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LAND RESOURCES INFORMATION SYSTEMS IN THE CARIBBEAN

Food and Agriculture Organization of the United Nations

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Proceedings of a Subregional Workshop held in Bridgetown, Barbados 2-4 October 2000

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
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Preface

A Subregional Workshop on Land and Water Resources Information Systems (LWRIS) in the Caribbean was held in Bridgetown, Barbados, 2 – 4 October 2000. The meeting was part of the first Annual Technical Meeting of the Caribbean Land and Water Resources Network (CLAWRENET). This meeting was held in collaboration with the Caribbean Agricultural and Research Development Institute (CARDI), the Inter-American Institute for Cooperation on Agriculture (IICA), the Technical Centre for Agricultural and Rural Cooperation (CTA), the International Service for National Agricultural Research (ISNAR) and the Brace Centre for Water Resources Management of Mc Gill University. The purpose of the meeting was to launch the network and to promote the use of land and water resources information systems in the assessment, mapping and monitoring of land and water resources in the Caribbean. The workshop was attended by 38 participants, including 15 from Caribbean countries and seven resource persons from Costa Rica, Malaysia, Trinidad and Tobago, Barbados and the United States of America. The resource persons contributed by sharing their experiences from their respective countries and organizations and assisted in the preparation of the plan of action to promote future reporting and exchange of information in the region. Each country reported on the progress in preparing its national report on the state of Land, Water and Plant nutrition resources, using the FAO guidelines. It was proposed that each country should be responsible for updating as and when new information becomes available. The Technical Officer in the Subregional Office will send annual reminders to the Regional Coordinator of the network, and the coordinator in turn will contact all countries at the end of each year to solicit any new information. It was suggested that CARDI through its PROCICARIBE Secretariat should serve as the coordinating unit with the various countries on LWRIS activities and that FAO should provide technical support, training and funding, where necessary and possible, to ensure the preparation of the reports.

Acknowledgements

These proceedings were compiled by Ms. Lystra Fletcher-Paul and Mr. Jacques Antoine and edited by Mr. Robert Brinkman. Thanks are offered to the persons who made valuable contributions to the workshop, particularly Misses Aurora Devers-Noguera and Kathleen Gittens of CARDI and Messrs. Mike Broten and Sachimine Masui.

Contents

Acronyms

AEZ	Agro-ecological Zoning
AGL	Land and Water Development Division, FAO
APT	Agricultural Planning Tools
ALES	Automated Land Evaluation System
BARC	Bangladesh Agricultural Research Council
CARDI	Caribbean Agricultural Research and Development Institute
CARICOM	Caribbean Community
CATIE	Tropical Agricultural Research and Higher Education Center
CDB	Caribbean Development Bank
CDE	Centre for Development and Environment, University of Bern
CFRAMP CARICOM	Fisheries Resource Assessment and Management Programme
CLAWRENET	Caribbean Land and Water Resources Network
COAG	Committee on Agriculture, FAO
CPACC	Caribbean Planning for Adaptation to Global Climate Change
CSIC	Superior Council of Scientific Research, Spain
CTA	Agricultural Technical Centre (E.U.; Wageningen)
DEM	Digital Elevation Model
DLD	Department of Land Development, Min. Agric. and Cooperation, Thailand
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GIS	Geographic Information System
ICLARM	International Center for Living Aquatic Resources Management, Philippines
IIASA	International Institute for Applied Systems Analysis, Vienna, Austria
IICA	Inter-American Institute for Cooperation on Agriculture
IPGRI	International Plant Genetic Resources Institute, Rome
ISNAR	International Service for National Agricultural Research, The Hague
ISRIC	International Soil Reference and Information Centre, Wageningen

LRI	Land Resource Inventory
LRIS	Land Resource Information Systems
LWRIS	Land and Water Resources Information Systems
MAFF	Ministry of Agriculture, Forestry and Fisheries
MCDS	Multi-Criteria Decision Support
MCMA	Multi-Criteria Model Analysis
OECS	Organization of Eastern Caribbean States
OSS	Observatoire du Sahara et du Sahel
PROCICARIBE	Agricultural Science and Technology System of the Caribbean
RELMA	Regional Land Management Unit, Kenya
SARD	Sustainable Agricultural and Rural Development
SDBM	Multilingual Soil Database Programme Suite
SLAC	FAO Subregional Office for Latin America and the Caribbean
SNAP	Soil Nutrition and Agricultural Productivity
SOTER	Soils and Terrain Database
SWC	Soil and Water Conservation
TAC	Technical Advisory Committee of the Consultation Group for International Agricultural Research
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UWI The	University of the West Indies
WAICENT	World Agricultural Information Centre, FAO
WOCAT	World Overview of Conservation Approaches and Technologies

Summary report and recommendations

Background

Historically, agriculture has played a dominant role in the economies of the member states of the Caribbean, and particularly in the Eastern Caribbean. In Dominica, for example, agriculture's contribution to GDP was 20.5 percent in 1994 and in many countries it is a main foreign exchange earner and employer of the labour force. However, Caribbean agriculture faces a number of challenges. Foremost among these is globalization, which has resulted in declining fortunes for the banana and sugar industries of most countries. The role that agriculture will be required to play in the future economic development in these countries is now more critical than ever.

A number of regional and sub-regional initiatives are being pursued to ensure that substitute agricultural enterprises make an optimal contribution to the region's economic development. Some of these initiatives include the exploitation of agriculture for food security, for import substitution, to earn foreign exchange for national needs and as a source of revenue for countries with limited fiscal options. Linkages between agriculture and tourism, including eco- and agri-tourism, are also being pursued vigourously.

To address these challenges, the member states of the Caribbean Community, CARICOM, have embarked on a Regional Transformation Programme for the agricultural sector, which seeks to address the competitiveness of the sector. At the sub-regional level, the Organization of Eastern Caribbean States, the OECS, has formulated a Strategic Plan of Action to improve the effectiveness of the OECS agricultural Diversification Programme. This plan was approved by the OECS Ministers of Agriculture and has identified land use and land zoning as essential elements of the Diversification Programme. The region also needs to develop mechanisms to identify marginal or idle lands, which can be used in the diversification effort.

The stakeholders in water resources have indicated the need for a co-ordinated approach to the management of this resource for agricultural development. High levels of wastage, inefficient water use in the agricultural sector and pollution of watercourses are growing problems for most countries. Additionally, poor land use and land management practices have entailed degradation of watersheds, forests, farms, aquifers, coastal zones, fisheries and coral reefs, all of which affect the Caribbean environment and its peoples.

With respect to plant nutrient resource management, most farmers apply high levels of inorganic fertilizer to their commercial crops; the rates of application of these fertilizers are based on trials conducted over 30 years ago. Despite declining crop responses to increasing levels of fertilizer, farmers continue to invest large sums of money into this input, thus suffering economic losses and causing pollution of ground and surface waters. There is very little information on the availability of alternative sources of plant nutrients, nor is there a scientific approach to the application of plant nutrients to crops.

The National Environmental Action Plans for the Caribbean countries as well as the stakeholders at several levels in the society have stated the need for a coordinated approach to

land, water and plant resource management for agricultural development in the Caribbean Region. In 1998, the first CLAWRENET working group met in St. Lucia and identified a number of priority projects to be developed and implemented. Among these was the collection and dissemination of information on land and water resources as well as promotion of public awareness of natural resources management. This workshop is an initial step in these efforts, bringing together key national representatives involved in land and water resources management, to examine national and regional constraints and to develop national and regional programmes of work.

The meeting was held in two parts (Programme in Annex 3). The first part comprised the presentation of technical papers that will be compiled into a publication on natural resources management in the Caribbean and published by PROCICARIBE. The second part of the meeting, reported in this volume, dealt with the issue of land, water and plant nutrient resources information systems.

Objectives

The overall objective of the Regional Workshop on Land and Water Information Systems in the Caribbean is to formally establish CLAWRENET and to hold technical consultations on land and water resources management and specifically on land and water information systems.

Workshop attendance

Land and Water Resources Specialists from Antigua and Barbuda, Barbados, British Virgin Islands, Cuba, Dominica, Grenada, Guyana, Haiti, Jamaica, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname and Trinidad and Tobago attended the meeting, as well as experts and resource persons from several institutions (Annex 4).

Workshop activities

Inaugural Session

Dr. Lystra Fletcher-Paul, Integrated Natural Resources Management Officer, FAO Subregional Office for Latin America and the Caribbean (SLAC), chaired the opening ceremony. There were welcome remarks by the Executive Secretary of PROCICARIBE and the Representative of IICA. The FAO Subregional Representative presented the Welcome Address (Annex 1). The keynote address was presented by Dr. Chandra Madramootoo, Director of the Brace Centre for Water Resources Management of McGill University, Canada (Annex 2).

Technical presentations

Jacques Antoine, Senior Technical Officer, Land Resources, presented an introduction to the AGL Land and Water Gateway. In his presentation, Dr. Antoine indicated that the Land and Water Development Division (AGL) of FAO manages the land and water resources information system and that AGL has developed computer-based systems to analyze data and generate information to support decisions on various land and water issues. The following five (5) tools are used as a means to store and analyze information and generate and disseminate information products for land and water resources management:

i. Database tools
ii. Model tools
iii. Decision support tools
iv. Documents and Publications
v. Multi-media tools.

Details of the information systems can be found at the following internet site: http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGL/Aglhomep.htm.

This presentation was followed by a demonstration of the Report on the State of Land and Water Resources by Mr. Sachimine Masui, using the websites for China and the Caribbean as examples. These sites may be viewed at the following internet site: http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGL/swlwpnr/swlwpnr.htm.

Mr. Mike Broten, International GIS Consultant, also gave a demonstration of the Bangladesh LRIS, which is used to inventory, archive, display and share spatial information, as well as analyse and model spatial information. It allows for raster (grid) based modeling; provides strong data visualization and analytical tools; has the capacity to simplify complex spatial data processing; and stores data and applications into a common format that can be easily archived and shared.

Mr. Broten's second presentation was on the Internet Map Server Technology.

Demonstrations of computer-based data and information systems

Computer demonstrations were conducted on the structure, content and functions of the FAO LRIS tools, including the AEZ software and databases and the AGL Internet Web site on Land and Water Information Systems. The LRIS for Bangladesh was also demonstrated.

Presentation of country reports on the state of land resources

Country reports on the state of land, water and plant nutrition resources were presented by National Coordinators from Antigua and Barbuda, Barbados, British Virgin Islands, Cuba, Grenada, Guyana, Haiti, Jamaica, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, and Trinidad and Tobago. Each participant gave an overview of his or her respective country, the hot spots and bright spots, and the challenges and problems encountered in preparing the report.

Status Reports

Participants were asked to give an assessment of the status of completion of their country reports, to identify the constraints to completion and to estimate the additional time required to present a preliminary report. This status report is presented in Annex 5.

Follow-up and Planning Sessions

In two working sessions on follow-up and planning, participants consulted on the way forward and the programmes of work, both regional and within each country.

Issues and recommendations from the national reports sessions

The following items represent the main issues and recommendations from the national presentations:

- Identification of resource persons. Country representatives indicated that one of the first steps in preparing the reports was the identification of resource persons from the various government and non-government agencies involved in Natural Resources Management. Some representatives stated that they had no authority to convene meetings of the various stakeholders and therefore needed government support to enable them to contact the stakeholders and request information from them.
- Identification and access to data and data sources. Another area of concern, which also resulted from the previous point was the identification and access to data. The participant from Barbados gave the example of a project currently being executed in his country, in which it took almost a year for the Ministry of Agriculture to access GIS information from the Ministry of the Environment. This access was gained only after high level communications between the Ministers concerned and still the base maps were not available.
- Data extraction, preparation and presentation. Some participants indicated that even when the data were available, they were not in a format suitable for the Internet. The data still had to be extracted, analysed and summarised before they could be posted. This required additional time and manpower, which were not available in the Ministries. It was explained that in a number of countries there was no one in the specific Department with the sole responsibility for this activity. Thus this activity was viewed as additional work for which more resources had to be obtained to hire more staff or to pay existing staff overtime to do the work. It was suggested that rather than create an additional post in the various divisions to do this work, participants should identify agencies where data processing and presentation is part of their existing work programme and seek to have the additional land and water resources data included in these work programmes.
- Accuracy and verification of data. Since the data were from various departments and agencies, participants felt that it was the responsibility of the respective department or agency to verify the accuracy of the data. However, since the National CLAWRENET Coordinator had no jurisdiction over the work of the national stakeholders, it was impossible to ensure that the data obtained were of high quality.
- Timing of completion. With the exception of the participant from the British Virgin Islands, all other participants indicated that they had had insufficient time to complete their country reports for the Workshop. This was mainly because of late notification by their respective governments of their designation as National Coordinators and consequently of their responsibility to prepare the report for the meeting .
- Gaining national and regional support. Participants felt that since the report was not part of the national work programme there was no widespread support for it. Additionally, since the Ministries had limited resources, the report was seen as a one-time effort as there was no updating capability within the Ministry. The role of the National CLAWRENET Committee was seen as a key element in addressing this problem as the committee would comprise stakeholders from all the National Organizations involved in LRIS, thus there was a greater possibility of adopting the report as their own.
- Creating awareness at all levels. To get resources to support the various sectors in updating the databases and promoting the work of the network, participants agreed that awareness must be created at all levels, particularly the level of decision-makers.

- Ownership: FAO/CARDI/National Agency. The issue of ownership was seen as another key element, which was necessary for the system to be updated on an on-going basis. Participants reiterated that the LWRIS will only be successful if it is included as part of the National Work Programme.
- Hosting of the Report. Participants indicated that although various institutions contributed data for the report, it was important to designate one institution to house it and be responsible for regular updates. In this regard, it was felt that it would be better to use the National Statistical Units rather than create new institutions to "reinvent the wheel".

WORKSHOP RECOMMENDATIONS

Recommendations were made for two main areas of work – (i) the Gateway country reports and (ii) the Regional Programme of work.

Country reports

With respect to the country reports, the group recommended that:

- CLAWRENET National Coordinators should be responsible for identifying and compiling information for the reports.
- Existing structures within the region should be used and reports should be incorporated into the work programmes of national institutions to ensure that data are collected on an on-going basis.
- The PROCICARIBE Secretariat should ensure that the Bahamas, Belize, Curacao and the Dominican Republic, which did not attend the meeting, should received a copy of the Gateway Information system and prepare a report.

Definition of the plan of action

- To address the issues raised and collect the necessary information to complete the reports, it was recommended that CLAWRENET National Coordinators develop a work programme including the following steps:
  - Form a National Committee involving representatives from the various stakeholder organizations and a national network to get other persons involved. Each representative should bring to the committee a set of information relevant to his or her area of focus, which could then be loaded onto the system. The National Coordinator would then start loading information already available through their Division or the Ministry. Where maps or data are not available, areas can be left blank and other methods or maps used to illustrate the items.
  - Organize a national workshop to sensitize decision-makers and give a copy of the guidelines and the Gateway template to relevant organizations in the country.
  - Identify related Internet sites within the country and establish links to the CLAWRENET site.

- Foster shared ownership of the system by hosting available information and having the PROCICARIBE Secretariat liaise with the concerned Division or Ministry.
- The skeleton of the report should be completed and the first version of the reports for the Caribbean region placed on the Internet by December 2000. Countries should commit to obtain the necessary information to fill gaps and update the report in the future, in collaboration with the CLAWRENET Secretariat, FAO SLAC and AGL.

Regional Programme of Work

- The Workshop recommended that the following projects should form the regional Programme of Work of CLAWRENET:

  1. Development of a Land and Water Management Database
  2. GIS application for the Caribbean region: Utilization of GIS & Natural Resources Management data
  3. Training of Caribbean scientists in Land and Water Resources Management
  4. Watershed and coastal area data collection and processing for decision-making
  5. Pesticide use management in the Caribbean: monitoring of pesticides in waters and soils
  6. Publication of a text book entitled "Land and Water Resources Management for Sustainable Agricultural Development in the Caribbean".
  7. Upgrade meteorological stations in Caribbean countries
  8. Disaster preparedness and mitigation/rehabilitation programme. Issues to address include: land tenure, access, flood forecasting – real time.

- It was further recommended that CLAWRENET should develop a coherent regional programme incorporating these activities and that an integrated approach be followed rather than stand-alone, piecemeal projects, thus avoiding overlapping and duplication. Sources of funding identified so far include the CARICOM/MEXICO agreement and the EU.

Technical papers

Overview of land and water resources information systems (LWRIS) 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 data analysis and information systems 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 sub-national 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 seventies and early eighties, the systems were developed for mainframe and mini-computers. From the late eighties 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 networked PC workstations, rapid application development and multimedia tools and the Internet have opened an era of new possibilities in the development and application of the systems.

Table 1 summarises some of the main issues related to sustainable land and water resources management which concern FAO.

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 programme shells for the creation of soil, water, climate, crop and land use databases; and also some databases that have been created using the programmes. Geographic Information Systems (GIS) databases and analytical and visualisation tools for rapid production of information products are used to an increasing extent. GIS are useful because of three main qualities:

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

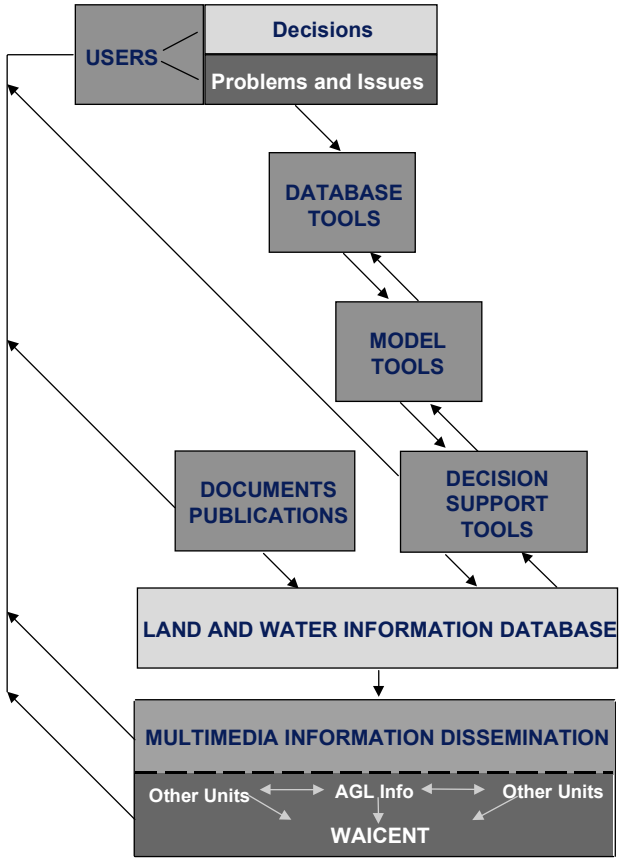
Jacques Antoine
Senior Officer, Land Resources Information and Policy Group
Land and Water Development Division
FAO, Rome, Italy

TABLE 1
Scales of land and water use planning and management

Level of analysis	Scale 1)	Issues
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 bio-diversity; 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.

FIGURE 1
Information and Decision-Support Systems in AGL



- 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- and three-dimensional locations of earth features with dynamic (time) four-dimensional processes.

2. Model tools

Models for crop growth and estimation of both potential and actual yields. Crop modeling 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 hazards.

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

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 cover and the situation and trends in implementing land management plan. In particular, they can be used to 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

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

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 that 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 that were used in the compilation of the FAO-UNESCO Soil Map of the World, and continuously enriched with new maps. These include maps 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 its database. The Centre has a direct link with FAO's main Library databases (FAOBIB and SERIAL)

and uses 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), 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 of 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, graphic, statistic and 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 information systems are provided at the following internet site:

http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGL/Aglhomep.htm

Six systems are selected and described below.

1. SDBm Plus : Multi-Lingual Soil Database

Background

The SDBm Plus : FAO-CSIC Multilingual Soil Profile Database is being developed by the Consejo Superior de Investigaciones Cientificas/ Instituto de Recursos Naturales y Agrobiologia de Sevilla (CSIC/IRNAS) with the collaboration of AGLL through a joint project. Its development is funded mainly by the Spanish Ministry of Environment through the programme SEIS.net: Sistema Español de Informacion de Suelos sobre Internet. Some financing is also provided by AGL through a letter of agreement with CSIC/IRNAS. SDBm Plus is a component of AGLL computer-based decision support tools for land resources analysis. This new database draws on the SDBm database previously prepared jointly by FAO, CSIC and ISRIC (International Soil Reference and Information Center, the Netherlands). SDBm itself was based on a programme called SDB, the original version of which was developed by FAO and ISRIC in the late 1980s.

Description

SDBm is a collection of programmes incorporated into a menu-based interactive user interface to enter data and manage the database. Data storage is greatly facilitated by the multilingual function providing help menus in English, French and Spanish.

SDBm is a database tool useful for storage of primary soils information assembled at national level, or data collected in subnational or local soil surveys. SDBm data are used in the computerised AEZ land evaluation systems.

Target Audience

Soil scientists, land evaluators, agricultural extension officials and environmental modellers.

Functions

Calculation of weighted averages or dominant values of selected variables by soil unit, depth range and group of soil profiles; graphic presentation of soil analysis data, such as pie chart image of relative percentages of selected groups of attributes in a given soil profile.

Data Content

Soil profile data: location and soil physical and chemical properties.

Updating procedure

AGLL in collaboration with CSIC/IRNAS, through letters of agreement

Quality Assessment

SDBm has been extensively tested in the field and quality assessment carried out through user feedback.

Database software

Dbase

Hardware platform

JBM compatible PCs

Software platform

MS-DOS (Windows Beta version now being distributed (End of December 2000) Clipper 5.2, C)

Accessability of data

CD-ROM

Number of users

About 100 worldwide

Usage rate (CD's sold/hits on website)

At least 500 copies on diskette sold or distributed by FAO. New Windows version distributed on CD-ROM and downloadable from FAO and CSIC/IRNAS web sites.

Maintained by

AGLL in collaboration with CSIC/IRNAS

Date created

1990

Language versions available

English, French and Spanish

Future enhancements

Provide spatial interpolation and mapping capability.

Responsible Officer: Jacques Antoine

URL: http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGL/agll/infotech.htm#sdbm

2. WOCAT – World Overview of Conservation Techniques and Approaches

Background

WOCAT's mission is to provide tools that allow Soil and Water Conservation (SWC) specialists to share their valuable knowledge in soil and water management, that assist them in their search for appropriate SWC technologies and approaches, and that support them in making decisions in the field and at the planning level.

WOCAT was established as a global network of SWC specialists. It is organized as a consortium of national and international institutions and operates in a decentralized manner. (*core members are CDE - Centre for Development and Environment, University of Bern; DLD-Department of Land Development, Ministry of Agriculture and Cooperatives, Thailand; FAO; ISRIC- International Soil Reference and Information Centre, The Netherlands; OSS - Observatoire du Sahara et du Sahel, Tunisia; and RELMA - Regional Land Management Unit, Kenya*)

A set of three comprehensive questionnaires and a suite of databases have been developed to document all relevant aspects of SWC technologies and approaches, including area coverage. These tools have been tested in many workshops worldwide, and they have been systematically optimised for five years through application in a context of international expertise. WOCAT results and outputs are accessible via the Internet, in the form of books and maps, or on CD-ROM.

The WOCAT knowledge base is in the public domain, i.e. everyone is invited to share it and use it. The WOCAT network is open to all individuals and organizations with a mandate or an interest in SWC.

System name

WOCAT Technologies Database (this is the major part of a suite also including the WOCAT databases: *WOCAT Approaches Database, WOCAT Images Database, WOCAT Addresses Database)*.

Description

At the field level, SWC specialists work under very different bio-physical, socio-economic and institutional conditions. They search for SWC technologies successfully practised elsewhere under a set of similar conditions. Querying the WOCAT Technology database will return technologies that are most likely adaptable to their specific situation and needs.

Target Audience

Soil and Water Conservation (SWC) specialists and decision makers searching for appropriate SWC technologies and approaches supporting them in making decisions in the field and at the planning level

Functions

The query system provides access to SWC technologies at various points. The 27 search criteria (21 criteria in the www-version) comprise, for example, agro-ecology, climatic and slope conditions, degradation processes to be tackled, farming systems, cost and input levels. Thus, a choice can be made among relevant SWC options.

Data Content

Presently, the results of approx. 50 SWC Technology questionnaires (mid 2000).

Updating procedure

Soil and Water Conservation Technologies data are gathered during WOCAT workshops by means of an approx. 50 pages questionnaire. These data are then verified and entered into the WOCAT Technologies Database (MS-ACCESS version) and subsequently uploaded into Oracle via an automated procedure, thus becoming available in the www version.

Database software

CD-Version: MS-ACCESS 97
www-Version: Oracle

Hardware platform

CD-Version: IBM compatible PCs
www-Version: FAO web server environment

Software platform

CD-Version: MS-ACCESS 97
www-Version: HTML and ASP (Active Server Pages)

Usage rate (CD's sold/hits on website)

500 WOCAT CD-ROMs (version I) were produced in 1998 and distributed within weeks; distribution of the 2000 copies of the new version II started October 2000. Web access is not being monitored yet as the www.wocat.net site was not yet fully implemented before mid-January 2001.

Maintained by

AGL in Cooperation with the Centre for Development and Environment of the University of Berne, Switzerland

Date created

Data collection of SWC questionnaire data started approx. 5 years ago as a set of MS-WORD documents. The first WOCAT database was presented 2 years ago. The www version was introduced this year.

Language versions available

CD-version:Trilingual, English, French, Spanish
Web-version: English only

Future enhancements

Trilingual web version

Responsible Officers: Rod Gallacher and Wolfgang Prante

URL: http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGL/agll/wocat.htm

3. AQUASTAT - Information system on water in agriculture and rural development

Background

In 1993, FAO initiated an activity to meet the considerable demand for data on rural water use from national governments and development agencies. This resulted in the AQUASTAT Programme, the objective of which is to generate data at country and sub-country level in a systematic and standard form. The programme currently contains data on Africa, the Near East, Former Soviet Union, Asia, and Latin America and the Caribbean.

System name

AQUASTAT

Description

The system presents a description of the rural water situation in Africa, Near East, Former Soviet Union, Asia and Latin America and the Caribbean. The information is presented as regional surveys and country profiles in 5 FAO-publications containing charts, tables, graphs and maps. All information, except for the survey on Latin America and the Caribbean is also available on the World Wide Web.

Target Audience

FAO and other international agencies, academic institutions and general public.

Functions

Provides information on the state of water resources and use at global, regional and country level in relation to agriculture and food security

Data Content

More than 100 variables on water resources, irrigation and drainage

Updating procedure / quality assessment

Ad-hoc by AGLW officer and feed-back from the field.

Database software

HTML / Oracle (planned)

Hardware platform

Web server

Software platform

HTML

Accessability of data

Through FAO publications and on the Internet

Maintained by

AGLW

Date created

1995

Language available

English, French and Spanish (planned)

Future enhancements

Global directory on institutions dealing with water in agriculture; coverage of OECD-countries; statistical and query functions; expansion of the system through on-line map viewing and map query facilities.

Responsible officer: Jean-Marc Faures

URL: http://www.fao.org/ag/AGL/aglw/aquastat/aquastat.htm

4. Gateway to Land and Water Information

Background

The World Food Summit in November 1996 and 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 Sustainable Agricultural and Rural Development (SARD).

FAO needs to monitor and project the capacity to produce the food required in the future at regional and global levels, and also the domestic potential in the least developed countries with inadequate food supplies and limited market demand. Member countries and the international community need consistent and easily accessible information for assessment of the situation, projections and decisions. Country-level information on land and water is the foundation for national planning and also provides the building blocks for regional and global 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 COAG committee recognized the need for periodic reporting on the State of The World's Land and Water Resources, synthesising 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.

This is the context within which the Land and water Development Division of FAO (AGL), as part of its normative programmeme, is collaborating with other FAO units, national institutions and other partners in building up this land and water information Gateway.

Description

The Gateway is designed as a globally networked information base on the present use and the trends in use of land and water resources in relation with food security.

It is meant to contain national and regional reports on the state of land, water and plant nutrition resources management in FAO member countries. The reports are compiled in the form of a digital atlas to be made available through the Internet and on CD-ROM.

Target Audience

The reports are addressed to FAO Governing bodies, planners and decision makers in Government ministries, donor agencies, researchers and University students, but also to the public at large.

Functions

The Gateway has two functions:

1. An access point to global, regional and national reports compiled by FAO and participating institutions worldwide

2. An entry point to the worldwide web of information on land, water and plant nutrition and related subjects.

Data Content

Text, maps, charts, tables and photos.

Updating procedure

AGLL maintains and updates FAO internal links and global links and organises such links. The network institutions are responsible for updating the national and regional information, and together with users are expected to participate in amplifying possible new links by using the feedback function of the site.

Quality Assessment

AGLL assists in reviewing reports prior to posting on the sites. The feedback function of the AGLL site is also intended for gathering comments and suggestions on improving the quality of the reports.

Database software

Various

Hardware platform

IBM compatible PCs

Software platform

Windows NT and Windows 95/98
HTML 4.0

Accessibility of data

Internet

Number of users

Potentially: 10,000-20,000 worlwide

Usage rate (CD's sold/hits on website)

Number of hits at FAO site: 500/month

Maintained by

AGLL in collaboration with participating network institutions

Date created

1999

Language versions available

English and Spanish, (French in preparation). Country reports in several languages

Future enhancements

The Gateway site has recently been redesigned and is continually being upgraded to increase interactivity and access to information and improve information quality standards. It is planned to gradually expand the network to include most countries in Africa, the Near East, Latin America and the Caribbean, Asia and the Pacific Islands.

Responsible Officer: Jacques Antoine

URL: http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGL/swlwpnr/swlwpnr.htm

5. AEZWIN :Agro-Ecological Zoning System

Background

Since the early 1980s, FAO and the International Institute for Applied Systems Analysis (IIASA) have been collaborating on expanding FAO's Agro-Ecological Zones (AEZ) methodology of land resources appraisal by incorporating computer-based decision support tools for optimizing the use of land resources. Agro-ecological zoning involves the inventory, characterization and classification of land resources for assessments of the potential for agricultural production systems.

This effort culminated in the publication in 1994 of AEZ software for MS-DOS PCs for national and sub-national applications, based on a Kenya AEZ study. The decision support tools included in the software consisted of the application of linear optimization techniques for analysing land use scenarios with regard to single-objective functions, such as maximizing agricultural production or minimizing the cost of production under specific physical environmental and socio-economic conditions and constraints.

AEZWIN is an upgraded, multi-objective version for WINDOWS 95 and NT of the Kenya AEZ software.

Description

AEZWIN is an interactive multi-objective and multi-criteria analysis tool for land resources appraisal. When evaluating the performance of alternative land utilization types, often the specification of a single objective function does not adequately reflect decision-makers' or stakeholders' preferences, which are of a multi-objective nature in many practical problems dealing with resources. AEZWIN implements interactive multi-criteria model analysis (MCMA) in the analysis of AEZ models.

The software package is a specialised tool meant primarily for two kinds of use:

1. Land resources appraisal studies for land use planning and management.

   Capability to adapt the system to the user's needs and to develop the required databases and scenarios is a prerequisite to use the software in projects and studies.

2. To teach and research the AEZ methodology of land resources appraisal.

   Good knowledge of the FAO AEZ methodology, as described in the Kenya AEZ reports, is required in order to use the system.

Target Audience

Land use specialists, agricultural and environmental planners in Government ministries and research institutions, University teachers, students and researchers.

Functions

The software incorporates the FAO AEZ methodology, a Linear Programmeming package and a multi-criteria analysis tool. The AEZ models are applied on a land resources database to analyse potentials of land for various kinds of use. The main functions include: database management, calculation of length of growing period, irrigation requirements, crop biomass, land suitability and productivity analysis, multi-objective and multi-criteria optimization.

Data Content

AEZWIN databases integrate various kinds of geo-referenced data sets generated using a GIS, and which can include the following:

- topography; administrative boundaries; road and other communications; towns and settlements; rivers and water bodies; geology; soils; physiography; landforms; erosion; rainfall; temperature; moisture regime; watersheds; irrigable areas; land use/land cover and forest reserves; population, fertilizers, seeds, labour and other inputs, production cost, crop prices, income, etc.

Updating procedure

AGLL in collaboration with IIASA, through letters of agreement

Quality Assessment

The software has recently been reviewed by two visiting scientists and is continually assessed through user feedback.

Hardware platform

IBM compatible PCs

Software platform

Windows NT and Windows 95/98
FORTRAN and C++ and GIS (IDRISI)

Accessibility of data

Off-line

Number of users

About 50 (estimated) worldwide, but number continuously increasing

Usage rate (CD's sold/hits on website)

At least 700 CDs sold or distributed by FAO. Number of hits at FAO and IIASA sites from where the software can be downloaded still to be determined

Maintained by

AGLL in collaboration with IIASA

Date created

1991

Language versions available

English

Future enhancements

The software reviews show that there is a need to:
- improve user interface
- provide interactive help facility

Future development of AEZWIN depends on the possibility of further collaboration with IIASA or other partners. AGLL does not have the in-house capability to maintain alone such a complex package.

Responsible Officer: Jacques Antoine

URL: http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGL/agll/aez.htm

6. GAEZ - Global Agro-ecological Zones 2000

Description

Documented methodology to evaluate the productive capacity of the land resource based on its soil, terrain and climatic characteristics, applied to the whole world. Many data, maps, pictures etc.

Target Audience

Crop growth simulation modellers, Universities, regional and environmental planners. Perspective studies on agriculture, food security, global climatic change.

Functions

Provides a global inventory of (agro)climates, soil and terrain conditions and evaluates land resources potential and constraints and productivity possibilities for more than 250 combinations of crop and management level.

Data Content

Global Soil and terrain constraints for agriculture. Global Climatic data parameters. Potential productive land by country. Suitability for each crop considered by country. More than 100 maps and tables downloadable and compatible with report and GIS (IDRISI/Arc/INFO) requirements

Updating procedure

Jointly with IIASA. Will only be undertaken if one of the major layers is updated (climate or soil most likely).

Quality Assessment

Feedback from users. Earlier models tested. Quality depends partly on resolution and base material which can only be improved slowly. Warnings included.

Database software

Most maps are in bnm format and can be viewed on screen, all tables are in EXCEL. All maps also come in Arc/Info and IDRISI compatible formats.

Hardware platform

Pentium PC with Windows 95/98/NT with browser installed.

Software platform

GIS software (IDRISI or Arc/Info for maps)

Accessibility of data

On CD-ROM and via web, both IIASA and FAO: http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGL/agll/gaez/index.htm http://www.iiasa.ac.at/Research/LUC/GAEZ/index.htm

Number of users

Potentially 5 – 10 000 scientists plus organizations such as World Resources Institute, IFPRI, World Bank.

Usage rate (CD's sold/hits on website)

1500/month (IIASA website since August)

Maintained by

AGLL and IIASA

Date created

August 2000 on the web. December 2000 on CD ROM

Language versions available

English only

Future enhancements

A number of related products are being prepared for additional data release and for publication as a FAO Soils Bulletin and IIASA Research Bulletin.

Responsible Officer: Freddy Nachtergaele

7. Country application of AEZ/LRIS

The AEZ system has been applied in various countries in the last two decades. An example of a current application in a Latin America regional project can be viewed in a slide show on the AGL web site at the following address:

http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGL/lwrisdoc.htm

Demonstration of *Gateway to Land* and *Water Information* on the Internet

This text is based on the Gateway Home page revised after the Caribbean workshop. The demonstration made at the Workshop was based on the previous version, but was executed with the same concept and similar content as the present format. The following text is mainly an extract from the Gateway Home page, but has been further modified for specific application to the Caribbean region. The Gateway can be accessed :

http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGL/swlwpnr/swlwpnr.htm

The purpose of the gateway

The overall purpose of the Gateway is to inform the world community on the state and trends of land, water and plant nutrition management at national, regional and global scales. The Gateway has two functions (Table 1): to provide access to national, regional and global reports by national institutions, FAO and others; and to facilitate entry to the worldwide web of information on land, water, plant nutrition and related subjects.

This Workshop is particularly relevant in realising the first function. However, it is anticipated that the second function will gain significance since the entire internet-based information on land and water resources is rapidly expanding. The reports produced therefore should be of such a quality that they can survive the competitive internet information environment. It is also expected that the reports will feed into, and eventually merge into, the global web and at the same time be enriched through the linkages which this global web provides. Thus, the two functions should be considered together as dynamic processes.

The Caribbean countries in the global network

The core part of the Gateway information network consists of the Global prospect, Regional and Sub-regional Reports, and Country Reports.

The Global prospect summarises the state of land and water resources and agricultural land use trends and challenges in the global perspective. The structure includes a collection of relevant worldwide Internet links.

Sachimine Masui
Associate Professional Officer
Land and Water Development Division, FAO, Rome, Italy

TABLE 1
Main functions of the Gateway to Land and Water Information

1	2
An access point to global, regional and national reports compiled by FAO and the participating institutions worldwide. This applies to the sections: · reports · what's new · feedback · contact worldwide Common process: 1. A national or regional institution is identified. 2. The institution starts compiling its report using the Guidelines and Checklist provided by FAO. 3. The draft is sent to FAO for preliminary review. 4. Final report is posted on the local website and linked to the FAO Gateway (this website). 5. The institution keeps the report updated regularly, reflecting suggestions made by FAO and through feedback from various visitors of the report.	An entry point to the worldwide web of information on land, water and plant nutrition and related subjects. This applies to the sections: · FAO internal links (FAO links) · global links by sectors (globallinks) · database · feedback Common process: 1. FAO maintains and updates FAO internal links and global links by sector and database, and organises such links. 2. The institutions working on the updating of the reports as well as users of this network are expected to participate in amplifying the possible new links by using the feedback function of the site

Each Regional or Sub-regional Report discusses regionally relevant land and water issues, in particular hot spots, bright spots and challenges identifiable in that region. It also serves as an entry point for the Country Reports, prepared by the countries within the region.

Country Reports are the principal part of the Gateway, and form the substance on which the Regional Reports are based. They are prepared by the respective country representatives and their collaborators. In the case of the Caribbean, twenty-one countries or territories are identified at the time of the Workshop:

Antigua and Barbuda
The Bahamas
Barbados
Belize
British Virgin Islands
Cuba
Curacao
Dominica
Dominican Republic
The French Territories
(Martinique – Guadeloupe - Cayenne)
Grenada
Guyana
Haiti
Jamaica
Montserrat
Puerto Rico
St. Kitts and Nevis
St. Lucia
Saint Vincent and the Grenadines
Suriname
Trinidad and Tobago

REPORT COMPILATION, STRUCTURE AND PRESENTATION

Some general aspects of report compilation, presentation and structure are briefly discussed below.

The report needs to be concise and to the point. It is part of a gateway. More important than giving much detail is to provide reliable meta-data (title, year, data provider, place of data origin, etc.), rich references and well-sorted related Internet links.

The report needs to be easily understandable, reliable and accurate in content. The information in the form of maps, tables, charts and photographic images should be comprehensible, colour should be distinguishable and legends readable. The information has to be reasonably up-to-date. This requires both constant updating in content and an indication of "when last updated". Technical terms with definitions must be clarified. Notes should be provided on how information has been generated. When the FAO approach and methodology cannot be used, data gathered by other methodologies should be used with an indication of that methodology. It is important to make sure there is no redundancy or inconsistency among pieces of information in the different forms.

The report has to be attractive. Whatever the differences in graphic and editorial taste may be, the report has to look in such a way that it encourages visitors to surf through with due comfort, curiosity and interest.

The standard structure and content of the report is shown in the Checklist : Gateway Home page > Report > Checklist. The Checklist can be partially modified to suit specific needs and pertinence to each region or country.

In summary, the report consists of eight sections:

1. Country overview
2. Land resources
3. Water resources
4. Plant nutrient resources
5. Hot spots
6. Bright spots
7. Challenges and viewpoints
8. References and related Internet links

Each section comprises several subsections.

Guidelines to facilitate compilation of the report are provided in the Report section of the Gateway Home page: Gateway Home page > Report > Guidelines, and in Annex 6 of this volume.

Each institution should prepare its own information and upload it on a local Internet server using the common HTML framework or Internet Template, thus creating an *in-situ* web site. FAO (AGL) will provide the Template on request. The site will then be networked to the Gateway through a hyperlink. FAO will update the Home Page as new country reports become available. Each institution is responsible for updating the contents of the report including the newly found related Internet links.

The Gateway facilitates access to the reports either via Region or via Country. From the Gateway home page, the following paths are available.

Gateway Home page > Report > Region List or Entry by map > Regional Report > Country Report.

Gateway Home page > Report > Entry by Country > Country Report.

GIS applications for agricultural planning in Bangladesh

In the period 1980-1987 a national Agro-Ecological Zone (AEZ) database was successfully developed in Bangladesh. The database contains information on the country's land resources, including physiography, soils, climate, hydrology, cropping systems and crop suitability. The database is housed in the Bangladesh Agricultural Research Council's (BARC) computer center at Dhaka, Bangladesh. It has been used to generate readily accessible information on the physical land resources of the country for use by researchers, extension workers and decision makers in land and agricultural resources management as well as agricultural development planning.

The AEZ database constitutes the foundation for a new effort to develop a comprehensive multiscale GIS-based Land Resources Information System (LRIS). This system is designed to better deal with the intricacies of land resource planning under the complex environmental conditions that prevail in large parts of Bangladesh. The LRIS includes additional databases and procedures, in particular data on socio-economic and demographic factors influencing agricultural production. The system is being implemented by BARC with financial support from the United Nations Development Programmeme (UNDP) and technical support from FAO.

The technology being used to establish the LRIS includes ArcView GIS, the ArcView Spatial Analyst and Dialog Designer extensions, and Avenue, ArcView GIS software's programming language, as well as multicriteria analysis tools.

Conceptual System Design

At the start of the new development efforts in 1997, an overall system design (Figure 1) was established to allow for a dynamic analysis and modeling capability. In the past, natural resources modeling systems were based on static GIS overlays. Due to the limited capacity of computers at the time, the overlay of individual maps, such as soil, climatic and flood zones was cumbersome and much time was needed to refine the resulting layer. With the advent of more powerful desktop computer systems and more powerful software tools, such as ArcView GIS and ArcView Spatial Analyst, it has become possible to develop more flexible and dynamic modeling tools.

The approach taken in Bangladesh is to create a dynamic multilayered GIS database in which the component layers are modeled as variables that change over time. Due to the inherent variability of climatic and hydrologic conditions in Bangladesh, an open-ended system that

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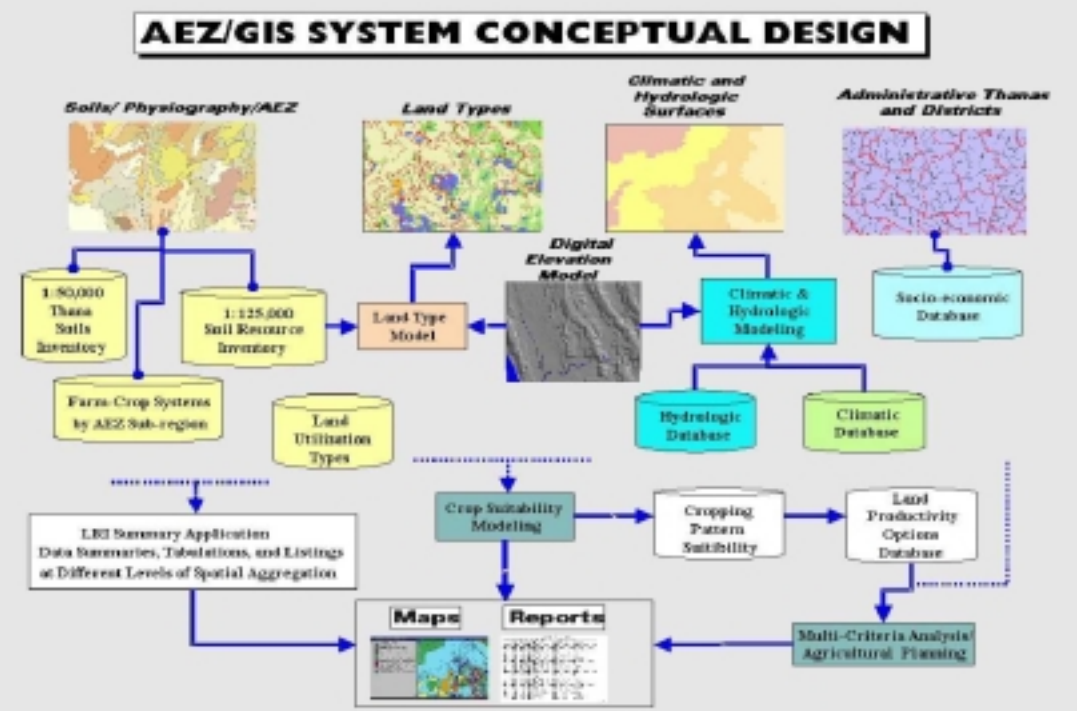
FIGURE 1
AEZ/GIS system conceptual design



allows for modeling of a wide range of dynamic scenarios, from the historical record as well as predicted future scenarios, will be of greater use and will yield higher quality results than a static system.

The land resources inventory application

The land resources inventory (LRI) application allows for the classification and mapping of soil characteristics from the LRI database. The LRI contains several attributes describing 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 merged and renamed to provide for more effective map output.

The output of this application is a new grid-based Soil Inundation Land Type layer in which the number of many-to-one relationships between soil attributes and soil mapping units is greatly reduced.

Soil/land type mapping model

An ArcView GIS-based application has been developed to dynamically combine a user-specified digital elevation model (DEM) with the national (reconnaissance level) soil association layer

to create a more detailed "Soil/Inundation Land Type" layer. The application is written in Avenue and uses the ArcView Spatial Analyst extension. It has been programmemed to handle future updating of both the soil and the DEM layers.

The first step in development of this application was to refine a previously generated 300-meter DEM by filling in areas of missing elevation with values taken from a 1,000-meter DEM. Then, an Avenue programme was written to assign soil association- and topographically-derived "inundation land type" designations to each 300-meter grid cell. In Bangladesh, the following designations are used to specify a range of inundation depths based on the average peak water depth: highland, medium highland 1 and 2, medium lowland, lowland, and very lowland (Figure 2). This new layer provides for a more explicit, accurate, and dynamic soil mapping capability.

Cropping systems

A database containing detailed information on the various cropping systems of Bangladesh has been created by this project. The database lists the cropping pattern details within each of the physiographic sub-zones of the country. Details include the approximate planting and harvesting dates for each crop, the inundation land type on which it is grown, and whether the crop is irrigated.

A GIS application named "CropViewer" was created to provide a GIS-based interface to this database. It allows the user to view the spatial distribution of each cropping pattern within a given sub-zone or for the entire country. It also "looks-up" the full name of the numerically coded crops and can create detailed maps showing the distribution of each crop.

Crop suitability model

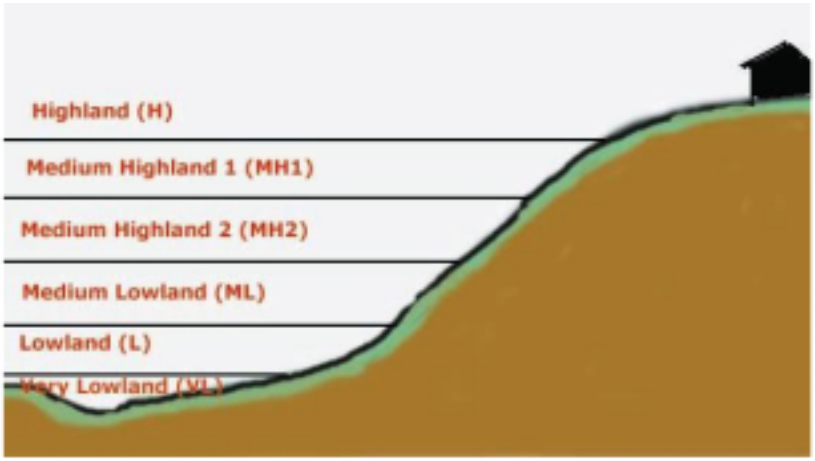
The system includes a component that permits the evaluation of crop suitability. First, individual crop suitability ratings are analysed and then suitabilities for various cropping patterns are rated using a database of known and potential cropping patterns (rotations). This suitability modeling takes into account individual crop characteristics, input/management levels, soil physical characteristics, hydrologic and climatic conditions, and seasonal variability. Extrapolations of existing cropping system technologies can also be made to delineate suitable areas on a national scale.

The ArcView Spatial Analyst and Dialog Designer extensions are used for the crop suitability modeling. A main dialog allows the modeler to specify thematic layers and other options associated with each model run.

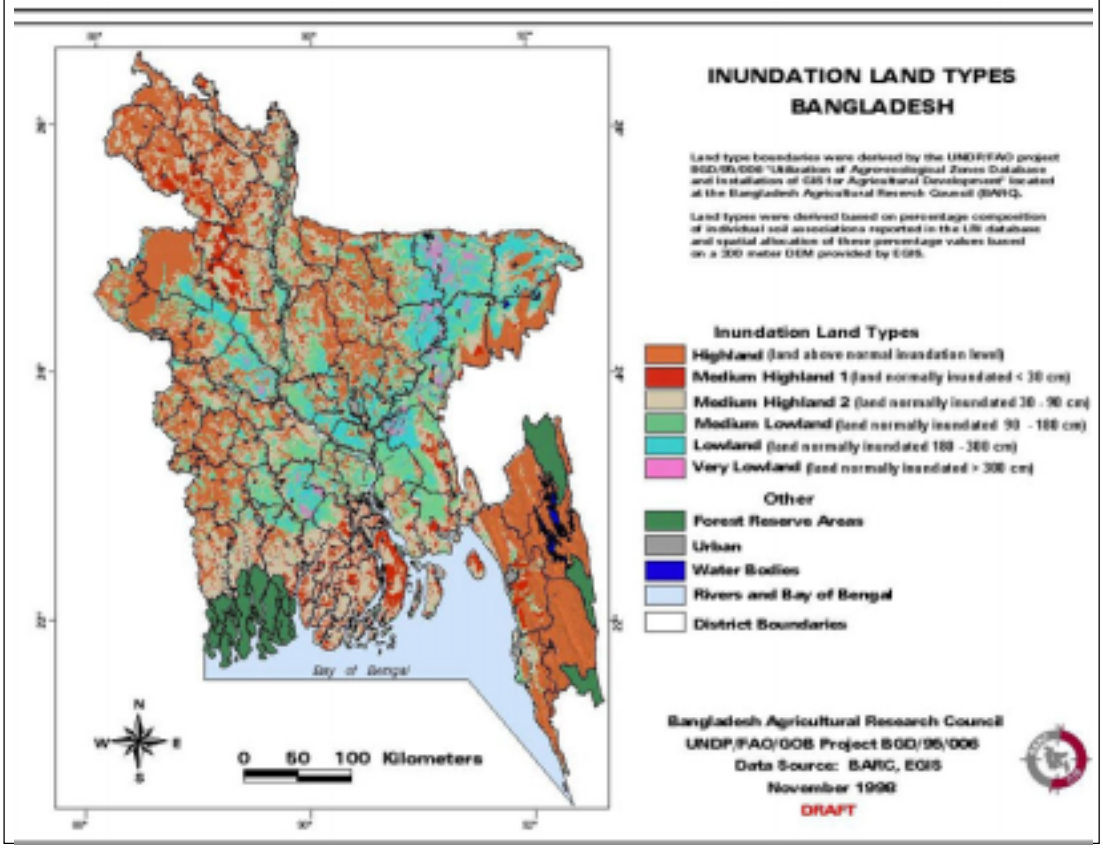
Climatic modeling

Much effort has been devoted to expand existing historical climatic data with recent records obtained from various institutions. Procedures have been developed to perform quality control and enhance database management and modeling capabilities. Meteorological station data are analysed using the APT (Agricultural Planning Tools) calculator and the resulting data are used to create GIS surfaces showing important climatic properties related to plant growth by season,

FIGURE 2
Inundation land types



Highland	(H)	Land which is above normal inundation level and would normally not develop wetland conditions unless rainwater was retained on the surface by bunding on less permeable soils
Medium Highland 1	(MH1)	Land which normally is inundated less than 30 cm deep
Medium Highland 2	(MH2)	Land which normally is inundated in the range30-90 cm deep
Medium Lowland	(ML)	Land which normally is inundated in the range 90-180 cm deep
Lowland	(L)	Land which normally is inundated in the range 180-300 cm deep
Very Lowland	(VL)	Land which normally is inundated more than 300 cm deep



such as the average starting date of the kharif (monsoon) growing seasons, as well as the variability of these properties.

Hydrologic modeling

On average, about 60 to 70 percent 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. The enhanced system now in place enables quantification of year-to-year variation in extent, depth and timing of inundation. This information will greatly improve the suitability assessment of individual inundation land types for single crops and cropping patterns.

Multi-criteria analysis model

Another primary goal of this project is the analysis of land use scenarios integrating the physical suitabilities for various cropping patterns and socio-economic factors of agricultural production. Relevant socio-economic and farming system databases are being constructed for this purpose. The analysis will 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 solver based on multi-objective linear optimization; and the application of multicriteria analysis to the core model solutions to determine compromise solutions that adequately reflect the preferences of decision-makers in real-life situations. Various software tools have been put in place for this application, and GIS plays a pivotal role in all aspects of this work.

Conclusion

- GIS provides powerful tools for agricultural planning and modeling. These tools include data automation and processing, conversion, analysis, and visualisation.
- The use of GIS ensures that data and applications are archived in a common format that can be shared and understood by others.
- Raster-based modeling can be more efficient and dynamic. A software package such as ArcView's Spatial Analyst is very useful in that its analytical capabilities are based in raster surfaces (grids) and that it allows quick conversion of vector layers into grids. The approach used in Bangladesh employs this software to allow for a very dynamic database and modelling capability. Historically, similar modeling efforts were based on static vector-based systems.
- The Bangladesh agricultural applications include several good examples of how GIS can be integrated in agricultural inventory and analysis efforts.

GIS on the Internet

GIS software technology has undergone several revolutionary changes over the past 20 years. The relatively recent expansion of internet technology is now promising to facilitate another quantum leap for GIS and other software applications. The current paradigm shift involves the migration of application software from individual desktop computers into an internet-based client/server architecture. As a result, we are now seeing large-scale development of GIS applications that can be accessed by the user through a web browser interface.

Previously, it was a simple matter to attach static map images to HTML pages and display them through the browser interface. But now, it is possible to connect the browser to a map server application that provides dynamic GIS capabilities including the following:

- Pan and zoom
- Identify functions (point at an object and retrieve its database records)
- Database query
- Control of thematic layers
- Markup and posting of comments back to the server

Map server technology includes a map server application that is run either on a server or on a computer that is directly networked to the web server. The web server software (such as MS Internet Information Server – IIS) is aware of the map server application and funnels any browser-based URL commands (from the internet) to the map server application for action. The map server then processes the URL request, generates a new map image (jpg or gif format) or database listing (html) and sends the location of those objects back to the user's browser.

Figure 1 shows an example of a browser-based zoom and query on the National Geographic's map server website (MapMachine@ nationalgeographic.com).

Major advantages of map server technology include:

- GIS client software is not required, GIS software is installed only on the server. Therefore, GIS access is free of charge (unless a charge is imposed on the server connection). However, some map servers may require installation of a plug-in to run the software.
- The client interface is the web browser. All the user needs for access is a web browser such as Netscape or Internet Explorer with a connection to the Internet.
- The end user does not need special GIS training or skills.

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FAO Consultant, GIS Specialist
California, USA

FIGURE 1
Example of a browser-based zoom and query on the National Geographic map server website (MapMachine@ nationalgeographic.com)

Country reports

Antigua and Barbuda

Within the last two years, there have been many examples of human actions that have led to land degradation in Antigua and Barbuda. Topsoil and sand from stream beds were indiscriminately mined in prime agricultural lands such as Betty's Hope, Belvederre and Christian Valley. This brought about rapid land degradation and accelerated soil erosion. The soil transported by intense rainstorms in turn silted stream channels, dams and even wetlands.

Antigua and Barbuda's coastal areas are extremely vulnerable to hurricanes, sea surges and tidal waves. During hurricane Lenny in 1999, it became evident that the roadways at Darkwood and Runaway Bay were improperly designed and located without consideration to the natural flow of seawater to the salt pond as well as the reverse flow. These wetland areas are prime nursery habitats for reef fish and other marine life forms.

Given the climate change effects within the last decade, Antigua and Barbuda can expect to experience storms and hurricanes with greater frequency and intensity in the future. This will necessitate effective and sustainable land use and development management practices.

Population increase and economic expansion will place extreme pressure on industry and agriculture to compete for scarce natural resources. Therefore the agricultural sector should send a strong signal to local government and demonstrate that lands demarcated for agriculture are, in fact, developed with appropriate infrastructure and used for crop and livestock production. Such lands, if left idle, could be lost to competing interests.

Institutional arrangements

The Public Utility Act of 1973 establishes the right of the Antigua Public Utilities Authority (APUA) to supply, allocate and manage water supplies (Table 1). This overall mandate, however, has proven to be unsustainable since the management of groundwater and surface water reserves depends on the health of the forests and lower reaches in the watersheds. It is important, therefore, that some financial support in the management of the watersheds be provided by the APUA to the Forestry and Soil and Water Conservation Divisions. It is appropriate that the water supply to the public be vested in the APUA. However, the responsibility for the allocation of water to the various sectors should be vested in an independent body to minimise conflicts of interest.

Hot spots

Waste disposal

Antigua has one solid waste disposal site, Cookes Dump, located at Cookes in the Five Islands area. This dump site borders a swamp of area 225 ha that contains mangrove trees and functions

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Soil and Water Conservation Division, Ministry of Agriculture
Antigua and Barbuda

TABLE 1
Institutional Arrangements for Management of Land, Water and Plant Resources

Agency	Ministry	Legislation	Functions
Development Control Authority (DCA)	Prime Minister's Office	Land Development and Control Act, No 15 of 1977	Review and approval of development applications; development surveillance.
Lands Division	Ministry of Agriculture	The Crown Lands (Regulation) Act (Cap 130) of 1917	Planning and allocation of government lands for residential, agricultural and other land uses; administration of Government of Antigua and Barbuda land leases and rentals.
St. John's Development Corporation	Prime Minister's Office	St. John's Development Corporation Act of 1986	Upgrading of downtown St. John's through urban renewal and implementation of other development projects (e.g. Heritage Quay, a tourism complex including shopping, hotel and cruise ship berthing facilities).
National Parks Authority (NPA)	Ministry of Tourism	National Park's Act of 1985	Development and management (including development control) of national parks, at present limited to Nelson's Dockyard National Park.
Antigua and Barbuda Port Authority	Ministry of Finance		Development and management of lands at St. John's Deep Water Harbour.
Central Housing and Planning Authority (CHAPA)	Prime Minister's Office	Slum Clearance and Housing Act (Cap 277) of 1948	At one time CHAPA functioned as Government's primary residential land allocation agency, but some of its functions have been assumed by the Lands Division, Ministry of Agriculture; Implementation of low-income housing schemes.
Barbuda Council			Responsible for the management of Natural Resources in Barbuda, however, there is some collaboration with the Central Government.
Extension Division	Ministry of Agriculture		Control rental of agricultural lands to farmers.
Antigua Public Utility Authority	Ministry of Public Utilities	Public Utilities Act (1973)	Control streams and groundwater resources.
Soil and Water Conservation Division	Ministry of Agriculture		Soil & Water Conservation Activities. Water storages for agriculture. Monitor soil mining activities.
Forestry	Ministry of Agriculture	Forestry & wildlife Act (1941)	Control forested areas (flora & fauna) in Antigua.
Plant Protection	Ministry of Agriculture		Monitor pest & disease problems.
NSWA	Ministry of Health	Litter Act (1983) SWMA (1995)	Control collection and disposal of solid & liquid waste.
Public Works	Ministry of Public Works		Control sand mining operations on beach lands

as a nursery, breeding ground and habitat for marine and terrestrial wildlife. Although no definitive studies have been conducted to date, there is a strong possibility that some seepage of liquid waste from the dump is entering adjacent wetlands, affecting mangrove and other species that inhabit the wetland area.

Immediately after hurricanes and floods, the Cookes Dumpsite has been difficult to access due to fallen trees, debris and flooding caused by inadequate drainage. Efforts will have to be made to improve the drainage system and to plan additional mitigation strategies to minimize debris and other objects blocking vehicular access to the site.

St. John's city, which contains approximately 25 percent of Antigua's population, accounts for much of the economic activity. The city, which borders the St. John's Harbor and occupies

a land area of 7.4 km^2, has a relatively high population density of about 3000 persons per km^2. During heavy rains, drains overflow and wastewater, oils, detergents and other pollutants are discharged into coastal areas. These areas have extremely poor drainage, and in the case of the Green Bay and Grays Farm areas, this poor drainage has been exacerbated by the construction of the Exhibition Center, which has interfered with the natural drainage of the area. These three areas still have a considerable number of households using a night-soil collection system. This situation combined with the poor drainage of the areas, implies that the potential for sewage-related outbreak of disease is quite high.

Land mining

Uncontrolled and unregulated topsoil and sand mining in the streambeds of Body Ponds, Christian Valley and Pattersons areas are impinging on farm fields and creating unsightly areas that are prone to the erosive force of heavy rains. Topsoil is also mined illegally in the Betty's Hope area and the material is used for landscaping and road construction. There is also illegal movement of sand from a number of beaches around the island with consequent beach erosion in areas such as Yorks, Valley Church and Dark Wood Beach.

Forest degradation

The forest is being degraded in the Body Ponds upper watershed areas. This is due to indiscriminate farming practices, overgrazing by roaming livestock, wildfires and extreme climatic events such as drought, floods and hurricanes. Deficiencies in existing forestry and wildlife policy, legislation and regulations are recognized as inhibiting proper protection and management of forest resources.

The Gaynors area, in the east of Antigua, is a vibrant ecosystem that is currently being cleared for agricultural development. This area is a unique ecosystem that contains mangrove forests and wetlands. Land clearing activity is damaging some of the mangrove stands and, if continued, will result in a loss of habitat and biodiversity within the area.

The intense rainstorm experienced in Antigua during hurricane Lenny in 1999 triggered mudslides in places such as Christian Valley Hills, Monks Hill and Cades Bay. This new phenomenon is causing great concern to the natural resource community as the causes for this problem are analysed and solutions sought.

Encroachment on agricultural lands

Built-up development is increasingly encroaching on good quality agricultural lands, especially in Paradise View, Weatherhills, Cedar Grove, Woods Centre and New Winthropes in St. John's Parish, but to a lesser extent, also in rural areas such as Bathlodge. At present, the Development Control Authority has little influence over the use of agricultural land or its conversion to non-agricultural uses. There is dire need for coordination and collaboration among stakeholders in formulating plans and strategies for development.

Coastal erosion

Some roadways have been constructed across wetlands and beaches, without any provision for the natural drainage of the area, resulting in degradation of the ecosystem. During Hurricane

Lenny in 1999, two such roadways, at Dark Wood and at Runaway Bay, were destroyed, with adverse impact on adjacent wetlands along with their flora and fauna such as mangrove stands, birds, fish nurseries and crabs.

Land resources issues

Land resource management in the twin-island state is fragmented and requires clearer lines of authority as well as meaningful collaboration among all stakeholders in land resource planning, management and development. In a number of agricultural areas farmers do not own the land, but rent it from government or private land owners on an annual basis. Where leases are granted they are usually for a period of 5 years. Long-term leases of 25 years are available, with an option to renew, subject to Cabinet approval. However, the process of land acquisition for agriculture is time-consuming and costly and the inadequate land use policy creates conflicts among land users.

Watersheds are not well maintained, nor are the waterways leading from these watersheds. Years of indiscriminate cutting, clearing for agriculture, uncontrolled grazing and fires have resulted in serious degradation, accelerated erosion, reduced productivity of the land, increased siltation of reservoirs, loss of biodiversity, including wildlife habitat and loss of aesthetics. The watersheds are no longer efficient in trapping the rainfall and flooding is common in low-lying fields and in settlements where the water channels are not well maintained. Soil loss from the Body Ponds and Potworks watersheds has caused excessive sedimentation of downstream dams and streams as well as coastal habitats such as mangroves, beaches, sea grass beds and coral reefs. There has also been mangrove destruction at a number of coastal areas such as Jolly Beach, Fort James and Cades Bay.

Water resources issues

Some of the land resource issues at the watershed level also affect the water resources. For example, high sediment loads in the watershed have resulted in increased maintenance costs for cleaning dams, ponds, streams, and drains. Additionally, the application of pesticides, herbicides, fungicides and other chemicals in agricultural production has polluted the Potworks Reservoir and its accompanying watershed area.

Other water resources issues include poor allocation and inadequate supply of fresh water to agencies and stakeholders and conflicts among water users. In particular, in Yeamans, Creekside and Potworks reservoir there are conflicts over water from public dams and ponds, especially where individual farmers have provided some financial resources and equipment for building or maintenance of the structure.

Plant nutrient issues

In the Creekside area, some of the croplands have been severely compacted by grazing livestock and use of heavy machinery. Such actions have affected the soil structure and developed a crusted surface, which has increased the flooding hazard of the area. The intermittent stream in the Cookes area has high salinity levels; lands within the floodplain of this stream have also proven saline, allowing only salt-tolerant crops to produce viable yields. With the land degradation occurring in the Potworks and Body Ponds Watersheds there is a general reduction in soil fertility, increased use of inorganic fertilizer and loss of biodiversity in these habitats.

BRIGHT SPOTS

Waste disposal

The National Solid Waste Authority (NSWA) is planning to redesign the Cookes Dump. The landfill site will contain three 9-acre basins with membrane liners to minimize the effect of toxic wastes on adjacent lands. The work on this dump is ongoing and should be completed towards the end of 2001. Nevertheless, littering and unauthorized disposal of solid waste remains a significant environmental health and aesthetic concern.

APUA, in collaboration with the NSWA, is presently developing plans to install a sewage treatment plant to handle waste in the St. John's City area. Designs for this plant have been completed and the government is currently seeking finance and contractors to undertake the project. Obviously, the laying of a sewage pipe network would cause great disruption in St. John's, but it would give a perfect opportunity for replacing old water mains and placing electricity and phone lines underground, thus minimizing the potential damage of hurricanes.

Land issues

Government has realized that the soil is an extremely valuable natural resource in Antigua & Barbuda. In this regard, Cabinet has declared that the land resource must be conserved and managed in a sustainable manner. To this end, they have requested the Soil and Water Conservation Division to begin drafting a policy paper to establish guidelines for the management, extraction and sale of soil in the twin-island state. Collaboration is being sought from agencies such as the APUA and the Extension Division and other stakeholders such as farmers, contractors and earthwork operators involved with soil management and use.

Antigua and Barbuda is a signatory to the Desertification Convention and, hence the government supports a proposed regional project for "Biodiversity Conservation and Prevention of Land Degradation" in the Body Pond and Potworks ecosystems.

Farmers in the Bendals area, which is a steep hillside, have carried out operations to install bench terraces. The site now produces tomatoes, melons, chive and thyme. The Forestry unit is now working with the Ministry of Trade and Environment to embark on an island-wide tree planting programme using specific trees like seaside grapes. With the scarcity of financial and human resources, community groups and civic-minded agencies are encouraged to play an active role in such initiatives.

The Agricultural Sector Plan for technology and research, natural resources, markets, production, trade, communication, etc. is currently being formulated and will be integrated with the National Economic Sector Plan.

Water resources issues

A pipe distribution system along with pumping facility is been planned by the APUA in collaboration with the Soil and Water Conservation Division. Presently, the Soil and Water Conservation Division is working closely with farmers in the area as well as the Extension Division. The plan will provide farmers in the surrounding area of the Potworks Reservoir with access to irrigation water for their fields. It is hoped that this project will irrigate an additional 200 hectares of farmland.

The rich agricultural soils in the southwest sector of the island of Antigua are volcanic and have high infiltration rates. The government of Antigua and Barbuda, in collaboration with the Cuban government is about to conduct assessments of two main agricultural areas, Christian Valley and Orange Valley, with the intention of designing and installing surface water storage systems. Consideration is being given to sealing these storage systems with clay or membrane liner material.

Collaboration between APUA, Soil and Water Conservation Division and farmers is ongoing to consider the development of policy guidelines regarding water use from public lands. The APUA is now encouraging farmers, in areas where ground water quality and yield are appropriate, to site individual wells close to their fields. In addition, farmers have recently been given improved access to the APUA water supply grid.

Plant nutrient issues

The Soil and Water Conservation Division, working closely with the Extension Division and the government's chemical laboratory, has started monitoring and collating salinity levels for 18 sites around the island. It is hoped that appropriate information will be made available to farmers regarding soil and water management and crop suitability for different salinity levels.

It is hoped that a conservation tillage research programme for specific soils and crops will be started next year. It is envisaged that such a programme will allow farmers to reduce their tillage operations without compromising crop yields. Such actions will reduce overhead costs and significantly reduce soil loss, land degradation and pollution.

Challenges and viewpoints

There is need for the political will and commitment to ensure that te country's development proceeds in a sustainable manner, with an understanding that economic development must be inter-locked with environment issues. In the past, the government reacted only when the damage was already done. In addition, there is need for synergy between Government's vision and the technicians' action plans and programmes. The whole development cycle should be considered for integrating policies, programmes and budgets regarding land, water and plant nutrition issues. The establishment of links between economic sectors, for example, tourism and agriculture is essential to clearly show the benefit of each supporting the other and their overall value to the national economy. Given budgetary constraints, it should be ensured that programmes and projects have a sustainable component built-in. In addition, to effectively utilise scarce resources, there must be a community- and private agency-oriented approach to sustainable land use and natural resource management.

The true value of the natural resource base should be incorporated in the National Accounts. There is also need to improve communication and dialogue among stakeholders nationally, regionally and internationally.

To better prepare for the effects of natural hazards, it is important that the country does not just react but rather prepares mitigation strategies and policies. In this regard, Antigua & Barbuda is developing a National Disaster Preparedness Plan with input from all sectors.

Finally, in order to plan and develop meaningful programmes there is need for credible data collection on a sustained basis with appropriate dissemination of information.

Institutional support for updating and maintaining the information system and country report

The Soil and Water Conservation Division will be the focal point for CLAWRENET in Antigua and Barbuda. Presently, however, there is no computer system housed at the agency. In this regard, it will be extremely timely if the Division could obtain such a system so that effective contact could be maintained with other CLAWRENET members.

Barbados

General Information

Barbados is the most easterly of Caribbean islands. It has a land area of 430 sq. km. The 1990 census reported 260 491 inhabitants, with a population density of 605 residents per km^2, making Barbados the most densely populated of the Caribbean islands. The population growth rate is 0.27 percent per annum. The rural population accounts for 52 percent of the total population.

Annual rainfall ranges between 1 140 and 2 150 mm/yr (Figure 1), with a mean annual rainfall of 1 422 mm/yr. Evapotranspiration is estimated at 1 540 mm/yr and renewable water resources at 82 km^3/yr.

Agriculture accounted for 4 percent of GDP in 1997 and employed 5.1 percent of the labour force. The main agricultural outputs are sugar, vegetables, cotton, cut flowers, bananas, sheep, chicken and pork.

Institutional Arrangements

Institutional arrangements for land, water and plant nutrient resources are presented in Table1 below.

Hot spots

Cultivated lands are increasingly being lost to non-agricultural uses, particularly in the tourism sector for the establishment of golf courses and in the housing sector. Between 1992 and 1997 the extent of cultivated land was reduced from 22 472 ha to 17 000 ha.

Pollution is also an area of concern, especially groundwater and near-shore pollution.

Water is inefficiently used in the area of water resources management and the potable water delivery system is also inefficient. A significant number of small farmers are dependent on potable water supply for irrigation. A 1997 Water

FIGURE 1
Rainfall in Barbados

Average annual rainfall (mm) 1937-1970

Glenn Marshall
Soil Conservation Unit, Ministry of Agriculture and Rural Development
Barbados

TABLE 1
Institutional Responsibilities of Land, Water and Plant Nutrition Resources Management

Institution		Responsibility
Town and Country Planning Department		Overall responsibility for development applications guided by the Physical Development Plan
Ministry of Agriculture and Rural Development	Crops Section	Food crops and floriculture. Plant/foodstuff Quarantine at air & sea ports
	Fisheries Division	Fisheries resources
	Soil Conservation Unit	Scotland District conservation Landslide and erosion mitigation Forestry
	Meteorological Department	Meteorological forecasting
	Analytical Services Lab.	Soil, plant, water analysis
	Pesticide Control Board	Agrochemical import certification
	Quarantine Unit	Sanitary and phytosanitary certification
	Land and Water Use Unit	Hydrology and Agromet data Irrigation extension and agronomy
	Extension section	Crop husbandry advice and extension
Ministry of the Environment, Energy and Natural Resources	Environmental Unit	Environmental policy and international treaties Environmental education
	Coastal Zone Management Unit	Coastal area management
	National Conservation Commission	Parks and beaches Marine Museum Underwater Park Caves of Barbados
	Energy Division	Mined resources and energy
Ministry of Health	Environmental Engineering Division	Water quality Hazardous waste disposal
	Solid Waste Unit	Landfills and solid waste disposal
Barbados Water Authority		Assessment, development, management, licensing of island's water resources. Potable Water Supply Bridgetown Sewage Treatment Plant
Barbados Agricultural Development and Marketing Corporation		Government irrigation water supply schemes
Barbados Agricultural Management Company		Manages Sugar lands for Government
Lands and Surveys Department		Cartography, map production
Educational institutions	Barbados Community College	Associate degree in Agriculture
	SJP Polytechnic	
	Caribbean institute for Meteorology and Hydrology	Certificates in meteorology and hydrology
OTHER: Barbados Agricultural Society, FAO, IICA, CARDI, etc		

Resources Study suggests that as much as 60% of water in the potable water supply is unaccounted for. There are ongoing efforts to reduce this level by at least 30%. A draft Policy Framework for Water Resources Development and Management was accepted in 1997, but key components have not yet been implemented.

Area Development Plan proposals for the agricultural sector were made in 1999 but they have not yet been accepted by Government.

In the area of plant nutrition management, very little soil and plant nutrient testing is carried out, nor are there attempts to optimize fertiliser application . Generally, agricultural research is inadequately applied in the areas of plant nutrition, irrigation agronomy and water use. There is also inadequate knowledge of soil infiltration rates and water storage capacities.

Other issues include a municipal landfill to be operated in the proposed Scotland District National Park and inadequate training in GIS modeling and analysis tools.

Bright spots

The bright spots include:

- The establishment of a national Geographic Information System, with contributions from all key Government departments.
- The implementation of the Groundwater Protection Zones policy, in 1963, to prevent bacterial contamination of groundwater supply.
- The Bridgetown sewerage system became operational and the South coast system is currently under construction. The West coast system is planned for 2004 to reduce impact on the near-shore marine environment.

To address the problems of inefficient water use , leaks and unaccounted-for water, the Government has launched a number of public awareness/sensitisation initiatives to encourage use of water saving devices. A potable water tariff structure adjustment and a leak detection and mains replacement programme are also planned. There will also be universal metering.

A desalination plant became operational in 1999 to augment the potable water supply and mitigate against impact of drought.

Other noteworthy initiatives include:

- The proposal of a Code of Agricultural Practices to address potential pollution problems attributed to pesticides, herbicides and fertilizer use in agriculture.
- The implementation of a Land for the Landless Farmers project to provide land for small farmer production.
- Women involved at all levels of agriculture from labour to manager and owner.
- The mapping and prioritisation of landslide- and erosion-prone areas in Scotland District GIS; and
- The establishment of the Ministry of Agriculture Web Page.

Challenges

The main challenge in the area of land resources management is the threat to food security caused by the reduction of available arable land for agriculture. This reduction is due to increased demand for housing.

For water resources management, the challenge is insufficient water for agriculture, as there is increased competition from other sectors in terms of price, quantity and quality. Optimising water use efficiency in agriculture is therefore a major challenge. The establishment of Water Resources Authority to assume regulatory and assessment functions, thereby enabling the Barbados Water Authority to concentrate on potable water supply and sewerage systems operation, is another challenge.

In the agricultural sector, the loss of the preferential markets for sugar will result in a reduction of foreign exchange earnings for the country. Moreover, replacement of the sugar crop could result in reduced protection against erosion. The challenge is therefore to develop new markets for agricultural produce for export and to promote linkages with the tourism industry.

As more tourists visit the island the challenge is to determine the carrying capacity of the key attractions, nature trails, beaches and the near-shore environment. Sewerage and other waste disposal systems must also be able to handle the considerable amounts of waste generated by increasing numbers of tourists visiting the island. There are also implications for maintaining acceptable groundwater quality.

With the removal of trade barriers, the importation of produce which possibly carries new pests and diseases is also a threat and the challenge is for the quarantine unit and the government analytical services laboratory to detect them and prevent their entry.

The establishment a of Code of Agricultural Practices is seen as another challenge.

Data availability

The following data are readily available:

- Land use data (from aerial photos, field verification, census)
- Water resources (assessment 1978 & 1998, total rainfall +100 yrs, rainfall intensity, hydrology and agro-meteorology)
- Crops (aerial photos, field verification, census)
- Protocol for Access to Digital/GIS Data.

Table 2 shows the types of data collected by various institutions in Barbados, and the institutions with a GIS capacity.

TABLE 2
Types of data collected by various institutions in Barbados and their GIS capability

PARAMETER MONITORED	Land and Water Use Unit	Soil Conservation Unit	Meteorological Department	Barbados Agric. Dev. & Marketing Cooperation	Barbados Agricultural Management Company	Barbados Water Authority	Coastal Zone Management Unit	Environmental Eng. Div.	Caribbean Institute for Hydrology & Meteorology	Private plantations	Environmental Unit	Town and Country Planning Department
Rainfall Total	✓	✓	✓		✓	✓			✓	✓		
Rainfall Intensity		✓							✓			
Wind Speed	✓		✓						✓			
Sunshine									✓			
Temperature and Humidity	✓		✓						✓			
Evaporation	✓	✓							✓			
Ground Water Abstraction	✓	✓		✓		✓						
Ground Water Quality	✓	✓		✓		✓		✓				
Spring/Stream Flow Rate		✓										
Spring/Stream Water Quality		✓					✓					
Established GIS		✓				✓	✓				✓	✓

British Virgin Islands

General information

Physical Characteristics

The British Virgin Islands (BVI) is a UK Territory comprising over forty islands, islets and rocks in the Virgin Islands archipelago. The islands are about 60 miles east of Puerto Rico and 140 miles northwest of St. Kitts, located near latitude 18.3° N, and 64.5° W. The three largest are Tortola, Virgin Gorda and Anegada respectively.

The largest island, Tortola, is about 62 square km in size. The highest point, Mount Sage on Tortola, is 543 m above sea level.

Population

The population increase of about 2.1% per year, from 16 000 to 20 000 over the last ten years, has increased pressure on the use of land. The population density is about 50 persons per square km. Over half of the population is between 15 and 44. Twenty one percent of the labour force is in the public sector and 0.2% in agriculture. The BVI consist of 38,248 acres (15,499 ha) of land, 39% of which is Crown land and 61% is privately owned.

Economy

The tourism and financial services sectors are the mainstay of the BVI economy. Total visitor arrival was 0.5 million in 1999 with 1300 rooms contributing approx. 300 million. The visible trade balance is –172 million, the balance of Services, 230 million, resulting in a net overall trade balance of 62 million.

There are a total of 360 000 international business companies, paying a total of 73 million in licence fees.

Major food crops and cash crops, imports and production

The annual food importation cost is about 36 million dollars (DPU statistics for 1998). Fruits and vegetables account for ten million dollars while beef, chicken, milk, fish, cereals and non-alcoholic beverages account for about three million dollars each. The annual domestic agricultural production amounts to 850 tons of beef, sheep and goat meats, pork, fruits, vegetables

Leland Dennis
Agricultural Engineer, Department of Agriculture
Paraquita Bay, Tortola, British Virgin Islands

and root crops at a value of 2.25 million dollars. The main crops produced in the BVI are bananas, sweet potato, cassava. The local agricultural production therefore accounts for about six percent of food consumption.

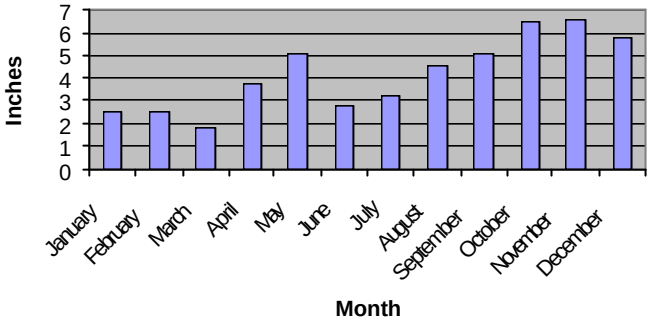
Imports

It is clear that the British Virgin Islands cannot produce, locally, sufficient food and materials needed for its survival. It has no control over the supply of its requirements from abroad and is susceptible to international market forces, importing all its fuel and supplies and almost all the food consumed from overseas.

Climate

The average rainfall is about 59 inches (1 300 mm) per year, with the heaviest showers occurring between September and December producing about half of the annual rainfall (Figure 1). The driest period is January to July, with monthly deficits of two to four inches (Figure 2).

FIGURE 1
British Virgin Islands average monthly rainfall



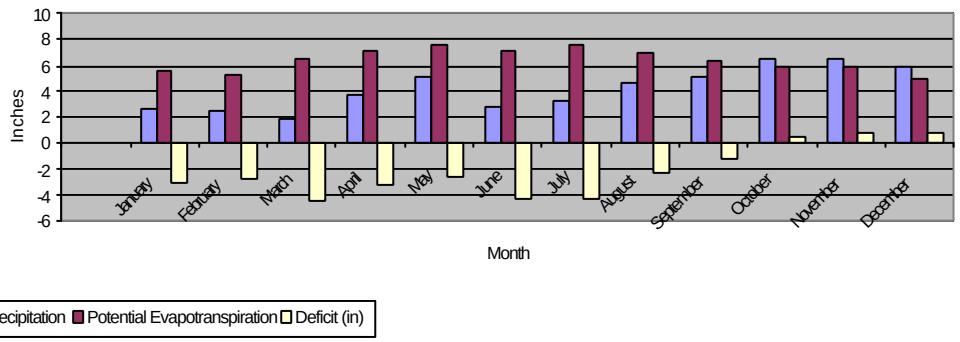
Land resources and land use

Most islands with the exception of Anegada consist of steep slopes which rise precipitously from the sea. Anegada is a very flat limestone island; one quarter of its surface area is occupied by salt ponds and a number of sand dunes.

Soils throughout the islands are shallow, friable, immature residual soils generally less than 0.5 m thick. These soils are medium to coarse grained, well graded, sandy silts generally with a dark yellow brown colour.

Large boulders form significant surface deposits, especially in southern Virgin Gorda where large boulders up to 10 meters in size form an extensive boulder field.

FIGURE 2
British Virgin Islands average monthly water balance



The present and proposed land use are outlined in the Draft Physical Development Plan.

A number of the wetlands are continually being filled. A number of salt ponds are also being lost. Recently there has been an initiative of replanting some mangroves. Prior to the current development boom in the BVI the main communities were located in the flats and most of the area was used for cultivation. This has changed recently, and wetlands that were previously cultivated and even virgin areas are now being encroached upon.

At its present scale, agriculture does not constitute an urgent threat to wetland areas. Those that have been abandoned have quickly reverted to their original vegetation. There are not many intensive agricultural holdings and pesticides are not used at high levels. The major threat to the wetlands from agriculture are the livestock farms, but this is still minor in comparison to the issues of encroachment and landfills.

Water Resources

All the natural surface water bodies in the BVI are estuaries, cays or salt ponds. All of them are of very high salinity. The only fresh surface water that in the BVI consists of small ponds or Minidams created by the Department of Agriculture, for use by farmers. They have a total capacity of about 14 000 cubic metres. This has also improved the hydrology and the microclimate in the immediate area.

There are a few perennial springs in the hills but the volume of their flows has not been documented.

Irrigation

Most of the water supplied as potable water originates from desalination. Although it is reported to comply with WHO standards, its effects on crops, which vary greatly, indicate that it is not suitable at all times as drinking water.

There are only two major irrigation system in the BIV, one on Tortola where the Department is located and the other on Virgin Gorda. These supply the Department and 48 farmers on Tortola on 12ha. The project on Virgin Gorda serves 14 farmers on 5.6 ha. The project on Tortola is fed by public water and well water. The Project in Virgin Gorda is fed only by well water and spring water. Other farmers are supplied with public, surface and well water.

A major irrigation system is being repaired that will serve over fifty farmers plus the needs of the Department.

Institutional arrangements

The Ministry of Natural Resources and Labour is the main agency that has control over land in the Territory, both directly and through its Departments of Agriculture, Conservation and Fisheries and the National Parks Trust. The other Government agencies involved are the Ministry of Communication and Works and the Town and Country Planning Department, which is responsible for physical development planning. Wetlands and mangroves are the responsibility of the Department of Conservation and Fisheries.

Conservation in the Territory is handled by three Department: Agriculture (DOA), Conservation and Fisheries (CFD), and the National Parks Trust (NPT). CFD deals with the

marine and coastal areas and the NPT with established parks. All other areas are left to the Engineering Division of DOA by default or established laws.

The Engineering Division has one engineer and three daily paid workers to perform these duties and others throughout the territory. Recruitment of additional staff has been recommended.

There are three review committees for all development work:
- the Technical Review Committee (TRC) , reviews all marine development applications;
- the Development Control Authority (DCA), which grants permission for all developments; and
- the Project Review and Advisory (PRA), which reviews major developments.

Hot spots

The Department of Agriculture is not represented in any of the developmental committees or authorities.

The high silt load from development on the hillsides which causes erosion affects the drainage of the streams into the ocean. The sediment load from hillside development also destroys the coral reefs, sea grass beds and mangroves.

The Department of Agriculture is not appraised of any development in areas where there are protected watersheds.

Sewage disposal is a main concern. There is only one community treatment plant in the entire Territory.

There are conflicts regarding policies, resource use and agency jurisdiction.

Environmental considerations are not effectively integrated into the national development process.

There are no comprehensive environmental policy and associated management plans.

There is no adequate enforcement and monitoring policy.

Pending legislation needs to be approved and passed.

There is a proliferation of developments along the shorelines. Clear cutting of the hillsides for access to building sites is widespread.

The effects on erosion are aggravated by the high rate of deforestation and by encroachment on marginal hillside lands for settlement.

Bright spots

The overall bright spot throughout all governmental agencies is the National Integrated Development Plan entitled *The environment of the British Virgin Islands, Emerging Issues* – 1998.

The following legislation was drafted and is pending:
- Coast Conservation Bill
- Land Use Planning Bill

- Ground Water Monitoring and Control
- Parks and Protected Areas Systems Plan.

The Department has a policy of assisting farmers with water storage tanks by means of a lease. To date, the Department has provided a total of 200 tanks to farmers.

Presently there are regulations governing developments in a number of areas and in some cases the Department of Conservation and Fisheries are asked for their input. In some cases the DOA, reportedly, was also asked for its input.

Presently there are LIS/GIS in the Town and Country Planning, Conservation and Fisheries, and Survey departments as well as the Office of Disaster Preparedness.

An agricultural census, proposed for 2000, will take place in 2001. After this an agricultural LIS/GIS is proposed to be requested for the Department of Agriculture.

All government offices are on a Wide Area Network (WAN), which is accessed by dialup and is primarily used for accounting purposes. A true dedicated WAN will be introduced in the near future. The Survey Department has all land in the territory mapped in its LIS/GIS, and parcel sizes and owners can be readily called up.

It is proposed that the land registry be computerised in 2001. A national project is proposed that will fly coloured aerial photo coverage and create better base data and controls for all Departments in 2001.

A fully computerised weather station has been set up by the US Meteorological service. This station is part of their global monitoring of the impact of global warming and of groundwater flow and storage. This station will also be used by the department in developing well monitoring and recharging methods. This station is fully computerised and can be accessed remotely, via a telephone line and a computer.

The possibilities of introduction of salt tolerant crops is being investigated.

There are numerous wells throughout the territory which have been used in the past but a number of them have now become saline. This was brought about by overpumping and improper monitoring of the well water quality. Pilot projects will be set up in the near future for the rehabilitation of these wells.

Challenges and viewpoints

Agroforestry

Prior work has been done in this area as mentioned below. A number of forested areas were replanted but problems remain: staff shortage, droughts and how to deal with replanted private lands. The extremely high land prices, create great pressure for the sale of these lands; even of lands used for agriculture. There are a number of laws that deal with water areas and protected areas.

Erosion and Soil Conservation

Due to the high labour cost there are limitations to the amount of mitigation that can be done by the farmer. Programmes on soil conservation methods were set up earlier with the farmers.

Methods of erosion prevention have been introduced to the Departments involved in road construction.

Monitoring

Equipment has been purchased for the monitoring of salinity and other substances present in the water to be used for irrigation. A meeting was held for the formation of a committee involved in collection of rainfall data. This will be expanded to encompass other aspects to be used for the measurement of natural environmental variables.

Legislation

A general law, "Trees, soil and water conservation" governs most of these areas. Review of this law is proposed.

BVI Country priorities

Priorities for the British Virgin Islands include:

- Land Use, Capability and Soil Maps
- Recycling
- Irrigation Technology
- Water use efficienty
- Agroforestry systems
- Training
- Information Systems.

BVI CLAWRENET programme of work

Ongoing

- Investigation of how rainfall, groundwater, salinity and extraction rates will affect agricultural production in the BVI.
- Collection and storage of meteorological information at one place and distribute to other agencies.
- Review of various forecasts at various times of the year.
- Assistance in construction and rehabilitation of terraces by farmers.
- Work with Public Works Department (PWD) in their streambed (ghut) cleaning programme.
- Introduction of waste collection and reuse for all agricultural enterprises.
- Establish a new metered water system for farmers at the Paraquita Bay Farm water system.
- Introduction of a water subsidy for farmers.

New

- Build closer ties with the Conservation and Fisheries Department.

- Compile a list of salinity tolerant crops relevant to the BVI and their ranges of tolerance.
- Develop key strategies relevant for the BVI, together with the Conservation and Fisheries Department.
- Investigate and plan the use of socially important trees in the BVI for agroforestry.
- Introduce materials and methods for protection against erosion for all works being done on hillsides.
- Educate households on soil conservation methods.
- Investigate and introduce subsoil field irrigation for pastures.
- Relining of existing Minidams throughout the territory.
- Recycling of agricultural waste to use on irrigation.

Cuba

Cuba is the largest island in the West Indies and is also the westernmost—just west of Hispaniola (Haiti and the Dominican Republic), and 145 km south of Key West, Florida, at the entrance to the Gulf of Mexico. The country also includes 4195 smaller islands, islets, and cays. The island is 1 250 km long and its width ranges from 32 km at its narrowest point, to 210 km at its widest. It is mountainous in the southeast and south-central area, Sierra Maestra, and flat or rolling elsewhere. Total land area is 110 922 km^2. There are about 11 million inhabitants with an annual growth rate of 0.5 percent and a population density of 99.6 persons per km^2. Approximately 2.2 million persons live in the capital, Havana. The country is divided into 14 counties. Mean annual rainfall is 1375 mm and mean annual temperature is 25°C.

Institutional arrangements

The National CLAWRENET comprises the Instituto de Suelos, Instituto de Riego y Drenaje, Instituto de Investigaciones Forestal, Instituto de Agraria de la Habana, CENICA, La Agencia del Medio Ambiente and the Instituto de Meteorología. The Instituto de Suelos is the lead institution, providing the scientific base for the sustainable use and protection of soils in the agricultural sector. Its main functions are the execution or participation in research and development projects linked to the agricultural sciences and the protection of natural resources and the environment. The Institute also offers technical and methodological soil services on soil and fertilizer use. Research is also conducted in soil genesis, classification, cartography and evaluation, as well as soil conservation, agricultural management, soil fertility and biology. There are soil research stations located throughout the country as well as provincial technical and soil analytical services.

The main scientific results of the Institute include national soil maps at scales of 1: 250 000, 1: 50 000 and 1:25 000. Detailed maps have also been drawn to characterize soil fertility and fertilizer recommendations for the main crops; soils affected by erosion, salinity, compaction, acidity and poor drainage; as well as methods to improve these problems.

The Institute has developed technologies for the production of organic manures from industrial domestic and agricultural solid wastes and for the production of biological fertilizers such as Rhizobium and phosphate solubilizers. Additionally, to enhance soil physical properties, the Institute promotes minimum tillage technologies based on the use of the horizontal cutting plough and technologies to restore degraded soils and vegetation at the river basin and watershed levels.

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Hot spots

The main factor contributing to natural resource degradation in Cuba is low soil productivity caused by salinity, sodicity, erosion, poor external and internal soil drainage, low fertility, compaction, low organic matter content, low soil moisture retention, rockiness and stoniness. Table 1 shows the extent of these land degradation problems in the island.

TABLE 1
Total soil area affected by soil degradation processes

Limiting Factor	Area affected (million ha)	Percentage of Agricultural area
Salinity and sodicity	1.00	14.9
Erosion (strong and medium)	2.90	42.2
Poor drainage	2.70	40.3
Poor internal drainage	1.80	26.9
Low fertility	3.00	44.8
Compaction	1.60	23.9
Acidity (pH KCl < 6)	1.66	24.8
(pH KCl < 4.6)	0.47	7.00
Low organic matter content	4.66	69.9
Low water retention	2.50	37.3
Stoniness and rockiness	0.80	11.9

Salinity is caused by unsuitable management of the saline water table, overexploitation of subterranean water, poor drainage systems and inappropriate soil management techniques. Low adoption rates of soil conservation measures, deforestation, shifting cultivation, poor land management and overgrazing are the main reasons for soil erosion. Poor drainage is attributable to natural and artificial soil water drainage, lack of geographic studies which consider the watershed as a unit in which to establish irrigation and drainage systems and low rates of rectification of drainage systems. Inappropriate use of agricultural machinery, continuous tillage at a constant depth, overgrazing and inadequate use of irrigation systems are the main causes of soil compaction.

Soil organic matter is reduced by erosion processes, lack of incorporation of crop residues in the soil, burning, low application rates of organic matter and inappropriate crop rotations. Low soil fertility is generally due to monocropping, indiscriminate use and application of inorganic fertilizers, overexploitation of soils by crops which impoverish the soil and little use of sustainable agricultural practices. This poor soil management also results in soil acidity.

Fourteen percent of Cuba's total land area, approximately 1.58 million ha, is also affected by dry conditions and threatened by desertification. These dry conditions are distributed over 24 climatic zones as shown in Figure 1.

FIGURE 1
Dry and Sub-humid Zones of Cuba

Bright spots

Table 2 shows the areas and periods of execution of measures against the factors which contributed to land degradation.

Challenges and viewpoints

Cuba uses a multidisciplinary approach to generate integrated natural resources management methods and these methods are used on the basis of hydrographic units. Researchers are currently working to develop an indicator to evaluate the true extent of natural resource degradation.

TABLE 2
Periods of execution and extent of reclamation and improvement measures

MEASURE	TIME PERIOD	AREA (thousand ha)
Soil Erosion		
Simple anti erosion measures	1986 - 99	839
Planting on the contour	1997 – 99	314
Planting perpendicular to the slope	1986 – 99	634
Live barriers	1986 – 99	72
Dead barriers	1989 – 99	298
Live ground cover	1986 – 99	160
Dead ground cover or plastic mulch	1992 – 99	191
Dams	1087 – 99	45
Terraces using ploughs	1989 – 99	38
Individual terraces	1993 – 99	66
Maintenance and complementing measures	1992 – 99	40
Other measures	1992 – 99	175
Salinity and Poorly Drained Soils		
Control of quality of irrigation water	1986 – 99	23 396*
Application of gypsum	1987 – 89	1.6**
Simple drainage on parcels of land	1987 – 99	157
More technical drainage on parcels of land	1987 – 99	19
Modernization of rice	1988 – 95	7
Levelling	1986 - 99	372
Soil Compaction		
Subsoiling	1986 - 99	466
Minimum tillage	1986 - 99	1064
Soil Acidity		
Calcareous amendments	1976 - 99	1697

*Springs

**Million Metric tonnes

Other areas of work are the development and introduction of technologies to harvest and manage rainwater for agricultural and domestic use and the training of farmers and civil society by applying appropriate regional agricultural extension methods.

The application of GIS to evaluate and process available data for a more rapid response to the problems and to follow the evolution of the effects of applied practices is also important.

Grenada

Country overview

The state normally referred to as Grenada comprises the three islands of Grenada, Carriacou and Petit Martinique. Grenada is located at the southern end of the Lesser Antilles, between 11°58‘ and 12°13‘ N latitude and 61°20‘ and 61°35‘ W longitude. Grenada has a land area of approximately 312 sq.km, Carriacou 34 sq.km. and Petit Martinique 2.3 sq.km. The state is divided into six parishes and one dependency – Carriacou and Petit Martinique.

In 1997 the population was estimated at 96 000, with 44 percent residing in the rural and agricultural regions. Annual growth rate was estimated at 1.8 percent and average population density at 279 persons per sq.km.

The economy attained a favorable growth rate of 5.8 percent in 1998, compared with a growth rate of 4.2 percent and 2.9 percent in 1997 and 1996 respectively. This growth is a result of increased manufacturing activity, buoyancy in the construction sector, falling inflation and a stable financial sector. Data from the unemployment survey conducted in August 1998 indicates that the unemployment rate fell from 17.0 percent in 1996 to 15.2 percent in 1998.

Following a one percent decline in 1997, output in the agriculture sector grew by 2.4 percent in 1998. The sector contribution to GDP decreased to 9.1 percent from 9.5 percent the previous years. Though the role of the sector in the economy is declining, it still continues to be of importance, especially in the rural areas. However, the sector continues to be affected by decreasing productivity, the use of undesirable and insufficient inputs, and pests and diseases. While the pink mealy bug was brought under control in 1997, a new challenge of controlling the mango seed weevil has arisen. Nutmeg continues to be the leading agricultural crop in terms of export, followed by cocoa. The banana industry, which in the past was the main pillar of the economy, has declined continuously since in 1988. Government with the assistance of the European Union has jointly embarked on a plan to attempt to resuscitate the industry.

Grenada has a humid tropical marine climate, with little seasonal variation in daylength and relative humidity. Rainfall distribution throughout the year is divided into a dry season from January to May and a wet season from June to December. Mean annual rainfall is 2350mm. Variations in rainfall range from 1 500 to 5 000mm per annum. The temperature at sea level is generally high with little seasonal or locational variation. The country is divided into eight agro-climatic zones based on temperature and rainfall.

Water resources originate from a system of perennial streams and rivers, with some groundwater available from the limestone areas along the northwest coast. Surface water systems

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such as rivers, streams and ponds are the major sources of fresh water for human consumption and agriculture. The entire population has access to domestic water supply.

Data from the National Water and Sewage Authority(NAWASA) suggest that about 52 percent of the population receives private water service, 23 percent uses public standpipes, and 23 percent use rain water catchments, private springs, streams or ponds. Presently there are 29 water supply facilities in the country.

The soils of Grenada are dominated by clay loams (84 percent), followed by clays (12 percent) and sandy loams (three percent). The soils are mostly well drained and reasonably fertile. The combination of high temperatures, high rainfall and reasonably fertile soil in most areas provide the country's land base with considerable potential for productive cropping. However, this potential can be constrained by steep slopes and their proneness to erosion.

The report "State of Land, Water and Plant Nutrition Resources in Grenada" is available on the Internet and is summarised below.

Institutional arrangements

Land resources

The main institutions responsible for land resources are the Land Development Control Authority, the Forestry Division, the Land Use Division, the Extension Division and the Lands and Surveys Division.

Plant nutrition resources

The main institutions dealing with plant nutrition resources are the Agronomy Division, the Forestry Division, the Caribbean Agricultural Research and Development Institute, and the Republic of China on Taiwan (RCT) Agricultural Technical Mission.

Water resources

The National Water and Sewerage Authority (NAWASA) is responsible for the development of potable water supplies as well as the sanitary disposal of sewage. The Ministry of Agriculture's Forestry Division is responsible for the protection of water catchment areas, while its Agronomy Division is responsible for the development of irrigation on the island. The Land Use Division houses the Land Resources Information System and that database contains rainfall data for over 60 stations located throughout the country, for varying periods of time. For 10 of those stations, data are available for the past 50 years. For three agrometeorological stations data are available on mean monthly temperature, sunshine, relative humidity, cloud cover and wind speed.

Hot spots

Land resources

The main issues related to land resources are the loss of arable lands to non-agricultural land use, land degradation due to inappropriate solid waste disposal and poor agricultural practices

such as the misuse of steep slopes leading to soil erosion and landslides, the lack of a national land policy, weak and insufficient land management legislation and declining returns from traditional export crops.

Properly constructed landfills are required to replace the open dump sites. This should be followed by closure of all previously approved and informal open dump sites. It is recognized that properly designed landfill sites are necessary to serve the islands. However, because of the shortage of suitable land away from existing residential developments, procurement of a suitable site may be problematic. In rural areas it is uneconomic to maintain and operate separate landfills because of the small volume of garbage generated. Other appropriate technologies should be pursued at these locations.

Uncertain land tenure and an absence of an efficient land registration system cause problems with land title and ownership.

Coastal erosion was also considered to be an issue of serious concern. Though it was noted that some of this erosion is the result of natural processes, it is believed that sand mining is contributing to coastal erosion. In the absence of a suitable alternative source of fine aggregate and with the growing demand for sand in an expanding economy, the problem is not expected to be resolved in the near future.

Water resources

The main water resources issues are waste disposal at sea, wastewater management, encroachment within the water catchment areas, overfishing and siltation of coral reefs.

Commercial shipping and cruise ships plying the country's sea lanes must dispose of their solid waste either in port or at sea. Failure to provide such facilities at ports increases the probability of disposal of such waste at sea, with the resulting deleterious effects on the marine environment. Port reception and disposal facilities are to be put in place.

The Government of Grenada intends to implement a policy to ensure that all wastewater is disposed of in a sanitary manner. The operational problem associated with this policy is that less than seven percent of all water customers are metered. Even after connection to the sewerage system was made mandatory, very few of those customers were metered.

The increasing demand for land for agriculture has resulted in many small farmers entering forested areas and clearing lands for small farming. Such encroachments result in deforestation, soil erosion and pollution of streams, rivers and coastal waters, with a consequent decrease in volumes of fresh water sources. There are insufficient water storage facilities to harness water lost during the rainy season. In the case of water used for irrigation, there is some indecision as to the price that farmers should be charged.

The issue of major concern to the authorities responsible for the management of coastal resources is overfishing, particularly of reef fisheries and other exotic species such as conch and lobster. Most of the western coastal reefs are covered with solid waste, debris, old vehicles etc. There have also been sightings of reefs being smothered with silt. The main causes of these problems are related to inland development activities, particularly in the building and agricultural sectors, where erosion and other activities pollute the streams and other waterways which lead to the sea.

Plant nutrition resources

Inadequate soil analytical services, unavailability of appropriate fertilizers and misuse of the fertilizers that are available are the main issues of plant nutrition resources.

Bright spots

Land resources

The government of Grenada intends to implement a policy aimed towards the conservation of the country's forest resources. The objectives of the policy are to conserve species, ecosystems, and genetic diversity; maintain, enhance and restore the ability of forests to provide goods and services on a sustainable basis; and optimize the contribution of forest resources to social and economic development

The government has also adopted an integrated approach to watershed management, with appropriate institutional arrangements. With respect to land resources, the approach aims to, maximize soil cover and prevent deforestation, as far as possible, in all watershed areas; minimize soil erosion and sedimentation; control infrastructural development; improve farming practices in catchment areas and identify and recommend alternatives for activities detrimental to watersheds.

Government also encourages tree planting to reduce soil erosion, improve soil fertility, beautify and enhance the environment, provide timber and other products and maintain biodiversity.

Programmes have also been developed to encourage stakeholders (e.g. schools and other community groups and organizations) in tree planting in urban and rural areas. Incentives are also created for tree planting on private lands.

In 1995, FAO, through its technical cooperation programme, implemented a project to establish a computer-aided Land Information System for Grenada. That information system contains databases of soil, land use and climatic data, and has the capacity to estimate the potential for production of alternative cropping options at various locations on the island. It is a very useful tool for decision-making.

Other initiatives which are considered bright spots for land resources in Grenada are the Draft Crown Lands Policy, the Dry Zone Forest Management Project, the Carriacou and Petit Martinique Integrated Land Use and Forest Management Project, the Grand Etang Forest Reserve and the remnant site of the Mardigras Soil and Water Conservation Project.

Water resources

With respect to water resources, the integrated approach to watershed management mentioned in the previous section also aims to conserve all groundwater and surface water resources and protect them from pollution and depletion. Additionally, it aims to minimize sedimentation, particularly for the benefit of aquatic species and freshwater and marine ecosystems.

The Marine Protected Areas Project, the draft Revised Water Legislation, the Grenada Irrigation and Drainage Project, the Annual School Coastal Zone Management Competition and the legal designation of Clarks Court/Woburn Bay and Molinière/Beauséjour Bay as Coastal

Protected Areas are all initiatives which are intended to promote more sustainable systems of water resources management.

Plant nutrition resources

With respect to plant nutrition resources, the current analytical laboratory can be easily upgraded to do soil and plant testing.

Challenges

The main challenges facing land, water and plant nutrition resource managers in Grenada are:

- The management of the land resources in a sustainable manner, given the growing demand for land and the country's limited land and financial resources
- The prevention of degradation of the resources in the interim, in the absence of the required enabling policy and supporting legislation
- How to effectively develop policy and legislation related to the resources in an environment in which the state owns a very marginal part of the land
- Convincing the National Water and Sewage Authority to provide financial support for watershed management activities not directly related to water harvesting
- Developing and maintaining closer linkages and partnerships among users and managers of the resources
- How to break the "Public is ours and Private is Yours" attitude of our people.

Viewpoints

- Efforts must be made to collect, develop and centrally store inventories of the resources available
- Policies and supporting legislation are essential
- Plant resources management needs attention
- Government must place land among its top priority areas, bearing in mind that food is life and land is its source
- Efforts must be made to efficiently maintain CLAWRENET and include the broadest range of users and managers of the resources
- Emphasis must be placed on research and development in the areas where clear deficiencies exist
- All programmes developed must be able to show physical evidence of the benefits from effective resources management activities. This is particularly important in convincing private landowners.

Issues on the availability of data

Data are limited in quantity and detail. Some of the available data are inadequate and outdated. The data that are available are kept in decentralized areas, which impedes access. Data sets are not standardised so they vary widely for the same parameters. The format of the data also limits their use for statistical analysis. Finally there is institutional reluctance to share valuable data.

Problems encountered

Data were generally in a raw and disorganized state, not detailed nor validated and they were fragmented in terms of type and storage. It was also difficult to identify persons responsible for data maintenance.

Solutions

To solve some of the problems identified above, it is proposed that a central depository for all data should be created and maintained in one location and an operator should be assigned specific responsibilities to maintain the database. Data should also be standardised and a coherent network should be maintained among users and providers of data.

The validity of the data should also be tested through appropriate field research.

The full report is available at: http://www.tidco.co.tt/uwigeospatial/Grenada/home.htm.

Guyana

Overview

Guyana is located in the northern part of South America. It is bounded in the northwest by Venezuela, in the west and south by Brazil and in the east by Suriname. Total area is 214 970 km², with a population of approximately 764 000 people, making it one of the least densely populated countries of the world. The country is endowed with rich natural resources. About 16.5 million ha are inaccessible forests and woodlands, 1.2 million ha are under permanent pasture and only 0.496 million ha are cultivated. Despite the abundant resources, Guyana is one of the poorest countries in the Americas with annual per capita income of US$ 800.

Population growth rate was –0.78 percent in 1997 and there was net outmigration rate of –15.5 migrants/1000 population in 1997.

Total GDP was estimated at US$ 717 million, of which agriculture accounts for 36 percent. The economy is based on exports of gold, bauxite, sugar, rice and forestry products. The agricultural sector has experienced steady growth over the past five years, primarily because of the privatization of the rice and sugar industries. In the case of rice, production has tripled and sugar exports have increased from 50 000 tons in 1985 to 3.5 million tons in 1995. Sugar is the most important industry of the agricultural sector, accounting for 20% of GDP and employing some 30 000 persons.

Guyana enjoys a tropical climate with uniformly high temperatures and humidity. Average temperatures in the capital, Georgetown range between 24 and 30°C and humidity averages 70% year round. Rainfall decreases from the northwest to the southeast of the country with maximum annual rainfall of 2 500 mm near the Venezuelan border to 1 500 mm in the southern savannahs. The rainy season lasts from May to July along the coast and from April to September inland. Coastal areas have a second rainy season from November to January.

The name Guyana is Amerindian for "Land of Water". There are numerous rivers which flow into the Atlantic Ocean, the largest of which is the Essequibo River which runs from the Brazilian border in the south to the delta west of Georgetown. Estimates of surface water resources are unavailable, while the groundwater system comprises three aquifers.

Most agricultural activity is conducted along the coast. As much as 8 km inland, the land is below sea level at high tide so drainage and water control are the major problems and agricultural development is linked to defence against seawater intrusion and rainwater runoff. Land requires extensive drainage networks before it is suitable for agricultural use. Approximately one-eighth

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of the area cultivated in sugar cane is occupied by drainage canals. Total length of irrigation canals is 485 km of main canals and 1 100 km of secondary canals. The main and secondary drainage infrastructure is about 500 km and 1500 m in length, respectively. Most irrigation infrastructure needs rehabilitation. This state of disrepair contributes to low water use efficiency in the country.

TABLE 1
Institutional Arrangements of Ministries involved in Land and Water Resources Management

Office of the President

- Environmental Protection Agency
- Natural Resources and Environment Advisory Committee

Ministry of Agriculture

- Guyana Sugar Corporation
- Rice Agencies
- National Drainage and Irrigation Board
- National Agricultural Research Institute
- Hydrometeorological Service
- Commission for Lands and Surveys
- Guyana School of Agriculture

Ministry of Fisheries, Crops and Livestock

- Fishereies Department
- National Dairy Development Programme
- Other Crops Programme
- Guyana Forestry Commission

Ministry of Housing and Water

- Guyana Water Authority
- Georgetown Water and Sewerage Commission

Ministry of Communication and Transport

- Sea and River Defence Department
- Transport and Harbours Department

Ministry of Regional Development

- Regional Extension Units
- Regional Irrigation Boards
- Regional Land and Survey Units
- Regional Coordination of National Policies

Institutional arrangements

Table 1 presents the institutional arrangements of the various governmental bodies dealing with land, water and plant nutrient resources in Guyana.

Hot spots

The main hot spots are:

Water erosion – this causes surface wash after dry periods and sedimentation and sediment build-up in conservancies (shallow water resevoirs in level areas).

Fertility decline – with the removal of topsoil by erosion, there is a decline in soil fertility. Additionally, the continuous production of rice in some areas and the reduced use of fertilizer lead to overworked lands and a decline in soil fertility

Salinization occurs during dry spells as a consequence of irrigation water having higher salt levels and salt water intrusion into groundwater resources . Since the coastal region of Guyana is around or below near sea level, there is a constant threat of salinization.

Waterlogging – the coastal, agricultural part of the country has two rainy seasons with an average rainfall of more than 2 000 mm per annum. This results in crop loss during flood conditions.

Human settlement stress – despite the country's vast land resources, about 80% of Guyana's population lives on or near the coast. There is pressure from human settlements as more people migrate from the interior in search of employment and "better" living conditions on the coast.

Water resources are inefficiently used and management practices are inadequate.

Global Warming – average temperature in Guyana has shown an increase of about 1.0^{o}C over the past 100 years in Georgetown. Climate change is therefore a real possibility for the country.

Sea level rise and land subsidence – records have shown a rise of about 10 mm per year since 1951; Guyanese may be mining groundwater which may be resulting in coastal subsidence.

Weak institutional capacity – this is a real threat to management of the resources as skill, finance, poor salaries, lack of equipment and inadequate or no maintenance stymie the country's development.

Bright spots

Despite the many hot spots in the country, some advances have been made to protect and preserve the natural resources. These include:

- Changes in land use and water policy which have been submitted to the Cabinet for approval
- The establishment of a number of training institutions
- The conversion of the Lands and Surveys Department into a Commission
- The approval of the national Biodiversity Plan
- A National Development strategy being tabled in Parliament; and
- The establishment of a national Climate Change Committee. This committee has developed an Action Plan and technologies that can be transferred to other developing countries.

Updating and maintaining the information system and country report

Guyana has a large number of computer-literate persons employed in the Government service and some government agencies have web sites to which linkages could be established. Existing agencies, though operational, are inefficient, however. Institutional support is therefore needed to purchase additional equipment and for establishing networking facilities. There is also a lack of current data on climate and hydrology. The country needs equipment for field personnel to regularly collect the data and transmit them from the field to the main offices.

With respect to GIS, there is a weak coordination of services and a lack of networked linkages.

Some institutions are willing to share information rather than data, but at a cost. However, questions arises as to who will pay for the information and where will the information be housed.

Problems encountered

In Guyana, no team has been established to collect and continually update the database and information required for the country report. It was suggested that FAO should follow up country action and provide funding to continue the work of preparing the National Report.

Haiti

Overview

Haiti is located in the high latitude tropics, between 18 and 23° north. Its position and mountainous terrain, with peaks up to 2 684 meters and few arable plains, have created extremes of weather and temperature regimes which vary greatly with altitude. Haiti's land area of 27 700 km^2 is primarily mountainous, 63 percent of the land has slopes greater than 20 percent, over 40 percent of all lands are above 400 meters in elevation and only 29 percent has slopes less than 10 percent. Rainfall ranges from 300 mm in the northwest peninsula to 3 000 mm in the mountains of the southwest. Extreme events such as hurricanes, droughts and floods are quite frequent.

Due to its mountainous nature and its high population of almost eight million persons on the relatively small surface area, Haiti relies upon a disproportionate amount of steep hillsides to meet much of its agricultural production. Erosion is thus the most serious problem affecting the agricultural sector, with an annual soil loss of about 36 million Tons. The overwhelming environmental problem of the country is thus soil erosion. This has led to declining crop yields, damage to downstream lands and water development projects and the destruction of coastal marine resources. Most hillsides are highly eroded and most widely practised cropping systems encourage continued erosion.

With limited economic growth and resources, and severe infrastructure problems, Haiti remains vulnerable to environmental degradation. Two or more crops a year are grown in most areas under the bimodal rainfall distribution with its possibilities of multicropping.

Institutions responsible for the management of the environment in Haiti

Table 1 shows the institutions responsible for management of environmental resources in Haiti and their respective functions.

Hot spots

Since the major part of the territory, including the mountains, is used for agriculture, the MARNDR has always been considered as primarily responsible for renewable natural resources management. The newly created Ministry of the Environment (1994) should be able to play a major role in that matter as well, but its organic law has not yet been approved by the Parliament, so that its mission is not very clear. Moreover, there is a National Commission for the Environment" (CNE) consisting of the Prime Minister and the Ministers of the MDE, the

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TABLE 1
Institutions[1] responsible for management of environmental resources in Haiti and their respective functions

Ministry	Directorates, services & satellite organizations	Types of interventions
MDE	Minister's Staff Direction General Technical Direction OSAMH	Policies & Strategies for Environment Management ATTPF: Forest management and conservation, natural parks, buffer zones, legal and institutional aspects Water policies: management of used waters.
MARNDR	Natural Resources Directorate SNRE, SPNS, SDRT, SRF, SIGR	Management of: lands, forest, surface and groundwater, watershed, marine, meteorology.
MPCE	DAPTE (Directorate of Territory Management and Environment Protection)	Global and functional zoning of the national territory; Definitions of management strategies for the territory
MTPTC	BME, EDH Directorate of Urbanism Directorate of "Cleaning/ Assainissement") SNEP	Mineral and energy resources exploration and exploitation ; Hydroelectricity; Runoff, industrial and used waters; Drinking water distribution

[1] Ministries: MDE - Environment; MARNDR-Agriculture, natural Resources and Rural Development; MPCE - Planning and External Cooperation; MTPC - Public Works, Transport and Communications. Services : SNRE - National Water Resources; SPNS - National Parks and Wildlife; SDRT - Land Conservation and Rehabilitation; SRF - Forest Resources; SIGR - Irrigation and Engineering; SNEP - National Drinking Water. Others: ATPPF - Technical Support for Protection of Parks and Forests; BME - Bureau of Mines and Energy; EDH - Haiti; Electricity; OSAMH - Monitoring and Management Unit for Morne de L'Hôpital.

MARNDR and the MTPTC. A National Environmental Action Plan (PAE) has been elaborated, the implementation of which requires structures and funds not really guaranteed so far. The main institutional problems are, therefore, a dispersion of the responsibilities regarding natural resources management, lack of a coordinating authority, lack of financial resources and lack of spatial and temporal continuity regarding natural resources management.

In addition, uncertain land tenure has contributed to the land management problems as land users have no sense of ownership and are thus unwilling to invest in sustainable land management practices.

Bright spots/natural resources management

The MARNDR has recently elaborated a watershed management policy for the country. There is now a better understanding of the natural resource management issues, as the concerned institutions are more involved.

Haiti currently has a number of NGOs operating in the country, collecting important information on its natural resource base. There is therefore the possibility to collect these data from the NGOs and other institutions.

The assignment of responsibilities to the local authorities is also seen as a bright spot.

Issues on data availability

Since 1986, there have been serious political and administrative problems resulting in the depletion of data collecting systems. Nevertheless, there are agricultural production data for at least 10 years, economic data and about 60 years of rainfall data for some stations. Recently, efforts are being made to rectify the data availability problems.

Jamaica

Land and water resources are critical to the sustainable development of the country. Through PROCICARIBE, a land and water resources network (CLAWRENET) has been created to ensure collaboration, identify priorities for research and development at the local and regional levels. At this time of the launch of the regional network, the national network in Jamaica is not yet in place.

Ministries with responsibility for land and water resources

In Jamaica, the work of four Ministries - Land and Environment, Water, Agriculture and Transport and Works - impacts on soil and water resources. Within these ministries there are many agencies such as the Water Resources Agency, National Environment and Planning Agency, National Water Commission, National Irrigation Commission and Land Administration and Management Project. Table 1 lists some other agencies and their functions.

Projects on soil and water conservation

Projects addressing soil and water conservation issues have been ongoing in Jamaica for more than 50 years. These projects include:

- Yallas Valley Land Authority
- Christiana Area Land Authority
- Morant-Yallas Agricultural Development
- Hope River Watershed Project
- Hillside Agricultural Project
- Integrated Rural Development Project
- Soil Nutrients for Agricultural Productivity
- Jamaica Agricultural Research Project

Current projects

These include the Eastern Jamaica Agricultural Support Project and the "Ridge to Reef" Watershed Management Project.

Joseph lindsay
Senior Director, Research and Development
Ministry of Agriculture and Mining, Bodles Research Station
St. Catherine, Jamaica

TABLE 1
Agencies and their respective responsibilities

Agency	Function
Ministry of Agriculture	
Rural Agricultural Development Authority	▪ Land husbandry and on-farm irrigation
Forestry Department	▪ Management and Reforestation of state lands
Rural Physical Planning Unit	▪ Soil and land use survey
	▪ Soil and plant analyses
Research and Development Division	▪ Crop production and research
	▪ Livestock research
	▪ Soil and water management
	▪ Soil fertility
Other Ministries and Institutes	
Ministry of Geology and mines	▪ Regulation of mining – bauxite, limestone, gypsum, sand
	▪
Sugar Industry Research Institute	▪ Irrigation in sugar cane
	▪ Tillage and soil preparation
	▪ Analyses of soil, plant and water
Universities and Regional Institutions	
University of the West Indies	
Geography and Geology	▪ Geology, GIS, sustainable development
International Centre for Environmental and Nuclear Sciences	▪ Use of slow-poke reactor
	▪ Assessment of heavy metals
	▪ Use of nuclear techniques
	▪ GIS
Life Sciences	▪ Agroforestry
	▪ Aquaculture/Fisheries
	▪ Waste water
	▪
University of Technology	▪ GIS
	▪ Land Surveying
	▪ Planning training
	▪ Architecture
	▪ Engineering
	▪
Bauxite Industry	▪ Jamaica Bauxite Industry
	▪ Mining – largest disturbance
	▪ Land reclamation

The above list is not exhaustive as other projects have been executed in related areas such as irrigation expansion and soil, water and environmental issues. Several short-term studies have been conducted by various university departments, CARDI, IICA, the Jamaica Agricultural Development Foundation (JADF), etc. The data need to be collected and collated for a comprehensive land and water resources database.

Environmental NGOs

Several non-governmental organizations with interests in environmental management exist in Jamaica. Whereas some are independently funded, most depend on projects for funding. The National Environment Society's Trust (NEST) is a network of environmental groups in Jamaica. The Jamaica Conservation Development Trust (JCDT) has major responsibilities such as

management of the first National Park established in Jamaica – the Blue and John Crow Mountains National Park.

Other NGOs involved in environmental work are the:

Negril Environment Protection Trust
South Trelawny Environment Agency
Saint Thomas Environment Protection Agency, and Portland Environment Protection Agency

Funding of projects and activities

The bulk of the funding for land and water research and management has been provided by the state. These funds have come from the annual budget for support of its agencies or through bilateral loans and grants.

The Environment Foundation of Jamaica is probably the best-known local agency which has resources for funding smaller projects in local land and water management. The Jamaica Agricultural Development Foundation has also provided funding in these areas. Major sources of funds - grants and loans - over many years have been UNDP-FAO, CDB and the Government of the Netherlands

Hot spots

There are many land and water resource situations and issues, that can only worsen and impact negatively on the development of the country and its people, if they are not addressed. The list is not exhaustive but the following are the main issues:

1. Watershed degradation

   The country has been divided into 26 watershed management units. Each is being degraded to different extents. Deforestation, charcoal burning and annual fires are some of the main problems.

2. Waterway and harbour contamination

   Kingston Harbour and other river outlets are being seriously damaged by agro-chemicals, soil sediments, sewage and other household wastes. Nutrients and other chemicals are resulting in contamination and bleaching of corals. This is posing a threat to the reefs and the sustainability of the beaches.

3. Soil salinity

   In the major irrigated areas of the southern parts of the parishes of St. Catherine and Clarendon, large areas of land have become saline. Much of this area has been taken out of production. Measures to halt this process as well as to mitigate saline areas are urgently required.

4. Sand mining

   Illegal sand mining in river beds and on agricultural land is posing major problems mainly in the parishes of St. Catherine and Clarendon.

5. Soil fertility depletion and management

   Information on the nutrient status of major soils needs to be updated or reviewed. The management and restoration of soil organic matter should also be addressed urgently.

6. Access to information

   The vast amount of information generated in various projects is considered "grey" literature and is often inaccessible.

7. Lack of a coordinating mechanism for research in land and water management

   There is no coordinating mechanism for the myriad projects and activities in land and water management.

Bright spots

It is not all gloom and doom in the area of land and water management. The following are the bright spots:

1. Policies enacted or being reviewed

   Land, Forestry, Watershed and Soils Policies are being enacted or reviewed.

2. Agencies for enforcement and management

   The following agencies have been established for enforcement or management of the respective resources:

   - National Environment and Planning Agency – a recently created executive agency
   - Water Resources Agency – maintains control of water use and development of new water sources or schemes
   - Pesticides Control Authority – regulates pesticide import, manufacture and disposal. Limits imports and manufacture of highly toxic and persistent pesticides into the country.

3. Establishment of secondary and tertiary centralized sewage schemes in Negril, Montego Bay, Ocho Rios, Portmore and Kingston.

4. Reuse of grey water from sewage systems for irrigation e.g. Portmore St. Catherine.

5. The Soil Nutrition and Agricultural Productivity (SNAP) project is reviewing nutrient levels in major soils

6. Availability of GIS with relevant data for land and water management

7. Standardised scales used in network of GIS users groups.

Funding and personnel

Pockets of local funding for environment projects exist. There is a cadre of trained personnel in land and water management-related areas. Several courses in GIS are available locally. The UWI has a supercomputer which provides internet server and other facilities for scanning and digitizing maps.

Priorities for the development of national work programmes

The following are the next steps involved in establishing priorities for the development of national work programmes:

- Invitation to agencies to nominate representatives and alternates
- Review areas of operation and responsibility
- Identify areas of overlap
- Identify priorities for CLAWRENET
- Develop land and water management databases
- Provide links to Web pages
- Identify information gaps

St. Kitts - Nevis

The Federation of St. Kitts and Nevis is located in the Eastern Caribbean between latitudes 17° 10' N and 17° 25' N and longitudes 62°W and 63° W. The Nevis Island Administration (NIA) is the local legislative body which runs the affairs of Nevis. Matters relating to St. Kitts and the Federation as a whole are dealt with in the Federal Parliament. Not all ministries and departments within the Federal Parliament are duplicated within the NIA. This holds particular importance for the management of the country's resources.

Institutional arrangements

The institutions which manage the land resource on St. Kitts are primarily government ministries or parastatal institutions. The Southeast Peninsular Board and the Frigate Bay Development Corporation manage land development in the Southeast of the island which is the heart of the tourism industry.

The St. Kitts Sugar Manufacturing Corporation (SSMC) controls about 4000 hectares of land (29 percent of the land surface), the majority of which is planted in sugar cane. The integrity of forests and wetlands is jointly monitored by the Ministry of Environment and the Ministry of Agriculture, which also houses the Fisheries Management Unit.

The Department of Lands and Housing has the responsibility for development projects on government lands, while the National Housing Corporation oversees several government housing projects at various locations on the island.

On Nevis, the Nevis Lands and Housing Development Corporation is responsible for the lease, sale and development of government lands. Their activities have been primarily in the area of housing. The Ministry of Agriculture, Lands, Housing and Co-operatives has control over the annual rental and management of government lands, including government estates used for either crop or livestock production. There is an Environment Desk within the Planning Unit which has authority over environmental matters.

The Water Departments on both islands are mandated with the development of the country's water resources. On Nevis the Department of Agriculture maintains a single mountain spring and a series of earthen dams, which are used for supplying irrigation water. Eighty percent of Nevisian farmers have immediate access to water. The Water Department on St. Kitts previously allowed the St. Kitts Sugar Manufacturing Corporation (SSMC) to utilise a shallow well for sugar cane and vegetable irrigation trials. The Water Departments have maintained strict control over water production and utilisation.

Gene Knight
Department of Agriculture
La Guerite, Basseterre, St. Kitts

The St. Kitts Sugar Manufacturing Corporation is the primary user of plant nutrient resources in the country. There has been no monitoring of the impact on soils, or the environment in general. Plant nutrients have been used rather than managed.

Hot spots

There is a concern on Nevis about the way in which private construction in some cases has obstructed waterways and diverted water, resulting in erosion, overflowing of drainage ditches and flooding.

Tropical cyclones over the last twelve years have visibly decimated the upper levels of the forests on both islands. The effect of this decimation is partly evidenced in the increased stream flows during the rainy season. Roads to hillside farms have been major casualties of this situation. In some areas portions of surrounding farms have had to be used as fill to repair roads.

Bright spots

In 1997 the Department of Agriculture established a multi-purpose laboratory which, when fully functional will include a soils laboratory, a plant pathology laboratory and a water quality laboratory, among other services. This multi-purpose laboratory should, in the future, contribute significantly to the management of the plant nutrient resource.

Nevisian farmers having access to domestic water supplies now pay a concessionary rate which is 50 percent of the normal rate. Consideration is being given to placing existing government irrigation schemes under the control of the Water Department. Under this plan water meters will be installed and farmers charged for water use.

The Planning Unit has prepared zoning plans with recommendations in respect of land allocation for agriculture, mining, tourism, housing, etc.

During 1999 the management of the two government farming settlement on St. Kitts was returned to the Department of Agriculture. The result was a marked increase in agricultural activity.

The Water Department on St. Kitts recently made available several wells for agricultural use. Costing of various utilisation options is ongoing.

The Nevis Water Department commissioned a new well during 2000. In St. Kitts a one million gallon reservoir is being constructed in the Frigate Bay area.

Challenges

The major land management challenge for the Federation will be optimising of lands presently used for sugar cane production. Several public fora have been held to discuss the future of the sugar industry. When eventually the industry is shut down or reduced in size, the susceptibility to erosion could be greatly increased if an adequate land management plan is not speedily implemented.

The Water Department on St. Kitts continues to struggle to identify water sources for the villages of Cayon and Saddlers on the north of the island. Two recently dug wells have proved to be unproductive. These two villages are hardest hit by water shortages during the dry season.

As construction increases on the Southeast Peninsula, the Water Department will need to find and develop additional water supplies for the population in Basseterre.

Data issues

There is a considerable amount of available data on the land and water resources. However, much of it is not current. The updating of this information does not appear to be a major component of any work programme in the various sub-sectors. Settlement maps are not being updated in a timely fashion. With regard to the plant resources, there are some incomplete data on the production resource (i.e. sugar cane and small farming). However, the forests, grasslands and wetlands are only known in general terms. There is no inventory of flora or fauna. This does not allow a proper assessment of damage after significant environmental events such as hurricanes and droughts.

There is a need for closer local collaboration in respect of optimally utilising the scarce natural resources. The availability of current data on land and water issues will be crucial to success. There are plans to establish a local committee to provide this vital information.

St. Lucia

Country overview

St. Lucia is the second largest of the Windward Islands, with an area of 616 km^2. It is 42 km long and 22 km wide with very irregular, steep terrain especially in the interior. The island has fertile, volcanic soils but due to mainly topographical constraints, only 28 percent (17 360 ha) of the total land area is suitable for agriculture. According to the 1996 Agricultural Census, a total of 15 784 ha are under cultivation and 13 945 ha under permanent crops.

The estimated population in 1996 was 146 000 inhabitants of which 62 percent live in rural districts. Population density was 235 inhabitants per km^2 and the growth rate was 1.3 percent.

Agriculture accounted for 13 percent of GDP and 13 percent of exports over the period 1985 – 1995. Bananas is the most important contributor to the agricultural GDP, accounting for over 30 percent of export earnings in 1995. With the loss of the preferential market for bananas, the agricultural sector of St. Lucia has been on the decline and tourism is gaining in importance.

Institutional arrangements

St. Lucia currently has no stated policy governing the management of its land, water and plant nutrition resources, resulting in an *ad hoc* and uncoordinated approach to management. Overall, land-use planning and land zoning occur in an ineffective and inefficient fashion.

Land Resources

The Ministry of Planning, Development and the Environment has responsibility for land-use planning with major emphasis placed on physical considerations. The planning process is expected to allocate land resources for the best possible uses and zone these accordingly. The *Land Development (Interim Control) Act of 1971* and it amendments and the *Town and Country Planning Ordinance (1946)* provide the legal framework for physical planning. The Act establishes a Development Control Authority (DCA) with responsibility for regulating all land development. Sectors such as Health, Housing, Public Works and Agriculture are all represented on the DCA. In spite of this, the view is often expressed from within the agricultural sector in particular, that development often takes place at the expense of the natural environment. This is probably due to the inadequacy of land-use planning and the absence of a comprehensive zoning of lands.

Deborah Bushell
Project Coordinator, Water Resources Management Unit
Ministry of Agriculture, Forestry and Fisheries
Castries, St. Lucia

Through the *Forest, Soil and Water Ordinance (1946),* the Department of Forestry of the Ministry of Agriculture, Forestry and Fisheries (MAFF) is able to establish forest reserves and protected forests, oversee the use of forest resources (e.g. timber), and implement soil and water conservation programmes. The Department has a management plan in place for all lands (private and state-owned) classified as forest lands and a legal framework is in place for their protection. In practice however, tremendous conflicts exist with respect to the management of privately owned forest-lands. In the case of state-owned lands outside the jurisdiction of the Forestry Department, the *Crown Lands Ordinance (1946)* provides for a Crown Land Committee to review and advise on issues regarding the use and allocation of such lands. The *Agriculture Small Tenancy Act (1983)* is focused specifically at small farm holdings and provides for adequate soil and water conservation measures on smallholdings.

As a means of instituting a more comprehensive regulatory mechanism for the management of private and state-owned lands, a *Land Conservation and Improvement Act* was promulgated in 1992 and a Land Conservation Board was subsequently constituted under the auspices of the Department of Agriculture. To date, however, the Board only convened once and supporting regulations are yet to be developed.

In recognition of the inadequacy of these institutional arrangements, a "National Land Policy Symposium" was convened in February this year toward the development of a Land Policy for the country.

Water Resources

The *Forest, Soil and Water Ordinance (1946)* and the *Land Conservation and Improvement Act (1992)* also deal with the protection of water resources through the land protection measures to be instituted. The *Water and Sewerage Act (1999)* assigns responsibility for water resources management, allocation and planning to the National Water and Sewerage Commission. A review of the water sector and the current actors and roles in water management undertaken in April 2000, indicated an area of conflict inherent in the Act in that it attempts to assess and manage the resources while simultaneously supervising the water and sewerage utility. There is no articulated water policy and no regulations have been put in place. Attempts to assess water resources have historically been undertaken by the MAFF as a means of supporting agricultural productivity. Data generated, although of varying quality and reliability, has however found more widespread use nationally. The Ministry of Health has responsibility for regulating water quality to safeguard public health. In April this year the MAFF, with EU assistance, embarked upon a Water Resources Management Project to address such aspects as resource assessment, watershed management, rationalisation of existing institutional frameworks and public awareness and sensitisation.

Plant Resources

The MAFF also has responsibility for providing services to enhance agricultural production in general and, through its Forestry Department, for the management of forests.

HOT SPOTS AND BRIGHT SPOTS

Hot spots

During the rainy season in particular, the silt-laden streams and rivers are visible evidence of the higher rate of soil erosion in the country. High levels of silt deposition contribute to the drainage problems in the three major agricultural valleys, Roseau, Cul-de-Sac and Mabouya and there is evidence of continued denudation of lands in upper watersheds as well as extensive riverbank erosion in most watersheds. A spatial analysis of the extent of degradation has not been undertaken, however; the relationship between soil loss and reduction in crop yield has not been determined either.

Widespread use of agro-chemicals is another area of concern with respect to water quality, human health and loss of biodiversity. Here again very little analysis has been undertaken with respect to agro-chemical residues and no specific problem areas can be identified.

BRIGHT SPOTS

Legislation and Policy

Recent attempts to develop a Land Policy, are evidence of the growing recognition at the highest policy level of the need to improve the decision making process where the use of land is concerned. Initiatives with respect to Water Policy include the establishment by the MAFF of a Water Resources Management Unit that has as one of its mandates, a review of the legal and institutional frameworks for water resources management. While the MAFF's main interest is in water for agriculture, it has recognised that the inadequacies at the national level need to be addressed as an important first step.

Community Involvement

Two Water Catchment Groups have been established with the assistance of the Forestry Department to address the protection of water intakes in those communities. In both cases the communities made the decision to engage in these activities and subsequently sought the assistance of the Department. Also, a Watershed Management Action Force was formed in another community under the Watershed and Environmental Management Project that was completed in 1998. These groups all play an active role in identifying issues negatively affecting watershed management in their communities and subsequently seek assistance to address those problems. Currently the Talvern Water Catchment Group is undertaking a riverbank stabilisation exercise.

Efforts by the Solid Waste Management authority to sensitise communities with respect to waste disposal issues are also important as solid waste has been adversely affecting river health and often results in blocked drains, contributing to the incidence of flooding.

CHALLENGES AND VIEWPOINTS ON NATURAL RESOURCES MANAGEMENT

The management of natural resources requires first and foremost an understanding of the nature of the resource to be managed. Baseline studies are therefore necessary to identify and quantify existing resources and if possible, to attach some economic value to them. The inter-relationships

between the various components of the island's ecosystems are likewise undetermined, posing tremendous challenges to sustainable development.

Land use and land tenure issues have contributed significantly to land degradation on the island and pose a major obstacle to natural resource management. Past efforts to encourage the implementation of land conservation have met with limited success and therefore innovative measures must be devised for the widespread adoption of these practices. Factors affecting land degradation are also linked to water resources. As the country faces increased water demands, it may be necessary to factor some of the cost of watershed conservation to the consumer.

The widespread cultivation of bananas for export was accompanied by an expansion into previously forested areas unsuited to intensive cultivation. During the period when this crop was a major income earner, conservation measures, where they existed, were grossly inadequate. Now that difficulties are being experienced in this industry, farmers will be more hard-pressed to institute such measures. In cases where farmers have chosen to diversify there will be new issues to be addressed with respect to the extent of vegetative cover and other factors related to the crop to be introduced. Access to water for irrigation is also a serious challenge that the agricultural sector has to face. Issues such as water rights and adopting measures for irrigation water management require attention as well.

For these and the many other natural resource management issues to be addressed it is necessary that the existing legislative and institutional frameworks be reviewed. Currently there is considerable overlap in departmental mandates and several gaps exist. Prime among these is the absence of a proper management data base on the existing natural resources.

Availability of data on land, water and plant nutrition resources

The Biodiversity Country Study Report for St. Lucia is the most up-to-date compilation of information on land, water and plant resources. Due to financial constraints, data are not systematically or frequently updated with the introduction of geographic information systems. With the increased availability of satellite imagery, it is expected that land cover information can be more readily updated.

Data on water resources, where available, are generally very unreliable. It is expected that this aspect will be addressed through the Water Resources Management Project.

Plant nutrition management data are generally available from the Forestry and Agriculture Departments.

Problems encountered

1. The first problem is an organisational one. Though a CLAWRENET National Coordinator was nominated, the nominee was not informed of this until late August and therefore no allowance had been made to budget the time required for this exercise into the officer's work programme.

2. The Water Resources Management Unit, which is one of the important supporting agencies, is still in its start-up phase, with only a Project Coordinator in place. The support system required for data collection and verification is not in place.

3. There is no centralised repository for the baseline information (already limited in its availability) required for inclusion into the report.

4. Coming at the heels of the recently completed Biodiversity Country Study Report, and with the current initiatives taking place under the Climate Change Convention and others, the absence of financial incentive has proved to be a deterrent toward obtaining the assistance which is critical to this process.

5. There is considerable overlap among a number of the initiatives being undertaken at present. Officers employed in the area of natural resource management are already quite overloaded with individual work programme and the tasks required to support the country's commitment under various protocols and treaties. This exercise, though useful in itself, has actually proved to be quite burdensome because of the timing and the insufficiency of lead time.

EXISTING AND REQUIRED INSTITUTIONAL SUPPORT FOR UPDATING AND MAINTAINING THE INFORMATION SYSTEM AND COUNTRY REPORT

The Planning and Statistical Department of the MAFF is currently the department best suited to the management of data in general. However, it has not been involved in developing the Information System and Country Reports. The MAFF will seek to identify a funding source for a local contractor to develop the Information System and this will subsequently be maintained by the MAFF. The exact mechanism for this is still to be determined.

The full report is available at: http://www.tidco.co.tt/uwigeospatial/St%20Lucia/home.htm

St. Vincent and the Grenadines

Overview

St. Vincent and the Grenadines is situated in the Lesser Antilles of the Caribbean, 34 km southwest of St. Lucia and 160 km west of Barbados. St. Vincent has a total land area of 390 km² of which 11 000 ha are cultivated land and 7 000 ha under permanent crops. The island is volcanic with numerous small streams. The highest peak is the Volcano Soufriere (1234 m) in the north of the island. Soils are fertile. The population in 1997 was estimated at 114 000 inhabitants of whom 49 percent are rural. The annual growth rate was 0.87 percent from 1990 to 1997. The average population density over the islands in 1997 was 292 persons /km^2.

Agriculture is an important pillar of the economy, accounting for 12.8 percent of total GDP in 1998. Banana production is a main source of export earnings, accounting for US$ 20.4 million in 1995, despite government's policy to diversify the agricultural sector. Root crops, fruits and vegetables are also gaining in importance, earning US$ 12.6 million in 1998.

The climate is tropical with average temperatures at the capital, Kingstown ranging between 18 and 32°C. Average annual rainfall ranges from 1 500 mm on the coast to 1 800 mm in the central mountains. There are two seasons – a dry season from January to May and a rainy season from June to December. The islands are situated in the hurricane zone. Though there has been no major recent hits, the country is still vulnerable to the effects of hurricanes. Surges and tidal motions caused by hurricanes have a disastrous impact on the coastline. Heavy rains that follow the storms cause erosion and landslides.

Total annual water production from all currently used water resources is 9.95 million m^3, with a storage capacity of about 5 million m^3. A national irrigation programme aimed at irrigating 1 600 ha is well on the way.

Institutional arrangements

The Ministry of Agriculture is the policy making and executing agency for agriculture in the country. It is supported by a number of local, regional and international bodies such as the:

- Development Corporation which provides loans to farmers
- Banana Growers' Association
- Inter-American Institute for Cooperation on Agriculture, IICA
- French Mission/Co-operation

Patrick Ramlogan
Control Water and Sewerage Authority
St. Vincent and the Grenadines

- Caribbean Agricultural Research and Development Institute, CARDI
- Arrowroot Association
- Irrigation Management Unit – currently under the aegis of the Central Water and Sewerage Authority and European Union local office
- Lands and Surveys Department
- Department of Physical Planning/Physical Planning and Development Board.

Hot spots

Land Encroachment - Prime agricultural land is rapidly being subdivided for housing

Conflicts in Land Use - squatter settlements on crown lands reserved for forestry are among the problems faced by the Authorities. Lack of political will to deal with squatter settlements exacerbates the problem.

Water Erosion - The topography of the islands is mountainous. Inappropriate cultivation and tillage practices cause sheet erosion of topsoil and gully erosion. This topsoil is carried into the sea and affects the coral reef which in turn impacts negatively on fishing.

Bright spots

Land reform policy – land with access roads is being made available to small farmers. For agriculture, Government plans to:

1. Continue the National Irrigation Programme
2. Expand the Banana Tissue Culture Laboratory
3. Strengthen Extension Services
4. Improve the Farm Management Practices
5. Maintain the Pest control programme, and
6. Strengthen soil and water conservation methods.

Challenges and viewpoints

The challenge facing agricultural land at this time is to retain the land for agricultural use. Government intends to implement a land use strategy, based on the recommendation of the agricultural census results along with the Geographical Information System. These will be used to ensure optimum utilization of scarce arable lands. Since the mid 1980s, the government embarked on the land reform programme with some success. This process will continue with the implementation of the Mr. Wynne/Peter's Hope Project that will make lands available to small farmers.

The full report is available at http://www.tidco.co.tt/uwigeospatial/St%20Vincent/home.htm

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Suriname

Country overview

About 85 percent of the Suriname is covered by tropical rain forest. According to the Constitution, all Surinamese have the right to a piece of land if they apply for it. All the land is state owned.

The Minister of Natural Resources is in charge of the allotment of state-owned land. The Ministry of Agriculture, Animal Husbandry and Fisheries is consulted for advice on the allotment of land for agricultural purposes. Land may be held under proprietary right, hereditary tenure or land rent.

About 1.5 million ha, most of it located in the coastal area, have potential for agriculture. About 120 000 ha are currently used for agriculture, animal husbandry and aquaculture. Most of the land has been mapped and classified by the Soil Department of the Ministry of Natural Resources. Detailed soil surveys are done on request.

About 55 000 ha have been prepared for rice production and 2 000 ha for banana production. The rest of the land is used for livestock, fruit, vegetable and aquaculture production.

Institutional arrangements

The Government of Suriname plans, implements and maintains the physical infrastructure for agriculture. Because the cost of maintaining this comprehensive infrastructure is a heavy burden on the budget and the new way of thinking is that "the user should pay", the Ministry of Agriculture, in collaboration with the Ministry of Regional Development, is working on a programmes to install water councils, authorities and boards. Each district will have a water council. Water boards and a main water board or water authority may also be installed, depending on the hydrological units and their complexity. Farmers will make all the decisions, pay and be responsible for the organization of the water boards. The Ministries, along with the water councils, will act as facilitators and guides and will be responsible for overall supervision. Research results and data collection will be channeled through the water boards, under the instruction of the relevant authorities.

Water Resources, Irrigation and Drainage

Although Suriname has an average annual rainfall of 2 200 mm, some crops are still irrigated because the rainfall is not evenly distributed. Data on climate are collected by the Climate Department of the Ministry of Public Affairs.

Gerrit Breinburg
Deputy Director for Planning and Development
Ministry of Agriculture, Animal Husbandry and Fisheries
Paramaribo, Suriname

The main irrigated crops are rice and banana. About 30 000 ha of rice are irrigated per crop. Irrigation water comes from rivers and swamps.

For some crops irrigation is supplementary, with water use of about 1 200 mm/ha/crop. Most of the time drainage is the problem.

The system currently used is called an open system in agriculture engineering terms. The irrigation system may be divided into hydrological units, depending on the size of the production system, the water supply and drainage. Units vary in size and in the number of farmers using the system.

The irrigation system for banana is different. There is one banana company with two plantations. Trickle irrigation is used and fertilizers are applied through the system. Rice and banana are both grown on heavy clay soils.

Hot spots

The main natural resource issues are the use of agricultural chemicals and the regulation of the gold mining. Reliable agricultural planning data are also needed, and an agricultural census was prepared with the collaboration of FAO to obtain funding for the census. However, Donor funds were not made available so the census could not be conducted.

Bright spots

In Suriname people have been trained in the use of GIS and the Soil Division of the Ministry of Natural Resources is equipped to do GIS work. However, to date, the Ministry of Agriculture has no GIS facility.

Trinidad and Tobago

Country overview

The republic of Trinidad and Tobago is the most southerly of the Caribbean island chain. Trinidad lies 11 km off the north-east coast of Venezuela. This island has a total land area of 4 828 km^2. Tobago lies 32 km northeast of Trinidad and has an area of 300 km^2.

Agricultural land represents 26 percent of the total land area of the two islands. Some 75 000 ha of land is arable and an additional 47 000 ha are under permanent crops. Eleven thousand hectares (11 000 ha) are under permanent pasture and 235 000 ha under forest and woodland.

In 1998, the population of Trinidad and Tobago was estimated at 1 318 000 with an annual growth rate ranging between 0.77 and 0.84 percent over the period 1995 - 1998. Ninety-five percent of the population lives on the island of Trinidad. The percentage rural to urban population declined from 40.5 percent in 1994 to 36.7 percent in 1998.

Since the 1970s the country's economy has been - and continues to be - dominated by the petroleum sector. The agricultural sector contributes 2.4 percent to GDP and employs 10.6 percent of the labour force. Sugar, cocoa beans, coffee and citrus are the main agricultural products. Agricultural exports constitute 8 percent of total exports from the country.

Trinidad and Tobago enjoys a warm, humid tropical climate. Average temperature is 26^{o}C with a little daily variation. Temperatures on Tobago are somewhat lower than on Trinidad, with a marked decrease of about 4^{o}C in the Main Ridge area.

The mean annual rainfall for Trinidad is 2 200 mm (75 year mean 1911 – 85) and for Tobago the reported mean is 1 900 mm (30 year mean 1956 – 85). There is considerable spatial variation in rainfall with averages ranging from 1200 mm to 3800 mm in Trinidad and between 1 200 and 2 800 mm in Tobago.

Rainfall pattern is seasonal with a dry season from January to May and a wet season from June to December. Approximately 70 – 80 percent of annual rainfall occurs during the wet season. July to September also marks the hurricane season, although these two islands are not considered to be in the hurricane's path. A secondary dry season or Petit Carême occurs during September and October.

Groundwater is found throughout most of Trinidad. About two-thirds of Trinidad's current water supply is taken from aquifers.

Ronald Bryce
Hydrologist
Ministry of Agriculture, Land and Marine Resources
Centeno, Trinidad and Tobago

Large-scale development of surface water has been limited to four rivers in Trinidad and Tobago. These are the Caroni and Oropuche Rivers in the Northern Range, the Navet River in the Central Range in Trinidad, and the Hillsborough River in Tobago which is the principal source of supply for Scarborough and southwest Tobago.

There are five surface water impoundment reservoirs (four in Trinidad and one in Tobago) with a combined capacity of 75 million m^3. The largest of these reservoirs is the Arena dam from the Caroni river system, with a capacity of 46.6 million m^3. Private individuals have constructed and operate small impoundment reservoirs, mainly in south Trinidad, but no data are available for these reservoirs.

The report presented at the workshop dealt only with the water resources of the country. A more comprehensive report on the state of land, water and plant nutrient resources are available at the following website : *http://www.tidco.co.tt/uwigeospatial/trinidad/home.htm*

Annex 1
Welcome address

Madam Chairperson, Dr. Compton Paul, Secretary of PROCICARIBE, Dr. Francois Dagenais, IICA Representative for Barbados, Dr. Chandra Madramootoo, Director of the Brace Centre for Water Resources Management, Distinguished Guests, Ladies and Gentlemen:

It gives me great pleasure to welcome you to Barbados to the Annual Technical Meeting of the Caribbean Land and Water Resources Network (CLAWRENET). As you are aware, this year, the ATM is combined with the regional symposium on Land and Water Information Systems. This Symposium is one of several which FAO has held throughout the world – in Zimbabwe, the Philippines and Latin America. The objectives of these workshops are (1) to discuss the contribution of information system on land and water resources in improving decision-making for rational use, management, conservation and monitoring the Caribbean's resources, and (2) to promote Land and Water Resources Information Activities in Caribbean countries, using the existing regional land and water networks.

Today, Caribbean agriculture is being threatened by external and internal forces such as trade liberalisation, rural migration and competition from other sectors (e.g. tourism). In the Windward Islands, bananas which were once considered "green gold" in most islands, have come under severe pressure from the so-called dollar bananas of Latin America. Likewise diminishing quotas and low prices for commodities such as sugar, cocoa and coffee have resulted in reduced fortunes for the traditional export crops.

Despite these declining fortunes, Caribbean agriculture still plays an important role in the region's economies, as a source of foreign exchange, employment and food security. Furthermore, it has the potential to contribute to economic growth through export expansion and import substitution, especially in countries with limited natural resources. Linkages between agriculture and tourism through eco and agri-tourism are additional options for agricultural development.

There have been regional initiatives to address some of the problems of agriculture. For example, CARICOM's Regional Transformation Programme (RTP) and the OECS Agricultural Diversification Programme (ADP) are aimed at developing sound land use and land policies to increase production to meet the demands of the domestic and export market as well as the tourism industry.

But to develop these policies, decision-makers must have ready access to soil, climatic, topographic and socio-economic data, to answer questions such as:

1. How much land is available and suitable for the production of these crops?

Joseph S. Johnson
FAO Subregional Office for Latin America and the Caribbean
Barbados

2. Which crops are best suited to a particular location?
3. What are the potential benefits and costs of producing that crop in the location?
4. What is the potential of alternative kinds of land use?
5. Which alternative is most acceptable to all stakeholders?

In the water sector, decision-makers need information on ground water and surface water sources, quantities available during the year, water quality, and demand for agricultural, domestic, industrial use, and for the all-important tourism sector.

To answer these questions, the countries must have ready access to reliable and up-to-date information. In most Caribbean countries, however, the problem of data and information is not one of availability but accessibility. Generally, the data required are dispersed in different Ministries and other national organizations. For example, the Planning Division usually has information on land use, the Ministry of Agriculture has information on land suitability and soil types, the Meteorological Office has climatic data and the Research Division or CARDI may have information on crop responses to various plant nutrients. Thus, there is need to store this information in a readily accessible form.

This workshop is appropriate, therefore, as it introduces the Land and Water Resources Information System as a means of storing the information needed for decision-making on appropriate land and water use options. It also allows countries which have the facility, to make the information available on the internet if they so desire and so to share their information within the region and with the rest of the world. More importantly, for countries which do not have the information, it will assist in identifying data and information gaps so that appropriate measures may be taken to fill those gaps, allowing more informed decision-making in the future.

But the quest for better land and water resources information systems must not stop with this workshop. It must be a sustained and on-going exercise to ensure that the information is current and timely. FAO is committed to assist the region in developing such systems. Recently, the organization has approved US $ 329 000 to assist the OECS in developing a Land Use Planning and Agricultural Production Zoning system in the sub-region.

This project has three main objectives:

1. To assist the Governments to evaluate their land resource base with a view to developing policy options and programmes for the rationalization of land use, zoning agricultural production and utilizing idle lands.
2. To assist the governments to review existing land use policies and develop modified or new policy options that will facilitate the acceleration of the regional diversification programme.
3. To strengthen planning and management of land resources through improved systems of land evaluation in the OECS member states.

Through the project, all islands of the OECS will be equipped with new computer hardware and software, including GIS and LRIS software. The new hardware and software will be used to establish land use databases and maps for specific pilot areas and to enhance the capabilities of operational GIS and LRIS systems. Using the new software, evaluations will be conducted of existing idle and marginal lands to determine their potential for utilization. Moreover, short and medium-term policy options will be formulated to accelerate production on these lands and to rationalize zoning of agricultural production in the OECS.

The project will also undertake a review of existing policies and legislation on land use planning, land tenure and registration and land taxation.

Additionally, two workshops will be conducted to share experiences among the islands in the preparation and use of land suitability maps in land use planning and policy decisions and to devise a plan of action for the implementation of follow-up activities.

This initiative has the potential for linkages and synergies with other regional and sub-regional initiatives such as CPACC and the Regional Environmental Plan as the information and data provided will complement those being collected in these other programmes.

It is hoped that the results of this project would not be limited to the OECS sub-region but that there will be a ripple effect which will benefit the entire region. FAO is willing to assist member countries in their quest to manage their land and water resources more judiciously. Through our technical cooperation programme and our partnership programme, we offer expertise from all over the world, particularly from developing countries such as ourselves, which have had similar experiences.

In the area of water development, the Organization has also assisted member countries to develop small scale irrigation projects. Here I am referring to the recently concluded projects in St. Lucia and Dominica, where prefeasibility studies were conducted of small scale irrigation projects and pilot irrigation schemes were established in those islands. A similar project has just been approved for Grenada, where assistance will be provided for refurbishing some existing schemes and, more importantly, for training technical and extension staff in planning, operation and maintenance of small scale irrigation schemes. Through this project, a reputable university will be contracted to conduct a hydrological study of the island's water resources to determine the potential for rural and agricultural development.

The Organization stands ready to assist member countries by providing technical assistance to enable you to help yourselves in this very important area of land and water development. We look forward to your continued support and collaboration in the future. I wish you well in your deliberations over the next three days and a successful symposium.

Thank you.

Annex 2
Keynote address

An Integrated Approach to

Land and Water Resources Management in the Caribbean

By

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Keynote Address at the First Technical Meeting
Caribbean Land and Water Resources Network
(CLAWRENET)

Bridgetown, Barbados
1 October , 2000

Abstract

The land and water resources of the Caribbean region are being threatened by improper human practices. Deforestation and the intensive cultivation of short term crops on steep slopes lead to soil erosion. Contamination of rivers by agro-chemicals and the improper disposal of household waste are threatening aquatic ecosystems and off-shore habitats. High sedimentation rates in rivers are encountered during the rainy season. Inadequate capacity of culverts, bridge openings, stream crossings etc. leads to flooding of rural homesteads and agricultural lands, especially during the hurricane season. The region experiences a dry season during the first part of the year, and supplemental irrigation is required during this period to sustain the production of food crops and horticultural crops. However, irrigation is relatively small in most of the Caribbean islands. More water storage structures are required.

The lack of sound land use policies leads to loss of prime agricultural lands, and improper agricultural practices on steep, marginal hillside lands. In addition, there are no national water policies. Land and water management in the region is fragmented. Several agencies have responsibility for various aspects of land and water. This hampers sound and integrated management. A more coordinated and unified approach to land and water resources management is required. There is an urgent need for integrated watershed and resources management. Institutional frameworks and government policies which allow for increased stakeholder involvement and participation of the private sector, NGOs etc. need to be encouraged.

Decision support systems which include GIS and soil erosion/hydrologic/water quality models are useful in the selection of best management practices on watersheds. Soil and water conservation practices, which are well known, are not widely adopted. Land tenure issues and financing of conservation practices are some of the constraints to adoption of these practices. Lack of sound technology transfer programs in government agencies also limits the uptake of conservation practices.

In order to facilitate integrated management of land and water resources, the region will need to intensify efforts at improving the hydrometric network in all countries, improve the reliability of long term water quantity and water quality data, strengthen its technical capability in soil and water conservation, set up the appropriate institutional framework and legislation to protect land and water, develop models for pricing of water and land of varying classes, and establish international and regional networking and collaboration. Schemes for financing conservation practices among small farmers need to be developed.

Introduction

The Caribbean Region is generally regarded as the archipelago of islands stretching from Cuba in the north, to Trinidad in the south. This chain of islands lies within the Caribbean Sea. It must, however, be remembered that all of the Central America countries have a coastline with the Caribbean Sea. In fact, this coastline extends from the southeastern tip of Mexico, to the northern extremities of Colombia and Venezuela on the South American mainland. However, for the purpose of this paper, the Caribbean Region will be confined to the island chain. Due to their history and patterns of colonization, these islands have experienced different levels of social, economic and political development. The English speaking islands, together with Guyana on the South American coast and Belize in Central America, have had a common history and political development. Consequently, they have formed an economic union, CARICOM. There are two non-English speaking countries in CARICOM: Haiti and Suriname. Within CARICOM,

there is a sub-grouping known as the Organization of Eastern Caribbean States (OECS). The OECS countries are: St. Kitts and Nevis, Antigua and Barbuda, Montserrat, Dominica, St. Lucia, St. Vincent, and Grenada. The larger island states are Barbados, Trinidad and Tobago, and Jamaica. Much of the discussion in this paper is relevant to the entire archipelago, and to some extent to Guyana, Belize and Suriname. The physiography, scale of agriculture and agricultural systems, and land and water resources in the latter 3 countries are somewhat different than of the island chain.

The islands, especially those in the OECS, are mainly volcanic in origin. Some of the islands are of coral formation. They are of relative recent geologic history, and as such the soils are not well developed. The soil types range from sands to heavy alluvial clays in the major river valleys. Various series of loams, clay loams, and silts are encountered. The topography of the islands varies from very steep and rugged to moderately steep. The highest point, or points, in most of the islands is located in the approximate center, and the elevation radiates out to the flatter coastline. Temperatures are relatively constant year round, and range from 20 to 30 degrees Celsius. There is a well defined wet and dry season in the region. About 75 percent of the annual rainfall occurs during the period, July to December. This is also the hurricane season. Rainfall varies both between and within countries. For example, the Leeward Islands of Antigua, Montserrat and St. Kitts experience less total annual rainfall than the Windward Islands of Grenada, St. Lucia, St. Vincent and Dominica. This is primarily due to orographic influences. The Windward Islands are much steeper and receive in excess of 2500 mm of rainfall annually. Similarly, the steeper parts of an island experience more rainfall than the flatter, coastal regions. Annual rainfall in the steep mountainous regions of the Windward Islands exceeds 4000 mm. Hurricane damage has been quite severe in the region in the recent past. There has been extensive damage to infrastructure, property, and crops and animals. Lives have been lost in some instances.

Agricultural systems in the region vary considerably. Larger farm units with mechanization can be found in Guyana, Belize, Trinidad, Jamaica and Suriname. Agriculture in Guyana and Suriname is carried out primarily in the flat, coastal lands along the Atlantic Ocean. These lands are below the normal sea level, and therefore have to be protected from inundation. Sea and river defence structures are therefore a requirement for human settlements and agricultural production. The predominant crops in Guyana and Suriname are rice and sugarcane. The agriculture of these two countries is nevertheless quite diversified, with various types of fruit and vegetable production. There is an extensive surface irrigation and drainage network in both countries. Belize also has large expanses of rice, sugarcane, citrus and banana producing lands. Mechanization, drainage and irrigation are also essential components of the production systems in Belize. Agriculture in Jamaica and Trinidad is on a somewhat smaller scale than the above three countries. Sugarcane is a predominant crop in both countries, with some rice production. There is also extensive vegetable production in both countries, but this drops in the dry season, due to lack of intensive irrigation. Sugar production in the Caribbean is primarily for export. Jamaica and Belize, together with the Windward Islands, are banana exporting countries. Export markets are mainly the UK, because of tradition and historical, political ties.

In the OECS countries, and Barbados to some extent, agriculture is mainly carried out by small farmers, occupying land holdings of one hectare or less. Sugarcane is predominant in Barbados and is undertaken by larger land owners. Bananas are predominant in St. Lucia, St. Vincent and Dominica. Grenada has a more diversified agricultural system which includes nutmeg and cocoa. Sugarcane which was once the dominant crop in St. Kitts is now in decline. It is worth noting that most, if not all, of the Caribbean countries were originally built around the sugar industry, to supply the European markets during the colonial period. As for the other islands, small farmers in Barbados and the OECS countries, produce vegetables, primarily for

the domestic market. However, vegetable production declines in the dry season, due to lack of irrigation. Most of the small farmers in the OECS countries are located on the steeper, more marginal lands, without access to water and other facilities. The larger land owners occupy the more fertile flatter lands, either in the river valleys, or close to sources of water.

With the exception of Guyana, Belize and Suriname, the CARCOM region is net importer of food, including very basic products. Even the three former countries import some food products, especially processed foodstuffs, beverages, and flour.

Agriculture has always been an important part of the economies of the Caribbean. It accounts for the major share of the export earnings of most countries. In recent times, other sectors of the economy have been gaining importance, viz. industry, tourism, manufacturing, commerce and banking. Nevertheless, governments recognize the importance of the agricultural sector, and often state that this sector must continue to develop and expand, and rise to the new challenges associated with the liberalization of markets and the advent of the World Trade Organization. The social and economic turmoil associated with a weakened agricultural sector could be disastrous in most countries. Trinidad is an oil producing and exporting country, and has a more diversified economy. It is probably the only country in the region that can afford a lessened dependence on agriculture. But even there, the government strongly supports local food production and agro-processing, and the allied industries.

There are enormous land and water management problems in the region, due to the variable rainfalls, soil types, steep topography in the islands, and types of agricultural production systems. The problems are especially severe in the Eastern Caribbean, and have detrimental environmental effects, which are not being addressed. Protection of terrestrial and aquatic ecosystems is a major challenge, which the region will need to address, if its development is to be advanced and sustainable. This paper highlights some of the problems and challenges in land and water resources management, and outlines some of the approaches which could be followed.

Land and water degradation problems

Soil erosion and deforestation

In addition to high amounts of rainfall in some countries, rainfall intensities are very high. The September 1994 Tropical Storm Debbie produced rainfall intensities as high as 125 mm/hr in St. Lucia (Rodman, 1996). This factor coupled with the steep topography, and agricultural production on the sloping lands, leads to severe soil erosion. There are very little soil conservation measures and "slash and burn agriculture" is practised in most countries. Several studies on soil loss have been conducted, primarily in Trinidad (Alleyne and Percy, 1966; Ahmad and Breckner, 1974; Gumbs et al., 1985), in Jamaica (Scheng and Michaelsen, 1973) and in St. Lucia (Madramootoo and Norville, 1993). Soil loss as high as 133 t/ha/yr were recorded on unprotected lands in the Jamaica study. The generally low levels of organic matter in the soils also contribute to the soil erosion rates. Given their recent geologic formation, the soils are not as well developed as in other parts of the world. In the Windward Islands, farmers have been clearing trees and moving into the upper extremities of catchments on very steep and fragile slopes to plant crops such as bananas and to build houses. There has also been similar deforestation in other countries. Not only has this led to loss of valuable tree species, but has also exposed fragile lands during the high rainfall periods. Significant land slides have thus occurred, blocking waterways and roads, and destroying crops and property.

Improper land management

There are no sound and regulated land policies in the region. While there have been attempts at land use classification, there are no established land management programs. Little is done to prevent people from occupying and farming steep hillsides. The land tenure situation compounds the problem. Farmers who do not own land tend to cultivate steep inaccessible mountainsides. These farmers have no incentive to undertake soil conservation measures. Unplanned housing also occurs on lands for which there is no title. Poorly constructed roads and runoff from houses exacerbate the soil erosion problems.

Water pollution

There is significant use of fertilizers and pesticides in the region. In many cases, agro-chemicals are being applied without firm agronomic recommendations and soil tests. These chemicals end up in streams and rivers, destroying aquatic flora and fauna, and limiting downstream use. Eroded sediment is also a source of pollution. Firstly, sediment in rivers increases turbidity. Secondly, some chemicals, e.g. N, P and pesticides are bound to sediment and thereby conveyed to water bodies. In other words, sediment is a transport mechanism for some agro-chemicals. Eutrophication in streams, rivers and lakes is stimulated with abnormally high concentrations of N and P. This leads to the creation of algal blooms.

Groundwater pollution may occur if chemicals, especially nitrate from fertilizer, leaches to aquifers. There are also cases where over-pumping of wells is leading to intrusion of brackish water in aquifers.

Improper industrial and municipal waste disposal is another source of soil and water pollution. Heavy metals in waste products and pathogens from municipal waste degrade both soil and water quality.

Coastal ecosystem destruction

There is growing concern about the destruction of coral reefs, mangroves and other coastal ecosystems by inappropriate land use and inadequate waste treatment facilities. Uncontrolled sediment, agrochemicals, and effluent from industries, hotels and homes end up in the Sea. Large plumes of sediment are being observed along the Sea coast, at the outlets of major rivers. This is especially in catchments where unplanned agricultural, quarrying, industrial and housing developments are taking place.

This brings out the point that inappropriate land and water management practices create adverse environmental impacts both within watersheds and as far downstream as the Caribbean Sea.

Inadequate designs

There is a lack of long term, reliable hydrologic data in most countries. This has led to the inappropriate designs of runoff conveyance structures, culverts, bridge openings, and erosion control systems. In order to cut costs, undersized structures have been constructed in some cases. This has caused flooding, and rivers to overflow their banks and bridges. Also, sediment and debris are trapped at bridges, culverts etc. There is no established routine of cleaning of rivers and debris removal. This aggravates the flooding problem in successive rainy seasons.

Water availability

While large amounts of surface runoff are produced during the wet season, there is a soil-water deficit during the dry season. Crop yields therefore decline during the dry season and irrigation is essential for horticultural crops. Average daily evapotranspiration varies between 5 and 6 mm during the year. Streamflows are also reduced during the dry season, and water shortages are sometimes encountered. The irony is that during the rainy season, much of the runoff goes to the Sea. Apart from reservoirs constructed for municipal and industrial use, runoff collection and storage facilities are rare. Although, some homes may have cisterns where roof runoff is collected for individual use. But this is not a general feature.

Integrated watershed and resources management

Water and land resources are managed in a very fragmented manner in the Caribbean. The sectors are not looked at in their entirety. There is no single agency in any of the countries responsible for overall management of these two resources. Agencies responsible for land fall within several Ministries or departments, such as agriculture, planning and development, lands, forestry, or statutory bodies such as development control authorities or national development corporations. The same applies to water. In countries where Ministries of Water exist, their responsibility only pertains to drinking water. Ministries of Agriculture are responsible for irrigation. Ministries of Health, Tourism, and the Environment also touch the water sector. This lack of coordination means that planning and management of the land and water sectors are not undertaken in an integrated or holistic manner. Most countries do not have national land or water management policies, or appropriate legislation. These shortcomings lead to conflicts in the use and allocation of the resources.

It is critical that governments develop integrated policies for both land and water. Integrated planning and management means that all stakeholders are involved in the development and implementation of policies and programs. This entails an interdisciplinary approach, and involvement of the water users and stakeholders in activities ranging from policy formulation to program and project delivery. For example, specialists in water resources engineering, the environment, agriculture, municipal systems, industry, health, economics, governance etc. all contribute to the development of solutions. Enactment of water and land laws is also key to integrated resources management. Legislation on water rights, ground water protection, control of water pollution, land and catchment protection etc. is essential components. Furthermore, governments need to develop and enforce land zoning and land use policies, in order to prevent the loss of prime agricultural lands, and degradation of sensitive areas in catchments. Apart from land use planning, governments need to take firmer control of the urban infrastructure planning process. This will go a long way towards the unauthorized establishment of housing units on sensitive lands, and the attendant problems of waste disposal.

As noted by Cosgrove and Rijsberman (2000), a holistic approach to water resources management is based on coordinating the following water uses:

- Water for people (municipal, industrial, health requirements etc.)
- Water for food and rural development (irrigation etc.)
- Water for nature (environment and ecosystems)

Integrated watershed management is recognized as a critical step early in the process. The watershed is defined as the single unit in which all hydrologic functions can be integrated, to

ensure sound management of land and water resources. By adopting the principles of integrated watershed management, land owners and water users define the common interests and agree on a set of actions which will not lead to a degradation of the land and water resources base. These actions are undertaken within a sound social, economic, environmental and institutional framework. All watershed functions and uses are considered in the management principles. So called Priority Areas (PAs) are defined. These may include:

- Drinking water catchments
- Ground water aquifers
- Sensitive eco-zones, e.g. natural wetlands, marshes, forests etc.
- Unstable soils and steep sloping lands
- Riparian zones

Successful integrated watershed management projects are built on strong stakeholder participation and involvement. The stakeholders usually form organizations such as river basin organizations, catchment protection associations, watershed councils etc. to administer and implement policies, programs, and projects. These organizations help to identify and define issues and problems, identify best management practices (BMPs), share experiences, and monitor the performance of the BMPs. The latter is essential as it provides for lessons learned. Policies and BMPs could then be modified to suit site specific requirements.

Governments, universities, the private sector and NGOs are all partners in integrated water and land management strategies. Watershed plans need government institutional, legislative, financial and technical support. The private sector and NGOs can also provide funding and some technical support. Universities are a useful partner in identifying and researching solutions, providing advice, and assisting with monitoring of activities. Information exchange and technology transfer are activities which the river basin organizations may undertake on behalf of the stakeholders.

The St. Lawrence River Action Plan is a very useful model of integrated water and watershed management. This river falls under several jurisdictions: The Canadian and US federal governments; US state governments, e.g. Vermont and New York; Canadian provincial governments of Quebec and Ontario. Dozens of municipalities on both sides of the border touch the watershed. The river has multiple uses e.g. shipping and navigation; agriculture; industry; water for human consumption; tourism and recreation; hydroelectric energy; maintenance of aquatic ecosystems. Therefore, all water users and jurisdictions play key roles in defining the problems, developing solutions, and implementing policies and remedial programs. They have also developed cost sharing mechanisms, and the stakeholders in the basin have formed groups which implement conservation projects. Major thrusts of the St. Lawrence River Action Plan have been the reduction of industrial and agricultural pollution in the basin, by introducing clean up legislation, wastewater treatment plants, reduction in the use of agro-chemicals etc. An over-riding objective of these actions has been to restore the biodiversity in the aquatic and terrestrial ecosystems of the basin.

Farm conservation planning

In some developed countries, there is now legislation requiring farmers to implement farm conservation plans. This legislation has been driven by the growing environmental concerns of soil and water pollution in rural areas. There is public pressure on the farming community to

reduce the degradation of land and water resources, since this causes major downstream environmental and economic damage. Farm conservation planning requires that farmers, in conjunction with technical officers, identify sources of soil erosion, water pollution etc. and then implement best management practices to mitigate against these adverse impacts. Tools for farm conservation planning can be found in Upper Thames River Conservation Authority (1990).

Specific conservation practices which ought to be considered are:

- Terracing, contour cropping, contour drainage, and strip cropping on hillsides, to reduce soil erosion
- Planting of cover crops and leguminous crops to increase soil productivity and reduce erosion
- Limit the planting of short term crops and bananas on the steep hillsides
- Agroforestry, i.e. planting of food crops between rows of trees
- Reforestation of denuded hillsides
- Utilization of economic tree crops, such as fruit trees, cocoa, nutmeg, coconuts, breadfruit etc. in agroforestry systems and reforestation projects
- Control of streambank erosion through a combination of river straightening, and vegetated buffer strips and trees along rivers
- Grassed waterways and rock chutes to control gully erosion
- Use of geotextiles, gabion baskets, or stone riprap on river embankments, to reduce streambank erosion
- Prevention of slash and burn practices and indiscriminate deforestation on hillside lands
- Collection and safe disposal of runoff from hillsides, and road ditches in steep areas
- Prevention of animal grazing on step lands and along streambanks
- Increased use of animal manures and crop residues in cropping systems, in order to increase soil productivity and organic matter levels, and to reduce soil erosion
- Use of drip irrigation and mini-sprinkler irrigation systems for horticultural production
- Construction of small reservoirs and weirs to harvest runoff during the rainy season, so that water is available for irrigation during the dry season
- Use of mulches, either crop residues or plastic tunnels, to conserve soil moisture for fruit and vegetable production
- Regulated pumping of groundwater, so as to avoid salt water intrusion in aquifers
- Reduced and controlled applications of agro-chemicals to avoid surface and ground water contamination
- Prevention of dumping of pesticides and herbicides in streams, and washing of agro-chemical sprayers in streams
- Implementation of waste handling and disposal measures on homesteads and farms, thereby reducing the dumping of wastes into rivers

Farmers have been slow to adopt conservation practices for several reasons. Primary reasons are the lack of knowledge of the appropriate practices, failure of government agencies to provide the technical expertise to farmers and a lack of financial capital. In many instances, government agencies do not have sufficiently trained professionals in soil and water conservation. The financial issue is important, because farmers who do not own land, find it almost impossible to obtain the money required for conservation practices. They have no collateral and their farm

sizes are very small. Furthermore, these farmers have no incentive to undertake conservation measures. These socio-economic constraints need to be studied and solutions developed. They cannot be left unattended, because of the national importance to safeguarding land and water resources.

Decision support systems for land and water resources management

There is now growing use of decision support tools for land and water resources management. Such tools include Geographic Information Systems (GIS) and computer simulation models. One of the earliest tools used for soil conservation planning was the Universal Soil Loss Equation (USLE). Many refinements and variations of the USLE are incorporated in current hydrologic models. Use of GIS allows for the archiving of physical and socio-economic data on a watershed basis. Watershed parameters could therefore be easily entered into various hydrological models.

One of the best GIS applications for land use and land capability in the region is the Grenada Land Information System (GLIS). The GLIS operates under PC ARCINFO, and contains digital databases on hydrology, climate, soils, infrastructure, parishes, terrain elevation, land use, protected areas, forest reserves and geology. The GLIS has been used to create different agro-ecologic zones in the country based on factors such as the length of the growing period, mean annual temperature, mean annual rainfall, mean temperature during the growing season, length of the dry season etc. The agro-ecologic zone information is combined with data on soil types and land slopes to establish the most appropriate cropping systems for the entire country. Market prices for the crops are also considered in the simulations. The GLIS allows the most economic cropping systems for various soil types and land slopes to be selected, while minimizing soil erosion. An added feature of the GLIS is that areas within watersheds that are suitable for agriculture, forestry etc., and areas that should be kept under conservation measures could be delineated. This is a powerful tool for integrated watershed management.

Cox and Madramootoo (1998) went a stage further and linked a GIS (SPANS) to the USLE, to estimate soil loss from two watersheds in St. Lucia. Based on these estimates of soil loss, conservation practices were selected, which reduce loss. The challenge with such decision support systems is how to deal with intensive crop production on land slopes in excess of five degrees. There is significant cultivation on steep lands, greater than five degrees, in many islands. While agro-forestry is recommended on slopes in excess of five degrees, there is a need to implement additional physical and biological conservation measures, as described in the preceding section. An additional problem is that decision support systems may call for land slopes exceeding 20 degrees to be under permanent forest cover. In this case, farmers on such land slopes will have to be relocated to flatter lands. They may also require some form of financial compensation. Governments have so far failed to address these issues of farmer relocation. One of the reasons for inaction in this area so far, is that national land inventories have never been undertaken. While some private lands in flatter areas are being abandoned, there has been no attempt to create land banks, so that these abandoned lands can be purchased by farmers located on very steep, marginal lands.

As noted earlier, GIS allow for watershed data to be easily entered into hydrologic models. GIS is now being coupled to water quality models such as AGNPS, ANSWERS etc. In this case, phosphorus loads in watersheds are being predicted. Best management practices to reduce agro-chemical pollution can then be selected. With this advance, various strategies for controlling runoff, peak flows, soil erosion, and pollutant loads could be evaluated for various storm recurrence intervals.

Other potential applications of advanced technologies lie in the use of remote sensing for assessing land use changes with time, and the use of radar measured rainfall to do real time flood forecasting and runoff predictions.

Requirements for sustainable integrated land and water resources management in the caribbean

If the region is to make advances in integrated land and water resources management, it needs to pay concerted attention to the following:

1. Data

There is a shortage of data on land water resources in the region. For example, national land inventories have not been undertaken in most of the countries. In addition, there is a lack of reliable, consistent, long term hydrometeorological and water quality data. There are not sufficient stream gauging stations in most countries, and in cases where there are gauges, the data is scant. There have hardly been any routine and consistent water quality measurements. Robust and secure database systems need to be created.

2. Human resources

The region lacks a cadre of skilled professionals and technicians in land and water resources management, soil conservation, water quality, irrigation, and drainage. People with strong analytical skills are required for data collection and analysis, and also with the knowledge base to advise farmers.

3. Financial programs

Financial resources are required to undertake studies in land and water management, and to cover large and small scale soil and water conservation measures. Development finance institutions and commercial banks in the region do not have a strong history of supporting land and water resources management programs. There have been loans for irrigation. However, soil conservation programs have not been funded in any significant manner.

Related to the lack of skilled human resources is the lack of government and regional financial support for training of professionals, technicians, water users and land owners.

4. Institutional framework

National agencies working in all aspects of land and water resources need to collaborate much more closely, and undertake joint planning, management and programming. They all need to be involved in a more integrated manner in land and water policy development. A framework for integrated resources management ought to be developed. Well defined policies on water and land resources management need to be articulated to the public, and strongly promoted.

Legislation on land use zoning, catchment protection, water pollution control, water rights, water pricing etc. needs to be enacted and enforced by governments.

Governments have to create an enabling environment through which all stakeholders, including water users and land owners, the private sector, universities, research institutes etc. can participate in joint policy formulation and resources management. New forms of governance may emerge, including devolution of certain central government functions to river basin councils etc.

Within any institutional framework, the role of the government should be clearly defined. Government departments which touch land and water ought to play stronger leadership roles, especially in the areas of technology transfer, data collection and monitoring.

5. Economic considerations

The view has been expressed that undervaluation (or no valuation) of land and water leads to mismanagement of the resources (Cosgrove and Rijsberman, 2000). More work needs to be done on water pricing, valuation of lands of varying classifications, and the cost benefits of various best management practices.

6. Regional and international linkages and collaboration

Given the size of the region, similarity of problems between countries, scarcity of finances, and shortage of technical skills, more emphasis should be placed on regional collaboration, especially in sharing of knowledge and expertise, exchange of information, and policy development. It would also be advisable to approach international agencies and donors for financing of regional projects. The resources of the international community e.g. the NGOs, universities, research centers etc. should be drawn upon, to access the latest information and knowledge, and for assistance with training. A strong regional network with international linkages could be very attractive and beneficial.

Conclusions

The problems of land and water resources management are very similar in most of the Caribbean countries, with the exception of Guyana, Belize and Suriname. These countries lie somewhat outside the Caribbean archipelago. Land and water resources management are very fragmented. As a consequence, there is considerable soil erosion due to improper farming practices. Lack of land zoning policies results in the loss of prime agricultural lands to housing and other developments. Farmers are planting intensive short term crops on vulnerable steep lands. Stream pollution by agro-chemicals and municipal waste is deteriorating the rivers. Sediment and chemicals in rivers are threatening coastal ecosystems such as coral reefs and mangroves. The region needs to focus its efforts on integrated watershed and resources management. A more holistic approach to the planning and management of resources needs to be undertaken, involving all stakeholders. These include land owners, water users, government departments, the private sector, universities and research centers. New forms of governance of watersheds may emerge, as a result of integrated management and involvement of all stakeholders. The concept of farm conservation planning needs to be promoted, in order to identify and implement appropriate methods of soil and water conservation. Decision support tools such as GIS and hydrologic and soil erosion models are powerful techniques for integrated watershed management.

In order to facilitate a more rapid approach to integrated land and water resources management, the region must give urgent thought to improving its hydrometric network and

quality of hydrometric data, strengthening the skills of technical staff in government departments, establishing the institutional framework for integrated resources management, putting the financial programs in place to encourage soil and water conservation, doing a better job of valuing water and land of varying classes, and increasing regional and international collaboration and networking.

References

Ahmad, N. and E. Breckner. 1974. Soil erosion on three Tobago soils. Tropical Agriculture, 51:313-324.

Alleyne, E. P. and M. J. Percy. 1966. Runoff and soil loss on two small watersheds in the Northern Range, Trinidad. Tropical Agriculture, 43:323-326.

Cosgrove, W.J. and F. R. Rijsberman. 2000. World Water Vision – Making Water Everybody's Business. Earthscan Publications Ltd, London.

Cox, C. and C.A. Madramootoo. 1998. Application of geographic information systems in watershed management planning in St. Lucia. Computers and Electronics in Agriculture, 20:229-250.

Gumbs, F.A., J.I. Lindsay, M. Nasir, A. Mohmmed. 1985. Soil erosion studies in the northern mountain range, Trinidad, under different crop and soil management. In: *Soil Erosion and Conservation,* pp. 90-98. Soil Conservation Society of America, Ankeny, Iowa.

Madramootoo, C.A. and P. Norville. 1993. Runoff and soil loss from strip cropped and terraced hillside lands in St. Lucia. J. Agric. Engng. Research, 55:239-249.

Rodman, R. 1996. Hydrology of a major tropical storm, St. Lucia, West Indies. Water News, Canadian Water Resources Association, 15(2):15.

Scheng, T.C. and T. Michaelsen. 1973. Runoff and soil loss studies in yellow yams. FAO/UNDP Project Report, Jamaica.

Upper Thames River Conservation Authority. 1990. Cropland Conservation Farm Planning. A guide to conservation techniques and system selections. 24pp. London, Ontario.

Annex 3
Programme

Time (Hrs)	Speech/Topic	Speaker/Resource Person
Monday 2 October 2000		
08:30 - 9:00	Registration	Participants/Resources Persons
Opening Ceremony		
09:00 - 09:10	Welcome	Dr. Compton Paul, Executive Secretary, PROCICARIBE
09:10 - 09:15	FAO Greetings	Mr. Joseph Johnson, FAO, SLAC
09:15 - 09:20	IICA Greetings	Dr. Francois Dagenais, IICA Barbados
09:20 – 09:40	Keynote Address, Integrated Land and Water Resources Management in the Caribbean	Dr. Chandra Madramootoo, Director, Brace Centre for water Resources Management & Professor of Agricultural and Biosystems Engineering, McGill University
10:00 – 10:30	*Coffee Break*	
SESSION 1: Land and Water Resources in the Caribbean *Chair: L. Fletcher-Paul*		
10:30 – 11:00	GIS-based land and water resources information systems for the Caribbean	Jacob Opadeyi, UWI, Trinidad and Tobago
11:00 – 11:30	Sustainable fisheries management in the Caribbean Sea	Susanne Singh-Renton, CFRAMP, Trinidad and Tobago
11:30 – 12:00	Agro-forestry systems for the Caribbean	John Beer, CATIE, Costa Rica
12:00 – 12:30	The technical, economical and political implications of the acquisition and deployment of genetically modified crops in the Caribbean	Wendy Hollingsworth, IICA, Barbados
12:30 – 14:00	*Lunch Break*	
14:00 – 14:30	Sustainable land-use systems for hillside agriculture in the Caribbean	Joseph Lindsay and Frank Gumbs, Jamaica and Trinidad and Tobago
14:30 – 15:00	Climate change effects in the Caribbean	Neveille Trotz, CPACC, Barbados and Adrian Trotman, CMI, Barbados
15:00 – 15:30	Organic Farming in the Caribbean	Joan Petersen, CARDI, Trinidad and Tobago
15:30 – 16:00	*Coffee break*	
16:00 – 16:30	Sustainable Management of Coral Reefs in the Caribbean Sea	John Munro. ICLARM
16:30 – 17:00	Natural Resource Management for sustainable agricultural development in the Caribbean	Compton Paul, CARDI, Trinidad and Tobago
17:00 – 17:30	Biodiversity protection in Caribbean Agrecosystems	C. Paul and L. Guarino, CARDI, Trinidad and IPGRI, Colombia
Tuesday 3 October 2000 SESSION II: Demonstrations *Chair: Dr. Jacob Opadeyi*		
08:00 – 08:30	Introduction to the AGL Land and Water Gateway	Jacques Antoine, FAO, Rome
08:30 – 08:45	Demonstration of the Report on the State of Land and Water Resources	Sachimine Masui, FAO, Rome
08:45 – 09:15	GIS Applications for Agricultural Planning in Bangladesh	Mike Broten, USA
09:15 – 09:45	GIS on the Internet	Mike Broten, USA
09:45 – 10:00	*Coffee Break*	

Time (Hrs)	Speech/Topic	Speaker/Resource Person
SESSION III: Country Reports and Priorities for Development of National Programme of Work *Chair: Dr. Jacob Opadeyi*		
10:00 – 10:15	Antigua & Barbuda	Gerald Fernandez
10:15 – 12:30	Barbados	Glenn Marshall
	Country Report 5 - BVI	Dennis Leland
	Country Report 6 - Cuba	Sigfredo Hernandez Ortega
	Dominica	Odile Valmont
	Grenada	Raymond Baptiste
	Guyana	Sheik Kan
12:30 – 14:00	*Lunch Break*	
14:00 – 15:00	Haiti	Paul-Verlaine Jean Baptiste Joseph Lindsay
	Jamaica	Gene Knight
	St. Kitts & Nevis	
15:00 – 15:15	*Coffee Break*	
15:15 –16:30	St. Lucia	Deborah Bushell
	St. Vincent and the Grenadines	David Ramgolan
	Suriname	Gerrit Breinburg
	Trinidad and Tobago	Ronald Bryce
16:30 - 17:00	Summary of national Reports	Jacob Opadeyi
Wednesday 4 October 2000 SESSION IV: LWRIS Review – the way forward *Chair: Denis Leland*		
08:00 – 08:15	Review of AGL Guidelines and Internet Template	Jacques Antoine
08:15 – 10:30	Working group discussion on national and Regional follow-up action (Plan of Action) including provisions for updating the data on AQUASTAT, the database on Water Use in Agriculture and Rural Development	All participants
10:30 – 11:00	Coffee Break	
11:00 – 12:00	Presentation of report of Working Group	Denis Leland and Deborah Bushell
12:00 – 13:00	*Lunch Break*	
SESSION V: Development of Regional Plan of Work *Chair: Compton Paul*		
13:30 – 14:00	Review and Discussion of National Priority Areas to be included in regional POW	Compton Paul, PROCICARIBE
14:00 – 16:00	Regional POW Development (to include responsibility matrix)	Compton Paul, PROCICARIBE
16:00 – 16:30	Coffee Break	
16:30 – 17:00	Continuation of POW Development	Compton Paul, PROCICARIBE
17:00 – 17:15	Election of Regional Coordinator	All Participants
17:15 – 17:30	TAC Nominations	All Participants
17:30 – 18:00	Closing	Compton Paul. PROCICARIBE

Annex 4
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Annex 5
Status of preparation of country reports

A tentative timeframe was established for completion of the reports. This was summarized in Table 5.1.

TABLE 5.1
Status of preparation of country reports

COUNTRY	STATUS	CONSTRAINTS	TIME FRAME
Antigua	70 – 80%	Human resource scarcity, Staff busy on other work or projects, No computer in the Soil and Water Conservation Unit	Mid-November 2000
Barbados	30% - Water resources section done, no information on plant nutrition	Unlikely to get government funds to complete this year, Time	End Dec. 2000 (skeleton) March 2001 (with more information)
British Virgin Islands	80% - Plant Nutrition information needed	Manpower Time	Mid- November 2000
Cuba	75% - Plant nutrition information missing. Water resources from Aquastat through a Link	Time Other commitments No or limited computer time	December 2000
Dominica	0% Water resources information can get from Water Authority	Institutional and political changes Data availability (No Department in the Ministry of Agriculture collects this type of data) Funding for data acquisition	Mid-June 2001 (an intial incomplete form)
Grenada	65% Draft is ready - needs to be reviewed	Time	December 2000 (with financial assistance) June 2001 (without assistance)
Guyana	10% Land resources complete	Internet access not widely available. Disinterest. Human Resource Scarcity Need stipend for data entry (consider National Workshop to sensitise stakeholders)	End December 2000 (Preliminary Report)
Haiti	5%	Election trouble?? Time (to identify sources of data, data collection, data entry and report preparation	July 2001 (Preliminary Report) Country Overview Hot spots Bright spots (End 2001)
Jamaica	0%	Coordination	End December 2000 (Preliminary report) Can do in 1 month with coordination.
St. Kitts and Nevis	30% Aquastat Done	Trends (Spatial and Temporal) Difficulties to develop base maps	End December 2000 (Preliminary Report) Mid June 2001 (with assistance)
St. Lucia	40%	Need assistance to get maps	Mid December 2000

COUNTRY	STATUS	CONSTRAINTS	TIME FRAME
St. Vincent and the Grenadines	unknown	AEZ, Land Use changes, Data not readily available, Need to collect, analyze and interpret the data	Unknown
Suriname	0%	No network established Data availability Data processing	Unknown
Trinidad and Tobago	30% Water resources data done	Man power	End January 2001

Annex 6
Guidelines for country reports on the state of land, water and plant nutrition resources

These guidelines constitute a general framework to facilitate systematic compilation of information for the reports. The guidelines should ensure that country reports will be comparable along the lines of common themes, such as land use and land 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 from which a selection can be made depending on relevance and availability of information in specific situations. If the information is not available or is not relevant to the country or the part of the country considered it should not be included in the report or may be added at a later date. In certain cases the FAO approach (e.g. agro-ecological zoning) has been suggested. Where this information is not available, data gathered using other kinds of methodologies should be presented, and the methods described or a link to the methodology provided. The guideline will be updated from time to time as more experience is gained.

The report is a 'live' document. The aim of the report is to bring together the most up-to-date information on land, water and plant nutrient resources. Where possible, information should not be presented as static data but in the form of trends, preferably in a visual format (maps, tables, charts, images). The text should be short but suggestive, enriched with many simple but "attention catching" visual objects. Internet lends itself perfectly for this kind of presentation. Hypertext enables the information to be easily modified: items can be added or deleted at any time and with ease. As new 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 understood by decision makers and users.

In the hydrography, irrigation/drainage section, FAO (Aquastat) information, if available will be provided for the country. A country may then choose to add to this information or replace it with that from other sources.

National or Sub-National report

Users**:** **National Agencies**
Policy makers
International agencies/Donors
Educational/Research Institutions
NGOs and other interested groups
Private investors

The guidelines are incorporated into the Internet template which is downloadable from the AGL Gateway site at the following address: http://www.fao.org/ag AGL/swlwpnr/swlwpnr.htm

Tips for preparing the report

- In the first instance, the report can be prepared as a WORD document. This can then be stored, and converted to html format for dissemination via internet or cd-rom.
- Using the hyperlink function it is possible to link the various sections of the report that deal with common issues, as might be the case for example between 'Natural hazards'and 'Hot spots'. It is possible to do this even under WORD 95 by selecting 'cross reference' from the 'insert' menu. Links should be made to other web sites where appropriate.
- As general rule the most recent available data must be used. The main sources of information should be inserted in References at the end of the document.
- Where possible, data should be presented in the form of trends, preferably in a visual format (maps, tables, charts, pictures) that supports or replaces text.
- All data must be checked for internal consistency (e.g. percentage values should total 100).
- Text should be short and factual except in the more discursive 'challenges/viewpoint' section, which focuses on important topical issues. Here different opinions could be voiced and links made to relevant articles.
- It may be useful to include a list of addresses (e-mail or web sites) of institutions or people that can be contacted, at the end of the document.
- The length of the report should be no more than 30 pages including text, graphics and pictures.

A. Country Overview

Geographical location (description, localization map)

Geomorphology

Administrative units (Capital city, regions, provinces, other administrative units)

B. Socio-economic features

Population (population statistics: size, density, %rural/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 agriculture's role in the economy, contribution to GDP and employment)

Major food 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)

Cropping intensity (general cropping intensity, trends in single, double and triple cropping)

Crop diversification (crop diversification programmes, results)

C. Climate

Climate description (general climate type)

Table of climatic data (humidity range, temperature data, mean annual rainfall, monsoons and average seasonal rainfall)

D. Physiography

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

E. Soils

Soil types and distribution (soil map; area and proportions occupied by general soil types)

F. Inundation land types

Inundation land types (definition of inundation land types; inundation map, area and percentage cover of inundation land types; relation with cropping patterns)

G. Land cover

Definition of land cover, land cover map and area occupied by different land cover types; trends in land cover.

H. Land use

Definition of land use

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

Annual cropping: 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, vegetables).
- Perennial field cropping: cropping land under perennial crops. Crops harvested more than one year after planting (e.g. sugar cane, banana, sisal, and pineapple).
- Tree and shrub cropping: producing for a number of years without replanting (e.g. coffee, tea, grapes, oil palm, cacao, coconut, apple, pear).

Grazing: land used for animal production

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

Forestry: land used mainly for wood production and other forest products.

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

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

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

Land use areal trend. The changes in areal extent of the land use type, LUT can be represented by one of the following five classes:

-2: area coverage is rapidly decreasing, i.e. >2% per year of that specific LUT area.

-1: area coverage is decreasing, i.e. 0-2% per year of the LUT area

0: area coverage remains ± stable as a percentage of the LUT area

1: area coverage is increasing, i.e. 0-2% per year of the LUT area

2: area coverage is rapidly increasing, i.e. > 2% per year of the LUT area

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

-2: A major decrease in land use intensity

-1: A moderate decrease in land use intensity

0: No major changes in inputs, management level, etc.

1: Moderate increase, e.g. switch from no or low external input to some fertilizers/ pesticides; switch from manual labour to animal traction

2: Major increase, e.g. from manual labour to mechanization, from low external inputs to high external inputs.

Example:

LAND USE			
Land use type	Area %	Areal Trend	Intensity Trend
Annual cropping	40	2	2
Grazing	25	1	1
Forestry	10	-2	2
Mixed uses	20	0	0
Protected forest	5	-1	0

Land Productivity

Average production value. US$ equivalents for the production value per hectare for each land use type will be used as a relative indicator for productivity, and for estimating trends and regional differences. Figures for cropland will generally be obtained more easily than for other land uses, but if figures were known for grazing land or forest land as well, they would be welcome.

Average input. The production value for each LUT is related to inputs of materials, equipment and labour per hectare per year. Hence all inputs, should be estimated, including hidden

costs such as the farmer's own labour. Any establishment costs should be averaged over the period since implementation and added to the annual costs.

Inputs: labour – own and hired – seeds, fertilizers, pesticides, mechanization/hire of ox, cost of irrigation, income from outside farm, income from livestock.

Outputs: crop and livestock production

Land productivity trend. Although changes in productivity 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 is required here:

1: increasing outputs
0: no change in outputs
-1: decreasing outputs

Example:

LUT		Productivity	Av.prod.value (US$/ha/yr)	Av.inputs (US$/ha/yr)	Production Trend
Cropland	1	Contour tillage	125	100	1
	2	Grass strips	145	160	1
	3	Association (1/2)			
Grazing land	1	Controlled grazing	?	?	?
	2				
	3				
Forest land	1	Reforestation	200	250	1
	2	Area closure	180	150	1
	3				
Mixed Land	1				
	2				
	3				
Other land	1				
	2				
	3				

I. Agro-ecological systems

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

Land capability classes (definition of LCC, % cover)

J. 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)

K. Irrigation and drainage

Irrigation potential (method of calculation)

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

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

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

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

Irrigation schemes: typology by size and by operating mode: scheme size, number of beneficiaries, management, performance, cropping intensity, fees

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

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

Institutional and policy environment

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

Water and land legislation: status, implementation.

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

L. Plant nutrient resources

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

Trends in mineral fertilizer consumption per hectare (Kg/ha) and yields, per main food crop (also rice types) and cash crops

Types of fertilizer produced locally/imported

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

Fertilizer subsidies

Farm budgets in different cropping systems

Farmer cash flow

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

Water pollution

M. Natural hazards

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

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

The detail of items will depend upon particular country circumstances

Hot Spots ***(definition)***

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
- ***Water erosion (off-site effects):*** sedimentation of reservoirs/waterways, flooding and pollution of water bodies with eroded sediments.
- ***Wind erosion (on-site effects):*** loss of topsoil by wind action and "terrain deformation, deflation hollows, hummocks 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.
- ***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 weight/frequent use of machinery; and clogging of soil pores causing development of a thin impervious layer.
- ***Waterlogging:*** effects of human induced hydromorphism (rising water tables and flooding).

Map of areas affected by different types of soil degradation

Land use issues

Agricultural prime land encroachment/land conversion

Land tenure and land policy

Conflicts in 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)

O. Bright spots: Examples and perspectives of sustainability of production systems

The detail of items will depend upon particular country circumstances

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

Available lands for sustainable agricultural development

Sound land use/allocation policies

Sustainable land use systems

Land care programmes

Success stories in land use

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

New technologies (biotechnology etc.)

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

Sound use of water resources

P. Challenges, viewpoints

The challenges are country specific. They have to be clearly identified especially in land, water and plant nutrition resources management, and strategies developed to meet the challenges.

Q. References

This document contains the proceedings of the Subregional Workshop on Land and Water Information Systems (LWRIS) in the Caribbean, held in Barbados in October 2000. The meeting was organized by FAO Land and Water Development Division (AGL), in collaboration with the Caribbean Agricultural and Research Development Institute. LWRIS experiences in the countries are presented as well as recommendations for future collaboration in database development, reporting and exchange of information, expertise and experience in land and water management in the region and the implementation of regional projects. This includes the preparation of national and regional reports on the state of land, water and plant nutrient resources in the Caribbean for dissemination through the Caribbean Land and Water Resources Network (CLAWRENET) Web site that is linked to Web sites in the countries and with the AGL Web site.

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