World Soil Resources Report 93

LAND RESOURCES INFORMATION SYSTEMS IN ASIA

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LAND RESOURCES INFORMATION SYSTEMS IN ASIA

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Preface

A Regional Workshop on Land Resources Information Systems (LRIS) in Asia was held in Quezon City, Manila, Philippines, 25 to 27 January 2000. The meeting was organized by the Land and Water Development Division (AGL) of FAO, in collaboration with the Bureau of Soils and Water Management (BSWM). 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 sustainable agricultural development and food security in Asian countries. The workshop was attended by 26 participants from ten Asian countries and two FAO resource persons. The participants contributed LRIS experiences from their countries and prepared recommendations for future collaboration in LRIS in the region, including exchange of data, information and experiences. This includes the preparation of national and regional reports on the state of land, water and plant nutrient resources in Asia for the Internet in the coming years, using the existing FAO Guidelines.

Acknowledgements

The materials for these proceedings were compiled by the BSWM Workshop Committee directed by Dr. Concepcion. The proceedings were prepared by Messrs. J.Antoine and Masui and edited by Mr. R. Brinkman. Thanks are offered to the diligent BSWM team.

Contents

Acronyms

AEZ	Agro-ecological Zoning
AEZWIN	AEZ for Windows
AFMA	Agriculture and Fisheries Modernization Act, Philippines
AGIS	Agriculture Geographic Information System, Malaysia
AGL	Land and Water Development Division, FAO
AIS	The Agricultural, Livestock and Forestry Areas of Interest, Chile
ALES	Automated Land Evaluation System
AQUASTAT	Global Information System on water use in agriculture, FAO
BARC	Bangladesh Agricultural Research Council
BFS	Balanced Fertilization Strategy, Philippines
BMA	Bangkok Municipal Administration, Thailand
BSWM	Philippines Bureau of Soil and Water Management
CISTEL	Research and Remote Sensing Services Center, Bolivia
DEM	Digital Elevation Model
DLD	Department of Land Development, Thailand
DTCP	The Department of Town and Country Planning, Thailand
EPAGRI	State Agency of Agricultural Research and Rural Extension Enterprise of Santa Catarina, Brazil
FAO	Food and Agriculture Organization of the United Nations
FRISP	Forest Resources Information System, Malaysia
GDLA	General Department of Land Administration, Vietnam
GIS	Geographic Information System
GPS	Global Positioning System
IRRI	International Rice Research Institute
ISRIC	International Soil Reference and Information Centre
JICA	Japan International Cooperation Agency
LCC	Land Capability Classes, Malaysia
LGUs	Local Government Units, Philippines
LISP	Parcel-based Land Information System Project, Malaysia
LMU	Land Management Units, Philippines
LP	Linear Programming

LRI	Land Resources Inventory
LRIS	Land Resources Information System
LWRIS	Land and Water Resources Information Systems
LUT	Land Utilization Type
MBRLC	The Mindanao Baptist Rural Life Center, Philippines
MCDS	Multi-Criteria Decision Support
MEA	Metropolitan Electricity Authority, Thailand
NAP	National Agriculture Policy, Malaysia
NIA	National Irrigation Administration, Philippines
NIAPP	National Institute for Agricultural Planning and Projections, Vietnam
NTDB	National Topographic Database, Malaysia
NWRB	National Water Resources Board, Philippines
OFERMANA	Organic Fertilizers Association, Philippines
PEZs	Pedo-ecological zones
PRENADER	The Programme of Natural Resources and Irrigation Development
RAF	FAO Regional Office for Africa
RTSD	The Royal Thai Survey Department, Thailand
SAFDZ	Strategic Agricultural and Fishery Development Zones, Philippines
SARD	Sustainable Agricultural and Rural Development
SCLUPS	Soil Conservation and Land Use Planning Section of the Ministry of Agriculture, Tanzania
SIPH	Information System for Water Resource Planning, Argentina
SLSI	State Land Survey Institute of Lithuania
SLRD	Settlement and Land Records Department, Malaysia
SOTER	Soils and Terrain Database
SSIP	Small-scale irrigation projects
SWIP	Small Water Impounding Project, Philippines
TCDC	Technical Cooperation among Developing Countries
UNDP	United Nations Development Programme
WOCAT	World Overview of Conservation Approaches and Technologies
WAICENT	World Agriculture Information Center, FAO

Summary report and recommendations

Background

As an important result of the World Food Summit in November 1996, Food Security and Nutrition within the framework of Sustainable Agricultural and Rural Development (SARD) has become a major thrust of FAO's Mid Term Programme. 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. For Asia and the Pacific, regional and national priority actions in land resources management proposed to achieve sustainable food security include: raising land productivity and food output; arresting and reversing agricultural land degradation and water loss; and secure access to food for all persons to meet their minimum nutritional requirements.

The Asia and Pacific countries need to improve their ability to plan and monitor their land and water resources for better use and management to increase agricultural productivity while maintaining land and water quality. They need to establish 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. This information must not only be gathered but also transferred to 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; a 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 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 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 technologies for sustainable land and water management and rehabilitation. Major outputs expected include a series of reports on the State (sustainability/vulnerability) of World 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 and easily updatable in the future.

A first phase of methodology development and testing has been completed. It included the elaboration of guidelines for the preparation of the reports. These guidelines were reviewed at the Regional Workshop which was held at FAO's Regional Office for Asia and the Pacific, Bangkok, Thailand, in November 1987. Twenty-four experts from 13 Asian countries participated in the Workshop.

A second phase of application of the methodology to prepare country and regional reports is being implemented, in collaboration with national and regional land and water institutions. These compile information, prepare reports and post them on their Internet sites in linkage with the FAO AGL web site and are committed to maintain and update the reports. FAO has been organizing workshops in the different regions to discuss the project and enroll 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 networks were established in Asia, West Africa, Eastern and Southern Africa, Latin America and the Caribbean and several countries including Bangladesh, China, Malaysia, the Philippines, Ghana, Nigeria, Botswana, South Africa, Egypt , Brazil and Chile have prepared or are currently preparing such reports.

Objectives

The workshop was organized by FAO AGL, in collaboration with the Bureau of Soils and Water Management to promote LRIS activities in the Asia region using the existing regional networks.

The workshop focused on existing Land Resources Information Systems (LRIS) in the region and demonstrated their operation and practical application in the assessment, mapping and monitoring of land in relation to food security and the preparation of land and water reports. The workshop discussed the methodology for report preparation and the techniques of information diffusion for practical use in food security programmes and actions in the field, as well as the use of modern electronic communication tools. It discussed ways to promote future exchange of information, data, expertise and experiences in land information in the region using Technical Cooperation among Developing Countries (TCDC), and to prepare and maintain national reports and a sub-regional report for the Asian countries.

Workshop attendance

Senior land resources specialists from **Bangladesh**, **India, Indonesia, Malaysia**, **Myanmar, Nepal, Sri Lanka, Thailand and Viet Nam** participated in the meeting. Besides representatives from these countries, some ten land and water specialists and land/agricultural development planners from relevant departments of the Philippines as well as representatives of the Japanese International Cooperation Agency (JICA) and IRRI also attended the meeting. The Philippines was chosen as the site of the meeting because BSWM has one of the best infrastructures in the region, including a state-of-the art national LRIS system and excellent meeting facilities.

Workshop activities

The activities of the workshop included presentations, computer demonstrations, and discussions in working groups and in plenary sessions. The workshop topics were as follows:

- Presentations on the latest developments in GIS-based Land and Water Resources Information Systems (LWRIS) and demonstrations of structure and contents of FAO LWRIS tools, including Agro-ecological Zoning (AEZ) software and databases, AQUASTAT and the Guidelines and Internet template for the preparation of the digital reports on the state of land, water and plant nutrient resources in countries and regions.

- Presentation of the Philippines Land Resources Information system (LRIS) in its technical components, its activities and its practical use in generating and disseminating information products.
- Presentations and discussions of country reports from Asian countries.
- Elaboration of a programme of cooperation among the participating countries in Land Resources Information systems and their application in assessing and monitoring the state of land resources in the region.

The workshop programme is given in Annex 2.

The keynote address in the opening ceremony was presented by Hon. Edgardo J. Angara, Secretary, Department of Agriculture, the Philippines. Dr. Sang Mu Lee, FAO Representative, Philippines and Dr. Rogelio Concepcion, Director BSWM also addressed the meeting in the opening ceremony (Annex 1).

TECHNICAL PRESENTATIONS

The workshop sessions addressed four main topics:

1 Development of Land Resource Information Systems (LRIS) (sessions 1 and 2)
2 Country Reports on National Information on Land, Water and Plant Nutrition (sessions 3-5)
3 Guidelines for the preparation of the Country Reports (session 6)
4 Follow-up activities: Agreements and resolution regarding an action plan (session 7)

1: DEVELOPMENT OF LRIS

An overview of LRIS in FAO focused on the different tools (methodologies and models, software) developed by FAO and partners for the purpose of Land Resources Assessment, including AEZ, WOCAT and SOTER.

Issues raised relate to:

- Integration, interfacing and complementarity of existing systems with those being developed by local and international institutions.
- The requirements of the technology itself, such as the use of common software and other tools including mapping tool, database management and modeling, GIS, Remote Sensing, and GPS.
- Network and communication facilities (centralized or distributed network, e-mail, conferencing, and internet homepages).

Country experiences by the Philippines and Bangladesh in the development of LRIS confirmed the various applications of LRIS. In addition to land use planning at various scales, other applications include risk assessment and monitoring of lahar(mudflow) affected areas as in the case of Mt.Pinatubo area in the Philippines. IRRI, being both a user and a generator of

LRIS data, makes use of GIS and Remote Sensing in support to rice research, including crop suitability mapping as well as crop and water management models.

The Bangladesh LRIS system is one of the most advanced in Asia. It provides a range of tools for decision support in agriculture, including national, district and thana digitized agro-ecological zone (AEZ) databases on soil/land type, climate, hydrology, crops, land use and crop suitability as well as demographic and socio-economic information and computerized procedures for land productivity assessment and mapping. Trained manpower to operate the system and multi-media tools and Internet facilities for the dissemination of information are in place.

The Bangladesh system is under the guidance of an AEZ/GIS Network acting as a steering body. It provides services to the Ministry of Agriculture and other ministries, national research institutes, Universities, International Organizations such as World Food Programme and the World Bank, and NGOs. Information from the system has been used in various programmes. This includes:

- strategic planning for the production of 25 million MT of food grain by the year 2002;
- mapping extent and severity of flood damages and areas for disaster relief operations;
- preparing action plans for cereal production in post-flood agricultural rehabilitation programmes; mapping economically depressed areas for assistance to theVulnerable Group Feeding (VGF) programme of the government;
- area delineation for deepwater rice research at the Bangladesh Rice Research Institute;
- extrapolation of farming system technologies for the whole country based on agro-ecoregions;
- mapping of areas suitable for various forest species;
- delineation of seasonally saline areas for Coastal Zone Management.

Recent advances in PC-based LRIS have significantly increased the capability, the cost effectiveness and the accessibility of these systems in comparison to the earlier mainframe based systems.

Financial assistance for the improvement of facilities and equipment is critical to the successful implementation of LRIS. JICA support to the Philippine BSWM in this endeavor was a major step forward.

Major issues on the implementation of LRIS raised by the participating countries are as follows:

- Data standardization, improvement of data resolution, quality and documentation
- System maintenance and periodic updating of databases
- Improvement of data availability through consultation, data sharing and interconnection
- Interagency networking at national level and identification of lead agencies or institutions
- Establishment of GIS-user network and identification of network leaders
- Sustainability of the network
- Need for effective field validation of data in LRIS databases
- Need for follow-up activities including meetings and e-mail conferences
- Clearance of legal aspects in data sharing and data uses.

LRIS is recognized as an integrated, multi-disciplinary, inter-institutional exercise. The effectiveness of LRIS spatial data must be evaluated with respect to how they are being used and how beneficial they are to the users.

2: Country reports on the national information on land, water and plant nutrition resources

The AGL Gateway of FAO has led the development of Internet-based systems to organizing and making available land and water information to support decisions on land and water use planning and development, and to inform the public on land and water issues.

So far, China, Malaysia, Bangladesh, Lithuania, Nigeria, Ghana, Latin America and Spain are linked to the Gateway. All other countries are invited to membership and participation in the Gateway.

Country reports of the participating countries to this workshop, namely Bangladesh, Malaysia, China, Philippines, India, Indonesia, Myanmar, Nepal, Sri Lanka, Thailand and Viet Nam, were presented following the same order in sessions 3 to 5.

Bright prospects with regard to the increasing demand and wide acceptability of LRIS technology open up opportunities for grants and financial support. It is vital to sustain this activity through participatory networking and linkages.

3: Guidelines for the Preparation of Materials

A standardized methodology for reporting on the state of land and water resources was prepared by FAO in the form of guidelines. The guidelines are exhaustive: they are presented in the form of a checklist of items which can be selected depending on relevance and availability of information in any specific situation.

The country report consists of seven sections:

Country overview
Land resources
Water resources
Plant nutrient resources
Hotspots
Bright spots
Challenges and viewpoints

4: Agreements and resolutions in the action plan

The points for discussion in the action plan took into account that not all of the countries in the Asian region were represented at the meeting.

The following points were considered in the discussion:

- Consolidation of country information into regional information
- Adoption of AGL Gateway as a common framework and tool to develop country and regional reports
- Formalization of the LRIS network in Asia
- Formation of a core group by the countries currently represented
- Access to and exchange of national and regional land and water information

It was proposed that:

- each member country prepare its national report
- information exchange be initiated through the Internet
- each country contact the other Asian partners and becomes part of the Asia LRIS network
- FAO provide the report guidelines and act as a facilitator in the process of LRIS network development.
- The Philippines initiate the assembly of the regional report subject to agreement among the partner countries.
- The Philippines also initiate the creation of home page for the regional report.

This will require consultation and agreement among partner countries in Asia.

In conclusion, the group came up with a seven-point agreement as follows:

1 The group agreed to establish the Network on Land and Water Resources Information System (LWRIS) in Asia with the objective of providing the basis for technical cooperation, particularly the exchange of expertise concerning food security and disaster preparedness among the Network members.

2 The country representative in consultation with appropriate government institutions shall determine the focal institution to represent the Network.

3 The database shall include land and water resources including environmental information.

4 Information must be focused to the country's decision-makers rather than merely the scientific community.

5 The identified focal institution shall prepare a checklist of available information and its sources that would respond to the objectives of the Network.

6 The terms of reference shall be drafted by the Philippines for refinement through e-mail and other means of communication by the participating countries.

7 A high-level policy makers' meeting shall be initiated by the Philippine Department of Agriculture through the Bureau of Soils and Water Management with the assistance of FAO and other international institutions to establish the Network and agree on its terms of reference.

Overview of land and water resources information systems in FAO

Over the last two decades the Land and Water Development Division (AGL) has been at the forefront of the development and application of computer-based systems to analyse data and generate information to support decisions on various land and water issues. Soil and land as well as water systems have been developed. The soil and land systems focus on methodologies and tools for the assessment of global, regional, national and subnational land resources potentials. The water systems concern irrigation water use and management at field level and regional and national water resources assessment.

AGL has been cooperating with various units within FAO and numerous international agencies and national institutions in developing and applying the systems.

Initially, in the late 1970s and early 1980s, the systems were developed for mainframe and mini-computers. From the late 1980s they were gradually adapted to microcomputers. At the same time computer tools for managing spatial data, including geographic information systems (GIS), remote sensing and global positioning systems (GPS) were introduced. Since the last few years the availability of powerful networked PC workstations, rapid development in GIS, multimedia tools and the Internet have opened an era of new possibilities in the development and application of the systems. Table 1 summarizes some of the main issues related to sustainable land and water resources management which concern FAO.

TABLE 1
Scales of land and water use planning and management

Level of analysis	Scale 1)	Issue
Field/production unit (site specific)	<1:5 000	Productive crops and animals conservation of soil and water; high levels of soil fertility; low levels of soil and water pollutants; low levels of crop pests and animal diseases.
Farm or village (local)	1:1 000-1:50 000	Viable production systems; food requirements, economic and social needs satisfied; awareness by farmers.
Country (national or sub-national)	1:25 000-1:2 500 000	Judicious development of agro-ecological potential and use of irrigation water resources; drought and flood risks; food production and food security; conservation of natural resources and bio-diversity; land degradation; public awareness.
Continent/world (regional or global)	1:1 000,000-1:5 000 000	Land degradation and desertification; preservation of biodiversity; water sharing; water pollution; population development and food security; climate change and agricultural potential; awareness of regional and global institutions.

[1] A range of scales is indicated at each level of analysis. In practice the scale of an application is selected according to the extent of the area and the availability of maps.

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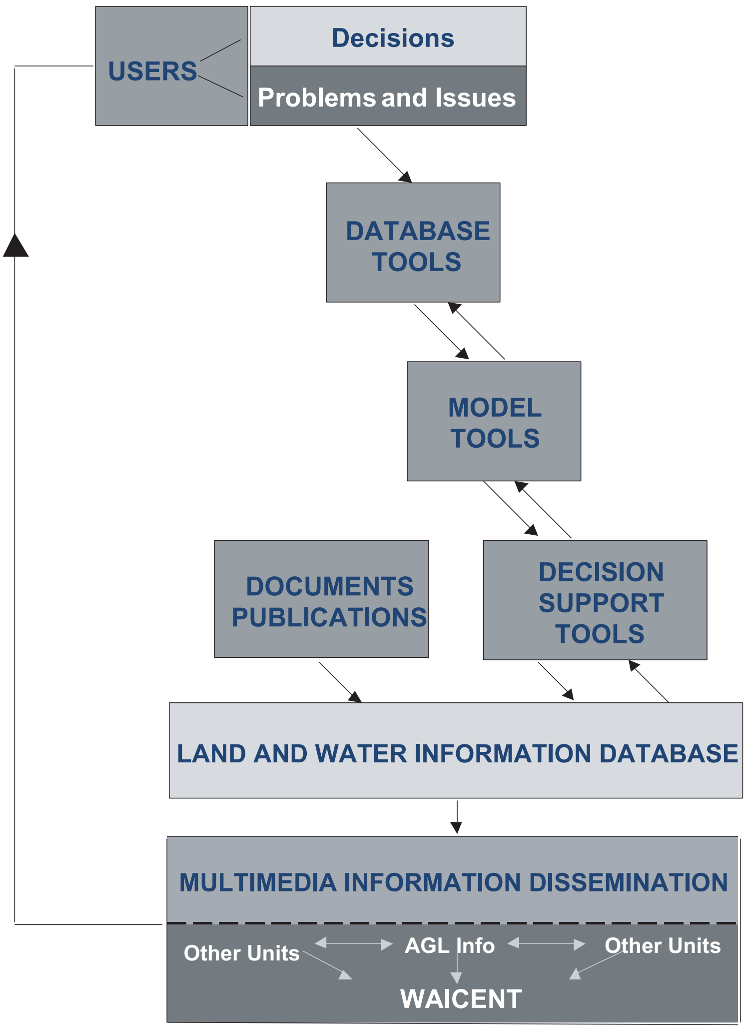
FIGURE 1
Information and decision-support systems in AGL



Currently AGL systems comprise a set of tools to store and analyse information and generate and disseminate information products for land and water decision. The systems integrate tools of essentially five kinds (Figure 1):

1. Database tools

These include database program shells for the creation of soil, water, climate, crop and land use databases; and sometimes also the databases which have been established using the programs. Geographic Information Systems (GIS) databases and analytical and visualisation tools for rapid production of information products are used to an increasing extent. GIS utility derives from a capacity for dynamic functionality based on the following three main qualities:

- the physical computing capacity to manipulate data, including overlay, join, disaggregate;

- the related capacity to query the data by formulating hypotheses for testing assumptions defining potential relationships and developing theoretical constructs;
- the capacity to relate two-dimensional and three-dimensional locations of earth features along with dynamic (time) four-dimensional processes.

2. Model tools

a) Models for crop growth and estimation of both potential and actual yields. Crop modelling has proved a valuable and multipurpose tool in land resources management, which can assist in the estimation of crop yields and the prediction of crop shortfalls due to environmental risks.

b) Models for water balance, crop water requirements and irrigation requirements. Water modelling is an essential tool of quantitative assessment of water resources for the purpose of planning and managing the efficient use of the resource.

c) Remote sensing techniques to characterize and map land cover, and land use patterns and to evaluate and monitor soil and water resources. Remote sensing techniques offer a unique way of quickly assessing land use situation and trends in implementing land management plans and, in particular, detect biophysical degradation of the land due to improper use or mismanagement. Remotely sensed data can be integrated with other data layers stored in a GIS to derive various kinds of maps, such as of soil moisture condition or land degradation.

3. Decision support tools

a) Expert systems tools to provide advice on deciding on land and water use and management options, based on available information and knowledge.

b) Multi-Criteria Decision Support (MCDS) to analyse optimal land and water use scenarios. MCDS tools facilitate interactive negotiations on land and water use. This is because feasible real-world solutions in interactive negotiations are compromise solutions resulting from trade-offs between various conflicting objectives, in order to find an efficient and acceptable balance between the requirements of the different stakeholders in the land and water resources.

4, Documents and publications

AGL has a documentation centre which collects and maintains two kinds of documents:

- a collection of FAO and non-FAO technical documentation (country information, field documents). This includes monographs (acquired or received through exchange);
- a map collection containing thousands of maps which were used in the compilation of the FAO-UNESCO Soil Map of the World, and continuously enriched with new maps. The maps include those published by FAO field projects, maps in technical reports, maps published by national institutions or development agencies. The subjects covered are mainly soils, land use, land suitability, agro-ecology, geology, hydrogeology, topography and administrative units for the developing countries and generalized and other maps for the industrialized countries.

The AGL Documentation Centre uses an adaptation of the ISIS software to manage the database of the documentation centre. The Centre has a direct link with FAO's main Library databases (FAOBIB and SERIAL) and use of on-line Virtual Library databases (AGRIS, CABI, etc.) for more comprehensive searches; lends and internally circulates documentation, books and, serials; and disseminates information and publications produced by AGL.

5. Multi-media tools

AGL uses INTERNET and INTRANET facilities to disseminate information under the umbrella of the World Agriculture Information Centre (WAICENT). WAICENT is FAO's Corporate Information Dissemination System. In this way AGL reaches its target audiences more effectively at reduced processing costs in all phases of receiving, treating and disseminating land and water information.

AGL takes advantage of the three principal interactive and complementary components which make up WAICENT:

FAOSTAT, for the storage and dissemination of statistical information,
FAOINFO, which covers hypermedia information(text, images, audio and video), and
FAOSIS covering specialized information systems.

In particular AGL uses the services of the FAOINFO Group of WAICENT to prepare the textual, graphical, statistical, tabular information to be placed on the Web.

Description of main information and decision-support system tools used by AGL

There are three kinds of systems, corresponding to the three areas of applications mentioned above:

1) land resources assessment systems;
2) water resources assessment systems;
3) irrigation water management systems.

Details of the systems are provided at the following internet site: (http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGL/lwris.htm)

AEZ - Agro-Ecological Zoning System
The main system for land resource assessment with supporting software packages for global, regional, national and sub-national application. AEZ uses various databases, models and decision support tools.

AQUASTAT
An information system on water in agriculture and rural development. It produces regional analyses and country profiles on water resources development, with emphasis on irrigation and drainage.

CLIMWAT
A climatic database to be used in combination with the computer program CROPWAT.

CROPWAT - Program for Irrigation Planning and Management
It allows the ready calculation of crop water requirements, irrigation supply and irrigation scheduling for various crops for a range of climatological stations worldwide.

ECOCROP 1 - Crop Information Database (Enviromental Adaptability Info)
The adaptability level of the FAO crop environmental requirements database

ECOCROP 1I - Crop Information Database (Environmental Response Info)
The response level of the FAO crop environmental requirements database

FCC3 - Fertility Capability Classification System
Diagnosing constraints to crop growth with a decision aid linked to a soil database

LCCS - Land Cover Classification System
The result of the initiative by the Africover Programme of the Environment and Natural Resources Service (SDRN) to develop an approach for concept, definition and classification of land cover.

MCDA - Multi-Criteria Decision Analysis
A software module which implements multi-criteria decision analysis techniques, using the Aspiration-Led Decision SUpport (ALDS) approach.

SDBm - Multi-Lingual Soil Database
A collection of programs written in CLIPPER 5.2 and C languages incorporated into a menu-based interactive user interface to enter data and manage the database.

The Digital Soil Map of the World (DSMW) - Digital Soil Map and Databases

WORLD-SOTER - Global Soil and Terrain Database

WOCAT - World Overview on Conservation Approaches and Technologies Databases
This aims to promote the integration of successful soil and water conservation approaches and techniques into land use systems worldwide.

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/UNESCO soil map of the world. Since 1984 the methodology has been continually expanded and refined to address applications at increasing detail: from national to subnational (district) down to local (watershed, community). 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 systems (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 sound evaluation of land resources:

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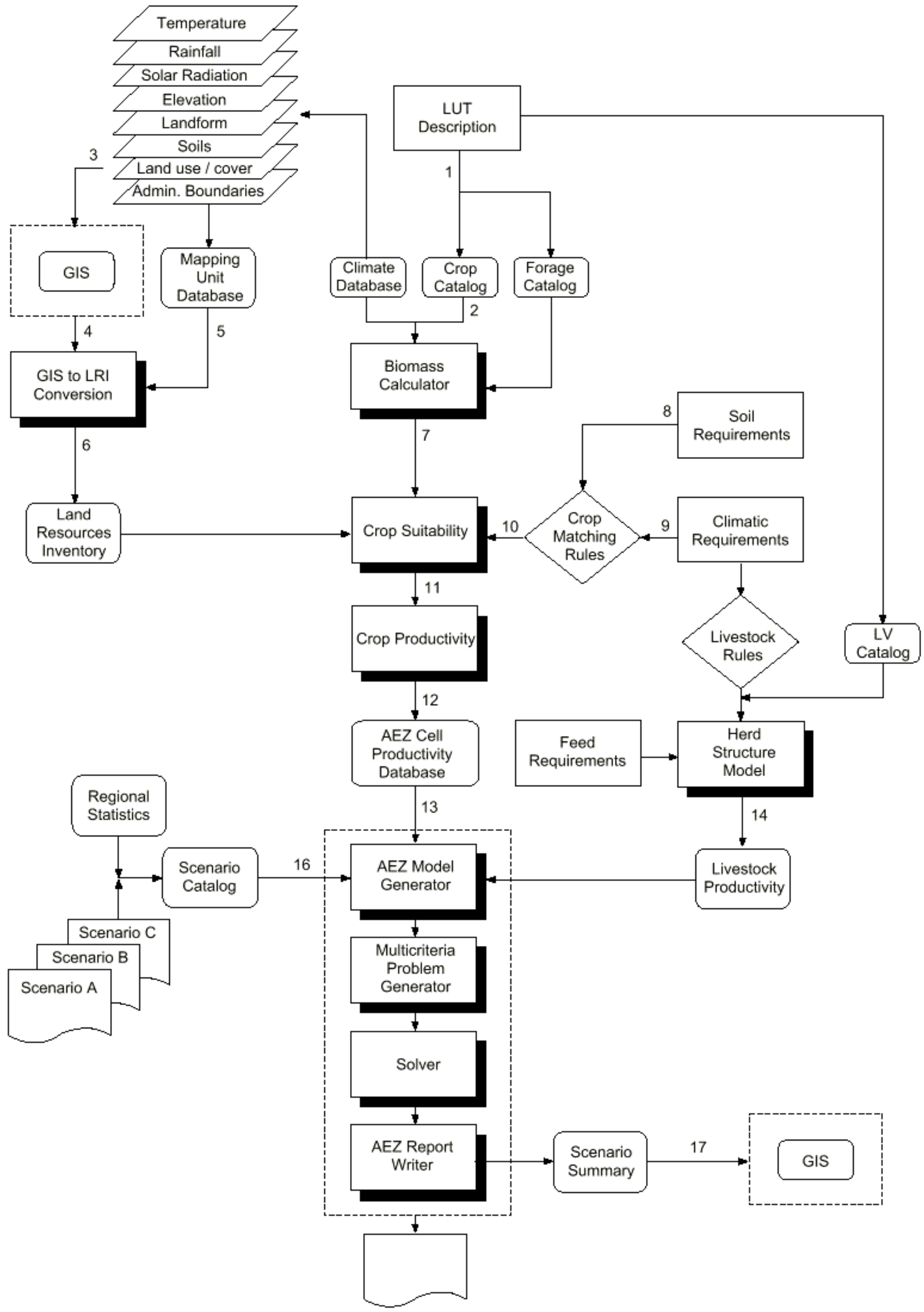
FIGURE 1
AEZ information flow and integration



i. An inter-disciplinary approach is followed, based on inputs from crop ecologists, pedologists, agronomists, climatologists, livestock specialists, nutritionists and economists;

ii. land is evaluated for specific land uses;

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. Production potential is evaluated with respect to specified kinds and levels of inputs, e.g., fertilizers, pest control measures, whether 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. The paragraph numbers in the following explanations relate to the numbers used in Figure 1.

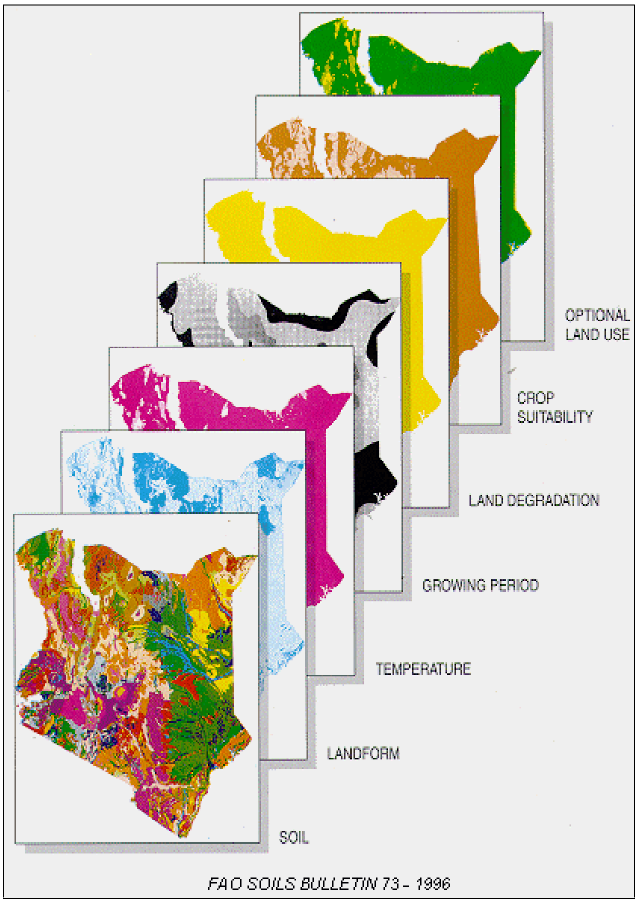
1. LUT descriptions: These define the fundamental objects of analysis which comprise the set of alternative activities available to achieve specified objectives. The first step in an AEZ application is the selection and description of land utilization types (LUT) to be considered in the study. FAO (1984) 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 [1] grassland LUT, each at three levels of input. Also, 10 representative livestock systems are considered per input level.

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 distinct 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).

Figure 2
Kenya GIS database



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 termal regime, moisture regime, soil type, slope class. The collection of agroecological cells consitutes the land resources inventory (LRI). The land resources inventory used in the Kenya study, compiled at a scale of 1:1 million, distinguishes some 90 000 agro-ecological cells.

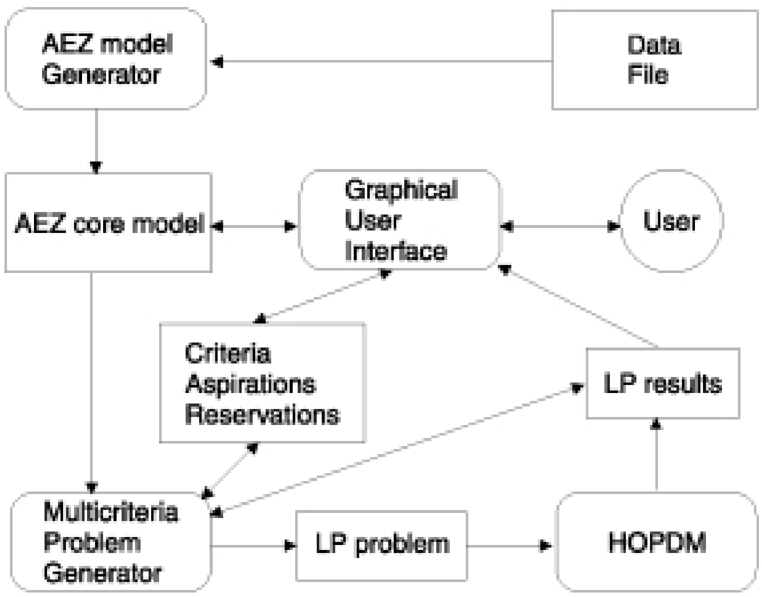
[1] Twenty-four grass and eight legume pasture species were rated in relation to temperature regime and moisture availability, and combined into a generalized grassland productivity assessment, assuming that for different ranges of environmental conditions respectively the most suitable and productive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

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 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 by 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 are 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 (e.g. 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, which is based on Multiple-Criteria Model Analysis (MCMA), is illustrated in Figure 3.

Figure 3
Functional structure of the MCMA module



A linear programming (LP) solver called HOPDM is used to compute optimal land use options.

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 Zones (AEZ) database was successfully developed in Bangladesh with financial support from the United Nations Development Programme (UNDP) and technical support from the Food and Agriculture Organization of the United Nations (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.

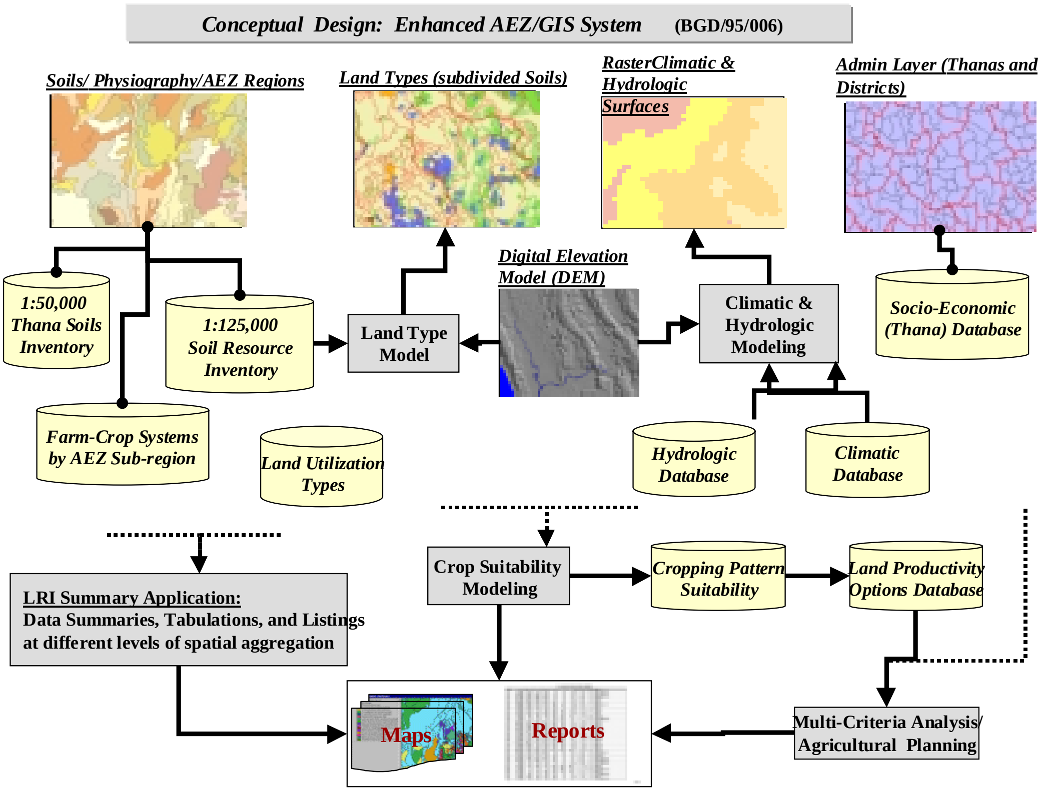
A comprehensive multi-scale Land Resources Information System (LRIS) is being currently developed on the basis of this AEZ database to improve its capability to deal with the intricacies of land resource planning under the complex environmental conditions prevailing in large parts of Bangladesh. The 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: the application of 'state of the art' geographic information system (GIS) technology and 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 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.

FIGURE 4
Bangladesh LRIS



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 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 1990s. 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, 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 is available at 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:

- Methodological Development and Improvement of LRIS
- Validation and Application of the LRIS in the participating countries
- Training and Technical Assistance
- Dissemination of Results

Methodological guide for the development of LRIS

The Project has developed a methodological guide based on the FAO/AEZ approach for the development of a land resource information system (LRIS) for use by counterpart institutions. Using the guide, 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 or 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: An Information System for Water Resource Planning (SIPH) included AEZ procedures 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)

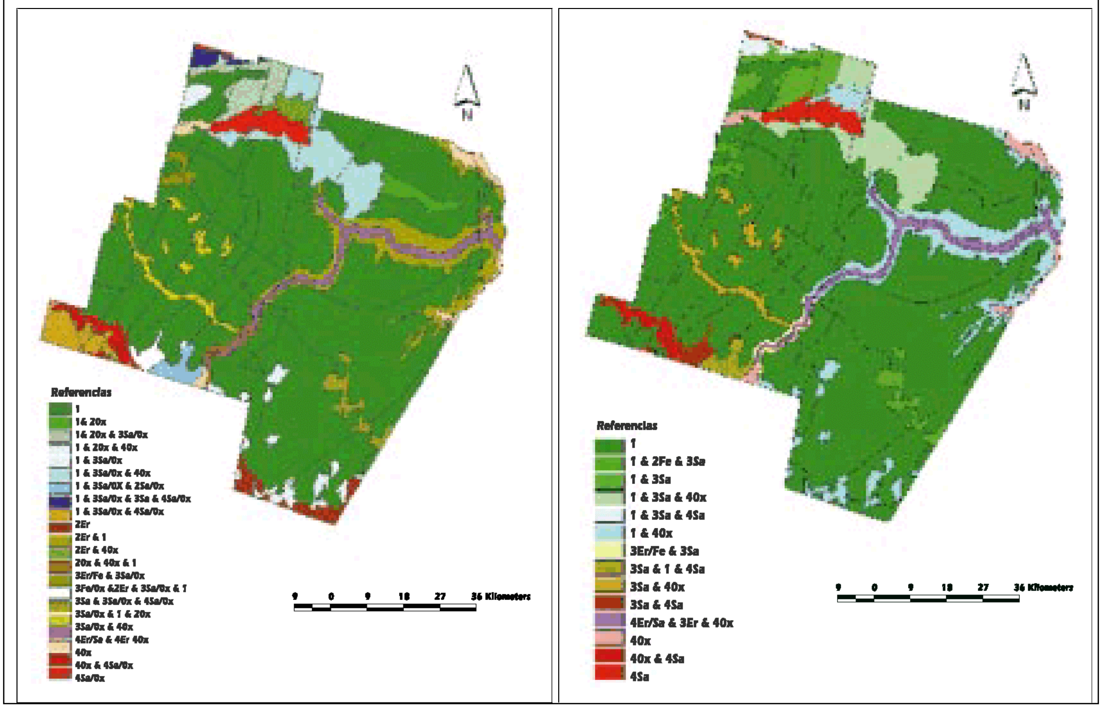
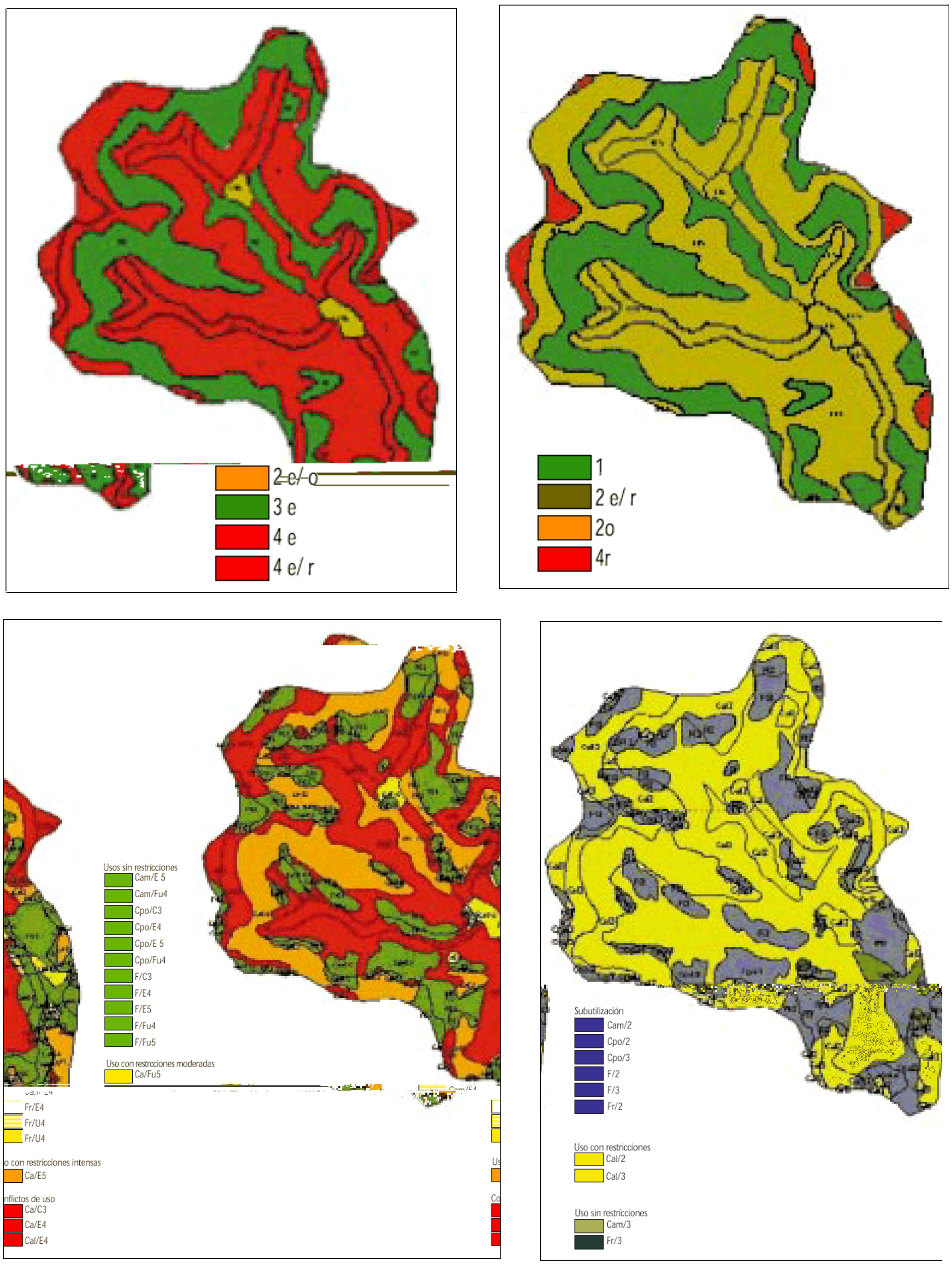


Figure 6
Land suitability maps (Brazil)



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 Arbieto, 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.

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.

Paraguay: Establishment of an LRIS based on a GIS, with land resource and socio-economic databases, for the Oriental Region of the country. The LRIS is used to elaborate maps and reports on suitability for specific land uses, 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

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

Project Web Page

Further information is available at 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 national, regional (district) and local land use planning and land policy formulation. 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 a scale of 1:200 000, a district database for two districts (Trakai and Kaisiadorys) at a scale of 1:50 000 and a local area database for two local areas within the districts (Dovainonys and Akmena) at a 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 existing data covering all the country to FAO and EU compatible systems.

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:

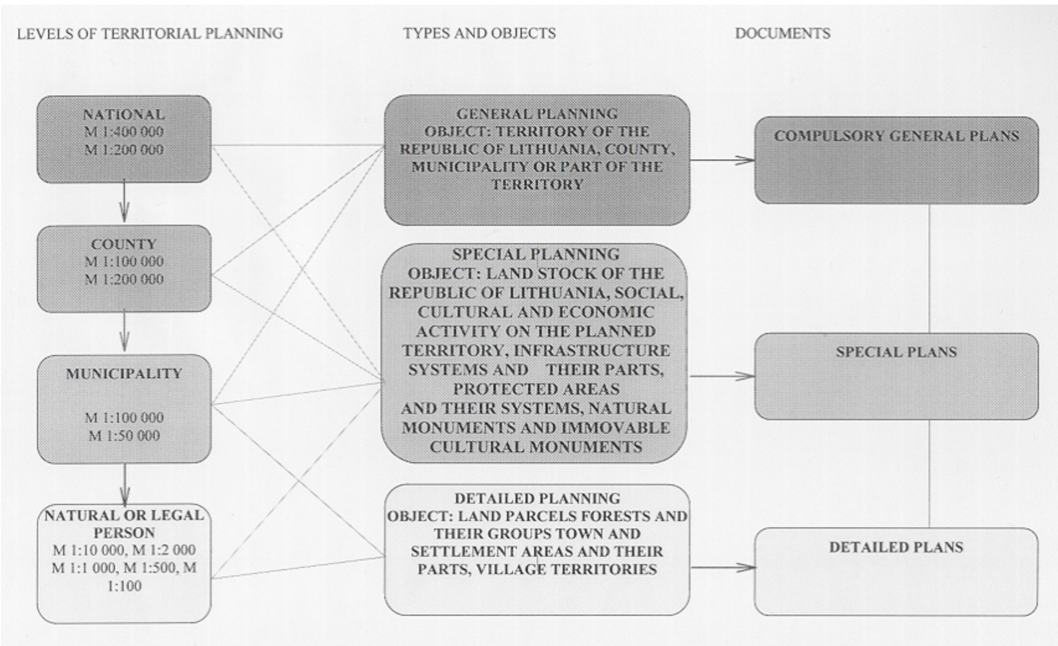
Land use and Land Cover:
- Personal and State Farms
- Forests, settlements, lakes and rivers, agricultural land, gardens, communities
- Recreational forests and territories
- Quarries, natural resource deposits, industrial zones
- Roads and railroads
- Filling stations, campgrounds, motels
- Waste dumps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

- High voltage electric lines
- Restriction and Protection Zones (district and local level only)
- Electric line restricted zones

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
- Water body protection zones

Figure 7
Structure of the Lithuanian information system



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 data. In this process, a systematization of Soil Cover Structure of Lithuania was carried out and maps at scales 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 that of the former USSR) to that of FAO and the European Union. The map at a 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 the analysis of climatic, soil, land cover, land use, water resources, land suitability and socio-economic data.

Land drainage and reclamation

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

TANZANIA

Project: Establishment of a Land Resources 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 resources information system based on a 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 land management programmes of SCLUPS.

The land resources information system

The land resources information system is located at SCLUPS. The system consists of several components:

Hardware and software: The system is PC based. It uses commercial software including ARCInfo and ARCView as 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 a 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.

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Summaries of national reports

Land, water and plant nutrition in Bangladesh

Bangladesh, situated at the confluence of the Ganges, Brahmaputra and Meghna rivers and their network of tributaries is in a unique geographic location, between the Himalayan mountain chain in the north and the Bay of Bengal in the south. Bangladesh, with an area of 14.5 million hectares, is one the largest deltas in the world with half of the area less than 12.5 metre above MSL. It has a catchment area of 1.66 million km^2 of which more than 90 percent is located outside the country. Because of its low-lying topography, the country is highly vulnerable to natural hazards such as floods, droughts, cyclones and storm surges.

Bangladesh ranks as the world's eighth and Asia's fifth most populous country.

The population of Bangladesh is now over 126 million resulting in a population density of nearly 850 persons/km^2 with one of the lowest proportions of arable land per capita (0.06 hectare in 1997). High population pressure has already started affecting the sustainability of agricultural development and may cause ecological imbalances leading to destruction of the natural resources of the country.

The natural environment

In Bangladesh, land resources are scarce compared with the increasing food needs, while there are many instances of misuse and abuse of land. In order to prevent degradation of the natural resources and to optimize production, assessment of land vulnerability and effective land use planning and implementation based on that assessment, are, of high priority and importance. A comprehensive land resources information system (LRIS) is a tool for such planning purposes.

Bangladesh has three broad landscapes : floodplain, terrace and hills. These are divided into 34 physiographic units and subunits.

Around 574 soil series have been identified which ranges from juvenile alluvium or man-made soil deposits to old, deeply weathered red soils with wide variations in characteristics. These soils series have been grouped into 21 general soil types.

Bangladesh has a tropical to sub-tropical humid monsoon climate. The climate is alternate hot and humid in the rainy season and dry and cool in the winter season. Mean annual temperature is around 25^0 C. Mean monthly temperatures range between 17^0C in January and 30^0 C in April-May. Extreme temperature ranges between 4^0 C and 40^0 C except in coastal area. The mean annual rainfall is nearly 2150 mm, ranging from 1400 mm in the northwest region to over 5000 mm. in the northeast region.

Md. Anwar Iqbal
National Project Director: GIS/AEZ Project BGD/95/006, Dhaka, Bangladesh

The most striking feature of the country's water resources is the seasonal cycle of flooding alternating with dry conditions. The extent of irrigation increased to over 4.0 million hectares in 1997/98 (nearly 50% of the net cropped area) from 2.65 million hectares in 1990/91.

Assessment of land potentials during reconnaissance soil surveys in 1964 to 1974 indicated the following classes: Very good agricultural land (1.6%), Good agricultural land (34.3%), Moderate agricultural land (39.4%), Poor agricultural land (15.8%), Very poor agricultural land (8.9%).

Thirty agro-ecological zones (AEZ) and 88 sub-zones have since been identified. Some impressive applications of the AEZ/GIS database have been made (last section of this report) and under the BARC implemented GIS project, efforts are underway to turn it to a GIS based Land Resources Information Systems (LRIS) and link it up with available models for crop and other simulation purposes.

Land use and land use planning

Of the total land surface of 13.5 million ha, 9.15 million ha are used for agriculture and an estimated 2.45 million ha (17% of the total land of the country) is under forest or potential forests. Besides agriculture and forestry, settlements occupy 2.31 million ha and the remaining 0.16 million ha are wasteland or have some other uses. Agriculture dominates the land use and is determined mainly by the monsoon climate and the seasonal flooding, which affects the greater part of the country. With the high pressure on land resources due to population expansion and infrastructaral development, modernization of agriculture and conservation of the natural ecosystems by appropriate vegetation coverage are essential.

A survey showed that nearly 51% of the agricultural lands are owned by only 10% of people (GOB, 1989) and the big landlords are absentee landlords. In general, there are larger proportions of small and medium farmers in the densely settled floodplain and over 50% of the population are functionally landless. A major part of the landless community encroaches on government owned land and forests, turning them into agricultural lands, and cultivating steep stopes and fragile newly accreted lands. Given the declining availability of land it has become extremely important to focus on the enhancement of agricultural productivity through provision of agricultural inputs, credit and technologies for the small farmers.

The socio-economic setting

Bangladesh's socio-economic environment is complex, dynamic and diverse. Over 80% of the population live in rural areas and are mostly engaged in farming and fishing. In Bangladesh, per caput income is only US$ 360 (1997). Poverty and malnutrition are widespread.

The head count measure of rural poverty has gone down from 53 percent in 1991/92 to 51 percent in 1995/96. The situation with respect to the rural poorest has remained virtually unchanged during the first half of the nineties. There is, however an improvement in the urban poverty situation during the nineties.

Ensuring national food security is the top priority of the Bangladesh government. Food security is stressed both at the national and household level (FAO, 1999). The country has to import on average 1.5-2 million tons of rice and wheat each year. Natural calamities such as floods and droughts cause inter-year fluctuations in rice production, which affecting foodgrain availability from domestic production. In Bangladesh, there is a strong food preference for rice which supplies 1464 Kcal (75.%) out of the average energy intake of 1950 Kcal/capita/day.

The agricultural marketing system in Bangladesh is atomistic, fragmented and widely dispersed all over the country.

Bangladesh has been pursuing a number of policy changes in accordance with the Structural Adjustment Policy (SAP).

The agricultural production system

Bangladesh is rich in germplasm resources of some of the world's most important crops, namely rice, jute, sugar cane, tea, cotton, pulses, oilseeds, fruits and vegetables.

Since rice is the staple food of the population, food security always implies security in rice production.

Bangladesh has about 15 million households in the rural areas, spread over 68 thousand villages. Of the homestead areas (526 m^2 on average), 13% are under vegetable production. The environmental, economic and social benefits of the homestead area are much higher than those of crop field farming. The homestead area thus has an important role in the total production system of the country.

The year-to-year fluctuation in foodgrain production has been influenced mainly by relative profitability of high-yielding varieties (HYV) rice and wheat. HYV Aman, rice and wheat cultivation are generally found to be reasonably profitable, both on cash cost and full cost basis. But due to the high variability in farmers' yield together with the increasing cost of production, profitability of foodgrain production fluctuates and shows a declining trend over the years.

In Bangladesh, land utilization is largely determined by land inundation in relation to flooding, depth and duration, and soil and climate characteristics.

Fertilizer use in Bangladesh

Plant nutrients used in the country are nitrogen, phosphorus, potassium, zinc and sulphur. Recently, deficiencies of magnesium, boron, molybdenum have been reported in some soils. Of the total nutrients used in the country, nitrogen alone constitutes about 72%, which may lead to nutrient imbalance in soil-plant systems.

Intensification of agriculture in Bangladesh has resulted in higher demand for fertilizer nutrients because of higher removal of plant nutrients by crops. At the preset level of production of food crops about 0.98 million tons of nutrients (NPKS) are removed annually from the soils (Karim, 1997).

Impact of agriculture on the environment

Over the last two decades, fertilizer and other agro-chemicals use in agriculture has increased. Use of fertilizer nutrients at present is only 110 kg. per hectare per year.

Pesticide use in crops is around 11 000 tons/year (of the order of 1kg/ha per year) of which about 70% is used in rice. Neither would present any major pollution hazard at present.

Emission of methane from flooded rice culture, livestock (through enteric fermentation and manure management) and agricultural biomass burning have been estimated in a recent study on the subject (DOE, 1995). Total methane emission from agriculture and livestock has been estimated to be 970 Gg/year.

Constraints to sustainable agriculture

Bangladesh is environmentally vulnerable: natural hazards are common and the severity of these effects is increasing in Bangladesh. Problems include floods, droughts, salinity and coastal tidal surges, loss of land and soil resources by shifting river channels, cyclones, global warming and sea level rise.

Factors contributing to decline or stagnation in productivity in the country include loss of soil organic matter, depletion of soil micronutrients, steep land clearing, dense ploughpans,and puddling pans, deposition of sandy overwash, irrigation-related problems, genetic erosion and poor seed quality, urban encroachment on agricultural land , land ownership and uncertainty of tenure.

Conflicts in land and water use

Rice occupies most of the cropped area (nearly 75%), the remainder is used for wheat, vegetables, pulses, oilseeds, sugarcane, jute, etc. While there is a very little land left for pasture or for growing animal feed, there is an intense competition for land between crops and fisheries. Opening up of new land for rice cultivation by draining perennially wet low-lying areas (khals & beels: old river channels and flood plain depressions) adversely affected capture fisheries. Conversely, the rapid expansion of the area under fish ponds has also been reducing land available for rice cultivation.

Land use priorities have to strike a balance between the competing needs of different sectors. The Bangladesh National Conservation Strategy identified six important areas of conflicting land use (NCS, 1990) these are: agriculture vs. shrimp and capture fisheries, forest land vs. shrimp and capture fisheries; arable agriculture vs. livestock; agriculture vs. settlements; agriculture vs. industries and brickfields; and agriculture vs. newly accreted charlands (tidal flats, coastal wetlands).

Surface water is required in abundance by the fisheries sector and for navigation. Wetland agriculture, also requires water for irrigation, especially in the dry seasons. Industries requires large volumes of water as well. With the withdrawal of water for irrigation and industry, especially during the dry season , fishing and navigation suffer. Flood control and drainage structures built during the last two decades are hindering fish migration and breeding.

In Bangladesh, groundwater is used both for irrigation and drinking water. As the volumes of water required for irrigation have been increasing, exhaustion of shallow and deep aquifers is impeding normal supply of water for drinking purposes.

Food production is the most important part of the agricultural production system of Bangladesh, and it largely determines the degree of food security. To meet the increasing food demand of the population, agricultural production must increase at a much faster rate than at present. This must take place on the existing land base through crop intensification, modernization of agriculture, narrowing the yield gap and sound management to preserve the environment.

These developments will require continual updating of scientific knowledge, intellectual capacity, vision and leadership as an integral part of human resources development programme, especially addressing gaps in innovation, dissemination and adaptation of promising and rewarding technologies.

Now that the extensive biophysical database (popularly known as the AEZ database) of Bangladesh has been transformed into a GIS based agricultural land resources information system, this LRIS can play an efficient and effective role in planning and its implementation of agricultural and rural development.

Challenges

- The level of animal and vegetable sources of protein needs to be improved through massive animal and fish breeding/production programmes and crop diversification (World Bank, 1991).
- It is extremely urgent and important that, Bangladesh formulate a comprehensive national land use policy covering and introducing multi-disciplinary and inter-sectoral approaches to integrate and safeguard interest of all sectors.
- Environmentally sound management practices with emphasis on maintenance of soil health, conservation of biodiversity, use of renewable energy, eco-friendly input use, efficient consumptive use of water and rapid afforestation should be undertaken as a national policy with strong regulations for their effective implementation.
- In order to satisfy the increasing demand of food beyond 2000, it is essential to adopt frontier technologies in agriculture to develop different crop cultivars and crops to address present problems and to cope with future changes and challenges. Further development of the present LRIS, its continual updating and greater use by all concerned is of utmost importance.

Some project achievements

The Project (BGD/95/006) “Utilization of Agro-ecological Zones Database and Installation of GIS for Agricultural Development” was officially initiated in July 1996 with funding from UNDP and technical assistance from FAO. The Bangladesh Agricultural Research Council (BARC) under the Ministry of Agriculture is nationally executing the project. Its main objectives are to create a National Agricultural Land Information System Database in a GIS environment to fulfil information needs of the Agricultural Planners, the National Agricultural Research System and the development agencies. The project has been producing information directly usable for agricultural policy making, disaster management and agricultural planning. In addition, the project aims at the development of skilled manpower capable of using the database, maintaining and updating it, and apply it in agricultural research and development planning .

Since the commissioning of the GIS hardware and software (27 April 1998) the project has successfully implemented and produced the following outputs:

The Land Resources Inventory (LRI) created in the past AEZ project was not geographically referenced. In this project, the digitized soil maps were linked to the LRI database to produce several national maps: AEZ regions and sub-regions, suitability of wheat, rice and other major crops, inundation landtypes, economically depressed thanas, climatic variability (reference kharif, i.e. rainy season growing period), general soil types, soil pH, moisture holding capacity, soil texture, flood-prone areas, generalized land capability etc.

For local planning the project has digitized soil and landuse maps of 200 thanas. Another 100 thana maps are being digitized and should be completed by February 2000. These 300 thanas cover over 70% of the country. The thana soil mapping is also being edge-matched for use at the district level and for site-specific agricultural planning.

The project has developed a comprehensive database on the present agricultural landuse by landtype polygon in each agro-ecological sub-region which can be used to produce maps of present and potential landuse and cropping intensity, and is also useful for local crop production planning.

As part of the technology transfer, the potential suitability of 15 different farming system research technologies generated at different places of the country has been estimated for the whole country using the AEZ/GIS Database.

A GIS based crop or cropping pattern suitability model was developed based on the revised suitability rules, updated climatic layers and incorporating inundation layers for the Tangail pilot district. The model is also being used for multi-criteria analysis, in which the socio-economic factors are incorporated to assist the farmer's decision making. The suitability model is replicable to other areas or even to the whole of Bangladesh provided the input information required is available.

In 1998, the country experienced the most devastating flood of the century. Crop damage of the standing transplanted Aman (Monsoon-season rice) was estimated using the AEZ/GIS Database, and was provided to the Prime Minister's office and to the Ministry of Agriculture and Food. The project also prepared outputs to reflect the effects of incessant rainfall during November 1998 caused by a depression in the southern belt of Bangladesh. This was to assist in crop-rehabilitation and post-flood agricultural mitigation activities. Further, as a part of the disaster management, the drought-affected and coastal saline areas have been delineated and are being used for localized agricultural planning purpose.

Through the AEZ/GIS network, the project has established collaboration among different GIS user agencies to exchange views and databases. It has also started joint programs with several agencies: the Surface Water Modeling Center (SWMC) for crop damage estimation due to flood; the environment and GIS Support project for Water Sector (EGIS) to create a water availability and drought map; the department of Agricultural Extension (DAE) for a local level decision support system; the Local Government Engineering Department (LGED) to exchange views and technology transfer; and the Space Research and Remote Sensing Organization (SPARRSO) for crop yield estimation using Remote Sensing and GIS technology.

The project established links with different international institutes such as the International Center for Integrated Mountain Development (ICIMOD), the International Rice Research Institute (IRRI), the International Maize and Wheat Center (CIMMYT), International Fertilizer Development Center (IFDC) on different aspects of collaboration and database exchange.

The project successfully implemented five orientation workshops for over 600 high level decision makers and planners and 13 training programs of different duration (7 days to 2 months) on the theory and hands-on use of GIS software and application of the database where over 185 scientists, extension officials and NGO workers have been trained.

The project has its own map storage and digital map development facilities with most of the base maps at 1:50 000 scale (SOB, LGED, SPOT Pan Image etc.) and 300 digitized thana base

GIS databases availability at BARC

Sl No	Description of the spatial database	Scale and source	Attribute database and associated applications
1	Thana boundary, roads, rivers, urban boundaries, railways	1:250 000 scale AEZ inventory maps published in 1988	Thana population of 1980 and 1990, Thana irrigation status (NMIC), District irrigation status
2	Rainfall stations of BWDB, water level and discharge stations of BWDB, climatic stations (rainfall, temperature, humidity, wind speed, sunshine, cloud cover, dry-wet bulb temperature) of BMD	Location reasonably accurate (1: 50 000 scale), collected from respective organization and corrected consulting 1:50 000 scale base maps	Daily rainfall of BWDB 1961-1993, daily climatic record of BMD stations for 1960-1995
3	Soil and land resources database (mapping unit is soil association)	1:250 000 scale AEZ inventory maps published in 1988	All kinds of soil attribute, Land Resources Inventory(LRI) which includes soil texture, drainage, soil series, relief, slope, soil type, PH, soil moisture, top soil erosion, effective soil depth, plough-pan, consistency, reaction, nutrient status, salinity, alkalinity, calcic/acid sulphate phase, permeability, hazards frequency (flood/storm surge/cyclone), landtype/inundation status, etc.
4	Landtype map generated based on the LRI and Digital Elevation Model (DEM) at 300 m pixel size	Based on the soil resources database (explained in Sl. no 3) and DEM of 500 m spot elevation obtained from EGIS	An application for DEM processing and landtype database creation has been developed, which can be applied for further updating of landtype when better resolution DEM or/and 1: 50,000 scale soil polygons are available
5	Climatic resources for whole Bangladesh which includes moisture regime (length kharif & rabi growing period, Beginning of kharif growing period, beginning and end of humid period, pre-kharif transition period, end of kharif growing period, end of rabi growing period etc.) and temperature regime (frequency of days cooler than 5, 10 and15^{o} C, and frequency of days with extreme summer temperature higher than 35, 40 and45^{o} C)	Based on the climate data analysis using the database explained in sl 2 and climatic data analysis using APT4.0.and surface creation using ArcView Spatial Analyst	An application for climatic surface creation for different layers based on the climatic data and station location has been developed, which was used to create the surfaces at national level and to create maps.
6	Groundwater table database collected from BWDB GW Circle of about 1100 wells distributed all over Bangladesh	NMIDP and BWDB	Historical record of GW table (weekly) from 1973-1993
7	Cropping system database based on AEZ (88 subregions) and Land type	BARC	All necessary details of cropping pattern, crop sequence, irrigated or non-irrigated
8	Thana guide based soil mapping (300 thanas)	1:50 000 scale	All the soil resources database published in the Thana Guide
9	Administrative boundaries up to mouza level, roads with different hierarchy categories, Rivers as of 1990 SPOT panchromatic image, growth centres/markets locations, union and thana centres (for 300 thanas)	1:50,000 scale topographic map. LGED thana map, DLRS thana map, SPOT Pancromatic Images	An application has been developed to create customized map (one base and one soil map) at 1:50 000 scale.
10	Thana guide based soil sample points (for 300 thanas)	1:50 000 scale	All the attributes of soil samples are available in the thana Nirshika (nutrient status etc.)
11	Admin HQ, markets, growth centers	1:50 000 scale	Socio-economic data in various forms collected; further collection is under process
12	Marketing locations	Based of 1:250 000 scale mapping	Growers-level price data collected from different markets by DAM
13	Thana locations	Based of 1:250 000 scale mapping	Thana level socio-economic data eg. population, cropped area, production, irrigation data (from NMIC) and farmsize distribution etc.
14	Fisheries, forestry and livestock database	DoF, Doforestry, DLS, BLRI etc.	Some available data are stored at the project and more data collection is under process

and soil maps along with the Thana Nirdesika booklet. The table lists the GIS databases presently available.

Discussion Topics on Bangladesh Report

- Agreements among network members as to how to maintain an updated database
- Upscaling of data/information
- Problem of changes of spatial units due to changes in political boundaries

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The state of land, water and plant nutrition resources: Philippine National Report

Country overview

Geography and administrative units

The Philippines is an archipelagic nation and comprises 7 107 islands, spanning 1,840 km from north to south. It lies at the western rim of the vast Pacific Ocean and fronts the southernmost extension of the Eurasian Continent. The total land area of the Philippines is 299 404 km^2 or approximately 30 M ha. The islands are actually the peak of mountains uplifted from the sea floor by the horizontal pressure exerted by the Indo-Australian Plate and the Asiatic Plate on the eastern borders of the Philippine Plate during the Miocene Period.

The country's island groups are politically divided into regions; regions into provinces; and provinces into cities and municipalities. The cities and municipalities are further divided into barangays. As of March 31, 1999, based on the data of the Department of Interior and Local Government, there are 16 regions, 78 provinces, 83 cities, 1 525 municipalities and 41 940 barangays.

Socio-economic features

Population in the Philippines has grown from 27 million in 1960 to 63.5 million as of July 1995. There is an increasing proportion of urban population relative to the rural population. In a span of 35 years, population in the country has grown at an average rate of 2.6 percent per year. The major employment sectors, in descending order of magnitude, are agriculture, fishing and forestry, followed by community, social and personal services, wholesale and retail trade, and manufacturing.

Based on gross domestic product, the services sector provides the greatest contribution to the economy with about 40 percent share from 1985 to 1995, followed by the industry sector contributing about 35 percent during the last ten years. The agriculture sector contributes at least 20 percent over the last ten years. Specifically, almost 21 percent of the 1997 GDP was attributed to agriculture. From 1985 to 1997, agriculture has contributed at least 40 percent of the country's employment.

In value terms, the leading crops are rice, corn, coconut, sugarcane, banana, pineapple, mango and cassava. But in terms of harvest area, pineapple and mango over a relatively small area, less than coffee, abaca (banana/fibre) or even sweet potato.

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This summary report has been formulated along the general lines of the report profile in Annex 4. Full text, tables and figures of this report are available at htp://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGL/swlwpnr/philippi/home.htm.

On food self-sufficiency, the Bureau of Agricultural Statistics of the Dept. of Agriculture (BAS-DA) reported that for the past five years, the country has not been self-sufficient in rice and corn. The same source cited the greater dependency on importation in the cases of garlic, peanut and mung bean. For its beef requirements, BAS-DA reported an import representing 18.5 percent of its total supply.

Irrigated rice is grown at a high cropping intensity: 2-3 times a year. The non-irrigated areas are planted once or twice a year depending on available moisture. Similarly, corn is grown once or twice a year.

Crop diversification was supported by the implementation of the “Gintong Ani” of Golden Harvest for High Value Commercial Crops of the Department of Agriculture, as provided in Republic Act 7900. The program has encouraged growing of various high-value commercial crops including cut flowers, ornamentals, fruits, vegetables, bulbs, legumes, nuts, herbs and spices, beverages, essential oils, fiber and industrial crops.

Climate

Several systems of climatic classification have been adopted in the Philippines. The classification taken from the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) is based on seasonal rainfall distribution; that is, considering the two most important rain periods in the country. Using the average monthly distribution of rainfall at different stations, Corona defined four types of rainfall distribution in the Philippines.

The principal air streams that significantly affect the Philippines are the Northeast Monsoon, the Southwest Monsoon and the North Pacific Trades. In the Philippines, the winds are the usual composite of the major currents, tropical cyclones and local circulations produced by diurnal and topographic effects.

Rainfall in the Philippines is brought about by different rainfall-causing weather patterns such as air streams, tropical cyclones, the intertropical Convergence Zone (ITCZ) and to a lesser extent, by fronts, easterly waves, local convection, etc. Its intensity and amount are influenced by latitude, geographical setting, topography and exposure and the season.

The Philippines generally has high temperatures because of its tropical maritime setting and the warm air currents flowing over its land masses. The mean annual temperature is about 27^{0}C. In general, the highest temperatures are observed in valleys and plains while the lowest temperatures occur at stations with high elevations.

Because of the warm moist air streams flowing over the archipelago, its surrounding seas, rich vegetation and abundant rainfall, the humidity of the air throughout the Philippines is high. The average annual relative humidity for the whole Philippines is about 82%.

The average annual cloudiness for the whole Philippines is six oktas (6/8 of the sky coverage) with values ranging from four to seven oktas.

Land resources

Physiography

The different landscapes found in the Philippines are: Coastal and Alluvial Plains, Residual Terrace, Footslope, Hills, Mountains, Volcanic cone, Miscellaneous land types.

Soils

The Land Resources Inventory conducted by the Bureau of Soils and Water Management classified the soils of the country according to the FAO Classification. Cambisols, Luvisols and Acrisols are dominant soil types.

Land types

Soil types prevalent in the Philippines may be grouped into seven land types based on moisture storage capacity, soil fertility, acidity, and related physical and chemical characteristics. The Bureau of Soils and Water Management (BSWM) established a standard physiographic mapping unit in its land resource assessment studies. These mapping units are termed Land Management Units (LMU).The LMUs serve as a basis for the integration of field and resources information. They are the basic units in the suitability rating for the different crops and land uses, wherein each suitability class can be related to specific sets of management inputs and requirements.

Land cover

The actual land cover has been subdivided into five main categories, i.e. (1) agricultural land, (ii) grass/shrubland, (iii) woodland, (iv) wetlands and (v) miscellaneous lands. The categories agriculture land, grass/shrubland and woodland each cover about 30% of the total land area of the Philippines.

Land use

Of the country's total land area, "forest land" (in fact mostly covered by grass, shrub, or woodland) has the highest share of 65 percent, as of 1988. Agricultural land has about 33 percent, while those used for inland fisheries, settlements and open land account for 2, 0.44 and 0.04 percent, respectively. Land used for mining and quarrying covers only 0.03 percent.

There was an increase in agricultural land use starting from mid-1980 to early 1990. The changes with time in the distribution of land by land use are represented by one of the following five classes: -2 where area coverage is rapidly decreasing, i.e. >2% per year; -1 where area coverage is decreasing in size, i.e. 0-2% per year; 0 where area coverage remains stable; 1 where area coverage is increasing in size, i.e. 0-2% per year; 2 where area coverage is rapidly increasing in size, i.e. >2% per year.

Soil productivity, expressed in average production value per ha per year in 1993, is highest for sugarcane, followed by cassava, then rice and corn. Nonetheless, farmers benefited more from growing cassava than rice, sugarcane or corn considering the profit cost ratio. Over time profitability of rice and corn growing has shown a declining trend.

Rough indication of trends in productivity (change with time in the yield per hectare) is presented with the indicator: 1 for increasing outputs; 0 for no change in outputs; -1 for decreasing outputs.

Agro-ecological systems

Pedo-ecological zones (PEZs) are the natural unit developed by the BSWM and subsequently adopted for national planning. PEZs represent broad ecological resource management units derived from an association of soils and their environments, particularly such factors as landscape, elevation, slope and temperature.

Four PEZs were identified from this soil-environment association process conducted in the whole country. These are the Warm Lowlands, Warm-Cool Uplands, Warm-Cool Hilly lands and Cool Highlands.

Land capability is a method for defining the broad land use potential in the country. Based on soil types and slope analyses, this scheme groups the soil units in accordance with soil conservation measures with reference to general land use, namely:

Class A (Very good land), Class B (Good land), Class C (Moderately good land), Class D (Fairly good land), Class L (Level to nearly level land), Class M (Steep land), Class N (Very steep land), Class X (Level land), Class Y (Very hilly and mountainous).

Land suitability for major crop types has been presented in two tables in the main report:

Table I.3.1. Major Groups of Crops In The Suitability Classes
Table I.3.1 Agro-edaphic Suitability Class for Major Groups of Crops

WATER RESOURCES

Hydrography

The Philippines has abundant water resources, having 59 natural lakes and 421 river basins with drainage areas ranging from 40 to 25 649 km^2. From among the principal river basins, 18 were identified as major river basins with drainage areas of at least 1400 km^2. With an average annual rainfall of 2 400 mm, the annual run-off is estimated to exceed about 257 000 million cubic meters (MCM) 90% of the years.

The country is also underlain by extensive groundwater reservoirs covering approximately 50 000 km^2 with an estimated storage capacity of about 251 000 MCM.

The Philippines has adequate water supplies to meet the projected demand. The surface water alone from rivers and streams available 90% of the time, will be sufficient to meet the water requirements of the country even beyond the year 2000. Agriculture has the largest share of water, followed by domestic and industrial users.

Irrigation and drainage

Irrigation has a long history in the Philippines: starting in the pre-Spanish era; through the Spanish period; the American regime (1990-1936); the Commonwealth and Japanese regime (1937-1946); the early Independence period (1947-1965) to the current expansion period (since1966).

Institutions in charge with water resources assessment and development of irrigation systems include the National Water Resources Board (NWRB); the National Irrigation Administration (NIA); the Bureau of Soils and Water Management (BSWM); and Local Government Units (LGUs).

As of May 31, 1999, NIA estimated that about 1.339 M ha are served by national, communal and private irrigation systems. These exclude 0.119 M ha being served by small-scale irrigation projects (SSIP) established by DA-BSWM, primarily for soil and water conservation. Thus, about 1.458 M ha are provided with irrigation facilities out of the a potential irrigable area of 3.126 M ha.

NIA and DA-BSWM provide different estimates of constructing new irrigation systems and rehabilitating existing ones. One reason is that Da-BSWM is working on smaller systems so that its cost estimates are lower than those of NIA. The multi-purpose nature of NIA-implemented projects is also another reason for the higher investment cost per hectare of service area. In case of shallow tubewells (STW), the difference in cost between NIA-implemented and DA-BSWM implemented STWs lies in the differences in technology adopted (i.e., type of materials, drilling techniques, and well development).

Most irrigation systems in the Philippines were designed to irrigate rice through a network of open canals, canal structures and control facilities. Pressurized irrigation systems (e.g. sprinkler, micro-sprinkler and drip systems) have been adopted and used primarily to irrigate high-value crops such as vegetables, ornamentals, citrus, banana, coffee, sugarcane, fruit trees, and are widely used for greenhouses.

Constraints to irrigation development include:

- environmental degradation and natural calamities
- competing use of land and water
- increased cost of irrigation development
- rapid deterioration of existing irrigation systems
- inadequate funding and support services to improve the performance of existing irrigation systems
- absence of significant R and D efforts in support to irrigation development and irrigation management research
- peace and order situation in some areas.

To provide specific policy guidelines on land and water utilization and management, the Government promulgated supportive legislation in accordance with the fundamental laws contained in the Constitution. This legislation describes and prescribes the specific uses for land and water resources.

Plant nutrient resources

There was an increasing use of nitrogen fertilizers resulting in an imbalance among fertilizer nutrients exemplified by an increasing ratio between N and P. This leads to soil chemical degradation affecting the productive capacity of the soil, and hence crop yield. The promotion of the Balanced Fertilization Strategy (BFS) of the Department of Agriculture, a government intervention to combat further land degradation, has been enhancing soil fertility. Nutrient availability has improved over time, particularly P and Zn, with continual use of combined organic an inorganic fertilizers.

The amount of fertilizer applied to rice is presented based on BAS data comparing the use of fertilizer in irrigated and rainfed rice farms. The former use 65, 15, 9 or a total of 89 kg/ha NPK while the latter consumed 52, 11, 6 or a total of 69 kg/ha NPK yielding 3.38 and 2.11 mt/ha, respectively, in 1994.

In 1997, an average of 201 kg/ha of fertilizer was applied on maize. Sugarcane has high fertilizer requirement: a total of 190 to 520 kg/ha NPK is applied in Luzon and Visayas/Mindanao, respectively.

Fertilizer prices

Imported fertilizers include urea, ammonium sulfate, complete fertilizer, ammonium phosphate, potassium chloride and di-ammonium phosphate. Since 1985, their world prices were exceptionally low in 1993. Retail prices in the country did not necessarily exhibit the same trend as the world prices.

Commercial organic fertilizer prices ranged from PhP 155 to 250(roughly US$4-6) per 50 kg bag (FOB factory), as cited by the Organic Fertilizers Association (OFERMANA).

The CO2 equivalent from agricultural activities contributes about 17% to the total Philippine Greenhouse Gas Emission (GHG). Rice paddy cultivation, enteric fermentation, waste management of livestock, agricultural waste and savannah burning, and ploughed agricultural soils are sources of greenhouses gases, particularly methane and CO2.

Hotspots

Natural environmental hazard

Major drought events in the Philippines, through climatological studies, have been related with the El Niño occurrences or warm episodes in the central and eastern equatorial Pacific. The last quarter of 1982 represented the start of the most severe El Niño-related drought in the country.

Tropical cyclones are the most common natural hazard in the country. On average 20 tropical cyclones pass through the Philippine Area of Responsibility each year: a larger number than for any other country.

The Philippines is a seismically active country, with at least five earthquakes occurring per day. One of those strongest earthquakes in recent times occurred on July 16, 1990.

The Philippines has more than 200 volcanoes, 21 of which are classified as active as of 1986. One of the major volcanic eruptions in recent times was that of Mt. Pinatubo on June 12, 1991.

The consolidated report on the damages on agricultural production due to El Niño in 1998 indicates a total of 1.05 million hectares affected and damages valued at PhP7.767 billion (in the order of US$200 million).

Planning agencies and LGUs should further link and integrate disaster prevention and mitigation into national and regional physical framework plans and comprehensive land use plans.

Land and water constraints to sustainable agriculture

General issues of concern with respect to sustainable agriculture include:

- Archipelagic character of the country;
- Vulnerability to natural hazards;
- Pressures of increasing population
- Indiscriminate conversion of agricultural lands
- Absence of a national land use policy

- Undelineated forest lands
- Outdated land use plans and poor implementation of zoning ordinances
- Poor enforcement of land use policies and monitoring of land use conversion
- Growing urban centers
- Increasing role of LGUs in land use
- Lack of institutional linkages.

Soil-related problems for sustainable agriculture include:

- Steep slopes
- Poor drainage
- Coarse textures
- Heavy cracking clays
- Severe fertility limitations
- Land with saline/sodic soil limitations
- Land with acid sulphate limitations
- Peatland
- Mine tailings polluted/silted soils
- Soil erosion.

Bright spots

The work of the Mindanao Baptist Rural Life Center (MBRLC), an example of a success story, is a 19 hectare demonstration farm dedicated to the upland farmers in the Philippines, as well as in the rest of Asia. Emphasis is given to helping upland farmers find sustainable upland farming systems that fit the farmers' situations and meet their needs. The MBRLC has developed and demonstrated technologies known as Sloping Agricultural Land Technologies or SALT, utilizing agroforestry for soil conservation as their base.

Sound land use and allocation policies are supported by Section 20 of Local Government Code, the Draft National Land Use Act of the Philippines and the Agriculture and Fisheries Modernization Act of 1997 (RA 8435).

Sustainable use of water resources is promoted by the Small Water Impounding Project (SWIP). This works by the construction of small water-scale dam structure across narrow depressions or valleys to hold back water and develop a reservoir that will store rainfall during the rainy season for immediate or future use. The long-term benefits of the SWIP to the environment and ecological stability are flood control, reduced soil erosion and sedimentation, and water conservation through agro-forestry development in the watershed.

The Balanced Fertilization Strategy (BFS) in the Philippines provides the legal and institutional basis for the adoption of a science-based policy on food security and food production research focused on the use of cost-efficient and location-specific combinations of organic and inorganic fertilizers to sustain the increases in rice productivity. Thus, the BFS contributes to the national effort toward food security and environmental stability. The BFS is guided by an operational framework for the analysis of the potential impacts of organic-based fertilization strategy. This framework is based on the use of visual impacts that will help the farmers and the extension workers understand the qualitative and actual effects of properly designed fertilization programme on the rice crops.

The operational research was carried out in several phases: adaptation, verification and piloting (up-scaling).

Discussion Topics on the Philippines Report

- Improvement of the declining organic matter content of the soil
- Improvement of goundwater recharge
- Difference and similarity between Pedo-ecological Zones (PEZ) and Agro-ecological Zones (AEZ)
- The popularity of urea as N source and sulphur deficiency

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National report on the state of land, water and plant nutrition resources in China

China has the largest population and very little cultivated lands per caput. The shortage of water resources and frequent natural disasters are the reasons why the realization of food security has become one of the toughest tasks for China.

There is a major international concern whether China is able to feed its people in the future. China's food security is not only an alarming domestic issue but also an issue of potential international influences.

The report is intended to probe into the chances, challenges, and prospects of China's food security issue, to provide the international community with a reliable base to judge the real situation of China's food security through comparison and sharing of information.

With the maintenance and further improvements, updating and enrichment of the information, the report is expected to have powerful effects on China's policy making and to influence domestic and international society in the issues of food security.

CONTENTS AND NATURE OF THE REPORT

The report "State of Land, Water and Plan Nutrition Resources in China" is available on the Internet in two corresponding Chinese and English editions. It covers eight major parts: Country overview; Land resources; Water resources; Plant nutrition resources; Hotspots; Brightspots; Challenges and viewpoints; and Search engines. It includes 88 text files, 192 tables, 199 pieces of charts and graphs, 204 thematic maps and 328 landscape images. The total amounts to some 1500 pages, including the bilingual interface in Chinese and English. The website is hyperlinked to other Internet websites and documents that are related to the land, water, and plant nutrition resources in China.

The Report comprises the most important findings and statistical results related to China's land, water and plant nutrition resources found in open publications in China and abroad since 1949. The sources include yearbooks, diagram albums, government reports, encyclopaedia, scientific findings, internationally authoritative organizations' and institutes' findings and circulation and latest information of related internet websites.

Source materials were carefully selected on the criteria that they should objectively reflect key factors and major contradictions in China's food security situation. China's unique historical experiences, present achievements and localized experiences in its efforts toward food security were also included.

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The full report is available at: http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGL/swlwpnr/china/home.htm.

The report, based on abundant reference materials, has provided its own answers to China's food security prospects, which are embodied under the subjects of "Hotspots and Brightspots", and especially "Challenges and Viewpoints".

The report is concise, with as much visual description and expression as possible, in order to assure high readability and convenience for browsing. Differences in modes of expression between Chinese and English were also taken into consideration.

Latest information and materials, as late as 1999, were chosen to allow longer effect of the report. Also included is information on dynamic changes in the state of natural resources, in order to enable simulation and modelling of future developments in food security.

Findings during compilation and conclusion

The report deals with two clear and important thematic aspects. It addresses the theme of China's food security situation in diverse perspectives of land resources. It also points out directions towards solutions for the problems highlighted by such perspective analyses.

It was considered essential to introduce functional file coding system in the Report. Cascading letters and numbers were used to distinguish levels of topics. Types of information were also denoted by a set of letters: T for text, Tb for table, C for chart, M for map, and I for image.

The challenge was to find a reasonable balance between two contradictory factors: visual effects and the time it takes for loading. Through repeated experiments it was found that an appropriate resolution rate for a common scanned landscape image is 75-100 dpi, and for a map, 150-250 dpi. Vector maps that carry attribute data are highly recommended for ease of modification and updating. In China, however, there were no existing vector maps available for the purpose.

The report should take advantage of network communications in order to enlarge sources of information and expand the range of dissemination.

The National Report on the State of Land, Water and Plant Resource in China is the first website created in China focusing on food security and covering the major land, water and plant nutrition resources in the country. The Report will give supports to policy-making by the government in the realization of food security in China. The results of the report will also be used by various Chinese and foreign research institutes on the development of natural resources, as well as by scholars and educators. The report will thus have a profound social influence.

Information on the state of land, water and plant nutrition in Peninsular Malaysia

Peninsular Malaysia, 13.16 million ha in extent, is divided into 12 states. The climate is classified as “wet equatorial” or “humid tropics”, governed by the northeast and southwest monsoon. Population is about 17 million with average population growth of 1.9% per year.

Land resources and use

Up to 240 soil series have been identified. About half of the major soil series are Ultisols. Soil maps at 1:250 000 and 1:500 000 scales exist for 60% of the country. The country is divided into five Land Capability Classes (LCC).

Six broad agro-ecological zones were identified, based on climate, landform, and soil characteristics: two zones in the highlands (one for the Histosols), and three zones in the lowlands. Sixty-five agro-climatic zones have been identified on the 1:500 000 scale agro-climatic map. The suitability of a given area for a specific crop was classified into six categories, ranging from the best to the poorest. 16 crops were evaluated for their suitability at various locations on the basis of their water requirements.

Major land cover categories are agriculture and forestry, followed by settlements and water bodies. Maps at 1:250 000 and 1:500 000 scales have been produced by remote sensing, covering parts of the Peninsula.

Land uses are classified into nine groups, seven of which are related to crops and vegetation and the others, to urbanization, mining and unused land. Land use change has occurred mostly through deforestation of primary forest.

Water resources

Out of 556 000 million m^3 of water annually received by rain, only 12 000 million m^3 is being used. Agriculture consumes 75% of the surface water supply, mainly for irrigation. 66 reservoirs are in operation. Requests for well irrigation are increasing. Per caput availability of water declined from 40% to 60% during 1955-1990. Reclamation projects for cultivation of dryland crops have been installing drainage systems in peat soils. Fully irrigated double cropping rice has increased from 20 000 ha in the 1960s to 240 000 ha presently. Another 55 000 ha are irrigated in small schemes.

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The full report is available at: http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGL/swlwpnr/malaysia/home.htm.

Plant nutrient resources

The average mineral fertilizer consumption is around 250kg/ha/yr, mainly applied to Oil Palm, Rubber, Cocoa, and Rice. A large portion of the plantation crops is mono-cropped, though they have been integrated with other crops or livestock. Demand for fertilizer increased by 39% during 1985-94. Imports increased by 57% , local production by 66%.

The share of agriculture in GDP was 13.6% in 1996. Oil palm, rubber and rice production show increasing trends during 1994-1996.

Vegetable and fruit production increased by 218% and 288% respectively while rice production decreased by 3.3% during 1983-1990.

Future food demand is expected to show an upward trend in foods with higher protein and fiber content and a downward trend for starch and carbohydrates. Promotion of vegetable and fruit production will be a strategy to meet this change.

Hot spots in agricultural resources

Fifty percent of the land consists of problem soils, considered unsuitable for agriculture. These comprise steep lands, deep peat, acid sulphate soils, saline soils, tin tailings, and sandy coastal soils or Birs.

Human-induced land degradation problems include erosion, fertility depletion, dystrification, land subsidence, salinization.

Water-use problems include water deficits in the Northwest of the peninsula, conflicting use of land for agriculture versus water catchment, and pollution of water catchment.

Fertilizer use is causing environmental problems in areas with short term crops where intensive farming is practised.

Bright spots in agricultural resources

About 6.19 million ha of land are considered suitable for agricultural activities, only part of which is presently being farmed.

Land allocation and use policies were initiated by the government with the First and Second Outline Perspective Plans and National Agriculture Policy (NAP).

Development of water management infrastructure (e.g. dams, pumps, canals) plays a major role in rice production. Mechanization efforts have been undertaken in perennial crop production (oil palm, rubber, cocoa).

The Federal Land Development Authority has the task of developing new agricultural land schemes for the settlement of the rural poor. Other private and government agencies focus on increasing productivity and crop diversification.

Challenges

A broad range of challenges is to be addressed to ensure continual sustainable agricultural development:

- Database development, provision of sound land use options to policy makers, and addressing problems associated with land ownership
- Proper policies and management for steepland, hilly terrain, and peatland
- Efficient water and fertilizer use, soil fertility maintenance, and adoption of soil conservation measures, in order to avoid soil degradation
- Effective utilization of the land and water resource information system to optimize management of land development projects
- Development of dams, increase of irrigation efficiency, provision of guidelines for effective sharing and allocation of water
- Finding alternatives to burning for land clearing, and minimizing pollution resulting from inappropriate use of agrochemicals

Discussion Topics on Malaysia Report

- Indication of linkages to other institutions for acquisition of official data

Agriculture resources in Indonesia

Indonesia is the largest archipelago nation in the world, extending across 5 000 km of the Indian and Pacific Oceans. The country covers 5.3 M km^2 of the tropics. This includes 3.1 M km^2 of territorial water and almost 2 M km^2 of lands. Indonesia is also regarded as the fourth most populous country in the world with a population of 210 million.

Climate resources

Indonesia has a generally warm and humid climate with mean annual precipitation of over 2000 mm and mean annual temperature of over 25^0C. The rainfall pattern can be distinguished in three different types. Areas away from the equator have a monsoon type with distinct dry season from April to August. Around the equator, the rainfall pattern is bimodal without a distinct dry season. The third type in Eastern part of Sulawesi and around Ambon and Ceram has seasons opposite of the first type: rainy from April to August. With warm temperature and adequate moisture throughout the year, there is no limit in growing period. It is very common to have three annual crops in relay planting.

Land resources and land use

Based on Soil Taxonomy, all 10 soil orders are found in the country, with Inceptisols as the dominant soil order, covering 880 million ha or 45.8% of the total area.

With about 81 000 km of coastline, the country has vast wetlands along the cost and extensive peat wetlands further inland. The wetlands, covering 43.5 M ha, are divided into five categories.

Amid relatively vast available lands and with a largely agrarian population, still only a small portion of the lands in Indonesia are utilized for agriculture. Only about 4% are used for wetland agriculture, mainly rice, 5% for upland agriculture, and 7% for tree plantations.

Agricultural Land Use Change: The fastest growing area for plantation is for oil palm that increased from 339,000 ha in 1968 to 2.2 M ha in 1997. Rates of increase in area for some crops are as follows: oil palm (16.3%); rubber and coconut (2%); cacao (33%). The rice area, whether irrigated, rainfed or tidal swamp rice, increased at about 100 000 ha annually.

The increasing population and rapid development of services and industry particularly on Java has resulted in conversion of agricultural lands into non-agricultural uses. From 1988 to 1993, irrigated rice fields were converted into non-agricultural uses at the rate of 8 255 ha annually.

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The agricultural lands are not utilized intensively, particularly in Outer Islands of Sumatra and Kalimantan. The low intensities are indicative of the low competitiveness of agriculture compared with other occupations in the labour market.

Water resources

The southeastern part of the country experiences water deficit in the dry season. Adequate storage systems in the upstream are needed to solve the problem. Sumatra and Kalimantan have abundant water resources.

Java has three large watersheds, namely: Citarum (269 km long and draining an area of 6,080 km^2), Bengawan Solo (600 km long with catchment area of 16,100 km^2), and Brantas River (320 km long and draining an area of 12,000 km^2).

Human resources

The agrarian work force has decreased from 35.7 million in 1990 to 35.2 million in 1995. A major problem is the decrease of young people willing to undertake agriculture and the ageing of farming population. Another problem is the low educational level among farmers. These result in the lack of readiness for technological innovations.

Agricultural production and trends

The share of food crops production to GDP in 1998 was 9% (the highest in agriculture sector), estate crops 2.6%, livestock 1.9%, fishery 1.5%, and forestry 1.7%. Among the major food crops (corn, cassava, sweet potato, peanut, and soybean) production of corn experienced higher growth rate since 70s. Production of palmoil and rubber has increased with the expansion of plantation areas. Rubber, coffee, tea, shrimp and tobacco are the major agricultural export commodities. Although the share of agriculture in the economy is continuously declining, it is still the key sector of Indonesia's economy. Agriculture directly provides employment to some 45% of the labour force and generates about 54% of the non-oil export value.

Agro-ecological systems

Analyses for land allocation and crop options are based on terrain type, which is divided into four classes according to slope. Steep slope of more than 40% should be kept vegetated for conservation purposes. When the slope is about 8% or less, annual crop agriculture is recommended if the soil is suitable. Land with slopes between 8 to 15% is recommended for agro-forestry uses in which annual crops are cultivated along with perennials. Land with slopes in the range of 15 to 40% is for permanent crops such as perennial tree plantations, forestry or pasture. Crop selection is also based on moisture and temperature regimes.

Discussion Topics on Indonesia Report

- Soil as a renewable resource
- Protection of prime agricultural lands

Present status of utilization of GIS-based LRIS in Myanmar

Myanmar is an agro-based nation. Fifty-six percent of its population is engaged in agriculture, forestry and fisheries.

Effective management of land resources, efficient land use planning, and land utilization practices are essential to solve conflicts between arising demands for agricultural development and resources decreasing in extent and declining in quality.

There is an increasing demand for incorporating GIS as a tool for the collection, integration, analysis, and supply of land resources data and information in support of the planning of land resources management.

Key current effort in LRIS

Forest Department (Ministry of Forest) has been undertaking a range of LRIS-related activities. In the past, forest cover status was examined using aerial photographs (taken in1950s) and satellite images (in 70s/80s). In 1989 Landsat TM imageries were used for the analysis of forest cover in Myanmar. Assessment in 1990 of the change in forest cover showed that the forest cover had decreased at an annual rate of 0.64% of the actual forested area from 1975 to 1989. The change has been due mainly to shifting cultivation, illegal cutting of trees, and encroachment for agriculture.

Large scale forest inventories at the national level were initiated in 1981-82 under the National Forest Survey and Inventory Project with the assistance of UNDP/FAO, which was followed by National Forest Management and Inventory Project. As a result, 95% of the country was covered by aerial photography. Since 1993, Forest Department has been conducting forest inventory with its own resources covering about 2 million hectares each year.

A PC based Arc/info GIS was installed in July 1993. Several geographic databases and land-use maps were produced on a pilot scale. In 1996 a digital image processing system PCI EASI/PACE was installed at the Department. The system incorporated a GIS component to produce land-use maps for sustainable development of critical areas. GPS units have been in action, locating ground control points in the process of ground truthing in digital image processing.

FAO and UNDP have provided the main support to the Forest Department for technical assistance and provision of equipment in remote sensing and GIS. Japanese Ministry of

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Agriculture, Forestry and Fisheries, the Japan Forest Technical Association, and ESCAP/NASDA have provided additional cooperation for digital image processing and information system development respectively.

The Settlement and Land Records Department (SLRD) of the Ministry of Agriculture and Irrigation has been responsible for recording current land-use information on cadastral levels, collecting data on extend of crops, their yield, monthly rainfall, and number of farm families, and for releasing periodic survey reports. Efforts have been made to transform former techniques of manual operations into computerized management, especially utilization of GIS.

Several subsystems are being set up: Photogrammetry (with computers, soft-copy photogrammetry and related software, aerial photographs and satellite imagery); Field survey (with total stations and GIS units); Image processing (with GIS software and GIS equipment). SLRD plans to use the information for monitoring land degradation for sustainable agriculture; improving crop acreage forecasting and estimation; improving yield forecasting and estimation of main crops; and monitoring shifting cultivation.

The Meteorology and Hydrology Department (Ministry of Transportation) introduced satellite meteorology first in 1973 with a satellite APT station provided by NOAA, upgraded in 1979 with NOAA LR-FAX ground station equipment. A NESDUS APT receiver was provided by JICA in 1986. The department covers collection of rain fall, temperature, solar radiation, relative humidity, wind speed, and evaporation data.

The Land Use Division (Ministry of Agriculture and Irrigation), since its existence in 1957, is responsible for soil classification, soil survey (soil physical characteristics, soil chemical characteristics, soil temperature), soil mapping for the production of soil and land use reports, soil crop correlation studies, and demonstrations and research activities on farmers' fields.

CONSTRAINTS AND PROSPECTS

In spite of these activities by several government agencies whose functions relate closely to land resources and spatial information, each agency seeks a different level of adoption of remote sensing and GIS technology. In Myanmar, the different systems still have to be linked and collaboration among the agencies has yet to be initiated in order to realize effective national-level management of land resources.

At present, Myanmar is making significant progress in transforming a mixed traditional and modern agricultural system to a wholly modern one through a strategy of harmonious combination of local know-how and global technologies. In this context, the subject matter of the present seminar will be particularly helpful for Myanmar to set out its directions for the future, in the light of experiences by other participating countries that have already made headway in using LRIS.

Discussion Topics on Myanmar Report

- Number of institutions involved in the Information Systems
- Difficulty in data gathering

Status of GIS-based land resources information systems in Nepal

Land resources are the key resources in Nepal since agricultural production accounts for 40% of GDP. Optimization in the use of land resources, efficient land use planning, and land utilization practices are critical to alleviate poverty in Nepal, since 45% of the total population is below the absolute poverty line. Like many other countries in the world, Nepal is using GIS as a tool for the collection, integration, analysis, and extraction of land resources data and information in support of the planning of land resources management.

Past land resources information projects

During the Land Resources Mapping Project (LRMP) of the Survey Department of Nepal (1976-1984), scientific surveys were conducted by multidisciplinary working teams, based on interpretation of aerial photographs and ground truthing. Resultant map products include: Land Utilisation; Land Systems; Land Capability; Geology; Climate. Supporting reports cover geology, land systems, land capability; land utilisation; agriculture and forestry; water resources; economics; and a summary report. Several shortcomings on the project have now been recognized: non-digital format; obsolete data; insufficient data credibility; no updating system available; inconsistencies in scale and report format; lack of data sharing systems for acquisition and dissemination.

The Forest Resources Information System (FRISP) project, operated in the 90's in cooperation with FINNIDA, used latest remote sensing and GIS technology; and the resulting database indicates the current status of forest resources in the country. A continuous system in the same nature is felt necessary.

Main current LRIS efforts

The parcel-based Land Information System Project (LISP), under the Ministry of Land Reform and Management of His Majesty's Government, is to develop a modern computer-based national-level spatial information system. This will deal with land ownership, tenancy and cadastral maps of the whole country, to support increased agricultural productivity, poverty alleviation, environmental conservation and sustainable development.

Since 1998 the Ministry of Agriculture has been developing an Agriculture Geographic Information System (AGIS). This is to create a district and local level disaggregated database system in agriculture, create and maintain a national spatial database infrastructure in agriculture sector; assist the concerned authorities in central and local level planning, monitoring, evaluation

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and implementation activities with available information based on the AGIS database; and establish and strengthen the AGIS network at central, regional, district and local level.

Kathmandu Metropolitan City in cooperation with the European Commission has launched an urban /municipal GIS program. The information will be based on latest large-scale aerial photography, modern digital/ortho photogrammetry and GIS.

Started in the early 1990s, the National Topographic Database (NTDB) programme by the Survey Department has covered most of the country at scales of 1:25 000 or 50 000. The Department has launched NTDB as a supporting and organizing programme to provide national specifications and standards for topographic data: (scales 1:25 000/50 000), data codes, data formats, data quality, etc. Preparation of NTDB for all the inhabited part of the country will be completed in 2000.

It is now common for most of the organizations in Nepal to have their own GIS (e.g. Road Department, Ministry of Population & Environment). Consequently, the major problem now is finding ways to standardize the data sets to facilitate systematic data sharing and metadata sharing among sectors.

Constraints and current and planned actions

GIS activities in Nepal are facing several problems:

- Lack of national level coordination for uniformity, compatibility, and systematization of GIS-based land resources information systems
- Insufficient financial and technical resources to develop the system
- Insufficient human resources
- Lack of an appropriate organizational and institutional framework.

To address these problems, the following actions are under way:

- Preparation by the Survey Department of documents on national mapping issues and strategies, specifications for national geoinformation services and the NTDB, and specifications for urban GIS.
- Strengthening organizational and institutional set-ups
- Human resources development plan by the Survey Training Center of the Survey Department
- Search for technological and financial support from bilateral and multilateral aid agencies.

Discussion Topics on Nepal Report

- Use of standard base map and template
- Accessibility of base maps
- Mapping regulation

Land resources information systems and utilization of GIS in Sri Lanka

Sri Lanka has earned a high reputation for its water resources development in the past. It has also benefited from favourable climatic conditions, which has enabled the local production of most of her food requirement. However, the country is facing problems of decreasing per capita land availability, depletion of water resources, and decline of land productivity. These problems are aggravated by the low efficiency of resource use as a result of an inefficient coordination in information management on land and water. A comprehensive database coupled with an efficient information system will be a prime necessity in addressing these problems.

Constraints for sustainable production

Soil Degradation

In Sri Lanka, several kinds of soil degradation have been affecting agricultural land: soil erosion, fertility decline, pollution, salinization, sodication, dystrification, eutrification, and waterlogging.

Three main types of problem soils occur in Sri Lanka: saline soils (covering an area of 16 000 ha in the coastal regions), waterlogged soils (affecting an area of 1 000 ha), and potential acid sulphate soils (an area of 27 500 ha).

Conversion of agricultural land to other uses such as residential purposes, industrial activities, infrastructure development and mining has been increasing over the last few decades. The census result (1973/1982) shows a decrease of the net agricultural land extent in the country by 3% in the period in spite of new land being taken into cultivation.

Other problems include uncertainties in land tenure, fragmentation of agricultural lands, escalation of fertilizer prices, and low water use efficiencies.

Challenges

The main challenge for Sri Lanka is to meet the future food demands of the nation in a sustainable manner. Careful observation and analysis indicate specific areas of focus:

- Resource conservation
- Increasing efficiency in water use

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- Increasing land productivity
- Land and water resources development particularly in the wet zone
- Development and introduction of policies for land consolidation and tenure

These challenges can only be tackled by scientific land management, use of efficient ways of water conveyance and application, land suitability evaluation and land-use planning and proper policy initiatives. To facilitate all this, integrated information management is required.

NECESSARY ACTIONS AND DEVELOPMENTS

One of the main problems in land resource management in Sri Lanka is lack of effective and easy accessibility to the resource information such as soils, agro-climate conditions, water resources, physiography and other relevant information to the farmers, extensionists, planners and other stakeholders who are interested in development activities. Such information is available in conventional hard-copy format, but it is not easily retrievable and accessible.

In addition, these data are located in several organisations and departments. This, along with a lack of bilateral cooperation, data sharing systems and facilities, makes compilation of relevant information very difficult. Therefore it is highly necessary to establish a coordinating body to develop an integrated information system on land and water resources.

Sustainable management of land and water resources can only be achieved if a comprehensive, updated database is available. The efficient generation of Information according to user needs can be with a land and water resources information system running in a geographic information system environment. This system must be readily accessible for land and water resources managers, planners, and other users. Therefore it should be located in a Central Government entity.

Discussion Topics on Sri Lanka Report
- Collaboration of institutions in developing the system
- Establishment of a central coordinating body

GIS-based land resources information systems in Thailand

Over the past five years GIS technology has gained significant recognition in Thailand and has spread into various fields of operations. A figure from the GIS National Action Plan shows that in the period of Thai's 8th National Social and Economic Plan (1997-2001), government organizations propose budgets for their GIS related projects to a total of about 3 600 million baht (100 million US$). The GIS industry is now booming in Thailand. Many agencies have already started implementing their systems and databases. Some have already developed specific user-oriented applications programs and have started using them in their duties.

Through more than ten years of development, the Department of Land Development (DLD) has acquired almost every well known software used for GIS with all hardware accessories. In the GIS database, more than ten layers of selected areas are available, including soils, topography, DEM, landforms, land use, rivers, watersheds.

Main GIS-related activities in Thailand

The Digital Line Map Production Capability Enhancement Project proposed by the Royal Thai Survey Department (RTSD) and currently under way, is intended to re-survey the 1:50 000 topographic maps of the whole country and produce them in digital format. Its specific agenda comprises 830 map sheets; aerial photographs taken by RTSD; photo control points (both horizontal and vertical) to be produced by Thai private companies; map compilation and digital line map production to be conducted by the US National Imagery and Mapping Agency. The project should be completed in five years (by 2003).

The GIS/AM/FM programme of the Metropolitan Electricity Authority (MEA) is under way since 1994 with the objective to automate mapping and planning the electricity distribution system. Base map data are surveyed and produced with an accuracy equivalent to a 1:1 000 scale. They comprise of five data layers: hydrology, road centerline, road edge, boundary of important buildings (landmarks), and boundary of customer buildings. The project area covers 1769 sq. km of greater Bangkok. The project should be completed in 2001.

The Department of Land Development (DLD) has produced a GIS system database at scale 1:50 000, which includes maps of soil series groups, soil series, land use (updated from satellite images); permanent forest, potential soil erosion and land use planning. The databases are used for provincial planning, zoning of suitable lands for crops, environmental management, etc.

The Meteorological Department has produced 1:2 million scale GIS climate data layers (evaporation, rainfall, relative humidity etc.) to answer requests from scientific researches for the evaluation of natural resources.

Parida Kuneepong
Soil Scientist, Soil Survey and Classification Division, Department of Land Development, Bangkok, Thailand

The GIS system implemented by the Office of Agricultural Economics covers the whole country with eith GIS data layers at a scale of 1:250 000: soil series, average precipitation, irrigation project boundaries, river basin boundaries, existing land use, administrative boundaries, roads, and legal forest areas. The system is used to analyze the potential area for specific crops, e.g. rice, tapioca, rubber, soya bean.

The Department of Town and Country Planning (DTCP) has started a programme of surveying and constructing a digital large scale (1/4,000) base map of the whole country, to be utilized in land use zoning at Tambon (sub-district) level.

In the fields of forest, water, and mineral resources management, responsible government agencies are now using GIS as their tools to analyze the data and present the information. Analyses are also sub-contracted to other research institutes and private consulting firms with terms of references specifying their GIS components.

The Bangkok Municipal Administration (BMA) has launched pilot projects on using GIS in taxation mapping, land use zoning analysis, integrating PC GIS software with the SCADA-based sewer control system. Project plans include production of medium scale (1:10 000) and large scale (1/1 000) base maps, continual updating of data, development of one single transparent information system integrating BMA's GIS, Management Information System (MIS) and other information systems.

GIS technology has been introduced to other kinds of local governments such as municipalities, sanitary districts (small municipalities) and Tambon (sub-district) administrations.

The Ministry of Agriculture and cooperatives set up a centre of agrotechnology transfer at Tambon level in 1999. The centre will transfer appropriate technology to be used to support Tambon agricultural planning for a better quality of life of the farmers. Input data include water management, plant and animal production, land management and land uses.

GIS policy and coordination in Thailand

The ministry cabinet has set up a National Committee for GIS Development Coordination and Promotion with five sub-committees. Its mandate includes coordination of GIS related interests and actions of the various agencies, taking initiatives for national GIS action plans, maintaining the country's GIS data inventory, conducting GIS training courses, and promotion of information dissemination on GIS.

Constraints

GIS activities in Thailand face a range of major problems:

- Good quality, large-scale base map data are not readily available, either in analogue or digital form; lack of data on land parcel and building usage is also a problem
- National policies supporting GIS development are insufficient
- Top-level policy changes depend upon politics
- There are not enough incentives for GIS training or functional cooperation among staff
- Huge projects require more time than it is possible to maintain the required morale
- Planners and decision-makers cannot easily specify their information requirements or model their problem systematically

Discussion Topics on Thailand Report

- Strategy to encourage agencies to set-up their own land and water information systems

GIS-based land resources information systems of Viet Nam

GIS technology arrived in Vietnam in the early 1980s and first became available through scientific and technical cooperation projects, chiefly through development programs supported by UNDP and FAO. It started to gain more significance as the potential of the technology began to be acknowledged through experimental products and once the need for the country to integrate itself in the world and its current information technology became an essential issue.

Not only is GIS itself in use today but there are also GIS training centres at the University of Mining and Geology and Ho Chi Minh Polytechnical College. Presently GIS is implemented in 42 provinces/cities and 10 fields of study in the scope of the National GIS project through the help of MoSTE (the Ministry of Science, Technology, and Environment).

Current status of GIS land resources database and development

Three groups of organizations are involved in GIS-based Land Resources Information Systems in Viet Nam:

- Research institutes and universities are using GIS/LRIS in research and teaching
- The National Institute of Agricultural Planning and Projections, Forestry Institute for Planning and Inventory, Department of Geology, Ministry of Industry, Petroleum Inc., and departments of Science and Environment in numerous provinces make use of GIS thematic applications. The General Department of Land Administration (GDLA) and the Army Mapping Service use GIS for topographic application.
- Among the informatics companies in Viet Nam, DOLSOFT, for example, produced WINGIS – a popular GIS program in South Viet Nam.

Many kinds of GIS software are being used in Viet Nam: ARC/INFO, PAMAP, SPANS, ILWIS, INTERGRAPH, and GEOCONCEPT. There is some software written by Vietnamese, such as POPMAP, WINGIS. Recently, AGROMA-integrated Remote Sensing and Spatial analysis for agricultural monitoring has been implemented by the PCI GEOMATICS Group (Canada). Most GISs are installed on PCs, in some institutions on workstations. Outputs are in the form of digital database or paper maps.

The National GIS project for natural resources management and environment monitoring (implemented in 42 provinces and cities and 10 fields of study) has created 16 information layers: administrative; communication; water system; topography; geology and minerals; hydrology; land use; forestry and vegetation cover; soils; potential for tourism; climate; population; culture, health care, education; environmental conditions; farming systems; and power supply.

Nguyen Nguyen Han
National Institute of Agricultural Planning and Projections, Viet Nam

LAND RESOURCES DATABASE STRUCTURE AND CONTENTS

Among the various structures designed by different institutions, the land resources database designed by the National Institute for Agricultural Planning and Projections (NIAPP) can serve as an example. It is divided into four levels: national, regional, provincial, and detailed. The several levels contain the following layers.

- National (scale 1/1 000 000): Soil map (FAO/UNESCO classification), temperature, rainfall, land mapping units (Land use evaluation), land, land use planning, geomorphology, geo-hydrology, climate, inundation, annual flow, average radiation, agro-ecological zoning.
- Regional (scale 1/250 000) based on 7 economic zones in Vietnam: soil maps, land mapping units (Land evaluation), agro-ecological zoning, land use (1992), agricultural and use planning for some regions, landuse maps for the Central Highlands (1985, 1994), landuse change (1985-1992).
- Provincial (scale 1/100 000): soil maps, landuse maps, landuse maps (1979, 1989, 1994) of Srepok basin, change detection analysis of Srepok basin, suitability maps for coffee and some other crops.
- Detailed: 1/50 000 topomaps for the whole country, 1/25 000 topomaps (Red River delta, Mekong delta), 1/10 000 topomaps (Hanoi and Hochiminh city).

Metadata creation has also been emphasized. The metadata include natural resources datasets by which information is not only gathered but also transferred to decision-makers, planners, scientists and land users.

PROSPECTS FOR GIS-BASED LRIS DEVELOPMENT

GIS databases are being implementated with the objective to:

- serve the of population census and to make some related analyses, serving the problem of family planning
- contribute to management and monitoring of water resources, reforestation, and problems with the environment
- serve urbanization planning
- transform existing GIS database institutions into centres of technology transfer for information management as well as planning and decision-making.

In order to further develop GIS-based Land Resources Information Systems in Vietnam, it is necessary to:

- update existing Land Resource information Systems by producing new land use maps while incorporating remote-sensed data
- standardize the database structures
- increase the application abilities of GIS in order to support decision-making
- train GIS users.

Annex 1
Welcome Addresses

Keynote address: HON. EDGARDO J. ANGARA, Secretary, Department of Agriculture, Philippines

Honorable guests: Dr. Sang Mu Lee, FAO Representative in the Philippines, Mr.Jacques Antoine, Senior Officer, FAO-Rome, Mr. Frank Dent, Senior Officer, FAO-Bangkok, Director Rogelio Concepcion of Bureau of Soils and Water Management, Participants and delegates of the Regional Workshop on Land Resources Information Systems in Asia, Guests, Ladies and Gentlemen:

In behalf of the Republic of the Philippines and of President Estrada, we wish to extend to you our hand of welcome. We hope your short stay in the Philippines will not only be pleasant but also productive. We are both pleased and privileged to be asked to host this gathering, which we realize is a very important conference for our region. The region, as you know, has probably more than its share of people. And in the next 25 years, we will have even more people to feed than any other region. So, I believe that this get-together is very timely, so that we can develop strategies and technologies that will maximize not only the productivity of our land and water resources but also in the long term, their sustainability. And so, I hope this collaboration and data sharing in international research that we are inaugurating today will result in a long-term information system network in our region.

All our countries in this region, including participants around this table, try to seek lasting solutions to the complex issues involved in sustaining agricultural development. We want to establish a network of land and water resources information system to support decision-making both government and private sectors in our countries. I am sure I speak for all countries in Asia, especially of the participants here in expressing how much we owe FAO for this initiative. FAO has been helping its member countries develop their land and water resources more efficiently and sustainably by building up an information base to monitor these resources and how they are being used. We certainly look forward to the series of reports on the world state of land and water resources for food and agriculture by country and by region.

Let me just quickly note that in the last two decades, we've seen great strides and improvement in the material quality of human life. But the advances in material prosperity are being threatened by unhindered population growth. The UN has estimated that by 2025, the world population will grow to 8.5 billion, from the present 6 billion. That is 2.5 billion more mouths that we need to take care of. These are far in excess of what cultivated soils can support from their own nutrient reserves or from natural recycling. Soils in many parts of the world suffer from multiple nutrient deficiencies brought about by monocropping, overgrazing, deforestation, desertification, shifting cultivation, to cite some of the destructive practices.

With residential, commercial and industrial users also competing increasingly and aggressively for prime agricultural land, any increase in agricultural production must depend on shrinking areas of prime lands. Bringing marginal lands into cultivation, I think, will not provide an answer because cultivating marginal lands would merely contribute to environmental degradation. It is better to set aside marginal lands for other purposes than agricultural use. The only long-term strategy, I believe, that will enable global agriculture to feed and clothe more people is for us to develop better management techniques/methods and more important perhaps, more productive technological inputs applicable to the most productive lands. In our country, we have come to realize quite late that agricultural modernization is the only way we can abolish mass poverty and achieve the full modernization of our economy. In 1997, as a member of the Philippine Senate, I headed a national commission to study Philippine agriculture; the outcome of that study is a law that we passed, called the Agriculture and Fisheries Modernization Act or AFMA. Now, I have a position as Secretary to implement what I have passed as a law in Congress.

One of the main provisions of AFMA is the mapping of all our land in this country, a technical suitability classification map. The map is formally known as National Protected Areas for Agriculture and Agro-industrial Development. That's the bureaucracy's name for it. But it is really an atlas, a land atlas of the Philippines. You can look at it and find the prime finest agricultural land, the kinds of crops it can support, etc.

It is the first baseline data and information we put together under AFMA. We could have done this early in the 90s, but only since the second half of the 90s we have had access to computer-assisted land resources information systems and GIS. In the 70s and 80s, we had to do all this manually. So you can see how difficult and tedious the job was. Now with the magic of computer and other technologies, we could put together all the data we need to take sound decisions. For instance, we have now determined and identified that we have 14 million ha of agricultural lands in our country. And out of that, 12 million ha is highly suitable for agriculture and fisheries. Two million ha can be set aside as marginal. But we did not stop at just simply defining the physical boundaries of our agricultural lands. We also want to find out where are those fine and prime agricultural lands. And so we also came up with the Strategic Agricultural and Fishery Development Zones (SAFDZ). Now we can provide any farmer or investor who wants to invest in agriculture and agri-business in this country with SAFDZ map because these zones are characterized by certain outstanding qualities. The most important is the presence of a critical mass of farmers, producers and cultivators in that zone who are entrepreneural and technology-oriented. That is the first important criterion for identifying those food baskets. The second is that the food basket zones are close to rural infrastructure: access roads, ports and airports so that we can bring the harvest quickly to the loading areas. These can be brought to market, then to the urban consumer.

Now, we did not simply identify those productive food baskets, we also got together with the local officials. We sat down with them and asked them to identify their own prime agricultural and fisheries zones. We gave them the SAFDZ data and now they are rewriting their own food security program to fit into these food basket zones, because these zones will now be the magnet of infrastructure construction. If you are located there, then we will channel and generate money for your access road or farm-to-market road or postharvest facilities.

So, we are now strengthening our national and provincial links. We try to bring the participation and involvement of local officials into agricultural development. This is a key feature in our agricultural modernization-the partnership between the national and local government units. And this appears to be successful given the short time that we have tested this scheme. One definite advantage of this partnership is that for the first time we are seeing agricultural provinces and towns setting aside money for agricultural development. In the past there were only a few governors and mayors who were agriculture-oriented. Many were public works-oriented: school buildings, waiting shed but not rural farm-to-market roads, irrigation canals.

It is in this context that we are pursuing a modernization program of our agriculture and we thank FAO for choosing us to host this workshop. This workshop focuses on methodologies for preparing technical reports and on techniques of disseminating agricultural information, including the use of modern electronic communication tools. This will undoubtedly help along our programme through sharing of national experiences and insights led by more advanced countries. We support wholeheartedly and fully the exchange of information, expertise and experiences in the region. I hope that this workshop will spark sustained regional cooperation in this field.

In closing, let me thank once again FAO (Rome, Bangkok and Philippines) for choosing us to host this workshop. I know that we were given a short time to organize this and I hope that you will understand if there are some deficiencies - not on account of any desire to let you down but because of the shortness of time. Nonetheless, as I said, we hope that you will have a pleasant stay. And as we say among Filipinos "Please treat our home as your home". Mabuhay and good morning to you all.

MESSAGE: Dr. SANG MU LEE, FAO Representative, Philippines

Honorable Secretary of Agriculture, Edgardo J. Angara, Director Rogelio Concepcion of the Bureau of Soils and Water Management, Mr. Jacques Antoine from FAO Headquarters in Rome, and my colleagues from the Regional Office in Bangkok and other places in this region, distinguished guests and participants of this important Regional Workshop from many countries, ladies and gentlemen.

On behalf of the Food and Agriculture Organization of the United Nations, first of all, I would like to express my gratitude and appreciation to the Philippine Government through the Bureau of Soils and Water Management for co-hosting this Regional Workshop on Land Resources Information Systems in Asia. I would also like to join Director Concepcion in welcoming all participants, resource persons and visiting FAO staff to the Philippines.

I was informed that there are many distinguished participants from 12 countries outside this country and also from the Philippines in this Workshop. Let me also convey my compliments to the Bureau of Soils and Water Management officials that the Philippines was chosen as the venue of this important regional initiative - due to the fact that this Bureau has one of the best infrastructures in the region including a state-of-the-art national Land Resources Information System and excellent meeting facilities for the workshop.

The presence of so many eminent personalities involved in this topic in this region is a manifestation of the importance and relevance of this subject to sustainable agriculture and rural development. It is indeed heartening to note that so many knowledgeable persons have come together to deliberate on various issues of this area and exchange notes on their experiences in their respective countries, which I am sure will have some bearing on the assessment, mapping and monitoring of land in relation to food security and the preparation of the land and water reports. I am sure that you will also agree that the first responsibility of any nation to its people is to ensure adequate food so as to sustain food security. Yet many countries are finding it difficult, even impossible to do so. Where production has not kept pace with demand, nations are compelled to commit scarce foreign exchange to importing food. This reinforces the vicious cycle of debt and dependency. Although food production in the Philippines this year is generally good, it has remained inadequate in many countries, particularly in Africa. The prospects for the years ahead remain grim unless food comes first on the list of national priorities and world leaders commit themselves to implement the World Food Summit Plan of Action through their national action plans.

Since its foundation on 16 October 1945, FAO has pursued the major goals of ensuring food security and improving the conditions of rural populations alongside those of conserving natural resources and the environment. This has not always been sufficient and we all know that erosion is outpacing erosion control and annual rates of deforestation are far in excess of area reforested. It cannot be denied therefore that our efforts have largely failed to eliminate these problems.

With increasing populations and changing economic structures the threshold of tolerance of the natural resources has been exceeded. We have therefore largely failed to control the deterioration of the natural resources. As mentioned elsewhere, it is only recently that we have come to know the reasons for this failure; in the past, we have attempted to rectify the symptoms and not the true causes. The situation has however been worsening and is directly linked with an increasing number of poor rural people and inequitable distribution of wealth.

How can the poor people be expected to care for their natural resources and worry about future generations when their immediate survival is at risk? Thus the true enemies for natural resources degradation must be seen and must be acknowledged at all levels - they are poverty and social inequality, as you know very well.

Management and conservation of natural resources at national level will be the key issues and unless a solid policy is established and politically accepted, efforts and resources will continue to be wasted. FAO's approach to sustainable agriculture and rural development is therefore inspired by considerations of human needs and production incentives. Natural resources should be managed by people to safeguard their wellbeing and should emphasize the social and economic aspects, rather than only the technical dimensions. We are, therefore, of the view that sustainable development and safeguarding the natural resource base can only be promoted through a well-defined policy framework and facilitating legislation and institutions that secure the following of these elements.

First, food security by ensuring an appropriate and sustainable balance between self-sufficiency and self-reliance; second, employment and income generation to eradicate poverty in rural areas; and third, natural resource conservation and environmental protection.

At the national level, an overall policy framework to promote sustainable development while safeguarding the natural resource base should have the following goals.

First, to create an overall economic environment conducive to growth with equity;

Second, to create an overall policy environment that enables and encourages people's participation and addresses gender issues;

Third, to establish an appropriate policy for human settlement which exploits the benefits of urbanization and ruralization;

Fourth, to establish a population policy such that growth should stabilize given the current knowledge of the stock of natural resources and the technologies available to exploit them;

Fifth and lastly, to induce changes in consumption pattern and lifestyles and to reduce wastage and ease pressure on the resource base and the environment.

Over the last three decades, the world has seen different strategies to achieve these goals, an enhanced dialogue and awareness of the need to conserve natural resources. During 1960-72, there was an urgent need to raise local agricultural productivity in countries where it was most needed. In the period 1972-86, new issues related to the degradation of the world's resources through soil erosion, deforestation, overgrazing, over-exploitation of resources and other abuses emerged. From 1987 to where we stand today, we have witnessed the Den Bosch Conference on Agriculture and the Environment held in April 1991. The Den Bosch declaration indicated the steps that need to be taken to keep agricultural practices in line with sustainable production. Such steps include first, the alleviation of poverty, second, the need to recognize the key role of women in development, third, the need for more equitable land tenure arrangements and fourth, more balanced human settlement and population policies.

Conservation and development are interdependent and it is not by coincidence that the term sustainable development was underscored in the World Conservation Strategy in 1980's. This was followed by Our Common Future in 1987 and Caring for the Earth in 1991. And also followed by the UNCED of June 1992 which focused on Conservation and Management of Resources for Development. To cap it all, the Member Countries at the World Food Summit held in FAO Headquarters in Rome in November 1996 approved seven commitments which include participatory and sustainable development.

The common denominators of these strategies that have been developing over some time are the critical requirements of implementable and affordable conservation and development policies at the national level and the need to secure the participation of the people through the organizations of their local communities.

It is in this broader and historical context and within the scope of sustainable agriculture and rural development that I have the honor to re-state FAO's commitment and support with encouragement for the work that lies ahead. In the light of the foregoing, I would like to assure the participants of today's Regional Workshop on Land Resources Information Systems that FAO is anxious to continue the support for this and similar efforts geared towards food security and the sustainable management and development of natural resources.

Finally, I wish you brainstorming discussions that will allow you to tackle a number of difficult issues and give us a fruitful result within the framework of food security and sustainable agriculture and rural development. I have no doubt that your deliberations will form the basis for effective and well coordinated activities to conserve the natural resources and also foster Technical Cooperation among developing countries. I wish you all the best. Marami pong salamat sa inyong pakikinig!

WELCOME REMARKS: DR. ROGELIO N. CONCEPCION, Director, Bureau of Soils and Water Management

Good morning to everybody. Honorable Secretary Edgardo Angara, Frank, my friend from Bangkok, Jacques Antoine, our expert from Rome, Mr. Sang Mu Lee, Resident Representative, Fellow participants from Asian countries, Fellow participants from the Philippines, My colleagues from the Bureau of Soil. Good morning. Magandang umaga sa inyong lahat.

When we were asked by FAO to take over this program which supposed to be held in Bangladesh, we said yes. And we tried to assemble as best we can and I am very glad that all of us are here. I would like to thank everybody for spending their precious time and enjoying this particular very important occasion which is the regional Workshop on LRIS in Asia.

I am sure the information to be gained is very critical for all of us, especially now that population growth is outpacing crop production. I am sure that the information coming out of this forum will allow us to understand every step and every requirement that will be needed to mitigate the problems related to food production in Asia. It is equally important to know that this forum will allow us to understand areas that will be insecure with respect to food sources and supply. So, this morning is very important to the Department of Agriculture. I'm sure our Department is equally appreciative of what is going on around this part of the globe. In our country, we are very much concerned with the identification, preservation and putting into use our prime agricultural lands.

On this note, I would like to welcome everyone to this forum: on behalf of the Department of Agriculture and on behalf of the Bureau of Soils and Water Management, we welcome you all. Thank you.

Annex 2
Workshop Programme

Time (Hrs.)	Speech/Topic	Speaker/Resource Person
24 January		
	Arrival of overseas participants	
Tuesday 25 January		
08:30-09:00	Registration	BSWM Staff
Opening Ceremony		
09:00-09:10	Welcome remarks and introduction of participants	MC BSWM
09:10-09:20	Welcome remarks on behalf of FAO	FAO Representative, Philippines
09:20-09:30	Inaugural Address	Representative, DOA, Philippines
09:30-10:00	Group Photo & Refreshments	
SESSION I. Development of Land Resources Information Systems		
10:00-10:20	Overview of Land Resources Information Systems in FAO	Jacques Antoine, Senior Officer, AGLL, FAO, Rome
10:20-10:40	Overview of Land Resources Information Systems in the Philippines	Dr. R. N. Concepcion, Director, Bureau of Soils and Water Management, Philippines
10:40-11:00	Land Resources Information Systems at BSWM	BSWM Staff
11:00-11:20	Land Resources Information Systems at the Philippines Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD)	PCARRD Staff
11:20-11:40	Land Resources Information Systems at the Department of Environment and Natural Resource (DENR).	DENR Staff
11:40-12:00	Discussion	
12:00-13:30	Lunch Break	
SESSION II. Development of Land Resources Information Systems (cont.)		
13:30-14:00	Land Resources Information System at BARC: Overview of Project BGD/95/006 – "Utilization of Bangladesh AEZ Database and Establishment of GIS for Agricultural Development".	M. Anwar Iqbal, NPD, GIS Project, BARC
14:00-15:00	Visit to BSWM LRIS Facilities and demonstrations of LRIS tools	BSWM Staff
15:00-15:30	Refreshments	
15:30-16:30	Discussion	all participants

Wednesday 26 January		
SESSION III. National Information on Land, Water and Plant Nutrition		
09:00-09:20	Introduction to the AGL Land and Water Gateway	J. Antoine, Senior Officer, AGLL, FAO, Rome
09:20-09:40	The Bangladesh National Report	M. Anwar Iqbal, NPD, GIS Project, BARC
09:40-10:00	The Malaysia National Report	Dr. Muhamad Radzali Bin Mispan, Research officer, SENR Centre, (MARDI), Malaysia

10:00-10:20	The China National Report	Canpeng LUO, Fujian Teachers University, China
10:20-11:00	Refreshments	
11:00-11:20	The Philippines National Report	Dr. R. N. Concepcion, Director, Bureau of Soils and Water Management, Philippines
11:20-11:40	GIS-based Land Resources Information Systems of India	TBA
11:40-12:00	Discussion	
12:00-13:30	Lunch	
13:30-13:50	GIS-based Land Resources Information Systems of Indonesia	Dr. Istiqlal Amien, Senior Soil Scientist, Center for Soil and Agroclimate Research, Indonesia
13:50-14:10	GIS-based Land Resources Information Systems of Myanmar	U Saw Hlaing, Deputy Director, Settlement and Land Records Department, Ministry of Agriculture and Irrigation
14:10-14:30	GIS-based Land Resources Information Systems of Nepal	Mr. Babu Ram Acharya, Director General, Survey Department, Nepal
14:30-14:50	GIS-based Land Resources Information Systems of Sri Lanka	Mr. H.B. Nayakekorala, Deputy Director, Natural Resources Management Centre, Sri Lanka
14:50-15:10	GIS-based Land Resources Information Systems of Thailand	Mrs. Parida Kuneepong, Soil Scientist, Department of Land Development, Thailand
15:10-15:30	Refreshments	
15:30-15:50	GIS-based Land Resources Information Systems of Viet Nam	Mr. Nguyen Nguyen Han, Head of the GIS Division, National Institute of Agricultural Planning and Projection, Vietnam
15:50-16:10	Discussion	All participants
Thursday 27 January		
SESSION IV. Guidelines for National Land, Water and Plant Nutrition Report Preparation		
09:00-09:30	Review of AGL Guidelines and the Internet Template	Jacques Antoine, Senior Officer, AGLL, FAO, Rome
09:30-10:00	Prospects for a Regional Land, Water and Plant Nutrition Report	F. J. Dent, Senior Officer, RAPG, FAO, Bangkok
10:00-10:30	Refreshments	
10:30-12:00	Discussion on national and regional follow-up action (Plan of action)	All participants
12:00-13:30	Lunch	
13:30-13:50	Report on Workshop Achievements	BSWM Staff
13:50-14:10	Report on Workshop Achievements	Antoine/Dent on behalf of FAO
14:10-14:30	Report on Workshop Achievements	Representative of Overseas Participants
14:30-14:45	Concluding Remarks	Dr. R. N. Concepcion, Director, Bureau of Soils and Water Management, Philippines
Friday 28 January		
	Overseas participants depart for home countries	

Annex 3
List of participants

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Annex 4
Guideline and profile for country reports on the state of land, water and plant nutrition resources [1]

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 15th 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.

Countries need to improve their ability to plan and monitor the use of their land and water resources in order to increase agricultural productivity while maintaining land and water quality through better use and management of these resources. 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 the use and sustainable management of these resources.

At regional and global levels, 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. For assessment of the situation, projections and decisions, consistent and easily accesible information needed by Member countries and the international community. Country-level information on land and water is the foundation for national planning and also provides the building blocks for regional and global systems monitoring 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 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 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 promoting the exchange and dissemination of information.

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[1] The full text, tables and annexes of the guideline and profile are available at the site: http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGL/swlwpnr/swlwpnr.htm.

This is the context within which the Land and water Developemnt Division of FAO (AGL), as part of its normative programme, is collaborating with other FAO units, national instutions and other partners, in building up an information base and reporting framework on monitoring and assessing the sustainability and vulnerability of present use of land and water resources in relation with food security, as well as the related aspects of national policies and policy instruments.

The purpose of these efforts is to enhance the capacity of countries to monitor the state of land and freshwater resources in terms of availability, scarcity, quality and trends in use, in order to facilitate sound decisions on their sustainable use worldwide. 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. The national report is addressed 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 within which existing information can be inserted. 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 information may be added at a later date once it 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 with indication of that methodology. The source of information should always be described.

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 more easily used by decision makers and users.

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

Special care should be taken to avoid or eliminate 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 in a river moves from one country to another. In order to avoid double counting, water information has to be cross-checked and verified between neighbouring countries.

There is need to consult and collaborate with other national and regional institutions involved in similar activities and to establish electronic communication linkages among the institutions.

The guidelines are applied to prepare country as well as regional reports in collaboration of 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 has been organizing workshops in the different regions to discuss the project, including the guidelines, and enrol countries to participate 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.

How to design and draft a National Report

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, globally, within the region and within the country.

The web site is designed as an HTML framework for the hosting of 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 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 as new country profiles become available.

Guideline for inserting information in the Internet template

A guideline has been prepared to facilitate the insertion of information in the template of the report profile. It is being used to prepare country and regionally based websites that 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 from which it is possible to start navigating through all the sections. In the Home Page (home.htm) there are eight buttons that give access to the main sections:

1. Country overview
2. Land resources
3. Water resources
4. Plant nutrient resources
5. Land cover and land use
6. Hot Spots And Bright Spots
7. Challenges And Viewpoints
8. References and search engines

Then, from each main section page, it is possible to go through hyperlinks to other pages related to specific sub-topics. A suggested report structure within each main section is given at the end of the paper.

The first modification to do 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 address: 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-organised structure throughout 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, …) 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. Nevertheless, 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 possibility for the user to navigate more rapidly and smoothly through the whole website.

A "Related Internet sites" section has been put in all the pages, with the purpose to collect hyperlinks to websites that host any relevant information about the main topics to which a page is dedicated. On 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 concerning 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 much 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 the References. It contains a bibliographic reference plus eventual links to publications, papers and articles available on the web either for viewing 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 on remote servers to files whose integrity and virus-free status are not assured).

The whole Guideline and Report Profile template 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. The archive with the French version is being prepared.

SUGGESTED STRUCTURE OF MAIN REPORT SECTIONS

1. Country overview

1.1 Geography and administrative units

Geographical location (description, localization map)

Administrative units (regions, countries, capital cities, provinces, other administrative units and areas). Include the name and the area of the different administrative units in the country.

1.2 Socio-economic features

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

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

The role of agriculture in the country's economy (trends in the role of agriculture in the economy, contribution to GDP and employment, history and institutional arrangements 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 source, present and future food demand, methods to achieve this – cropping intensity, crop diversification)

Crop diversification (crop diversification programmes, results)

1.3 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.

2. Land resources

2.1 Physiography

Geomorphology

Physiographic units (definition of physiographic units; map and area covered by physiographic units)

2.2 Soils

Soil types and distribution (soil map according to FAO classification, wherever available; area and proportions occupied by general soil types)

Soil Map legend according to FAO Classification (see Annex 2 of the Guideline and Report Profile) whenever available. Countries that are yet to convert their local soil classification data into the FAO standard classification can present their own soil classification, with a full description and clear definition of the method and systems used to classify the soils.

2.3 Agroecological systems

Agroecological zones (definition of AEZ, AEZ map): Agro-ecological Zones are land resource mapping units, defined in terms of climate, landform and soils, and/or 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) (See Annex 3 of the Guideline and Report Profile).

2.4 Wetlands, mangroves and inland valley bottoms

Location; size of wetlands, mangrove areas or inland valley bottoms; size of catchment area
Present use (bio-diversity, agriculture, water treatment and use, fuel wood, building material, tourism, pasture, fishing, etc. etc.)
Importance for the environment versus agriculture
Role of the areas in the society (food security, etc.)
Types of soil (organic, mineral, etc.)
Topography (slopes)
Hydrological situation (waterlogged, dry in part of the year, violence of flooding, water availability and quality over time and place, etc)
Natural vegetation
Pollution

If used for agriculture:
Type of management (traditional, fully equipped or controlled, etc)
When first cultivated
Cultivated all year round or only part of the year
Main crops grown per season
Who are the main cultivators
If irrigation or drainage equipment is present, what type, indication of costs, etc.
Changes noticed over the years (drying up, waterlogging, decrease or increase in fertility, etc.)
Etc. etc.
Changing role over the years (positive or negative from different perspectives, such as social, economic, agricultural, bio-diversity)

2.5 Inundation Land Types

This section is relevant only if the country has land that is seasonally inundated and regularly used for arable agriculture. Inundation land types (definition of inundation land types; inundation map, area and percentage cover of inundation land types)
Inundation land types and cropping patterns

2.6 Natural hazards

Incidence of fire, drought, floods, cyclones, type, location, frequency, damage to food crops, control methods adopted and their effectiveness.

3. Water Resources (AQUASTAT)

The following sections 3.1 and 3.2 are extracted from the FAO AQUASTAT programme. The FAO Aquastat database contain information for most countries. Therefore to avoid duplicating information and inconstencies it is advised that, instead of recording information on 3.1 and 3.2, a link be established to the FAO Aquastat home page.

3.1 Hydrography

Water resources: Surface water, groundwater, non-conventional water resources, fossil resources. Major basins (surface and groundwater).
International rivers, agreements...
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, reuse (agriculture)

3.2 Irrigation and drainage

Irrigation potential (method of calculation):
Place of irrigation/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, return form irrigation
Irrigated crops: major crops, areas and production, comparison rainfed/irrigated yields for major crops.

Institutional environment: Institutions in charge of water resources assessment, development of irrigation: mandates of the main institutions.
Legislation on water and land status, implementation.
Trends in water resources and irrigation development, constraints to development, institutional changes, perspectives.

4. Plant nutrient resources

4.1 Plant nutrient use and nutrient balance

Use of plant macro nutrients (forms 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 amount (in kilograms) of nutrients applied per hectare of arable land and yields per main food crops (also rice types) and cash crops, broken down into three important

nutrient components- N, P2O5 and K2O, as well as (where the necessary crop related information on the usage of nutrients is available) trend 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 amount of nutrients applied per hectare of arable land, broken down into main types of nutrients – fertilisers, 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.).

4.2 Fertilizer production and costs

Types of fertilizer produced locally or imported
Cost of different fertilizer products (port handling, transport price, storage price)
Fertiliser subsidies
Farm budgets in different cropping systems
Farmer cash flow

5. Land cover and land use

5.1 Land cover

Definition of land cover, land cover map and area occupied by different land cover types (Indicate classification scheme used)
Trends in land cover (the period over which the trend has occurred should be specified)

5.2 Land use

Definition of land use, land use map and area occuped by different land use types
(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 setting 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/annual crops harvested within one year (e.g. maize, rice, wheat and vegetables).
- 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)
- 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 crops (e.g. coffee, tea, grapevines, oil palm, cacao, coconut, apple, pear).

Grazing land: land used for animal production
Extensive grazing land: grazing on natural or semi-natural grasslands, grasslands with trees/ 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 areas, 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.

Notes to the area under temporary and permanent crops should provide details on area under mixed, monoculture, shifting cultivation, subsistence cultivation, large scale plantation.

5.3 Land use change

As land use is dynamic only major changes should be recorded, but the time period over which the estimate was made should be indicated.

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. 0.5-2% per year of the LUT area
0: area coverage remains ± stable as a percentage of the LUT area, i.e. change between -0.5 and +0.5% per year
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 trends (intensification of agriculture)
A change in the intensity of land use is expressed through changes in inputs, management, or cropping intensity (number of harvests per year), 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, major increase in cropping intensity, ...

Example:

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	2	2	0

5.4 Land Productivity

US$ equivalents for the average production value per hectare per year 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 should be reported as well.

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: labour (own and hired), high yielding variety/improved seeds, fertilizers, pesticides, mechanization/hire of ox, cost of irrigation (source of funds for inputs may include income from outside farm, income from livestock)
The data might be affected by several factors such as shift in government policy; subsistence/ commercial farming, illiteracy, etc.

Productivity trends: Although changes in productivity of crop and 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 or LUTs) is required here, but the period should be specified in view of variation in crop types and farming practices.

5.5 Environmental Impact of land uses

Agricultural inputs: effects of nutrient imbalance on soil fertility; the application of mixed fertilizer programmes and results.
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.
Extent of eutrophication of water bodies, soil acidification resulting and contamination of water supply with nitrate resulting from excessive levels of nutrients in the soil.

Deforestation and land management: Extent of gaseous nitrogen losses and CO_2 and methane emissions adding to the total emissions of nitrous oxide, CO_2 and methane contributing to problems of climate change.

6. Hot spots and bright spots

6.1 Hot spots: land and water constraints to sustainable agriculture

The detail of items will depend upon particular country circumstances

Identification and definition of Hot Spots – flash points or issues of concern

Problem soils (definition of problem soils, localization map and area 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 and/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 hectare 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 of 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 hectare per year).Trend in the area affected by terrain deformation (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 by 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 numbers 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:
Agricultural prime land encroachment/land conversion
Land tenure and land policy
Conflicts in land use
Abandonment of land because of salinity or other kinds of degradation
Resettlement/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 agrochemicals and pollutants
Genetic erosion and biodiversity depletion (risk areas)

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

The detail of items will depend upon particular country circumstances. Some examples are indicated below.

Available lands for sustainable agricultural development

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

Examples and perspectives of sustainability of production systems: sustainable land use systems. Success stories in land use

Land care programmes. Number and type of farmer organisations 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, soil conservation tillage, use of special inputs (manure, lime) etc.

Sustainable use of water resources (Response indicators):
Implementation of schemes to provide adequate drainage and ensuring 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 intensive crops
Review of policies about the pricing of irrigation water or of energy for water pumping.

Sustainable use of nutrients (Response indicators):
Implementation by governements of policies, e.g. price policies, and 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 (farmers' field schools).

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

New technologies (biotechnology etc.)

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

7. Challenges and 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).

8. References and search engines