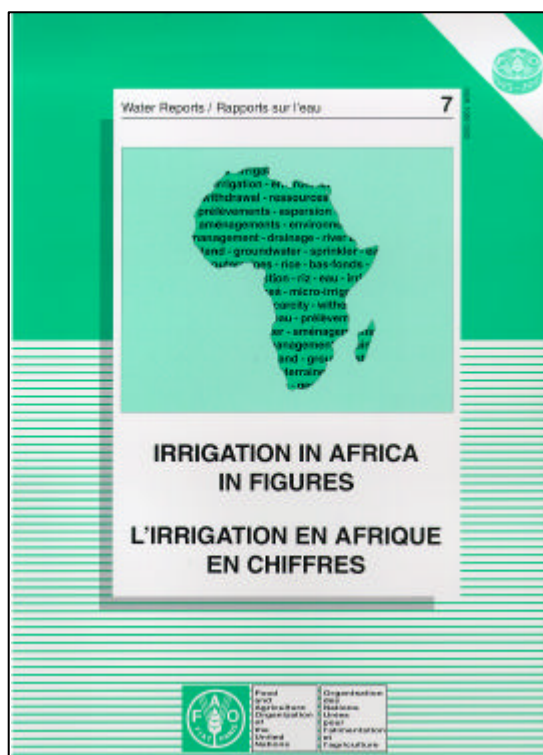


Information on quantity and quality of fresh water and its availability and use is essential for sustainable development. Since a major share of the world's water resources is used for agricultural production and water development plays a key role in increasing food production and achieving food security, information on agricultural water use has assumed greater importance. The "thirst" for water data is ever increasing and there is indeed considerable demand for data on rural water use from national governments and development agencies.

To meet this demand, in 1993 the Water Resources, Development and Management Service (AGLW) of the Land and Water Development Division (AGL) of FAO developed a global information system on water use in agriculture and rural development. Called AQUASTAT, its main objective is to collect, analyze, standardize and disseminate basic information on water resources and its use by country. AQUASTAT is essentially a database on water availability and use in agriculture and rural development, which produces regional analyses and country profiles on water resources development, with emphasis on irrigation and drainage.

The collection of information is organized through extensive literature reviews, assembly of existing information on the country and the sub-region, and through a detailed questionnaire. Critical analysis and data processing is undertaken at FAO Headquarters in Rome. The database consists of 120 quantifiable variables, comprising:

- ten variables related to geography and population
- forty variables related to climate and water resources
- twenty variables related to water use
- fifty variables related to irrigation and drainage.



**Karen Frenken**

*Water Resources Management Officer*

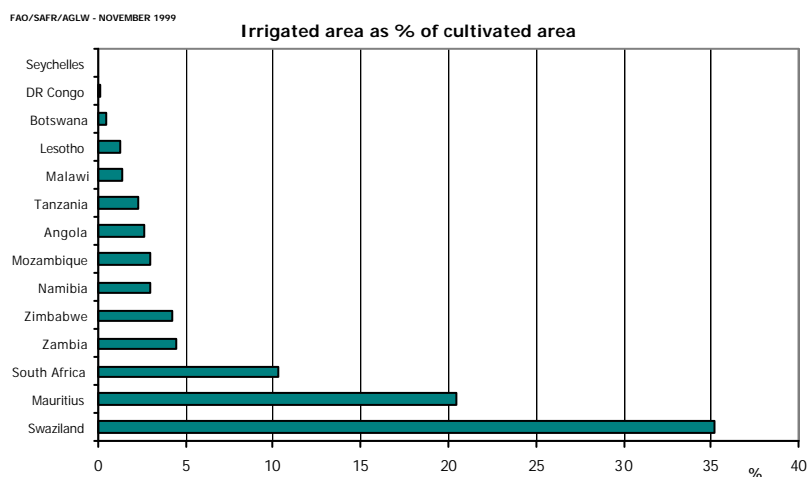
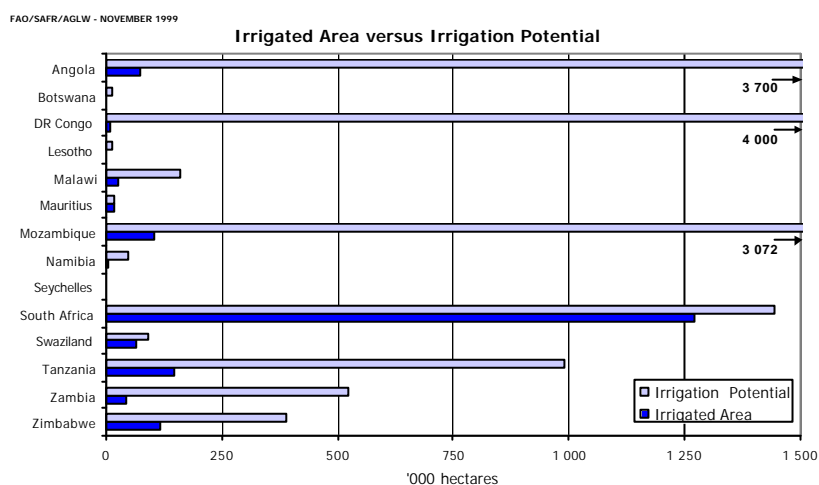
*FAO Subregional Office for Southern and East Africa, Harare, Zimbabwe*

Additional information on irrigation development, institutional environment and trends in water resources management is also presented for each country. One of the strengths of the AQUASTAT programme is that a bibliographical reference is attached to each figure for verification purposes.

In 1994-1995, all 53 African countries were surveyed, resulting in FAO Water Report 7 "Irrigation in Africa in Figures". The (then) 29 countries of the Near East Region were surveyed in 1995-1996 (FAO Water Report 9 "Irrigation in the Near East Region in Figures"), followed by the 15 countries of the Former Soviet Union in 1997 (FAO Water Report 15 "Irrigation in the Countries of the Former Soviet Union in Figures"). The 21 countries of Asia not included in the two previous reports (9 and 15) were surveyed in 1998-1999 (FAO Water Report 18 "Irrigation in Asia in Figures"). At present, Latin America is under preparation.

Information is disseminated through the preparation of country profiles, regional and sub-regional tables and maps, and summaries. A country profile provides an overview of water resources and their use in the country, especially for the irrigation and drainage sub-sectors, in a standardized format. Its aim is to emphasize the particularities of each country, as well as the problems encountered in rural water management and irrigation. The report also summarizes trends in irrigation. Standardized tables are used for all country profiles.

Country profiles, regional summaries, tables and maps are all available on the Internet at the following address: <http://www.fao.org/waicent/faoinfo/agricult/agl/aglw/aquastat/aquastat.htm>





## IRRIGATION WATER MANAGEMENT SYSTEMS

### **CLIMWAT: A Climatic Database**

(<http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGL/AGLW/climwat.htm>)

CLIMWAT is a multi-purpose climatic database which was developed primarily for use in providing climate data inputs for the calculation of crop water requirements, irrigation supply and irrigation scheduling for various crops in combination with the program CROPWAT (see below). CLIMWAT is also useful in providing climatic data to AEZ land resources assessments.

The CLIMWAT database was originally compiled by the Agrometeorological Group of the FAO Research and Technology Development Division (SDR) and has been converted into a format suitable for use by CROPWAT. The CLIMWAT database includes data from a total of 3262 meteorological stations from 144 countries, divided into five continents, and is contained on five diskettes arranged according to continent and country.

Programs are included to facilitate management of the database, including the selection of suitable climatic stations from the concerned countries. The climatological data included are maximum and minimum temperature, mean daily relative humidity, sunshine hours, wind speed, precipitation and calculated values for reference evapotranspiration and effective rainfall. The reference evapotranspiration has been calculated for all stations according to the Penman-Monteith method, as recommended by the FAO Expert Consultation held in Rome, May 1990.

Various procedures to set up the system and to address the selected climatic stations are available to assist the user of CLIMWAT in the use of the database and the CROPWAT programme. Included are examples to show how the various data can be addressed and used for planning and management of irrigated and rainfed agriculture. CLIMWAT has been applied in numerous irrigation management projects in various countries.

The CLIMWAT programme is a new element of the CROPWAT irrigation management programme, which is now available as FAO Irrigation and Drainage paper No. 49 (manual and diskettes).

### **CROPWAT: A computer program for irrigation planning and management**

(<http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGL/AGLW/cropwat.htm>)

CROPWAT is a decision support system developed by the Land and Water Development Division of FAO. Its main functions are to:

- calculate reference evapotranspiration, crop water requirements and crop irrigation requirements;
- develop irrigation schedules under various management conditions and scheme water supply;
- evaluate rainfed production and drought effects and the efficiency of irrigation practices.

CROPWAT is a practical tool to help agro-meteorologists, agronomists and irrigation engineers to carry out standard calculations for evapotranspiration and crop water use studies and more specifically the design and management of irrigation schemes. It allows the development of recommendations for improved irrigation practices, the planning of irrigation schedules under varying water supply conditions and the assessment of production under rainfed conditions or deficit irrigation.

Calculations of crop water requirements and irrigation requirements are carried out with inputs of climatic and crop data. Standard crop data are included in the programme and climatic data can be obtained for 144 countries through the CLIMWAT-database. The development of irrigation schedules and evaluation of rainfed and irrigation practices are based on a daily soil-water balance



using various options for water supply and irrigation management conditions. Scheme water supply is calculated according to the cropping pattern provided.

Procedures for calculation of the crop water requirements and irrigation requirements are based on methodologies presented in FAO Irrigation and Drainage Papers No. 24 "Crop water requirements" and No. 33 "Yield response to water".

CROPWAT includes a revised method for estimating reference crop evapotranspiration, adopting the approach of Penman-Monteith as recommended by the FAO Expert Consultation held in May 1990 in Rome. Further details on the methodology are provided in the Revised FAO Methodology for Crop Water Requirements and in the Irrigation and Drainage Paper No 56: "Crop Evapotranspiration".

The current version of CROPWAT (7.0) contains a completely new version in Pascal, developed with the assistance of the Agricultural College of Velp, Netherlands. It overcomes many of the shortcomings of the original 5.7 version (that was distributed as Irrigation and Drainage paper No 46, with manual and guidelines).

CROPWAT version 7.0 is concise and fits easily onto one diskette. The programme can be downloaded as CRW70-EN.ZIP (234 Kb) from FAO's FTP-server. After unzipping in a suitable directory or diskette, the original directory structure will be restored with the SETUP command. CROPWAT 7.0 is a DOS-application, but it runs without any problem in all MS-WINDOWS environments. A manual explains the use of the computer program, while the guidelines elaborate on calculation procedures and applications in irrigation planning and management, with examples.

CROPWAT for WINDOWS contains a CROPWAT version in Visual Basic to operate in the Windows environment. It has been developed with the assistance of the International Irrigation & Development Institute (IIDS) of the University of Southampton, UK. The programme and the manual in Acrobat format can be downloaded from FAO's FTP-server as CRW4W2.ZIP and CRW4W-MN.ZIP, respectively. The programme should be unzipped in a temporary directory and will be installed with the SETUP command as explained in the included readme.txt file.

### **SIMIS - Scheme Irrigation Management Information System**

(<http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGL/AGLW/simis.htm>)

When managing irrigation systems, a tool is needed which facilitates the management tasks of irrigation systems. SIMIS can be used to provide timely and complete information for decisions on day-to-day management activities including water deliveries and other major issues such as accounting, crop production, control of maintenance, water fees and other relevant tasks.

SIMIS is a modular system of programs containing 19 different and independent modules. The first module is addressed to identify the characteristics of the project where all the subsequent information will be stored. SIMIS can store information for one or several projects as needed. This is a useful feature for large projects which can be subdivided into smaller units and corresponding information entered separately so that information can be processed faster and more clearly. The following seven modules are utilized to store basic data on the irrigation system such as: climate, soils, crops, physical infrastructure, land tenure, project staff and machinery (for O&M tasks). This information is shared by the other seven modules that are management tools covering the main aspects of managing an irrigation system. These include:

- Agricultural activities (crop production, area planted, production costs, crop prices and others)
- Crop water requirement (for all crops grown in the project)
- Seasonal irrigation planning (allowing matching of supply and demand)

- Irrigation scheduling (under different methods: fixed rotation, on demand, rational, soil moisture balance)
- Water consumption (control of water used by every farm)
- Accounting/O&M activities (control of costs)
- Water fees (determination of fees under different hypotheses and preparation of bills for every farmer, control of payments).

The last four modules are for setting the work environment and include: output setting, password, re-indexing and reconfiguration of files when required.

Additional information on CLIMWAT, CROPWAT and SIMIS and can be obtained from the following address:

<http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGL/aglw/homeaglw.htm>

The FAO Publications Catalogue can be accessed on Internet at <http://www.fao.org> or at gopher: //gopher.fao.org/

The following Internet pages can also be consulted for more detailed information on AGL systems:

- **land, land resources, land use (planning):**

<http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGL/agll/homeagll.htm>

- **sustainable development, natural resources:**

<http://www.fao.org/waicent/Faoinfo/SustDev/EIdirect/EIhomepg.htm>



# SADC LRIS: Harmonized Datasets for SADC

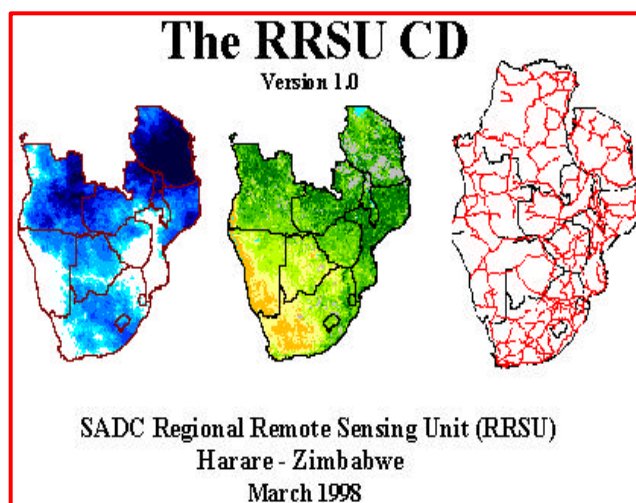
## THE REGIONAL REMOTE SENSING UNIT CD-ROM

The SADC Regional Remote Sensing Unit (RRSU) is part of the Regional Food Security Programme, located in the SADC Food, Agriculture and Natural Resources (FANR) Development Unit (DU) in Harare, Zimbabwe. The RRSU started as a project in 1988 and received technical assistance from the Food and Agriculture Organization (FAO) for a period of ten years, through financial support from the Governments of Japan and the Netherlands. In July 1998 the project was integrated into the organizational structure of FANR DU, as a Unit. The RRSU is operated with funding from the SADC Member States and it receives additional financial and technical support through a bilateral agreement between the Government of the Netherlands and SADC. The RRSU is a center of technical expertise, which can facilitate training programmes and technical support in the field of remote sensing and GIS as applied to early warning for food security and natural resources management.

On an operational scale the RRSU acquires low resolution and high temporal frequency satellite information from the NOAA and Meteosat satellites, which is processed into a number of information products such as rainfall occurrence and vegetation development. A variety of training courses and national and regional workshops are used to create a core of trained experts in the SADC region, but also to create awareness among potential users and stakeholders.

A major activity of the RRSU is the establishment of a uniform regional standard vector dataset for SADC, at a scale of 1:1 million. This activity commenced in 1995, mainly to create a reference vector dataset to be used with the satellite data using GIS technology. The Digital Chart of the World (DCW) was used as a starting point and this was further enhanced by the merging of existing and newly digitized national datasets. A first SADC Vector Dataset was prepared in late 1995 and put onto a number of CD-ROMs. These were evaluated by several contact points in the SADC region, as well as internationally.

A first official version of the RRSU CD-ROM (Version 0.9a) was released in June 1997, followed by Version 1.0 in March 1998. Version 1.0 includes a number of changes, mainly to the vector dataset, and includes all satellite images up to March 1998. Version 2.0 of the CD is planned for release in early 2000.



The SADC Vector Dataset includes information on national and sub-national administrative boundaries, elevation, infrastructure, hydrology, major growing areas, land use, forests, protected areas and cultural sites. In addition, the CD-ROM includes the RRSU's satellite image archive; a digital elevation model (DEM); raster maps with general climate information; soil maps; and basic agricultural and population statistics. Version 2.0 will include a newly processed NOAA-based NDVI archive, as well as a detailed meta-database which is being developed with a partner in South Africa.

The specific objectives of the RRSU CD-ROM are:

- to ensure the sustainability of the vast amount of images, maps and data collected by the RRSU;
- to allow the exchange of maps and information between countries and organizations;
- to provide the basis for the development of a food security information database and application for analysis using GIS technology as well as other environmental applications;
- to ensure that it can be easily and regularly updated.

While the RRSU CD-ROM was initially planned to serve the early warning for food security community, it became clear that the data is also very useful for a wide range of environmental applications. As a result, the RRSU is now a recognized centre for environmental data in the SADC region.

The original vector data processed by the RRSU are in Arc/Info format, but has been converted into an ASCII BNA format for the RRSU CD-ROM. This was done because this format can be easily used in a range of thematic mapping and commonly used GIS software programmes. In addition, and to further support this, a software routine, "BNA formatter", is available to convert the text strings in BNA files to numerical values, while an associated attribute file is also created.

The resolution of the vector data is 1:1million, while the raster maps have an operational pixel size of 6 arc minutes (approximately 8 km.). Every effort has been made to be as accurate as possible, but it is understandable that accuracy at this scale is sometimes coarse. However, the RRSU datasets, and the vector dataset in particular, are unique because of their uniformity and standard coverage for the whole of the SADC region.

The RRSU is using the freely available *WinDisp* programme for vector data and raster images, *MapViewer* from Golden Software for thematic mapping, and *IDRISI* for GIS applications. The RRSU has chosen these programmes because they can be easily used by those working in the early warning for food security sector in the SADC region. These experts are not always GIS experts and these programmes provide easy entry into a number of thematic mapping and GIS applications. The RRSU has developed a number of training manuals to assist the potential user in the use of these programmes. Because of the increased use of more advanced GIS technology in the SADC region, the RRSU will start in early 2000 an activity to make the vector data also available in ArcView format.

The RRSU CD-ROM is a good example of a uniform and harmonized regional database. It has set a standard for the SADC region and is used by many as a starting point when working with spatial data. The CD-ROM is available from the SADC Regional Remote Sensing Unit at a cost of US\$ 30.

For more information, the RRSU can be contacted at:

C.A.J. van der Harten: [cvanderharten@fanr-sadc.co.zw](mailto:cvanderharten@fanr-sadc.co.zw)

K. Masamvu: [kmasamvu@fanr-sadc.co.zw](mailto:kmasamvu@fanr-sadc.co.zw)

WWW: <http://www.zimbabwe.net/sadc-fanr/intro.htm>

## CLIMATE DATA LAYERS FOR THE SADC REGION

Since 1994, the SADC RRSU has collaborated with the University of Stellenbosch, with funding from the Development Bank of Southern Africa (DBSA), to establish a detailed socio-economic description of the individual SADC countries. This has resulted up to now in the development of a capacity to generate information on agricultural resources, as well as on their use for production. The vast amount of data on the agricultural resources of SADC has been captured in a georeferenced information system, using GIS technology. This information system, the SADC Agricultural Potential Information System (APIS), can be used to retrieve and manipulate information according to specific needs. For example, to determine the quantity and location of various classes or qualities of arable land and areas suited to a particular crop (refer to section below for more details). At present the APIS needs to be further modified to include more detailed information. As part of the collaboration, the RRSU will assist in obtaining more detailed climate information and to process it in a uniform grid or raster format.

The RRSU has an interest in this activity, because it would like to use and present climate information in the same raster format as the satellite images, so that data can be used in a wide range of GIS applications that are beneficial to early warning for food security.

The creation of the Climate Data Layers is a first step in this direction. The present data set contains 4104 raster maps with information about rainfall and temperatures at dekadal (10-daily) intervals for 38 years (1961-1998). All data used for the creation of the data layers are stored in a regional database in Access format, and available on CD-ROM. Data were compiled during a Technical Workshop in June-July 1999 from meteorological data received from the following SADC Countries: *Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia, and Zimbabwe*. In addition, data were also made available from:

- The Drought Monitoring Centre (DMC) in Harare, Zimbabwe.
- The Institute for Soil Climate and Water (ARC-ISCW) in Pretoria, South Africa.
- DNA in Maputo, Mozambique.
- African Weather Data (197-1995) from the U.S. National Weather Service, Climate Prediction Centre in Washington, USA (referred to as NOAA data).
- SADC National Early Warning Units.
- LUCC CD-ROM Series No. 1: MIOMBO, LUCC International Project Office in Barcelona, Spain.

**Data compilation:** Rainfall and temperature data from the SADC countries and other sources were compiled for each country in a "multiple year" file using a fixed format. During Phase 1, the data were organized per country in a fixed or comma delimited format in so-called "country multiple year" files. During Phase 2 these files were used to create *WinDisp-SEDI* compatible files that are used for interpolation. Data from approximately 800 to 1000 meteorological stations were used. The Digital Elevation Model (DEM) from USGS/Eros Data Center in the United States was used as a background image to create the Climate Data Layers. The original image has a resolution of 30 arc seconds (approximately 1 km.) and was released in February 1997. Altitude intervals of 100m were used.

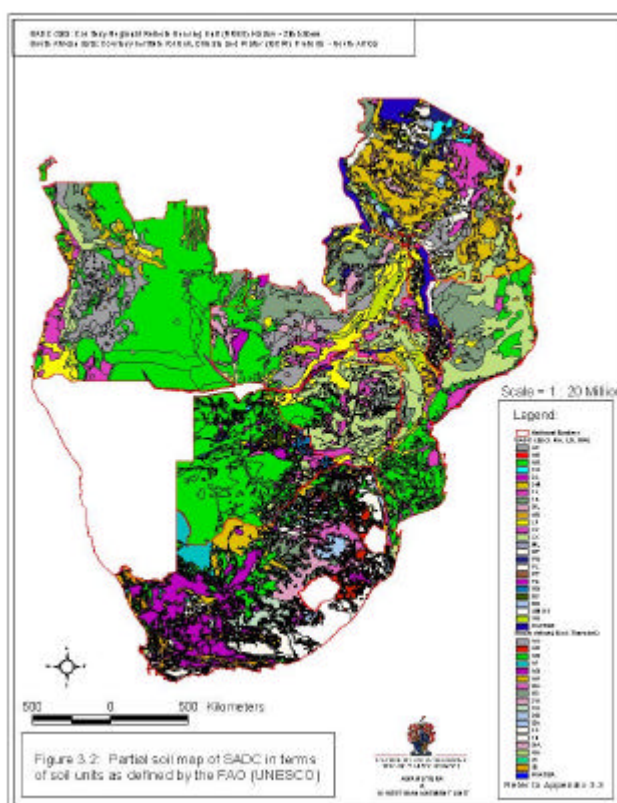
The RRSU continues to update and improve the data in the present database and will work on other climatic data sets, such as Potential Evapotranspiration (PET).

## SADC Agricultural Potential Information System (APIS)

The SADC Agricultural Potential Information System (APIS) is a decision support tool for policymakers in public and private sector institutions who need information about the quantity, quality, location and suitability of agricultural resources in a spatial context in the SADC region. The specific aim of the development of APIS is to enhance regional planning to support cooperation within the SADC region, by providing a rational basis for strategy and policy formulation in agriculture.

By integrating country data sets, agricultural resource comparisons can be made in order to select more effectively resources suitable for particular purposes, e.g. areas best suited for maize production from a land quality point of view and taking into account transport cost. The assumption is made that moving towards optimal agricultural resource use by utilizing comparative advantages within the broader regional context should increase rural welfare in the region, promote markets and stimulate regional economic growth. Utilizing opportunities of cross-border trade and relying less on sub-optimizing strategies such as promoting national food self-sufficiency should increase food security in the region, if production efficiency and stability and income generation can be improved.

SADC APIS was initiated by the Development Bank of Southern Africa (DBSA) after previous studies by the African Development Bank and DBSA. These earlier studies emphasized possible advantages to be gained from closer cooperation in the region and expected changes in agricultural resource use patterns whereby countries with ample agricultural resources can use opportunities to supply markets in countries less well endowed with resources. Although agricultural producers will gradually respond to market opportunities all over the region and outside the region, the provision of production support services (such as research and extension services) and physical infrastructure (roads, rail, airports) will have to be planned in time.



**Ben Opperman**

*Researcher (GIS/Remote Sensing), University of Stellenbosch*



Phase One of SADC APIS was commissioned by DBSA in 1994 and implemented by a project team of the Department of Agricultural Economics of the University of Stellenbosch. The goal of the Agrifutura Project was to generate information for strategic planning in agriculture in SADC. At the start of this phase, information on the socio-economic profiles of the SADC countries was completed.

Phase Two resulted in the development of a GIS that captured SADC Country data sets and integrated these into regional sets to make transnational comparisons possible. Digitized climate, topography, soils, demography and infrastructure data sets were obtained from the SADC RRSU. The SADC soil map, based on the FAO classification system, was supplemented by a South African soil map, specially adapted by the Institute for Soil, Climate and Water, to be as compatible as possible. The GIS is currently accommodated at the Forest Management Unit of the University of Stellenbosch, where it is supported by disciplines such as Soil Science, Agronomy, Agricultural Economics and Geography.

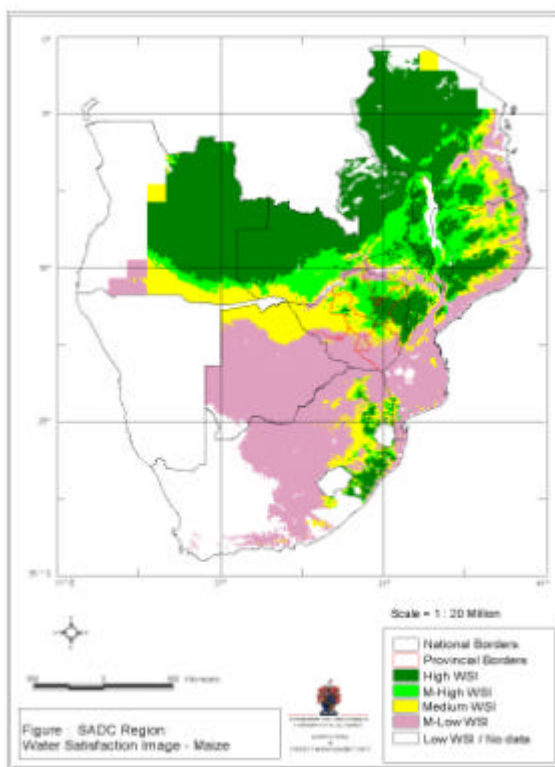
Currently, Phase Three is aimed at developing various facets of the SADC APIS, with input by agro-meteorologists, agronomists and soil scientists from nearly all SADC countries, to build a network of expertise that can provide data and verify and interpret results to increase the quality of the system output. Network members have also developed a general crop suitability model that is appropriate for the type and scale of resource data available at the regional level. This model will be used to investigate and develop production and trade scenarios - based on agricultural potential information and transport models - to generate information needed for development planning.

The following applications of the SADC APIS are possible in support of policy and planning:

- *Identification of areas that meet certain criteria, e.g. minimum average annual precipitation, soil depth, maximum slope.*
- *Areas suitable for, for example, maize production within a certain distance from a specified destination.*
- *Agricultural potential possibilities for a particular area.*
- *Comparison of areas with regard to their resource quality and accessibility by importing the results of the crop suitability map from the GIS into a transport model. The relative advantages of areas in terms of their fertility and proximity to markets can be taken into account in determining optimal production and distribution patterns for a particular crop.*
- *Determination of the potential impact of various development strategies.*

A GIS-transport model combination can be used to quantify and express visually the possible impact of investment options such as:

- The provision of chemical amelioration and physical improvement of soil.



- The provision of irrigation infrastructure.
- The provision of better transport infrastructure.
- The provision or expansion of airport or seaport facilities for export of agricultural products.
- The provision of processing infrastructure.

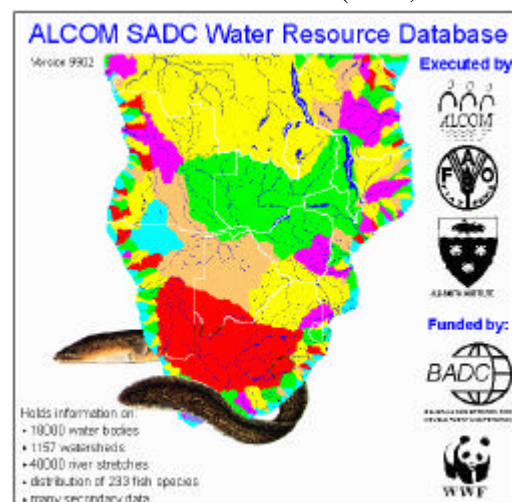
The visual expression of possible production and distribution scenarios supports the development of a common understanding of the characteristics and wider implications of a development strategy and a clearer shared vision of a desired outcome. This should increase the effectiveness of cooperation in the region. The SADC APIS through the established network will generate products in support of many aspects of food security and trade in the SADC region. In a general sense the expected outcomes are an enhanced food security early warning system for SADC through a better information and analytical system, and better supply and demand schedules to determine the effects of policy changes, e.g. infrastructure, transport and market development, on producer and consumer surplus.



## ALCOM's water resource database for SADC: a decision support tool for regional water resources management

The Aquatic Resource Management Programme for Local Communities (ALCOM) is institutionally linked to the SADC Inland Fisheries Sector in Malawi and is based in Zimbabwe. Besides aquaculture and fisheries field activities, the programme has been working on a SADC surface water body inventory since 1992 with the main purpose of estimating the fisheries potential of small water bodies in the SADC region. Since fish distribution data were needed to estimate fisheries potential, the database was gradually expanded to include watersheds, rivers and fish distribution. In February 1999, the first version of the SADC Water Resource Database (WRD) became available on CD-ROM, with information on more than 18 000 surface water bodies (dams, lakes and swamps), 1 157 watersheds, 40 000 river stretches and 233 fish species.

Data formats were standardized with those used by the Units of the SADC Food, Agriculture and Natural Resources Sector (FANR) and similar mapping software was adopted for the interface of the database. The GIS interface uses a commercial database package (Lotus Approach) combined with two mapping programmes (*Windisp*, free; *Mapviewer*, commercial). The database allows users to query any data field and subsequently map the selection of watersheds, rivers and water bodies. It is also possible to open standard hydrological maps, click on a certain object and query for the attribute data of this object whether it is a watershed, river stretch or water body. All database components are interlinked, allowing users to establish fish species lists for water bodies as well as river or water body lists for watersheds. The database is aimed at providing assistance to both fisheries and water departments in the SADC region but is also used extensively by research, conservation and private institutions and individuals.

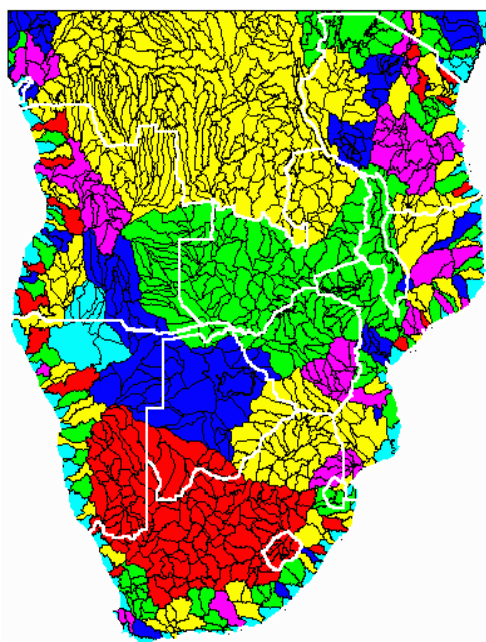


The WRD (on CD-ROM) consists of a number of major interlinked components:

- **Surface Water Body data (SWB):** The SWB database holds information on more than 18 000 reservoirs, lakes and swamps in 11 SADC countries. Data fields include geographical, administrative, meteorological, socio-economic, physical and chemical data as well as data on the use of the water body, presence of plant and animal species and fishing activity.

**Lieven Verheust**  
Chief Technical Adviser, Aquatic Resource Management Programme  
for Local Communities (ALCOM)

Point locations in decimal degrees are given in the database for the dam wall or for the middle of territorial waters for natural water bodies. Polygons (form of the water body) are available for the larger water bodies only. The database enables automatic mapping of selected water bodies as well as the display of data for water bodies found on electronic maps.



- Watershed data (WS):** The WS database holds both information and polygons of 1 157 sub-watersheds in subequatorial Africa. Sub-watersheds were delineated at the app. 5000 km<sup>2</sup> surface level based on a 1 km<sup>2</sup> digital elevation model and the river layer of the Digital Chart of the World (at 1:1 000 000 scale). All watersheds were named and ordered which enables determination of upstream basins (complete watershed), mega-basins or downstream basins. The largest mega-basins (such as the Zambezi, Zaire, Orange) have been split up into a number of sub-basins. Rainfall, PET and elevation data were GIS generated for each sub-watershed.
- River data (RIV):** About 40 000 river stretches from the Digital Chart of the World coverage were integrated in a database. Elevation data, soil data, watershed data and administrative information were generated through GIS overlays. For some countries, more detailed coverage is available including names of the rivers. For all other countries, names of major rivers can be derived from the watershed database.
- Aquatic Species Distribution data (ASD):** This database currently holds information on the distribution ranges of 233 fish species in Southern Africa, based on the work of Dr. Paul Skelton of the J.L.B. Institute of Ichthyology in Grahamstown, South Africa. The database allows the display of full species lists for each sub-basin or a list of basins in which a certain species is present. In addition to this, distribution maps can be displayed automatically. The database is being updated through the analysis of a large number of museum collection catalogues that were integrated in a GIS. These data were linked to the SWB database.

The following components are under development and will be released in the near future:

- Experimental Fisheries data :** This database combines several components which hold results of experimental fisheries and water quality data collected by ALCOM pilot projects on 21 water bodies in Malawi, Zambia and Zimbabwe. It includes data on capture and effort, length frequency, gonado somatic index and water quality data. Besides experimental data, creel survey<sup>1</sup> data of non-experimental fishing in the same water bodies are also being included.
- Fishing gear data:** A database of all fishing gear encountered in the framework of the ALCOM pilot projects holds information on occurrence, species and size selectivity of the gear.

<sup>1</sup> A creel survey assesses total fishing effort as well as catch and effort of individual fishers through direct observation and interviews

- **Aquatic resource mailing list:** The ALCOM aquatic resource mailing list holds references of a selected number of people and institutions involved in water and fisheries within and outside the SADC region.

**Database interface:** Four different data types can be accessed through one interface: regular cell data, geographical data (digital map components), graphical data (figures, pictures and drawings) and descriptive documents. Most of the data are geo-referenced which allows immediate mapping or querying for data on geographical locations from a map. Standardized administrative and hydrological maps are available in digital format for each SADC country and can be overlaid with other data from the water resource database.

**Data sources:** Since the database includes data from different disciplines and different countries, the data had to be sourced from a range of governmental and non-governmental organizations. Data were compiled from:

- Existing databases (international and national). In most of the countries, fisheries departments and hydrological departments (or their equivalents) provided data.
- Published literature
- Hardcopy and digital maps
- Informal information and gray literature (all stored in the ALCOM library)
- ALCOM Field visits (Malawi, Mozambique, Tanzania, Botswana, Lesotho, Zambia and Zimbabwe)

All information in the WRD can be traced back to it's source through the meta-databases.

**Application of the WRD as a decision support tool:** The WRD allows analysis, queries and mapping of several water issues. Mapping of water bodies with certain criteria, upstream catchment areas, species distribution areas are simple and direct in the current database interface. Zooming in on digital hydrological maps and querying information for characteristics of certain water bodies, species lists for a specific watershed, or downstream and upstream areas are equally simple and fast operations. With a little more knowledge, information on variables such as min, max or average elevation, rainfall, temperature or other climatological data is extracted for whole areas or certain points.

Applications are numerous, for example:

- **Hydrology:** Monitoring of filling and drying of dams by overlay of rainfall, land use and catchment area
- **Health:** Monitoring of water-borne diseases such as bilharzia or malaria by distribution mapping and climatology





- Fisheries and aquaculture: choice of the right species to stock by overlay of species distribution maps and climatological maps; determination of fisheries potential by modeling physico-chemistry on climatological maps
- Irrigation: Analysis of potential for irrigation by overlay of water availability and water demand
- Environment and ecology: Monitoring of aquatic pests and aquatic exotics by modeling migration; wildlife management by digital distribution mapping
- General development and food security.

**Status and future of the Water Resource Database:** The WRD is still growing and has not yet reached its full potential. Major work has been achieved in standardization of identifiers for water bodies, watersheds and many other components of the databases. This was an imperative to enable linkage of all data from different sources. Efforts are made to promote more widespread use of these identifiers in order to enable linkage to more external data. This will open up the WRD to programmes that are active in many different disciplines such as health, dam construction or general environment. It also stresses the importance of an official establishment of the WRD in a leading regional institution to avoid the loss of this standardization. Efforts are also being made to extend some of the WRD components to the whole African continent. This is particularly the case for the watershed database and the inland water polygon coverage. The Lotus Approach interface is being translated into a stand-alone MS Access interface, which will avoid the purchase of commercial software to run the database.

All data in html format are also available on the Web (ALCOM home page mirrors) at:

<http://www.fao.org>,

<http://www.zamnet.zm/zamnet/alcom/alcom.htm>

and <http://www.internet.co.zw>

## The FIVIMS initiative

At the World Food Summit in 1996, FAO member states recommended that accurate and timely information be made available on the incidence, nature and causes of chronic food insecurity and vulnerability. This is crucial for national policy makers in their efforts to formulate and implement policies and programmes to reach World Food Summit goals of reducing the number of undernourished and achieving food security for all. Information about the food insecure and vulnerable people is often lacking in many countries.

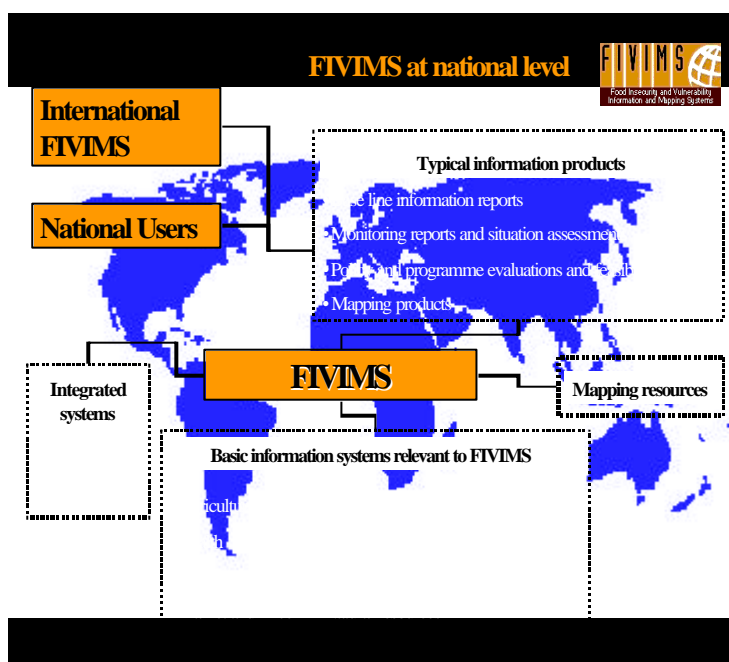
To help remedy this gap FIVIMS was born. It stands for “Food Insecurity and Vulnerability Information and Mapping Systems.”

The idea behind FIVIMS is that improved information can be actively used at sub-national, national, regional and international levels, to realize the goals of reducing the number of undernourished and of achieving food security for all.

The acronym FIVIMS refers to the overall framework and the concepts and ideas associated with it, and not necessarily to any one particular system or network of systems already in place. In none of these efforts are new databases or reporting relationships envisioned.

The international FIVIMS seeks immediately to help improve the amount and quality of information available on food insecurity and vulnerability at national and sub-national levels through internationally supported, country-specific applications of the FIVIMS concept.

At the national level, the FIVIMS initiative encourages the linking of information systems that gather and analyze data relevant for measuring and monitoring food insecurity and vulnerability. These systems are collectively referred to as a national FIVIMS. A national FIVIMS is country driven and user focused, based on information systems already in existence, responsive to the information needs of the different user groups, and operated and controlled by the country itself.



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Food Systems Officer  
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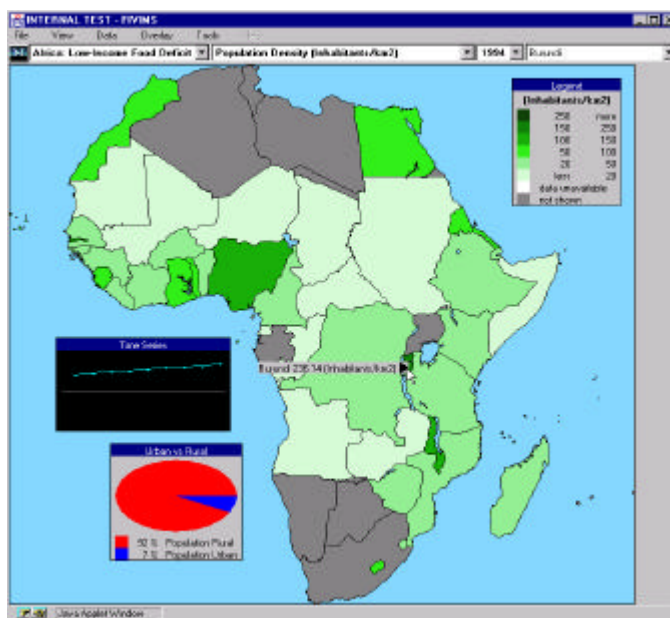


In common with the other information systems in the SADC region presented at this Consultation, the FIVIMS initiative encourages data sharing and analyses required to better understand and guide progress towards meeting common food security and development objectives.

Some typical information systems already in existence and relevant to FIVIMS are:

- Agricultural Information Systems
- Health Information Systems
- Land, Water and Climate Information Systems
- Early Warning Systems
- Household Food Security and Nutritional Information Systems
- Market Information Systems
- Vulnerability Assessment and Mapping Systems

The international FIVIMS programme is being developed and coordinated through an Inter-agency Working Group on FIVIMS (IAWG-FIVIMS) to support both national and global FIVIMS. Membership of the IAWG currently includes representatives of more than 20 agencies and organizations, comprising bilateral donor agencies, UN agencies, the CGIAR system and international NGOs. The IAWG-FIVIMS has its Permanent Secretariat at FAO in Rome.



Additional information on FIVIMS can be obtained from the following sources:

E-mail: [fivims@fivims.net](mailto:fivims@fivims.net)  
 WWW: <http://www.fivims.net>

## FAO AEZ/LRIS tools and country applications

Since 1975 FAO has been working on developing and applying the Agro-ecological Zoning (AEZ) methodology. First it was applied at the global level in assessing food production potential in the developing countries using the 1:5 000 000 scale FAO soil map of the world. Since 1984 the methodology has been continually expanded and refined to address applications at increasingly detailed levels: from national to subnational (district) down to local (watershed, community) levels. This upgrading concerns three main areas:

- the introduction of models for complex production systems including multi-cropping and intercropping of annual crops, consideration of perennial crops (including forestry) and linkage to livestock production.
- the incorporation of decision support tools based on multi-objective and multi-criteria analysis for optimizing the use of land resources.
- the introduction of Geographic Information System (GIS) as spatial database management tools.

More recently land resources information systems (LRIS) have been developed incorporating these elements, including WINDOWS based AEZ software packages. In LRIS the AEZ software packages are used in combination with standard GIS software and database tools.

### LRIS/AEZ APPROACH FOR COUNTRY STUDIES

A Kenya case study was used to develop and test the upgraded AEZ methodology for country assessments. Agro-ecological zoning involves the inventory, characterization and classification of the land resources for assessments of the potential of agricultural production systems. This characterization of land resources includes components of climate, soils and landforms, basic for the supply of water, energy, nutrients and physical support to plants. The Kenya AEZ study involves analysis at district level. The Kenya methodology includes models for land suitability and land productivity assessment and for land use analysis based on multi-objective land use optimization.

The Kenya AEZ methodology has been used to assess the crop and livestock production potential of each district in the country. The methodology includes the following principles which are fundamental to any sound evaluation of land resources:

- i. application of an inter-disciplinary approach, based on inputs from crop ecologists, pedologists, agronomists, climatologists, livestock specialists, nutritionists and economists;
- ii. land is evaluated for specific land uses;

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- iii. land suitability refers to use on a sustained basis, i.e., the envisaged use of land must not lead to degradation, e.g. through wind erosion, water erosion, salinization or other degradation processes. Soil regeneration is assumed to be achieved by means such as fallowing, appropriate crop rotations and soil conservation measures.
- iv. evaluation of production potential with respect to specified kinds and levels of inputs, e.g., fertilizers' pest control measures, if machinery or hand tools are used (agricultural inputs and farming technology);
- v. different kinds of land use are considered in the context of meeting the national or regional food crop mix and demand for livestock products.
- vi. different kinds of livestock feed resources are considered, e.g., natural pastures and browse, sown pastures, crop residues and by-products and feed concentrates, in the context of meeting seasonal and spatial feed requirements.
- vii. land-use patterns are constructed so as to optimize land productivity in relation to political and social objectives, taking into account physical, socio-economic and technological constraints.

Figure 1 gives a general overview of the flow and integration of information as implemented in the AEZ Kenya case study. In the following explanations the paragraph numbers relate to the numbers used in Figure 1.

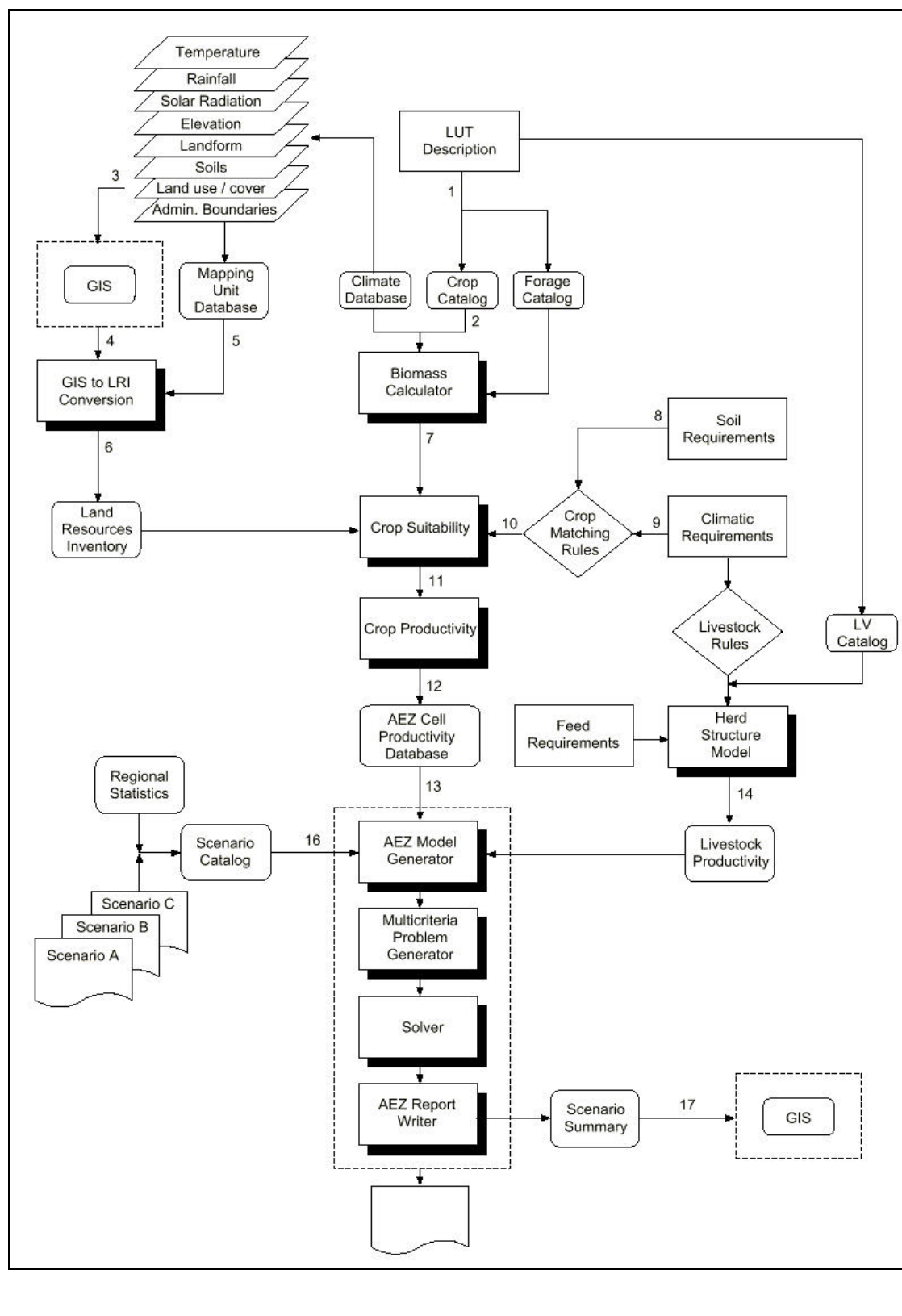
1. LUT descriptions: These define the fundamental objects of analysis which comprise the set of alternative activities available to achieve specified objectives. The first step in an AEZ application is the selection and description of land utilization types (LUT) to be considered in the study. FAO (1984) characterizes an LUT as follows: *"A Land Utilization Type consists of a set of technical specifications within a socio-economic setting. As a minimum requirement, both the nature of the produce and the setting must be specified"*. It is suggested that the description of LUTs is prepared according to a hierarchical structure that defines, for example,
  - elements common to all land utilization types: typically such elements would include the socio-economic setting of a (fairly homogeneous) region for which a number of land utilization types may be defined (Level 1);
  - elements common to certain groups of land utilization types: e.g. several land utilization types could be defined for a particular farming system. Holding size, farm resources, etc., could be recorded at this level of LUT description (Level 2);
  - elements specific to particular land utilization types: crop specific information such as cultivation practices, input requirements, cropping calendar, utilization of main produce, crop residues and by-products are to be described at this level (Level 3).

The specific aspects that can be meaningfully included in the description and the amount and detail of quantitative information provided must match the needs and scale of the application. The AEZ Kenya study distinguishes 64 crop LUTs, 31 fuelwood LUTs and a synthetic<sup>1</sup> grassland LUT, each at three levels of input. Also, 10 representative livestock systems are considered per input level.

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<sup>1</sup> Twenty-four grass and eight legume pasture species were rated in relation to temperature regime and moisture availability, and combined into a generalized grassland productivity assessment, assuming that for different ranges of environmental conditions respectively the most suitable and productive species would dominate, depending on level of inputs.

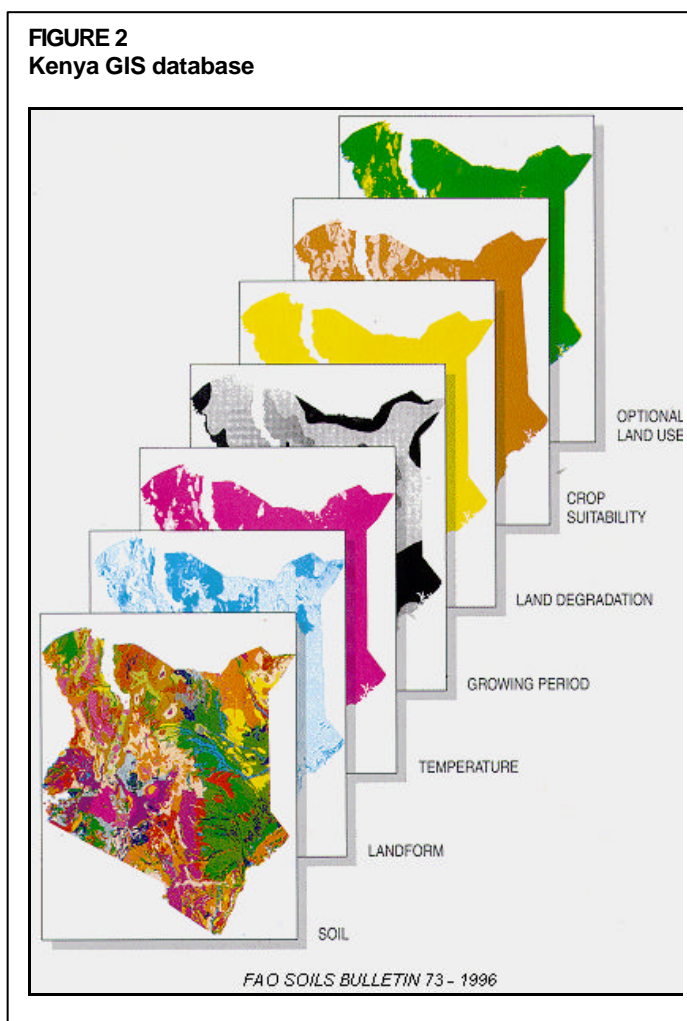
**FIGURE 1**  
**AEZ information flow and integration**



2. The term 'Crop Catalog' refers to a computer representation in a database format of the quantitative aspects of the crops in the LUT description. At minimum, the parameterization will contain information on the photosynthetic pathway, crop adaptability group, crop cycle length, temperature thresholds, harvest index, etc.
3. Several land utilization types are assessed for a set of land units, i.e., areas of land with specific and distinguished characteristics. In the modeling, the defined land units represent unique and homogeneous land management units. In practice, land units are often obtained by superimposing various thematic maps (in raster or vector format) regarding aspects such as different attributes of climate, soils, landform, slope, vegetation, present land use and administrative boundaries (Figure 2).

4. For storage and manipulation of complex spatial information, the geographic datasets are best entered into a geographic information system (GIS).
5. Additional attribute data related to the mapped information, e.g. a description of soil mapping units in terms of soil associations, soil phases and texture classes, landform, slope, etc., is linked to the polygon geometry or to gridcells in the form of attribute tables.

6. Combining overlaid spatial information with the contents of relevant attribute files results in the creation of georeferenced extents of land units, termed agro-ecological cells, which form the basic unit of analysis used in AEZ applications. These are all unique in terms of a set of selected attributes such as thermal regime, moisture regime, soil type, slope class. The collection of agroecological cells constitutes the land resources inventory (LRI). The land resources inventory used in the Kenya study, compiled at scale 1:1 million, distinguishes some 90 000 agro-ecological cells.



7. The methodology used in regional or national AEZ applications for determination of agronomically attainable yields in an agro-ecological cell proceeds in three steps. It starts out from estimation of maximum agro-climatic yield potential as dictated by climatic conditions. Biomass accumulation is described in terms of photosynthetic characteristics and phenological requirements, to calculate a site-specific constraint-free maximum yield. Then agro-climatic constraints are assessed to derive agronomically attainable yields taking into account yield losses

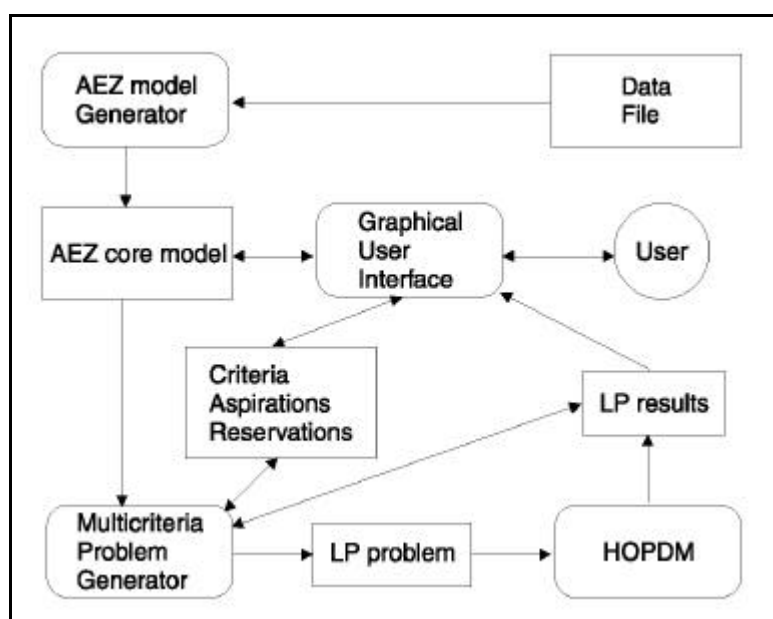
occurring due to temperature limitations, moisture stress, pests and diseases, and workability constraints. Attainable yields are estimated for different levels of management and inputs.

8. Crops, grasses and fuelwood species, as well as livestock species have climatic requirements which must be known for suitability assessment. These include, for instance, temperature limitations for cultivation, tolerance to drought or frost, optimal and marginal temperature ranges for cultivation, and, for some crops, specific requirements at different phenological stages.
9. To match soils to the requirements of particular land utilization types, soil requirements of crops must be known. These requirements must be understood within the context of limitations imposed by landform and other features which, perhaps, do not form a part of soil but may have a significant influence on the use that can be made of the soil. Distinction is made between internal soil requirements of crops, such as soil temperature regime, soil moisture regime, soil fertility, effective soil depth for root development, chemical soil properties, and external requirements related to slope, occurrence of flooding and accessibility to the land.
10. Matching rules for comparing requirements of crops and livestock to the attributes of a particular agro-ecological cell are devised by experts (or modeling) and stored in a database.
11. As a result of the agro-climatic and agro-edaphic matching procedures, each agro-ecological cell is characterized in terms of suitability classes for all land utilization types relevant in that location.
12. Based on crop suitability, the productivity assessment considers important factors that impact upon the average production levels that can be attained on an annual basis: (i) production increases due to multiple cropping resulting from intensification of cultivation in space and time; (ii) productivity losses due to soil erosion; (iii) fallow requirements, to maintain soil fertility and structure and to counteract soil degradation caused by crop cultivation, depending on climatic conditions, soil type, crop group, and level of inputs and management. The fallow requirements are imposed because the productivity estimates related to production on a sustainable basis.
13. The productivity assessment records production of relevant and agro-ecologically feasible cropping activities at specific input levels. The information stored includes amounts of main produce and by-products, input requirements and estimated soil erosion. The algorithms applied impose a filter which eliminates activities that are ecologically unsuitable in the agro-ecological cell under consideration, too risky with respect to climatic uncertainties, environmentally unacceptable, (i.e., too much erosion) or much inferior to other possible activities in this land unit in terms of expected economic benefit and nutritional value. At this stage of the analysis a database is created that contains quantified information on all feasible land utilization types for each agro-ecological cell. This database can be used to tabulate or map potential arable land by crop or zone but, more importantly, the database contains the necessary geo-referenced agronomic data for district or national planning scenarios.
14. The performance of livestock systems is estimated in two steps: (i) describing a representative herd composition, by age and sex, fertility rates and mortality, and (ii) quantifying production of meat, milk and other outputs in relation to different management levels and feed quality. Input/output relationships of livestock systems, expressed per reference livestock unit, as well as feed requirements and the resulting production of the total herd are recorded in a livestock systems productivity database for use in the planning model.
15. Planning scenarios in the AEZ application are specified by selecting and quantifying objectives and constraints related to various aspects such as demand preferences, production targets, nutritional requirements, input constraints, feed balances, crop-mix constraints and tolerable environmental impacts (i.e., tolerable soil loss). Given the large number of agro-ecological cells and the variety of LUTs to be taken into consideration, the objective function and the constraint

- set of the district planning model have been defined by linear relationships to allow for application of standard linear programming techniques in the interactive decision support system.
16. Different sets of assumptions, e.g. regarding population growth, availability and level of inputs, consumer demand, etc., are stored in the scenario catalogue, a database used by the application programs.
  17. Output from the AEZ application report writer is kept in a scenario summary database and can be passed to a geographical information system for visualization of the results.

A software package called AEZWIN (abbreviation for AEZ Windows) with a manual and detailed tutorial have been prepared to implement the Kenya AEZ methodology. AEZWIN makes it possible to interactively generate models corresponding to various scenarios of land use and then to analyse these models using modular tools for multi-criteria model analysis. The general structure of the Decision Support System - that can be applied to other problems – as well is illustrated in Figure 3.

**FIGURE 3**  
**Functional structure of the MCMA module**



### Examples of country applications

FAO has assisted various countries in developing and applying LRIS/AEZ technology at various scales following the Kenya approach. The countries include Bangladesh, the Philippines and China in Asia, Chile, Brazil and Uruguay in South America, Grenada in the Caribbean; Tanzania, Nigeria and Namibia in Africa.

Four examples of country application of LRIS are presented.

## BANGLADESH

**Project:** Establishment of a GIS-based agricultural/land resources information system in Bangladesh (BGD/95/006)

### Overview

From 1980-1987 a national Agro-Ecological Zone (AEZ) database was successfully developed in Bangladesh with financial support from the United Nations Development Programme and technical support from the Food and Agriculture Organization of the United Nations (UN-FAO). The database contains information on the country's land resources, including physiography, soils, climate, hydrology, land use and crop suitability. The database is housed in the Bangladesh Agricultural Research Council's (BARC) computer centre (in Dhaka) and has been used to generate readily accessible information on the physical land resources of the country for use by researchers and decision makers in land and agricultural resources management as well as agricultural development planning.

A comprehensive multi-scale Land Resources Information System (LRIS) is being currently developed on the foundation of this AEZ database to improve its capability to deal with the intricacies of land resource planning under the complex environmental conditions prevailing in large parts of Bangladesh. The LRIS will include additional databases and procedures, in particular data on socio-economic and demographic factors influencing agricultural production. It is implemented by BARC under this follow-up project which is financed by UNDP with technical assistance being provided by FAO.

The technology being used to establish the LRIS consists of two parts: (1) the application of 'state of the art' geographic information system (GIS) technology and (2) the integration of multi-criteria analysis tools.

### Conceptual system design

At the start of this project in 1997 an overall system design was established to allow for a very dynamic analysis and modeling capability. In the past, natural resources modeling applications were based on static GIS overlays. Due to the limited memory capacity of the available computers, the overlay of individual maps such as soil, climatic and flood zones maps was time-consuming, and much more time still was needed to refine the resulting layer. With the advent of more powerful desktop computer systems and more powerful software, it has become possible to develop more flexible and dynamic modeling tools.

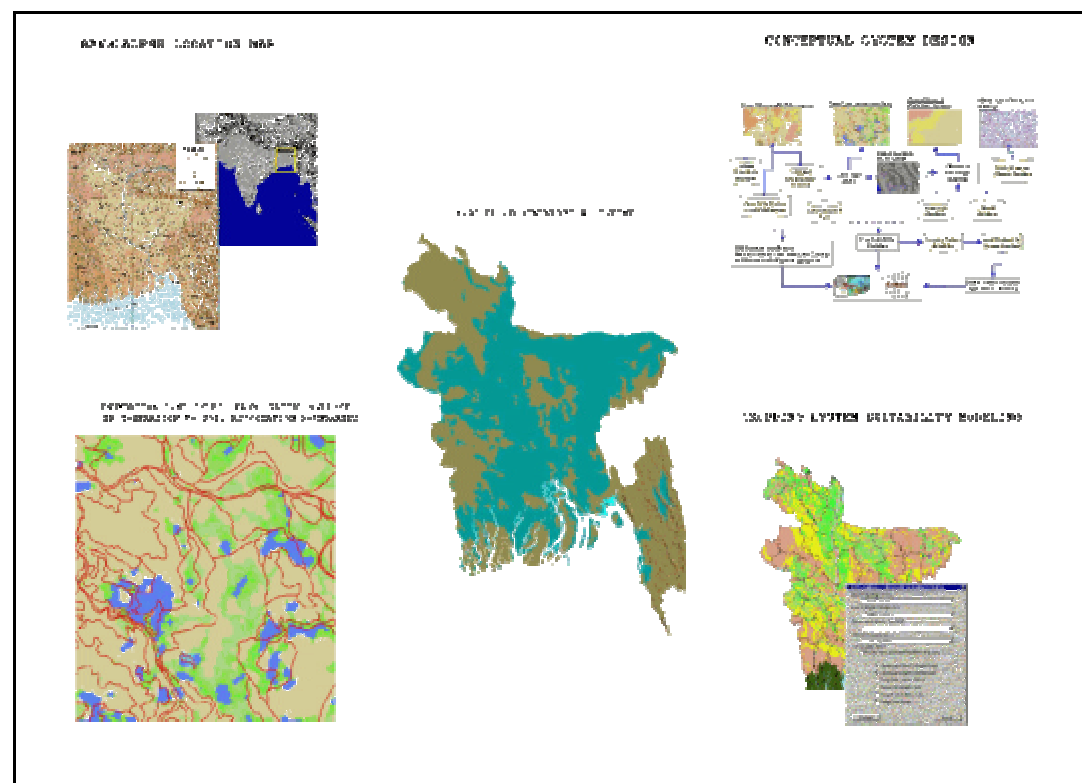
The approach taken in Bangladesh is to create a multi-layered GIS database in which each component layer is allowed to change, and which can be used for modeling based on any selected layers. Because of the inherent variability of climatic and hydrologic conditions, particularly in Bangladesh, an open-ended system that allows for modeling of a wide range of specific dynamic scenarios, based on the historical record as well as on predicted future conditions, will be of greater use and will yield higher quality results.

### LRI summary application

This application allows for the classification and mapping of soil characteristics from the land resources inventory (LRI) stored in the database. The LRI contains several attributes describing various physical soil characteristics. Since LRI attribute data have a many-to-one relationship to soil



**FIGURE 4**  
**Bangladesh LRI**



mapping units, the data must first be summarized by mapping unit and the resulting mix of LRI characteristics classified for mapping purposes.

The LRI Summary Application was developed using the ArcView Dialog Designer extension. It allows the user to specify the study area, the data to be classified, and the number of classes to be created. The user is then able to edit the resulting mix of classes based on the percentage area covered by each class. Classes can be combined (merged) and re-named to provide meaningful map output with a more informative legend.

### Soil/land type mapping model

An Avenue/Spatial Analyst application has been developed to dynamically combine a user-specified digital elevation model (DEM) with the national (reconnaissance level) soil delineations to create a more detailed Soil-Land Type Map. The methodology and base DEM were developed by the Environmental and Geographic Information Support for Water-Related Resource Development Project (EGIS-II) in the early 1990. The application is based in ArcView and has been programmed to handle future updating of both the soil and the DEM layers.

The first step in development of this application was to refine the previously created 300 metre DEM by filling in areas of missing elevation with values taken from a 1 000 metre DEM. This procedure was performed using the Spatial Analyst map calculator utility. Next, an Avenue program was written to loop through each soil mapping unit, extract an elevation mask grid for that soil unit, sort the elevation values and then determine the elevation cut-offs for each of the topographically oriented land type designations (highland, medium highland, medium lowland, lowland, and very lowland). The approximate percentage coverage for each land type was extracted from the original

soil survey reports and the data was fed into the Avenue program to assign the cut-off values. The mask grids created for each mapping unit are merged into a larger grid as the program runs.

The output of the Avenue program is a new grid-based Soil Land Type layer in which the number of many-to-one relationships between soil attributes and soil mapping units is greatly reduced. This new layer provides more detailed and harmonized data for enhanced and flexible soil mapping capability.

### **Climatic modeling**

Much effort has been made to expand existing historical climatic data involving different types of data with recent records obtained from various institutions. Procedures have been developed to perform quality control and enhance database management and modeling capability. Data are loaded into a system called an ATP Calculator and analysed to create GIS surfaces showing important edaphic properties related to plant growth by season as well as the variability of these properties (example: average starting date of the pre-kharif growing season).

### **Hydrologic modeling**

On average, approximately 60% of Bangladesh is inundated by rising water table levels between July and September of each year. Previous AEZ assessments indicated that the year-to-year variation in inundation regime is affecting long-term suitability and productivity of land. With the enhanced system now in place, the year-to-year variation in extent, depth and timing of inundation can be quantified. This information will greatly improve the assessment of single crop and cropping pattern suitabilities in individual inundation land types.

### **Crop suitability model**

The system also includes a component that permits the evaluation of crop suitability. First, individual crop suitability ratings are analyzed and then suitabilities for various cropping patterns are rated using a database of known and potential cropping patterns (rotations). This suitability modeling takes into account soil physical characteristics, hydrologic and climatic conditions, and the seasonal variability in these properties.

ArcView's Spatial Analyst and Dialog Designer extension are the main tools used for the crop suitability modeling. A main dialog allows the modeler to choose the dynamic layers and options to be associated with each model run.

### **Multi-criteria analysis model**

The next activity envisaged is the analysis of land use scenarios integrating the physical suitabilities for various cropping patterns and socio-economic factors of agricultural production. The relevant socio-economic databases are being constructed for this purpose. The analysis will essentially involve three steps: the formulation of scenarios, each scenario represented by a core model; the analysis of solutions of the core model using a linear programming (LP) solver based on multi-objective linear optimization; the application of multi-criteria analysis to the core model solutions to determine compromise solutions which adequately reflect the preferences of decision-makers in real life situations. Software tools have been put in place for this application. They are all linked to the GIS which plays a pivotal role in this work.

Further information can be obtained from the Project web page, on website: <http://www.citechco.net/barc/>

## LATIN AMERICA

**Regional Project:**     **Agricultural Land and Water Information for Sustainable Agricultural Development In Latin America (GCP/RLA/126/JPN)**

### Overview

Six countries: Argentina, Chile, Brazil, Bolivia, Paraguay and Uruguay are participating in the project. The project is financed by Japan and executed by FAO. The Project is overseen by an Advisory Committee.

The objectives are to:

- establish a computerized land information system with GIS support, comprising computer hardware and software, a database and human resources;
- develop and test a methodology and software for the systematic and comprehensive evaluation of land resources as a source of information regarding decisions for the rational utilization of these resources on a sustainable basis;
- assess the potential of natural resources in each country for alternative uses on a sustainable basis at different production, management and input levels;
- develop human resources for planning and decision making on land information systems.

The Project provides each participating country with the opportunity to benefit from the experience obtained in other countries and with training in the use of methodologies for collecting and processing land resources information for the purpose of preparing sustainable agricultural development plans. Strengthening the technical capacity of national agencies, including technical staff as well as decision-taking personnel, is an important component of the project.

The project covers four groups of activities:

1. Methodological Development and Improvement of LRIS (Land Resource Information System)
2. Validation and Application of the LRIS in the participating countries
3. Training and Technical Assistance
4. Dissemination of Results

### Methodological guide for the development of LRIS

The Project has developed a Methodological Guide for the Development of a Land Resource Information System (LRIS) for use by counterpart institutions. Using the FAO AEZ methodology the project is developing several computational tools to evaluate land suitability, monitor land degradation and optimize soil use. Each tool will first be validated by the technical staff and later disseminated.

### Methodological guide for the optimization of land use

A Methodological Guide for the Multicriteria Optimization of Land Use has been elaborated to analyse land use scenarios based on land evaluation results using mathematical optimization. This leads to the development of optimized scenarios including alternatives for land use based on AEZ land units.

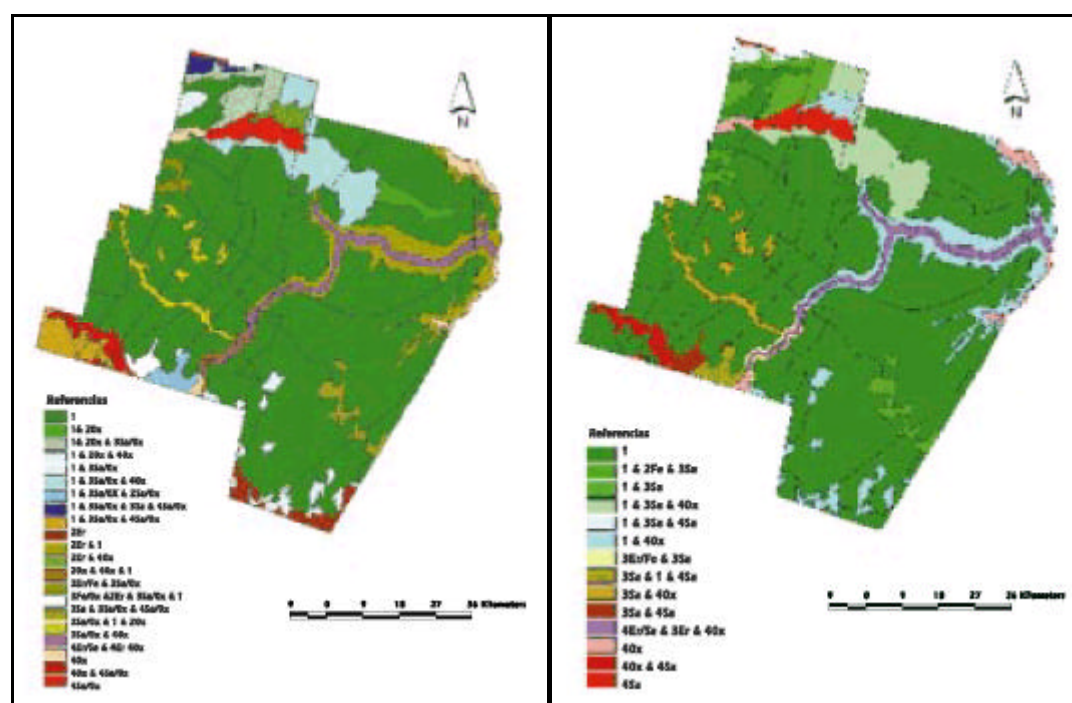
### AEZ at community/watershed level

To validate the methodology case studies are carried out based on real socio-economic and biophysical data including agro-ecological zoning (AEZ).

### Examples of AEZ applications

**Argentina:** Information System for Water Resource Planning (SIPH) for the analysis and processing of information to be used in the evaluation and optimization of sustainable agricultural uses of land under irrigation systems and the determination of potential areas for irrigated agriculture.

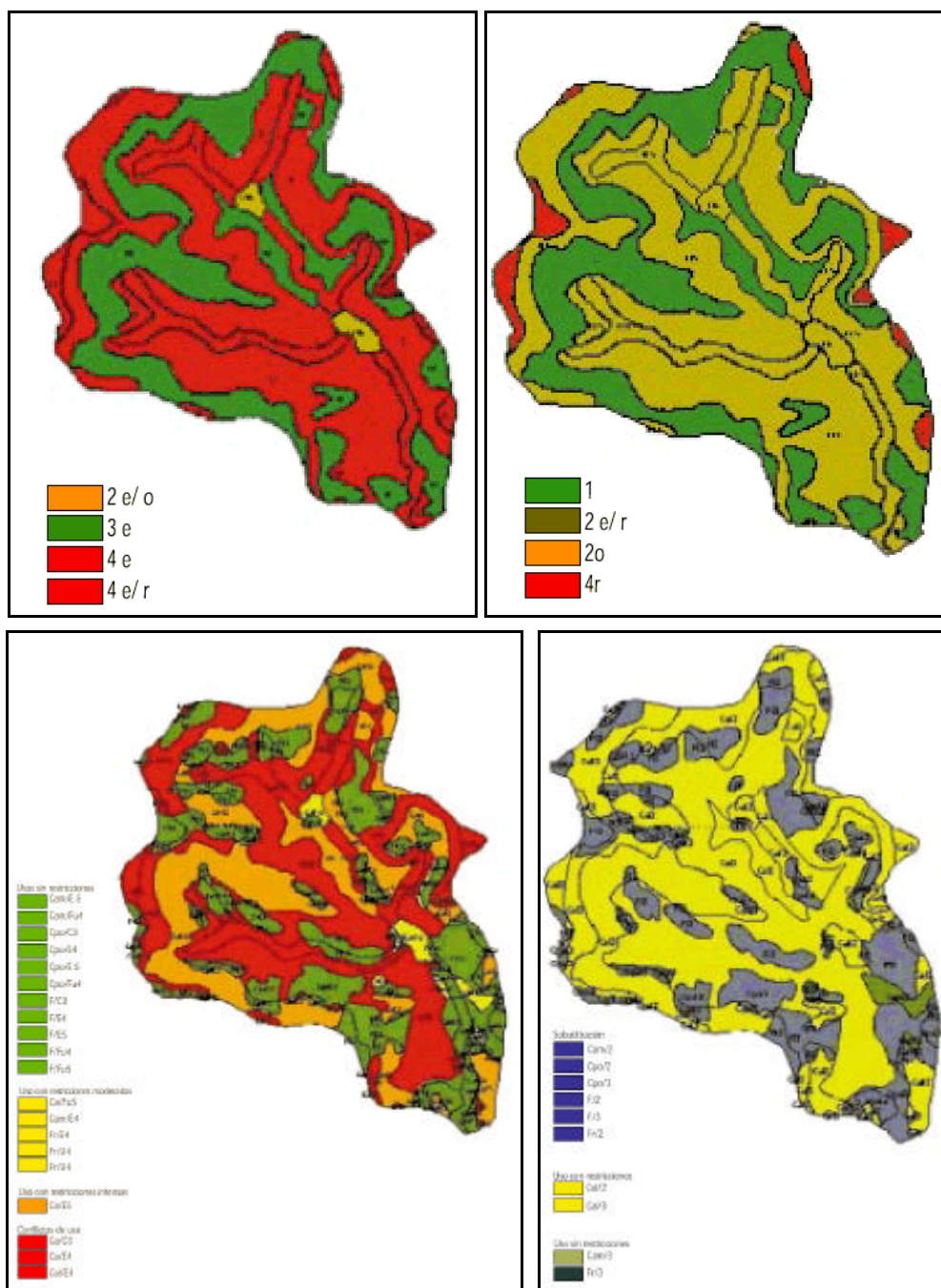
**FIGURE 5**  
Land suitability maps (Argentina)



**Bolivia:** Land Resource Information System (LRIS) established by Research and Remote Sensing Services Center (CISTEL). CISTEL is collecting local information by means of maps, images, reports and general economic statistics, all of which will be inserted into the LRIS. The information will be processed and analyzed in order to elaborate maps of the potential uses of the Municipality of Arbipto, as well as other reports as a basis for land use planning for this pilot municipality.

**Brazil:** LRIS developed by the State Agency of Agricultural Research and Rural Extension Enterprise of Santa Catarina (EPAGRI). EPAGRI will collect information in the pilot area of the *Arroio do Tigre* micro-catchment in Concordia and store it in a database. The LRIS will be used to process and analyse the information to evaluate and optimize sustainable agricultural land uses by means of a participative farmer planning process.

**FIGURE 6**  
Land suitability maps (Brazil)



**Chile:** Case studies in the Municipalities of Portezuelo and of Quillota. The purpose is to use the Project's Land Evaluation Methodology as the official instrument for zoning strategy to identify the Agricultural, Livestock and Forestry Areas of Interest (AIS) in these Municipalities. This information will be the basis of actions and regulations for the physical development of these AIS, which will be incorporated into the Ordinance of the Communal Regulation Plans of the Municipalities.



**FIGURE 7**  
**Participatory land use planning (Brazil)**



**Paraguay:** Establishment of an LRIS based on a GIS, with land resource and socio-economic databases, on Oriental Region of the country. The LRIS is used to elaborate maps and reports on suitability for specific land use types, on potential and conflictive areas of the region, as well as recommendations for sustainable agricultural development of selected areas, including conservation measures and opportunities for the improvement of the production systems in the region.

**Uruguay:** Implementation of an LRIS with a database containing diverse information including maps, images and reports as well as general economic statistics. The LRIS has been used to elaborate maps and potential uses of the watershed of the Cuareim River, located in the Northern part of Uruguay, in addition to the necessary reports, as a basis for the planning of the sustainable use of land and water resources in the area. The LRIS products are used to prepare inputs for the Programme of Natural Resources and Irrigation Development (PRENADER) used in feasibility studies on the irrigation and livestock development programmes in the area.

### **Capacity building**

The counterpart institutions conduct training in the use of GIS, management of natural resource information and concepts related to land evaluation. The acquired capacities are applied in the execution of the activities.

### **Information dissemination**

For the dissemination of information on natural resources and the most effective management systems, the project is building a regional information network, operating through the Internet. An enquiry at-distance system of geographic information (Geo RLC) has been put in place.

### **Project Web Page**

Further information can be obtained from the Project website: <http://www.rlc.fao.org/proyecto/gcp/rla/126/jpn/>

## LITHUANIA

### **Project: Establishment of a Land Resources Information System (LRIS) for Sustainable Land Use**

#### **Overview**

This two-year FAO Technical Cooperation Project was successfully completed in October 1998. The objective of the project was to assist the Government of Lithuania in establishing a land resources information system (LRIS) to provide a basis for land use planning and land policy formulation at the national, regional (district) and local levels. As planned, a fully operational pilot LRIS was established in the State Land Survey Institute of Lithuania (SLSI). The LRIS comprises Geographic Information System (GIS) equipment, a three-level multi-layered GIS database, methodologies of land evaluation for land use planning and management and staff trained to operate and maintain the LRIS and to use the information products.

The LRIS involves a multi-scale database, consisting of a national database at the scale of 1:200 000, a district database for two districts (Trakai and Kaisiadorys) at the scale of 1:50 000 and a local area database for two local areas within the districts (Dovainonys and Akmena) at the scale of 1:10 000. Thus, the structure of the information system corresponds to the three levels of land use planning in Lithuania: national, district or regional and local. The system is now fully operational at SLSI. The system was created in such a way that it can be expanded in future to cover the whole country.

The experience obtained during the project has enabled trained Lithuanian land resources specialists to transform the old data covering all the country to the new FAO and EU compatible system.

A wide range of outputs and information products were prepared including a digital report on the state of land, water and plant nutrient resources in Lithuania for the Internet. A follow-up project is envisaged with a view to applying the LRIS for land and water use monitoring and land drainage management both within Lithuania and in the regional context of the three Baltic states -Lithuania, Latvia and Estonia- and Poland.

#### **GIS Database**

The database contains soil, land cover and climate data layers and various other layers:

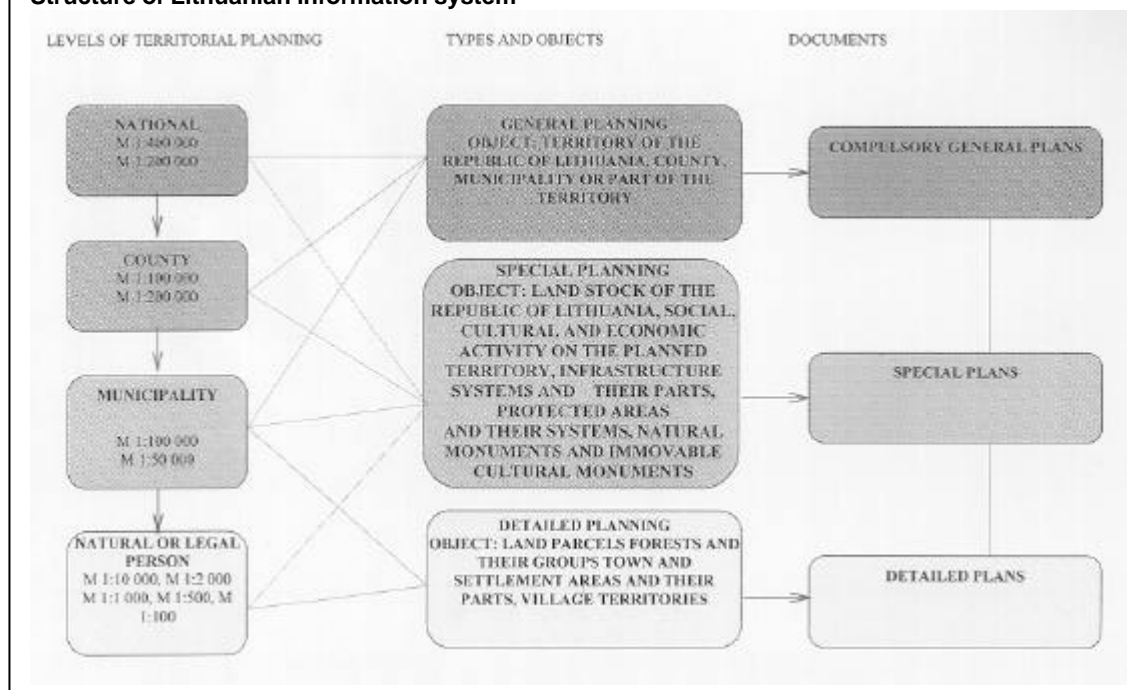
Land use and Land Cover:

- Personal and State Farms
- Forests, settlements, lakes and rivers, agricultural land, gardens, communities
- Recreational forests and territories
- Quarries, natural resource deposits, industrial zones
- Roads and railroads
- Filling stations, campgrounds, motels
- Waste dumps
- Cemeteries
- Urban developments
- Cultural monuments
- Reserves
- High voltage electric lines

Restriction and Protection Zones (district and local level only):

- Electric line restricted zones

**FIGURE 8**  
**Structure of Lithuanian information system**



- Water body protection zones
- Quarry restricted zones
- Natural meadows, pastures and bogs
- Drained lands
- Cultural monument restricted zones
- Restricted zones around filling stations, industrial zones and waste dumps
- Restricted zones around roads and railways
- Restricted areas around cemeteries

Climatic Layers (national level only):

- Average annual precipitation
- Average precipitation during cold period
- Average precipitation during warm (growing) period
- Annual evaporation
- Evaporation during the growing period
- Timing (average date) of soil freezing
- Timing (average date) of soil thawing
- Soil temperature (10cm) by month for May through September
- Planting and sowing timing for various crops

### SOTER database

A key component of the Lithuania LRIS is a Soil and Terrain (SOTER) database. Following the FAO/ISRIC methodology for the development of SOTER databases, the Lithuanian version of SOTER was prepared on the basis of the national level data. In this process, a systematization of Soil Cover Structure of Lithuania was carried out and maps at the scale of 1:1 000 000 and 1:300 000 were compiled. The project facilitated the transition from the former Lithuanian soil classification system (similar to USSR) to that of the European Union and FAO. The map at the



scale of 1:1 000 000 will be used for development of the EU soil map. Lithuanian landscape classification was correlated with that of FAO. FAO classification equivalents are not absolute; however they are useful for developers of a land use model base in application of the existing data. The methodology used in this work may be used for improvement of soil mapping by using relief data.

### **Land Resources Information System (LRIS) applications**

The digital LRIS allows the combination of data layers in developing land use models as well as in preparing zoning maps and other thematic maps. In this way numerous applications are developed using the basic data sets and computerized models. The various output maps present the results of climatic, soil, land cover, land use, water resources, land suitability and socio-economic data analysis.

### **Land drainage/management**

Land drainage is an important factor influencing the whole agricultural production process in Lithuania. There are 2.6 million ha of drained land, 80% of the total agricultural land area. About 90% of the total agricultural production comes from drained lands.

A digital database of land drainage areas was prepared for several cadastral units at a scale of 1:2000. It contains map layers of drains, boundaries of farms, boundaries of drainage systems and watersheds. The information is used by owners, individual users of drainage systems and associations of drainage users in the self-management and maintenance of the systems in the administrative or watershed units. It is used by county offices of land reclamation in exercising the ownership functions for the state-owned part of the systems, including the administration of state funds for support and subsidies to land reclamation and monitoring of land reclamation projects.

### **Land evaluation at detailed scales**

Following the FAO methodology, land evaluation plans and maps were prepared for the pilot areas. It is intended to cover the majority of private farms, all cadastral areas, administrative districts and all the territory of Lithuania in the near future.

The plans and maps are mostly used for preparation of different land reform projects, for land price calculations as well as for planning and allotment of subsidies and loans. Agricultural land productivity grade is the criterion for selection of agricultural crops and place of their cultivation, forest planting areas and etc.

Computerized land evaluation procedures using the ALES (Automated Land Evaluation System) were developed and tested for small parts of the pilot areas.

### **National agro-ecological land resource assessment**

Using the national database, a study of land suitability was carried out for the most important crops based on the FAO agro-ecological zoning (AEZ) methodology. This included land suitabilities for potatoes and winter wheat at a high level of input.

### **Digital report on the state of land, water and plant nutrient resources in Lithuania**

Using the FAO framework and guidelines prepared for this purpose, the project compiled a digital report on the State of Land, Water and Plant Nutrient Resources in Lithuania in English and Lithuanian. The report is posted on an Internet home page:

[http://www.zum.lt/Resources/Internet\\_senas/Project.htm](http://www.zum.lt/Resources/Internet_senas/Project.htm)

## TANZANIA

### **Project: Establishment of Land Information System for Land Use Planning and Policy**

#### **Overview**

This FAO Technical Cooperation project was implemented from 1995 to 1997, to create the technical basis to support the rational development and conservation of the soil and land resources of Tanzania. This was achieved through the establishment of a pilot land information system based on Geographic Information System (GIS) at the Soil Conservation and Land Use Planning Section of the Ministry of Agriculture (SCLUPS) with FAO assistance. A national team assisted by international experts developed the system and demonstrated its value in rapidly generating useful information, including various kinds of land suitability maps, for improved planning and management of agricultural land resources within the decentralized district-based land management programme of SCLUPS. The system includes GIS hardware and software, computerized land evaluation procedures, a database for Morogoro district and staff trained in land evaluation and GIS. The project recommended follow-up activities that would expand the system with livestock, extensive grazing and irrigated crop models and incorporate it fully in the various district and village level land management programmes of SCLUPS.

#### **The land information system**

The land information system is now operational at SCLUPS. The system consists of four main components:

#### **Hardware and software**

It is a PC based system using commercial software including ARCInfo and ARCVIEWS Geographic Information Systems (GIS), Visual dBASE and Excel for Windows 95 and various application programs for evaluating and mapping physical and economic land suitabilities. The application programs were developed using ALES, an Automated Land Evaluation System running under DOS. A Users' Guide has been produced describing all components of this system including methodologies and procedures.

#### **Databases**

A geo-referenced database was created for Morogoro District as pilot area. The database contains GIS coverages including digital maps and tabular databases (attribute tables) on the following themes:

1. Topographic information (District boundary, railroads, major roads, streams and rivers and relief using contour lines with 200m intervals).
2. Historical climatic data on rainfall and temperature.
3. Soils and terrain data on various landform and soil characteristics including physiography, soil classification, slope class etc.
4. Plant environmental requirements: climatic and edaphic requirements for 11 tree species and 36 annual crops.
5. Farming systems data, including crop name, utilization, production (market orientation), management units, agronomic practices and cropping characteristics (labour requirements, land preparation, recommended varieties, planting, fertilizing, weed control, etc.), pests and diseases, yields, detailed costs of input and output prices (economic data).

## **Database application examples**

### ***Land evaluation using ALES***

Applications of the database include physical land suitability assessment and identification of constraints for 18 Land Utilization Types (LUTs) under traditional crop cultivation and under improved traditional crop cultivation, and for 11 Land Utilization Types (LUTs) under Forestry as well as assessments of economic land suitability and gross margins for 24 LUTs.

### **Information products**

A land use planning application for Morogoro district was developed for the identification of areas best suited for various types of land use, including rainfed crops, forestry and protected areas. The results include maps and reports.

### **District level land use planning**

Applications include the identification of conservation areas; areas having various degrees of agricultural potential (for semi-commercial and subsistence rainfed cropping systems); forestry areas; and areas for other uses.

### **Trained personnel**

Several SCLUPS staff were trained on-the-job in operating and maintaining the system. This includes the main GIS functions such as digitizing, editing and querying coverages and generating map outputs.

## **REFERENCES**

- FAO. 1993. Agro-ecological assessment for national planning: the example of Kenya. FAO Soils Bulletin No. 67. Rome. Also nine technical annexes issued as World Soil Resources Reports 71/1-71/9.
- Fischer, G.W. and Antoine, J. 1994. Agro-ecological land resources assessment for agricultural development planning. A case study of Kenya. Making land use choices for district planning. User Manual. FAO and IIASA. Rome.
- FAO. 1999. Land and water resources information systems. FAO Land and Water Bulletin 7. Rome.

# Annex 1

## Welcome address

Dear Participants, Colleagues, Ladies and Gentlemen

On behalf of FAO's Subregional Representative, Ms. Victoria Sekitoleko, it is my pleasure to welcome you all to this regional workshop on Land Information for Food Security in SADC Countries, and trust that you are well rested from your journeys. This regional workshop is a collaborative effort between FAO's Subregional Office for Southern and East Africa, based here in Harare, the FAO Land and Water Development Division (AGL) in Rome, and SADC's Food, Agriculture and Natural Resources Development Unit, also headquartered here in Harare.

I wish to start off by extending a special welcome to our invited resource persons from Egypt, Ghana, Iran, Kenya and Nigeria who, in spite of their heavy commitments, have given freely of their time for the benefit of this workshop. These gentlemen have traveled long distances in order to be with us today. We are also fortunate to have with us several officers from the SADC Food Agriculture and Natural Resources Development Unit, and I am very grateful to their Director, Dr. Reginald Mugwara, for making them available for this meeting to give us the benefit of their experience from a regional perspective.

Ladies and gentlemen, discussions on land and water information systems will be the main pre-occupation of this meeting. Decision-making in the work of most of us here depends on timely information on the present land-use situation in our countries, on possible ways of improving this situation and on the consequences of implementing each option. The gathering and storing of data requires much time in planning, but it is not an end in itself. It is important to reserve time to interpret and apply these data to the task in hand. There must also be a trade-off between the excellence of the data and the time and cost of collecting them.

These types of functions and their activities are very familiar to you all. Such information is an essential input to the efficient use of resources, to mutual agreement, and to sustainable management of the environment. Arresting environmental degradation is a matter of high priority to the countries of southern and eastern Africa. The amount of information needed to make informed decisions about the use of land and water resources is so large that the only practical way to store, manipulate and access it is through the use of computerized databases.

The benefits offered to natural resource management by remote sensing and GIS technology are recognized and reflected in a growing range of land-use planning activities. They are playing an increasingly important role in the development of institutionalized programmes of integrated natural resources planning, management and conservation in several countries and regions. Several countries and organizations in this region have set up their own digital geo-information systems and networks for the assessment of (theoretical) land use potential, usually restricted to an evaluation of soil, terrain and climate, and to identifying physical constraints.

*Owen Hughes*  
*FAO Subregional Office for Southern and East Africa, Harare, Zimbabwe*

Some countries have applied economic analysis to this type of work, while in recent years crop growth simulation models and GIS have been used in order to achieve a more quantitative evaluation. During this Consultation you will be exposed to several of these types of tools and of their applications.

Now, I would like to give you a brief preview of the programme for this workshop.

The Land and Water Development Division (AGL) of FAO has long been involved in the collection of data and development and promotion of information systems related to land and water resources. The systems include methods and tools for the inventory of soil, land and water resources; the delineation of agro-ecological zones (AEZ); global and national soil terrain databases (SOTER); rural water use database (AQUASTAT) and methodologies for land use evaluation and planning. Some of these tools will be presented by my colleagues this morning.

In cooperation with our member countries, other FAO units and partners, AGL is currently undertaking a major exercise of building up an information base for monitoring and assessing the sustainability of present use of land and water resources in relation to food security. One of the several major outputs expected from this exercise is a series of reports on the global State of Land and Water Resources for Food and Agriculture by country and region. During the workshop we will also see examples of country reports on the State of Land and Water Resources for Food and Agriculture, prepared by Egypt, Ghana, Iran, Kenya, and Nigeria. Also, the guidelines to prepare such a report will be presented and discussed in working groups.

Other speakers will provide a selective overview of other related information systems and initiatives currently operating in this region and one challenge, at least from my perspective, is how to bring together these different systems for the benefit of all those working in natural resources management and food security.

Ladies and Gentlemen. During the next three days there will be ample room for an exchange of experiences and for discussion on a possible way forward, which is one of the objectives set for this workshop. Without taking too much of your time, we trust that this consultation will enrich our experiences and will strengthen the cooperation between the different national, regional and international institutions and programmes that we represent. Our mutual effort during these three days and later, back in our institutes, can contribute to the development of Land and Water Information Systems which can then be used as a tool to meet the demand for food in a sustainable way.

However, in all this work, please do not forget that such tools are purely mathematical routines and we must never lose sight of field realities, where the great majority of land users still take decisions that do not correlate with what planners consider to be technically optimal. How can this gap be bridged??

On behalf of my colleagues here from FAO, we wish you all a fruitful meeting.

## Annex 2

### Programme

Time (Hrs.)	Speech/Topic	Speaker/Resource Person
Sunday to Tuesday: Arrival of participants		
Tuesday 02 November		
18:00-20:00	Registration	Participants/Resource Persons
Wednesday 03 November		
Opening Ceremony		
09:00-09:30	Welcome remarks and introduction of participants	Mr. Owen Hughes, Integrated Resource Management Officer, FAOSAFR
09:30-10:00	Introduction to Technical Sessions and Election of Chairpersons	J. Antoine, Senior Officer, AGLL, FAO, Rome
10:00-10:30	Coffee Break	
SESSION I: Land and Water Resources Information Systems Chair: Mr. A.T. Chipato		
10:30-11:00	The FAO Land and Water Resources Information Systems (LWRIS)	J. Antoine, Senior Officer, AGLL, FAO, Rome
11:00-11:30	Overview of existing LWRIS Programmes and Initiatives in Sub-Region (SADC countries)	SADC Food Agriculture and Natural Resources Development Unit, Harare
11:30-11:50	SADC Agricultural Potential Information System (APIS)	Mr. Ben Opperman, RS/GIS Specialist, University of Stellenbosch, South Africa
11:50-12:10	Presentation of AQUASTAT (Rural Water Use Database)	Ms. Karen Frenken, Water Resources Management Officer, SAFR, Harare
12:10-12:40	Presentation of ALCOM SADC Water Resource Database	Mr. Lieven Verheust, Chief Technical Adviser
12:40-13:00	Food Security Information Systems – development and status in Sub-Region, and linkage with LWRIS	Mr. Mark Smulders, Food Systems Officer, SAFR, Harare
13:00-14:00	Lunch Break	
SESSION I: Land and Water Resources Information Systems (Contd.) Chair: Mr. H. Lindemann		
14:00-14:20	FAO AEZ/LRIS tools and country applications	J. Antoine, Senior Officer, AGLL, FAO, Rome
14:20-14:40	Introduction to AGL Guidelines and the Internet Template for LWR reports	J. Antoine, Senior Officer, AGLL, FAO, Rome
14:40-15:00	Kenya LRIS report	Mr. Peter Macharia, Research Scientist (Land Resources), Kenya Soil Survey
15:00-15:20	Ghana National Report	Mr. Jonathan Addo Allotey, Environmental Protection Agency

15:20-15:40	Nigeria National Report	Mr. Daniel Daudu, National Agric. Land Development Authority
15:40-16:00	Iran National Report	Mr. Gholam Hossein Sarrafi, Iranian Remote Sensing Centre
16:00-16:15	<i>Coffee Break</i>	
16:15-16:40	Egypt National Report	Mr. Mohamed Gomaa, Executive Authority for Land Improvement
16:40-17:30	Discussion and system demonstrations in Working Groups	Resource Persons
18:30-20:30	Cocktails hosted by FAO	
<b>Thursday 04 November</b>		
SESSION II: Demonstrations and Working Groups Chair: Mr. Camille van der Harten		
09:00-10:30	Review of Guidelines in Working Groups	Resource Persons
10:30-11:00	<i>Coffee Break</i>	
11:00-13:00	Continue Review of Guidelines in Working Groups	Resource Persons
13:00-14:00	<i>Lunch Break</i>	
14:00-15:00	Prospects for a Sub-Regional State of Land, Water and Plant Nutrition Report, including Plan of Action	SADC, FAOSAFR and participants
15:00-16:00	Discussion on national and regional LWRIS priorities and follow-up action	SADC, FAOSAFR and participants
16:00-16:15	<i>Coffee Break</i>	
16:15-17:30	Informal LRIS Networking and Framework	SADC, FAOSAFR and participants
<b>Friday 05 November</b>		
SESSION III: Guidelines for National Land, Water and Plant Nutrition Report Preparation Chairperson: Mr. J. A. Allotey		
09:00-10:30	Elaboration on a Plan of Action	All participants
10:30-11:00	<i>Coffee Break</i>	
11:00-13:00	Elaboration on a Plan of Action	All participants
13:00-14:00	<i>Lunch Break</i>	
14:00-16:00	Report on Workshop Achievements	Antoine/Hughes/Belder
16:00-16:15	<i>Coffee Break</i>	
16:15-16:45	Report on Workshop Achievements	Representatives of Participants
16:45-17:00	Concluding Remarks	
<b>Saturday 06 December</b>		
	Participants depart	

## Annex 3

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## **Annex 4**

# **Comments on guidelines for report preparation**

### **A GENERAL COMMENTS**

#### **1. Report and data**

Include Aims and Objectives of the report.

Re-arrange Format for Report Presentation.

Clearly establish a systematic presentation pattern with respect to illustrations, tables and volume of text.

Data presented should be highly reliable and current, as such a very good quality control process should be established during preparation of the report.

Countries that are yet to convert their soil classification data into FAO pattern should be allowed to present their reports as such except that the method and the systems used should be clearly defined.

#### **2. A wetland section**

Add a separate section, called “wetland, mangroves and inland valley bottoms”. This section could be placed for example, before section M. It is important to highlight these areas in a separate section in view of their growing importance for agriculture and at the same time their importance for bio-diversity and the conservation of the environment. Sub-headings could be:

- a. Location; size of wetland/mangrove/ivb; size of catchment area
- b. Present use (bio-diversity, agriculture, water treatment and use, fuelwood, building material, tourism, pasture, fishing, etc.)
- c. Importance for the environment versus agriculture
- d. Role of the areas in the society (food security, etc.)
- e. Types of soil (organic, mineral, etc.)
- f. Topography (slopes)
- g. Hydrological situation (waterlogged, dry in part of the year, violence of flooding, water availability and quality over time and place, etc)
- h. Natural vegetation
- i. Pollution
- j. If used for agriculture:
  1. Type of management (traditional, fully equipped/controlled, etc)
  2. When first cultivated
  3. Cultivated all year round or only part of the year
  4. Main crops grown per season
  5. Who are the main cultivators
  6. If irrigation or drainage equipment present what type, indication of costs, etc.
  7. Changes noticed over the years (drying up, waterlogging, decrease or increase in fertility, etc.)

- k Changing role over the years (positive or negative from different perspectives such as social, economic, agricultural, bio-diversity)

### 3. Quality of information

There is a need for quality control and harmonization of information between sections and between the countries. Consistency between data systems within and between countries and programmes is necessary. Verification mechanisms are therefore indispensable. This concerns in particular water resources. As an example, water moves from one country to another country. In order to avoid double counting, water information between the different countries has to be cross-checked and verified before publishing it.

### 4. Target audience

It is necessary to clearly define the target audience so as to facilitate the reporting style and volume of information to be provided.

### 5. Institutional linkages

There is need to consult and collaborate with other relevant institutions involved in similar activities at the national and regional levels. However, these linkages would require funding on the part of FAO both for information sourcing and verification and should therefore be taken into consideration. Accordingly the inclusion of institutions relevant to each subject should also be considered, in which case provision needs to be made for their contact addresses. It may also be necessary to establish electronic communication linkages between countries.

## B SPECIFIC OBSERVATIONS

Item No.	Observations	Remarks
A Overview	Okay	Include history and institutional arrangement of the agricultural sector and the area of the different administrative units in the country.
B Socio-economic features	Okay	Provide information on infrastructure education, health, agriculture, transport, communication and an inventory of agricultural institutions. The relationship between unemployment rate and other social ills to be included. Crop intensity and diversification should be moved to H
C Climate	Okay	Include rainfall distribution pattern, climatic data preferably presented in maps.
D Physiography	Okay	
E Soils	Okay	
F Inundation Land Types	Okay	
G Land Cover /Land Use		Merge with "H" and re-title as Land Use/Cover <b>Land use may be dynamic as such only major changes should be recorded.</b> Land Use intensity: Information may not be readily available hence we suggest that the report should form a benchmark from where we continue. Soil Productivity: It is difficult to distinguish between inherent productivity and fertilizer enhanced productivity due to several conflicting soil management practiced carried out by the different individual farmers Trends in use of major Inputs: The data might be affected by several factors amongst which include: shift in government policy; subsistence or commercial farming, illiteracy, etc. Productivity Trend: The period should be specified in view of variation in crop types and farming practices. Where land use maps are available they should be provided in place of text.

H Agro-ecological systems	Okay	These two sections should be part of the AQUASTAT programme. Care should be taken that there are no contradictions between the different documents and that a link is made to the AQUASTAT site, rather than writing new pages.
I Hydrography	Okay	
J Irrigation and Drainage	Okay	These two sections should be part of the Aquastat programme. Care should be taken that there are no contradictions between the different documents and that a link is made to the Aquastat site, rather than writing new pages.
K Plant Nutrient Resources		In view of the assumed target audience information required particularly on extent of nutrient balance, farmer budget and farmer cash flow may not be relevant. Climate change: Move this sub topic to M and it may be necessary to define the scale of measurement
L Natural Hazards	Okay	This section should be titled Hazards and Disasters
M Hot spots	Okay	Activities such as resettlement and reclamation and effects of industrialization could be included
N Bright Spots	Okay	
O Challenges and Viewpoints	Okay	May need to include current development with respect to government policies and programs on the subject matter.



## **Annex 5**

# **Country report: state of land, water and plant nutrition resources**

(see the Internet framework)

### **BACKGROUND**

As an important result of the World Food Summit in November 1996, a major thrust of FAO's Mid Term Programme is Food Security and Nutrition within the framework of Sustainable Agricultural and Rural Development (SARD). SARD has identified the sustainable management and use of the available natural resources and the environment as both a prerequisite and a means of achieving food security.

The 15<sup>th</sup> session of the FAO Committee on Agriculture (COAG), in January 1999, emphasized the importance of land and water resources assessment and monitoring at all levels for food security and SARD.

At national level, countries need to improve their ability to plan and monitor the use of their land and water resources for better use and management of the resources to increase agricultural productivity while maintaining land and water quality. They need to establish land and water resources information systems capable of providing a variety of information on the status of land and water resources in support of sound decision-making for their use and sustainable management.

At regional and global level, FAO needs to project and monitor the capacity to produce the food required in the future and also the domestic potential in the least developed countries with inadequate food supplies and limited market demand. Consistent and easily accessible information is needed by Member countries and the international community for assessment of the situation, projections and decisions. Country-level information on land and water is the foundation for national planning and also provides the building blocks for regional and global monitoring systems for food security and the health of the planet.

This information must not only be gathered but also transferred to the users, including decision-makers, planners, scientists and rural land users. The Committee on Agriculture recognized the need for periodic reporting on the State of the World's Land and Water Resources, synthesizing information from the vast amounts of existing data, maps, statistics and documents. Such reporting should enhance awareness about land and water development problems and facilitate decisions on the sustainable use of land and water.

It is the primary responsibility of the Member Nations themselves to collect information and prepare the reports. FAO has a role in supporting methods and data standards, ensuring consistency of information and promote its exchange and dissemination.

This is the context within which the Land and Water Development Division of FAO (AGL) is collaborating with other FAO units, national institutions and other partners, and as part of its normative programme, in building up an information base with periodic reports on monitoring and assessing the sustainability and vulnerability of present use of land and water resources in relation to food security and relevant aspects of national policies and policy instruments.



## PURPOSE

Enhance the capacity of countries to monitor the state of land and freshwater resources in terms of availability, scarcity, quality and trend in use, in order to enable all countries to take sound decisions for their sustainable use. The Reports are to be prepared by country and by region. They are to be compiled in the form of a digital atlas to be made available through the Internet and on CD-ROM.

## TARGET AUDIENCE

The national reports are addressed primarily to planners and decision-makers in government ministries, to donor agencies, researchers and University students, but also to the public at large.

## GUIDELINES

A standardized methodology for reporting on the state of land and water resources was prepared in the form of guidelines. The guidelines have been elaborated in interaction with specialists from national institutions all over the world and are valid for national reports. They constitute a general framework into which existing information can be incorporated. This is to ensure that reports will be comparable along the lines of common themes, such as land use and degradation, state of water resources, hot spots and bright spots. The guidelines are exhaustive; they are presented in the form of a checklist of items which can be treated depending on relevance and availability of information in any specific situation.

If the information is not available or is not relevant for the area considered, the item content should be left empty in the report or may be added at a later date when the information is available. In certain cases, an FAO approach (e.g. agro-ecological zoning) has been suggested to describe information. Where this information is not available, data gathered using other kinds of methodologies should be presented and that methodology should be specified. The source of information should be given.

The guidelines will be updated from time to time as more experience is gained. As information becomes available and topical issues change (discussed in the challenges/viewpoint section), the report can be updated, new sections inserted and new links made. Combining information and presenting it in this format will make it more useful and also easier to comprehend by decision-makers and other users.

The report is thus a 'live' document. Where possible, information should not be presented as static data but in the form of trends, preferably in a visual format (maps, tables, charts, images). Information presented should be highly reliable and current, and a good quality control process should be established during preparation of the report.

Care should be taken that there are no contradictions between the different sections of the report. There is a need for quality control and harmonization of information between the sections. Consistency between data systems within and between countries and programmes is necessary. Verification mechanisms are therefore indispensable. This concerns, in particular, water resources. As an example, water moves from one country to another country. In order to avoid double counting, water information between neighboring countries has to be cross-checked and verified.

There is a need to consult and collaborate with other relevant institutions involved in similar activities at the national and regional levels and to establish electronic communication linkages between the institutions.

The guidelines are applied to prepare country as well as regional reports in collaboration among national and regional land and water institutions. They compile information, prepare reports and post these on their Internet sites in linkage with the FAO AGL web site and underwrite commitments to maintain and update the reports. FAO AGL organizes workshops in the different regions to discuss the project, including the guidelines, and promote countries' participation in its implementation. Workshops were organized in West Africa in November 1998, South America in August 1999 and Southern Africa in November 1999.

As a result, informal Asia, West Africa, Latin America and Caribbean networks were established and several countries including Bangladesh, China, Malaysia, Ghana, Nigeria, Egypt, Iran, Botswana and South Africa have prepared or are preparing such reports.

The guidelines are presented in the form of a report profile as follows<sup>1</sup>.

The report will have sections on Land Resources, Water Resources, Plant Nutrient Resources and an overview section containing general information on geography, climate, socio-economic characteristics, food security and agriculture. A list of key land and water terms that are useful in preparing the report are given in the FAO Publication "Terminology for Integrated Resources Planning and Management (Rome 1999).

## **A. Overview**

Geographical location (*description, localization map*)

Administrative units (*regions, countries, capital cities, provinces, other administrative units and areas*)

## **B. Socio-economic features**

Population (*population statistics: size, density, % rural and urban population, % population growth, major employment sectors, per capita income and arable land per caput*).

Economy (*brief description of the main economic sectors of the country*).

*Trends in the role of agriculture in the economy, its contribution to GDP and employment, history and institutional arrangement of the agricultural sector, information on infrastructure, education, health, agriculture, transport and communication*).

Major food crops and cash crops and trends in production

Food security (*major food sources, present and future food demand, methods to achieve this – cropping intensity, crop diversification*)

Crop diversification (*crop diversification programmes, results*)

## **C. Climate**

Climate description (*general climate type; length of growing period*)

*The growing period is the period of the year when both moisture and temperature conditions are suitable for crop production (FAO).*

Climatic data (*humidity range, temperature data, mean annual rainfall, monsoons and average seasonal rainfall, rainfall distribution pattern*) preferably presented in maps.

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<sup>1</sup> The guidelines presented in this annex have been revised according to the suggestions made by the meeting.

## D. Physiography

Geomorphology

Physiographic units (*definition of physiographic units; map and extents of physiographic units*)

## E. Soils

Soil types and distribution (*soil map according to FAO classification, whenever available; extent and proportions occupied by general soil types*)

*Soil Map legend according to FAO Classification (see FAO World Soil Resources Report 60) whenever available.* Countries that are yet to convert their local soil classification data into the FAO standard classification can present their own soil classification, together with clear specifications and definitions of the methods and the systems used to classify soils.

## F. Inundation Land Types

Inundation land types (*definition of inundation land types; inundation map, area and percentage cover of inundation land types*)

Relationships between inundation land types and cropping patterns

## G. Land cover/land use

Productivity Trend: The period should be specified in view of variation in crop types and farming practices.

Where land use maps are available they should be provided.

**Land cover** (*definition of land cover, land cover map and extents of different land cover types*)

(Indicate classification scheme used)

Trends in land cover

**Land use** (*definition of land use, land use map*)

(Indicate classification used)

*Land use types (LUTs): Uses of land defined in terms of a product, or products, the inputs and operations required to produce these products, and the socio-economic settings in which production is carried out (FAO).*

*The following major Land use types, (and subtypes) are recognized:*

*Cropland: land used for cultivation of crops, including fallow (field crops, orchards)*

- *Annual field cropping: land under temporary or annual crops harvested within one year (e.g. maize, rice, wheat and vegetables).*
- *Perennial field cropping: land under perennial crops. Crops harvested more than one year after planting (e.g. sugar cane, banana, sisal, pineapple).*
- *Tree and shrub cropping: producing several harvests over more than a year (e.g. coffee, tea, grapevines, oil palm, cacao, coconut, apple, pear).*

*Cropping intensity (Defined as number of times crops cultivated per year on a piece of land: i.e. single, double and triple crop. Current figures which are significant should be used as much as possible)*

*Grazing land: land used for animal production*

- *Extensive grazing land: grazing on natural or semi-natural grasslands, grasslands with trees or shrubs (savannah vegetation) or open woodlands (for livestock and wildlife).*
- *Intensive grazing land: grass production on improved or planted pastures, including cutting for fodder (for livestock production).*

*Forest land: land used mainly for wood production and other forest products or for protection.*

*Mixed land: mixture of land use types within the same land unit: agroforestry (trees and crops), agro-pastoralism (crops and livestock), agro-silvo-pastoralism (crops, trees and livestock).*

*Other land: recreation, road sites, construction sites, etc.*

**Area percentage of the land use type** (For each land use type, the relative area should be assessed as a percentage of the total land use area and displayed in a pie chart).

Area under temporary and permanent crops with details on area under mixed, monoculture, shifting cultivation, subsistence cultivation, large scale plantation.

### **Land use change**

As land use is dynamic only major changes should be recorded.

*The change with time in the distribution of land by land use type (and/or land cover type), LUT can be represented by one of the following five classes:*

- 2: *area coverage is rapidly decreasing in size, i.e. >2% per year of that specific LUT area.*
- 1: *area coverage is decreasing in size, i.e. 0-2% per year of the LUT area*
- 0: *area coverage remains  $\pm$  stable as a percentage of the LUT area*
- 1: *area coverage is increasing in size, i.e. 0-2% per year of the LUT area*
- 2: *area coverage is rapidly increasing in size, i.e. > 2% per year of the LUT area*

### **Land use intensity (intensification of agriculture) trends**

*A change in the intensity of land use is expressed through changes in inputs, management, or number of harvests, etc., over approximately the last 10 years. Only changes within the same LUT and on the same area (change of intensity) are to be considered here - not changes from one LUT to another.*

- 2: *A major decrease in land use intensity*
- 1: *A moderate decrease in land use intensity*
- 0: *No major changes in inputs, management level, etc.*
- 1: *Moderate increase, e.g. switch from no or low external input to some fertilizers/pesticides; switch from manual labour to animal traction*
- 2: *Major increase, e.g. from manual labour to mechanization, from low external inputs to high external inputs, etc.*

*Example 1:*

LAND USE			
Land use type	Area %	Areal Trend	Intensity Trend
Cropland	40	2	2
Grazing land	25	1	1
Forest land	15	-2	2
Mixed land	20	0	0
Other land	0		

## Soil Productivity

### Average production value

*US\$ equivalents for the production value per hectare for each land use type will be used as a relative indicator for productivity, and for estimating trends and regional differences. Figures for cropland will generally be easier to give than for other land uses, but if figures are known for grazing land or forest land, they would be welcome.*

### Trends in use of major inputs

The production value for each LUT is related to inputs of materials, equipment and labour per hectare per year;

*Inputs: e.g. labour – own and hired, high yielding variety or improved seeds, fertilizers, pesticides, mechanization/hire of ox, cost of irrigation, income from outside farm, income from livestock.*

The data might be affected by several factors such as shift in government policy; subsistence or commercial farming, illiteracy, etc.

### Productivity trend

Although changes in productivity of crop/livestock LUTs can be attributed to a wide variety of causes, they may also be an indication of soil degradation or, if positive, of effective soil conservation and appropriate land management. Only a rough indication of trends in productivity (change with time in the rate of growth of yield per hectare of important crops/ LUTs) is required here.

## H. Agro-ecological systems

Agro-ecological zones (*definition of AEZ, AEZ map*)

Agro-ecological Zones are land resource mapping units, defined in terms of climate, landform and soils, and land cover, and having a specific range of potentials and constraints for land use (FAO).

Land capability classes (*definition of LCC, % cover*)

Land suitability for major crop types (definition of land suitability, land suitability maps)

## Water Resources (AQUASTAT)

**The following sections I and J are extracted from the FAO AQUASTAT programme. The FAO Aquastat database contains information for most countries. Therefore to avoid duplicating information and inconsistencies it is advised that instead of recording information on I and J, a link be established to the FAO Aquastat home page.**

### I. Hydrography

Water resources: Surface water, groundwater, non-conventional water resources, fossil water resources. Major basins (surface and groundwater).

International rivers, agreements, etc.

Dams, flood control, mobilization of water resources

Water withdrawal

Water use by sector and trends (*trends in agricultural water withdrawal - irrigation and livestock watering - domestic water withdrawal and industrial water withdrawal, other uses*).

Future: competition between sectors.

Wastewater, treatment, re-use (agriculture)

## **J. Irrigation and drainage**

Irrigation potential (method of calculation)

Place of irrigation and drainage in agriculture, percentage of cropland which is irrigated.

History of irrigation in the country, trends. Description of the different irrigation systems.

Irrigation methods (spate, flood recession, full control...).

Irrigation techniques, breakdown by technique (sprinkler, surface..). Trends in development of drip and sprinkler irrigation. Breakdown by source of water (river, groundwater..). Waste water reuse in irrigation.

Irrigated schemes: typology by size and by operating modes: scheme size, number of beneficiaries, management, performances, cropping intensity, fees.

Cost of irrigation development, cost of O&M, returns from irrigation

Irrigated crops: major crops, areas and production, comparison of rainfed and irrigated yields for major crops.

Institutional environment

Institutions in charge of water resources assessment, development of irrigation: mandates of the most important institutions.

Water and land legislation: status, implementation.

Trends in water resources and irrigation development, constraints to development, institutional changes, perspectives.

## **K. Plant nutrient resources**

Use of plant nutrients (*types of plant nutrients used, trends in plant nutrient use, projections in plant nutrient consumption*).

Change over time in the content of organic matter, macro-nutrients (nitrogen, phosphorus, potassium) and micro-nutrients (zinc, boron, manganese, etc.) in the soil

Use of mineral fertilizers and micro-nutrients

Change over time in the amounts (in kilograms) of inorganic (fertilizer-based) nutrients applied per hectare of arable land for the main food crops (also rice types) and cash crops, broken down into three important nutrient components- N,  $P_2O_5$  and  $K_2O$ . Where the necessary crop related information on the usage of nutrients is available, trends in the application of nutrients per hectare of land under important crops and comparison of nutrients used with recommended dosages.

Change over time in the amounts of nutrients in organic form applied per hectare of arable land, broken down into main types of nutrients – fertilizers, manure, sewage sludge and crop residue resulting from leguminous crops in rotation with other crops.

Change over time in the use of micro-nutrients such as sulphur, zinc, boron and manganese.

Extent of nutrient balances (i.e. total withdrawal of nutrients from the soil in the form of nutrient content of the outputs from harvested and fodder crops *minus* total inputs of nutrients from the application of fertilizers, manure, etc.).

Types of fertilizer produced locally and imported

Cost of different fertilizer products (*port handling, transport price, storage price*)

Fertilizer subsidies

Farm budgets in different cropping systems

Farmer cash flow

Impacts of fertilizers and of pesticides, insecticides on the environment

Nutrient imbalance (*effects of nutrient imbalance on soil fertility; the application of mixed fertilizer programmes and results*)

Land degradation: increase over time in degradation of cultivated fields resulting from deficiency of nutrients, lack of balance in the use of N, P and K, or excessive depletion of micro-nutrients.

Water pollution: extent of eutrophication of water bodies, soil acidification and contamination of water supply with nitrate resulting from excessive levels of nutrients in the soil.

#### **L. Wetlands, mangroves and inland valley bottoms**

- a. Location; size of wetland/mangrove/ivb; size of catchment area
- b. Present use (bio-diversity, agriculture, water treatment and use, fuelwood, building material, tourism, pasture, fishing, etc.)
- c. Importance for the environment versus agriculture
- d. Role of the areas in the society (food security, etc.)
- e. Types of soil (organic, mineral, etc.)
- f. Topography (slopes)
- g. Hydrological situation (waterlogged, dry in part of the year, violence of flooding, water availability and quality over time and place, etc)
- h. Natural vegetation
- i. Pollution
- j. If used for agriculture:
  1. Type of management (traditional, fully equipped or controlled, etc)
  2. When first cultivated
  3. Cultivated all year round or only part of the year
  4. Main crops grown per season
  5. Who are the main cultivators
  6. If irrigation or drainage equipment present what type, indication of costs, etc.
  7. Changes noticed over the years (drying up, waterlogging, decrease or increase in fertility, etc.)
- k. Changing role over the years (positive or negative from different perspectives, like social, economic, agricultural, bio-diversity, etc.)

**M. Natural hazards (*Fire, Drought, Flood and Rainstorms, other*)**

Natural Hazards (*type, location, frequency, damage to food crops, control methods adopted and their effectiveness*)

Climate Change: If known, extent of nitrous oxide and CO<sub>2</sub> emissions adding to the total emissions of nitrous oxides and CO<sub>2</sub> contributing to climate change.

**N. Hot spots: land and water constraints to sustainable agriculture**

*The detail of items will depend upon particular country circumstances*

**Hot Spots (*Definition – Flash points or Issues of concern*)****Problem soils (*definitions of problem soils, localization map and extents of problem soils*)**

Human-induced soil degradation (*types, extent, localization and effect on crop yield*)

- **Water erosion (on-site effects):** loss of topsoil by sheet erosion/surface wash and terrain deformation by gully or hill erosion or mass movement. *Trend in the amount of soil removed by water (in tons per hectare per year). Trend in the land area eroded by water (in hectares per year). Trend in nutrient loss caused by the removal of top-soil. Change in the impact of soil nutrient depletion on agricultural productivity.*
- **Water erosion (off-site effects):** sedimentation in reservoirs or waterways, flooding and pollution of water bodies with eroded sediments. *Trend in the incidence of sedimentation levels in rivers or behind dams. Trend in the deposit of sediment in coastal areas.*
- **Wind erosion (on-site effects):** loss of topsoil by wind action and terrain deformation (deflation hollows, hummocks and dunes). *Trend in the amount of soil removed by wind (in tons per hectare per year). Trend in the land area eroded by wind (in hectares per year). Trend in the area affected by terrain deformation (in ha) (e.g. gullies and dunes).*
- **Wind erosion (off-site effects):** overblowing of terrain with wind-borne soil particles from distant sources.
- **Fertility decline:** net decrease of available nutrients and organic matter in the soil. *Trend in soil nutrient depletion*
- **Salinization:** net increase of salt content in the topsoil leading to productivity decline.
- **Dystrification:** lowering of soil pH through the process of mobilizing or increasing acidic compounds in the soil.
- **Compaction and crusting:** deterioration of the soil structure due to trampling by cattle or the weight or frequent use of machinery and clogging of soil pores causing development of a thin impervious layer. *Change over time in percentage area on which compaction or crusting is frequently observed. Change over time in the number of agricultural machinery (tractors and harvester-threshers) in use.*
- **Waterlogging:** effects of human induced hydromorphism (rising water tables and flooding). *Change over time in the extent of area waterlogged (in ha); in the depth of stagnant water (in metre); and in the duration of waterlogging in a year or season.*

**Map of areas affected by different types of soil degradation and trend in incidences****Land use issues**

Conversion of prime agricultural land or encroachment by other uses

Land tenure and land policy



Conflicts in land use

Abandonment of soils because of salinity

Resettlement or reclamation and effects of industrialization on land use

### **Water use issues**

Conflicts related to use of water resources

Inadequate use of water resources

### **Other hot spot issues**

Concentration of pesticides and pollutants

Genetic erosion and biodiversity depletion (risk areas)

## **O. Bright spots: Society's response to ameliorate the situation (Response indicators).**

**The detail of items will depend upon particular country circumstances**

### **Bright spots (success stories for hotspot items)**

Available lands for sustainable agricultural development

Sound land use/allocation policies. *Number and proportion of local governments or local communities to which resource management has been devolved.*

## **Examples and perspectives of sustainability of production systems**

### **Sustainable land use systems**

Land care programmes. *Number and type of farmer organizations or associations promoting soil conservation practices, conservation tillage practices or treating lands suffering from salinity, etc.*

*Number of farmers participating in soil conservation and other land improvement technologies promoted by government, e.g. soil conservation structures, conservation tillage, use of special inputs (manure, lime) etc.*

Success stories in land use

### **Sustainable use of water resources (Response indicators)**

Implementation of schemes to provide adequate drainage and ensure proper maintenance; improving water management practices, particularly discouraging over-watering; improving maintenance of canals and on-farm ponds and reducing seepage from water courses; undertaking soil reclamation schemes

Increased cultivation of salt-tolerant crops, or water efficient crops

Review of policies about the pricing of irrigation water or of energy for water pumping.

### **Sustainable use of nutrients (Response indicators)**

Implementation by governments of policies, e.g. price or credit policies to promote balanced applications of nutrients, as well as to ensure that dosages applied are neither too low nor too high.

Extension efforts, including demonstrations on farmers' fields to promote the required levels of nutrients (farmer's field schools).

**Biodiversity/genetic resources conservation and use (e.g. crop diversification)**

New technologies (biotechnology etc.)

Infrastructures and mechanization or automation (e.g. precision farming)

**P. Challenges, viewpoints**

*The challenges are area specific. They have to be clearly identified especially in land, water and plant nutrition resources management and strategies developed to meet the challenges (e.g. may include current development with respect to government policies and programmes).*

**Q. References****The Internet template**

The report profile has been incorporated into an Internet template for direct use in preparing web pages for a web site on Land, Water and Plant Nutrient resources as part of the World Wide Web. The web site will facilitate the sharing of up-to-date information on land, water and plant nutrient resources in a network environment, at a global, regional and national level.

The web site is designed as an HTML framework for hosting the information available in the various countries. Each country will provide its own information and upload it on a local internet server using the common HTML framework, thus creating an in-situ national web site. The various sites will then be networked to each other through hyperlinks and a common Home Page will be the starting point for the navigation. Initially FAO will provide this software template and take care of updating the Home Page and the links as new country profiles become available.

Basic guide for filling the internet template with the country specific information

**A basic guide has been prepared to facilitate the storage of information in the template. It is being used to prepare country and regionally based websites which will be networked with an FAO based Home page.**

The template consists of various "pages" (HTML files) divided into categories that reflect the subjects illustrated in the report profile document.

As for every web document of several pages, a Home Page has been prepared for use by each country wishing to set up its site, from which it is possible to start navigating through all the sections. In the Home Page (home.htm) there are eight buttons that allow the access to the eight main sections:

- COUNTRY OVERVIEW
- LAND RESOURCES
- WATER RESOURCES
- PLANT NUTRIENT RESOURCES
- HOT SPOTS
- BRIGHT SPOTS
- CHALLENGES AND VIEWPOINTS
- SEARCH ENGINES

Then, from the page of each one of the main sections, it is possible to access other hyperlinked pages related to specific sub-topics.

The first step is to type the name of the Country in the Home Page and substitute the UN flag with the Country national flag (flags of all countries are available digitized at this URL: <http://www.theodora.com/flags/>)

To insert new information in the pages (texts, charts, pictures, hyperlinks, etc...), it is only necessary to open the page concerned with any HTML editor and start adding the desired items (the actual framework has been prepared using the Netscape Composer editor included in the Netscape Communicator 4.5 or higher suite). This software is free and can be downloaded at this address:

<http://home.netscape.com/computing/download/index.html>

In order to preserve a common and well-organized structure throughout all the pages, it is advisable to insert the new items into the existing table present in any page. The objects that would not fit in the table (e.g.: maps, charts, pictures, other larger tables, etc.) should be placed in new pages properly hyperlinked. For this purpose a blank page, with the general properties of the other pages, (e\_blank.htm) is included to be used as a template for new pages. It is always better to create a single page for each map or any other graphical object and hyperlink to such a page from the concerning section and/or sub-section. This will allow a faster loading of the pages containing textual information, giving the user the possibility to navigate more quickly through the whole website.

A "Related Internet sites" section has been put in all the pages, with the purpose to insert hyperlinks to websites that host any relevant information about the main topics to which a page is dedicated. In selecting the sites to hyperlink to, attention must be paid to the specific content of every website. It is necessary to avoid any redundancy of information as well as to clearly indicate the source of the data: institution, year of publication, purpose (commercial, governmental, NGO, etc.). Thus, the known sites will be put as the first ones, while, later on, it will be helpful to regularly search the Internet to find more sites with useful information on the arguments of interest.

For this purpose, a page has been created with hyperlinks to the most common search engines on the net. In this way it is possible to search for other addresses that contain specific words or sentences. The results is usually a list of URLs whose number depends on how refined the search operation has been (e.g. how many words, and in which order, have been used for the query).

At the bottom of the page there is also a section dedicated to References. It contains a bibliographic reference plus eventual links to publications, papers and articles available on the web either for visualization or direct download. The latter case implies that the files are properly checked and stored on the local server, in order to preserve the integrity of the software to be downloaded (avoid hyperlinking to files on remote servers whose integrity and freedom from virus infection are not sure).

The whole framework is available as a zipped self-extracting archive. It will self-install automatically on execution in a directory on the user's C drive named "Report". The archive with the English version is called template\_en.exe. The archive with the Spanish version is called template\_sp.exe.

## Annex 6

### Evaluation sheet

Please rate each question using a scale of 1 – 5 (check the appropriate box)

1. Poor      2. Fair      3. Good      4. Very good      5. Excellent

QUESTIONS	RATING				
	Poor	Fair	Good	Very good	Excellent
<b>Objectives</b>					
How clearly were the workshop objectives explained and defined?			5	9	1
How well did the workshop meet its stated objectives?		2	2	11	
<b>Technical Content</b>					
How relevant are Land and Water Resources Information Systems for your work?			2	8	5
How relevant is a national report on the state of Land and Water and Plant nutrient resources for your work?			2	8	5
<b>Workshop Logistics</b>					
The overall duration of the workshop to achieve its objectives was: [ 3 ] too short [ 11 ] good [1] too long					
Workshop handouts and documentation were:		1	7	6	1
The workshop facilities (e.g. conference room, equipment, etc.) were:			4	8	3
The guidance by the resource persons of the workshop was:			6	9	1
<b>Impact</b>					
How well were your personal expectations of the workshop met?		1	4	9	
Do you think that you will be able to initiate preparations for a report?		1	5	4	3
How would you rate the workshop overall?			6	7	1

#### Indicate three strong points of the workshop?

- Participatory setup of workshop.
- The idea of country reports and the examples presented
- The guidelines (presentation and review)
- Interaction with member countries
- Presentation of activities going on in the region and information available

**Indicate three weak points of the workshop?**

- More information should have been sent prior to meeting
- No microphone during first morning
- There should have been more cooperation with SADC beforehand. SADC absence during the Friday morning sessions
- Time schedule was too tight
- Final commitments remain hanging in the air
- No formulation of a project
- No follow-up funds available.

**Any recommendations or further comments?**

- Follow-up after this workshop
- Attention to sustainability issues in the country reports
- Working groups should have flipcharts to write on
- FAO software should be made available to SADC members

## WORLD SOIL RESOURCES REPORTS

1. Report of the First Meeting of the Advisory Panel on the Soil Map of the World, Rome, 19-23 June 1961 (E)\*\*
2. Report of the First Meeting on Soil Survey, Correlation and Interpretation for Latin America, Rio de Janeiro, Brazil, 28-31 May 1962 (E)\*\*
3. Report of the First Soil Correlation Seminar for Europe, Moscow, USSR, 16-28 July 1962 (E)\*\*
4. Report of the First Soil Correlation Seminar for South and Central Asia, Tashkent, Uzbekistan, USSR, 14 September-2 October 1962 (E)\*\*
5. Report of the Fourth Session of the Working Party on Soil Classification and Survey (Subcommission on Land and Water Use of the European Commission on Agriculture), Lisbon, Portugal, 6-10 March 1963 (E)\*\*
6. Report of the Second Meeting of the Advisory Panel on the Soil Map of the World, Rome, 9-11 July 1963 (E)\*\*
7. Report of the Second Soil Correlation Seminar for Europe, Bucharest, Romania, 29 July-6 August 1963 (E)\*\*
8. Report of the Third Meeting of the Advisory Panel on the Soil Map of the World, Paris, 3 January 1964 (E)\*\*
9. Adequacy of Soil Studies in Paraguay, Bolivia and Peru, November-December 1963 (E)\*\*
10. Report on the Soils of Bolivia, January 1964 (E)\*\*
11. Report on the Soils of Paraguay, January 1964 (E)\*\*
12. Preliminary Definition, Legend and Correlation Table for the Soil Map of the World, Rome, August 1964 (E)\*\*
13. Report of the Fourth Meeting of the Advisory Panel on the Soil Map of the World, Rome, 16-21 May 1964 (E)\*\*
14. Report of the Meeting on the Classification and Correlation of Soils from Volcanic Ash, Tokyo, Japan, 11-27 June 1964 (E)\*\*
15. Report of the First Session of the Working Party on Soil Classification, Survey and Soil Resources of the European Commission on Agriculture, Florence, Italy, 1-3 October 1964 (E)\*\*
16. Detailed Legend for the Third Draft on the Soil Map of South America, June 1965 (E)\*\*
17. Report of the First Meeting on Soil Correlation for North America, Mexico, 1-8 February 1965 (E)\*\*
18. The Soil Resources of Latin America, October 1965 (E)\*\*
19. Report of the Third Correlation Seminar for Europe: Bulgaria, Greece, Romania, Turkey, Yugoslavia, 29 August-22 September 1965 (E)\*\*
20. Report of the Meeting of Rapporteurs, Soil Map of Europe (Scale 1:1 000 000) (Working Party on Soil Classification and Survey of the European Commission on Agriculture), Bonn, Federal Republic of Germany, 29 November-3 December 1965 (E)\*\*
21. Report of the Second Meeting on Soil Survey, Correlation and Interpretation for Latin America, Rio de Janeiro, Brazil, 13-16 July 1965 (E)\*\*
22. Report of the Soil Resources Expedition in Western and Central Brazil, 24 June-9 July 1965 (E)\*\*
23. Bibliography on Soils and Related Sciences for Latin America (1st edition), December 1965 (E)\*\*
24. Report on the Soils of Paraguay (2nd edition), August 1964 (E)\*\*
25. Report of the Soil Correlation Study Tour in Uruguay, Brazil and Argentina, June-August 1964 (E)\*\*
26. Report of the Meeting on Soil Correlation and Soil Resources Appraisal in India, New Delhi, India, 5-15 April 1965 (E)\*\*
27. Report of the Sixth Session of the Working Party on Soil Classification and Survey of the European Commission on Agriculture, Montpellier, France, 7-11 March 1967 (E)\*\*
28. Report of the Second Meeting on Soil Correlation for North America, Winnipeg-Vancouver, Canada, 25 July-5 August 1966 (E)\*\*
29. Report of the Fifth Meeting of the Advisory Panel on the Soil Map of the World, Moscow, USSR, 20-28 August 1966 (E)\*\*
30. Report of the Meeting of the Soil Correlation Committee for South America, Buenos Aires, Argentina, 12-19 December 1966 (E)\*\*
31. Trace Element Problems in Relation to Soil Units in Europe (Working Party on Soil Classification and Survey of the European Commission on Agriculture), Rome, 1967 (E)\*\*
32. Approaches to Soil Classification, 1968 (E)\*\*
33. Definitions of Soil Units for the Soil Map of the World, April 1968 (E)\*\*
34. Soil Map of South America 1:5 000 000, Draft Explanatory Text, November 1968 (E)\*\*
35. Report of a Soil Correlation Study Tour in Sweden and Poland, 27 September-14 October 1968 (E)\*\*

36. Meeting of Rapporteurs, Soil Map of Europe (Scale 1:1 000 000) (Working Party on Soil Classification and Survey of the European Commission on Agriculture), Poitiers, France 21-23 June 1967 (E)\*\*
37. Supplement to Definition of Soil Units for the Soil Map of the World, July 1969 (E)\*\*
38. Seventh Session of the Working Party on Soil Classification and Survey of the European Commission on Agriculture, Varna, Bulgaria, 11-13 September 1969 (E)\*\*
39. A Correlation Study of Red and Yellow Soils in Areas with a Mediterranean Climate (E)\*\*
40. Report of the Regional Seminar of the Evaluation of Soil Resources in West Africa, Kumasi, Ghana, 14-19 December 1970 (E)\*\*
41. Soil Survey and Soil Fertility Research in Asia and the Far East, New Delhi, 15-20 February 1971 (E)\*\*
42. Report of the Eighth Session of the Working Party on Soil Classification and Survey of the European Commission on Agriculture, Helsinki, Finland, 5-7 July 1971 (E)\*\*
43. Report of the Ninth Session of the Working Party on Soil Classification and Survey of the European Commission on Agriculture, Ghent, Belgium 28-31 August 1973 (E)\*\*
44. First Meeting of the West African Sub-Committee on Soil Correlation for Soil Evaluation and Management, Accra, Ghana, 12-19 June 1972 (E)\*\*
45. Report of the Ad Hoc Expert Consultation on Land Evaluation, Rome, Italy, 6-8 January 1975 (E)\*\*
46. First Meeting of the Eastern African Sub-Committee for Soil Correlation and Land Evaluation, Nairobi, Kenya, 11-16 March 1974 (E)\*\*
47. Second Meeting of the Eastern African Sub-Committee for Soil Correlation and Land Evaluation, Addis Ababa, Ethiopia, 25-30 October 1976 (E)
48. Report on the Agro-Ecological Zones Project, Vol. 1 - Methodology and Results for Africa, 1978. Vol. 2 - Results for Southwest Asia, 1978 (E)
49. Report of an Expert Consultation on Land Evaluation Standards for Rainfed Agriculture, Rome, Italy, 25-28 October 1977 (E)
50. Report of an Expert Consultation on Land Evaluation Criteria for Irrigation, Rome, Italy, 27 February-2 March 1979 (E)
51. Third Meeting of the Eastern African Sub-Committee for Soil Correlation and Land Evaluation, Lusaka, Zambia, 18-30 April 1978 (E)
52. Land Evaluation Guidelines for Rainfed Agriculture, Report of an Expert Consultation, 12-14 December 1979 (E)
53. Fourth Meeting of the West African Sub-Committee for Soil Correlation and Land Evaluation, Banjul, The Gambia, 20-27 October 1979 (E)
54. Fourth Meeting of the Eastern African Sub-Committee for Soil Correlation and Land Evaluation, Arusha, Tanzania, 27 October-4 November 1980 (E)
55. Cinquième réunion du Sous-Comité Ouest et Centre africain de corrélation des sols pour la mise en valeur des terres, Lomé, Togo, 7-12 décembre 1981 (F)
56. Fifth Meeting of the Eastern African Sub-Committee for Soil Correlation and Land Evaluation, Wad Medani, Sudan, 5-10 December 1983 (E)
57. Sixième réunion du Sous-Comité Ouest et Centre Africain de corrélation des sols pour la mise en valeur des terres, Niamey, Niger, 6-12 février 1984 (F)
58. Sixth Meeting of the Eastern African Sub-Committee for Soil Correlation and Land Evaluation, Maseru, Lesotho, 9-18 October 1985 (E)
59. Septième réunion du Sous-Comité Ouest et Centre africain de corrélation des sols pour la mise en valeur des terres, Ouagadougou, Burkina Faso, 10-17 novembre 1985 (F)
60. Revised Legend, Soil Map of the World, FAO-Unesco-ISRIC, 1988. Reprinted 1990 (E)
61. Huitième réunion du Sous-Comité Ouest et Centre africain de corrélation des sols pour la mise en valeur des terres, Yaoundé, Cameroun, 19-28 janvier 1987 (F)
62. Seventh Meeting of the East and Southern African Sub-Committee for Soil Correlation and Evaluation, Gaborone, Botswana, 30 March-8 April 1987 (E)
63. Neuvième réunion du Sous-Comité Ouest et Centre africain de corrélation des sols pour la mise en valeur des terres, Cotonou, Bénin, 14-23 novembre 1988 (F)
64. FAO-ISRIC Soil Database (SDB), 1989 (E)
65. Eighth Meeting of the East and Southern African Sub-Committee for Soil Correlation and Land Evaluation, Harare, Zimbabwe, 9-13 October 1989 (E)
66. World soil resources. An explanatory note on the FAO World Soil Resources Map at 1:25 000 000 scale, 1991. Rev. 1, 1993 (E)
67. Digitized Soil Map of the World, Volume 1: Africa. Volume 2: North and Central America. Volume 3: Central and South America. Volume 4: Europe and West of the Urals. Volume 5: North East Asia. Volume 6: Near East and Far East. Volume 7: South East Asia and Oceania. Release 1.0, November 1991 (E)

68. Land Use Planning Applications. Proceedings of the FAO Expert Consultation 1990, Rome, 10-14 December 1990 (E)
69. Dixième réunion du Sous-Comité Ouest et Centre africain de corrélation des sols pour la mise en valeur des terres, Bouaké, Odienné, Côte d'Ivoire, 5-12 novembre 1990 (F)
70. Ninth Meeting of the East and Southern African Sub-Committee for Soil Correlation and Land Evaluation, Lilongwe, Malawi, 25 November - 2 December 1991 (E)
71. Agro-ecological land resources assessment for agricultural development planning. A case study of Kenya. Resources data base and land productivity. Main Report. Technical Annex 1: Land resources. Technical Annex 2: Soil erosion and productivity. Technical Annex 3: Agro-climatic and agro-edaphic suitabilities for barley, oat, cowpea, green gram and pigeonpea. Technical Annex 4: Crop productivity. Technical Annex 5: Livestock productivity. Technical Annex 6: Fuelwood productivity. Technical Annex 7: Systems documentation guide to computer programs for land productivity assessments. Technical Annex 8: Crop productivity assessment: results at district level. 1991. Main Report 71/9: Making land use choices for district planning, 1994 (E)
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74. Global and national soils and terrain digital databases (SOTER), 1993. Rev. 1, 1995 (E)
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77. Onzième réunion du Sous-Comité Ouest et Centre africain de corrélation des sols pour la mise en valeur des terres, Ségou, Mali, 18-26 janvier 1993 (F)
78. Land degradation in South Asia: its severity, causes and effects upon the people, 1994 (E)
79. Status of sulphur in soils and plants of thirty countries, 1995 (E)
80. Soil survey: perspectives and strategies for the 21st century, 1995 (E)
81. Multilingual soil database, 1995 (Multil)
82. Potential for forage legumes of land in West Africa, 1995 (E)
83. Douzième réunion du Sous-Comité Ouest et Centre africain de corrélation des sols pour la mise en valeur des terres, Bangui, République Centrafricain, 5-10 décembre 1994 (F)
84. World reference base for soil resources, 1998 (E)
85. Soil Fertility Initiative for sub-Saharan Africa, 1999 (E)
86. Prevention of land degradation, enhancement of carbon sequestration and conservation of biodiversity through land use change and sustainable land management with a focus on Latin America and the Caribbean, 1999 (E)
87. AEZWIN: An interactive multiple-criteria analysis tool for land resources appraisal, 1999 (E)
88. Sistemas de uso de la tierra en los trópicos húmedos y la emisión y secuestro de CO<sub>2</sub>, 2000 (S)
89. Land resources information systems for food security in SADC countries, 2000 (E)

Availability: April 2002

E – English  
F – French  
S – Spanish

Multil – Multilingual  
\*\* Out of print



**This document presents the results of the FAO-sponsored Subregional Workshop on Land Resources Information Systems (LRIS) for Food Security in SADC Countries. The purpose of the meeting was to promote LRIS and their application in the assessment, mapping and monitoring of land in relation to food security in the SADC countries. The workshop reviewed advances made in this field both within and outside SADC. The meeting discussed LRIS experiences in the countries and the subregion and prepared a plan of action to promote future reporting and exchange of information, data expertise and experiences in land information in the subregion, using technical cooperation among developing countries (TCDC), within existing SADC regional networks on land and water. This includes the preparation of national and subregional reports on the state of land, water and plant nutrient resources in SADC countries with the support of the SADC Environmental Technical Unit.**

